Public Health Assessment

Public Comment Release

Public Health Implications of Exposures to Chlorinated Volatile Organic Compounds in Public Supply Wells

ORANGE VALLEY REGIONAL GROUNDWATER CONTAMINATION

ORANGE AND WEST ORANGE, ESSEX COUNTY, NEW JERSEY

EPA FACILITY ID: NJD002148799

Prepared by the
New Jersey Department of Health

SEPTEMBER 15, 2015

COMMENT PERIOD ENDS: OCTOBER 15, 2015

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.

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Summary

Introduction

On March 15, 2012, the United States Environmental Protection Agency (USEPA) proposed to add the Orange Valley Regional Ground Water Contamination site, Essex County, New Jersey, to the National Priorities List (NPL). On September 18, 2012, USEPA listed the site as final on the NPL. The New Jersey Department of Health (NJDOH), in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR), prepared the following public health assessment to review environmental data obtained from the site, to evaluate potential human exposure to contaminants, and to determine whether the exposures are of public health concern. The top priority of ATSDR and NJDOH is to ensure that the community around the site has the best information possible to safeguard its health

The site consists of a regional ground water contamination plume with no specific source identified. During the course of a site investigation in West Orange, the USEPA collected ground water samples from public water supply wells which provide drinking water to 33,000 people. The Orange Park and Gist Place municipal supply wells were found to contain tetrachloroethylene (PCE), trichloroethylene (TCE), and cis-1,2-dichloroethylene (cis-1,2-DCE), with PCE and TCE exceeding the drinking water standards. Orange Water department data for the period of January to June 2009 confirms the constant presence of the contaminants in the wells. A third public supply well, known as the Brook Alley well, exhibited similar contamination and is no longer in use. When all three wells were in use in the 1980s, they only contributed about 15 percent of the total blended water that was distributed to the public. The other wells in the Orange Water Department supply system are not known to be contaminated.

Conclusions

The NJDOH and ATSDR have reached two conclusions in this health assessment on the Orange Valley Regional Ground Water Contamination site:

Conclusion 1

NJDOH and ATSDR conclude that, from the 1987 to the present, drinking water from the public supply wells will not harm people's health.

Basis for Conclusion	The adjusted maximum level of TCE was used to calculate the exposure from the ingestion pathway. Based on the evaluation, non-cancer and cancer health effects are not expected. Treatment systems, consisting of aerator towers, were installed at the well heads for Gist Place and Orange Park wells in approximately 1991-1992 to remove volatile organic compounds. Ongoing sampling efforts confirm tetrachloroethylene (PCE) and trichloroethylene (TCE), levels are below federal drinking water standards and ATSDR health-based guidelines. Between 1988 and 1991, pumping data indicates that the Gist Place, Orange Park and Brook Alley wells were not used to provide water to Orange residents. Therefore the pathway is considered interrupted for this time period.
Next Steps	ATSDR recommends that monitoring and maintenance efforts continue to ensure that water supplied to residents meets federal drinking water standards for PCE, TCE, and cis-1,2-DCE.
Conclusion 2	*NJDOH and ATSDR conclude that from 1981 up to 1987, drinking water from the public supply wells did not harm people's health.*
Basis for Conclusion	There are limited data available (1985-87) from the three contaminated wells. Assuming the 1985-87 results are representative of previous years, we conclude that non-cancer and cancer health effects are not expected from the ingestion pathway. It should be noted that some TCE-associated adverse health effects have been documented after short-term exposures. There are no data available to address if this could be applicable in this community as estimates were made based on limited historical data assumed to be reflective of previous years prior to VOC treatment (1981-1984).
For More Information	Copies of this report will be provided to concerned residents in the vicinity of the site via the township libraries and the internet. NJDOH will notify area residents that this report is available for their review and provide a copy upon request. Questions about this health consultation should be directed to the NJDOH at (609) 826- 4984.

Statement of Issues

On March 15, 2012, the United States Environmental Protection Agency (USEPA) proposed to add the Orange Valley Regional Ground Water Contamination site, Essex County, New Jersey, to the National Priorities List (NPL). On September 18, 2012, USEPA listed the site as final on the NPL. Pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act (SARA) of 1986, the federal Agency for Toxic Substances and Disease Registry (ATSDR) is required to conduct public health assessment activities for sites listed or proposed to be added to the NPL. The New Jersey Department of Health (NJDOH), in cooperation with the ATSDR, prepared the following health consultation to review environmental data obtained from the site, evaluate potential human exposure to contaminants, and to determine whether the exposures are of public health concern.

The site consists of a regional ground water contamination plume with no specific source identified. In June 2009, during the course of a site investigation in West Orange, the USEPA collected ground water samples from public water supply wells which provide drinking water to 33,000 people. The Orange Park and Gist Place municipal supply wells were found to contain tetrachloroethylene (PCE), trichloroethylene (TCE) and cis-1,2-dichloroethylene (cis-1,2-DCE), with PCE and TCE exceeding the drinking water standards. Orange Water department data for the period of January to June 2009 confirms the presence of the contaminants in the wells. A third public supply well, known as the Brook Alley well, exhibited similar contamination and is no longer in use. When all three wells were in use in the 1980s, they only contributed about 15 percent of the total blended water that was distributed to the public. The other wells in the Orange Water Department supply system are not known to be contaminated, based on the available data.

