ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

OAK GROVE VILLAGE WELL
SULLIVAN, FRANKLIN COUNTY, MISSOURI
EPA FACILITY ID: MOD981717036
MARCH 8, 2004

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment 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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PUBLIC HEALTH ASSESSMENT

OAK GROVE VILLAGE WELL

OAK GROVE VILLAGE, FRANKLIN COUNTY, MISSOURI

CERCLIS NO. MOD981717036

Prepared by:

Missouri Department of Health and Senior Services
Division of Environmental Health and Communicable Disease Prevention
Section for Environmental Public Health
under cooperative agreement with the
Agency for Toxic Substances and Disease Registry

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. (The legal definition of a health assessment is included on the inside front cover.) If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state and federal agencies, the companies responsible for cleaning up the site, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When informed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E60), Atlanta, GA 30333.

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SUMMARY

The Oak Grove Village Well site is an uncontrolled and undefined plume of trichloroethylene (TCE) contaminated groundwater in an area where groundwater movement is somewhat variable because of karst geology. Oak Grove Village is a small community with a population of 382 that is located adjacent to the northeast boundary of the city of Sullivan, Missouri. TCE contamination was originally detected in the Oak Grove Village well on June 10, 1986, by the Missouri Department of Natural Resources (MDNR) at 6 parts per billion (ppb), above the Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) of 5 ppb.

TCE is a volatile organic compound (VOC) that evaporates easily in air, but stays in soil and water without much decomposition. Since it is heavier than water it can easily pass through the soil into the groundwater. TCE is a manufactured VOC that is used mainly as a solvent to remove grease from metal parts, but can also be found in household products such as wood stains, varnishes, lubricants, adhesives, typewriter correction fluids, paint removers, and cleaners.

Following the initial detection of TCE, MDNR continued to sample the village well and various distribution points through October 1990. That sampling indicated continuing TCE contamination. Because of this ongoing contamination, MDNR issued a Notice of Violation to Oak Grove Village. The village closed its well in July 1991 and began purchasing water from Sullivan. In September 1992, Oak Grove Village disconnected from the Sullivan water supply and again began using their well, only to find that it still remained contaminated with TCE. The village again purchased their water from Sullivan. Other private wells in two separate locations in the area and a spring that drains the area also have shown TCE contamination.

Since the undefined plume(s) of TCE contaminated groundwater has affected the Oak Grove Village well, numerous private wells, a spring, and other municipal wells and because the source(s) of the contamination has not yet been determined, the site was proposed for EPA's National Priorities List (NPL) on September 13, 2001. The site was officially placed on the NPL on September 5, 2002. Since the city of Sullivan ended the contract to supply water to Oak Grove Village in December 2002, the village decided to drill a new well. Sullivan continues to supply water on a month-to-month basis as long as the village continues to show progress in providing their own water source. Due to unforeseen problems or a disagreement between the communities, the potential exists that the village may have to reactivate their old well (which contains an unknown level of TCE contamination under pumping conditions), to supply the village with water. EPA has asked what the health consequences of that action would be, so the Missouri Department of Health and Senior Services in cooperation with the Agency for Toxic Substances and Disease Registry will also assess that situation in this public health assessment.

Use of the contaminated Oak Grove Village well in the past represents a completed exposure pathway to users of the village public water system. A completed exposure pathway also existed in the past and presently exists to some private well owners in two separate areas, although presently at levels below the MCL. Because no health guidelines exist to determine the health effects from low-level long-term exposure to TCE, calculations were done to estimate the worse

case risk from ingestion and inhalation exposure for non-cancerous adverse health effects as well as the risk of that exposure causing additional cancer in the population. Because no adverse non-cancerous health effects are expected and only a slight theoretical additional cancer risk exists from past exposure, the site was assigned a hazard classification of No Apparent Public Health Hazard for the past and present. The category of No Apparent Public Health Hazard is used for sites where human exposure to a contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.

Since it is not known if the old Oak Grove Village well will have to be reactivated, or the future levels of TCE contamination in the old well or new well, in public or private wells, or in the LaJolla Spring and its cave complex, or how many additional wells may also be affected, the site is assigned a Indeterminate Public Health Hazard for the future. The category of Indeterminate Public Health Hazard is assigned to sites for which no conclusions about the public health hazard can be made because data are lacking.

PURPOSE AND HEALTH ISSUES

The Missouri Department of Health and Senior Services (DHSS), in cooperation with the federal Agency for Toxic Substances and Disease Registry (ATSDR), evaluated the public health impact of the Oak Grove Village Well site. This public health assessment determined if exposures at levels of health concern occurred or are likely to occur, and recommends actions to reduce or prevent possible adverse health effects. ATSDR is a federal agency within the U.S. Department of Health and Human Services and is authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to conduct public health assessments at hazardous waste sites. This document will assess past, current, and future exposure to the contaminated groundwater at the site. As requested by the Environmental Protection Agency (EPA), this public health assessment will also consider the health implications of Oak Grove Village reactivating their existing well to provide public water until a new well can be drilled and placed into operation.

BACKGROUND

Site Description and History

The Oak Grove Village Well site is an uncontrolled and undefined plume(s) of trichloroethylene (TCE) contaminated groundwater detected in the Oak Grove Village municipal well. The source(s) of the contamination that has affected the village's well, other public and some private wells in the area, and a spring in a nearby commercial cave has yet to be determined. Oak Grove Village is a small community located adjacent to the northeast boundary of Sullivan, Missouri. See Figure 1 in Appendix A for the site location. The village has only one well that supplies the village's municipal water system of approximately 200 connections (1,2). The well was drilled to a depth of 805 feet in 1964, but has a current depth of approximately 725 feet based on a video log performed during the Phase 1 Remedial Investigation (RI). To date, only Phase 1 of the RI for the remedial investigation/feasibility study (RI/FS) has been completed for the Oak Grove Village Well site in March 2002, but further investigations are ongoing.

The Oak Grove Village well was first found to be contaminated on June 10, 1986, after water sampling by the Missouri Department of Natural Resources (MDNR) detected TCE above the EPA's Maximum Contaminant Level (MCL). TCE was detected at a level of 6 parts per billion (ppb), above its' MCL of 5 ppb. An MCL is the maximum permissible level of a contaminant in water, which is delivered to any user of a public water system. Following the initial detection of TCE, MDNR continued to sample the Oak Grove Village well and points in the distribution system on a quarterly basis through October 1990. During this period TCE continued to be detected at concentrations ranging from 2.4 to 12.0 ppb. Tetrachloroethylene (PCE) was detected in two of the sampling events in 1986 at a maximum level of 59 ppb, but has not been detected since. Because of the continued presence of TCE in the well, MDNR issued a Notice of

Violation (NOV) to Oak Grove Village and the village closed the well in July 1991 and began purchasing water from Sullivan (1,2).

In September 1992, Oak Grove Village disconnected from Sullivan's water supply and reopened their well. MDNR reinstated sampling on a quarterly basis once Oak Grove Village reopened the well. During all four quarters, TCE exceeded the MCL with concentrations ranging from 10 to 25 ppb. Due to the continuing detection of TCE above the MCL, MDNR issued a second NOV, and in February 1994 Oak Grove Village closed the well and again began purchasing water from the city of Sullivan (2,3). The Oak Grove Village well remains functional and is capable of being returned to service (2). In the hope of reducing the concentration of TCE in the well, the well was pumped to waste (not used for drinking) between May 16, 1997 and June 9, 1997. Concentrations did not decrease and remained between 10 and 13 ppb. On September 11, 1997, the Oak Grove Village well was sampled as part of an MDNR Additional Site Assessment. After being purged for 20 minutes, TCE contamination had increased to 42.3 ppb from the last known concentration of 13 ppb in June of 1997 (2). Because the undefined plume(s) of contaminated groundwater have affected the Oak Grove Village well and numerous private wells and because the source(s) of the contamination has not yet been determined, the site was proposed for EPA's National Priorities List (NPL) on September 13, 2001, and officially placed on the NPL on September 5, 2002 (4,5).

Recent sampling of the Oak Grove Village well for the Phase 1 RI (by MDNR) during September, October, and December 2001, as well as the most recent by MDNR in June 2002, has found TCE at a level of less than 1 ppb. All of these samples were taken without the well in an active pumping condition. In the June 2002 sample, MDNR used a packer system to isolate and sample a low volume of water from the Oak Grove Village well at different depths. Of the depths sampled, only one revealed detectable levels of TCE at 0.9 ppb. MDNR plans to do further sampling under actual pumping conditions to determine the level that would be present under actual usage (1,6).

On May 23, 2002, the city of Sullivan notified Oak Grove Village by letter that the water agreement with the village would expire on December 31, 2002, and the city did not plan to extend the agreement except on a month-to-month basis (7). Options for the village's future public water supply were discussed in a June 13, 2002, meeting between representatives of Oak Grove Village, MDNR, EPA, and DHSS. The decision was made to proceed with plans to drill a new well, and if needed, add a treatment system to provide a safe source of public water. EPA requested a health consultation to determine what health effects might be expected to occur to the village's water users if the village finds it necessary to reactivate their old well (8). This public health assessment will also address that issue. During a phone conversation with a representative of Oak Grove Village, DHSS learned that a new well will probably be ready by the spring of 2003, and it was confirmed that as long as the village can show progress toward getting their own public water supply, the city of Sullivan will continue to supply the village with water until the new well is operational (telephone conversation with Denise Revelle, clerk of Oak Grove Village, 2002 August 5). Oak Grove Village has drilled their new well and analysis of preliminary sampling results collected over a 48-hour period (April 12-13, 2003) indicated that the level of TCE varied from 5.8 ppb to 70.8 ppb (9). To provide the village with a safe public water supply, the village has plans to add an air stripper to eliminate the TCE before

it is supplied to the public water system (telephone conversation with MDNR site project officer, 2003 May 5).

