Public Health Assessment

Public Comment Release

ALAMO CONTAMINATED GROUND WATER

ALAMO, CROCKETT COUNTY, TENNESSEE

EPA FACILITY ID: TNN000410203

Prepared by
The Tennessee Department of Health

JULY 1, 2013

COMMENT PERIOD ENDS: AUGUST 14, 2013

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

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release 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's Cooperative Agreement Partner 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. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR's Cooperative Agreement Partner will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR's Cooperative Agreement Partner. This revised document has now been released for a 45-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Use of trade names is for identification only and does not constitute endorsement by the U.S. Department of Health and Human Services.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Attn: Records Center
1600 Clifton Road, N.E., MS F-09
Atlanta, Georgia 30333

You May Contact ATSDR Toll Free at
1-800-CDC-INFO or
Visit our Home Page at: http://www.atsdr.cdc.gov

PUBLIC HEALTH ASSESSMENT

ALAMO CONTAMINATED GROUND WATER

ALAMO, CROCKETT COUNTY, TENNESSEE

EPA FACILITY ID: TNN000410203

Prepared by:

The Tennessee Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry
Atlanta, Georgia 30333

Foreword

This document summarizes an environmental public health investigation performed by the State of Tennessee Department of Health's Environmental Epidemiology Program. Our work is conducted under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry. In order for the Health Department to answer an environmental public health question, several actions are performed:

Evaluate Exposure: Tennessee health assessors begin by reviewing available information about environmental conditions at a site. We interpret environmental data, review site reports, and talk with environmental officials. Usually, we do not collect our own environmental sampling data. We rely on information provided by the Tennessee Department of Environment and Conservation, U.S. Environmental Protection Agency, and other government agencies, businesses, or the general public. We work to understand how much contamination may be present, where it is located on a site, and how people might be exposed to it. We look for evidence that people may have been exposed to, are being exposed to, or in the future could be exposed to harmful substances.

Evaluate Health Effects: If people could be exposed to contamination, then health assessors take steps to determine if it could be harmful to human health. We base our health conclusions on exposure pathways, risk assessment, toxicology, cleanup actions, and the scientific literature.

Make Recommendations: Based on our conclusions, we will recommend that any potential health hazard posed by a site be reduced or eliminated. These actions will prevent possible harmful health effects. The role of Environmental Epidemiology in dealing with hazardous waste sites is to be an advisor. Often, our recommendations will be action items for other agencies. However, if there is an urgent public health hazard, the Tennessee Department of Health can issue a public health advisory warning people of the danger, and will work with other agencies to resolve the problem.

If you have questions or comments about this report, we encourage you to contact us.

Please write to: Environmental Epidemiology
Tennessee Department of Health
1st Floor Cordell Hull Building
425 5th Avenue North
Nashville TN 37243

Or call us at: 615-741-7247 or toll-free 1-800-404-3006 during normal business hours
email: *eep.health@tn.gov*

Table of Contents

SUMMARY

Introduction

The Tennessee Department of Health's Environmental Epidemiology Program (EEP) conducted this Public Health Assessment under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

The purpose of this Public Health Assessment (PHA) was to determine whether the community was harmed by exposure to chemicals at the Alamo Contaminated Ground Water (ACGW) Superfund Site located in Alamo, Crockett County, Tennessee. In September 2011, the ACGW Site was added to the Environmental Protection Agency's National Priorities List (NPL). This PHA is being completed as part of the NPL process.

Conclusions

EEP has reached four conclusions about the Superfund Site located in Alamo, Crockett County, Tennessee.

Conclusion 1

EEP concludes that drinking water supplied by the City of Alamo is not expected to harm people's health.

Basis for Conclusion

While the concentrations of volatile organic concentrations (VOCs) in untreated groundwater are above levels that could potentially harm people's health, the levels of VOCs in treated water are well below levels that would harm human health. Water from the individual municipal wells is mixed in a water storage area inside the water treatment plant known as the Clearwell before being distributed to the public. This mixing reduces the concentration of VOCs in the water. In addition, on July 2, 1991, the City installed an air stripper to treat the groundwater before it enters the public water distribution system. Concentrations of the VOCs, tetrachloroethylene and trichloroethylene were below detection limits in the latest post-treatment sampling and analysis conducted in February 2011.

Next Steps

Data for finished drinking water being distributed to the public are limited and dated. Sampling frequency is once every three years. The most recent data provided to EEP are from February 2011. It is recommended that the City of Alamo increase the frequency of monitoring of finished water being provided to the public as long as the air stripper is used to treat water from municipal wells or until concentrations of contaminants are below levels of concern in pre-treated water.

Conclusion 2	**EEP cannot conclude whether drinking water supplied by the City of Alamo before July 1988, could have harmed people's health.**
Basis for Conclusion	The water was not sampled for VOC contamination before July 1988. There were no data available to assess exposure to VOCs from drinking municipal water before the investigation that was initiated in July 1988 following a report of an oily film on city water.
Next Steps	None.
Conclusion 3	**EEP cannot conclude whether site-related chemicals are present in groundwater that could harm the health of people who are using private wells.**
Basis for Conclusion	The concentrations of site-related chemicals in untreated groundwater near the ACGW Site are above levels that could potentially harm people's health. Records reviewed show that there are at least 37 private wells within a 2-mile radius of the ACGW Site. In addition, the Tennessee Department of Environment and Conservation (TDEC) identified several other sites with potential releases of tetrachloroethylene and trichloroethylene over the past 20 years. Sampling has not been done to determine if site-related chemicals still remain in these areas.
Next Steps	It is recommended that an investigation to study potential impact to private wells closest to the ACGW Site be initiated as part of the Superfund investigative process.
Conclusion 4	**Data suggests that there was a health risk to people breathing contaminants in indoor air in homes or businesses near the ACGW Site in 1989. EEP does not have data after 1989 to conclude whether or not that potential continued beyond 1989.**
Basis for Conclusion	Investigation into the continued presence of surface soil contamination has been limited. The calculated risk estimated by using the Johnson & Ettinger model with the highest recorded soil-gas concentration in 1989 [USGS] was $3x10^{-3}$ or about 3 excess cancers in 1,000 people. This estimate indicated a potential risk to citizens breathing indoor air near the ACGW Site in 1989.

Next Steps	Additional soil-gas samples and/or indoor air samples would provide information needed to verify whether or not vapor intrusion is occurring in homes and businesses surrounding the ACGW Site. EEP recommends that TDEC initiate soil-gas and/or indoor air sampling in areas near municipal wells #1 and #2, as well as near the former Volunteer Circuits building, to determine whether an inhalation exposure exists.
Conclusion 5	**EEP cannot determine the potential impact to human health from discharging contaminated water to a drainage ditch from mid-1989 to mid-1991.**
Basis for Conclusion	A newspaper article from the Crockett Times believed to have been published in 1989 refers to dissipating chemicals in water from municipal water well by mixing them with air as they are being discharged into a drainage ditch. EEP cannot determine if anyone had direct contact with ground water that was pumped from well # 1 and discharged to a nearby drainage ditch from mid-1989 to mid-1991. In addition, it is not known to what extent the levels of chemicals in groundwater that discharged to the surface may have been lessened by mixing the water with air.
Next Steps	None.
Conclusion 6	**EEP concludes that exposure to surface soil near The Crockett Times, Volunteer Circuits, the city garage and near the Alamo municipal wells is not expected to harm people's health. In addition, exposure through direct contact with subsurface soil is not likely to take place. EEP cannot determine with certainty whether adverse health effects exist with exposure to subsurface soil without further investigation.**
Basis for Conclusion	VOCs were not found in surface soil samples collected between 0 and 6 inches below land surface in 2004 at The Crockett Times, Volunteer Circuits, the city garage and near the Alamo municipal wells. Chemical concentrations of VOCs in subsurface soil samples collected in 1992 and 1999 were below ATSDR comparison values. Exposure through direct contact with subsurface soil is not likely to take place unless soil is disturbed as during construction.
Next Steps	Should the subsurface soil be disturbed in any of the investigated areas, further investigation would be needed to determine if any potential health effects exist.

For More Information

If you have any questions or concerns about your health, you should contact your healthcare provider. For more information on this environmental site call TDEC toll free at 1-888-891-8332. For more information on this health report, please call TDH EEP at 615-741-7247 or 1-800-404-3006 during normal business hours. You can also email TDH EEP at eep.health@tn.gov.

STATEMENT OF ISSUES AND BACKGROUND

Statement of Issues

The Tennessee Department of Health's Environmental Epidemiology Program (EEP) conducted an evaluation of possible environmental exposures in relation to the Alamo Contaminated Ground Water (ACGW) Superfund Site. The U.S. Environmental Protection Agency (EPA) proposed to add the ACGW Site to its National Priorities List (NPL) of hazardous waste sites in March 2011. The ACGW Site was officially listed on the NPL in September 2011. The NPL is part of the EPA Superfund cleanup process and is primarily intended to guide EPA in determining the hazardous waste sites that warrant further investigation and possible clean-up. EEP has become involved with the ACGW Site because Congress mandates that the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) conduct public health activities at Superfund sites that EPA proposes adding to its NPL. This project was conducted under a cooperative agreement between ATSDR and EEP to conduct public health assessments at NPL sites and other sites with environmental contamination in Tennessee.

Background

The ACGW Site is located near the intersection of West Park Street and South Bell Street in Alamo, Crockett County, Tennessee. Alamo is located in west Tennessee. The site consists of a VOC-contaminated groundwater plume that extends approximately ⅓-mile northeast to southwest in the area of the Alamo municipal well field. The well field will be used as the geographic location of the ACGW Site. The well field consists of four municipal wells near the water treatment plant. Two of the wells are about 125 feet deep while the others are more than 200 feet deep [TDEC-DOR 2010]. Logs of monitoring wells installed in May 2010 indicate groundwater flows in a westerly direction. The Alamo water department estimates that 300,000 gallons of water is pumped from the four municipal wells per day [USGS 1992].

