

Letter Health Consultation

Evaluation of exposure to tetrachloroethylene (perchloroethylene, or PERC), benzene, and trichloroethylene (TCE) in indoor air

Raymark Industries, Inc.

Stratford, Fairfield County, Connecticut

EPA Facility ID: CTD001186618

Prepared by
State of Connecticut Department of Public Health
Hartford, Connecticut
06134

November 20, 2024

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Office of Capacity Development and Applied Prevention Science
Atlanta, Georgia 30333

Letter Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR 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 which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

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Commissioner



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Environmental Health Section

November 20, 2024
Andrea Boissevain
Director of Health
Stratford Health Department
Stratford, CT

Dear Ms. Boissevain:

In response to your request, the Connecticut Department of Public Health (DPH) evaluated the public health implications of exposure to tetrachloroethylene (perchloroethylene, or PERC), benzene, and trichloroethylene (TCE) in indoor air at 635 East Broadway, Stratford, CT. The property has two commercial tenants, a dry cleaner and a dance studio.

DPH has made the following preliminary assessment of indoor air at the dry cleaner and dance studio based on the available data. DPH notes that there is only one round of indoor air sampling data. A single round of data does not provide information about variability in indoor air concentrations that may exist over time. Therefore, DPH's preliminary assessment is based on the assumption that the single round of indoor air data is representative of exposures over time. The collection and evaluation of additional data may reduce the uncertainty associated with the limitations inherent in one sampling event. The limitations and uncertainties in this preliminary assessment are presented later in this letter.

- Breathing contaminants in the indoor air of the dance studio is not expected to harm the health of adults and children who visit the dance studio to work, teach, take dance classes, pick up and drop off students, or observe classes.



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- Breathing contaminants in the indoor air of the dry cleaner is not expected to harm the health of adult or child customers/visitors.
- Breathing contaminants in indoor air of the dry cleaner is not expected to cause noncancer harmful health impacts to workers.
- Breathing contaminants in indoor air of the dry cleaner over a long period of time (more than 20 years) could pose a concern for increased cancer risk in dry cleaner workers.

Background

The Raymark Industries, Inc. Superfund Site consists of more than 500 acres of land in Stratford, Fairfield County, CT. Raymark Industries, Inc., manufactured automotive and heavy brake friction components for more than 70 years (1919–1989). Raymark disposed of waste as “fill” material in various locations in Stratford, including the Raymark facility, various commercial and residential properties, and wetlands adjacent to the Housatonic River. Raymark also disposed of waste materials in unlined lagoons at the Raymark facility. The United States Environmental Protection Agency (EPA) listed the Raymark site on EPA’s National Priorities List of Superfund sites on April 25, 1995. Raymark is bankrupt, and EPA is conducting the cleanup in coordination with the Connecticut Department of Energy and Environmental Protection (CT DEEP).

The site has been divided into nine parts, or Operable Units (OUs). This evaluation focuses on OU2: Groundwater. The groundwater investigation involves a 500-acre area extending from the former Raymark facility to Ferry Creek and the Housatonic River (see Figure 1 in the Attachments). Contaminants in the groundwater include volatile organic compounds (VOCs) and metals. From 2000 to 2002, extensive groundwater, soil gas, indoor air, and sub-slab evaluations found that VOCs were volatilizing from the groundwater into buildings (primarily residential dwellings). As a result, from 2003 to 2004, EPA and CT DEEP installed 106 sub-slab ventilation systems in residential homes and two commercial buildings to mitigate potential vapor intrusion (VI) and human health exposure. EPA has groundwater monitoring wells at and beyond the OU2 boundaries. The wells provide information about potential movement of the contaminated groundwater plume and the potential for completed VI pathways at additional properties.

Since the sub-slab ventilation systems were installed, EPA has conducted VI investigations at commercial properties beyond the original OU2 boundaries. None have shown indoor air levels of Raymark-related VOCs that exceed EPA’s acceptable risk levels (EPA 2023). In March 2023, EPA identified a commercial property (635 East Broadway) near the southern edge of the groundwater plume that had never been sampled. Figure 1 in the Attachments shows the location of the former Raymark facility, the boundary of OU2, the approximate area where sub-slab ventilation systems were installed, and the location of 635 East Broadway.

635 East Broadway is a single-level building with a slab-on-grade concrete foundation and two tenants: a dance studio and a dry cleaner. The Stratford Health Department (SHD) indicates that the dry cleaner performs dry cleaning operations in the building (not in a remote location) and uses tetrachloroethylene (PERC) in its cleaning process. PERC was once a common dry-cleaning solvent, but many dry cleaners have switched to less hazardous chemicals. In 2012, hazardous waste manifests reported that the dry-

cleaning facility at 635 East Broadway was using PERC. In June 2024, the facility owner confirmed to the Stratford Health Department (SHD) that he was still using PERC, but not every day.

