Health Consultation

Evaluating Post-Filter Residential Water Samples Near

BAGHURST DRIVE NATIONAL PRIORITIES LIST SITE
UPPER SALFORD TOWNSHIP
HARLEYSVILLE, MONTGOMERY COUNTY, PENNSYLVANIA

EPA FACILITY ID: PAN000306939

Prepared by:
Pennsylvania Department of Health

MARCH 8, 2016

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

Health Consultation: A Note of Explanation

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

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or 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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Foreword

The Pennsylvania Department of Health (PADOH) evaluates the public health threat of hazardous waste sites through a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR) in Atlanta, Georgia. This health consultation is part of an ongoing effort to evaluate health effects associated with contaminated residential well water from Baghurst Drive site located within the northwestern portion of Upper Salford Township, Montgomery County Pennsylvania. The PADOH evaluates site-related public health issues through the following processes:

- **Evaluating exposure:** PADOH and ATSDR begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is, and how human exposures might occur. The Pennsylvania Department of Environmental Protection (PADEP) provided the information for this assessment.
- **Evaluating health effects:** If PADOH finds evidence that exposures to hazardous substances are occurring or might occur, PADOH and ATSDR will determine whether those exposures could be harmful to human health. PADOH focuses this report on public health; that is, the health impact on the community as a whole, and bases it on existing scientific information.
- **Developing recommendations:** In this report, the PADOH outlines, its conclusions about any potential health threat posed by using contaminated water during showering, and offers recommendations for reducing or eliminating the exposure. The role of the PADOH is primarily advisory. For that reason, the evaluation report will typically recommend actions for other agencies, including the US Environmental Protection Agency (EPA) and the PADEP. If, however, an immediate health threat exists or is imminent, PADOH will issue a public health advisory warning people of the danger and will work to resolve the problem.
- **Soliciting community input:** The evaluation process is interactive. The PADOH starts by soliciting and evaluating information from various government agencies, individuals or organizations responsible for cleaning up the site, and those living in communities near the site. PADOH shares conclusions about the site with the groups and organizations providing the information.

If you have questions or comments about this report, please contact us.

Mailing address:

Division of Environmental Health Epidemiology

Bureau of Epidemiology Pennsylvania Department of Health

Health and Welfare Building, Room 933, Harrisburg, PA 17108

Telephone: 717-787-1708

Fax: 717-772-6975

Summary

Introduction

At the request of the Montgomery County Health Department (MCHD) and the Pennsylvania Department of Environmental Protection (PADEP), the Pennsylvania Department of Health (PADOH), under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), evaluated environmental data on the post-filter residential water samples. In 1999, the MCHD discovered a groundwater contaminant plume when they sampled residential wells in the area. The site has contaminated 17 residential drinking water wells, including a common well that serves 11 residences. The source of contamination is not fully determined. The EPA listed the Baghurst Drive site on the National Priorities List (NPL) in 2014 and is currently providing bottled water to affected residences for drinking and cooking, as well as maintaining carbon filtration systems.

The purpose of this health consultation is to review post-filtered water sample data, including 1,4-dioxane, to determine whether the action taken by PADEP is protective of the health of the residents near the Baghurst Drive site who use contaminated well water for showering and bathing. Ingestion is not currently a completed exposure pathway because bottled water is provided for drinking and cooking, thus we did not evaluate the possible health risks from drinking the filtered water.

PADOH and ATSDR's top priority at this site is to ensure that nearby residents have the best information to safeguard their health.

Conclusion

PADOH and ATSDR reviewed site conditions and environmental data provided by PADEP for the Baghurst Drive site and conclude that using the post-filtered water for showering and bathing is safe for adults and children.

Basis for Conclusion

The highest concentrations of all chemicals detected in post-filtered water samples except for 1,4-dioxane, were either below the ATSDR health comparison values, or near the PADEP residential groundwater medium-specific concentration. Using a shower model and

incorporating multiple conservative assumptions, including the use of the highest concentration of 1,4-dioxane, we estimated the inhalation exposure while showering or bathing. The estimated exposure concentration is below the ATSDR health comparison values; therefore, noncancer health effects are unlikely to occur. The estimated cancer risk ranged from $6x10^{-5}$ to $7x10^{-6}$, which is considered low.

Limitations

Several limitations in our analysis include: 1) The exposure concentration of 1,4-dioxane in the shower room does not account for exhaust ventilation, water temperature, or multiple showers; 2) The highest concentration detected once in 10 years was used in our calculation; 3) Conservative shower times ranging from 30 minutes to 50 minutes were used in the cancer and noncancer risk calculations. Many of these factors may tend to overestimate the calculated cancer risks.

Next Steps

The PADOH and ATSDR recommend:

1. EPA continue to provide clean drinking water and carbon filtration maintenance to all affected residents.
2. Residents continue to use the supplied bottled water for drinking and cooking until the permanent remedy is in place.
3. MCHD not permit new private drinking water wells within the contaminated area.
4. EPA consider connecting residences to the municipal water supply to eliminate the need and maintenance of the carbon filtration systems and to prevent potential high exposures to chemicals caused by occasional breakthrough in the filtration systems.

Statement of Issues

At the request of Montgomery County Health Department (MCHD), the Pennsylvania Department of Health (PADOH) and Agency for Toxic Substances and Disease Registry (ATSDR) prepared this health consultation document for the Baghurst Drive site located in Upper Salford Township, Montgomery County. In 1999, MCHD discovered the contaminated groundwater plume when they sampled residential wells in the area. The source of the groundwater contamination is unknown. The Baghurst Drive site has 17 contaminated residential drinking water wells, including a common well that serves 11 residences (EPA 2015). Twenty-seven (27) residences have been affected by the site.