Volatile organic compounds (VOC) were first discovered in the groundwater supplying the Alamo public water supply in 1988 when an oily film was reported by people using city water. It was determined that the oily film was a result of a hydraulic oil leak in association with the water treatment operation [TDHE 1988a]; however, the hydraulic oil leak was not the source of the VOC contamination. VOCs present in water samples collected in July 1988 were 1,1,1-trichloroethane (1,1,1-TCA) and trichloroethylene (TCE) in municipal well # 1; methylene chloride, 1,1,1-TCA, and TCE in municipal well # 2; and 1,1-dichloroethane, methylene chloride, 1,1,1-TCA and TCE in municipal well # 3. Tetrachloroethylene (PCE) was not detected in water samples from the Alamo City wells in 1988 [TDHE-lab 1988]. PCE was first detected in September 1989 [USGS 1992]. It was detected again in February 1992 during sampling conducted at the Alamo Water Treatment Plant [TDEC-DWS 2011a]. PCE has been detected consistently in water samples from municipal wells since 1992.

Various studies have found multiple possible sources of VOCs in the vicinity of the plume, including Volunteer Circuits, The Crockett Times, various dry cleaners, and businesses that used VOCs as degreasers (Figure 2). Due to likely co-mingling of possible multiple releases over

Figure 1: Contaminated Groundwater Plume Map. Alamo, Crockett County, Tennessee.
Source: EPA Hazard Ranking System Documentation Record, March 2011, Tetra Tech

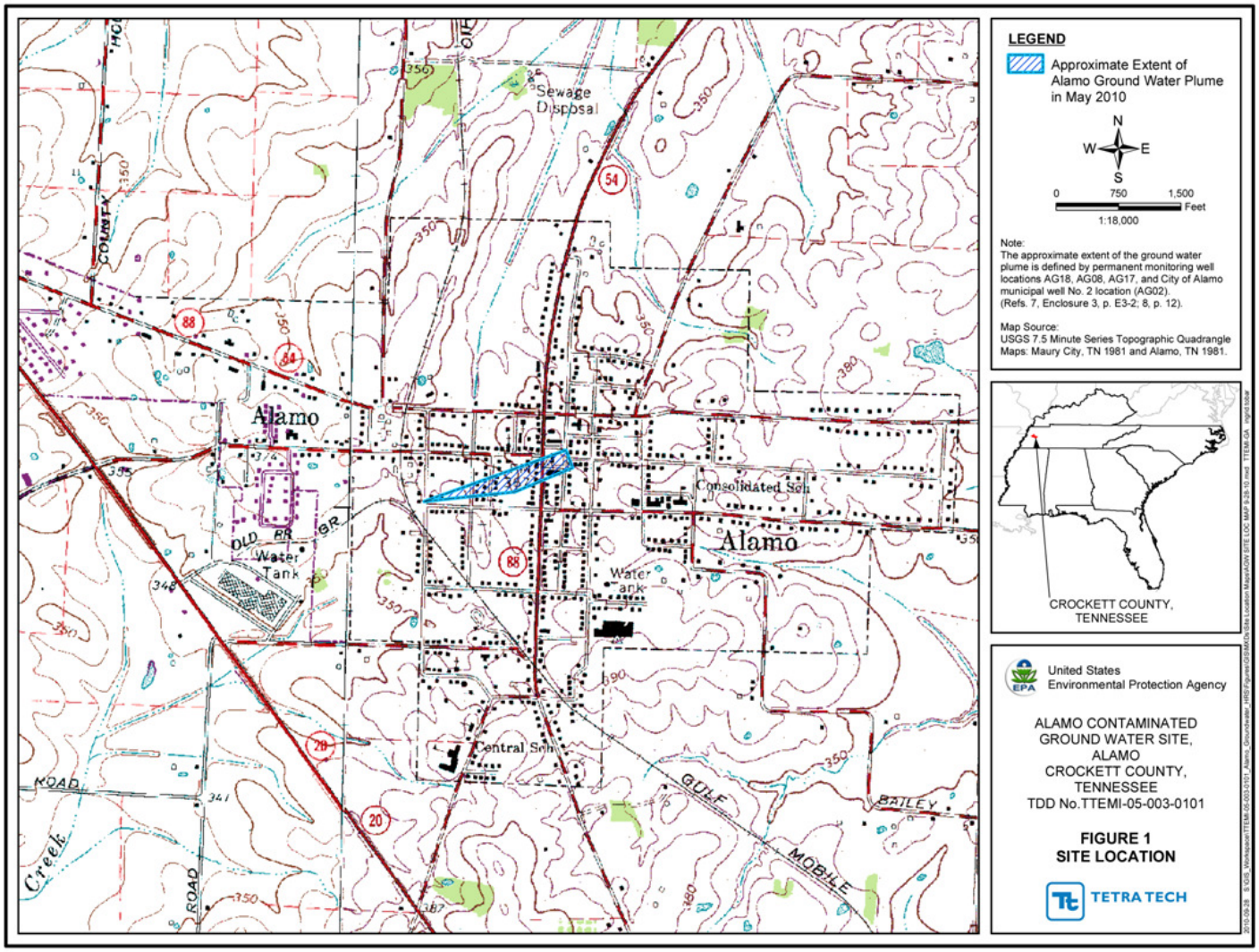


Figure 2: Potential Sources of Contamination at the Alamo Contaminated Drinking Water Site.
Alamo, Crockett County, Tennessee.
Source: EPA Hazard Ranking System Documentation Record. March 2011

time, the contamination in the groundwater plume cannot be attributed to any particular source [EPA 2011c].

Volunteer Circuits manufactured printed circuit boards for the electronics industry from 1973 to 1975. Printed circuit board manufacturing involves use of various cleaners including 1,1,1-TCA and TCE [EPA 2011c]. A parking lot exists in the location of the former Volunteer Circuits building.

The Crockett Times is a local newspaper located at 46 West Main Street. The newspaper was printed weekly from 1933 until the 1960s at the Alamo office. PCE, 1,1,1-TCA, and TCE are associated with newspaper printing. Waste storage and disposal practices employed by *The Crockett Times* during the years the newspaper was printed are unknown [EPA 2011c]. The building formerly housing *The Crockett Times* is now being used as the newspaper office and a cable television office.

PCE was also used as a dry cleaning solvent and degreaser at various nearby businesses over the years. Through spills and improper handling, PCE could have been released to the environment by these businesses [TDEC-DOR 2010].

On July 2, 1991, the City of Alamo installed an air stripper to treat water being provided to the public. Water is combined from each of the municipal wells and then flows into the air stripper. The air stripper is turned on automatically when the pumps start [TDOH 2011a]. PCE and TCE had become the main chemicals of concern at this site. In reviewing the sampling data from the municipal water plant, it appears that the sampling frequency of the treated water decreased from quarterly in the early years using the air stripper to approximately once per year around 2002 and to a three-year interval in 2005. The air stripper continues to operate and effectively remove the VOCs, including PCE, TCE, and 1,1,-TCA, from the water.

Land Use and Demographics

2010 Census figures report that Crockett County has a population of 14,586 with approximately 55 people per square mile. The majority of the population in the county is White (79%), with 13% African-American and 9% Hispanic or Latino [Census 2010].

According to the 2005-2009 American Community Survey 5-Year Estimates [Census 2009], there were 2,397 people, 867 households, and 590 families residing in Alamo. There were 576 owner-occupied housing units and 291 renter-occupied housing units. The average size of a household in Alamo was 2.6 people.

According to 2010 Census data, approximately 2,758 people live within 1-mile of the ACGW Site. Approximately 4,808 people live within a 4-mile radius.

History of Environmental Investigation Activities (1988 – Present)

In 1988 and 1989, groundwater samples were collected from the City of Alamo's municipal wells. As a result of the 1,1,1-TCA and TCE found in well #1 in July 1988, the City

discontinued use of that well as a municipal water source. The City pumped water from well #1 and discharged it to a drainage ditch from mid-1988 until July 1991. On July 2, 1991, the City installed an air stripper and well #1 was put back into service as part of the municipal water source. VOCs were still present in two of the City's four municipal wells at that time. Water from all four wells is combined and processed through the air stripper. All City of Alamo municipal wells were monitored for VOC concentrations on a quarterly basis. Monitoring of finished water has continued over the years at various sampling intervals.

In 1989, the U.S. Geological Survey (USGS) conducted a soil-gas investigation. Soil-gas was sampled at a former industrial site and near all four Alamo municipal wells. The industrial site was the former location of Volunteer Circuits, a circuit board manufacturing facility, where organic solvents had been used in the cleaning of electronic components. Groundwater samples were also collected from the 4 municipal wells.

A preliminary assessment (PA) was completed for Volunteer Circuits in April 1992 by TDEC's Division of Superfund. This assessment concluded that Volunteer Circuits posed a potential threat to the public and environment and recommended further investigation. Between July and November 1992, the TDEC Division of Superfund conducted sampling activities as part of a site inspection (SI) at the Volunteer Circuits property. The SI included collection of soil samples at and in the vicinity of Volunteer Circuits and groundwater samples from the City of Alamo's municipal wells. Soil samples were collected from two areas, a former TCE drum storage area and a film developer equipment area where spent TCE had been dumped. The areas of VOC soil contamination identified during the TDEC SI corresponded to the areas identified during the previous USGS soil-gas investigation.

In November and December 1999, ATC Associates, Inc. (ATC), on behalf of TDEC, conducted a soil and groundwater investigation at the Volunteer Circuits property [ATC 1999].

In June 2000, ATC conducted a second investigation of the area surrounding the Volunteer Circuits property. As part of the investigation, 10 additional borings were advanced to depths ranging from 48 to 64 feet below land surface (bls). Only groundwater was sampled and analyzed for VOCs during this investigation.

In September 2000, ATC conducted a third investigation of the area surrounding the Volunteer Circuits property at locations identified as potential areas of concern. ATC personnel advanced eight borings at depths ranging from 46 to 60 feet bls where groundwater was sampled and analyzed for VOCs.

