Letter Health Consultation

GROUNDWATER CONTAMINATION IN
THE FAIRMONT NEIGHBORHOOD
GOLDEN, JEFFERSON COUNTY, COLORADO

Prepared by the
Colorado Department of Public Health and Environment

APRIL 28, 2009

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
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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LETTER HEALTH CONSULTATION

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GOLDEN, JEFFERSON COUNTY, COLORADO

Prepared By:

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LETTER HEALTH CONSULTATION

TO: ROBERT BEIERLE, PROJECT MANAGER, HMWMD/CDPHE
FROM: THOMAS SIMMONS, HEALTH ASSESSOR, CCPEHA/DCEED/CDPHE
SUBJECT: GROUNDWATER CONTAMINATION IN THE FAIRMONT NEIGHBORHOOD GOLDEN, JEFFERSON COUNTY, COLORADO
DATE: 4/27/2009

Mr. Beierle,

This letter is in response to your recent request to evaluate the potential health concerns of the groundwater contamination beneath a property in the Fairmont Neighborhood of Golden, Jefferson County, Colorado. In 2007, the Colorado Department of Public Health and Environment (CDPHE), in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR), conducted a health consultation on the groundwater contaminant plume in this area (CDPHE 2008[1]). The groundwater plume of concern consists of Volatile Organic Compounds (VOCs) including tetrachloroethene (PCE), trichloroethene (TCE), and chloroform. My understanding is that since the completion of the initial health consultation, new owners have moved into the Fairmont Neighborhood and have been concerned about the groundwater contamination affecting their property. As per your request, the purpose of this letter is to evaluate the public health implications of exposure to the groundwater contaminants found in the new owners' irrigation well based on the following exposures pathways: (1) Currently occurring indoor air inhalation exposures through the vapor intrusion pathway and irrigation of domestic vegetable/fruit garden; and (2) Potential exposures based on the hypothetical use of irrigation well water for domestic purpose (e.g., drinking and showering) and alternative outdoor uses for child and adult recreational activities (e.g., using the irrigation well for filling child pools and hot tubs).

The sampling data that was utilized in the initial health consultation indicates that the groundwater well on this property is contaminated with PCE, chloroform, and TCE. The sampling data collected to date indicates that one source of this contamination is the Hazen Research Incorporated (Hazen) facility located approximately ½ mile west of the owners' property at 4601 Indiana Street. In the 1960's and 1970's, Hazen utilized small amounts of PCE for coal sink/float research (HWS 2007[2]). The groundwater plume of concern was initially identified in 2007 and it is unknown how long the plume has existed. In addition to the groundwater (one sample) and indoor air samples (one sample) collected from the owners' property in August of 2007, Hazen collected one additional groundwater and indoor air sample as well as a tap water sample (city water) in 2008. The complete sampling results are provided in Tables 1 and 2 below.

[1] Colorado Dept. of Public Health and Environment (CDPHE 2008). *Hazen Research Inc. Health Consultation*, September 5, 2008. Available on the Internet at: http://www.cdphe.state.co.us/dc/ehs/HazenResearch.pdf

[2] HWS Consulting Group, Inc. (HWS 2007). *Integrated Corrective Action Plan for the Hazen Research Inc. Facility*, December 2007.

Table 1. Groundwater Sampling Results

Sample Date	Tetrachloroethene (in µg/L)	Trichloroethene (in µg/L)	Chloroform (in µg/L)
8/1/2007	140	3	7.8
12/10/2008	**160**	**3.1**	**12**

Notes:
1) Other VOCs including chloroethane, 1,1-dichloroethane, cis-1,2 dichloroethene, methylene chloride, 1,1-trichloroethane, and vinyl chloride were also analyzed for, but were not detected.
2) Bolded values indicate the exposure point concentrations used for dose calculations.

Table 2. Indoor Air Sampling Results

Sample Date	Tetrachloroethene (in µg/m^3)	Trichloroethene (in µg/m^3)
11/6/2007	**9.9**	0.089
12/24/2008	6.8	**0.24**

Notes:
1) Other VOCs including 1,1-dichloroethane, cis-1,2 dichloroethene, trans-1,2 dichloroethene, and vinyl chloride were also analyzed for, but were not detected.
2) Bolded values indicate the exposure point concentrations used for dose calculations