The groundwater plume is approximately 2,500 feet long and 750 feet wide and is contaminated with the following compounds: 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene (1,1-DCE), trichloroethylene (TCE), vinyl chloride (VC), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), dichloromethane (DCM), and 1,4-dioxane. 1,1,1-TCA, 1,1-DCE, TCE, VC, 1,2-DCA, and DCM were detected above EPA's Maximum Contaminant Levels (MCLs) in at least one residential well. At this time, no EPA MCLs exist for 1,1-DCA or 1,4-dioxane.

At the request of MCHD, in 1999 the PADEP immediately began supplying 27 residences with bottled water for drinking and cooking. PADEP equipped the residential wells with carbon filtration systems, so that the home owners could use the water for showering, washing clothes, etc**.** Recently, EPA has taken over responsibility for providing the bottled water and maintaining the carbon filtration systems. Since 1999, PADEP has been collecting water samples from residential homes that have carbon filtration systems to monitor contaminant concentrations and filter performance. In 2004, PADEP detected 1,4-dioxane in post carbon filtration water samples. Other volatile organic compounds (VOCs) were detected occasionally at low concentrations. PADEP concluded that the carbon filtration systems were not effective for removal of 1,4-dioxane. The PADEP referred the Baghurst Drive site to EPA to provide an alternate solution and reduce further exposure to these chemicals originating from the groundwater plume. The Baghurst Drive site was added to the NPL on September 22, 2014.

The purpose of this health consultation is to review post-filtered water sample data, including 1,4-dioxane, to determine whether the action taken by PADEP is protective of the health of the residents near the Baghurst Drive site who use contaminated well water for showering and bathing.

Background

Site Description and History

The Baghurst Drive site is located in a rural, residential area in Harleysville, Montgomery County (Figure 1) in Southeastern Pennsylvania about 35 miles northwest of Philadelphia. Much of the surrounding land was and continues to be used for agricultural purposes with a furniture refinisher, post office, and township municipal building located just to the south and downgradient of the site. The Baghurst Drive site (Figure 2) consists of 34 acres adjacent to the Perkiomen Creek in Upper Salford Township, Montgomery County, PA. In 1999, a homeowner submitted a water sample to the MCHD per county regulations to receive a permit for a residential drinking water well. Analytical results of the water sample indicated concentrations of 1,1,1-TCA above the EPA's MCL of 200 micrograms per liter (µg/L). The resident was required to install a filter before being granted permission to use the new well. To identify the source of the contamination, PADEP conducted an investigation, but was unable to produce definitive documentation about the source. From December 1999 to January 2000, PADEP collected samples from several residential drinking water wells in the area and found the wells contained one or more VOCs with maximum concentrations such as 1,1-DCA (131 ppb), 1,1-DCE (2,560 ppb), 1,1,1-TCA (4,770 ppb), TCE (25 ppb), DCM (220 ppb), and 1,2-DCA (7 ppb). The concentrations were above health comparison values in one or more wells (see Appendix A Table 1). Based on these high levels of VOCs detected, PADEP immediately began supplying residences with bottled drinking water for drinking and cooking purposes, and PADEP subsequently equipped the homes with carbon filtration water systems. PADEP advised the resident to avoid using the raw/unfiltered water for all purposes, including showering and bathing.

Since 2000, PADEP has been collecting water samples from residential homes that have carbon filtration water systems to monitor contaminant concentrations and filtered performance. In 2004, PADEP started testing for 1,4-dioxane. 1,4-Dioxane was detected in post-filtered water samples. Because of its high water solubility, 1,4-dioxane is not removed by the carbon filtration systems installed on the affected residential wells. The carbon filtration systems have been effectively removing the other site-related VOCs from the residential well water but not 1,4-dioxane. The residences are not connected to an alternate water supply. Affected residences continue to receive bottled water, now from EPA, for drinking and food preparation. Because 1,4-dioxane continues to be present in post-filtered water, MCHD and PADEP requested PADOH and ATSDR to evaluate exposure to 1,4-dioxane particularly during showering and bathing.

Discussion

Site Environmental Data

The pre-filtered sample analysis at 17 locations with carbon filtration systems initially showed the presence of seven chemicals, including 1,1-DCA, 1,1-DCE, 1,1,1-TCA, TCE, DCM, 1,4-dioxane, and 1,2-DCA at varying concentrations (Appendix A, Table 1). Beginning in 2004, 1,4-dioxane was detected in both pre and post-filtered water samples. The highest concentration of 1,4-dioxane (195 ppb) was detected in one post-filtered sample at location 1920H. Over the 10- year period (2004 – 2014), 1,4-dioxane was detected only three times (195, 128, and 15 ppb) at this location. The next highest concentration of 1,4-dioxane (154 ppb) was detected at location 1886H. Over the 10-year period, 1,4-dioxane was detected five times at this location (95, 154, 61, 145 and 2.5 ppb) (Appendix A, Table 2).

Table 1: Range of Volatile Organic Compounds detected in Baghurst Drive residential well post-filtered water samples from July 2004 to June 2014.