In March 2023, EPA conducted indoor air testing in several locations in the dry cleaner and dance studio. In the dry cleaner, EPA elected not to collect sub-slab soil gas samples because they could not determine the location of sub-slab utilities. Instead, EPA collected one sample from the air in a crawlspace beneath the floor. In the dance studio, EPA could not collect sub-slab soil gas samples because of the type of flooring. EPA also collected one outdoor air sample for comparison purposes.

On November 8, 2023, EPA sent a letter to the property owner with the results of the crawlspace and indoor air testing. It concluded that there were no Raymark-related contaminants above levels that EPA considers acceptable for commercial occupancy at Superfund sites. EPA also stated that PERC was identified at elevated levels in indoor air in the building. Because PERC is not a target contaminant related to the Raymark site, EPA forwarded the sampling results to the SHD and DPH for review.

Discussion

1. Environmental Data

The EPA Indoor Air Soil Vapor Intrusion Study Report, Raymark Industries Superfund Site, OU-2 (EPA 2023) describes the sampling and analysis procedures in detail. To summarize, EPA followed the EPA Region I Standard Operating Procedure (SOP) for Canister Sampling to collect the indoor air samples and one outdoor sample. All canister samples were 8-hour time weighted average samples collected in evacuated 6-liter canisters. The EPA Region 6 laboratory analyzed the canisters using EPA Method TO-15 and following the Region 6 SOP for Toxic Organic Compounds in Ambient Air.

In the dance studio, EPA collected an indoor air canister sample from each of the five studios. In one studio, a duplicate canister sample was collected. EPA opted not to collect sub-slab soil gas samples because the floors were covered with laminate or rubber flooring. This made it impractical to install sub-slab sampling probes. In the dry cleaner, EPA collected two indoor air canister samples; one from the south side of the building and one from the north. The flooring here was concrete, but EPA discovered a small crawlspace between the slab-on-grade foundation and the floor in the south portion of the building. EPA opted not to install a sub-slab probe through the floor because there was not enough information about sub-slab utilities. Instead, EPA collected a canister air sample from the crawlspace. Finally, one canister sample was collected outside, at the southeast corner of the building.

EPA also collected air grab samples from each of the nine locations where a canister sample was collected, plus one additional location (inside a utility closet in the dance studio). At one location in the dry cleaner and one location in the dance studio, duplicate grab air samples were collected. Air grabs were collected with a 250-microliter steel-barreled glass syringe by drawing 200 microliters of air. EPA's mobile lab immediately analyzed the grab air samples following EPA Region 1's standard air screening method, Air Sample Analysis for Volatile Organic Compounds (EPA 2023).

There are important data gaps for this site. First, the data necessary to evaluate the VI pathway have not been collected. Specifically, there are no groundwater data from locations near the building and there is only one sample collected from beneath the flooring. This sample is from crawlspace air and as such, does not represent soil gas from beneath the foundation of the building. The single sample from the crawlspace air is not enough to determine whether there is a completed VI pathway for this site.

Because of this data gap, we cannot determine whether the source of the contaminants measured in indoor air are from VI, sources inside the building, or both. Another data gap is that there is only a single round of indoor air data. As stated previously, a single round of indoor air data does not provide information about variability in indoor air concentrations that may exist over time.

2. Indoor Air Screening Evaluation - Selection of Contaminants of Potential Concern

The first step in evaluating the indoor air exposure pathway is the screening analysis, which involves comparing detected concentrations at the site with health-based comparison values (CVs). Exceeding a CV does not mean that harmful health effects are possible. We use this screening process to select chemicals that require further evaluation.

DPH's CVs are identified from ATSDR's Public Health Assessment Site Tool (ATSDR PHAST 2024) and from CT DEEP (2003 and 2018). Table 1 in the Attachments provides the screening levels and results for the three contaminants detected at concentrations exceeding a CV (PERC, benzene, and TCE). Seven additional contaminants (acetone, methylene chloride, chloromethane, dichlorodifluoromethane, toluene, isopropyl alcohol, and xylenes) were detected in indoor air of the dance studio, dry cleaner, or both. They were all at levels below ATSDR CVs (and the state's Target Indoor Air Concentrations (TAC) when an ATSDR CV was not available).

