# Public Health Implications of Volatile Organic Compounds in Sub-Slab Samples in Fairlington Glen

Fairlington Cleaners
ARLINGTON, VA

Letter Health Consultation

February 7, 2018

Virginia Department of Health
Division of Environmental Epidemiology
Richmond, Virginia 23219

# COMMONWEALTH of VIRGINIA

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February 7, 2018

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Dear Mr. Chapman,

This letter is in response to your request for the Virginia Department of Health (VDH) to examine the environmental data obtained from Engineering Consulting Services in Arlington, Virginia, where there is an underground tetrachloroethylene (PCE) plume due to an historic environmental release from a dry-cleaning facility. Thank you for providing VDH with the sampling results. Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), we completed an evaluation of the sampling information you forwarded to VDH on October 22, 2017 and assessed the potential risks to human health from vapor intrusion from the contaminated groundwater.

## BACKGROUND

In 2003 a chlorinated solvent plume was discovered under the Fairlington Centre Plaza located at the intersection of North Quaker Lane and Fern Street in Alexandria, VA. It was determined that this release was likely from a dry cleaning facility located at 1712 Fern Street that has been in operation since 1950. Through Engineering Consulting Services (ECS), the owners of Fairlington Centre Plaza (TBR Associates, LLC) made attempts to remediate and to characterize the plume on the property. In 2014 ECS began additional off-site investigation, including the median of Quaker Lane and the neighborhood of Fairlington Glen, which is located across Quaker Lane to the west of Fairlington Centre Plaza. A map of the Fairlington neighborhood can be found in **Attachment 1**.

As a result of the groundwater sampling done throughout Fairlington Glen, it was determined that vapor intrusion of volatile organic compounds (VOCs) was a potential risk. Ingestion of groundwater is not a concern because residents of Fairlington Glen use city water in their homes. Sub-slab soil gas samples were collected from 47 homes and three common areas in the Glen. This occurred between November 17, 2016 and April 5, 2017. Samples were collected according to U.S. Environmental Protection

Agency (EPA) practices and sent to an independent laboratory for analysis for VOCs by EPA Method TO-15.[1]

On January 20, 2017, VDH was contacted by a Fairlington Glen resident, who was concerned about VOCs sampling results that were collected in their home as part of this investigation. VDH responded to that resident's request with a letter health consultation dated March 3, 2017, and also attended a community meeting to address general concerns of Fairlington Glen residents in May 2017.

VDH is now responding to a request for assessment of all of the data collected throughout the Fairlington Glen neighborhood. This letter will discuss the sub-slab soil gas results collected from the residents' homes at Fairlington Glen between November 17, 2016 and April 5, 2017, and will focus on potential health effects to residents from VOCs that may enter their homes through vapor intrusion.

## RESULTS AND DISCUSSION

### *Vapor intrusion and calculating indoor air concentrations*

The discussion begins with a description of vapor intrusion and attenuation factors described by EPA.[2]

> *Vapor intrusion (VI) is the general term given to the migration of volatile chemicals from subsurface contaminated soils and groundwater into the indoor air spaces of overlying buildings through openings in the building foundation (for example, cracks and utility openings). A key concept of VI is that the vapor concentrations attenuate (decrease) as the vapors migrate. The attenuation occurs as a result of the processes that control vapor migration in soil (for example, diffusion, advection, sorption, and potentially degradation), coupled with the dilution that results when the vapors enter a building and mix with indoor air. The term "attenuation factor," defined as the ratio of indoor air concentration to subsurface concentration, is used as a measure of the decrease in concentration that occurs during vapor migration and may vary with space and time.*[2]

Additional information about vapor intrusion can be found on ATSDR's "Investigating Vapor Intrusion" fact sheet.[3]