Between January and February 2001, TDEC completed a PA for *The Crockett Times,* a local newspaper located at 46 West Main Street. In January 2004, T N & Associates, Inc. (TN&A), on behalf of the EPA, conducted an SI at *The Crockett Times* in Alamo, Tennessee. During the SI, 14 surface soil samples, five temporary monitoring well groundwater samples, and three municipal well groundwater samples were collected [TDEC-DSF 2004].

In May 2010, TDEC, on behalf of EPA, conducted an expanded site inspection (ESI) at the ACGW Site. During the ESI, 14 permanent monitoring wells were installed and sampled in the

City of Alamo. A total of 20 soil samples were collected from borings advanced between the land surface and 23 feet bls. Groundwater samples were also collected from the City of Alamo's four municipal wells. [EPA 2011c]

In September 2011, the ACGW Site was added to the National Priorities List (NPL).

Data And Comparison Values Considered

To address concerns about possible environmental exposures associated with the ACGW Site, EEP reviewed sampling data from TDEC, EPA, and the USGS. Environmental contaminant data were available for groundwater, drinking water, soil, and soil-gas. A screening evaluation was conducted to identify those substances that may need to be considered for further analysis to determine whether they may be of potential health concern. The screening analysis identified maximum concentrations of constituents detected in various types of environmental media (i.e., water, soil, and air) and compared these concentrations to comparison values for each media established by the Agency for Toxic Substances and Disease Registry (ATSDR). If concentrations are above the comparison values [ATSDR 2012] for a particular chemical, then further evaluation is needed. If the chemical concentrations are below the comparison value, then health assessors and the public can be reasonably certain that no adverse health effects will occur in people who are exposed at the reported levels.

Non-Cancer Comparison Values

The Agency for Toxic Substances and Disease Registry (ATSDR) develops Minimal Risk Levels (MRLs) using reasonable worst case assumptions. MRLs are an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a set time of exposure. Environmental Media Evaluation Guidelines (EMEGs) are calculated by ATSDR from their MRLs. EMEGs represent concentrations of substances in water, soil, and air to which humans may be exposed during a specified period of time (acute, intermediate or chronic) without experiencing adverse health effects. EMEGs only consider non-cancer adverse health effects. These exposure durations are defined as acute (14 days or less), intermediate (15–365 days), or chronic (365 days or more). Chronic EMEGs are generally the more conservative and assume exposure for 24 hours per day, 7 days per week, 52 weeks each year, for 1 year or longer. Exposure to a level above the EMEG for a chemical does not necessarily mean that adverse health effects will occur (ATSDR 2007). EMEGs for the compounds found in the drinking water in Alamo are found in Table 3.

ATSDR derives Reference Dose Media Evaluation Guides (RMEGs) from EPA's oral reference doses. Like EMEGs, RMEGs represent concentrations of substances (in water, soil, and air) to which humans may be exposed without experiencing non-cancerous, adverse health effects. EPA's oral reference doses consider lifetime exposures. Therefore, RMEGs apply to chronic exposures.

The hazard quotient (HQ) is another tool used to evaluate non-cancer health effects. Because some chemicals of concern do not have comparison values for non-cancer health effects, the HQ was included in this evaluation. An HQ is the comparison of the potential exposure to the

substance and the level at which no adverse effects are expected. If the HQ is calculated to be equal to or less than 1, then no adverse non-cancer health effects are expected as a result of exposure. If the HQ is greater than 1, then non-cancer adverse health effects are possible. The HQ cannot be translated to a probability that adverse health effects will occur. It is especially important to note that an HQ exceeding 1 does not necessarily mean that adverse effects will occur [EPA 2011b]. Rather, additional evaluation of the chemical and site-specific exposure scenarios are warranted.

EPA has established National Primary Drinking Water Regulations that set mandatory water quality standards for drinking water contaminants. These are enforceable standards called "maximum contaminant levels" or "MCLs" and are established to protect the public against consumption of drinking water contaminants that could cause harmful effects to human health. An MCL is the highest level of a contaminant that EPA allows in drinking water. MCLs are enforceable standards that ensure that drinking water does not pose either a short-term or long-term health risk. [EPA 2011d]. MCLs of the compounds found in the drinking water in Alamo are found in Table 1.

EEP used the Johnson & Ettinger (J&E) model to evaluate non-cancer health effects from potential chemical off-gassing from soil-gas and groundwater. This off-gassing process is called “vapor intrusion” when the chemicals mix with breathable air and migrate inside a building. The J&E model is a conservative, simplified model that uses measured, site-specific groundwater concentrations, the type of soil at the site, the building foundation type, the depth to groundwater, and the exposure duration, among other chemical-specific details.

Cancer Comparison Values

Measured concentrations of solvents were compared to ATSDR cancer risk evaluation guides (CREGs) to understand if concentrations of these chemicals could possibly increase the risk of cancers in workers or visitors to the ACGW Site. The CREG comparison values are established for no more than one estimated excess incidence of cancer in 1,000,000 (a million) people exposed during a 70-year lifetime. Excess incidence of cancer is the risk of cancer that is in addition to the background risk of developing cancer. The background cancer risk is the risk that all people have of developing cancer which is currently 1 in 2 for men and 1 in 3 for women. EPA prefers to have a residential risk value less than 1 excess cancer in 1 million people or $1x10^{-6}$. EPA’s target cancer risk range is between 1 in 10,000 and 1 in 1 million people [EPA 1991]. CREGs of the compounds found in the drinking water in Alamo are found in Table 1.
Sampling results were also compared to MCLs. EEP also used the J&E model to calculate an estimated cancer risk from potential exposure resulting from the process of vapor intrusion as discussed above.

Pathway Analysis

To determine whether persons have been or are likely to be exposed to chemicals, TDH EEP evaluates mechanisms that could lead to human exposure. An exposure pathway contains five parts:

- a source of contamination,
- contaminant transport through an environmental medium,
- a point of exposure,
- a route of human exposure, and
- a receptor population.

An exposure pathway is considered complete if there is evidence that all five of these elements have been, are, or will be present at the ACGW Site. An exposure pathway is considered incomplete if one of the five elements is missing. For this site, exposure pathways for ingestion, inhalation, and dermal contact were complete in the past.

Physical contact alone with a potentially harmful chemical in the environment by itself does not necessarily mean that a person will develop adverse health effects. A chemical's ability to affect public health is controlled by a number of factors, including:

- the amount of the chemical that a person is exposed to (dose),
- the length of time that a person is exposed to the chemical (duration),
- the number of times a person is exposed to the chemical (frequency),
- the person's age and health status, and
- the person's diet and nutritional habits.

This Public Health Assessment evaluated the ACGW Site in regard to human exposures to hazardous substances. To evaluate exposure at this site, EEP used health comparison values. If the chemical concentrations are below the comparison value, then health assessors can be reasonably certain that no adverse health effects will occur in people who might be exposed. If concentrations are above the comparison values for a particular chemical, then further evaluation of that chemical is in order.

Groundwater Exposure Pathway

At this site, finished drinking water quality is a better indicator of actual exposure (a completed exposure pathway) than groundwater data. Initially, finished water was sampled quarterly for VOC content. Because the VOC content in finished water was consistently below detection limits, sampling frequency was modified and samples are now collected once every three years [TDEC-DWS 2008]. The most recent data used in this evaluation are from February 2011.

Two public water supply systems, the City of Alamo Water Department and County Wide Utility District, are within the 2-mile radius of the ACGW Site. A majority of the population within the 2-mile radius are served by the City of Alamo Water Department. All four Alamo municipal wells are located within the ACGW Site. Water samples collected from the County Wide Utility District wells have not detected VOCs [TDEC-DOR 2012].

An estimated 37 private wells are present within 2 miles of the ACGW Site [TDEC-DWS 2011b]. Direct exposure to contaminants in the groundwater could be possible for the citizens using private wells as their household drinking water source. Because of the irregular shape of

the defined contamination plume, it does not extend to all areas within the 2-mile radius. Therefore, it is not expected that all 37 private wells are impacted. Incidental contact with groundwater is not likely due to the depth of area groundwater. It is more likely that private wells within the 1-mile radius of the ACGW Site might be impacted by the contaminated groundwater. Without well data, it is not possible to determine if the exposure is occurring.

There was a potential for exposure to groundwater during a period of time between mid-1988 until mid-1991 when the groundwater from well # 1 was being pumped and discharged to a nearby drainage ditch [TDEC-DSF 1991]. A newspaper article from *The Crockett Times*, believed to have been published in 1989, refers to dissipating the chemicals by mixing them with air as they are being discharged into the ditch. It is not known to what extent the levels of the chemicals may have been lessened by this process.

Past potential exposure to VOCs in the groundwater via the municipal drinking water distribution system prior to July 1988, cannot be determined with the data available.