Residential Well ID	Contaminants in ppb							
	1,1-DCA		1,1-DCE		1,1,1-TCA		1,4-Dioxane	
	Conc. Range	Year detected	Conc. Range	Year detected	Conc. Range	Year detected	Conc. Range	No. of Years detected
CW	ND		ND		ND		ND–18	10
1746B	ND		ND		ND		ND–31	4
1760B	ND–4	2013	ND–2	2013	ND-43	2013	ND–92	8
1767B	ND		ND		ND		ND–53	8
1768B	ND		ND		ND		ND–85	3
1775B	ND		ND		ND		ND–62	8
1780B	ND		ND		ND		ND–24	8
1791B	ND		ND		ND		ND-96	3
1800B	ND		ND		ND		ND–59	7
1810B	ND		ND		ND–2	2014	ND–65	7
1747H	ND–2	2012	ND–2	2012	ND–4	2012	ND–48	6
1787H	ND		ND		ND		ND–46	7
1836H	ND–4	2008	ND–2	2008	ND–31	2008	ND–95	5
1858H	ND		ND		ND		ND–81	5
1886H	ND–32	2012	ND–67	2012	ND–84	2012	ND–154	5
1898H	ND		ND		ND		ND–28	4
1920H	ND		ND		ND		ND–195	3

1,1-DCA = 1,1 dichloroethane, 1,1 DCE = 1,1-dichloroethene, 1,1,1 TCA = 1,1,1-trichloroethane, CW = Common Well which is either 1737H or 1745H, B = Baghurst Drive, H = Hendricks Road, Conc. Range = Concentration Range. ND = Non-detect, TCE and DCM were undetected in post-filtered data, ppb = parts per billion

Exposure Pathway

To determine whether residents are, have been, or are likely to be exposed to contaminants associated with the site, PADOH evaluates the environmental and human components that could lead to human exposure. An exposure pathway is the way chemicals may enter a person's body. An exposure pathway includes the following five elements (ATSDR, 2005):

1. A contaminant source;
2. An environmental medium (or media) and transport mechanisms;
3. A point of exposure;
4. A route of exposure; and
5. A receptor population.

Exposure pathways are categorized as completed, potential, or eliminated. A completed exposure pathway is one in which all five elements are present. In a potential exposure pathway, at least one of the pathways elements is uncertain, indicating that exposure to a contaminant could have occurred in the past, may be occurring, or could occur in the future. A pathway is eliminated when one or more elements are missing and are unlikely to be present (ATSDR, 2005).

For this site, the source of contamination has not been identified. Bottled water is provided for drinking and cooking, so ingestion of post-filtered water is not evaluated in this assessment. Current exposures during showering or bathing are expected to occur by inhalation and dermal contact from chemicals present in post-filtered water. However, exposure to 1,4-dioxane via dermal contact during showering is not significant because the dermal absorption is very low (ATSDR, 2012).

Evaluation

PADOH and ATSDR compared the levels of chemicals detected in post-filtered water sampling results to available health based comparison values (CVs). Health-based CVs were used to select chemicals that should be evaluated further for their potential to cause adverse health effects. For example, if a chemical was detected at a level above the CV, it would be considered a chemical of health concern. PADOH used the following CVs in this health evaluation.

- ATSDR's child/adult Chronic Environmental Media Evaluation Guide (EMEG)
- USEPA's Maximum Contaminant level (MCL)
- ATSDR Cancer Risk Evaluation Guide (CREG)
- Reference Dose Media Evaluation Guide (RMEGs)
- PADEP's Medium Specific Concentration (MSC)

The post-filtered water is only used for showering and bathing. Potential exposure can occur when VOCs are released from water inside the home during showering and bathing. To be health protective, the highest concentration in the post-filtered water sample was used to estimate shower exposures. Only 1,4-dioxane was found consistently in the post-filtered water samples over the years, but other VOCs were also detected occasionally at low concentrations. Estimated adjusted maximum airborne concentrations during showering were compared with ATSDR screening values.

Because all the affected homes were equipped with carbon filtration systems, exposure to most chemicals by inhalation from showering has been minimized. The analysis of post-filtered samples frequently showed the presence of 1,4-dioxane above ATSDR's drinking water comparison value (Table 2). Other chemicals such as 1,1-DCA (32 ppb max. conc.), 1,2-DCE (67 ppb max. conc.), 1,1,1-TCA (84 ppb max. conc.) were detected once over a 10-year period in few residential wells (Table 1). However, the highest detected concentrations of 1,1-DCE and 1,1,1-TCA were below the ATSDR health comparison values (Table 2). ATSDR does not have a comparison value for 1,1-DCA so the PADEP's residential groundwater medium-specific concentration of 31 ppb was used.

Table 2: Maximum post-filtered water sample concentrations and respective health guideline screening values

Chemical	Maximum Water Concentration (ppb)	Health guideline screening value (ppb) / Source
1,1-DCA	32	31 / PADEP
1,1-DCE	67	90 / ATSDR Child chronic EMEG
1,1,1-TCA	84	20,000 / ATSDR Child RMEG
1,4-Dioxane	195	0.35 / ATSDR CREG

1,1-DCA = 1,1 dichloroethane, 1,1 DCE = 1,1-dichloroethene, 1,1,1 TCA = 1,1,1-trichloroethane, ATSDR = Agency for Toxic Substances and Disease Registry EMEG = ATSDR Environmental Media Evaluation Guide**;** RMEG = Reference Media Evaluation Guide**;** CREG = Cancer Risk Evaluation Guide; PADEP= Pennsylvania Department of Environmental Protection's residential groundwater medium-specific concentrations, ppb = parts per billion.

PADOH determined that no further evaluation of 1,1-DCA is needed for the following reasons: 1) it was detected only once (32 ppb) over a 10-year sampling period, at a concentration slightly above PADEP's residential groundwater medium-specific concentration of 31 ppb; 2) the affected resident at location 1886H does not use the well water for drinking but only for showering, and 3) toxicity of this chemical is very low (both acute and chronic) based on the review of literature (ATSDR, 2013).

The exposure pathway was considered complete for inhalation of 1,4-dioxane when the post-filtered water is used for showering or bathing.