Background

Site Description and Operational History

Figure 1: Location of Orange Valley Regional Ground Water Contamination

The Orange Valley Regional Ground Water Contamination site is located in the municipalities of Orange and West Orange in Essex County (see Figure 1). It includes two public-supply wells at Orange Park and Gist Place, which provide drinking water to 33,000 people. A third well (Brook Alley) between the two was previously closed due to contamination. The site consists of a "ground water plume," which is contaminated with various common commercial/industrial chemicals such tetrachloroethylene, trichloroethylene, and cis-1,2-dichloroethylene.

The volatile organic compounds were detected in

the Orange Park, Gist Place and Brook Lane wells in 1985 (NJDEP 1987; USEPA 2012). Brook Lane was shut down in 1988 due to the contamination. In 1991-1992, the Orange Water Department installed a water treatment system to remove the contaminants in the Orange Park and Gist Place wells. These two wells continue to remain active. The municipality of Orange's water supplier is presently United Water of New Jersey. The Orange Water Department supply system currently consists of six active wells including Gist Place and Orange Park.

Regulatory and Remedial History

During the course of investigating an industrial facility in West Orange, New Jersey in June-July 2009, USEPA collected untreated ground water samples from three public supply wells (Gist Place, Orange Park, and Well 6) within the Orange Water Department supply system (USEPA 2012). Well 6 was tested to serve as comparison for background contaminant levels. Analytical results indicated the presence of tetrachloroethylene (PCE), trichloroethylene (TCE), and cis-1,2-dichloroethylene (cis-1,2-DCE) in the Gist Place and Orange Park wells, at concentrations significantly above the background concentrations. Orange Water Department water data (untreated and treated water) for the period from January to June 2009 also confirmed the presence of the contaminants in the Gist Place and Orange Park wells (USEPA 2012). In addition, the former Brook Alley (also known as the Brook Lane) public supply well, which is located about midway between the Gist Place and Orange Park wells, is closed because volatile organic compound (VOCs) concentrations were higher than those found in the Gist Place and Orange Park wells. The detailed sampling results from these investigations are summarized in the Environmental Contamination section.

The USEPA site investigation identified some possible sources of contamination approximately one mile west of the contaminated wells, and review of available databases and state files identified several other possible sources of contamination in the vicinity of the wells (USEPA 2012). The USEPA is currently in the process of developing a remedial investigation work plan for the site.

Site Geology and Hydrogeology

The Gist Place and Orange Park wells withdraw water from the Brunswick aquifer. The Gist Place, Orange Park, and former Brook Alley wells are 500, 551, and 506 feet deep, respectively, and public supply wells in the study area range in depth from 40 to 551 feet (USEPA 2012). The Orange Water Department supply system, which currently serves approximately 33,000 people, consists of six active wells including Gist Place and Orange Park. The other wells (2, 3, 4, and 6) have not been found to be contaminated. In this blended system, all the residents may get at least some of their water from these wells (USEPA 2012). The water department treats the extracted ground water to remove VOC prior to distribution, and monitors the water quality and treatment system effectiveness regularly. The Orange Water Department closed the former Brook Alley public supply well in 1988. From the period 1981 through 1987, the Orange Water Department supply system consisted of eight wells: 2 (used only once in 1982), 3, 4, 5, 6,

7 (Orange Park), 8 (Gist Place) and 9 (Brook Alley). During that time, the latter three contaminated wells only contributed about 15% of the total blended and distributed water to the public, according to available well pumping data (NJDEP 2014). The Orange Park and Gist Place wells were not used from 1988-1991 prior to the installation of treatment system which consists of the use of air stripping towers that were installed in approximately 1991-1992. It also includes hypochlorination for organics removal and disinfection (USEPA 2012).

Prior ATSDR/NJDOH Involvement

There has not been any prior ATSDR/NJDOH involvement at this site.

Site Visit

No site visit was conducted as the site is groundwater contamination affecting public supply wells.

Community Concerns

No specific site-related health concerns have been raised by the community at this time.

Environmental Contamination

An evaluation of site-related environmental contamination consists of a two-tiered approach: 1) a screening analysis; and 2) a more in-depth analysis to determine public health implications of site-specific exposures (ATSDR 2005). First, maximum concentrations of detected substances are compared to media-specific comparison values (known as environmental guideline comparison values - CVs). If concentrations exceed the comparison values, these contaminants are selected for further evaluation. The second evaluation consists of the derivation of an Exposure Point Concentration (explained in detail in the following section) for each contaminant whose maximum value is elevated above the CVs. The Exposure Point Concentration (EPC) for a contaminant is subsequently compared to the CVs; if it is elevated above the CVs, the contaminant is classified as a contaminant of concern (COC).