VDH uses an attenuation factor of 0.03 when calculating indoor air concentrations from sub-slab gas concentrations. VDH multiplies the attenuation factor ($\alpha$) by the sub-slab soil gas concentration ($\mathbf{C_{sg}}$) to calculate the indoor air concentration ($\mathbf{C_{air}}$). This conservative health-based approach is used by the risk assessor to determine what concentration of VOCs the residents may be inhaling. [4]

Using the highest sub-slab soil gas concentration (1,820 $\mu g/m^3$) of tetrachloroethylene (PCE) measured at Fairlington Glen as an example to calculate indoor air concentration:

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[1] ECS Site Characterization Report, Addendum #3. ECS Project No. 1507 for TBR Associates, LLC. **August 14, 2017**.
[2] U.S. EPA. OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air. **June 2015.**
[3] https://www.atsdr.cdc.gov/docs/atsdr_vapor_investigation.pdf. Accessed online December 2017.
[4] ATSDR. Evaluating Vapor Intrusion Pathways: Guidance for ATSDR's Division of Community Health Investigations. **October 2016**.

$$C_{air} = 1{,}820\ \mu g/m^3 \times 0.03 = 54.6\ \mu g/m^3$$

***Exposure pathway evaluation***

Chemicals can only impact health when an individual is exposed. VDH determines if an exposure to environmental contamination occurred in the past, is occurring, or might occur in the future by identifying if a completed exposure pathway exists.

A completed exposure pathway consists of 5 elements:

*Element 1*: A source of contamination
*Element 2*: An environmental medium that can transport the contaminant
*Element 3*: A location where people might come into contact with the contaminated medium
*Element 4*: The route by which people physically contact the environmental contaminant
*Element 5*: A population that may or have come in contact with the contaminants

VDH eliminates an exposure pathway if at least one of the five elements above is missing and is unlikely to ever be present. Exposure pathways not eliminated can be either *completed* or *potential* pathways.

*Completed pathways*—all five pathway elements exist
*Potential pathways*—at least one of the five elements is missing or may be present but lacks sufficient information to exclude it

**Table 1: Site Specific Exposure Pathway Elements***

| **Pathway Name** | **Exposure Pathway Elements** | | | | | **Time Frame** | **Assessment** |
|---|---|---|---|---|---|---|---|
| | **Source** (*Element 1)* | **Environmental Transport Medium** *(Element 2)* | **Exposure Point** *(Element 3)* | **Exposure Route** *(Element 4)* | **Exposed Population** *(Element 5)* | | |
| Groundwater | Fairlington Centre Plaza | Groundwater | Drinking Water | Ingestion/ Dermal Contact | Fairlington Glen | Past<br>Present<br>Future | Eliminated<br>Eliminated<br>Eliminated |
| Indoor Air | Fairlington Centre Plaza | Groundwater/ Soil Gas | Indoor Air | Inhalation | Fairlington Glen | Past<br>Present<br>Future | Completed<br>Eliminated**<br>Eliminated** |

*This scenario assumes chemicals are migrating from sub-slab to indoor air.
** Exposure route is eliminated with the use of vapor mitigation systems. A potential pathway exists without the use of a vapor mitigation system.

VDH considers there to be a *completed* past exposure pathway for indoor air due to the presence of all five pathway elements. It cannot be known for sure the extent to which residents were exposed to PCE

in the air in their homes due to the lack of air sampling data from inside the residences, however based on the vapor intrusion assessment it is assumed that exposure has taken place. Residents that have mitigation systems in place are considered to have an *eliminated* exposure pathway for the present and future.

There is an *eliminated* pathway for groundwater from ingestion and dermal contact due to the fact that Fairlington Glen residents do not use well-water for their homes. There is no exposure from this route, and ingestion of groundwater will not be further evaluated for health effects.

A completed pathway does not indicate that a hazard exists, only that exposure exists. The following health effects evaluation will assess potential for health concerns due to exposure.