Because of the area's TCE groundwater contamination, other wells and an area spring have also been affected. To determine the extent of the contamination, Phase 1 of a RI sampled over 90 private wells in June and July 2001. Of these private wells only one had TCE levels above the MCL at 12 ppb (1). Previous sampling by MDNR in July 2000 found this well and a neighbor's well to be contaminated at 16.4 and 12.8 ppb TCE respectively. Although the wells remain contaminated, the two residences have been provided whole-house filtration systems by EPA as part of a short-term Removal Action to eliminate exposure. Unlike the Oak Grove Village well where exposure to users of the system was discontinued for a period of time while being connected to the Sullivan water supply, these private well users may have been exposed to TCE contaminated groundwater for a longer period of time. Assuming that TCE was present in these private wells around the time that sampling was first done on the Oak Grove Village well in 1986 until whole house filtration systems were installed in 2000, the residents would have been exposed to an expected increasing level of TCE contamination up to the 16.4 ppb over a 14 year period of time. TCE levels are expected to have gradually increased over time because nearby private wells that were sampled in 1992 by DHSS and again sampled by MDNR in 2002 have shown a gradual increase. For exposure calculation purposes the highest TCE level detected (16.4 ppb) will be used for the expected 14 years of exposure to develop a worse case exposure scenario.

Seven other private wells sampled during the RI had detectable TCE levels, but all were below the MCL and clustered in two separate areas. Levels ranged from 0.37 to 2.9 ppb in the RI sampling event, however levels in all the wells have varied during other sampling events. The well with elevated TCE (12 ppb) and four other wells are located northeast of the Oak Grove Village well and are clustered around the western side of the old Sullivan Landfill, a possible source of TCE and other contaminants. The remaining three private wells where TCE was detected are located approximately three miles northwest of the Oak Grove Village well in an area along Highway AF (See Figure 2 in Appendix A). Contamination of the private wells along Highway AF is possibly from a different contamination source than the private wells northeast of the Oak Grove Village well (1).

The RI also sampled 11 springs in the area, with only the LaJolla Spring having detectable levels of TCE at 5.7 ppb. Resampling by MDNR in June 2002 detected TCE at 2.3 ppb in the LaJolla spring water. The spring is located northeast of the Oak Grove Village well near the Meramec River. Dye tracing injected into points west and west-southwest, including points in Sullivan, confirms that LaJolla Spring drains the area to its west (1). LaJolla Spring flows through a cave complex before it drains into the Meramec River (See Figure 2). The cave complex is a large commercial cavern that is visited by approximately 150,000 people a year. The air in the caverns was sampled for TCE by EPA in 1995. TCE was not detected (10). MDNR and EPA sampled the cave air and spring water in October 2002 to determine if contamination was present. During this sampling event, it was reported that in the area of the cave visited by the public and employees, TCE was detected in the spring water at a maximum of 7.9 ppb at the end of the normal trail (11) and in the air of the ballroom at 19 parts per billion by volume (ppbv) or 19 ppb (12). Additional air and water samples were collected in the upper portions of the cave where the

public doesn't have access and employees seldom go. In these samples, TCE levels ranged in the air from non-detectable to 82 ppb and in the spring water from 2.0 to 12.6 ppb (11, 12). A second round of sampling was completed in May 2003. Air sampling results taken at three locations in the cave used by visitors indicated that TCE air levels have increased. These results indicated that TCE was at a level of 190 ppb in the ballroom. The highest TCE level detected in the cave air was at the far end of the tour route at 260 ppb (13). Additional sampling of the cave air has taken place since the release of the public comment version of the public health assessment (PHA) of August 7, 2003. In August 2003, air samples were taken but results were unusable because of equipment failure. In October 2003, another round of air and water sampling confirmed the elevated levels of TCE air contamination taken in May 2003. The maximum level of TCE detected in air was 310 ppb at the far end of the tour route (14). A water sample from the stream (at the same location) found TCE at a maximum of 12.3 ppb (14). The discussion under the Inhalation Exposure at the LaJolla Spring Cave Complex heading and the Cancer heading has not been changed because results are relatively similar. The public health implications would need to be reassessed if contaminant levels continue to increase. Chloroform was detected below health guidelines levels (14) at one of the six (plus background) sampling locations during the October 2003 sampling event and will not be considered in this PHA.

Because TCE contamination has affected the area's groundwater, some of the adjoining city of Sullivan municipal wells have also been affected. Of the current ten operational city of Sullivan wells, four have shown levels of contamination, with two of those having TCE contamination above the MCL. One of the wells is active with an air stripper and the other has a filtration system that did not perform as expected and is presently inactive (Written comments from MDNR site project officer, 2002 October 24). Sampling data since 1986 indicate that the level of TCE contamination has varied over time and the possibility exists that the level of contamination could increase or affect other city of Sullivan wells.

To determine the source(s) of the contamination in and around the communities, numerous investigations have been completed. The latest was the Phase 1 RI done for MDNR that determined there are several potential source areas of the TCE contamination (1). They are, but are not limited to the:

- Sullivan Landfill
- Former TRW facility
- Sohn property
- Blanton property
- Highway AF well site
- Potential dumping sites
- Current and former gas stations

Of the above listed sites, only the Former TRW Facility in Sullivan has been thoroughly investigated with remediation having been conducted at the site (See Figure 1 for location). The responsible party performed these actions under the Resource Conservation and Recovery Act. This remediation has included sludge and TCE contaminated soil removal and a groundwater investigation that determined the groundwater below the TRW site was contaminated with high levels of TCE and other volatile organic compounds (VOCs). To remediate the contaminated

groundwater, TRW has in place a groundwater monitoring system, a drinking water contingency plan, and a groundwater pump and treatment system to remove and treat the highest concentrations of VOCs in shallow groundwater. Also, TRW in conjunction with the city of Sullivan has installed treatment systems on certain contaminated city wells (15).

The Phase 1 RI concluded that contamination of the Ozark Aquifer in the area is becoming widespread and contaminated groundwater has been detected in the Oak Grove Village well, several nearby city of Sullivan wells, private wells west of the old Sullivan landfill, a group of private wells near AF Highway, and in the LaJolla Spring. The RI also concluded that it is possible that there may be overlapping contaminant plumes from more than one source impacting area wells. Recommendations from the RI included further site-specific investigations to better understand the hydrogeology of the area, identify sources of contamination, and propose potential remedial actions. Following the recommendations of the RI, MDNR continues to monitor and expand sampling of the area.

Land Use, Natural Resources, and Geology

The Oak Grove Village Well site is located on village property in the building occupied by the city hall. Land use around the Oak Grove Village Well Site is mostly residential in the village. Outside of the city limits, to the north through the southeast, are larger, usually wooded residential properties with their own private wells. The city of Sullivan abuts the village to the west and south. Other areas not used for residential property outside of the village are wooded rolling hills. The closed, old Sullivan landfill is located approximately one mile northeast of the village and has a small subdivision clustered around its western side (See Figure 2).

Natural resources in the area consist mostly of the Meramec River and the Meramec State Park located east of the Oak Grove Village Well site. LaJolla springs flows into and through an associated cave complex to its outlet into the Meramec River. The cave complex is a large commercial cavern that is visited by approximately 150,000 people a year.

The Oak Grove Village well draws groundwater solely from the Ozark Aquifer. All but one of the ten city of Sullivan wells also draw water from the Ozark Aquifer. The exception is one well that was drilled through a confining layer beneath the Ozark Aquifer; however, the majority of its water is believed to be coming from the Ozark Aquifer. Groundwater flow in the Ozark Aquifer, on a regional basis, is unconfined and is influenced by major topography (1). Hydrogeologic assessments indicate that the recharge area for the Oak Grove Village well is to the southwest of the site. However, major faults occurring in close proximity to the site and in all directions from the site, in addition to karst features in the groundwater aquifer make groundwater movement difficult to predict (1,2).

Demographics

According to 2000 census data, Oak Grove Village has a population of 382. The population of the village is 97.9% white, 0.3% American Indian or Alaska Native, 0.5% Asian. In addition, 5 individuals (1.3%) identified themselves as being of two or more races. In 2000, there were 35

children under the age of 5 years old and 45 individuals over 65 living in Oak Grove Village. The median household income for 1999 was $35,357. In 1999, ten families were listed as being below the poverty level. Of the 138 households in the village (2000 Census), 43 received Social Security incomes, 24 received retirement income and three received public assistance income (16). In general, the community represents a white, working-class community in a semi-rural area of Franklin County.