Environmental Guideline Comparison

There are a number of CVs available for screening environmental contaminants to identify (COCs) (ATSDR 2005). These include ATSDR Environmental Media Evaluation Guides (EMEGs) and Reference Media Evaluation Guides (RMEGs). In the absence of an ATSDR CV, CVs from other sources may be used to evaluate contaminant levels in environmental media. These include New Jersey Maximum Contaminant Levels (NJMCLs) for drinking water, USEPA MCLs for drinking water and USEPA Regional Screening Levels (RSLs).

In July 2009, USEPA collected untreated ground water samples from the Gist Place well, Orange Park well and background untreated samples from Well 6 (USEPA 2012). PCE, TCE and cis-1,2-DCE were detected in the Gist Place and Orange Park wells as follows: PCE concentrations ranged from 8.9 – 37 micrograms per liter (µg/L); TCE ranged from 2.1 – 14 µg/L and cis-1,2-DCE ranged from ND – 2.5 µg/L (see Table 1). PCE concentrations in the background samples from Well 6 ranged from 0.86-0.95 micrograms per liter (µg/L). TCE and cis-1,2-DCE were not detected in the background samples. Orange Water Department (now United Water of New Jersey) regularly performs routine compliance monitoring of ground water quality in these two wells, usually twice a month. Water department data collected from January to June 2009 for untreated water samples also showed the presence of PCE, TCE and cis-1,2-DCE at the wells at similar concentrations (see Table 1).

Table 1: Contaminant levels in untreated water samples (Jan – June 2009)

	Gist Place well untreated concentration (µg/L)		**Orange Park well untreated concentration (µg/L)**	
Contaminant	**USEPA[1]**	**Orange Water[2] Department**	**USEPA**	**Orange Water Department**
PCE	36	25 – 37	12	8.9 - 13
TCE	11	9.6 – 14	2.8	2.1 – 3.2
cis-1,2-DCE	2.2	1.7 - 2.5	1.2	ND - 1.3

[1]one sample collected from each well; [2]samples collected on a bimonthly basis from January through June 2009; ND: Not Detected

Historically, there is limited data available to evaluate any contamination of the wells prior to 1993 before NJDEP started collecting data under the Safe Drinking Water Information System (NJDEP 1987). Table 2 details the results from raw and distributed samples available for three wells from 1985-1987. Distributed water data can be used to characterize water quality prior to pre-VOC treatment which was instituted later in the early 1990s.

Table 2: Historical Orange Water Department data from 1985-1987 (NJDEP 1987)

Date	**Gist Place (µg/L)**		**Orange Park (µg/L)**		**Brook Alley (µg/L)**	
	PCE	*TCE*	*PCE*	*TCE*	*PCE*	*TCE*
7/2/1985	**26**[1]	**13**	NA[3]	NA	**25**	NA
8/28/1985	33[2]	24	NA	NA	38	2.8
11/21/1985	37	15	NA	NA	32	NA
12/11/1985	**22**	**11**	**5**	**6**	NA	NA
1/23/1986	41	16	NA	NA	50	6
2/13/1986	**45**	**19**	**5**	**5.7**	**71**	NA
6/2/1986	**27**	**19**	**7**	**7**	**48**	**8**
7/29/1986	31.6	NA	NA	6.6	NA	NA
9/11/1986	NA	NA	3.24	3.87	NA	NA
12/12/1986	**19**	**14**	**3**	**3**	NA	**63**
3/30/1987	NA	NA	8	5	NA	NA
Maximum Concentration (µg/L)	45	24	8	7	71	63

[1]distributed water; [2]raw water; [3]NA: not available

In the period between 1988 and 1991, the three wells listed in above table were not used to provide water to Orange residents (NJDEP 2014). The Orange Water Department closed the former Brook Alley public supply well prior in 1988. In 1991, aeration towers were installed at both the Gist Place and Orange Park well heads to remove VOCs.

Table 3 lists the contaminants that were detected in the public supply wells from data obtained by the Orange Water Department for treated water samples. Data are available for these wells from 1993 to present (NJDEP 2014). Most of the results were non-detects (ND). There were two instances (in October 2004 and in January 2009) when PCE and TCE were detected in the Gist Place well above CVs. These detections were 19 µg/L and 9.7 µg/L for PCE in October 2004 and January 2009, respectively. TCE was detected at 11 µg/L and 2.2 µg/L on October 2004 and January 2009, respectively. There was one instance when TCE was elevated above the CV in the Orange Park well in 1999 (0.9 µg/L).