Determining the public health implications of exposure to the contaminated water in the irrigation well is a multi-step process. First, the groundwater and indoor air data is screened with Comparison Values (CVs) to determine if there are contaminants of potential concern present (COPCs). If the concentration of a contaminant exceeds the CV, it is retained for further evaluation as a COPC. If the contaminant concentration is below the CV, it is dropped from further evaluation since exposures at this level are unlikely to result in adverse health effects. The second step of the process involves an examination of the ways that people could be exposed to COPCs. Simply having contaminants present in the environment does not necessarily indicate a health hazard. The potential for health hazards only exists when individuals are exposed to a substance at amounts and/or concentrations greater than the health-based guidelines ("safe levels"). Thus, the third major step of the evaluation process involves estimating the amount or dose resulting from exposure to COPCs during a given activity and comparing this dose with health-based guidelines. Health-based guidelines are chemical-specific health values that are thought to be acceptable levels ("safe levels") of exposure based on known health effect levels with built-in margins of protection. Non-cancer exposure doses are compared to the health-based guidelines such as the ATSDR Minimal Risk Levels (MRLs) and EPA Reference Doses (RfDs). Health guidelines for cancer effects are derived by the EPA and represent theoretical estimates of cancer risk at low levels of exposure. All estimated exposure doses below the health-based guidelines are not considered further since the exposure is not likely to result in adverse health effects. If the estimated exposure dose exceeds the health-based guideline, it is compared with the known health effect levels to better understand the public health significance of the exposure level.

The sampling data that has been collected from the owners' property to date was reviewed and screened with conservative CVs based on a residential use exposure

scenario. A total of 2 groundwater, 2 indoor air, and 1 tap water sample have been collected to date. Concentrations of PCE, TCE, and chloroform exceeded the CVs in the irrigation well water. In indoor air, the concentrations of PCE and TCE also exceeded the CVs (chloroform was not analyzed). No VOCs were detected in the tap water sampled from the property, which is supplied by North Table Mountain Water and Sanitation.

In February 2009, CDPHE staff attended a meeting with the new owners at their property to discuss their health concerns and examine ways that they could come into contact with contaminated water and indoor air. At this time, the new owners were conducting a home renovation and were not living on the property. The contaminated well under consideration had been disconnected from the house and was not being used for any purpose. The owners indicated that future use of the well might include irrigation of a domestic garden, but were not willing to use the well for this purpose until the concentration of contaminants has decreased. The possible pathways of exposure to the contaminated irrigation well include:

- alternative uses of irrigation water such as filling child pools, hot tubs, etc.;
- dermal (skin) contact with irrigation water,
- and transfer of contaminants to soil and homegrown produce.

In addition to the potential exposure pathways associated with the irrigation well, VOCs were also detected in the air inside the home, which could indicate that contaminants in the groundwater beneath the property are migrating from the aquifer, through soil, and into the home (commonly referred to as vapor intrusion). PCE and TCE are also present in a number of household products, so the exact source of these indoor air contaminants is difficult to determine. The public health implication of each potential and complete exposure pathway is discussed in greater detail below by order of importance.

The exposure dose estimation involves a number of variables. Some of these variables are chemical and site-specific; others are default exposure assumptions established by the EPA; and some are based on best professional judgment. Exposure doses are estimated for both carcinogenic (cancer) and non-cancer adverse health effects. Because of the limited amount of environmental sampling data available, the maximum concentrations detected in each media (i.e. groundwater and indoor air) were used as the exposure point concentrations. It should be noted that determining the public health implications of the groundwater and indoor air contamination is not an indicator of absolute risk. The actual health risks could be higher or lower than predicted in this health consultation due to multiple uncertainties and individual susceptibilities. More information on these topics is included in CDPHE 2008.

Breathing VOCs in the indoor air seems to be the most probable and important exposure pathway in this case because individuals typically spend a large degree of their time at home. Exposure doses were estimated using a modified version of the standard default assumption for the residential use scenario, which accounts for a maximum of 365 days per year for 30-years of exposure at the highest indoor air concentration found to date. The exposure frequency is a site-specific assumption, based on the information provided by the new owners during the February meeting. Table 3, shown below, summarizes the

results of the estimated exposure dose analysis, health-based guideline comparison, and the associated theoretical cancer risks from exposure to COPCs in indoor air.

The child and adult estimated exposure doses for non-cancer health effects are below the health-based guidelines for both PCE and TCE, indicating that non-cancer adverse health effects are not likely to occur from this pathway alone. The age-adjusted (includes children and adults) theoretical cancer risk for PCE is around the mid-point of the acceptable cancer risk range at 3.5 E-05, which literally means that 35 excess cancer cases per 1,000,000 exposed individuals would be expected from the indoor air pathway at this property. The acceptable cancer risk range, established by the EPA is 1 excess cancer case per million exposed individuals (1.00E-06) to 100 excess cancer cases per 1,000,000 exposed individuals (1.00E-04). This cancer risk is below the CDPHE immediate action level, but above the long-term target cancer risk goal of 1E-06. Theoretical cancer risks associated with TCE in indoor air are below the acceptable risk range. Overall, it does not appear that the current levels of contaminants in indoor air are likely to result in significant cancer and non-cancer health hazards from the vapor intrusion pathway, but remediation of the groundwater source is required in order to meet the CDPHE's long-term target cancer risk goal.