These seven contaminants are not included in Table 1 because they were below ATSDR CVs and TAC values. Note that in all the samples reported as non-detect for benzene and TCE, the detection limits slightly exceed the recommended CV for cancer. ATSDR's recommended cancer CV for benzene is 0.13 $\mu\text{g}/\text{m}^3$, and the detection limit for benzene was around 0.4 $\mu\text{g}/\text{m}^3$. The recommended cancer CV for TCE is 0.21 $\mu\text{g}/\text{m}^3$, and the detection limit for the canister samples was about 0.8 $\mu\text{g}/\text{m}^3$ and for the grab samples was 2.7 $\mu\text{g}/\text{m}^3$. The detection limit is not an issue for screening noncancer endpoints.

PERC

Indoor air at the dry cleaner and at the dance studio exceeded Connecticut's and ATSDR's CVs for PERC. CVs were exceeded in all locations sampled except the utility closet and outside air.

TCE

There were only two locations (both in the dry cleaner) with results above the detection limit. Both were canister sample results. These two locations did not exceed the state's TAC for TCE but did exceed ATSDR's CV. All other locations, including outside air, were non-detect. However, it is important to note that all the reported detection limits exceeded ATSDR's CV.

Benzene

While none of the sample results exceeded the state's TAC for benzene, there were four locations where canister sample results exceeded ATSDR's CV (two in the dance studio and two in the dry cleaner). As with TCE, all the reported detection limits for benzene exceeded ATSDR's CV.

3. Indoor Air Exposure Point Concentration

An exposure point concentration (EPC) is the representative contaminant concentration within an exposure unit or area in an exposure pathway to which people are exposed for acute, intermediate, or chronic durations during the past, present or future. We selected EPCs for the dry cleaner and the

dancer studio. For the dry cleaner, the EPCs were the maximum concentration of each contaminant detected above a CV that was measured in any location in the dry cleaner. For the dance studio, the EPCs were the maximum concentration of each contaminant detected above a CV that was measured in any location in the dance studio. Table 2 shows the EPCs for PERC, TCE, and benzene, the three contaminants detected at concentrations greater than a CV. All the results from 8-hour samples were higher than the grab samples, so all selected EPCs are 8-hour canister results. An EPC for TCE was not selected for the dance studio because TCE was not detected in any sample above the detection limit.

4. Exposure Pathways

We determine exposure to a contaminant of concern by examining human exposure pathways. A completed exposure pathway consists of five elements: a source, a contaminated environmental medium and transport mechanism, a point of exposure, a route of exposure, and a receptor population. There is one completed exposure pathway at this site: inhalation of contaminants in indoor air. In the dry cleaner, adult workers and customers (adults and children) could be exposed via inhalation of air. In the dance studio, adults could be exposed while teaching dance classes, taking dance classes, performing administrative work, dropping off or picking up dance students, or observing dance classes. Children ages 1 to <18 years could be exposed while taking dance classes, dropping off or picking up other students, or observing dance classes.

In consultation with the SHD, we focused on several potentially exposed population groups in the dry cleaner and dance studio. Table 3 presents these population groups. For the dance studio, we evaluated an elite dancer aged 9 to <18 years who takes the highest number of dance classes recommended by the dance studio (according to the website of the dance studio). We also assumed that this receptor group spends time in the studio assisting with some classes for younger students. We also evaluated a very young dancer ages 1 to <2 years (the youngest age group for which classes are offered). Finally, we assumed that a child could start taking classes at age 1 year and continue taking classes until age <18 years. We also evaluated an adult administrative worker or full-time teacher in the dance studio. For the dry cleaner, we evaluated a full-time adult worker and a very young child (age <1 to <3 years) who is brought into the dry cleaner regularly by an adult customer.

We selected these population groups to be representative of the most sensitive individuals and the populations likely to receive the greatest amount of exposure. Other population groups (such as dance studio maintenance workers or family members observing dance classes) would be expected to have less exposure. Therefore, the conclusions presented in this evaluation would apply to them as well.

We evaluated exposures via inhalation in accordance with ATSDR guidance (ATSDR 2021). We adjusted the EPC by an exposure factor (EF) to account for the time individuals are exposed and not exposed at the site. If the exposure is assumed to be continuous (such as in a home), the EF is 1. We further adjust the EF using a ventilation scaling factor if the inhalation rate of the exposed population is expected to be higher than typical. The scaling factor is a ratio of the higher breathing rate at the site over the normal breathing rate.

We used ventilation scaling factors for the two dancer groups (elite dancer and young dancer), assuming that inhalation rates during a dance class would be higher than normal. We used age-specific mean inhalation rates for a heavy intensity activity level from ATSDR guidance (ATSDR 2021, Table A2) for the

dancer receptor groups. As an added level of protection, we also used the age-specific mean inhalation rate for light intensity activity (ATSDR 2021, Table A-2) for the young child visiting the dry cleaner. Finally, we calculated EFs separately for noncancer exposures and cancer exposures. The factors considered in the EF calculation differ depending on the type of calculation.