***Comparison values are used to evaluate indoor air concentrations***

After calculating the indoor air concentration from sub-slab soil gas, this concentration is compared to health-based values called comparison values (CVs). CVs allow the risk assessor to screen a large number of chemicals to determine which ones may be a health hazard. Indoor air concentrations greater than their CVs are not necessarily a health hazard, but require further evaluation. CVs used in this health consultation include cancer risk evaluation guides (CREGs) and environmental media evaluation guides (EMEGs).

CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million persons exposed during their lifetime. ATSDR's CREGs are derived from EPA's cancer slope factors for oral exposure or unit risk values for inhalation exposure. These values are based on EPA evaluations and assumptions about cancer risks at low levels of exposure. VDH determined that only two chemicals, PCE and chloroform, exceeded their CREG.

EMEGs are estimated contaminant concentrations that are not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. They are based on conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight. ATSDR has developed EMEGs that apply to acute (14 days or less), intermediate (15–364 days), and chronic (365 days or more) exposures. VDH determined that only PCE exceeded its chronic EMEG, 41 $\mu g/m^3$.

***Evaluation of additional cancer risk from exposure to PCE and chloroform***

Five of the forty-seven homes where samples were collected showed calculated PCE indoor air concentrations higher than its CREG, 3.8 $\mu g/m^3$. These five samples were further evaluated for additional cancer risk (see Table 2). Six of the forty-seven homes sampled showed calculated indoor air chloroform concentrations higher than its CREG, 0.043 $\mu g/m^3$, and so these samples were also evaluated for additional cancer risk (see Table 3). For both of these contaminants, the CREG is the most health-protective CV. None of the samples showed contained both PCE and chloroform above their respective CREGs.

VDH assesses the additional calculated cancer risk PCE poses by multiplying its calculated indoor air concentration ($\mathbf{C_{air}}$) by EPA's inhalation unit risk (IUR) for PCE, $2.6 \times 10^{-7}$ per $\mu g/m^3$ (see equation

below). The IUR is an estimate of the increased cancer risk from inhalation exposure to a concentration of 1 µg/m$^3$ of a carcinogen for a lifetime (assuming 24 hours/day exposure for 70 years).

**calculated cancer risk = IUR x $C_{air}$**

Using the highest calculated indoor air concentration for PCE as an example, the calculated additional cancer risk is:

**calculated cancer risk = 2.6 x10$^{-7}$ per µg/m$^3$ x 54.6 µg/m$^3$ = 1.42 in one hundred thousand**

This increased calculated cancer risk from inhaling 54.6 µg/m$^3$ of PCE for a lifetime is considered very low. Regulatory agencies consider a 1 in 10,000 risk to be low and 1 in 1,000,000 to be extremely low. Anything between that range is considered acceptable. The expected cancer rate in the United States is 1 in 3, meaning that one in three individuals is expected to develop cancer in their lifetime.[5]

**Table 2: 2016 and 2017 results from samples that exceeded the PCE CREG (3.8 µg/m$^3$).***

| Housing Unit | Sub-slab Soil Gas Concentration (µg/m$^3$) | Calculated Air Concentration ($C_{soil\ gas}$ x 0.03) (µg/m$^3$) | Calculated Air Concentration ($C_{soil\ gas}$ x 0.03) (ppb) | Estimated Cancer Risk ($C_{air}$ x IUR[6]) | Qualitative Risk of Cancer |
|---|---|---|---|---|---|
| A | 267 | 8.01 | 1.18 | 2.08 E -06 | Extremely Low |
| B | 180 | 5.40 | 0.796 | 1.40 E -06 | Extremely Low |
| C | 1,670 | **50.1** | **7.39** | 1.30 E -05 | Very Low |
| D | 1,820 | **54.6** | **8.05** | 1.42 E -05 | Very Low |
| E | 260 | 7.80 | 1.15 | 2.03 E -06 | Extremely Low |

*Bolded air concentrations exceeded PCE chronic EMEG (41 µg/m3).