Table 3. Estimated Exposure Doses, Non-cancer Hazard Quotients (HQ) and Theoretical Cancer Risks from Exposure to Indoor Air

Health Effect Category	Tetrachloroethene (PCE) Dose (in mg/kg-day)		PCE Non-Cancer HQ[a] or Theoretical Cancer Risk	Trichloroethene (TCE) Dose (in mg/kg-day)		TCE Non-Cancer HQ[b] or Theoretical Cancer Risk
	Child	Adult		Child	Adult	
Non-Cancer Hazards	7.92E-03	2.83E-03	Child HQ = 7.92E-01 Adult HQ= 2.83E-01	1.92E-04	6.86E-05	Child HQ = 6.71E-02 Adult HQ= 2.40E-02
Cancer Risk	6.79E-04	9.70E-04	3.46E-05	1.65E-05	2.35E-05	2.80E-07

Note: TCE is evaluated using cancer and noncancer toxicity values recommended in the EPA-OSWER memorandum dated 1/15/09, which has been withdrawn on 4/9/09. However, the values used here are still consistent with the hierarchy approach referenced in the most recent memo dated 4/9/09.

[a] HQ is a ratio calculated by dividing the estimated dose by the non-cancer health based guideline (EPA Inhalation Reference Dose of 1.00E-02 mg/kg/day).

[b] HQ is a ratio calculated by dividing the estimated dose with the non-cancer health based guideline (EPA Inhalation Reference Dose of 2.86E-03 mg/kg/day).

Inhalation Cancer slope factor for PCE = 2.10E-02 mg/kg-day^{-1}, TCE = 7.00E-03 mg/kg-day^{-1}

It is also possible that the new owners could use the contaminated irrigation well for other purposes such as filling child pools, hot tubs, etc. Using the irrigation well for these purposes would result in both dermal (contact with skin) and incidental ingestion exposures to contaminated groundwater. It was assumed that this type of exposure could occur 1 hour per day, 52 days per year, over a period of 30 years (6 yrs. for children) at the default incidental ingestion rate of 50 ml water per event. Under these assumptions, significant non-cancer adverse health effects would not be expected since the combined

(ingestion & dermal contact) estimated exposure doses for children and adults are below the applicable health-based guidelines (Table 4). The age-adjusted theoretical cancer risks from this exposure were highest for PCE at 1.41E-04, or 141 excess cancer cases per 1,000,000 exposed individuals. The theoretical cancer risk for PCE is above the upper limit of the acceptable range. However, it is possible that this carcinogenic risk is an under- or over-estimation of actual risk due to differences between the exposure assumptions used in this evaluation and the actual exposure variables of this pathway.

Short-term dermal exposures to the irrigation well water, such as when connecting/disconnecting hoses, adjusting sprinklers, etc. is not considered particularly significant at these concentrations because of the extremely short duration of contact with contaminated water. However, it would be best to minimize contact with the contaminated groundwater as much as possible.

Exposure to VOCs from the ingestion of homegrown vegetables and/or fruits, irrigated with the owners' well, cannot be fully evaluated at this time because of the uncertainties associated with the available data. Some homegrown fruits and vegetables have been sampled from gardens in the Fairmont neighborhood, including the owners' garden, and the same VOCs that have been found in groundwater were not detected in any sample. This does not necessarily mean that no chemicals have been transferred to any crops that were being irrigated with contaminated groundwater. It is possible that some crops have been affected by the contamination, but those fruits/vegetables have not been sampled or the sampling method was inadequate for detecting the presence of PCE (i.e. high detection limit of the analytical method). However, the probability of highly contaminated crops, especially above-ground varieties, seems low due to the fact that heat and volatilization would transfer most of the PCE to the atmosphere. It is also unclear if the owners intend to use the contaminated water for gardening and subsequent consumption of homegrown produce. In addition, adequate data is not available on the bioaccumulation potential of PCE in fruits and vegetables. This pathway cannot be fully evaluated with the data that is currently available.

In summary, the public health implications of the currently occurring indoor air vapor inhalation exposure pathway represents No Apparent Public Health Hazard[3] based on estimated exposure doses for these pathways being below a level of significant health risk. However, using the irrigation well for filling child pools and/or hot tubs is not recommended because of the potential for long-term carcinogenic health effects. If the irrigation well were used for these purposes, it would constitute a Public Health Hazard[4] based on the assumptions and concentrations used in this health consultation. In addition, it cannot currently be concluded whether eating fruits and vegetables that have been irrigated with contaminated groundwater could harm people's health with the information that is currently available.