In selecting exposure assumptions for the dance studio receptor groups, we relied on site-specific information provided by the SHD and information on the website of the dance studio. This information included faculty and class schedules and the recommended numbers of classes per week for students. For other exposure assumptions, we relied on default exposure assumptions from ATSDR (ATSDR 2021). Table 3 includes the exposure assumptions and the sources for the assumptions we used to calculate the EF for the different groups. Table 3 in the Attachments and Section 5 of ATSDR 2021 [Equations (3), (4), (5) and (6)] provide details of these calculations.

The VI pathway for this site is a potential exposure pathway. We did not have enough data to evaluate it. There is only one sample of crawlspace air from beneath the foundation of the dry-cleaning facility, and no groundwater data were available from locations adjacent to the property.

Public Health Implications

1. Cancer Risk Estimates

All three contaminants we evaluated are known to be human carcinogens or reasonably anticipated to be human carcinogens. PERC is classified as “reasonably anticipated to be a carcinogen” by the National Toxicology Program (NTP) and “likely to be carcinogenic” by EPA (ATSDR PHAST, 2024). Benzene and TCE are classified as “known human carcinogens” by NTP and EPA (ATSDR PHAST, 2024).

In accordance with ATSDR guidance (ATSDR 2021), we calculated inhalation cancer risks using the EPC (adjusted by the EF) multiplied by an inhalation unit risk (IUR) for cancer. We used EPA IURs for each of the three contaminants evaluated (see Table 4). As shown in Table 4, TCE has separate IUR values for three types of cancer. So, we had to calculate cancer risks separately using each IUR and then sum them for a total cancer risk from TCE exposure (ATSDR PHAST). The EPA IUR is the incremental cancer risk posed by a specific concentration in air (typically 1 microgram per cubic meter [$\mu\text{g}/\text{m}^3$]). The cancer risk calculation yields the relative increase in cancer risk (above background cancer rates) from exposure to the pollutant for a specified duration. This is also referred to as the excess lifetime cancer risk (ELCR).

Chemicals that cause cancer by a mutagenic mode of action are evaluated differently from those that are not mutagenic. These chemicals require an additional step in the cancer evaluation because they might result in a higher cancer risk for children than for adults. Of the three contaminants evaluated in this assessment, the EPA regional screening level (RSL) table identifies only TCE as a mutagen (EPA, 2023).

As recommended by ATSDR guidance (ATSDR 2021), we followed the EPA process for quantifying the increased cancer risk for mutagens using age-dependent adjustment factors (ADAFs). The ADAF for ages birth to <2 years is 10. The ADAF for ages 2 to <16 years is 3. For simplicity, we used an ADAF of 10 for the very young dancer group (ages 1 to <3 years) and an ADAF of 3 for both the elite dancer (ages 9 to <18 years) and young dancer (ages 3 to <9 years) groups. Similarly, the dry cleaner young child customer/visitor (ages 1 to <3 years) includes children in both the ADAF 10 and ADAF 3 age groups. For

simplicity, we applied an ADAF of 10 to the entire group. Our simplified approach is more conservative than calculating pro-rated ADAFs for these groups.

Dance Studio Cancer Risk Estimates

Table 5a presents estimated cancer risks for each of the receptor groups for PERC and benzene and also as a total for both chemicals. The total excess lifetime cancer risk (ELCR) for the dancer group is summed for all dancers, to reflect someone who takes classes from ages 1 to <18 years. Table 5a shows that the estimated cancer risks for each of the dance studio groups range from 4.5E-9 to 4.7E-7. The cancer risks for the adult administrative worker/teacher range from 2.9E-7 to 5.4E-7. Each of these risk estimates are less than one excess cancer case in a million exposed (1E-6).

A cancer risk of 1E-6 is meaningful because it is the cancer risk limit Connecticut uses to derive cleanup standard for individual chemicals at hazardous waste sites (CT Remediation Standard Regulations). A cancer risk level of less than 1E-6 is considered insignificant or *de minimus*.¹ Chemicals present at concentrations less than the state's cleanup standards are considered to pose insignificant risks. So, they do not need to be cleaned up, stopped, or reduced. Exposures from inhalation of indoor air at the dance studio do not exceed a cancer risk estimate of 1E-6 for any individual chemical. Therefore, they do not pose a concern for increased cancer risk to people who work, visit, or take classes at the dance studio.