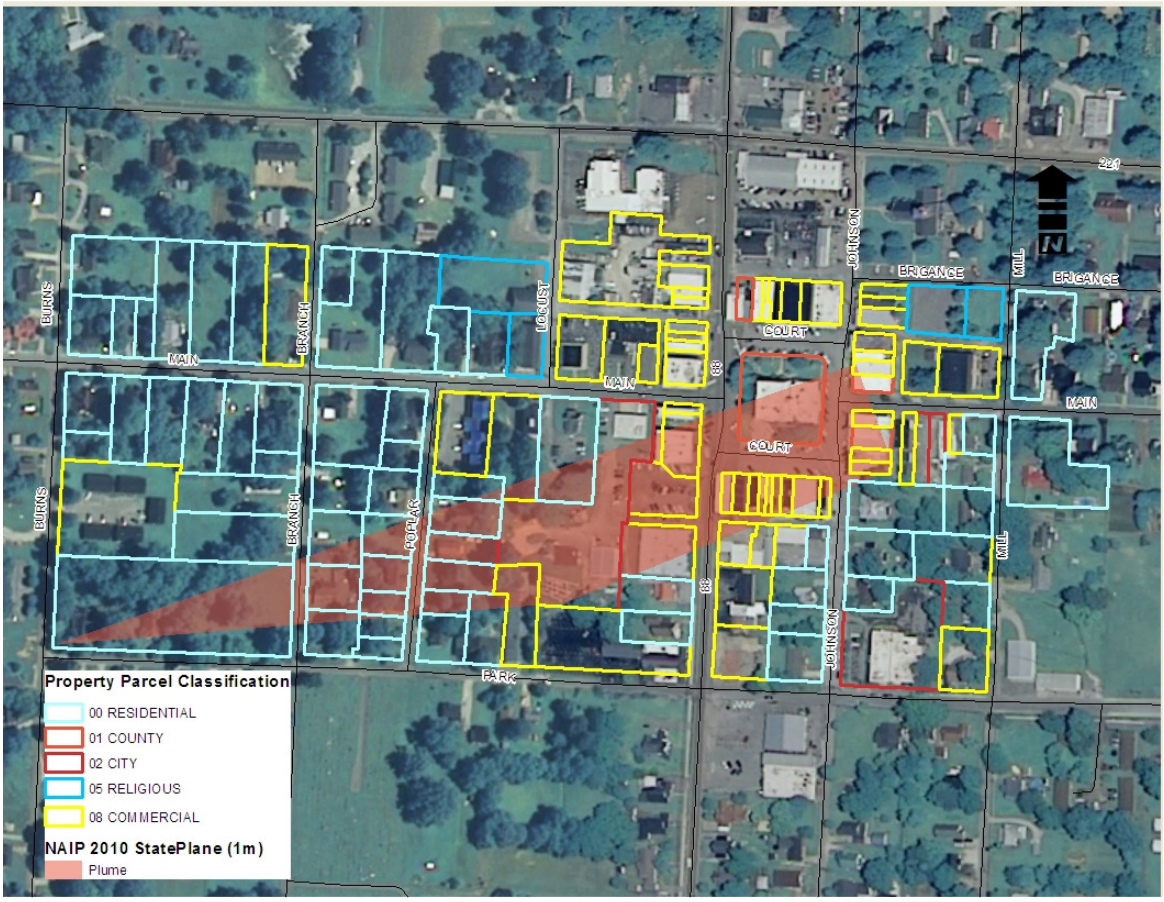
Soil Exposure Pathway

The former Volunteer Circuits location (Figure 2) was identified in 1992 as a potential source for contamination because of chemical handling practices in the past [EPA 2011c]. Concentrations of contaminants measured in surface soil in May 2010 were below comparison values. VOCs present in soil exist at depths not likely to result in incidental contact unless disturbed by excavation activities such as construction.

Vapor Intrusion Inhalation Pathway

Vapor intrusion was considered as a potential source for an inhalation pathway. The potential for vapor intrusion from PCE found in groundwater and soil-gas was modeled using groundwater data collected in 2010, soil-gas data from 1989, and the J&E simplified model [EPA 2011a]. Residential, commercial, city and county buildings are currently present over the plume of contamination (Figure 3).

Figure 3: Property Parcel Classification over the Alamo Contaminated Drinking Water Site Plume



DISCUSSION

The specific objectives of this Public Health Assessment were as follows:

- To evaluate the extent to which contamination at the ACGW Site could result in exposure to people in the area and whether adverse health effects would be possible if exposure occurred.

- To evaluate opportunities for environmental exposure(s) of current and former nearby residents to contaminants identified at the ACGW Site.

- To discuss possible exposure pathways related to the ACGW Site.

Below is a brief discussion of the investigations that have been conducted in Alamo from 1988 to the present. This discussion details the chemicals found and provides a brief evaluation of the concentrations measured and the potential health effects.

Municipal Well Water

In 1988, as a result of reports of an oily film submitted by a citizen using city water, the City of Alamo began sampling the municipal wells for volatile organic compounds (VOCs). Water samples collected from the City of Alamo's municipal wells in 1988 and 1989 revealed VOC contamination in municipal well #1. VOCs found included trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE), 1,1,1-trichloroethane (1,1,1-TCA), and carbon tetrachloride. TCE was detected at concentrations of 97.9 and 113 parts per billion (ppb) in municipal well #1 in September 1988 [EPA 2011c]. TCE was detected in municipal well #2 at a concentration of 4.9 ppb. The 1988 concentrations of TCE in the water from well #1 and well #2 exceeded the EPA maximum contaminant level (MCL) of 5 ppb and ATSDR's CREG of 0.76 ppb for drinking water [ATSDR 2012]. The concentration of 1,1-DCE was 52.2 ppb in municipal well #1 and 3.7 ppb in well #2. The concentration in well #1 was above its EPA MCL of 7 ppb. 1,1,1-TCA was measured at 88 ppb in well # 1 and 4.6 ppb in municipal well # 2. Both of these levels were below cancer and non-cancer comparison values. Water from the individual municipal wells was mixed in the Clearwell before distribution to the public. This mixing reduced the concentration of VOCs in the water; however the concentration of TCE in the finished water exceeded the ATSDR CREG during the months of August and September 1988.

Water samples collected from municipal well #1 in 1989 during the USGS investigation contained TCE at a concentration of 45 ppb. The TCE level exceeded both cancer and non-cancer comparison values. Water samples also contained 1,1-DCE at a concentration of 32 ppb. There is not an established CREG for 1,1-DCE. The concentration of 1,1-DCE is above its MCL of 7 ppb and below its chronic child EMEG of 90 ppb. 1,1,1-TCA was present in September 1989 at 38 ppb which was below its MCL of 200 ppb and its intermediate child EMEG of 200,000 ppb. The concentration of carbon tetrachloride measured in September 1989 was 1 ppb which is above its CREG of 0.05 ppb. The concentration of carbon tetrachloride was below the MCL of 5 ppb and its intermediate child EMEG of 70 ppb. VOCs were not detected in the other two municipal wells during the September 1989 investigation.

A summary of the VOC concentrations of water samples from 1988 to 2011 can be found in Appendix A.

On July 2, 1991, the City installed an air stripper and well #1 was put back into service as a municipal water source. VOCs were still present in two of the City's four municipal wells at that time. All City of Alamo raw municipal well water was initially monitored for VOC concentrations on a quarterly basis. In 2008, after repeated results indicated concentrations of VOCs below detection limits in finished water, the frequency of testing was reduced from quarterly to every three years.

Of 39 municipal water samples collected from the clearwell following the installation of the air stripper in 1991 until February 2001, TCE was detected in five samples. The five samples with concentrations above detection limits were collected between February 1992 and August 1996. See Table 1. Concentrations ranged from 0.5 ppb in August 1996 to 1.1 ppb in May 1996 [TDEC-DWS 2011b]. Except for the post-treatment water sample from May 1996 which contained TCE at a concentration of 1.1 ppb, concentrations were below ATSDR's CREG of

0.76 ppb [ATSDR 2012]. PCE in treated water has been consistently below its ATSDR CREG. Carbon tetrachloride in treated water has also been consistently below ATSDR's CREG. Levels of all chemicals discussed in this report were below detection limits in the most recent municipal water samples collected in February 2008 [TDEC-DWS 2011a].

Between July and November 1992, TDEC Division of Superfund, conducted sampling activities for a Site Inspection (SI) at the Volunteer Circuits property. VOCs detected in the City of Alamo's municipal wells #1, #2, and #3 before treatment included 1,1-DCE at levels up to 35 ppb; PCE at levels up to 0.7 ppb; 1,1,1-TCA at levels up to 31 ppb; and TCE at levels up to 45 ppb. Carbon tetrachloride was below its ATSDR CREG of 0.5 ppb. It was concluded by TDEC that the VOC contamination in the municipal wells, excluding PCE, was likely partially attributable to Volunteer Circuits. The concentration of TCE in the untreated water exceeded both cancer and non-cancer health comparison values for drinking water. After treatment with the air stripper, concentrations in finished water were negligible.

In January 2004, 3 untreated municipal well water samples were collected. VOCs found in the 3 municipal well water samples included 1,1-DCE at an average concentration of 14 ppb; PCE up to an average of 13 ppb; 1,1,1-TCA up to an average of 3.4 ppb; and TCE up to an average of 4.4 ppb [EPA 2011a].

In May 2010, untreated water samples were collected from the City of Alamo's four municipal wells. Water samples collected from the City's municipal wells contained 1,1-DCE at a maximum level of 3.9 ppb; PCE at a maximum level of 18 ppb; 1,1,1-TCA estimated at a maximum level of 0.55 ppb; and TCE at a maximum level of 1.8 ppb. PCE was detected above its EPA MCL of 5 ppb in municipal groundwater well samples AG01-0510-MS at 16 ppb, AG01-0510-MSD at 16 ppb, AG02-0510-MS at 18 ppb, and AG03-0510-MS at 9.9 ppb [EPA 2011c].

Data Evaluation

All water provided to the public by the Alamo Water Department is a mixture of the four municipal water wells that is treated using an air stripper before entering a water storage area inside the water treatment plant known as the Clearwell where it undergoes standard water treatment. The treated water is also tested to make sure the treatment process eliminates the chemicals. Upon the discovery of VOCs in municipal well # 1, use of that well was halted. In September, 1988, the city of Alamo agreed to begin monthly sampling for VOCs [TDHE 1988b]. With the installation of the air stripper in 1991, Alamo began sampling municipal water quarterly for VOCs. After repeated results indicated concentrations of VOCs below detection limits in finished water, the frequency of testing was reduced from quarterly to every three years in 2008. The finished water is currently required to be tested every three years for VOC content. A summary of the Clearwell sampling results can be found in Table 1 below.