[3] ATSDR uses this category for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.

You also requested that the public health implications of using the irrigation well for household purposes be evaluated. As mentioned previously, the contaminated groundwater well on this property is currently (and has been for some time) used for irrigation purposes only. So this is a hypothetical exposure scenario. The evaluation of household, or domestic, water use was conducted in the same manner as described above only with slightly different exposure scenarios. The exposure scenarios that were evaluated include:

- Consumption of contaminated water,
- Showering with contaminated water (includes dermal and inhalation pathways), and
- Inhalation of contaminated indoor air (same as above).

All exposure doses assumed a 350-day exposure frequency over a period of 30 years with the standard default assumptions for residential use. Because all of these household exposures would occur over the course of a typical day, exposure doses were calculated for each pathway and then combined to evaluate the overall health risks associated with using the groundwater well for domestic purposes.

As shown in Table 5, the estimated exposure doses indicate that harmful effects may occur for both non-cancer and carcinogenic health effects if the irrigation well was to be used for household purposes. The greatest risk for non-cancer health effects would result from exposure to PCE while showering and drinking the contaminated water. This is particularly true for children because the amount of PCE taken in by children per unit body weight (dose) is greater for children than it is for adults. The estimated exposure doses for PCE significantly exceed the health-based guideline and a more in-depth analysis is needed to understand the public health significance at this exposure level. It should, however, be noted that because of the uncertainties regarding exposure conditions and the adverse health effects associated with environmental levels of exposure, definitive answers on whether health effects actually will or will not occur are not possible. The in-depth analysis only serves as a means of gaining a better perspective on how strongly the available toxicological information in the scientific literature suggests potential for harmful exposures (i.e., public health hazard[4]). Thus, the estimated non-cancer exposure doses were compared with the known health effect levels that serve as the basis for the health-based guideline. The estimated non-cancer exposure dose was below the known health effects level. Thus, it appears that significant non-cancer adverse health effects are not likely for both children and adults based on what is currently known about the toxic potential of these compounds. However, it is important to note that the estimated exposure doses enter a range of potential concern for non-cancer adverse health effects based on the significant exceedance of health-based guideline (Table 5).

In addition, the estimated age-adjusted (includes children and adults) theoretical cancer risks from exposure to PCE would be 1.74E-03, which translates to 1,740 excess cancer

[4] ATSDR defines “public health hazard” as a category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances that could result in harmful health effects.

cases per 1,000,000 exposed individuals. This is an order of magnitude greater than the acceptable cancer risk range. The results clearly indicate that using the irrigation well for household purposes would pose a Public Health Hazard. Therefore, it is highly recommended that the irrigation well not be used for household purposes in the future unless contaminant levels in the well have dramatically decreased or the well water is filtered to reduce contaminant levels prior to groundwater entering the house.

The major risk driving chemical (PCE) for which the weight-of-evidence approach for carcinogenic potential is considered to be a probable human carcinogen based on sufficient evidence of carcinogenicity in animal studies and limited carcinogenicity in human studies. Exposure to PCE can also result in non-cancer health effects. It is, however, important to note that when you are exposed to PCE, many factors will determine whether you will be harmed. These factors include the dose, the duration of exposure, and the individual factors such as your age, sex, diet, family traits, lifestyle, and state of health.

It is also important to note that there are inherent uncertainties associated with any risk assessment and indoor air sampling. Thus, the conclusions stated in this document could be under- or over-estimation of actual exposures and health risks for the following main reasons: 1) exposure assumptions used in this evaluation can over or underestimate the actual exposure, 2) toxicity values for TCE and PCE are being evaluated by the EPA and provisional toxicity values were used in this evaluation; and 3) sampling data is limited to two samples from each medium (groundwater and indoor air). In addition, regarding the indoor air sampling uncertainties, the USEPA in the vapor intrusion guidance notes that concentrations of compounds found in indoor air are often subject to temporal and spatial variations, which may complicate estimates of exposure[5]. In part, this means that levels of contaminants in indoor air will fluctuate by small margins depending upon the season and the types of activities occurring inside the house. Therefore, the year-round concentration of contaminants in the home is unknown.