Table 3: Contaminant levels in treated water samples from Orange Water Department (1993-2014)

Contaminant	Comparison Value (µg/L)	Gist Place well			Orange Park well		
		Conc (µg/L)	No. of detects/No. of samples	No. of detects above CV[1]	Conc (µg/L)	No. of detects/No. of samples	No. of detects above CV
PCE	60 (RMEG[2]); 5 (MCL[4]); 17 (CREG[5])	ND[3] – 19	43/269	2	ND – 1.4	47/254	0
TCE	5 (EMEG[6]); 0.76 (CREG)	ND – 11	19/269	2	ND – 0.9	24/254	1
cis-1,2-DCE	20 (RMEG[2]); 70 (MCL)	ND – 2	3/269	0	ND - 0.8	40/254	0

[1]CV: Comparison value; [2] RMEG: ATSDR intermediate CV for a child; [3]ND: Non-detect; [4]MCL: Maximum Contaminant Level; [5]CREG: Cancer Risk Evaluation Guide; [6]EMEG: ATSDR chronic CV for a child

As previously mentioned, the maximum concentration levels of contaminants were compared to the CVs. If the concentrations were elevated over either comparison value, the contaminant was retained for further analysis and an EPC was derived. Results from Tables 2 and 3 indicate that maximum levels of PCE and TCE are elevated above the CV. It should be noted that almost all exceedances occurred in the years prior to 1987 and number of detections above the CV occurred very rarely after treatment systems were installed.

Exposure Point Concentration (EPC) Calculation

When assessing an exposure risk to a COC, the US EPA recommends the 95 percent upper confidence limit (95% UCL) of the arithmetic mean should be used to determine the exposure point concentrations (EPC) for site-related contaminants (USEPA 1989). An EPC is considered to be the concentration of a contaminant at the point of human exposure. The 95% UCL is considered a ‘conservative estimate’ of average contaminant concentrations in an environmental medium to represent the EPC. When five or more sample results were available the EPC was determined based on the 95% UCL and where less than five sample results were available the EPC was determined based on maximum COC concentrations detected.

For this site, the ProUCL® 5.0 software was used to estimate EPCs for PCE and TCE levels in the Gist Place and Orange Park wells from data collected from 1993 to present as there is sufficient number of samples for this analysis (USEPA 2013). The maximum concentration was used when evaluating the dataset from 1985-87 as there are limited data available for the ProUCL® analysis.

Furthermore, pumping data is available for all the wells in the Orange Water Department supply system from 1981 to the present time (NJDEP 2014). The amount that each well in the system was pumped proportionally across all wells (pumping proportion) will be used to adjust the EPC and the maximum concentrations to get a better estimate of

how much of the contaminated well supply was distributed to residents in Orange. The EPC will be adjusted using this pumping data as: 1) two of the contaminated wells were taken out of use prior to installation of the treatment system, and 2) Brook Alley was not in use after 1985 and was closed in 1988.

For the time period from 1981- 1987 (when the pumping data are available and when all three wells were being used), the mean pumping proportion was calculated to be 3%, 11% and 1.4% for Gist Place, Orange Park and Brook Alley wells, respectively. For the time period from 1993 to 2014, ProUCL® 5.0 was used to estimate the UCL of the mean pumping rate for the Gist Place and Orange Park wells (the Brook Alley well was closed in 1988) to provide a conservative estimate of the relative contribution of the two wells out of the six total wells in use. These were calculated to be 15% and 9.5%, respectively. Table 4 shows the adjusted EPC for PCE and TCE for the sampling time period from 1993 to 2014. The maximum concentration of each contaminant was also adjusted using the pumping rates for sampling time period 1985-87 and 1993-2014 as listed in the table below.

Table 4: Adjusted PCE and TCE concentrations detected in Orange Water Department wells for time periods: 1985-87 and 1993-14

Well	VOC[1]	CV[2]	1985 – 1987		1993-2014			
			Max[3]	Adjusted Max[4]	EPC[5]	Adjusted EPC[6]	Max	Adjusted Max
			µg/L					
Gist Place	PCE	PCE: 60 (RMEG[7]); 5 (MCL[8]) 17 (CREG[9]) TCE: 5 (EMEG[10]); 0.76 (CREG)	45	1.4[4]	0.70	0.11	19	2.9
	TCE		24	0.72	0.46	0.07	11	**1.7**
Orange Park	PCE		8	0.88	0.35	0.03	1.4	0.13
	TCE		7	0.77	0.29	0.03	0.86	0.08
Brook Alley	PCE		71	0.99	-[11]	-	-	-
	TCE		63	**0.89**[12]	-	-	-	-

[1]Volatile Organic Compounds; [2]CV: Comparison Value; [3]Max: maximum concentration; [4]Adjusted Max by relative well contribution: Max* pumping rate: 45*0.03 = 1.4; [5]EPC: Exposure Point Concentration; [6]Adjusted EPC: EPC*pumping rate; [7]RMEG: ATSDR intermediate CV for a child; [8]MCL: Maximum Contaminant Level; [9]CREG: Cancer Risk Evaluation Guide; [10]EMEG: ATSDR chronic CV for a child; [11]: results not available as well was closed in 1988; [12]**bolded** is concentration above the CV

The adjusted EPC for PCE and TCE are below CVs. The adjusted maximum concentration for TCE was above the CV for the Brook Alley well from 1985-1987 and for the Gist Place well in the 1993-2014 time period. The public health implications of exposures to TCE above the CV will be discussed in the following section.