Table 1: Alamo Clearwell Volatile Organic Compound Sample Results (ppb) 1988-2011

	trichloroethylene (TCE)	1,1-dichloroethylene (1,1-DCE)	1,1,1-trichloroethane (1,1,1-TCA)	tetrachloroethylene (PCE)	1,2-dichloroethane (1,2-DCA)	carbon tetrachloride
ATSDR EMEG *	ngv	90 (chronic)	200,000 (int)	ngv	2,000 (int)	70 (int)
ATSDR EMEG **	ngv	320 (chronic)	700,000 (int)	ngv	7,000 (int)	250 (int)
EPA MCL	5	7	200	5	5	5
ATSDR CREG	0.76	ngv	ngv	17	0.38	0.5
ATSDR RMEG *	5	500	20,000	60	ngv	40
ATSDR RMEG **	18	1,800	70,000	210	ngv	140
8/15/88	**2.04**	Not Reported	2.72	Not Reported	ND	ND
9/8/88	**10.7**	ND	6.61	Not Reported	Not Reported	ND
9/20/88	**2.1**	ND	2.0	Not Reported	ND	ND
9/20/88	**2.8**	ND	2.1	Not Reported	ND	ND
10/27/88	0.6	<0.5	0.6	<0.5	*<0.5*	<0.5
11/3/88	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
3/28/89	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
4/27/89	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
7/25/89	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
10/26/89	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
1/29/90	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
4/30/90	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
8/6/90	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
10/25/90	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
2/20/91	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
5/20/91	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
8/20/91	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
11/19/91	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
2/11/92	0.7	<0.5	<0.5	<0.5	*<0.5*	<0.5
4/15/92	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
7/15/92	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
11/4/92	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
2/2/93	0.6	<0.5	<0.5	<0.5	*<0.5*	<0.5

	trichloroethylene (TCE)	1,1-dichloroethylene (1,1-DCE)	1,1,1-trichloroethane (1,1,1-TCA)	tetrachloroethylene (PCE)	1,2-dichloroethane (1,2-DCA)	carbon tetrachloride
5/10/93	0.7	<0.5	<0.5	<0.5	*<0.5*	<0.5
8/16/93	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
11/2/93	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
2/8/94	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
5/31/94	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
8/10/94	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
11/30/94	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
2/22/95	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
5/22/95	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
9/5/95	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
11/21/95	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
5/21/96	**1.1**	<0.5	<0.5	<0.5	*<0.5*	<0.5
8/5/96	0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
10/10/96	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
2/25/97	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
5/5/97	Not Reported	<0.5	<0.5	<0.5	*<0.5*	<0.5
8/13/97	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
11/6/97	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
2/11/98	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
4/13/98	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
8/10/98	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
10/26/98	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
1/7/99	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
1/12/99	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
8/8/00	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
1/31/01	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
4/26/01	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
6/19/02	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
3/29/04	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
4/5/05	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5
2/20/08	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5

	trichloroethylene (TCE)	1,1-dichloroethylene (1,1-DCE)	1,1,1-trichloroethane (1,1,1-TCA)	tetrachloroethylene (PCE)	1,2-dichloroethane (1,2-DCA)	carbon tetrachloride
2/1/11	<0.5	<0.5	<0.5	<0.5	*<0.5*	<0.5

EMEG=Environmental Media Evaluation Guidelines MCL=Maximum Contaminant Level
RMEG=Reference Dose Media Evaluation Guidelines CREG=Cancer Risk Evaluation Guidelines
Units = parts per billion (ppb) Bold = concentration is greater than the ATSDR CREG Italics = Reporting Limit/Detection Limit is greater than the ATSDR CREG
ngv = No guidance value available ND = Concentrations below detection limit. Detection limit not specified int = Intermediate
* Child Drinking water CV (ATSDR August 2012) ** Adult Drinking water CV (ATSDR August 2012)
Note: All water provided to the public was treated with an air stripper beginning in July 1991. The Clearwell contains a mixture of water from all municipal water wells after treatment with the air stripper. In July 1988 Well # 1 was discontinued as source for public drinking water until July 1991 when an air stripper was installed [EPA 2001c].

While the concentration of various VOCs found in individual municipal wells over the years have exceeded comparison values, the combining of water from the four municipal wells and the use of an air stripper reduced the VOC concentrations in the Clearwell to below detection limits with relatively few exceptions since 1991.

The only VOC concentration to exceed its ATSDR comparison value in the Clearwell was TCE. The Concentration of TCE exceeded the ATSDR CREG during the months of August and September 1988 before the installation of the air stripper. The highest concentration of TCE measured in the Clearwell was 10.7 ppb on September 8, 1988. Assuming an adult water intake rate of 2 L/day and a child intake rate of 1 L/day, a calculated exposure dose for ingestion of this concentration was $6.69x10^{-4}$ mg/kg/day for children ages 1-6 and $3.06x10^{-4}$ mg/kg/day for adults. The municipal water at Alamo was not evaluated for TCE prior to August 1988; therefore, an exposure duration can only be estimated. The measured concentrations just prior to following the measurement on September 8, 1988 were 2.04 ppb and 2.1 ppb respectively. With one exception on May 21, 1996, the measured concentrations of TCE in the Clearwell have been below the ATSDR CREG for TCE following the installation of the air stripper in 1991. A lifetime exposure to a chemical at a concentration equal to its CREG comparison value could possibly result in a one in a million risk of developing cancer in addition to the background risk of developing cancer. It is believed that a exposure duration of 10 years is a very conservative evaluation period. At a 10-year exposure duration to 10.7 ppb TCE, the calculated risk to adults was $2.01x10^{-6}$ with the risk being $4.39x10^{-6}$ for children using the 10-year exposure duration. This would equate to two excess cancers in one million exposed adults and four excess cancers in one million exposed children. EPA target cancer risk range is between 1 in 10,000 and 1 in a million [EPA 1991]. To account for the possibility of inhalation exposure from showering, the concentration was doubled to 21.4 ppb. The calculated risk at a10-year exposure duration was $4.0x10^{-6}$ for adults and $8.8x10^{-6}$ for children. This would equate to four excess cancers in one million similarly exposed adults and nine excess cancers in one million similarly exposed children.

Likewise, the dermal exposure was evaluated for children ages 1-11, adolescents ages 12-17 and adults. The dermal exposure doses and calculated risks can be found in Table 2. Risk calculation formulas can be found at Appendix B.

Table 2: Dermal TCE Exposure Dose from Water and Calculated Cancer Risk, Alamo Municipal Water Clearwell

Age Group (years)	Dermal Exposure Dose (mg/kg/day)	Calculated Cancer Risk using a 10-year Exposure Duration
Children age 1-11	$1.7x10^{-6}$	$1.1x10^{-8}$
Adolescents age 12-17	$1.9x10^{-6}$	$6.1x10^{-10}$
Adults age 18-70	$1.7x10^{-6}$	$5.6x10^{-10}$

Exposure to water from individual wells or without treatment by the air stripper would be a potential concern. However, because the water is a mixture of the four municipal wells and has been treated with the air stripper since 1991, drinking municipal water will not cause harm to human health.

Discharge of Water from Well #1 to the Surface Drainage Ditch

Water from well #1 was discharged to a nearby drainage ditch for an unspecified period of time ending in July 1991 [EPA 2011c]. A newspaper article from the Crockett Times, believed to have been published in 1989, refers to dissipating the chemicals by mixing them with air as they are being discharged into the ditch. The drainage ditch is believed to have run between homes adjacent to the City of Alamo water treatment facility. It is not known if any incidental ingestion, dermal, or inhalation exposure may have occurred by children who may have been playing in the area.

Data Evaluation

It is not known to what extent the levels of chemicals in groundwater that discharged to the surface may have been lessened by mixing the water with air; therefore, the potential impact to human health cannot be determined.

Groundwater Investigations

Between November 1999 and September 2000, three separate groundwater investigations were conducted to try to identify the source of the ongoing groundwater contamination at the former Volunteer Circuits property. The third investigation was carried out off-site from the former Volunteer Circuits property. Various chemicals were found in the groundwater samples collected. The results are shown in Table 3 below. The groundwater samples were collected from borings drilled to depths of 42 to 64 feet below land surface (bls).

The levels of chemicals found in groundwater during these investigations were all above at least one of their respective EPA drinking water MCLs or ATSDR CREGs, RMEGs or EMEGs. Even though 1,2-DCA and carbon tetrachloride were not reported in the groundwater samples from these investigations, their detection limits were set at their EPA drinking water MCLs and exceeded the ATSDR CREGs.

Additional groundwater investigations were carried out in January 2004 and in May 2010.

In January 2004 VOCs were found in 3 temporary monitoring wells. The VOCs found and their levels include: 1,2-DCA at an estimated level of 13 ppb; 1,1-DCE at an maximum estimated level of 6 ppb; PCE, up to 240 ppb; and TCE at an estimated level of 4 ppb [EPA 2011a].

In May 2010, fourteen permanent monitoring wells were installed and sampled in the City of Alamo. Groundwater samples contained 1,2-DCA at 4.0 ppb and PCE at a maximum level of 1.2 ppb. [EPA 2011c].

Data Evaluation

Groundwater samples collected from the borings in 1999 and 2000 contained high concentrations of VOCs. Likewise, the highest concentration of PCE in the temporary monitoring

Table 3: Summary of Alamo Groundwater Monitoring Well Investigations Volatile Organic Compound Sample Results (ppb) 1999 – 2010

Source	Sample Date	trichloroethylene (TCE)	1,1-dichloro-ethylene (1,1-DCE)	1,1,1-trichloroethane (1,1,1-TCA)	tetra-chloroethylene (PCE)	1,2-dichloroethane (1,2-DCA)	carbon tetrachloride
ATSDR EMEG *		ngv	90 (chronic)	200,000 (int)	ngv	2,000 (int)	70 (int)
ATSDR EMEG **		ngv	320 (chronic)	700,000 (int)	ngv	7,000 (int)	250 (int)
EPA MCL		5	7	200	5	5	5
ATSDR CREG		0.76	ngv	ngv	17	0.38	0.5
ATSDR RMEG *		5	500	20,000	60	ngv	40
ATSDR RMEG **		18	1,800	70,000	210	ngv	140
Monitoring wells	November December 1999	**187**	233	231	<5	*<5*	Not Reported
	June 2000	**31**	159	125	**45**	*<5*	Not Reported
	September 2000	**6**	87	25	**98**	*<5*	*<5*
	January 2004	**4 (estimated)**	6	Not Reported	**240**	**13**	Not Reported
	May 2010	<0.5	<0.5	<0.5	1.2	**4**	0.05 (estimated)

EMEG=Environmental Media Evaluation Guidelines MCL=Maximum Contaminant Level
RMEG=Reference Dose Media Evaluation Guidelines CREG=Cancer Risk Evaluation Guidelines
Bold = concentration is greater than the ATSDR CREG Italics = Reporting Limit/Detection Limit is greater than the ATSDR CREG
ngv = No guidance value available ND = Concentrations below detection limit. Detection limit not specified int = Intermediate
* Child Drinking water CV (ATSDR August 2012) ** Adult Drinking water CV (ATSDR August 2012) ppb = parts per billion
Note: Results provided are the maximum values obtained during monitoring well sampling event.

wells sampled in 2004 was greater than the concentration allowable to achieve a hazard quotient that is less than or equal to 1. Further evaluation is needed to determine if there was a health concern for those who drank untreated water with these concentrations over a lifetime. However, there were no known municipal or private drinking water sources which would have delivered untreated water. No known drinking water sources other than the municipal wells were within a ½-mile radius of these samples. There are private wells outside the ½-mile radius that have not been sampled. In addition, groundwater occurred at depths equal to or greater than 42 feet, and it is not likely that direct contact would be made with this water.