Conclusions and Recommendations

- Currently occurring exposures through the indoor air inhalation pathway via vapor intrusion are considered no apparent public health hazard.
- Exposures to VOCs from the ingestion of vegetables/fruits irrigated with contaminated well water cannot be fully evaluated at this time.
- Exposures to VOCs based on the hypothetical domestic use of groundwater and alternative outdoor uses are considered a public health hazard.
- The future exposure is considered an indeterminate public health hazard because water concentrations are unknown and the latest sampling results show higher concentrations than the last sampling event.
- It is highly recommended that the groundwater well not be used for household purposes in the future unless contaminant levels in the well have dramatically decreased (to meet state standards) or the well water is filtered to reduce

[5] U.S. EPA, Office of Solid Waste and Emergency Response (EPA 2002). *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*, November 2002.

contaminant levels prior to groundwater entering the house. In addition, it should not be used for filling child pools or hot tubs.

- If the owners decide to use well water for irrigation purposes, they may want to consider some risk reduction methods such as a filtration system, the use of spray irrigation, and testing of a variety of the fruits and vegetables from their garden for PCE and other chemicals[6].
- In order to reduce exposure to VOCs, residents should ensure that indoor sources of VOCs (e.g., paints, and household cleaners) are stored in sealed containers preferably outside the home (e.g., garage). In addition, dry-cleaned clothes should not be stored in plastic bagging for extended periods of time and should also be kept in well-ventilated areas.
- In order to reduce theoretical cancer risks from the indoor air exposures via vapor intrusion pathway, engineering controls can be considered (e.g., installation of a vapor mitigation system).

Public health action plan

- Groundwater should be remediated to reduce indoor air levels for any contributions through the vapor intrusion pathway in order to meet the CDPHE long-term target cancer risk level.
- Continue indoor air sampling if no vapor mitigation system is installed.

I hope this information addresses your health concerns with groundwater contamination affecting the owners' property. If you have any questions or concerns about this evaluation, do not hesitate to contact me. Furthermore, if I can be of assistance in the future with any additional environmental health concerns, please contact me.

With Warm Regards,

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[6] This determination represents a professional judgment that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete, but that some additional data are required to support a decision.

Attachments:
1) Additional Tables, 2) Resident Fact Sheet, and 3) Certification

Additional Tables

Table 4. Estimated Exposure Doses, Non-Cancer Hazard Quotients, and Theoretical Cancer Risks for Combined Exposures in Child Pools/Hot Tubs

Health Effect Category	Tetrachloroethene (PCE) Dose (in mg/kg-day)		PCE Non-Cancer HQ [a] or Theoretical Cancer Risk	Trichloroethene (TCE) Dose (in mg/kg-day)		TCE Non-Cancer HQ[b] or Theoretical Cancer Risk	Chloroform Dose (in mg/kg-day)		Chloroform Non-Cancer HQ[c] (or Theoretical Cancer Risk
	Child	Adult		Child	Adult		Child	Adult	
Non-Cancer	9.49E-04	5.26E-04	Child HQ = 9.49E-02 Adult HQ = 5.26E-02	6.38E-06	3.18E-06	Child HQ = 2.13E-02 Adult HQ = 1.06E-02	1.57E-05	7.06E-06	Child HQ = 1.57E-03 Adult HQ = 7.06E-04
Cancer	6.51E-04	9.30E-04	1.41E-04	1.58E-05	2.25E-05	2.13E-08	1.33E-08	3.10E-08	1.17E-07

Note: TCE is evaluated using cancer and noncancer toxicity values recommended in the EPA-OSWER memorandum dated 1/15/09, which has been withdrawn on 4/9/09. However, the values used here are still consistent with the hierarchy approach referenced in the most recent memo dated 4/9/09.

Dermal dose was calculated using methods recommended in EPA RAGs Part E. For details of dermal and ingestion dose calculation, see the previous Hazen Health Consult (CDPHE, 2008) available at:http://www.cdphe.state.co.us/dc/ehs/HazenResearch.pdf.

[a] HQ is a ratio calculated by dividing the estimated dose by the non-cancer health based guideline (EPA Oral Reference Dose of 1.00E-02 mg/kg/day).
[b] HQ is a ratio calculated by dividing the estimated dose with the non-cancer health based guideline (EPA Oral Reference Dose of 3.00E-04 mg/kg/day).
[c] HQ is a ratio calculated by dividing the estimated dose with the non-cancer health based guideline (EPA Oral Reference Dose of 1.00E-02 mg/kg/day).
HQs greater than 1 indicate the potential for non-cancer adverse health effects. HQs below 1 are not considered further.
Oral Cancer slope factor for PCE = 5.40E-01 mg/kg/day^{-1}, TCE = 1.30E-02 mg/kg/day^{-1}, Chloroform 3.10E-02 mg/kg/day^{-1}