Inhalation

Studies have demonstrated that people can be exposed to VOCs in contaminated water while showering or bathing (McKone, 1989; Lindstrom et al., 1996; Kerger et al., 2000). The VOCs are volatilized from the water droplets which can then be inhaled. Complex models are available to calculate the transfer of chemicals from water into the air during a shower; however, site specific measurements are important to gather all the data needed to do the calculation. These data are currently unavailable. We used an alternative model to estimate the maximum contaminant concentration in the bathroom air during showering. The maximum concentration of 1,4-dioxane in the shower room can be estimated by using one-compartment modeling. This concentration of contaminants is calculated using Andelman's equation (Andelman, 1990) as shown in Appendix B. Some of the limitations of this method are that it does not take into account for exhaust ventilation, water temperature, or multiple showers. As such, this method may over- or underestimate the actual concentrations.

The maximum concentration in post-filtered water samples was used to calculate the average shower air concentration for 1,4-dioxane in the bathroom during and immediately after the shower (as shown in Appendix B). The calculated average shower air concentrations for 1,4-dioxane in the bathroom were adjusted to a 24-hour average concentration for further evaluation.

Public Health Implications

Evaluation of 1,4-Dioxane

An overview and toxicity of 1,4-dioxane are discussed in Appendix C. During the sampling period, 1,4-dioxane was detected at least once in all of the 17 post-filtered water samples. Of all the post-filtered water samples tested, the samples from well 1920H and 1886H had the highest concentrations of 195 ppb in 2008 and 154 ppb in 2007, respectively, as shown in Appendix A, Table 2. Inhalation exposure during one shower and immediately afterward during a post-shower bathroom stay was estimated using the highest concentration (195 ppb).

Health Effects Evaluation

We estimated cancer risks and noncancer hazard quotients due to inhalation of 1,4-dioxane from showering based on the calculated exposure concentrations (see Table 3 below).

Table 3: Estimated lifetime excess cancer risk and noncancer hazard quotient associated with potential inhalation of 1,4-dioxane during a shower using Baghurst Drive site well (1920H) water (maximum 1,4-dioxane water concentration of 195 ppb) in Harleysville, Montgomery County, PA.

Receptor Population	Age group duration (year)	Duration adjusted (Age group duration/78)	Average Bathroom air Concentration* $C_{air\ max}$ ($\mu g/m^3$)	C_{air} 24-hour air Concentration† ($\mu g/m^3$) (EC)	Cancer Risk‡ (IURxECxDuration adjusted)	Hazard Quotient (HQ) §
1 to <2 yr	1	0.01	156	82	$5x10^{-6}$	0.7
2 to <6 yr	4	0.05	156	64	$2x10^{-5}$	0.6
6 to <11 yr	5	0.06	234	34	$1x10^{-5}$	0.3
Total Cancer Risk for Children age group 1 to <11yr for 10 yrs of exposure					$3x10^{-5}$	
11 to 16 yr	5	0.06	234	45	$1x10^{-5}$	0.4
16 to < 21 yr	5	0.06	234	21	$7x10^{-6}$	0.2
Total Cancer Risk for Children age group 11 to <21yr for 10 yrs of exposure					$2x10^{-5}$	
Total Cancer Risk for age 1 to 21 year for 20 years of exposure					$5x10^{-5}$	
21 to <65 yr	33¶	0.42	234	28	$6x10^{-5}$	0.3
65 -78	13¶	0.16	156	26	$2x10^{-5}$	0.2

*Ninety-fifth percentile air concentration calculated using Andelman's model (Andelman, 1990) as shown in Appendix B.
†Ninety-fifth percentile adjusted for 24-hour air concentration calculated representing estimated exposure concentration from both showering and the time in the bathroom after the shower bathroom times and breathing rate as shown in Appendix B.
‡Cancer risk calculated using EPA's inhalation unit risk (IUR) for 1,4-dioxane of 5E-06 $(\mu g/m^3)^{-1}$.
§Hazard quotient calculated using ATSDR's chronic minimum risk level for 1,4-dioxane of 110 ($\mu g/m^3$).
¶Used 95th percentile residency occupancy period of 33 years.ppb = parts per billion

Cancer Evaluation

The International Agency for Research on Cancer (IARC) has determined that 1,4-dioxane is possibly carcinogenic to humans. The Department of Health and Human Services has stated that 1,4-dioxane is reasonably anticipated to be a human carcinogen based on sufficient evidence of carcinogenicity in experimental animals. The EPA has established that 1,4-dioxane is likely to be carcinogenic to humans based on inadequate evidence of carcinogenicity in humans and sufficient evidence in animals. The estimated cancer risks are calculated using EPA's inhalation unit risk (IUR) for 1,4-dioxane of $5x10^{-6}$ $(\mu g/m^3)^{-1}$. The estimated cancer risks among different age groups ranged from $6x10^{-5}$ to $7x10^{-6}$ (i.e., 6 in 100,000 to 7 in 1,000,000) at location 1920H where the maximum concentration of 195 ppb was detected. The estimated cancer risk is low and may be overestimated (see factors affecting risk calculation noted below in *Limitations* section).

Exposure to 1,4-dioxane via dermal contact during showering and bathing is not expected to contribute to the risk because dermal absorption is very low (ATSDR, 2012). PADOH did not estimate the cancer risk by dermal contact.