Soil Investigation

In September 1992, the TDEC Division of Superfund collected eight soil samples from a former TCE drum storage area and a film developer equipment area where spent TCE had been dumped at the Volunteer Circuits property. Soil samples were collected at a depth of 6 to 7 feet. Although some VOCs were present in the soil samples, the concentrations were not above ATSDR soil comparison values.

Four of a total of ten soil samples taken as part of an investigation into the Volunteer Circuits site during November and December 1999 contained detectable concentrations of VOCs. The depths of these samples ranged from 5 to 25 feet bls. The VOCs identified included 1,1-DCE measured in concentrations up to 111 ppb at a depth of 20 feet; cis-1,2-DCE, measured at 14 ppb at a depth of 15 feet; PCE, measured at 6 ppb at a depth of 5 feet; 1,1,1-TCA, measured at concentrations of up to 174 ppb at a depth of 20 feet; and TCE which was measured at concentrations of up to 73 ppb at a depth of 25 feet [ATC 1999].

In January 2004, fourteen surface soil samples were collected between 0 and 6 inches below land surface at The Crockett Times, Volunteer Circuits, the city garage and near the Alamo municipal wells. No VOCs were detected in these surface soil samples [TDEC-DSF 2004].

In May 2010, a total of twenty soil samples were collected from the borings between 0 and 23 feet bls. No site-related VOCs were measured above detection limits in these borings. [EPA 2011c].

Table 4: Cancer and Non-Cancer Comparison Values for Soil
Alamo Contaminated Ground Water Site, Crockett County, Tennessee

	ATSDR Non-cancer Environmental Media Guide (EMEG)	ATSDR Cancer Risk Evaluation Guide (CREG)
ATSDR Soil Comparison Values (February 2012) [micrograms per kilogram (µg/kg) or parts per billion (ppb)]		
trichloroethylene (TCE)	ngv	15
1,1-dichloroethylene (1,1-DCE)	450.000 chronic EMEG for child	ngv
1,1,1-trichloroethane (1,1,1-TCA)	1,000,000,000 Intermediate EMEG for child	ngv
tetrachloroethylene (PCE)	ngv	330

1,2-dichloroethane (1,2-DCA)	10,00,000 (intermediate EMEG for child	8
dichloroethylene, 1,2-cis- (cis-1,2-DCE)	20.000,000 (intermediate) EMEG for child	ngv

Notes: ngv = No guidance value available

Data Evaluation

No VOCs were detected in surface soil samples collected in 2004 at The Crockett Times, Volunteer Circuits, the city garage and near the Alamo municipal wells. The only soil contamination found from VOCs was in subsurface soil samples collected in 1992 and 1999. Except for TCE, contaminant concentrations were well below ATSDR soil comparison values. (Table 4) Due to the depth of soil contamination, it is not expected that the general public would come into contact with soils containing these chemicals.

Soil-gas/Vapor Intrusion

Soil-gas samples collected in 1989 during a USGS investigation were collected at a depth of 3.5 feet below land surface (bls) and were analyzed for VOCs. Analyses by gas chromatography indicated the presence of TCE in soils about 230 feet east of well #1 in the area of the former location of Volunteer Circuits [USGS 1992]. Volunteer Circuits discontinued operation in, or around, 1975 [TDEC-DSF 1992]. TCE concentrations in the soil-gas of this area ranged from 0.2 to 30 µg/L. TCE was not detected in soil-gas near any of the municipal wells during this investigation.

While VOCs were present in soil in 1999, concentrations of VOCs in soil in 1999 cannot be directly correlated with soil-gas. Expanded soil vapor testing or indoor air testing in adjacent commercial buildings and homes surrounding the ACGW Site would provide an indication of the presence of any vapor intrusion issues.

Data Evaluation

There are no health comparison values to compare directly to soil-gas results. Soil-gas results can be used to evaluate the potential for indoor vapor intrusion into a building using EPA's J&E model. The potential for vapor intrusion from TCE in the former circuit board manufacturing facility and nearby buildings in 1989 was modeled using soil-gas data and the J&E model. The calculated risk estimated by using the J&E model with the highest recorded soil-gas concentration of 30 µg/L in 1989 was $3x10^{-3}$ or 2 excess cancers in 1,000 people exposed daily for 30 years.. There was a potential exposure to people working buildings, as well as people in residential settings. The J&E model was developed for use as a screening level model. The model requires that certain assumptions be made regarding contaminant distribution and occurrence, subsurface characteristics, transport mechanisms, and building construction. [EPA 2003] EEP used the highest recorded soil-gas concentration and a conservative time-frame for a

person living in a home to provide a worst case scenario for evaluation purposes. Indoor air sampling would allow us to evaluate the actual exposures.

The potential for vapor intrusion from PCE in the groundwater into indoor air using groundwater data from May 2010 was modeled using the J&E model. The greatest calculated risk estimated by the J&E model was $3x10^{-7}$ using the PCE concentration of 1.2 µg/L in well AG18. The model estimate indicates that there should not have been any cancer risk to citizens breathing the indoor air near the ACGW Site in 2010 due to vapor intrusion. Depth to groundwater is a factor used in calculating the potential for vapor intrusion in the J&E model. While the concentrations in groundwater were high, the low risk estimated by the model is likely reflective of the fact that groundwater occurs at depths greater than 35 feet.

PUBLIC HEALTH IMPLICATIONS

Concentrations of PCE, TCE and 1,2-DCA in the individual municipal and monitoring water wells near the ACGW Site since 1988 have been at levels that could have lead to a concern about the health of those people drinking the water, if consumed over a period of time. Water from the individual municipal wells was mixed in the Clearwell before being distributed to the public. The contaminant volatilization during mixing reduced the concentration of VOCs in the water. The concentration of TCE exceeded the ATSDR CREG during the months of August and September 1988. While, it is not known how long the municipal water wells were contaminated with VOCs and to what extent, a calculated cancer risk for ingestion of water was $2.01x10^{-6}$ for adults and $4.39x10^{-6}$ for children using the highest sampled concentration of TCE in the Clearwell and a conservative 10-year exposure duration. This would equate to two excess cancers in one million adults and four excess cancers in one million children. EPA's target cancer risk range is between 1 in 10,000 and 1 in 1 million people [EPA 1991]. Likewise, the dermal exposure was evaluated and found to be within this range. See Table 2.

While there are an estimated thirty-seven private wells within 2 miles of the ACGW Site, no known private water sources other than the Alamo municipal wells have been identified with in a ½-mile radius of the known groundwater contamination plume. An ordinance against drilling drinking water wells in the City of Alamo is now in place. The mixing of water from the four municipal wells and the implementation of treatment practices using an air stripper has reduced the concentrations of VOCs in finished water to levels that are either negligible or within an acceptable range to ensure that human health is not harmed.

Groundwater is present at depths equal to or greater than 35 feet, and it is not likely that direct contact would be made with this water. Therefore, the chemical concentrations do not present a concern for human health. Impact to human health through exposure to groundwater during the time when water from municipal well #1 was being discharged to the surface was possible but cannot be evaluated. The duration of such exposure was likely minimal. Minimal exposure would not lead to adverse health effects.

The calculated vapor intrusion risk was estimated by using the J&E model with the highest recorded soil-gas concentration, as measured in 1989. The calculated risk was $2x10^{-3}$ or approximately 2 excess cancers in 1,000 people in 1989. While this risk is not considered

acceptable, the evaluation was conducted using assumptions providing a worst case scenario. Additional soil-gas samples and/or indoor air samples would provide information needed to verify whether or not vapor intrusion is occurring in buildings and homes surrounding the ACGW Site.

The J&E model estimates from 2010 groundwater data indicate that there should not have been any cancer risk to citizens breathing the indoor air near the ACGW Site from groundwater vapor intrusion. Results of calculations using groundwater are likely reflective of the fact that groundwater data were limited to areas at depths greater than 35 feet. The soil-gas concentrations found in 1989 for which there was an unacceptable calculated risk had likely dissipated by 2004 when no VOCs were found in soils.

Chemical concentrations of VOCs in subsurface soil samples collected in 1992 and 1999 were below ATSDR comparison values. VOCs were not found in surface soil samples collected in 2004 or the 2010 subsurface soil investigation. Exposure through direct contact with subsurface soil is not a concern to human health unless soil is disturbed as during construction. Should the soil be disturbed in any of the investigated areas, further investigation would be needed to determine if any potential health effects exist. Exposure to surface soil near The Crockett Times, Volunteer Circuits, the city garage and near the Alamo municipal wells is not a concern to human health because no VOCs were measured in samples in 2004.

EEP's Involvement with the Community

A major goal of EEP's work is to encourage communication with the public throughout each phase of the public health assessment process. Community input helps EEP create public health documents that accurately reflect how people in this community may have come into contact with chemicals from the ACGW Site. Community feedback can also help EEP understand individual health concerns related to the ACGW Site. EEP's partnership with the community begins as site-related community health concerns are gathered and continues throughout the public comment period on public health assessment documents. Even upon completion of a public health assessment, members of the community may contact EEP to discuss any on-going concerns regarding the ACGW Site or to inquire about other site-related activities. The manner in which EEP invites the community to share their health concerns related to the ACGW Site and input on the public health assessment are discussed in the next section.