DISCUSSION

Pathways Analysis

This section addresses the pathways by which residents of the area may have been exposed to the TCE contaminated groundwater. When a chemical is released into the environment, the release does not always lead to exposure. Exposure only occurs when a chemical comes into contact with and enters the body. To determine whether the residents of Oak Grove Village and surrounding areas were exposed to contaminants at this site, DHSS conducted an analysis of exposure pathways. For a chemical to pose a health risk, a completed exposure pathway must exist. An exposure pathway consists of five elements including a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and an exposed population. Completed exposure pathways require that all five of the elements of exposure exist. An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present. Potential exposure pathways, however, have at least one of the five elements missing or uncertain, but could exist. Completed and potential exposure pathways could have occurred in the past, could be occurring presently, or could occur in the future (17).

Completed Exposure Pathways

Past:

The five elements of a completed exposure pathway at the Oak Grove Village Well site are explained below:

1. **Contaminant source -** location not determined, but several may exist in the area.
2. **Environmental medium and transport** - TCE contaminated groundwater.
3. **Point of exposure** - public water supply, private wells, and cave air.
4. **Route of exposure** - ingestion, inhalation, and dermal contact.
5. **Exposed population** - public water system users, private well users, and cave users.

Table 1 in Appendix B illustrates the different exposure pathways present at the Oak Grove Village Well site.

People at the Oak Grove Village site can be exposed to TCE through ingestion, inhalation, or dermal contact. Ingestion exposure would occur by drinking water or eating food prepared with contaminated water. People can also be exposed to TCE through inhalation and dermal contact while showering, bathing, and washing clothes and dishes as well as other household activities. Exposure by inhalation can also occur in areas where TCE volatilizes from contaminated water into air that has limited circulation.

Completed exposure pathways to TCE contaminated water above its' MCL are known to have existed for the users of the Oak Grove Village public water supply from the time of first discovery in June 1986 and ended when the village closed the well in July 1991. During this 5-year period public water supply users were likely exposed to TCE at levels ranging from 2.4 to 12 ppb. The village then connected to the Sullivan public water supply. Completed exposure pathways again existed after the village reopened their well from September 1992 to February 1994. Residents were exposed to a maximum level of 25 ppb of TCE during this approximately 1.5-year period before again reconnecting to the Sullivan public water system. PCE contamination was detected in only two sampling events in 1986 (at 59 and 16 ppb) and has not been detected since. No further samples have shown PCE contamination; therefore PCE will not be discussed further as a contaminant in this public health assessment.

Completed exposure pathways to levels of TCE contamination above EPA's MCL existed to residents using private wells outside of the Oak Grove Village public water system until they were supplied with a whole-house water treatment system.

Present:

Presently no completed exposure pathways to TCE contaminated groundwater above its' MCL are known to exist. Completed exposure pathways to TCE contaminated groundwater below the MCL are presently occurring to a limited number of private well owners, but no adverse health effects are expected unless the level of TCE dramatically increases.

Workers at, and possibly visitors, to the cave complex associated with the LaJolla Spring are exposed to levels of TCE contaminated air. Long-term exposure (years) could potentially have adverse health effects.

Future Potential Exposure Pathways

Potential exposure pathways exist because the TCE contamination remains in the groundwater at the Oak Grove Village Well site and the surrounding area.

Because the Oak Grove Village's contract with the city of Sullivan to supply public drinking water expired on December 31, 2002 (Sullivan continues to supply water on a month to month basis), the potential exists that the village will have to reactivate their existing well to supply the village's water needs until a new well can be drilled and placed into service. Although the levels of contamination in the well under actual pumping conditions are not presently known, levels of

TCE could be at least as high as or even higher than the last time the well was known to be actively pumped (42.3 ppb). Early testing of the new village well has shown that it is also affected by the contamination.

Potential exposure pathways exist to residents outside of the Oak Grove Village public water supply area. The levels of TCE in presently contaminated private wells below the MCL could increase to levels above the MCL and the plume could migrate and impact additional wells. Users of new wells drilled into the TCE contamination plume also have the potential to be exposed to contaminated groundwater.

Workers at, and possibly visitors to the cave complex associated with the LaJolla Spring have the potential to continue to be exposed to levels of TCE contaminated air that could cause adverse health effects after years of exposure. Visitors will be exposed for only a short period of time during the tour (approximately 1.5 hours), while workers may be exposed for their expected period of employment (years). There is also the potential that the city of Sullivan public wells could be further impacted by the contamination.

TOXICOLOGICAL EVALUATION

Introduction

This section will discuss the health effects of exposure to specific contaminants. A discussion of non-cancerous health effects and the possibility that TCE exposure might cause cancer is evaluated in this section. To evaluate non-cancerous health effects, ATSDR has developed a Minimal Risk Level (MRL) for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily human exposure. Exposure to a contaminant level below the MRL is not expected to cause adverse non-cancer health effects. Levels above an MRL do not mean that health effects will definitely occur; rather, it calls for more investigation into whether health effects may or may not occur. MRLs are developed for each route of exposure, such as ingestion and inhalation, and for the length of exposure, such as acute (less than 14 days), intermediate (15 to 364 days), and chronic (greater than 365 days) (18). This toxicological evaluation section will discuss the possible adverse health effects that water users might expect from long-term exposure to low levels of TCE contamination in their drinking water. An MRL has not been developed for long-term low-level exposure to TCE, so exposures above EPA's MCL will be further evaluated. The possibility of TCE causing cancer and the theoretical risk of exposure to TCE causing additional cancers is discussed under the cancer section.

TCE is the major contaminant that was detected at the Oak Grove Village Well site. TCE has also been detected in various private wells in two separate areas around the Oak Grove Village Well site, but only above the MCL in two private wells near the landfill (presently on whole-house filtration systems). The other private wells have TCE at less than the MCL and are presently not considered a health concern. Considering that new research (16 studies) has been completed and are published in the Environmental Health Perspectives (19) on the toxicity of TCE and the cancer slope factor has been lowered accordingly (cancer slope factor now is

available as a range), long-term low-level exposure to TCE below the present MCL may become more of a health concern.

Trichloroethylene

TCE is a volatile organic compound that evaporates easily in air, but stays in soil and water without much decomposition. Since it is heavier than water it can pass easily through the soil into the groundwater. It is used mainly as a solvent to remove grease from metal parts, but can also be found in household products such as wood stains, varnishes, lubricants, adhesives, typewriter correction fluids, paint removers, and cleaners. Most people can begin to smell TCE in air at around 100,000 ppb. Once it enters the body it is changed to other chemicals that have been shown to be toxic to animals and are probably toxic to humans (18).

The major target of TCE is the nervous system where exposure to large amounts may cause dizziness, sleepiness, headaches and even unconsciousness (TCE was once used as an anesthetic for surgery at around 1,000,000 ppb). At higher levels and possibly long-term low-level exposure, liver and kidney damage and changes in heartbeat can occur (18).

When TCE is inhaled, approximately half of the amount breathed in is exhaled and the other half enters the bloodstream. When TCE contaminated water is ingested, most of the TCE will be absorbed into the bloodstream. Much of the TCE that enters the bloodstream will also be exhaled. Once in the blood, the liver breaks down TCE into other chemicals (dichloroacetic acid, trichloroacetic acid, chloral hydrate, and 2-chloroacetaldehyde). The majority of these chemicals will be excreted in urine within a day (18).

Exposure (non-cancerous)

People can be exposed through ingestion by drinking contaminated water or eating food prepared with contaminated water. People can also be exposed to air borne TCE through inhalation. Household activities using TCE contaminated water such as showering, bathing, and washing clothes and dishes, and other similar activities can increase TCE levels in the air. Exposure through dermal contact can take place during showering, bathing, or other activities that put the skin in contact with TCE-contaminated water. A more detailed explanation of the exposure pathways at the Oak Grove Village site can be found in Table 1 in Appendix B.

Dermal Exposure:

Dermal effects of exposure to TCE are usually the consequence of direct skin contact with concentrated solutions in occupational settings. Exposures to these concentrated solutions usually result in desiccation (drying) of the skin due to the defatting action of the solvent that may lead to dermatitis. Dermal contact with TCE at the levels present in the village well and in private wells are magnitudes lower (ppb versus the possibility of pure product used in occupational settings), do not pose a health concern through this route of exposure.

Ingestion Exposure:

Ingestion exposures were calculated using the worst-case exposure scenario for past and potential future exposures if the Oak Grove Village well was reactivated. Based on the discovery of TCE contamination in the Oak Grove Village well in 1986, exposure to TCE was estimated to have occurred in the past to users of the Oak Grove Village public water system at a maximum level of 25 ppb, in two separate periods of time totaling approximately 6.5 years. Residents were not exposed to this level for the full 6.5 years. However, this period of time and the maximum TCE level were used to calculate a worst-case exposure scenario. To calculate a dose, we assumed that adults, on average, drink 2 liters (66 ounces) of tap water each day and weigh 70 kilograms (Kg) or 154 pounds. For children (one to six years of age), we assume that they drink 1 liter (33 ounces) of tap water each day and weigh 10 Kg (22 pounds) (17). The calculated exposure dose from using the public water system in the past was 0.0007 mg/Kg/day for adults and 0.0025 mg/Kg/day for children. Exposure was also calculated for the potential exposure that could occur if the Oak Grove Village well was reactivated and public water users were exposed to 42 ppb TCE for a 2-year period until a new well and possibly a treatment system could be put into service. The calculated exposure dose was 0.0012 mg/Kg/day for adults and 0.0042 mg/Kg/day for children. The exposure that could have occurred to users of TCE contaminated private wells was also calculated and used the maximum detected TCE level (16.4 ppb) for an expected maximum length of time (14 years). The calculated exposure dose was 0.00047 mg/Kg/day for adults and 0.00164 mg/Kg/day for children. All of these theoretical calculations make very conservative (protective) assumptions and may over estimate the exposure that occurred or may occur. The calculations can be found in Appendix C.