Noncancer Health Effects Evaluation

PADOH evaluated the potential for noncancerous adverse health effects that may result from exposure to 1,4-dioxane using ATSDR's MRLs. This is referred to as a Hazard Quotient (HQ). The higher the air concentration (above MRL), the greater the chance for noncancerous health effects. If the HQ is less than 1.0, noncancerous harmful effects are unlikely to occur. If a HQ exceeds 1.0 the 24-hour average concentrations are then compared to levels in the scientific literature that cause health effects in laboratory animals and human epidemiological studies. The calculated inhalation exposure concentration (82 $\mu g/m^3$) was below ATSDR's acute inhalation MRL (7,200 $\mu g/m^3$) and chronic inhalation MRL (110 $\mu g/m^3$). As shown in Table 3, the HQ's are below 1.0, indicating noncancerous health effects are unlikely to occur based on the estimated maximum exposure concentration to 1,4-dioxane at the Baghurst Drive site.

Child Health Considerations

PADOH and ATSDR recognize that children are especially sensitive and at a greater risk than adults from exposure to hazardous substances. In communities faced with air, water, and soil contamination, the physical differences between children and adults require special consideration. Children are smaller which may result in higher doses of chemical exposure per body weight. If exposures to toxic substances occur during critical growth stages, the developing body systems of children can sustain irreversible damage. Children are dependent on adults for access to housing, medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions about their children's health. Child specific exposure situations and health effects are taken into account in PADOH health effect evaluations.

Children can be exposed to 1,4-dioxane during bathing or while in the bathroom during showering. The estimated cancer risk for children of different age groups ranged from $2x10^{-5}$ to$7.2x10^{-6}$, with total cancer risk for children with exposure for 20 years (from 1 to 21 years old) estimated to be 5×10^{-5} (i.e., 1 in 100,000). Thus, exposure to 1,4-dioxane during showering poses no apparent increased cancer risk for children at Baghurst Drive residential site. Because the HQs are less than 1.0 for children, noncancerous health effects are unlikely to occur.

Conclusions

PADOH and ATSDR reviewed site conditions and environmental data provided by PADEP for the Baghurst Drive site and conclude:

All chemicals detected in the post-filtered water samples, including 1,4-dioxane are not expected to harm the health of residents who use the water for showering and bathing. The basis for this conclusion is that the highest concentrations of all chemicals detected in post-filtered water samples except for 1,4-dioxane, were either below the ATSDR health comparison values, or near the PADEP residential groundwater medium-specific concentrations and also of low toxicity. Using a shower model and incorporating multiple conservative assumptions, including the use of the highest concentration of 1,4-dioxane, we estimated the inhalation exposure while showering or bathing. The estimated exposure concentration is below the ATSDR health comparison values; therefore, noncancer health effects are unlikely to occur. The estimated cancer risk ranged from $6x10^{-5}$ to $7x10^{-6}$ (i.e., 6 in 100,000 to7 in 1,000,000) which is considered low.

Limitations

Some of the limitations in our conclusions are as follows: 1) the calculated maximum inhalation exposure concentration of 1,4-dioxane in the shower room does not account for exhaust ventilation, water temperature, or multiple showers. As such it may over- or underestimate actual exposure concentrations; 2) the highest concentration (not the mean concentration) detected once in 10 years in one post-filtered sample (location 1920H-Appendix A Table 2) out of 17 post-filtered samples was used in our calculation. This does not reflect that the whole community was exposed to such high concentration of 1,4-dioxane. Also, based on discussion with PADEP, we learned that if there was a high concentration detected in any post-filtered water samples by breakthrough in the filtered systems in any locations, then those locations were tested more frequently (every 3 to 6 months) and filters were replaced as needed. Therefore, exposure to 1,4-dioxane would not have taken place for the a whole year at that high concentration; and, 3) conservative shower times ranging from 30 minutes (adults) to 50 minutes (children 1–6 years old) were used in the cancer and noncancer risk calculations. Many of these factors may tend to overestimate the calculated cancer risks.

Recommendations

PADOH and ATSDR make the following recommendations:

1. EPA continue to provide clean drinking water and carbon filtration maintenance to all affected residents.
2. Residents continue to use the supplied bottled water for drinking and cooking until the permanent remedy is in place.
3. MCHD not permit new private drinking water wells within the contaminated area.
4. EPA consider connecting residences to the municipal water supply to eliminate the need and maintenance of the carbon filtration systems and to prevent potential high exposures to chemicals caused by occasional breakthrough in the filtration systems.

Public Health Action Plan

The purpose of the Public Health Action is to ensure that this public health consultation provides a plan of action designed to mitigate or prevent potential adverse health effects.

A. Public Health Actions Completed

- PADOH and ATSDR have evaluated site information, analytical water quality data, and health effects information to determine the potential for health of the local residents to be adversely affected by chemicals detected in the residential well water at the site.

- A draft copy of the PADOH's health consultation was made available to EPA, PADEP, and MCHD prior to final publication through ATSDR

B. Public Health Actions Planned

- Public availability session will be held to discuss any community concerns about the site.

- The final health consultation will be available on the ATSDR and PADOH websites.

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Report Preparation

This public health consultation for the Baghurst Drive site, prepared by the PADOH and ATSDR, complies with the approved agency methods, policies, and procedures existing at the date of the 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.