Table 5a also presents cancer risk estimates summed for all chemicals. For the dancer receptor group, the ELCR reflects all three age groups. It represents the total estimated cancer risk to a dancer who takes classes from age 1 to <18 years. Total cancer risks for dancers and adult administrative workers/teachers are also less than 1E-6 for all chemicals combined. Total cancer risks for individuals visiting the dance studio to work, take classes, or pick up/drop off dance students are less than 1E-6. Therefore, there is no concern for increased cancer risks from exposures at the dance studio.

Dry Cleaner Cancer Risk Estimates

Table 5b shows that estimated cancer risks for the child visitor do not exceed Connecticut's cancer risk limit of 1E-6 per chemical. For the young child customer, cancer risks from PERC, benzene, and TCE range from 9.8E-10 to 4.9E-8, all well below the state's cancer risk limit of 1E-6 per chemical. Total cancer risks for the young child customer summed for all three chemicals are 8E-8; which is also well below 1E-6. Therefore, there is no concern for increased cancer risk from inhalation exposures to customers (even a very young child brought regularly with an adult) .

For the dry cleaner worker, Table 5b shows that their estimated cancer risk from 20 years of exposure to benzene is associated with a cancer risk estimate of 2.7E-7, which is less than the state's risk limit. However, cancer risks from exposure to PERC and TCE are greater than the state's cancer risk limit of 1E-6 per chemical. Additionally, the dry cleaner worker's total cancer risk estimate for all chemicals combined is 1E-5. This indicates that there may be a concern for increased cancer risk and actions may be warranted to reduce or stop exposure for dry cleaner workers.

2. Noncancer Risk Estimates

¹ For perspective, according to the National Cancer Institute, approximately 40% (400,000 in one million) of men and women in the United States will be diagnosed with cancer at some point in their lifetimes. <https://www.cancer.gov/about-cancer/understanding/statistics#:~:text=Approximately%2039.5%25%20of%20men%20and,on%202015%E2%80%932017%20data>).

In accordance with ATSDR guidance (ATSDR 2021), we evaluate the likelihood of noncancer health effects from inhalation by calculating hazard quotients (HQ) for individual contaminants. The inhalation HQ is the ratio of the EPC (adjusted by the exposure factor) to a noncancer health guideline. For inhalation, this is an ATSDR minimal risk level (MRL) or an EPA reference concentration (RfC).

We evaluated noncancer health impacts from acute and chronic exposures using ATSDR's MRLs for each of the three contaminants (PERC, TCE and benzene). EPA RfCs were also available for the three contaminants. The RfCs for PERC and TCE are similar or identical to ATSDR's chronic MRLs. The RfC for benzene is higher ($30 \mu\text{g}/\text{m}^3$) than ATSDR's chronic MRL and is based on a less recent study. ATSDR's chronic MRL is more protective and is the chronic noncancer toxicity value recommended in PHAST. The inhalation MRL is the concentration of a contaminant in air that is unlikely to cause noncancer health impacts for the specified duration of exposure. MRLs are developed for chronic (1 year or more), intermediate (15 days to 364 days), and acute (less than 14 days) exposure durations. If the HQ is equal to or less than 1.0, noncancer health impacts are unlikely to result from exposure to the contaminant. If the HQ is greater than 1.0, further evaluation is warranted by reviewing the principal and supporting studies used to develop the health guideline. We calculated HQs for chronic and acute noncancer health effects. MRLs used in the noncancer risk calculations are shown in Table 6.

Dance Studio Noncancer Risk Estimates

Chronic Hazard Quotients

Table 7a shows estimated chronic HQs for the three receptor groups (elite dancer, young dancer, and adult faculty/administrator) from exposure to PERC and benzene. The HQs range from 0.002 to 0.39. These chronic HQs are less than 1.0, the noncancer risk limit Connecticut uses to develop cleanup standards for individual chemicals at hazardous waste sites (CT Remediation Standard Regulations). Chemicals at concentrations less than 1.0 are not considered to pose significant risks and do not need to be cleaned up. Because exposures from inhalation of indoor air at the dance studio are not greater than a HQ of 1.0, chronic noncancer health impacts are unlikely to result.

Acute Hazard Quotients

Table 7b shows that estimated acute HQs for the three receptor groups from exposure to PERC and benzene do not exceed 1.0. Therefore, short-term inhalation exposures in the dance studio are unlikely to cause noncancer health impacts.

Dry Cleaner Noncancer Risk Estimates

Chronic Hazard Quotients

Table 7a shows that the estimated chronic HQs for the young child customer from exposure to PERC, benzene, and TCE range from 0.0003 to 0.07, far below 1.0. This means that the exposures are below the minimal risk level. Thus, there is no concern for chronic noncancer risks from inhalation exposures of customers (even a very young child brought regularly with an adult).