Discussion

The method for assessing whether a health hazard exists to a community is to determine whether there is a completed exposure pathway from a contaminant source to a receptor population and whether exposures to contamination are high enough to be of

health concern. Site-specific exposure doses can be calculated and compared with health guideline CVs.

Assessment Methodology

An exposure pathway is a series of steps starting with the release of a contaminant in environmental media and ending at the interface with the human body. A completed exposure pathway consists of five elements:

1. source of contamination;
2. environmental media and transport mechanisms;
3. point of exposure;
4. route of exposure; and
5. receptor population.

Generally, the ATSDR considers three exposure categories: 1) completed exposure pathways, that is, all five elements of a pathway are present; 2) potential exposure pathways, that is, one or more of the elements may not be present, but information is insufficient to eliminate or exclude the element; and 3) eliminated exposure pathways, that is, a receptor population does not come into contact with contaminated media. Exposure pathways are used to evaluate specific ways in which people were, are, or will be exposed to environmental contamination in the past, present, and future.

Ingestion, Inhalation and Skin Absorption of TCE from Public Supply Wells (past)

VOC exposure could have occurred in several ways:

- Ingestion: People could have drunk the water or eaten food prepared using the water.
- Inhalation: People could have breathed in VOCs that volatilized (moved into the air) from well water during showering, bathing, or other household use.
- Dermal Exposure: People could have absorbed VOCs through their skin during showering, bathing, or other use.

Often, ingestion exposure is the most significant source of exposure to hazardous substances from a site. In the case of VOC contamination, however, inhalation and dermal exposures can make a significant contribution to the total exposure dose (that is, the total amount of contaminant that enters and can affect a person's body). A precise estimate of these non-ingestion exposures is seldom achievable. A common estimation is that non-ingestion exposures yield a contaminant dose comparable to the ingestion dose (ATSDR 2005). This estimation may underestimate exposures to people who may be exposed to TCE from shower water for periods of 30 minutes or more per day. For the purposes of this evaluation, ingestion exposure doses were doubled using measured water VOC concentrations and default assumptions for the amount of water consumed per day and other exposure parameters to account for additional exposure from inhalation and

dermal exposures.

To summarize, pumping data is available for wells in the Orange Water Department supply system from 1981 to the present time. The Orange Water Department closed the former Brook Alley public supply well in 1988. In the period between 1988 and 1991, the Gist Place and Orange Park wells were not used to provide water to Orange residents (NJDEP 2014). In 1991, aeration towers were installed at both the Gist Place and Orange Park well heads to remove VOCs.

For the past, there was an exposure pathway to TCE from contaminated public supply wells (Gist Place, Orange Park and Brook Alley) prior to 1991. There are limited data available (1985-87) from the three contaminated wells. In order to estimate past exposures, it is assumed that this data are reflective of previous years prior to VOC treatment.

Between 1988 and 1991, pumping data indicates that the Gist Place, Orange Park and Brook Alley were not used to provide water to the residents in Orange municipality. Therefore the pathway is considered interrupted for this time period.

Current and future ingestion, inhalation (via showering) and dermal (via bathing) exposures are considered interrupted since 1991 as treatment systems were installed at the Gist Place and Orange Park wells. The Brook Alley well was closed in 1988 and pumping data indicates that it was not used after 1984 (NJDEP 2014). It is noted that residents experienced some level of exposure to PCE and TCE from contaminated drinking water sometime between September 21 – October 21, 2004, and December 8 – January 13, 2009. Within these time frames, there were two samples that showed PCE and TCE levels above their respective comparison values (see Table 3). However, these levels are not considered representative of what residents would be exposed to on a daily basis. As a conservative measure, exposure doses were calculated based on adjusted maximum TCE concentration to address the issue of community exposure regardless of the sporadic nature of the elevation.

Public Health Implications of Completed Pathways

Health Guideline Comparison – Non-Cancer Health Effects

To assess non-cancer health effects, ATSDR has developed Minimal Risk Levels (MRLs) for contaminants that are commonly found at hazardous waste sites. An MRL is an estimate of the daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of adverse, non-cancer health effects. MRLs are developed for a route of exposure, i.e., ingestion or inhalation, over a specified time period, e.g., acute (less than 14 days); intermediate (15-364 days); and chronic (365 days or more). When MRLs for specific contaminants are unavailable, other health guidelines such as the USEPA's Reference Dose (RfD) are used. The RfD is an estimate of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of

exposure.

Health guidelines (MRLs and RfDs) are based largely on toxicological studies in animals and on reports of human occupational (workplace) exposures. They are usually extrapolated doses from observed effect levels in animal toxicological studies or occupational studies, and are adjusted by a series of uncertainty (or safety) factors or through the use of statistical models. In toxicological literature, observed effect levels include:

- no-observed-adverse-effect level (NOAEL); and
- lowest-observed-adverse-effect level (LOAEL).

A NOAEL is the highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals. LOAEL is the lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals. In order to provide additional perspective on these health effects, the calculated exposure doses were then compared to observed effect levels (e.g., NOAEL, LOAEL). As the exposure dose increases beyond the MRL to the level of the NOAEL and/or LOAEL, the likelihood of adverse health effects increases.