Inhalation Exposure and Total Residential Exposure:

Because TCE inhalation levels in residences are not known, total exposure through ingestion and inhalation was estimated by doubling (x 2) the ingestion exposure level assumed to have occurred at the maximum levels and time periods. The calculations can be found in Appendix C. The worst case calculated total doses (ingestion and inhalation) for the Oak Grove Village Well site from past exposures were 0.0014 mg/Kg/day for adults and 0.0050 mg/Kg/day for children. For potential future exposure, given the Oak Grove Village well is reactivated, the total doses were calculated to be 0.0024 mg/Kg/day for adults and 0.0084 mg/Kg/day for children. The total doses were also calculated for the private well users at 0.00094 mg/Kg/day for adults and 0.0033 mg/Kg/day for children.

Total exposures (ingestion and inhalation) were found to be below ATSDR’s MRL for acute ingestion exposure (0.2 mg/Kg/day). Because of insufficient data, ATSDR does not have intermediate or chronic ingestion guidelines for TCE (18). Because no MRL has been developed for intermediate or chronic ingestion exposure for TCE, more investigation was needed to determine if health effects are likely to occur from ingestion exposure. The worst-case doses were compared to and found to be below the No Observed Adverse Health Effects Level

(NOAEL) of studies involving chronic exposures to TCE in animals. Using an additional safety factor of 10 for humans, the calculated exposures still did not exceed the NOAEL (18).

In studies of humans who were exposed to TCE contaminated drinking water, varying conclusions have been reached. ATSDR has maintained a TCE Subregistry Baseline data file on approximately 5,000 persons with documented environmental exposure to TCE (along with other chemicals) through private wells. For the report, ATSDR compared health conditions reported by the TCE Subregistry registrants with health conditions reported in a nation-wide survey of the general population. Certain age groups reported some health conditions more frequently, while some had higher rates for only men or only women. This study did not confirm the health conditions (they were self-reported) and the study did not completely identify the exposure level. Persons in the study were exposed from 6.5 to 18 years to concentrations varying from less than 1 ppb to 19,380 ppb (determined from limited sampling data, usually one to two sampling events) (20, 21). Findings of the latest follow-up of the study indicate that subregistry participants had a reporting rate above the national norms in various age groups for speech impairment and hearing impairment for children under 10 years of age (only on the baseline study), anemia and other blood disorders, stroke, urinary tract disorders, liver problems, kidney problems, diabetes rates, and skin rashes. Although the findings of ATSDR TCE Subregistry report do not identify a cause and effect relationship between TCE exposure and adverse health effects, they do reinforce the need to continue ongoing follow-up of the participants (21).

Of the reported health problems listed above, only the rate of strokes was reported to increase with increasing concentration of TCE. For the other health problems, their occurrence did not increase with higher exposure levels. If the health problems were related with the exposure to TCE, we would expect the number of people with a specific health problem to increase with higher levels. Therefore, it is unlikely that the reported health problems (anemia and other blood disorders, urinary tract disorders, liver problems, kidney problems, diabetes rates, and skin rashes) are associated with the exposure to TCE in private wells. Of those reporting strokes, a good portion also reported having other health problems including hypertension, diabetes, and being smokers, all of which contribute to the incidence of stroke (20).

Considering the concentrations and period of time that residents at the Oak Grove Village site were exposed to TCE contaminated drinking water and air, no adverse non-cancer health effects are expected from past exposure. If the village reconnected to the existing well, future exposure and health effects cannot be determined because of unknown TCE levels and the period of time that exposure would continue.

Inhalation Exposure at the LaJolla Spring Cave Complex:

Exposure at the cave complex associated with the LaJolla Spring consists only of inhalation of low levels of TCE contamination in the air of the cave. Spring water was also found to be contaminated, but is not used for drinking or body contact recreation and no exposure pathway is expected. Even though air concentrations of TCE were below detectable limits in sampling completed by EPA in 1995, sampling in October 2002 detected TCE at 19 ppb in the cave air of the area used by visitors and employees. In the May 2003 sampling, those levels had increased to

a maximum of 260 ppb. Exposure is expected to occur to the visitor to the cave for the length of the tour (approximately 1.5 hours) and to the workers for their workday. ATSDR has developed an MRL for the inhalation of TCE for acute exposure time periods (less than 14 days) of 2,000 ppb (18). Considering that the concentration of TCE detected in the cave air is below the MRL and the expected exposure time is short, the visitor exposure to the contaminated air in the cave complex is not expected to pose any adverse health risk.

Workers, on the other hand, are expected to spend an extensive amount of time in the cave complex when compared to visitors; thus, resulting in increased exposure to the TCE contaminated air. To determine if worker's exposure to the May 2003 maximum detected level of 260 ppb TCE would pose any non-cancerous health consequences, we compared the detected level to ATSDR's intermediate MRL (14 to 364 days) of 100 ppb. The elevated level of 260 ppb has since been confirmed by an October 2003 measurement of 310 ppb, both of which exceeds the intermediate MRL screening value. It is worth mentioning, that MRL screening values were derived from rat studies that determined a lowest observed adverse effect level (LOAEL) of 50,000 ppb. At this level, the following health effects were observed in rats: decreased wakefulness during exposure, decreased post exposure heart rate, and slow wave sleeping (18). However, one must keep in mind the MRL screening values usually have a safety factor for humans when data is taken from animal studies and the health effects implicated in animal studies with TCE do not apparently exist in humans. Therefore, given the built in safety factor, we do not expect any adverse health effects to the workers during an intermediate period of exposure (14 to 364 days).

Information on humans exposed to TCE for chronic periods of time (greater than 1 year) by the inhalation route consist mostly of studies of workers exposed to much higher levels than those detected or expected in the cave complex. These studies indicate that the nervous system may be the most sensitive target, such as in a study of 50 workers employed for various lengths of time (1 month to 15 years) in different industrial cleaning and degreasing operations using TCE. Complaints due to chronic exposure included decreased appetite, sleep disturbances, ataxia, vertigo, headaches, short-term memory loss, and fewer word associations. A greater frequency of symptoms was noted in workers exposed to higher (85,000 ppb) than lower (14,000 ppb) mean TCE concentrations (22). Other studies of workers occupationally exposed for chronic periods of time indicate that the liver and kidney are targets of TCE (18).

For long-term exposure (equal to or greater than 365 days), ATSDR has not been able to develop a chronic MRL because of the lack of adequate measurements of exposure levels in some studies and/or lack of health effects that could be specifically related to the exposures (18).

Because of the insufficient data from health studies and the likelihood that contaminant levels will change over time, it is not known what non-cancerous health effects long-term low-level inhalation exposure may have to workers who spend years working in the cave complex.

Cancer

The American Cancer Society estimates that in the United States, slightly less than half of all men and slightly more than one-third of all women will develop some form of cancer in their lifetime (23). To determine the theoretical cancer risk for adults exposed to hazardous chemicals, EPA has developed cancer unit risk factors (Oral Slope Factor). Cancer risks are calculated over a lifetime, estimated to be 70 years. DHSS calculated the cancer risk for the Oak Grove Village Well site and the different exposure pathways associated with the site using the worse case scenario (using the highest level of the cancer slope factor range, the maximum level detected, and the maximum expected exposure time). Because of the conservative nature of these calculations, this approach provides a theoretical estimated risk of cancer. In actuality, the true or actual risk is unknown and could be as low as zero. The cancer calculations can be found in Appendix C.

The ability of TCE to cause cancer from ingestion and inhalation exposure is presently under review by the EPA. TCE is classified by the International Agency for Research on Cancer as probably carcinogenic to humans (limited human evidence; sufficient evidence in animals). ATSDR has developed a Cancer Risk Evaluation Guide (CREG) for a number of chemicals. CREGs are comparison values set by ATSDR to determine if a chemical is above a level that should be further evaluated. CREG is a level that if exposed for a lifetime (70 years) could cause one additional cancer in a population of one million ($1x10^{-6}$). Because TCE is under review, no CREG value is available for the different exposure pathways (24).

Since the Oak Grove Village public water users were likely exposed to TCE contaminated groundwater for approximately 6.5 years, the theoretical cancer risk was calculated for this maximum exposure period with the maximum known value of TCE contamination (25 ppb). Calculations for additional risks of cancer for past total exposure (ingestion and inhalation) to users of the public water system at the Oak Grove Village Well site for adults are 5.2×10^{-5} (or 52 additional cancers in a million people) and for children is 1.75×10^{-4} (or 175 additional cancers in a million people). Theoretical cancer risks were also calculated for private well users assuming the maximum TCE level detected (16.4 ppb) for the expected maximum period of time (14 years) those residents could have been exposed. Additional cancer risks for adults were 7.52×10^{-5} (or 75.2 additional cancers in a million people) and for children 1.56×10^{-4} (or 156 additional cancers in a million people). It is not expected that residents were exposed to the maximum level of contamination for the calculated period of time, thus the actual cancer risk for this population may be much lower and could be as low as zero.