Table 7a also presents the estimated chronic HQs for the dry cleaner worker. The chronic HQs for the worker's exposure to benzene (0.01) and TCE (0.61) are below 1.0, so noncancer effects are not a concern. However, the HQ from exposure to PERC is 3.0. We need further evaluation to determine if harmful effects in workers might be possible.

Acute Hazard Quotients

Table 7b shows the estimated acute HQs for the young child customer and dry cleaner worker. As noted in this table, TCE was not evaluated because it does not have an acute inhalation toxicity value. For the young child customer, acute HQs for PERC and benzene do not exceed 1.0. For the worker, the acute HQ for benzene is also well below 1.0 (0.007). Therefore, short-term inhalation exposure to benzene for both groups is unlikely to cause noncancer health impacts. However, the acute HQ from exposure to PERC is 4.4. We need further evaluation to determine if harmful effects in workers might be possible.

3. Review of critical and supporting studies - PERC inhalation noncancer toxicity value

Because acute and chronic HQs for dry cleaner workers exposed to PERC exceeded 1.0, we need a review of the critical and supporting studies that were used to develop the health guideline.

As described in ATSDR's Toxicological Profile for Tetrachloroethylene (ATSDR 2019), ATSDR's chronic and acute duration MRL (41 $\mu\text{g}/\text{m}^3$ or 6 ppb) was derived based on a study by Cavalleri *et al.* 1994. The study identified a lowest observed adverse effect level² (LOAEL) of 7.3 ppm (49.51 mg/m^3) for color vision impairment in dry cleaning and laundry workers chronically exposed to PERC in the workplace. The LOAEL was converted to a continuous exposure concentration of 1.7 ppm (11.53 mg/m^3) and then divided by a total uncertainty factor of 300 to yield an MRL of 0.006 ppm (41 $\mu\text{g}/\text{m}^3$).

The adjusted EPC for chronic noncancer exposure to dry cleaner workers in this evaluation is 124.7 $\mu\text{g}/\text{m}^3$ (Table 7a). The adjusted EPC for acute noncancer exposure to dry cleaner workers is 182 $\mu\text{g}/\text{m}^3$ (Table 7b). Both concentrations are well below the LOAEL of 11.53 mg/m^3 (11,530 $\mu\text{g}/\text{m}^3$) used to derive the MRL. This indicates that even though the exposure of dry cleaner workers exceeds the MRL by several fold, the exposure levels are still well within the margin of safety built into the MRL. They are also well below exposure levels that could be associated with noncancer health impacts.

Uncertainties and Limitations

CT DPH has identified the following uncertainties and limitations in this evaluation:

- The assessment of exposure to contaminants in indoor air is based on limited data. This creates uncertainty in the risk estimates. Indoor air was tested only once. Levels of contaminants in indoor air could fluctuate over time and could have been higher or lower in the past. Indoor air concentrations could also be higher or lower in different seasons and could be impacted by weather and other variables.
- Because of the limited data, we used the maximum concentration as the EPC for all risk estimates. An average concentration might be more representative of long-term exposures. Use of the maximum concentration is generally a more health-protective estimate of the actual exposure concentration than an average.
- There was not enough data to evaluate the VI pathway. We don't know if the contaminants in indoor air originated from indoor sources, from the groundwater via the VI pathway, or a combination of both. This limitation will impact decisions about interventions to reduce indoor air concentrations.

² A lowest observed adverse effect level (LOAEL) is the lowest tested dose of a substance that has been reported to cause harmful health effects.

- The detection limits for benzene and TCE in many of the indoor air samples (and the outdoor air sample) were slightly higher than the recommended CVs for cancer. This did not affect our evaluation.

Conclusions

CT DPH has reached the following conclusions based on its preliminary assessment of indoor air at the dry cleaner and dance studio. As stated previously, there are important data limitations and uncertainties in this assessment. There is only one round of indoor air sampling data and there are not enough data to evaluate the VI pathway. A single round of indoor air data does not provide information about variability in indoor air concentrations that may exist over time. Therefore, DPH's conclusions are based on the assumption that the single round of indoor air data is representative of exposures over time. The collection and evaluation of additional data may reduce the uncertainty associated with the conclusions presented here.