If the NOAEL or LOAEL is not available, the BMDL (benchmark dose level) or BMCL (benchmark concentration level) may also be used. The lower limit of the BMDL or BMCL is a characterization of the dose or concentration corresponding to a specified increase in the probability of a specified response. For example, a $BMDL_{10}$ or $BMCL_{10}$ is the lower confidence limit of the estimated dose corresponding to an increase of 10 percent in the probability of the specified response relative to the probability of that same response at dose zero.

Ingestion of TCE in Public Supply Wells (past)

Past exposures are based on ingestion of public supply well water contaminated with TCE that have been adjusted with pumping rates for each contaminated well. Doses were calculated for the EPC as well as the maximum concentration detected for TCE in each well for two time periods: exposures up to 1987 and from 1993 to 2014. Past exposures were delineated across these time periods as treatment systems were installed in 1991 and pumping data indicates that the contaminated wells were not in use from 1988-1991.

Non-cancer exposure doses were calculated using the following formula:

$$\text{Exposure Dose (mg/kg/day)} = \frac{C \; x \; IR}{BW}$$

where

mg/kg/day = milligrams of contaminant per kilogram of body weight per day;
C = concentration of contaminant in groundwater (µg/L);
IR = groundwater ingestion rate (L/day);
BW = body weight (kg)

For the purposes of this evaluation, ingestion exposure doses were doubled using measured water VOC concentrations and default assumptions for the amount of water consumed per day and other exposure parameters to account for additional exposure from inhalation and dermal exposures.

Table 5 provides the site-specific exposure assumptions (USEPA 2011a) that were used to calculate past contaminant doses to area residents. The age-specific water ingestion rates are based on the 95th percentile. The following child assumptions were selected to represent the most highly-exposed group for children.

Table 5. Site-Specific Exposure Assumptions

Exposed Population	Body Weight (kg)	Ingestion Rate (Liter/day)	Exposure Assumptions
Child (0-1 year old)	7.8[1]	1.1[1]	365 days per year
Adult	80[1]	3.1[1]	

[1]USEPA (2011a)

As an example, the calculation of the child dose exposure follows. Multiplying by a factor of 2 to account for additional exposure from breathing in TCE from water and getting it on skin during bathing, the daily dose of TCE in milligrams TCE per kg of body weight per day (mg/kg/day) is estimated as:

$$2 \times \frac{0.87 \frac{\mu g}{L} \times 1.1 \frac{L}{day} \times \frac{1 mg}{1000 \mu g}}{7.8 \, kg} = 0.00025 \frac{mg}{kg - day}$$

Table 6 presents calculated doses for children and adults for the adjusted maximum TCE levels detected in Gist Place and Brook Alley wells. The TCE exposure doses calculated for children and adults for the Brook Alley and Gist Place wells did not exceed the health guideline, ATSDR MRL/USEPA RfD, and therefore, non-cancer health effects are not expected.

Table 6: Comparison of Calculated Exposure Doses with Non-Cancer Health Guideline

Well	Adjusted Max TCE (µg/L)	Exposure Dose (mg/kg-day)		Health Guideline[3] (mg/kg-day)	Potential for Non-cancer Effects
		Child[1]	Adult[2]		
Brook Alley	0.87	0.0003	0.00007	0.0005 (MRL/RfD)	No
Gist Place	1.7	0.0005	0.0001		No

[1]Child ingestion exposure assumptions: exposure 0-1 years old; 1.1 liter/day; 7.8 kg body weight. Dose was multiplied by two to account for inhalation and dermal exposures; [2]Adult ingestion exposure assumptions: 3.1 liter/day; 80 kg body weight. Dose was multiplied by two to account for inhalation and dermal exposures; [3]ATSDR Minimal Risk Level (MRL)/USEPA Reference Dose (RfD)

ATSDR adopted the USEPA RfD as its chronic oral MRL in January 2013 (ATSDR 2013). NJDOH compared the estimated exposure doses with effect levels from available studies. USEPA based its RfD on three principal toxicological studies.

- Johnson showed increased rates of heart defects in newborn rats born to mothers who were exposed to TCE in drinking water during gestation (Johnson et al., 2003). USEPA applied Physiologically Based Pharmacokinetic (PBPK) models of TCE metabolism in rats and humans to the study results to obtain a 99th percentile human equivalent dose (HED_{99}) of 0.0051 mg/kg/day. At 0.0051 mg/kg/day ingested TCE, a 1% response rate is expected for fetal heart malformations in humans (USEPA 2011b).

- A study in female adult mice showed immune system effects (decreased thymus weight) after exposure to TCE in a thirty week drinking water study (Keil et al., 2009). USEPA converted the study findings to obtain a HED_{99} of 0.048 mg/kg/day.

- A study in mice exposed during gestation and following birth to TCE in drinking water showed problems with immune system development (Peden-Adams et al., 2006). USEPA used the lowest study effect level of 0.37 mg/kg/day as a point of departure.