Author

Sasidevi Arunachalam, MSPH, Epidemiology Program Specialist
Health Assessment Program
Bureau of Epidemiology, Division of Environmental Health Epidemiology
Pennsylvania Department of Health

Farhad Ahmed, MBBS, MPH, Principle Investigator,
Health Assessment Program
Bureau of Epidemiology, Division of Environmental Health Epidemiology
Pennsylvania Department of Health

Technical Project Officer

Eva D. McLanahan, Ph.D., REHS/RS
CDR, US Public Health Service
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry
Centers for Disease Control and Prevention

ATSDR Regional Representative

Robert H. Helverson
Region 3 Representative
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry
Centers for Disease Control and Prevention

Figures

Figure 1: Site Location

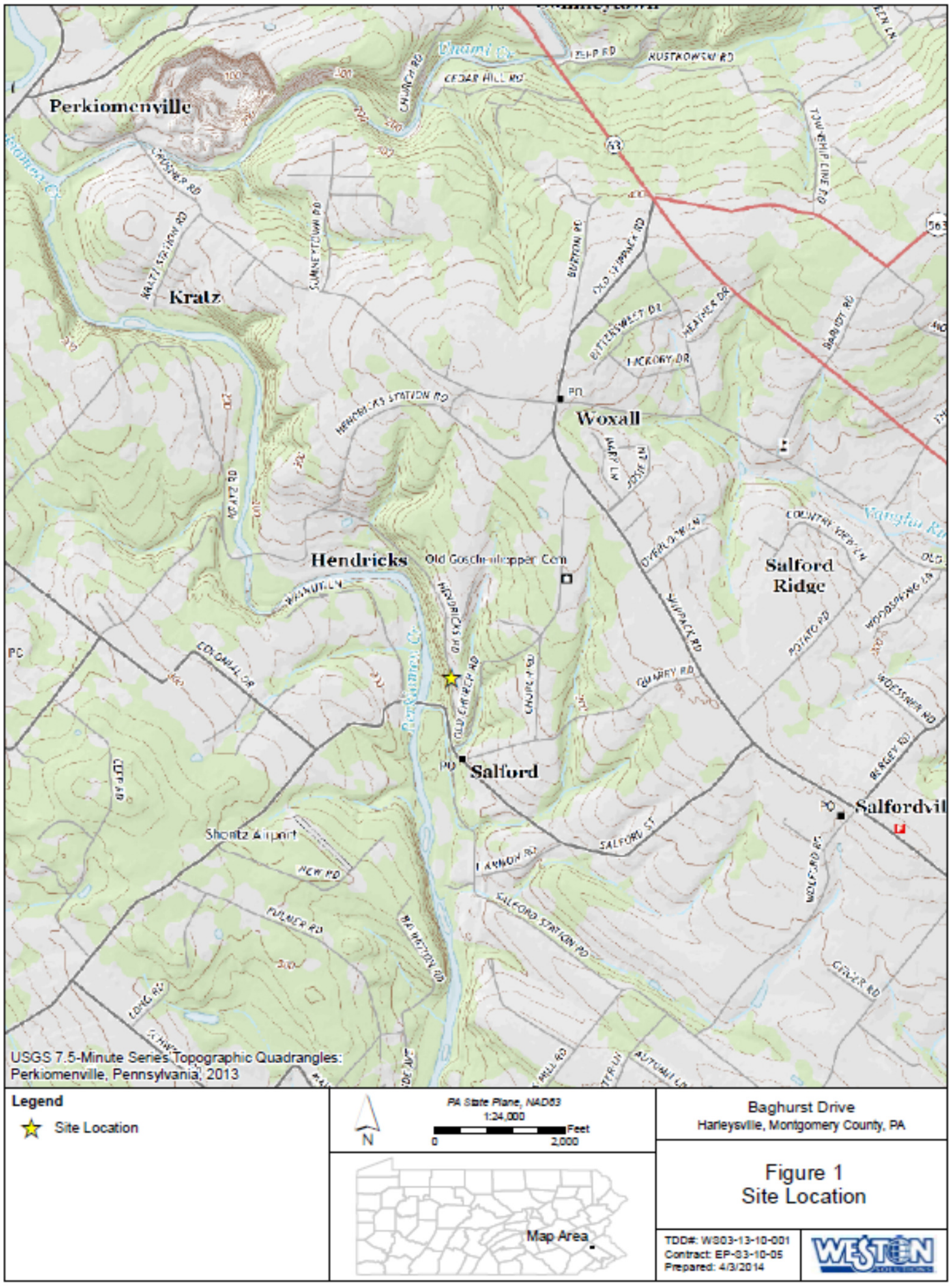

Figure 2: Site Layout

Appendix A:
Raw/Pre-Filtered Data

Table A.1: Range of VOCs detected in Baghurst Drive residential well raw/pre-filtered water samples from December 1999 to June 2014 (in ppb).

Residential Well ID	Contaminants in ppb						
	1,1 DCA	1,1 DCE	1,1,1 TCA	TCE	DCM	1,2 DCA	1,4-dioxane*
CW	ND–5	ND-71	ND–160	ND–3	ND–5	ND	ND–11
1746B	ND–15	62–445	ND–1001	ND–3	ND–24	ND	14–31
1760B	ND–20	101–500	460–1100	ND–3	ND–6	ND	ND–68
1767B	ND–16	93–549	229–1153	ND–3	ND–24	ND	14–45
1768B	ND–27	180–919	482–1900	ND–5	ND–6	ND–6	23–69
1775B	ND–15	85–514	222–2221	ND–4	ND–21	ND	ND–51
1780B	ND–1	ND–57	2–146	ND	ND	ND	ND–8
1791B	ND–26	153–780	272–1936	ND–5	ND–18	ND	23–67
1800B	ND–19	2–299	4–681	ND–3	ND–16	ND	ND–30
1810B	12–23	11–655	27–1600	ND–4	ND–17	ND	ND–62
1747H	5–13	81–350	136–700	ND–4	ND–1	ND–1	11–126
1787H	ND–28	67–280	137–730	ND–2	ND–8	ND	ND–29
1836H	ND–26	127–514	528–1208	ND–4	ND–15	ND	20–71
1858H	ND–20	27–514	62–780	ND–3	ND	ND	ND–48
1886H	ND–63	275–1123	600–1850	10–14	ND–220	ND	48–140
1898H	ND–63	ND–1474	134–2300	ND–25	ND–15	ND–7	ND–72
1920H	44–131	650–2560	1000–4770	12–25	ND–210	ND	ND–175

* data from 2004–2014; ND = Not Detected; Vinyl Chloride was detected only two times with a value of 0.285ppb and 1.0 ppb at 1920H in 2005 and 2009. CW is Common Well, which is either 1737H or 1745H; ppb = parts per billion; 1,1-DCA = 1,1 dichloroethane; 1,1 DCE = 1,1-dichloroethene; 1,1,1 TCA = 1,1,1-trichloroethane; TCE = Trichloroethene; DCM = dichloromethane; 1,2 DCA = 1,2-dichloroethane.