Table 5. Estimated Health Risk for the Hypothetical Household Use Scenario

Exposure Pathway	Adult Chloroform Non-Cancer HQs	Adult Tetrachloroethene Non-Cancer HQs	Adult Trichloroethene Non-Cancer HQs
Consumption	3.29E-02	4.38E-01	2.83E-01
Dermal	1.20E-03	1.05E-01	1.96E-02
Inhalation while Shower	9.82E-02	**1.83E+00**	1.24E-01
Indoor Air	Not Sampled	2.71E-01	2.30E-02
Total HQs	*1.32E-01*	***2.65E+00***	*4.50E-01*
Exposure Pathway	**Child Chloroform Non-Cancer HQs**	**Child Tetrachloroethene Non-Cancer HQs**	**Child Trichloroethene Non-Cancer HQs**
Consumption	7.67E-02	**1.02E+00**	6.61E-01
Dermal	2.05E-03	1.79E-01	3.35E-02
Inhalation while Shower	4.58E-01	**8.56E+00**	5.80E-01
Indoor Air	Not Sampled	7.59E-01	6.44E-02
Total HQs	*5.37E-01*	***1.05E+01***	***1.34E+00***
Exposure Pathway	**Age-adjusted Chloroform Cancer Risk**	**Age-adjusted Tetrachloroethene Cancer Risk**	**Age-adjusted Trichloroethene Cancer Risk**
Consumption	5.61E-06	**1.30E-03**	6.07E-07
Dermal	1.82E-07	**2.76E-04**	3.74E-08
Inhalation while Shower	3.82E-05	**1.32E-04**	8.53E-07
Indoor Air	Not Sampled	3.32E-05	2.68E-07
Total cancer risk	*4.40E-05*	***1.74E-03***	*1.77E-06*

Notes:
TCE is evaluated using cancer and noncancer toxicity values recommended in the EPA-OSWER memorandum dated 1/15/09, which has been withdrawn on 4/9/09. However, the values used here are still consistent with the hierarchy approach referenced in the most recent memo dated 4/9/09.

- HQs (Hazard Quotients) are equal to the estimated exposure doses divided by the non-cancer health-based guidelines. HQs greater than 1 indicate the potential for non-cancer adverse health effects.
- Bolded values indicate potential health hazards.
- For exposure assumptions information, refer to the previous health consultation for Hazen (CDPHE 2008).

Groundwater Contamination in the Fairmont Neighborhood – Golden, Jefferson County, Colorado

Colorado Department of Public Health and Environment

The Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) of CDPHE, in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR), conducted a public health consultation at the Fairmont Neighborhood in Golden, Colorado.

Q: How did CCPEHA and ATSDR become involved?

The Hazardous Materials and Waste Management Division of CDPHE requested assistance in evaluating the potential for health effects related to exposure to groundwater contaminants found in an irrigation well of a homeowner in the Fairmont Neighborhood. As a result, CCPEHA and ATSDR conducted a health consultation of the groundwater contamination beneath a property in the Fairmont Neighborhood.

CCPEHA works closely with ATSDR in completing health consultations at sites in Colorado. ATSDR is a federal public health agency of the U.S. Department of Health and Human Services, and is responsible for assessing the presence and nature of health hazards at sites. ATSDR provides funding and technical assistance through a cooperative agreement with CCPEHA to identify and evaluate environmental health concerns in Colorado.

History of the Hazen facility

Hazen Research Incorporated (Hazen) is an industrial research and development firm located in Golden, Colorado, about ½ mile west of the Fairmont Neighborhood. In the 1960's and 1970's, Hazen used small amounts of a chemical called Tetrachloroethylene (PCE). In March 2007, Hazen personnel investigated a floor leak in a concrete drain trench located in the commercial laboratory. This investigation lead to the discovery of PCE in groundwater beneath the Hazen facility and the Fairmont neighborhood.

Q: What is a public health consultation?

A public health consultation provides advice on a specific public health issue related to real or possible human contact (exposure) to a harmful substance. Public Health Consultations may consider

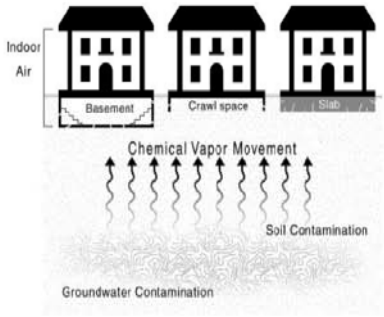
- The levels, or "concentrations, of hazardous substances
- If and how people might be exposed to contamination (through "exposure pathways" such as breathing air, drinking or contacting water, contacting or eating soil, or eating food)
- The harm the substances might cause to people (or the contaminants' "toxicity")
- If and how working or living nearby might affect people's health
- Other dangers to people, such as unsafe buildings, abandoned mine shafts, or other physical hazards

At this site, the following were considered:

- Current human contact (exposures) including indoor air through the vapor intrusion pathway and irrigation of home vegetable and fruit gardens.
- Future potential human contact (exposures) including well water used for household purposes (e.g. drinking and showering) and alternative outdoor uses of the well water for child and adult recreational activities (e.g., filling child pools and/or adult hot tubs).