Theoretical cancer risks were calculated for potential future exposure that would occur if the old village's well were reactivated. Calculations were made using the maximum known TCE level (42 ppb) for the estimated period of time (2 years) to get a new well operational. Additional cancer risks for adults were 2.74×10^{-5} (or 27.4 additional cancers in a million people) and for children is 9.6×10^{-5} (or 96 additional cancers in a million people), assuming the TCE concentration would remain constant. See Appendix C for calculations.

EPA presently has a draft document that draws information from 16 new state-of-the-science papers on the health effects of exposure to TCE. The slope factor for cancer calculations for ingestion uses these updated values to be more health protective. The EPA cancer slope factor for TCE ranges from 0.02 to 0.4 $(mg/Kg/day)^{-1}$(21). For the above cancer calculations we used the maximum slope factor of 0.4 along with the maximum levels of contamination and the maximum period of exposure time to develop the worse case exposure scenario.

Workers in the cave complex were expected to have been exposed in the past and are presently being exposed to elevated levels of TCE contaminated air (maximum level of 260 ppb). While the detected levels of TCE are not above the Occupational Safety and Health Administration (OSHA) permissible exposure limit of 100 ppm (or 100,000 ppb) for the time weighted average (TWA) for an 8 hour workday or above the guidelines set by the American Conference of Governmental Industrial Hygienists (ACGIH) TWA of 50 ppm (or 50,000 ppb)(18), there is still reason for concern. While the OSHA and ACGIH levels do not consider the cancer potential, TCE may be carcinogenic (under review) and considering that a worker may spend eight hours a day, five days a week, 50 weeks a year in the cave complex, for their expected period of employment (25 years), there is a theoretical elevated risk of cancer among workers if the level of TCE air contamination remains elevated.

These worst case theoretical cancer calculations show a slight increased risk of cancer from past and potential future exposure, but in reality, humans exposed to TCE for chronic periods via the inhalation and dermal route in the workplace apparently do not experience an increased incidence of cancer, as indicated by numerous epidemiological studies. Ingestion exposure to TCE and cancer in humans from long-term low-level exposure is inconclusive, with a number of studies indicating an association and a number of studies not indicating an association (18). After evaluation of these 16 new studies on TCE health risks are complete, some of the uncertainties may be cleared up or further studies may need to be done.

Children and Other Sensitive Populations

A sensitive population may exhibit a different or enhanced response to hazardous chemicals than will most persons exposed to the same level of hazardous chemicals in the environment. Reasons for sensitivity might include genetic makeup, age, gender, health and nutritional status, and exposure to other toxic substances. In general the elderly, with declining organ function, and the young, with immature and developing organs, are more vulnerable to toxic substances than healthy adults.

A number of studies have suggested or shown associations between TCE exposure and children's health effects, but these studies had limitations that question their validity. Developing fetuses are susceptible to the toxic effects of chemicals that can cross the placental barrier. Also, premature and newborn infants will be more vulnerable to TCE exposure than the general population because of their immature and developing organs. In general, several studies suggest, but do not conclude, that exposure to TCE may cause birth defects (heart defects, respiratory system defects, eye defects, neural tube defects, and oral cleft defects) or childhood leukemia in children who were exposed in utero (as a fetus). In some studies, other chemicals were present

besides TCE. Children listed in ATSDR's National Exposure Registry for TCE were reported as having higher rates of hearing and speech impairment, but there are still questions regarding these reports (18). Because it is difficult to predict the amount of exposure that a developing fetus may be exposed to at this site, it is also difficult to predict what birth defects or disease, if any, may result from exposure at this site. However, considering the maximum concentration of TCE (25 ppb) that Oak Grove Village water supply users may have been exposed to for a short period of time, it is not expected that developing fetuses and/or children would be affected. Women, who believe they were exposed to TCE during pregnancy and are concerned about possible health impacts to their unborn child, should consult their personal physicians.

Other sensitive populations including those that consume alcohol or who are treated with disulfiram (a drug used to treat alcohol dependency) may be at greater risk of TCE poisoning. This occurs because ethanol and disulfiram can both inhibit the metabolism of TCE and cause it to accumulate in the bloodstream, increasing its effects on the nervous system. Also, those with compromised liver and kidney function may be at a higher risk from exposure to TCE or its metabolites. The liver serves as the primary site of TCE metabolism and the kidney as the major excretory organ for TCE metabolites. People who smoke may also increase their risk of toxic effects from TCE (18).

COMMUNITY HEALTH CONCERNS

During the site visits, meetings, and water sampling events, residents raised no health concerns. On private well sampling events that DHSS sampled or participated in, some technical questions were asked about the chemical and detected levels. DHSS discussed their private well sampling results and provided health information to those residents.

On September 9, 2003, DHSS held a public availability session to present the public comment version of the Oak Grove Village Well Public Health Assessment to the public and to gather and discuss any health concerns the public might have. No health concerns were presented in person at the meeting or received in the mail. Some technical comments were received during the public comment period that was extended an additional 30 days and are discussed in Appendix D.

CONCLUSIONS

1. Based on current conditions, the Oak Grove Village Well site has been classified as a No Apparent Public Health Hazard for past and present exposures. The category of No Apparent Public Health Hazard is used for sites where human exposure to a contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard. This classification is based on the following considerations:

    - Because non-cancerous adverse health effects are not expected and only a slight theoretical additional risk of cancer may be present from past exposures to contaminated groundwater at the site.

    - Presently no known exposure to TCE contaminated groundwater is occurring above its' MCL at the Oak Grove Village Well site.

2. The Oak Grove Village Well site has been classified as an Indeterminate Public Health Hazard for the future because TCE contamination is still present in the area's groundwater and may continue to affect the Oak Grove Village well, private wells in the area, Sullivan's city wells, and the LaJolla Spring. The category of Indeterminate Public Health Hazard is assigned to sites for which no conclusions about the public health hazard can be made because data is lacking. This classification is based on the following considerations:

    - The groundwater at Oak Grove Village and the surrounding area continue to be contaminated with TCE. No source has been identified.

    - The old Oak Grove Village well and the new village well could potentially be contaminated with TCE levels higher than past levels used to supply public water to village residents.

    - Private wells in two areas around the Oak Grove Village Well site have TCE contamination that may increase in concentration or the number of private wells affected may increase if the TCE contamination plumes continue to move.

    - Analysis of the LaJolla Spring water and air has shown TCE contamination in a cave that is visited by thousands yearly. Although the spring water is not being used for drinking and no exposure is expected from it, low-levels of TCE were found in the cave air to which visitors and especially employees are exposed. Visitors should experience no adverse health effects, since the air levels are below

the acute MRL. Workers have the potential for adverse health risks if exposed to elevated levels for a long period of time (years).

- Sullivan municipal wells could potentially become more affected by the TCE contaminated groundwater.

RECOMMENDATIONS

1. Continue the remedial investigation to determine the nature and extent of the TCE contamination and remediate as appropriate to eliminate exposure pathways.

2. Continue efforts to supply Oak Grove Village with a safe public drinking water supply.

3. Continue to monitor private wells in the area for elevated levels of contamination and take measures to prevent exposure as needed.

4. Continue sampling of the cave air and spring water on a regular basis to confirm levels of TCE contamination. If levels remain elevated, initiate measures to reduce exposure.

5. Continue to monitor the Sullivan municipal wells to ensure that those wells having TCE contamination or others that become affected are not above a level of health concern and provide treatment if necessary.

PUBLIC HEALTH ACTION PLAN

This Public Health Action Plan (PHAP) for the Oak Grove Village Well site contains a description of actions to be taken by the Missouri Department of Health and Senior Services (DHSS), the Agency for Toxic Substances and Disease Registry (ATSDR) and other stakeholders. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards, but provides an action plan to mitigate and prevent adverse human health effects resulting from past, present, and future exposures to hazardous substances at or near the site. Below is a list of commitments of public health actions to be implemented by DHSS, ATSDR, or other stakeholders at the site:

1. DHSS/ATSDR will review additional sampling data from the Oak Grove Village Well site and provide guidance regarding possible health risk.

2. DHSS/ATSDR will coordinate with MDNR/EPA to implement the recommendations in this public health assessment to eliminate or lessen exposure to TCE contaminated groundwater.

3. MDNR/EPA sampled the air inside of the cave complex associated with the LaJolla Spring in October 2002, May 2003, and October 2003, to determine the levels of TCE that visitors and workers could be exposed to. DHSS has determined that the levels of TCE in the cave air do not pose a health concern to visitors, but workers may have an elevated risk of cancer. MDNR/EPA has tentatively agreed to do additional air sampling to determine the actual TCE concentrations over a period of time so DHSS can better determine the actual levels workers are exposed to and their potential health risks.

4. DHSS/ATSDR will continue to address community health concerns and questions as they arise and provide necessary community and health professional education.