One additional study was also cited as supporting the RfD:

- NTP (1988) showed kidney effects (toxic nephropathy) in female rats exposed to TCE by gavage for two years. USEPA obtained a HED_{99} of 0.0034 mg/kg/day for lifetime continuous exposure.

NJDOH compared the above HED_{99} doses with the estimated doses for adults and children to evaluate the potential for adverse health effects resulting from past exposure:

Using the 95th percentile water ingestion rate, the exposure doses calculated for all

of the age groups are below the HED_{99} of 0.0051 mg/kg/day for cardiac birth defects. None of the age groups exceed the HED_{99} of 0.048 mg/kg/day for immune system effects such as decreased weight of the thymus gland) using the 95th percentile water ingestion rate, and none of the estimated doses approach the effect level of 0.37 mg/kg/day for effects on the developing immune system. Using the 95th percentile water ingestion rate, none of the age groups exceed the HED_{99} of 0.0034 mg/kg/day for kidney effects.

Therefore, based on the adjusted maximum TCE detected in groundwater from the Brook Alley and Gist Place wells, non-cancer adverse health effects to individuals supplied with potable water from this well are not expected to have occurred in the past. It should be noted that some TCE-associated adverse health effects have been documented after short-term exposures. For example, fetal cardiac malformations have been shown to occur in rats after only 3 weeks of exposure at a level that would be equivalent to humans ingesting a dose of 0.005 mg/kg/day (Johnson et al., 2003). Although there is some uncertainty associated with the limited TCE data collected at the potential point of exposure (at the tap), short-term exposures to TCE during pregnancy are not expected to result in cardiac effects using the available historical data and well pumping estimates..

Health Guideline Comparison – Cancer Health Effects

The site-specific lifetime excess cancer risk (LECR) indicates the cancer potential of contaminants. LECR estimates are usually expressed in terms of excess cancer cases in an exposed population in addition to the background rate of cancer. For perspective, the lifetime risk of being diagnosed with cancer in the United States is 44 per 100 individuals for males, and 38 per 100 for females; the lifetime risk of being diagnosed with any of several common types of cancer ranges between approximately 1 in 6 and 1 in 100 (ACS 2014). Typically, health guideline CVs developed for carcinogens are based on one excess cancer case per 1,000,000 exposed individuals. The NJDOH considers estimated cancer risks of less than one additional cancer case among one million persons exposed as insignificant or no increased risk (expressed exponentially as 10^{-6}).

Following USEPA Guidelines for Carcinogen Risk Assessment, TCE is characterized as “carcinogenic to humans” by all routes of exposure (USEPA 2011b).

Ingestion of TCE in Public Supply Wells

The risk of cancer from ingestion, inhalation and skin absorption of TCE from domestic potable wells in the past was calculated using the following formula:

$$\textit{Cancer Exposure Dose (mg/kg/day)} = \frac{C \times IR \times ED}{BW \times AT}$$

where C = concentration of contaminant in groundwater (µg/L);
IR = groundwater ingestion rate (L/day);
ED = exposure duration representing the site-specific exposure scenario (years);
BW = body weight (kg); and
AT = averaging time (years).

$$LECR = CED \times CSF$$

where *CED* = cancer exposure dose (mg/kg/day); and
CSF = cancer slope factor $(mg/kg/day)^{-1}$

The LECR for adults was calculated by multiplying the cancer exposure dose by the cancer slope factor (CSF). The CSF is defined as the slope of the dose-response curve obtained from animal and/or human cancer studies and is expressed as the inverse of the daily exposure dose, i.e., $(mg/kg/day)^{-1}$.

The USEPA recently concluded, by a weight of evidence evaluation, that TCE is carcinogenic by a mutagenic mode of action for induction of kidney tumors (USEPA 2011b). As a result, increased early-life susceptibility is assumed for kidney cancer, and age-dependent adjustment factors (ADAFs) should be used for the kidney cancer component of the total cancer risk when estimating age-specific cancer risks. ADAFs are factors by which cancer risk is multiplied to account for increased susceptibility to mutagenic compounds early in life – standard ADAFs are 10 (for ages below 2 years old), 3 (for ages 2 up to 16 years old), and 1 (for ages greater than 16).

Based on the USEPA Exposure Factors and site-specific conditions, the following assumptions were used to calculate the exposure doses and the corresponding LECRs (see Table 7) (USEPA 2011a). An exposure duration of 13 years was selected for the Brook Alley well as this well was constructed in 1971 and was no longer in use after 1984. For the Gist Place well, an exposure duration of 33 years per USEPA default assumption about average residence times (USEPA 2011a).

Table 7. Assumptions Used to Calculate Exposure Doses and LECRs

Exposed Population	Intake Rate (liter/kg/day)	Exposure Assumptions	Number of Years Exposed
Child (birth through 6 years old)	0.049 to 0.235[1]	365 days per year	13 for Brook Alley; 33 for Gist Place
Adult	0.032[1]		

[1]USEPA 2011a

For a given period of exposure, the component oral cancer slope factor is multiplied by the daily exposure dose, appropriate ADAF, and a fraction corresponding to the fraction of a 78-year lifetime under consideration, to obtain the increased risk of cancer as shown below in Table 8.