Q: What is vapor intrusion?

Vapor intrusion is a way that chemicals in soil or groundwater can get into indoor air. Sometimes, chemicals are spilled on the ground at a factory or leak from an underground storage tank. These chemicals can seep down into the soil and groundwater. Some chemicals can also travel through soil as vapors. These vapors may then move up through the soil and into nearby buildings, contaminating indoor air. Vapor intrusion is uncommon, but should be considered whenever there is a known source of soil or groundwater contamination nearby. When it occurs, vapor intrusion may cause unhealthy indoor air quality.



Q: What is groundwater?

Groundwater is water that occurs below the Earth's surface at depths where all the open spaces in the soil, sediment, or rock are completely filled with water. All groundwater originates with and is replenished by precipitation. Groundwater will eventually come back to the surface, discharging to streams, springs, lakes, or the oceans, to complete the hydrologic cycle.

Q: How could I come into contact with the groundwater contaminants from the Hazen facility?

We don't know how long the groundwater could have been contaminated, or if Hazen is the only source of this contamination. However, contact with the contaminated groundwater could happen in the following ways:

- **By skin contact** – based on your current use of well water, skin contact with contaminated groundwater could happen when watering your garden with water from your irrigation well, or by playing in child tubs and in hot tubs that are filled from the irrigation well. In the future, if well water is used for household purposes, skin contact with the contaminated groundwater could happen while showering, bathing and hand washing.
- **By breathing** - the air inside your home may be contaminated through a process called "vapor intrusion". Also, these chemicals become airborne during household uses of water such as taking a shower, and further contaminate indoor air.
- **By Ingestion**- namely drinking contaminated well water, or eating the fruits and veggies irrigated by contaminated groundwater.

Currently, the only complete exposure pathway is exposure to groundwater contaminants by breathing indoor air affected by vapor intrusion. However, other future potential exposure pathways with exposure to contaminated well water were also considered in the health consultation.

Q: Which contaminants have been found in neighborhood wells?

PCE, trichloroethylene (TCE), and chloroform were detected; however, PCE is the major contaminant.

PCE: PCE or tetrachloroethylene is a man-made chemical used for dry-cleaning clothes, degreasing metal parts, and as an ingredient in the manufacturing of other chemicals. High levels of PCE when inhaled can cause dizziness, headache, sleepiness, confusion, unconsciousness, and possibly death. Skin contact with high levels of PCE can cause irritation. Laboratory animals exposed to high levels of PCE over long-term experienced liver/kidney damage, liver/kidney cancer, and leukemia. Scientists are uncertain if low level, long-term exposure to PCE can cause adverse health effects such as cancer, nervous system effects, organ damage, or reproductive effects in humans. The Department of Health and Human Services (DHHS) has determined that PCE may reasonably be anticipated to cause cancer.

TCE: TCE or trichloroethylene is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. TCE is most commonly used as a degreasing solvent in manufacturing plants. Breathing small amounts may cause headaches, dizziness, lung irritation, and difficulty concentrating. Drinking large amounts of TCE may cause nausea, liver damage, unconsciousness, impaired heart function, or death. Drinking small amounts of TCE for long periods may cause liver and kidney damage, impaired immune system function, and impaired fetal development in pregnant women, although the extent of some of these effects is not yet clear. Skin contact with TCE for short periods may cause skin rashes. The International Agency for Research on Cancer (IARC) has determined that TCE is "probably carcinogenic to humans."

Chloroform: Chloroform is a colorless liquid with a pleasant, nonirritating odor and a slightly sweet taste. Chloroform is used to make other chemicals and can also be formed in small amounts when chlorine is added to water. Breathing about 900 parts of chloroform per million parts air (900 ppm) for a short time can cause dizziness, fatigue, and headache. Breathing air, eating food, or drinking water containing high levels of chloroform for long periods of time may damage your liver and kidneys. It isn't known whether chloroform causes reproductive effects or birth defects in people. The Department of Health and Human Services (DHHS) has determined that chloroform may reasonably be anticipated to cause cancer.

Q: Were contaminants found in my drinking water?

None of these contaminants were detected in the tap water sampled. Your tap water is supplied by North Table Mountain Water and Sanitation and is different from the water in your well.

Q: What are the health implications of current exposure to these chemicals via vapor intrusion?