- Breathing PERC and benzene in the indoor air of the dance studio is not expected to harm the health of visitors. Exposure concentrations are below levels of health concern for cancer and noncancer and are associated with a very low risk of cancer. They are also well below ATSDR's health guidelines for noncancer health effects. Exposure levels also do not exceed the state's risk limits for health-based cleanup of contaminants. TCE levels in the dance studio did not exceed the detection limit.
- Breathing PERC, benzene, and TCE in the indoor air of the dry cleaner is not expected to harm the health of customers. Exposure concentrations are below levels of health concern for cancer and noncancer and are associated with a very low risk of cancer. They are also well below ATSDR's health guidelines for noncancer health effects. Exposure levels also do not exceed the state's risk limits for health-based cleanup of contaminants.
- Breathing PERC, benzene, and TCE in the indoor air of the dry cleaner for more than 20 years could pose a concern for increased excess lifetime cancer risks in workers.
- Breathing PERC, benzene, and TCE in the indoor air of the dry cleaner is not expected to cause noncancer harmful health impacts to workers. Benzene and TCE exposure levels do not exceed noncancer health guidelines for chronic and acute exposures. Although exposure levels of PERC exceed noncancer health guidelines for chronic and acute exposures, they are well within the margin of safety. Therefore, dry cleaner workers breathing PERC are unlikely to have noncancer health impacts.

Recommendations

- CT DEEP is encouraged to work with the property owner to identify whether the source of PERC, benzene, and TCE in indoor air is VI from groundwater, products used in the dry cleaner, or both. A better understanding of contaminant source(s) will inform strategies that could effectively reduce indoor air contaminant levels.

- It may be beneficial for the SHD to coordinate an effort to provide the tenants of the building (dry cleaner and dance studio) with indoor air testing results, along with risk communication information to help them understand their exposures and risks and information about additional actions planned for the site.
- The property owner is highly encouraged to take action as soon as possible to reduce the indoor air concentrations of PERC and TCE in the dry cleaner. Ideally, such action should be informed by an understanding of whether the source of these contaminants in indoor air is from groundwater vapor intrusion, use of PERC-containing dry-cleaning products, or both. Potential actions the owner of the dry cleaner may take include increasing the amount of ventilation in the dry cleaner and switching from using products containing PERC and TCE to dry cleaning products without such chemicals.
- After action is taken in the dry cleaner to reduce contaminant levels in indoor air, the property owner is highly encouraged to retest indoor air in both the dry cleaner and dance studio.

Public Health Action Plan

- CT DPH is expected to work with the SHD, EPA, and CT DEEP to develop and deliver risk communication messaging to the dry cleaner and dance studio.
- CT DPH is expected to help the SHD, EPA, and CT DEEP implement the recommendations in this document.
- CT DPH is expected to evaluate additional data from this site upon request from the SHD.

Report Preparation

The CT DPH prepared this letter health consultation for the 635 East Broadway property in Stratford, Fairfield County, CT. This publication was made possible by a cooperative agreement (program # TS-23-0001) with ATSDR. The CT DPH evaluated data of known quality using approved methods, policies, and procedures existing at the date of publication. ATSDR reviewed this document and concurs with its findings.

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Attachments

Figure, Tables and Risk Calculations

Figure 1: Location of 635 E. Broadway site within the Raymark Industries Superfund Site

Source: EPA Proposed Plan, Raymark Industries, Inc., June 2016.