5. DHSS/ATSDR will update this public health assessment as more information becomes available.

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CERTIFICATION

The Oak Grove Village Well Public Health Assessment was prepared by the Missouri Department of Health and Senior Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved methodology and procedures existing at the time the public health assessment was initiated.

Technical Project Officer, SPS, SSAB, DHAC

The Superfund Site Assessment Branch of the Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment and concurs with its findings.

Section Chief, SPS, SSAB, DHAC, ATSDR

APPENDIXES

Appendix A:

Maps: Figure 1: Site Location Map
Figure 2: Areas with TCE Contaminated Wells

Appendix B:

Table 1: Oak Grove Village Well Site Exposure Pathways

Appendix C:

Exposure Calculations: Past
Future

Appendix D:

Summary of Comments and Replies on the Public Comment Version of the Oak Grove Village Public Health Assessment

Appendix E:

Glossary of Terms and Acronyms List

Appendix A:

Figure 1: Oak Grove Village Well Site Location Map

Figure 2: Oak Grove Village and Other Areas with TCE Contaminated Water

Figure 1
Oak Grove Village Well Site Location Map

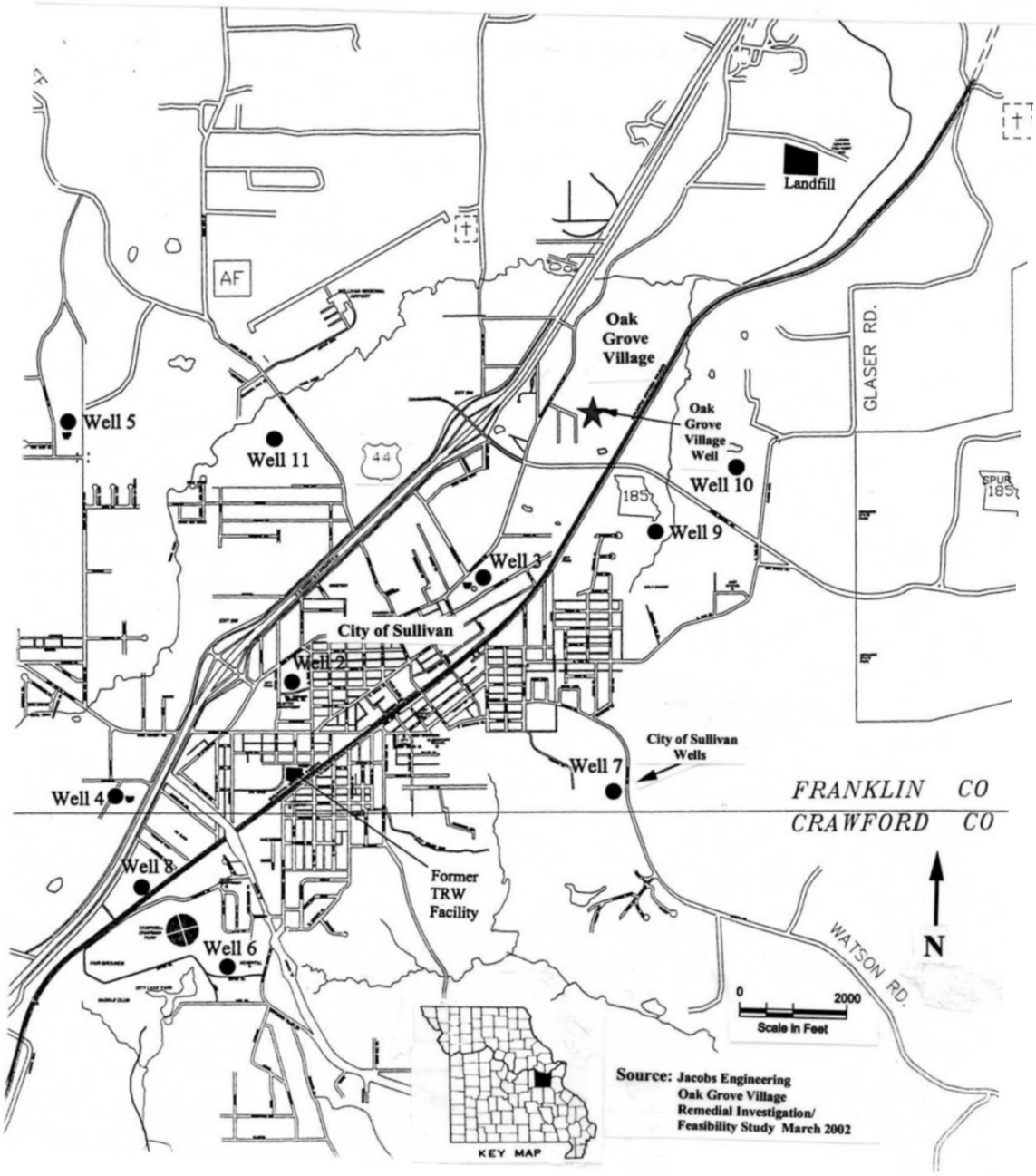
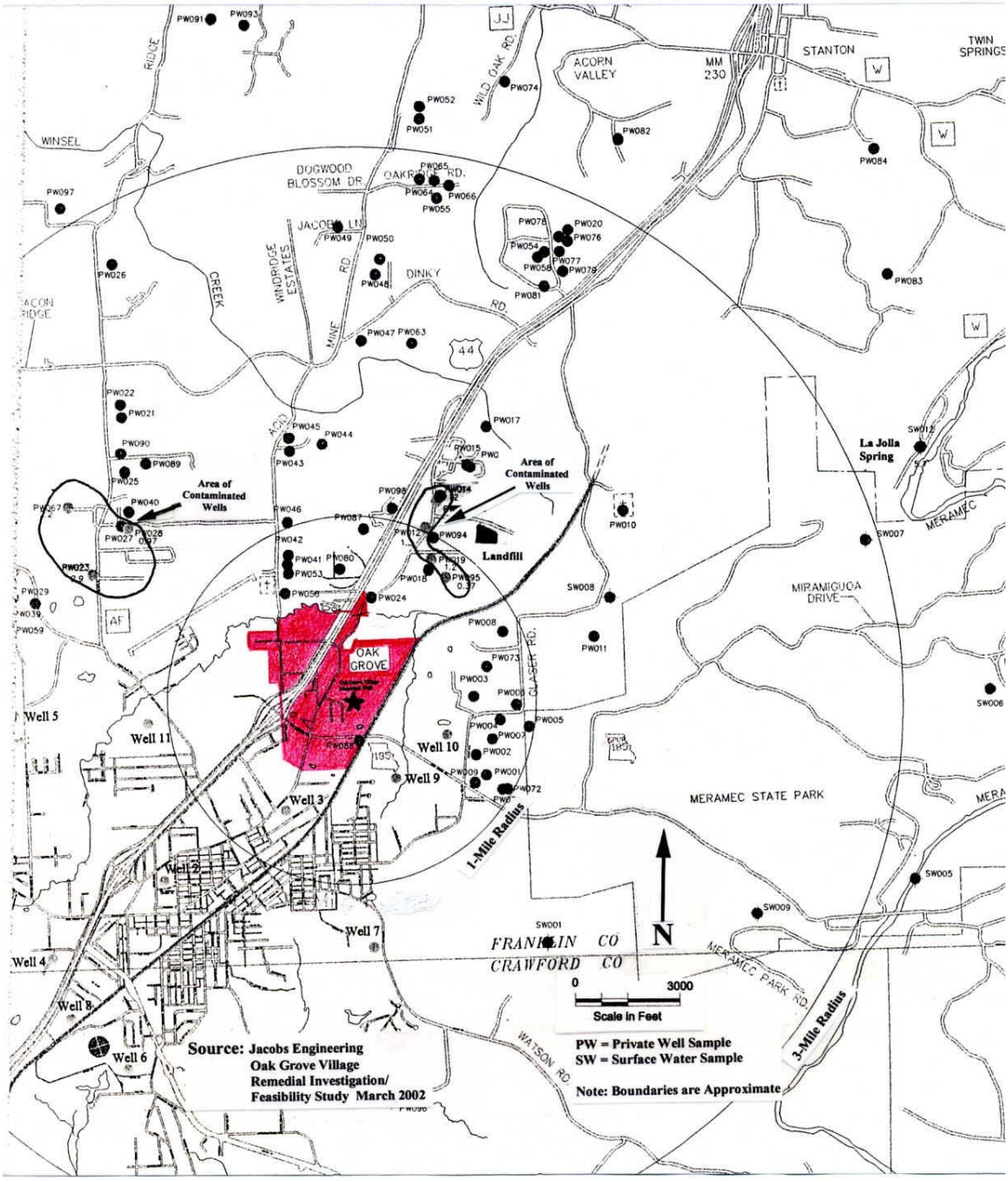


Figure 2
Oak Grove Village and Other Areas with TCE Contaminated Water



Appendix B:

Table 1: Oak Grove Village Well Site Exposure Pathways

TABLE 1

Oak Grove Village Well Site Exposure Pathways

Pathways Name	Exposure Pathways Elements					Time	Type of Pathway
	Source	Environmental Media	Point of Exposure	Route Of Exposure	Receptor Population		
Groundwater	TCE Contaminated Groundwater	Groundwater	Residents connected to Oak Grove Village Water	Ingestion Inhalation Dermal Contact	Oak Grove Village Public Water Users	Past	Completed
Groundwater	TCE Contaminated Groundwater	Groundwater	Private Well Owners below MCL	Ingestion Inhalation Dermal Contact	Private Well Users	Past, Present, Future	Completed, Potential
Groundwater	TCE Contaminated Groundwater	Groundwater	Private Well Owners above MCL	Ingestion Inhalation Dermal Contact	Private Well Users	Past	Completed
Groundwater	TCE Contaminated Groundwater	Groundwater	Private Well Owners above MCL	Ingestion Inhalation Dermal Contact	Private Well Users	Future	Potential
Groundwater	TCE Contaminated Groundwater	Groundwater	Residents Connected to Oak Grove Village Water	Ingestion Inhalation Dermal Contact	Oak Grove Village Public Water Users	Future	Potential
Groundwater	TCE Contaminated Groundwater	Groundwater	Residents Connected to Sullivan Public Water	Ingestion Inhalation Dermal Contact	Sullivan Public Water Users	Future	Potential
Air in Cave	TCE Contaminated Groundwater	Cave Air	Cave Interior	Inhalation	Cave Employees and Visitors	Present, Future	Completed

Appendix C:

Exposure Calculations

Appendix C

Exposure Calculations:

Past Exposures:

Non-Cancerous:

Ingestion Exposure for TCE in drinking water:

$$\text{Ingestion Exposure Dose} = \frac{C \times IR \times EF}{BW}$$

Where:
C = contaminant concentration in mg/L (example - 25 ppb = 0.025 ppm or mg/L)
IR = ingestion rate
EF = exposure factor (calculations considers complete absorption of contaminants)
BW = body weight in Kilograms

Adult using water from the Oak Grove Village Public Water System:
Calculations for adults assumes that they weigh 70 Kg and drinks 2 Liter (L) of tap water per day.

$$\text{Ingestion Exposure Dose} = \frac{0.025 \text{ TCE mg/L} \times 2 \text{ L/day water} \times 1}{70 \text{ Kg}} =$$

Adult Ingestion Exposure Dose = 0.0007 mg/Kg/day

Child using water from the Oak Grove Public Water System:
Calculations for children assume that they weigh 10 Kg and drinks 1 L of tap water per day.

$$\text{Ingestion Exposure Dose} = \frac{0.025 \text{ TCE mg/L} \times 1 \text{ L/day water} \times 1}{10 \text{ Kg}} =$$

Child Ingestion Exposure Dose = 0.0025 mg/Kg/day

Adult using water from contaminated private well (highest known contaminant level):

$$\text{Ingestion Exposure Dose} = \frac{0.0164 \text{ TCE mg/L} \times 2 \text{ L/day water} \times 1}{70 \text{ Kg}} =$$

Adult Ingestion Exposure Dose = 0.00047 mg/Kg/day

Child using water from contaminated private well (highest known contaminant level):

$$\text{Ingestion Exposure Dose} = \frac{0.0164 \text{ TCE mg/L} \times 1 \text{ L/day water} \times 1}{10 \text{ Kg}} =$$

Child Ingestion Exposure Dose = 0.00164 mg/Kg/day

Total Exposure for TCE in Drinking Water (Ingestion and Inhalation Exposure)

Because the user of a TCE contaminated water supply would also have exposure through inhalation as TCE volatilizes into the air, inhalation exposure must be included as part of the exposure. Most of this inhalation exposure takes place during and after showering as time spent in the bathroom. To consider both pathways of exposure and their additive effect, we double (x 2) the ingestion exposure dose for a conservative (more protective) value to include both pathways.

Using TCE Contaminated Oak Grove Village Public Water
Total Adult Exposure Dose = 0.0007 mg/Kg/day x 2 = 0.0014 mg/Kg/day

Total Child Exposure Dose = 0.0025 mg/Kg/day x 2 = 0.0050 mg/Kg/day

Using TCE Contaminated Private Well
Total Adult Exposure Dose = 0.00047 mg/Kg/day x 2 = 0.00094 mg/Kg/day

Total Child Exposure Dose = 0.00164 mg/Kg/day x 2 = 0.0033 mg/Kg/day

ATSDR's Acute (14 days or less) ingestion MRL for TCE = 0.2 mg/Kg/day
ATSDR has not derived an intermediate (15–364 days) ingestion exposure MRL for TCE
ATSDR has not derived a chronic (365 days or more) ingestion exposure MRL for TCE

Cancer:

Using the assumption that TCE is carcinogenic, even though it is under review as to its carcinogenicity, the following calculation is used to approximate its theoretical risk if it would be determined to be carcinogenic in humans.

Formula:

$$\text{Cancer Risk} = \frac{\text{Exposure dose x risk factor x years of exposure}}{\text{70 years (lifetime)}}$$

Cancer Risk using TCE Contaminated Oak Grove Village Public Water

(Risk factor = 0.4 (EPA's Oral Slope Factor))

$$\textbf{Adult Cancer Risk} = \frac{0.0014 \text{ mg/Kg/day} \times 0.4 \text{ (mg/Kg/day)}^{-1} \times 6.5 \text{ years}}{70 \text{ years}} =$$

$$\textbf{Adult Cancer Risk} = 0.000052 = 52 \times 10^{-6} = 5.2 \times 10^{-5}$$

$$\textbf{Child Cancer Risk} = \frac{[0.0050 \text{ mg/Kg/day} \times 0.4 \text{ (mg/Kg/day)}^{-1} \times 6 \text{ years}] + [0.0014 \text{ mg/Kg/day} \times 0.4 \text{ (mg/Kg/day)}^{-1} \times 0.5 \text{ years}]}{70 \text{ years}} =$$

$$\textbf{Child Cancer Risk} = \frac{[0.012] + [0.00028]}{70} = 0.000175 = 175 \times 10^{-6} = 1.75 \times 10^{-4}$$

(Note: Child is considered 1 – 6 years old, full six years are used for calculations)

Cancer Risk Using TCE Contaminated Private Well (Maximum level and time)

(Risk factor = 0.4 (EPA's Slope Factor))

Adult Cancer Risk = $\frac{0.00094 \text{ mg/Kg/day} \times 0.4 \text{ (mg/Kg/day)}^{-1} \times 14 \text{ years}}{70 \text{ years}} =$

Adult Cancer Risk = 0.0000752 = 75.2 x 10^{-6} = 7.52 x 10^{-5}

Child Cancer Risk =

$= \frac{[0.0033 \text{ mg/Kg/day} \times 0.4 \text{ (mg/Kg/day)}^{-1} \times 6 \text{ years}] + [0.00094 \text{ mg/Kg/day} \times 0.4 \text{ (mg/Kg/day)}^{-1} \times 8 \text{ years}]}{70 \text{ years}} =$

Child Cancer Risk $= \frac{[0.00792] + [0.0030]}{70} =$ **0.000156 = 156 x 10^{-6} = 1.56 x 10^{-4}**

(Note: Child is considered 1 – 6 years old, full 6 years are used for calculations)

Future Potential Exposures:

Non-Cancerous:

The following are calculations of the expected exposure to the Oak Grove Village public water system user if the village restarts their existing contaminated well until a new well can be dug and placed into operation. The expected time is two years for the new well to be placed into service. The actual level of TCE contamination in the village well under actual pumping conditions is not presently known and will not be known until the well is tested under actual pumping conditions. Sampling is planned by MDNR in the near future to determine the actual TCE level under pumping conditions. For calculation purposes, the last known maximum level of TCE detected under actual pumping conditions (42 ppb in 1997) when the well was pumped for 20 minutes before sampling will be used.

Ingestion Exposure to TCE from restarting old Oak Grove Village well:

$$\text{Ingestion Exposure Dose} = \frac{C \times IR \times EF}{BW}$$

Where:
C = contaminant concentration in mg/L (example - 42 ppb = 0.042 ppm or mg/L)
IR = ingestion rate
EF = exposure factor (calculations considers complete absorption of contaminants)
BW = body weight in Kilograms

Adult:
Calculations for adults assumes that they weigh 70 Kg and drinks 2 Liter (L) of tap water per day.

$$\text{Ingestion Exposure Dose} = \frac{0.042 \text{ TCE mg/L} \times 2 \text{ L/day water} \times 1}{70 \text{ Kg}} =$$

Ingestion Exposure Dose = 0.0012 mg/Kg/day

Child:
Calculations for children assume that they weigh 10 Kg and drinks 1 L of tap water per day.

$$\text{Ingestion Exposure Dose: } \frac{0.042 \text{ TCE mg/L} \times 1 \text{ L/day} \times 1}{10 \text{ Kg}} =$$

Ingestion Exposure Dose: 0.0042 mg/Kg/day

Total Exposure for TCE in Drinking Water (Ingestion and Inhalation Exposure)

Again, because the user of a TCE contaminated water supply would also have exposure through inhalation as TCE volatilizes into the air, inhalation exposure must be included as part of the exposure. Most of this inhalation exposure takes place during and after showering as time spent in the bathroom. To consider both pathways of exposure and their additive effect, we double the (x 2) ingestion exposure dose for a conservative (more protective) value to include both pathways.