**Table 3: 2016 and 2017 results from samples that exceeded chloroform CREG (0.043 µg/m$^3$).***

| Housing Unit | Sub-slab Soil Gas Concentration (µg/m$^3$) | Calculated Air Concentration ($C_{soil\ gas}$ x 0.03) (µg/m$^3$) | Calculated Air Concentration ($C_{soil\ gas}$ x 0.03) (ppb) | Estimated Cancer Risk ($C_{air}$ x IUR[7]) | Qualitative Risk of Cancer |
|---|---|---|---|---|---|
| F | 3.47 | 0.10 | 0.0213 | 2.39 E -06 | Extremely Low |
| G | 2.34 | 0.07 | 0.0144 | 1.61 E -06 | Extremely Low |
| H | 1.56 | 0.05 | 0.00959 | 1.08 E -06 | Extremely Low |
| I | 2.00 | 0.06 | 0.0123 | 1.38 E -06 | Extremely Low |
| J | 2.54 | 0.08 | 0.0156 | 1.75 E -06 | Extremely Low |
| K | 1.56 | 0.05 | 0.00959 | 1.08 E -06 | Extremely Low |

*No samples exceeded chloroform chronic EMEG (98 µg/m$^3$).

The results of the estimated cancer risk for both PCE and chloroform show that there is low or extremely low additional cancer risk as a result of exposure to these compounds.

[5] American Cancer Society: Lifetime Risk of Developing or Dying from Cancer. 2016. https://www.cancer.org/cancer/cancer-basics/lifetime-probability-of-developing-or-dying-from-cancer.html Accessed 01.19.18.

[6] Inhalation Risk Unit for Tetrachloroethylene is 2.30 x 10$^{-05}$.

[7] Inhalation Risk Unit for Chloroform is 2.30 x 10$^{-05}$.

***Evaluations of samples and calculated non-cancer risk***

Two of the samples collected exceeded the chronic EMEG for air exposure to PCE. To evaluate the potential health risks of exposure to these concentrations, they are compared to the studies that were used to develop the screening values. For chronic inhalation exposure, this is an assessment of color vision in PCE-exposed workers. It was found that after two years of exposure to PCE at work at an average concentration of 7.3 ppm (50,000 µg/m$^3$), there was a decrease in color vision. To account for the 40-hour work week of exposure in this scenario, 7.3 ppm was multiplied by 8/24 hours and 5/7 days to yield 1.7 ppm (11,530 µg/m$^3$), an estimate of continuous exposure. When compared to the highest estimated indoor air concentration of 54.60 µg/m$^3$ (at the Glen), there is low risk of health effects to residents exposed to this level of contamination. Furthermore, VDH uses conservative assumptions about exposure that include 24 hours/day for over 70 years further evaluation of the non-cancer effects, and when developing screening values, which do not reflect actual exposure. For example if an individual was to breathe the highest concentration of PCE for 24 hours a day, 365 days/year for 35 years this would equate to breathing an adjusted indoor air concentration equal to 27 µg/m$^3$.[8] This is less than the EMEG (41 µg/m$^3$), and this exposure scenario is unlikely to occur in real-life.

***Chemical-specific information***

<u>Tetrachloroethylene</u>

Tetrachloroethylene (also known as tetrachloroethene, perchloroethylene, PCE, and PERC) is a manufactured chemical used for dry cleaning and metal degreasing. The average concentration of tetrachloroethylene in the air of the United States is typically less than 1 µg/m$^3$.

Long-term exposure to PCE can cause vague neurological symptoms in humans such as changes in mood, attention, reaction time, or vision. These effects are mostly a concern with occupationally exposed populations. Some animal studies have shown effects in liver and kidneys and have shown problems in pregnancy, but it is not known whether exposed humans will show the same effects.[9] It is also not known whether children are more susceptible to PCE-exposure related health effects.