EEP's Process for Gathering Community Health Concerns

EEP carefully considers community members' health concerns as part of its public health assessment process. The issue of the contaminated groundwater in the City of Alamo is not new. The public has not shown concern over the need for treatment of the contaminated groundwater. EPA conducted a public meeting on March 15, 2011, prior to the listing of the ACGW Site as a Superfund Site, with limited attendance. No concerns were raised at this meeting. All indications are that Alamo residents are confident that the treatment being conducted by the City is sufficient to protect the water supply and their health. On June 28, 2011, EEP staff met with community leaders to discuss the public health assessment process

and to determine whether there were additional community concerns that needed to be addressed.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposures to hazardous substances. Children play outdoors and typically engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health. According to ATSDR, there is indication that TCE or PCE affects children differently than adults [ATSDR 1997a, 1997b].

EEP has determined that children are not likely to come in contact with chemicals at the ACGW Site at levels of health concern. The contaminated groundwater is at a depth that is not easily accessible. Unless there was exposure via a private water well, children would not be able to access the groundwater on their own. The water is treated such that the VOCs are taken out of the water before it is delivered to municipal water customers. Children should not be harmed by drinking the water from the City of Alamo's water system. EEP cannot determine whether children would be harmed by breathing indoor air in homes near municipal wells #1 and #2 and near the former Volunteer Circuits building without the recommended indoor air sampling. EEP also cannot determine whether children would have been harmed by dermal exposure or ingestion from playing in or near the drainage ditch to which water from well # 1was discharged between 1988 and 1991.

HEALTH OUTCOME DATA ANALYSIS

No health outcome data/information is available for the geographic area/population potentially exposed/impacted by this site.

CONCLUSIONS

EEP has reached four conclusions about the Superfund Site located in Alamo, Crockett County, Tennessee. EEP has also made recommendations for additional information needed to make public health conclusions that cannot be made at this time, based on the available information.

Conclusion 1

EEP concludes that drinking water supplied by the City of Alamo is not expected to harm people's health.

Recommendation 1

Data for finished drinking water being distributed to the public are limited and dated. Sampling frequency is once every three years. The most recent data provided to EEP are from February 2011. It is recommended that the City of Alamo increase the frequency of monitoring of finished water being provided to the public as long as the air stripper is necessary to treat the water.

Conclusion 2

EEP cannot conclude whether drinking water supplied by the City of Alamo before July 1988, could have harmed people's health.

Recommendation 2

None.

Conclusion 3

EEP cannot conclude whether site-related chemicals are present in groundwater that could harm the health of people who are using private wells.

Recommendation 3

Even though pumping the municipal wells likely draws the contamination to them, it is recommended that the EPA Superfund investigation include a study to determine potential impact to private wells closest to the ACGW Site be initiated as part of the Superfund investigative process.

Conclusion 4

Data suggests that there was a potential risk to citizens breathing indoor air in homes or businesses near the ACGW Site in 1989. EEP does not have data after 1989 to conclude whether or not that potential continued beyond 1989.

Recommendation 4

Additional soil-gas samples and/or indoor air samples would provide information needed to verify whether or not vapor intrusion is occurring in buildings and homes surrounding the ACGW Site. EEP recommends TDEC initiate soil-gas or indoor air sampling in areas near

municipal wells #1 and #2, as well as near the former Volunteer Circuits building to determine whether an inhalation exposure exists.

Conclusion 5

EEP cannot determine the potential impact to human health from discharging contaminated water to a drainage ditch from mid-1989 to mid-1991.

Recommendation 5

None

Conclusion 6

EEP concludes that exposure to surface soil near The Crockett Times, Volunteer Circuits, the city garage and near the Alamo municipal wells is not expected to harm people's health. In addition, exposure through direct contact with subsurface soil is not likely to take place. EEP cannot determine with certainty whether adverse health effects through exposure to subsurface soil exist without further investigation.

Recommendation 6

Should the subsurface soil be disturbed in any of the investigated areas, further investigation would be needed to determine if any potential health effects exist.

References

[ACS] American Cancer Society, 2012 Accessed online at: http://www.cancer.org/Cancer/CancerBasics/lifetime-probability-of-developing-or-dying-from-cancer. Last accessed February 6, 2012.

[ATC] ATC Associates, Inc. for Tennessee Department of Environment and Conservation, Division of Superfund. Report of Findings from Geoprobe Investigation. December 30, 1999.

[ATSDR] Agency for Toxic Substances and Disease Registry, 1997a. Toxicological profile for Trichloroethylene. Atlanta: U.S. Department of Health and Human Services. September 1997. Available from: www.atsdr.cdc.gov/toxprofiles/tp19. Last assessed December 6, 2011.

[ATSDR] Agency for Toxic Substances and Disease Registry, 1997b. Toxicological profile for Tetrachloroethylene. Atlanta: U.S. Department of Health and Human Services. September 1997. Available from: www.atsdr.cdc.gov/toxprofiles/tp18. Last assessed December 16, 2011.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2005. Public Health Assessment Guidance Manual (Update). Atlanta: U.S. Department of Health and Human Services. January 2005.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2012. Health comparison values. Atlanta: U.S. Department of Health and Human Services. February 2012.

[Census] U.S. Census Bureau, American Community Survey. 2009. Accessed online at: http://www.census.gov/acs/www/. Last accessed November 18, 2011.

[Census] U.S. Census Bureau, State & County Quickfacts. 2010. Accessed online at: http://quickfacts.census.gov/qfd/states/47/47033.html. Last accessed March 29, 2012.

[CCCC] Crockett County Chamber of Commerce. 2009. 2009 Crockett County Demographics. Accessed on-line at: http://www.crockettchamber.com/Economic-Development/demographics.html. Last accessed October 17, 2011.

[EPA] U.S. Environmental Protection Agency (EPA). 2011a. EPA on-line tools for site assessment calculation, Screening level implementation of the Johnson and Ettinger Vapor Intrusion Model with two variable/uncertain parameters (source depth, moisture content). Accessed on-line at: http://www.epa.gov/athens/learn2model/part-two/onsite/JnE_lite_forward.html. Last accessed December 7, 2011.

[EPA] U.S. Environmental Protection Agency. 1991. Role of the baseline risk assessment in superfund remedy selection determination. OSWER Directive 9355.0-30. Washington, D.C.

[EPA] U. S. Environmental Protection Agency (EPA). 2003. User's Guide For Evaluating Subsurface Vapor Intrusion Into Buildings. June 19, 2003.

[EPA] U. S. Environmental Protection Agency (EPA). 2011b. Glossary of Key Terms. Accessed on-line at: http://www.epa.gov/nata/gloss1.html. Last accessed November 18, 2011.

[EPA] U. S. Environmental Protection Agency (EPA). 2011c. Hazard Ranking System (HRS) Documentation Record. March 2011.

[EPA] U. S. Environmental Protection Agency (EPA). 2011d. National Primary Drinking Water Regulations. Accessed on-line at: http://water.epa.gov/drink/contaminants/. Last accessed November 18, 2011.

[ESE] Environmental Science and Engineering Corp. 1988. Letter to Tommy Greer, Mayor of Alamo. September 26 1988.

[TDEC-DOR] Tennessee Department of Environment and Conservation, Division of Remediation. 2010. Expanded Site Investigation Narrative Report (ESI). Alamo Contaminated Groundwater Plume Site. September 15, 2010.

[TDEC-DOR] Personal communication email from James Ron Sells, TDEC-DOR. 2012. July 9, 2012

[TDEC-DSF] Tennessee Department of Environment and Conservation, Division of Superfund. 1991. James Morrison memo to file. October 21, 1991.

[TDEC-DSF] Tennessee Department of Environment and Conservation, Division of Superfund. 1992. Potential hazardous Waste Site – Site Inspection Report – Volunteer Circuits Site. November 14, 1992.

[TDEC-DSF] Tennessee Department of Environment and Conservation, Division of Superfund. 2004. Crockett Times, Alamo, Crockett County, Tennessee – Site Inspection Report. April 9, 2004.

[TDEC-DWS] Tennessee Department of Environment and Conservation, Division of Water Supply. 2008. Letter to John Gorman, Operator, Alamo Water System. January 2008.

[TDEC-DWS] Tennessee Department of Environment and Conservation, Division of Water Supply. 2011b. Well Driller's Log database. March 2011.

[TDEC-DWS] Tennessee Department of Environment and Conservation, Division of Water Supply. 2011a. Alamo Water Treatment Plant Chemical Data. June 2011.

[TDHE] Tennessee Department of Health and Environment, Southwest Tennessee Regional Office. 1988a. Letter to the Honorable Tommy Green, Mayor of Alamo. July 21, 1988.

[TDHE] Tennessee Department of Health and Environment, Southwest Tennessee Regional Office. 1988b. Letter to the Honorable Tommy Green, Mayor of Alamo. September 12, 1988.

[TDHE-lab] Tennessee Department of Health and Environment, Environmental Laboratories, 1988. Lab Reports. July - September , 1988.

[TDOH] Tennessee Department of Health. 2011a. Trip Report. June 2011.

[TDOH] Tennessee Department of Health. 2011b. Tennessee Cancer Registry. September 2011.

[USGS] U. S. Geological Society for Tennessee Department of Health and Environment, Division of Superfund. 1992. Reconnaissance Investigation of Volatile and Semivolatile Organic Compounds in the Memphis Aquifer at Alamo, Crockett County, Tennessee.