Total Adult Exposure Dose = 0.0012 mg/Kg/day x 2 = 0.0024 mg/Kg/day

Total Child Exposure Dose = 0.0042 mg/Kg/day x 2 = 0.0084 mg/Kg/day

ATSDR's Acute (14 days or less) ingestion MRL for TCE = 0.2 mg/Kg/day
ATSDR has not derived an intermediate (15–364 days) ingestion exposure MRL for TCE
ATSDR has not derived a chronic (365 days or more) ingestion exposure MRL for TCE

Cancer:

Cancer calculation from exposure to TCE from reactivating the old Oak Grove Village well:

Using the assumption that TCE is carcinogenic, even though it is under review as to its carcinogenicity, the following calculation is use to approximate its theoretical risk if it would be determined to be carcinogenic in humans. It is expected that users of the Oak Grove Village

public water system will be exposed to contaminants from the old Oak Grove Village well for two years until a new well can be placed into service.

Formula:

$$\text{Cancer Risk} = \frac{\text{Exposure dose x risk factor x years of exposure}}{\text{70 years (lifetime)}}$$

Adult Cancer Risk = $\frac{0.0024 \text{ mg/Kg/day} \times 0.4 \text{ (mg/Kg/day)}^{-1} \times 2 \text{ years}}{70 \text{ years}}$ = (risk factor = 0.4 (EPA's Oral Slope Factor))

Adult Cancer Risk = 0.0000274 = 27.4 x 10^{-6} = 2.74 x 10^{-5}

Child Cancer Risk = $\frac{0.0084 \text{ mg/Kg/day} \times 0.4 \text{ (mg/Kg/day)}^{-1} \times 2 \text{ years}}{70 \text{ years}}$ =

Child Cancer Risk = 0.000096 = 96 x 10^{-6} = 9.6 x 10^{-5}

Appendix D:

Summary of Comments Received on the Public Comment Version of the
Oak Grove Village Public Health Assessment

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Summary of Comments Received on the Public Comment Version of the Oak Grove Village Well Public Health Assessment

Comments:

1. It is stated that the Oak Grove Village (OGV) public water users were only exposed to trichloroethylene (TCE) contaminated groundwater for approximately six and one-half years since the contamination was first discovered in the OGV well in 1986. However, the well was drilled in 1964. There is no way to know how many years, if any, water users were exposed to TCE prior to its discovery in the city well.

Agreed. However, considering that TCE was detected at only six parts per billion in 1986 and gradually increased from that point, we believe that using the worst case exposure scenario for the known years of exposure covers any additional exposure that may have occurred.

2. On page 14, levels of TCE that have been detected in the air are presented in ppbv units. The reference information was converted from parts per million (ppm) to parts per billion (ppb). However, if ppb and ppbv are the same unit when discussing TCE in air the 100,000 ppb should be rewritten as 100,000 ppbv to avoid possible confusion by the public.

Air sampling data is presented as parts per billion volume (ppbv) while health and regulatory levels are presented in parts per billion (ppb), which in reality are the same units. The text has been revised so that all concentrations are reported in ppb to avoid any confusion.

3. Comments that the public health assessment does not use EPA methodology to calculate the risks from exposure to TCE contamination, uses the upper range value when calculating cancer risk, and does not provide the sources for a majority of the exposure parameters and equations.

The public health assessment uses the ATSDR Public Health Assessment Guidance Manual for its methodology and is not intended to be a quantitative document, but instead, to explain to the public what their expected exposure may have been in the past, present, and future and the possible health effects from that exposure. The public health assessment uses the worse case scenario, which would include using the upper range number for cancer risk as per the guidance manual when actual exposure is not known. A reference to the ATSDR PHA Guidance Manual has been added to the text.

4. One comment stated that groundwater movement in the region is predictable whereas the PHA stated that groundwater movement in the region is unpredictable.

Agreed. The text has been changed to state that it will be difficult to predict groundwater movement in the karst geology, even though four of the five dye trace studies from the Sullivan and Oak Grove Village areas have appeared in LaJolla Springs. Also, the PHA recommends that more sampling be done to determine the nature and extent of the TCE contamination that should aid in creating a more complete understanding of groundwater movement.

5. A comment stated that PHA assumes that the source of TCE in the air of the associated cave complex of LaJolla Springs is from the groundwater flowing through the cave.

The PHA simply reports information from the Remedial Investigation and the levels of contamination detected during recent sampling events. The main purpose of the PHA is to determine how humans can be exposed to those contaminants and the possible adverse health effects from that exposure. Determination of the source(s) and levels of the TCE contamination in the groundwater, air, and spring water are part of the Remedial Investigation that is now in phase II.

6. The report contains a number of statements suggesting that TCE in the air of the LaJolla cave complex could be harmful to employees or, to a lesser extent, to visitors and that these statements are not supported by science-based Occupational Safety and Health Administration (OSHA) workplace standards.

OSHA standards assume that workers are exposed to hazardous chemicals used in or generated as a result of routine work activities and that workers are trained to control or prevent exceedances of its exposure standards (including the use of personal protective clothing, medical monitoring, and gear to help prevent excessive exposures. Because TCE is not used or generated at the LaJolla cave complex and accordingly these programs are not in place, DHSS has taken a more protective approach to the assessment of the health of workers and visitors. Even with this more protective approach, DHSS feels that visitors to the cave complex do not face any additional risk because their exposure does not exceed ATSDR's MRL for acute exposure to TCE.

7. The title of this document indicates that it is related to the Oak Grove Village Well site and information relating the LaJolla Spring and associated cavern complex to the site is questionable and inferences to the contamination and related potential health risks should be removed from the report.

The site is listed in EPA's National Priority List (NPL) as the Oak Grove Village Well Site, which is where in 1986 the original discovery of TCE contaminated groundwater occurred.

Besides the Oak Grove Village well, other areas in the vicinity of the well have also been affected by the TCE contaminated groundwater, including some Sullivan city wells, a number of private wells, and LaJolla Spring and its associated cavern complex.
The focus of the PHA is to determine if exposure to the public has, is, or will occur and to recommend ways to eliminate that exposure and to determine what adverse health effects that exposure may cause. Even if an area of contamination was found not to be associated with the Oak Grove Village Well site, but was still affecting or could affect the health of the public it would still be our obligation along with the regulatory agencies to investigate the site and eliminate that exposure to the public.

Appendix E:

Glossary of Terms and Acronyms used in the Oak Grove Village Well Public Health Assessment

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Glossary of Terms and Acronyms used in the Oak Grove Village Well Public Health Assessment

Acute Exposure: Contact with a chemical that happens once and only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect: A change in body function or the structure of cells that can lead to disease or health problems.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Cancer: A group of diseases, which occur when, cells in the body become abnormal and grow, or multiply, out of control.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure: A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Completed Exposure Pathways: **See Exposure Pathways.**

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): **CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

Concern: A belief or worry that chemicals in the environment might cause harm to people.

Concentration: How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant: **See Environmental Contaminant.**

DHSS Missouri Department of Health and Senior Services

Degradation: The reduction of a chemical compound to one less complex.

Dermal Contact: A chemical getting onto your skin. (See **Route of Exposure**)

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

Environmental Media: Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Exposure: Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:

(1) Source of contamination,
(2) Environmental Media and Transport Mechanism,
(3) Point of Exposure,
(4) Route of Exposure, and
(5) Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effects: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

Karst: An area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns.

MCL: **M**aximum **C**ontaminant **L**evel. The highest level of a contaminant that EPA allows in a public drinking water system. MCLs ensure that drinking water does not pose either a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible.

MDNR: Missouri Department of Natural Resources

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure - by a specified route and length of time - - to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predicator of adverse health effects.

NPL: The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: **N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposure are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PCE: Tetrachloroethylene, a manufactured volatile organic compound, closely related to trichloroethylene (TCE), which is widely used for metal degreasing and dry cleaning of fabrics.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Plume: A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds, and streams).

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food, or soil). For examples: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area; or the number of people in a certain area.

Potential Exposure Pathway: An exposure pathway with at least one of the five elements missing for a completed exposure pathway, but the potential exists for that element to be added allowing for exposure to a contaminant.

ppb: Parts per billion = One part of chemical/pollutant per a billion parts of water or air.

ppbv: Parts per billion per volume: One part of a contaminant per a billion parts of air contained in a certain volume of air. The same as ppb.

ppm: Parts per million = One part of chemical/pollutant per million parts of water or air.

PRP: **P**otentially **R**esponsible **P**arty. A company, government, or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of the site.

Public Health Assessment(s): See **PHA.**

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:
- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

Receptor Population: People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathways**).

Remedial Investigation: An in-depth study to gather data on contamination that will lead to long-term action to remediate the contamination problem and protect human health.

Removal Action: An immediate action taken over the short-term to address a release or threatened release of hazardous substances.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:
- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- or getting something on the skin (also called dermal contact).

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Sensitive Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Superfund Site: See **NPL**.

TCE: Trichloroethylene, a manufactured volatile organic compound used mainly as a metal degreaser, but is also used as a solvent in other ways as well as in the making of other products.

Toxicology: The study of a harmful effects of chemicals on humans or animals.

USGS: U.S. Geological Survey.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

Volatile Organic Compound: An organic (carbon-containing) compound that evaporates (volatilizes) readily at room temperature.