Animal studies have shown that PCE exposure can cause liver, kidney, and blood-related cancers in animals. Also, some studies in humans show that PCE exposure may lead to a higher risk for bladder cancer, multiple myeloma, or non-Hodgkin's lymphoma, but the evidence is not very strong. Based on this evidence, the International Agency for Research on Cancer (IARC) considers PCE to be probably carcinogenic to humans. The Department of Health and Human Services (DHHS) considers tetrachloroethylene to be reasonably anticipated to be a human carcinogen. PCE breaks down very slowly in the air.

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[8] $C_{adjusted\ indoor\ air} = \frac{C_{air}\ x\ frequency\ x\ duration}{\text{averaging time}}$

where $C_{air}$ is 54.6 µg/m$^3$; frequency is 365 days/year; exposure duration is 35 years (length of time at one residence); and averaging time is 25550 days (life time in days = 70 years x 365 days/year = 25550 days.

[9] Toxicological Profile for Tetrachloroethylene. ATSDR. **October 2014.**

Chloroform

Chloroform, also known as trichloromethane or methyltrichloride, is a colorless liquid that has been used in many different chemical industries. Its most common sources for environmental release include chemical companies, paper mills, and waste water treatment plants that use chlorine as a disinfectant. Due to the many potential sources of chloroform, including consumer products, it may be found almost anywhere in the environment. The air concentration of chloroform across the U.S. is 0.02 - 0.05 ppb.[10]

Chloroform was historically used as an anesthetic before it was known that it had negative effects on the kidneys and liver. At very high concentrations, chloroform can cause fatigue, dizziness, and headache in humans. Over a long period of time, liver, and kidney damage can occur. The concentration of chloroform found in the soil gas samples is far below any potential level for these non-cancer health effects (EMEG is 98 $\mu g/m^3$**).** Several studies in rats and mice showed that exposure to large amounts of chloroform in drinking water has the potential to cause tumors to develop. While it is not known whether humans would also develop cancer from a similar exposure, it has been determined by the IARC that chloroform is possibly carcinogenic to humans. DHHS has determined that chloroform may reasonably be anticipated to be a carcinogen.

## LIMITATIONS

The use of attenuation factors to determine indoor air concentrations has several limitations. Attenuation factors from sub-slab vapor to indoor air concentrations depend upon the assumption that the slab is solid. If there are direct routes to indoor air (for example, cracks, expansion joints, utility line openings, drain pipes, or sumps) the generic attenuation factor may be too low. Vapor intrusion can exhibit variability from a daily to seasonal basis. In addition, indoor air levels may vary with environmental conditions. Changes in temperature, ambient air pressure, wind direction and speed, and indoor air pressure can alter the pressure gradient from sub-slab to building and change the rate of diffusion into the indoor air. In these cases it is more accurate to measure indoor air concentrations.

Finally, the below-ground plume can change in direction or extent with changing environmental conditions. Changes in groundwater levels, ground contour or coverage, or vegetation can change the hydraulic gradient and alter the plume. For this reason, VDH cannot speculate about past or future exposures related to movement of the plume.

[10] Toxicological Profile for Chloroform. ATSDR. **September 1997.**

## CONCLUSIONS

VDH concludes that the indoor air concentration of PCE calculated from samples collected between November 17, 2016 and April 5, 2017 are not a health hazard.

VDH concludes that the indoor air concentration of chloroform calculated from samples collected between November 17, 2016 and April 5, 2017 are not a health hazard.

## RECOMMENDATION

VDH recommends that you share these findings with the residents where the sampling occurred and with the Arlington Health Department.

## PUBLIC HEALTH ACTIONS

No public health actions are recommended at this time.

Should you have any additional questions please contact Rachel Ellick, at (804) 864-8194 or at rachel.ellick@vdh.virginia.gov.

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**Attachment 1**. Map of Fairlington Glen and Fairlington Centre Plaza.


*Source:* (Google maps)