Pre/Post-filtered data with 1,4-dioxane

Table A.2: 1,4-Dioxane detected in Baghurst Drive residential well pre/post-filtered water samples from July 2004 to June 2014 (in ppb).

Residential well ID	Pre/Post	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CW	Pre	9	7	6	8	ND	6	11	6	6	4	6
	Post	ND	5	18	12	ND	8	12	6	3	7	6
1746B	Pre	14	19	NS	NS	NS	NS	26	30	15	13	16
	Post	NS	18	NS	NS	NS	NS	NS	31	20	ND	7
1760B	Pre	24	41	34	68	29	22	54	20	16	16	17
	Post	32	15	55	ND	ND	31	92	30	28	4	ND
1767B	Pre	33	24	38	14	ND	19	45	30	19	17	15
	Post	49	53	37	ND	ND	33	44	30	29	18	ND
1768B	Pre	50	38	45	39	NS	ND	69	NS	28	25	24
	Post	ND	ND	ND	ND	NS	ND	85	ND	45	12	ND
1775B	Pre	21	29	27	47	27	18	51	30	20	15	11
	Post	33	31	31	ND	ND	46	62	30	27	ND	5
1780B	Pre	4	6	ND	5	ND	2	8	ND	3	ND	ND
	Post	5	8	24	ND	8	4	8	ND	3	ND	4
1791B	Pre	37	32	NS	ND	ND	NS	67	NS	NS	NS	23
	Post	50	55	NS	ND	ND	NS	96	NS	NS	NS	ND
1800B	Pre	ND	30	ND	ND	ND	3	13	6	3	4	4
	Post	ND	59	ND	ND	ND	0.8	5	6	9	6	7
1810B	Pre	37	37	29	ND	ND	24	62	32	26	23	21
	Post	65	62	34	ND	ND	51	ND	43	3	ND	3
1747H	Pre	NS	21	27	10	20	20	35	30	16	11	13
	Post	NS	ND	35	27	ND	ND	42	30	4	ND	5
1787H	Pre	12	NS	29	18	NS	29	29	16	15	11	11
	Post	20	NS	18	23	NS	ND	46	25	17	16	ND
1836H	Pre	47	NS	NS	NS	ND	20	71	26	30	24	25
	Post	62	NS	NS	ND	ND	ND	95	27	8	4	ND
1858H	Pre	21	27	24	28	29	NS	48	NS	NS	26	24
	Post	ND	27	33	32	39	NS	81	NS	NS	ND	34
1886H	Pre	71	82	120	140	NS	NS	48	64	59	57	54
	Post	95	ND	ND	154	NS	NS	61	145	2.5	ND	ND
1898H	Pre	28	37	22	60	ND	13	72	NS	11	13	5
	Post	22	6	27	ND	ND	ND	ND	ND	28	ND	ND
1920H	Pre	147	147	128	NS	175	NS	175	NS	72	70	69
	Post	ND	ND	ND	NS	195	NS	ND	NS	128	ND	15

ppb = parts per billion; CW = Common Well which is either 1737H or 1745H, B = Baghurst Drive, H = Hendricks Road, ND = Non-detect

Appendix B:
Calculations and Variables

Table A.3:Breathing rates and showering/bathing variables from 2011 EPA Exposure Factors Handbook

	Breathing Rate	Breathing Rate	Minimum Breathing Rate	Minute Breathing Rate	Shower + Bath room Time	Shower + Bath room Time	Shower Time	Shower Time	Bath room Time	Bath room Time
Age Group	m^3/ day	m^3/ day	m^3/ min.	m^3/ min.	Mins.	Mins.	Mins.	Mins.	Mins.	Mins.
	mean	95%	mean	95%	50%	95%	50%	95%	50%	95%
1 to <2 yr	8.000	12.80	0.012	0.0160	15	70	10	50	5	20
2 to <6 yr	9.575	13.775	0.011	0.0145	15	70	10	50	5	20
6 to <11 yr	12.00	16.600	0.011	0.0150	20	60	15	40	5	20
11 to < 16 yr	15.20	21.900	0.013	0.0170	20	75	15	45	5	30
16 to <21 yr	16.30	24.600	0.012	0.0160	20	60	15	30	5	30
21 to <65 yr	15.52	20.660	0.012	0.0162	20	65	15	35	5	30
65+ yr	13.10	17.133	0.012	0.0153	15	60	10	30	5	30
Source -- EPA EFH 2011	Table 6–1	Table 6–1	Table 6–2, light activity	Table 6-2, light activity	Table 16–32	Table 6–32	Table 6–32	Table 6–32	Table 6–32	Table 6–32

EPA = Environmental Protection Agency

Calculations and Variables

Andelman's Model for calculating bathroom air concentrations from VOCs in shower water (Andelman, 1990)