Table 8: Calculated Lifetime Excess Cancer Risk (LECR) associated with TCE exposures in Public Supply wells

Well	Adjusted Max TCE (µg/L)	Lifetime Excess Cancer Risk
Brook Alley	0.87	0.000001 or 1×10^{-6}
Gist Place	1.7	0.000004 or 4×10^{-6}

Using the USEPA ADAF adjustments to the oral cancer slope factor of 0.046 $(mg/kg/day)^{-1}$ and assuming people were exposed to adjusted maximum TCE for either 13 or 33 years, the predicted increased theoretical cancer risk is approximately one in 1,000,000 and four in 1,000,000 for Brook Alley and Gist Place wells, respectively (see Table 8). The cancer risk is classified as no apparent increase to people who may have been exposed when compared to the excess background risk of all or specific cancers in both wells.

Health Outcome Data

Health outcome data can give a more thorough evaluation of the public health implications of a given exposure. Health outcome data can include mortality information (e.g., the number of people dying from a certain disease) or morbidity information (e.g., the number of people in an area getting a certain disease or illness). The review is most effective when (1) a completed human exposure pathway exists, (2) potential contaminant exposures are high enough to result in measurable health effects, (3) enough people are affected for the health effect to be measured, and (4) a database is available to identify rates of diseases plausibly associated with the exposure for populations of concern.

A review of health outcome data was not performed for this site at this time. People are not currently being exposed to contaminants because treatment systems are in place for the well heads that had VOC contamination. Although potential exposures in

the past prior to 1985 (when data were available) could have occurred, we do not have specific information about how long the contamination was present for each residence or the actual exposure levels at each residence. At the present time, NJDOH and ATSDR are not planning to review health outcome data. This is because a statistical evaluation of available health data for a relatively small potentially exposed population is unlikely to produce interpretable results.

Conclusions

The Orange Water Department supply system, which currently serves approximately 33,000 people in the Orange municipality, consists of six active wells. After discovering the presence volatile organic compounds such as PCE, TCE and cis-1,2-DCE in the public well supply system in 1985, the Orange Water Department installed treatment systems at the two of the impacted well heads to remove the contaminants and provide the community with safe drinking water. The Brook Alley well was taken out of service in 1988 to protect the public from the contamination. From the period 1981 through 1987, the Gist Place, Orange Park and Brook Alley wells only contributed about 15% of the total blended and distributed water to the public, according to available well pumping data. Furthermore, these three wells were not used from 1988-1991 prior to the installation of treatment system. The other wells in the Orange Water Department supply system are not known to be contaminated. Water from these wells is regularly monitored to ensure that the treatment system is effective and that people's health continues to be protected.

Based on the results of evaluation of the USEPA and NJDEP sampling results, NJDOH and ATSDR reached the following conclusions:

NJDOH and ATSDR conclude that based on the assumption that the pumping proportion and VOC levels from 1985-87 are reflective of previous years (1981-1984), drinking water from the public supply wells did not harm people's health for the time period from 1981 up to 1987. Exposure doses based on the adjusted maximum TCE concentration indicate that non-cancer and cancer health effects are not expected from the ingestion pathway.

NJDOH and ATSDR conclude that, from the 1987 to the present, drinking water from the public supply wells will not harm people's health. The adjusted maximum level of TCE was used to calculate the exposure doses from the ingestion pathway. Based on the evaluation, non-cancer and cancer health effects are not expected. Treatment systems, consisting of aerator towers, were installed at the well heads for Gist Place and Orange Park wells in approximately 1991-1992 to remove volatiles. Ongoing sampling efforts confirm tetrachloroethylene (PCE), and trichloroethylene (TCE) levels are below federal drinking water standards and ATSDR health-based guidelines.

Recommendations

Continue monitoring for volatile organic compounds in public supply wells to ensure that the water provided to residents is safe per the federal Safe Drinking Water Act regulation.

Public Health Action Plan

The purpose of a Public Health Action Plan is to ensure that this Public Health Assessment not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of the ATSDR and the NJDOH to follow-up on this plan to ensure that it is implemented. The public health actions to be implemented by the ATSDR and NJDOH are as follows:

Public Health Actions Taken

The ATSDR and NJDOH reviewed information and relevant data to evaluate the potential health implications for volatile organic compounds in drinking water for affected residents served by the Orange Water Department (now United Water of New Jersey).

Public Health Actions Planned

1. Copies of this public health assessment will be made available to concerned residents in the vicinity of the site in the township libraries and on the Internet.

2. In cooperation with the USEPA, public meetings can be scheduled, if needed, to discuss the findings of this report and to determine and address any additional community concerns.

3. The NJDOH and the ATSDR will continue to review data as it is made available.

4. The NJDOH will make available to residents any materials on site-related contaminants and provide assistance concerning the findings of this report.

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REPORT PREPARATION

This Public Health Assessment for the Orange Valley Groundwater Contamination Site was prepared by the New Jersey Department of Health 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.

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