Glossary and Acronyms

acute
Occurring over a short time [compare with chronic].

acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

adverse health effect
A change in body function or cell structure that might lead to disease or health problems.

cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

chronic
Occurring over a long time [compare with acute].

chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

dermal contact
Contact with (touching) the skin [see route of exposure]. For example, dermal absorption means passing through the skin.

detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration during laboratory analytical analysis.

dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed

dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

maximum contaminant level (MCL)
The maximum allowable concentration of some contaminants in surface or groundwater to be used in the drinking water supply under the Safe Drinking Water Act.

minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period

(acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

monitoring
Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

National Priorities List for uncontrolled hazardous waste sites (NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be smoke from a chimney or a substance moving with groundwater.

point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

ppb
parts per billion.

public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public Health Assessment (PHA)
A document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions needed to protect public health.

risk
The probability that something will cause injury or harm.

route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Superfund
[see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)

toxicology
The study of the harmful effects of substances on humans or animals.

volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as trichloroethylene, benzene, toluene, and methylene chloride.

REPORT PREPARATION

This Public Health Assessment for the Alamo Contaminated Ground Water Site was prepared by the Tennessee Environmental Epidemiology Program under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database, and the approving agency reviewers are listed below.

Author
Rebecca Gorham
Environmental Epidemiology Program (EEP)

Tennessee Department of Health (TDH)
Communicable and Environmental Disease Services (CEDS)
1st Floor Cordell Hull Building
425 5th Avenue North
Nashville TN 37243

State Reviewers
Ms. Bonnie S. Bashor, MS, former Director of Environmental Epidemiology Program
Mr. Joseph P. George, MS, PG, Environmental Health Assessor
Tennessee Department of Health

Mr. Rudy Collins, Regional Director for External Relations
Mr. Brian Caton, Environmental Field Office Manager
Mr. Bobby DePriest, Environmental Specialist
Tennessee Department of Environment and Conservation

ATSDR Reviewer

LCDR Trent LeCoultre, MSEH, REHS Division of Community Health Investigations, Central Branch

APPENDIX A - Pre-Treatment Sample Results 1988 - 2011 With Concentrations Above The Detection Limit

Sources: The Alamo Water Treatment Plant Data [TDEC-DWS 2011a], Tennessee Department of Health and Environment Environmental Laboratories [TDHE-lab 1988] and Environmental Science and Engineering Corp. [ESE 1988]

Contaminant	Alamo Municipal Well	Sample Date	Concentration (ppb)
1,1,1-trichloroethane	Well # 1	7/13/88	0.68
	Well # 2	7/13/88	0.32
	Well # 3	7/13/88	1.98
	Well # 1	8/15/88	18
	Well # 1	9/8/88	55.6
	Well # 2	9/8/88	0.81
	Well # 1	9/20/88	87.9
	Well # 2	9/20/88	3.8
	Well # 1	Sept. 1988	86.0
	Well # 1	10/6/88	64.4
	Well # 1	10/27/88	57.4
	Well # 2	10/27/88	4.6
	Well # 1	11/3/88	43.8
	Well # 1	11/19/1991	13.5
	Well # 1	2/11/1992	41.1
	Well # 1	4/15/1992	1.3
	Well # 1	7/15/1992	39.4
	Well # 1	11/4/1992	6.8
	Well # 1	2/2/1993	9.4
	Well # 1	5/10/1993	29
	Well # 1	8/16/1993	18
	Well # 1	11/2/1993	12
	Well # 1	8/10/1994	20
	Well # 1	11/30/1994	1.9
	Well # 2	1/18/1995	1.8
	Well # 1	1/18/1995	1.9
	Well # 1	2/22/1995	8.2
	Well # 1	9/5/1995	3.8
	Well # 1	5/21/1996	34
	Well # 1	8/5/1996	27
	Well # 1	10/10/1996	3.2
	Well # 1	2/25/1997	16
	Well # 1	5/5/1997	21
	Well # 1	8/13/1997	19
	Well # 1	11/6/1997	9.4
	Well # 1	2/11/1998	24
	Well # 1	4/13/1998	14
	Well # 1	8/10/1998	15
	Well # 1	10/26/1998	15
	Well # 2	8/8/2000	2.6
	Well # 1	8/8/2000	11

	Well # 1	3/29/2004	3.4
1,1-dichloroethylene	Well # 3	7/13/88	1.22
	Well # 1	8/15/88	12.2
	Well # 1	9/8/88	37.2
	Well # 2	9/8/88	2.09
	Well # 2	9/20/88	2.1
	Well # 1	Sept. 1988	52.2
	Well # 1	10/6/88	47.0
	Well # 1	10/27/88	41.4
	Well # 2	10/27/88	3.7
	Well # 1	11/3/88	24.7
	Well # 1	11/19/1991	12
	Well # 1	2/11/1992	54.4
	Well # 1	4/15/1992	1.8
	Well # 1	7/15/1992	90.4
	Well # 1	11/4/1992	8.4
	Well # 1	2/2/1993	13
	Well # 1	5/10/1993	47
	Well # 1	8/16/1993	32
	Well # 1	11/2/1993	22
	Well # 1	2/8/1994	40
	Well # 1	8/10/1994	40
	Well # 1	11/30/1994	3.5
	Well # 1	1/18/1995	4.5
	Well # 2	1/18/1995	6.2
	Well # 1	2/22/1995	29
	Well # 1	5/2/1995	14
	Well # 1	11/9/1995	45
	Well # 1	5/21/1996	75
	Well # 1	8/5/1996	47
	Well # 1	10/10/1996	7.5
	Well # 1	2/25/1997	31
	Well # 1	5/5/1997	35
	Well # 1	8/13/1997	39
	Well # 1	11/6/1997	17
	Well # 1	2/11/1998	37
	Well # 1	4/13/1998	23
	Well # 1	8/10/1998	29
	Well # 1	10/26/1998	19
	Well # 2	8/8/2000	7.6
	Well # 1	8/8/2000	27
	Well # 1	3/29/2004	12
carbon tetrachloride	Well # 1	8/15/88	0.72
	Well # 1	Sept. 1988	0.8
	Well # 1	10/27/88	0.9
	Well # 1	11/2/88	0.7
	Well # 1	5/10/1993	0.7
	Well # 1	11/2/1993	1.4
	Well # 1	5/21/1996	1.3

carbon tetrachloride (cont.)	Well # 1	5/5/1997	0.5
	Well # 1	2/11/1998	0.6
tetrachloroethylene	Well # 1	2/11/1992	0.6
	Well # 1	7/15/1992	0.7
	Well # 1	5/10/1993	1.1
	Well # 1	11/2/1993	1
	Well # 1	2/8/1994	1.2
	Well # 2	1/18/1995	1.6
	Well # 1	9/5/1995	0.6
	Well # 1	11/9/1995	1.2
	Well # 1	5/21/1996	1.3
	Well # 1	8/5/1996	1.6
	Well # 1	2/25/1997	1.4
	Well # 1	5/5/1997	1.8
	Well # 1	8/13/1997	1.1
	Well # 1	11/6/1997	0.7
	Well # 1	2/11/1998	1.4
	Well # 1	4/13/1998	0.9
	Well # 1	8/10/1998	0.8
	Well # 1	8/8/2000	1.4
	Well # 2	8/8/2000	15
	Well # 1	3/29/2004	5.3
trichloroethylene	Well # 1	7/13/88	0.75
	Well # 2	7/13/88	0.26
	Well # 3	7/13/88	1.93
	Well # 1	8/15/88	16.4
	Well # 1	9/8/88	63.1
	Well # 2	9/8/88	1.43
	Well # 3	9/8/88	1.17
	Well # 1	9/20/88	97.9
	Well # 2	9/20/88	3.3
	Well # 1	Sept. 1988	112.6
	Well # 1	10/6/88	72.6
	Well # 1	10/27/88	75.7
	Well # 2	10/27/88	5.1
	Well # 1	11/3/88	54.4
	Well # 1	11/19/1991	16.9
	Well # 1	2/11/1992	55.3
	Well # 1	4/15/1992	2.3
	Well # 1	7/15/1992	32.8
	Well # 1	11/4/1992	8.2
	Well # 1	2/2/1993	12
	Well # 1	5/10/1993	40
	Well # 1	8/16/1993	24
	Well # 1	11/2/1993	18
	Well # 1	2/8/1994	24
	Well # 1	5/31/1994	3.9
	Well # 1	8/10/1994	30
	Well # 1	11/30/1994	2.8

Trichloroethylene (cont.)	Well # 2	1/18/1995	2.7
	Well # 1	1/18/1995	2.9
	Well # 1	2/22/1995	13
	Well # 1	5/2/1995	9.4
	Well # 1	9/5/1995	4.6
	Well # 1	11/9/1995	28
	Well # 1	5/21/1996	55
	Well # 1	8/5/1996	29
	Well # 1	10/10/1996	7.5
	Well # 1	2/25/1997	20
	Well # 1	5/5/1997	27
	Well # 1	8/13/1997	23
	Well # 1	11/6/1997	13
	Well # 1	2/11/1998	28
	Well # 1	4/13/1998	18
	Well # 1	8/10/1998	20
	Well # 1	10/26/1998	22
	Well # 2	8/8/2000	2.8
	Well # 1	8/8/2000	12
	Well # 1	3/29/2004	4

APPENDIX B – Risk Calculation Formulas

Exposure doses from ingestion of water are calculated as follows:

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

Where:

D	= exposure dose (mg/kg/day)
C	= contaminant concentration (mg/L)
IR	= intake rate of contaminated water (L/day)
BW	= body weight (kg)

Default Drinking Water Intake Rates

2 L/day – adult
1 L/day – child
Note: L/day – liters per day

Doses from dermal contact with water are calculated as follows:

$$D = (C \times P \times SA \times ET \times CF) / BW$$

Where:

D	= dose (mg/kg/day)
C	= contaminant concentration (mg/L)
P	= permeability coefficient (cm/hr)
SA	= exposed body surface area (cm^2)
ET	= exposure time (hours/day)
CF	= conversion factor (1 L/1,000 cm^3)
BW	= body weight (kg) Source: EPA 1997

Default Dermal Exposure Values
50^{th} percentile total body surface area
(square centimeters [cm^2])

Age (years)	Male	Female
3 < 6	7,280	7,110
6 < 9	9,310	9,190
9 < 12	11,600	11,600
12 < 15	14,900	14,800
15 < 18	17,500	16,000
18 - 70	19,400	16,900

[ATSDR 2005]