Example shown using 1 to <2 yr age group:

$$C_{air\ max} = (k)\ (F_w)\ (T_s)\ (C_w)\ (CF) / V_a$$

Where, $C_{air\ max}$ = peak air concentration in bathroom/shower (µg/m^3)

k = volatilization coefficient from water to air = 0.1 (calculation shown below- Empirical formula for calculating volatilization rate constant k of 0.1)

F_w = flow rate of water through shower (L/min) = 8 (default McKone et al)

T_s = shower time (for 1 to <2yr is 50mins-varies by age as shown in Appendix B Table 3)

C_w = VOC concentration in water (µg/L) = 195µg/L

CF = Conversion factor = 1000 Liters air/m^3

V_a = bathroom air volume = 10,000 liters (default McKone et al)

10,000 L = 10 m^3 = 353 ft3 ~ 6 ft x 6 ft x 8 ft

$C_{air\ max}$ = (0.1) (8) (50) (195) (1000)/10,000

780 µg/m^3

Air concentration adj. for 24hr = Total intake in µg/day ÷ mean daily breathing rate in m^3/day

(Varies by age based on above breathing rate table. Here we are substituting the values for 1 to <2 yr)

Total intake = ($C_{air\ max}$) (mean breathing rate per minute) (95%shower+bathroom time in minute)

= (780) (0.012) (70) = 655 µg/day

Air concentration adj. for 24hr = 655/8 = 82 µg/m^3

Cancer Risk = (IUR) (Air conc. adj. for 24hrs) (Number of years exposed)/78yrs

Inhalation Unit Risk (IUR) for 1,4-dioxane = $5\text{x}10^{-6}$ (µg/m^3)$^{-1}$

Number of years exposed for children (for 1 to <2) = 1/78 = 0.01

Cancer Risk (for 1 to <2) = (5.0E-06) (82) (0.01) = $5x10^{-6}$

Number of years exposed for Adult = 33/78=0.42

Cancer risk for adult (for 21 to <65 yr) = (5.0E-06) (28) (0.42) = $6x10^{-5}$

Noncancer risk calculation (Hazard Quotient HQ) = Air concentration adj. for 24hr ÷ Health Guideline (EPA RfC or ATDSR MRL)

EPA RfC for 1,4-dioxane = 110 ($\mu g/m^3$)

HQ = 82/110 = 0.7

Empirical formula for calculating volatilization rate constant k of 0.1

EPA's simplified equation is f_i (expressed as percentage) = 7.95 x ln (H') + 68.2

Where H′= dimensionless = H/RT

H = Henry's Law constant = $4.91x10^{-6}$ (L/mol)
R = Gas constant = $8.205x10^{-5}$ (L/mol/ °K)
T = Temperature in Kelvin = 273 + 40 = 313°K

$$H' = \frac{4.91x10^{-6}}{8.205x10^{-5} \text{ x } 313}$$

$$= 1.91x10^{-4} \text{ (dimensionless)}$$

$$f_i = 7.95 \text{ x } \ln(1.91x10^{-4}) + 68.2$$
$$f_i = 0.13$$

Appendix C:
Overview and Toxicity of 1,4-Dioxane

1,4-Dioxane is a stable, clear liquid at ambient temperatures and is miscible with water. It is used primarily as a solvent for chemical processing. It has also been used as a laboratory reagent; in plastic, rubber, insecticides, and herbicides; as a chemical intermediate; as part of a polymerization catalyst; and as an extraction medium of animal and vegetable oils. 1,4-Dioxane may also be found as a contaminant in ethoxylated surfactants, which are used in consumer cosmetics, detergents, and shampoos.

The primary routes of human exposure to 1,4-dioxane are inhalation of 1,4-dioxane in air, ingestion of contaminated food and drinking water containing 1,4-dioxane, and dermal contact with contaminated consumer products (e.g., products containing ethoxylated surfactants). Because 1,4-dioxane may be found in tap water, human exposure to 1,4-dioxane may also occur during activities such as showering, bathing, and laundering. Occupational exposure occurs during the production, processing, and use of 1,4-dioxane, which may result in inhalation or dermal exposure (ATSDR, 2012).

The absorption of 1,4-dioxane after inhalation or oral exposure is rapid and essentially complete; absorption after dermal exposure is very low (ATSDR, 2012). Absorption is generally assumed to occur through passive diffusion. 1,4-Dioxane has not been shown to appreciably accumulate in tissues, possibly because of its high water solubility (ATSDR, 2012).

As summarized from the ATSDR Toxicological Profile (2012) limited information exists about the health effects of 1,4-dioxane in humans. Yet, the available data are sufficient to identify the liver and kidneys as the target organs for 1,4-dioxane noncancer toxicity after short-term exposure to relatively high amounts of 1,4-dioxane, regardless of the route of exposure. This finding has been corroborated in studies in animals. The liver and kidneys are also targets of 1,4-dioxane toxicity in the long-term or chronic exposure in animals.

The mechanism of carcinogenicity of 1,4-dioxane has not been elucidated, but studies suggest that 1,4-dioxane may be acting through a non-genotoxic mode of action. Based on inadequate evidence in humans and sufficient evidence in experimental animals, the International Agency for Research on Cancer has determined that 1,4-dioxane is *possibly carcinogenic* to humans. The Department of Health and Human Services has stated that 1,4-dioxane is *reasonably anticipated* to be a human carcinogen based on sufficient evidence of carcinogenicity in experimental animals. The EPA has established that 1,4-dioxane is *likely* to be carcinogenic to humans based on inadequate evidence of carcinogenicity in humans and sufficient evidence in animals.

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LCDR Donna K. Chaney, MBAHCM
U.S. Public Health Service
4770 Buford Highway N.E. MS-F59
Atlanta, GA 30341-3717
(W) 770.488.0713
(F) 770.488.1542