The current level of exposure is not likely to harm people's health. However, because some chemicals found in the groundwater are potential cancer causing chemicals, we suggest that you consider reducing exposure to the contaminated groundwater and indoor air vapors.We made this

conclusion based on the current use of water in irrigation wells, the current levels of contaminants in indoor air, and the levels of contaminants in irrigation wells. Additionally, as clean up is ongoing, we expect the levels of contaminants to decrease over time. It is important to note that this conclusion is associated with uncertainty due to the limited sampling data and the current state of knowledge regarding the toxicity of chemicals. In addition, individual potential for adverse health effects is based on many different factors, such as habits, family history of disease, nutritional status, and lifestyle.

Q: What are the health implications of current exposure to these chemicals from eating fruits and veggies that were irrigated with contaminated groundwater?

CCPEHA and ATSDR cannot currently conclude whether eating fruits and veggies that have been irrigated with contaminated groundwater could harm people's health as not all types of fruits and vegetables were sampled.

As such, there may be uncertainties associated with the sampling data. The available fruit and vegetable samples collected from gardens in the Fairmont neighborhood have not shown any contaminants thought to be related to the groundwater plume under investigation. These samples were collected from gardens irrigated with some of the most highly contaminated wells. This does not necessarily mean that no chemicals have been transferred to any fruits or veggies that are currently being irrigated with contaminated groundwater. But, different fruits and veggies appear to uptake chemicals in different ways. It is possible that some fruits and veggies have been affected, but have not been sampled, or the sampling method was inadequate for detecting the presence of PCE.

Q: Can I use my well water for watering my garden?

It is your personal choice. Again, CCPEHA and ATSDR cannot currently conclude whether eating fruits and veggies that have been irrigated with contaminated groundwater could harm people's health. But, as you know, your irrigation well contains elevated levels (about160 ppb) of PCE (i.e. above the federal and state standard of 5 ppb). If you decide to use well water for irrigation of produce, you may want to consider some risk reduction methods such as a filtration system, the use of spray irrigation, and testing of a variety of the fruits and veggies from your garden for PCE and other chemicals.

Q: What if I want to use the well water for more than watering my garden and lawn?

- We strongly recommended that you do not use the well water for household purposes such as showering and drinking. Use of the water in the household could harm people's health. The public health consultation estimated an elevated risk for cancer and increased potential for other harmful health effects if the well water was used inside the home.

- We strongly recommend that you do not use the well water to fill hot tubs and child pools. Use of the water in this way could harm people's health. The health consultation estimated increased cancer risk based on exposure over a long period of time.

Q: What can be done to lower risk for health problems?

- Consider installing a vapor mitigation system. The diagram at right is a picture of how a vapor mitigation system works to remove soil gasses and protect those who live in the home. These systems are similar to radon mitigation systems. They stop gases in the soil from entering the home. A low amount of suction is applied below the foundation of the home and the gasses are vented to the outside. These systems typically use only a little electricity, and should not increase your costs. These systems also prevent radon from entering the home, which would be an added health benefit. The system will probably remain in place until the contamination is cleaned up, and may remain in place permanently.

- Consider filtering all well water before using it for irrigation and other purposes. If you decide to use your well water in the current state, a spray irrigation method should be used to help reduce the amount of PCE in the water by evaporation. Do not use a drip system or soaker hose; these types of irrigation may help keep PCE in the soil and fruits/vegetables. In addition, due to the uncertainties associated with the available data for fruits/vegetables, you may want to have a variety of vegetables/fruits from your garden tested for PCE and other VOCs
- You should ensure that indoor sources of VOCs (e.g., paints, and household cleaners) are stored in sealed containers preferably outside the home (e.g., garage). In addition, dry-cleaned clothes should not be stored in plastic bags for extended periods of time, and should also be kept in well-ventilated areas.

Q: How do you estimate health risk?

Scientists and government officials use a four-step process called risk assessment to estimate people's increased risk of health problems as a result of exposure to chemicals.

We study health risks based on what people do and are likely to do on the site. We use risk assessment to estimate the chance that contact with chemicals from a site will harm people now or in the future. This process gives us numbers that show how great (or small) the risks may be. It also points to who is at risk, what is causing the risk, and how sure we are about the numbers.

Risk assessment cannot identify people likely to suffer health problems. Also, it cannot determine whether health effects have occurred or will occur.

An electronic copy of this health consultation can be found at: *http://www.cdphe.state.co.us/dc/ehs/healthconsult.html*. For more information about the health consultation, please feel free to contact Thomas Simmons, Health Assessor, at 303-692-2961 or Shannon Rossiter, Health Educator/Community Involvement Specialist, at 303-692-2617.

CERTIFICATION

This Hazen Research Letter Health Consultation was prepared by the Colorado Department of Public Health and Environment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement partner.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

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