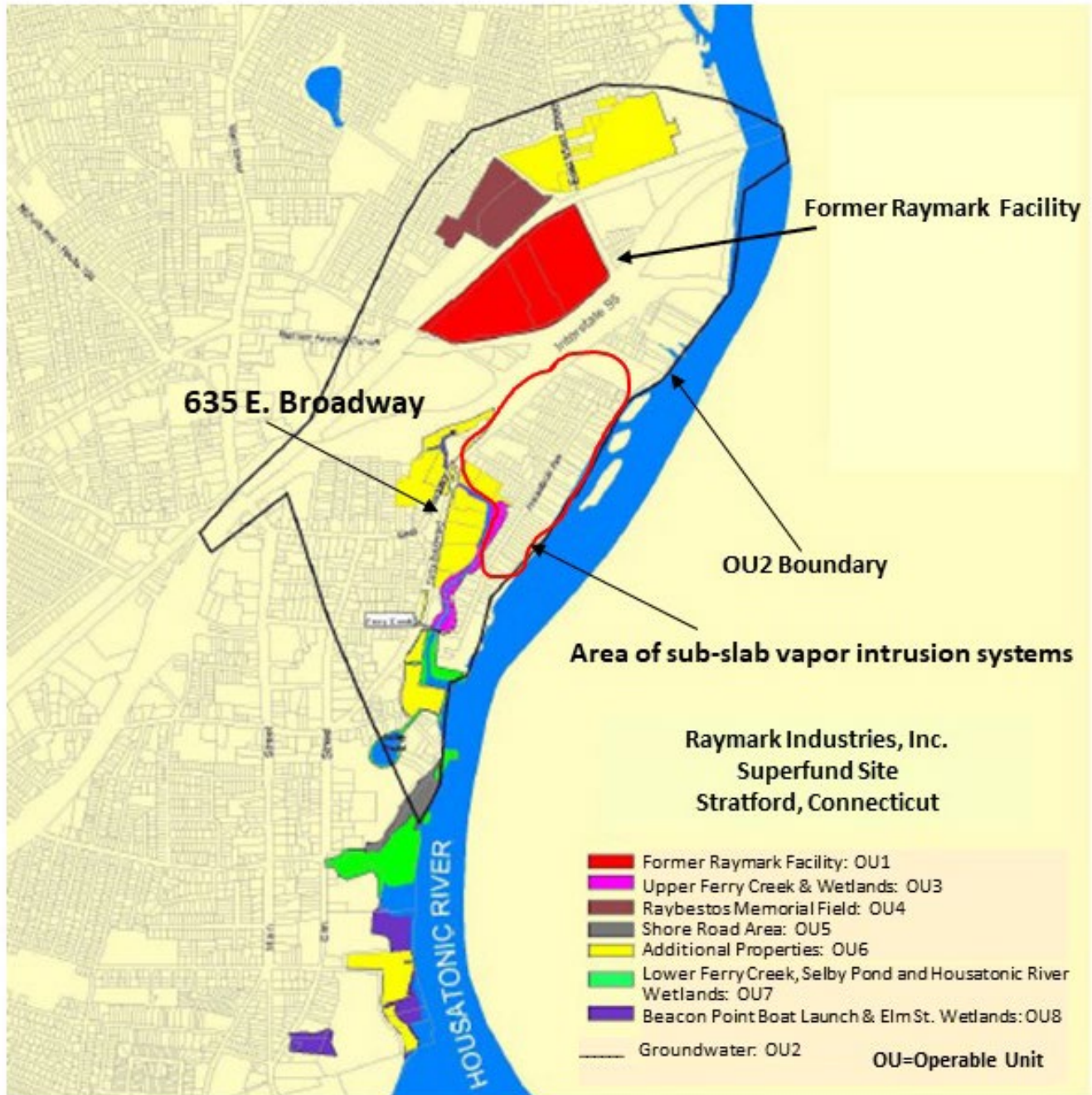


Table 1. Indoor Air and Ambient Air Sample Results from 635 E. Broadway, Stratford, CT Exceeding a Comparison Value. Samples Collected March 2024 by U.S. Environmental Protection Agency, All Units in $\mu\text{g}/\text{m}^3$.

Sample Location, Sample Type	PERC	TCE	Benzene
Dance Studio A, 8-hr canister	4.53*	ND (0.80)	ND (0.47)
Dance Studio A, 8-hr canister duplicate	3.06	ND (0.87)	0.52*
Dance Studio A, Grab	3.05	ND (2.7)	NA
Dance Studio B, 8-hr canister	5.16*	ND (0.80)	ND (0.48)
Dance Studio B, Grab	2.71	ND (2.7)	NA
Dance Studio C, 8-hr canister	4.90*	ND (0.73)	ND (0.44)
Dance Studio C, Grab	4.74*	ND (2.7)	NA
Dance Studio D, 8-hr canister	33.20*	ND (0.78)	ND (0.46)
Dance Studio D, Grab	21.7*	ND (2.7)	NA
Dance Studio D, Grab duplicate	18.9*	ND (2.7)	NA
Dance Studio E, 8-hr Canister	30.8*	ND (0.85)	0.60*
Dance Studio E, Grab	20.3*	ND (2.7)	NA
Dance Studio Utility Closet, Grab	2.71	ND (2.7)	NA
Ambient Air	ND (0.99)	ND (0.78)	ND (0.46)
Ambient Air Grab	ND (1.35)	ND (2.69)	NA
Dry Cleaner 1, 8-hr canister	442*	2.31*	0.56*
Dry Cleaner 1, Grab	433.8*	ND (2.69)	NA
Dry Cleaner 2, 8-hr canister	514*	5.31*	0.44*
Dry Cleaner 2, Grab	433.8*	ND (2.69)	NA
Dry Cleaner 2, Grab duplicate	271.13*	ND (2.69)	NA
Comparison Value	PERC	TCE	Benzene
CT TAC - Residential	5	1	3.3
CT TAC - Industrial/Commercial	5	1	3.3
ATSDR CREG – Residential	3.8	0.21	0.13

*result exceeds a Comparison Value.

$\mu\text{g}/\text{m}^3$ = micrograms of contaminant per cubic meter of air

ND = non-detect. Detection limit for ND samples is in parentheses. Note that all detection limits exceed one or more comparison values.

NA = not analyzed

CT TAC = Connecticut Target Indoor Air Concentration (CT DEEP 2003)

CREG = Cancer Risk Evaluation Guideline (from ATSDR Public Health Assessment Site Tool [PHAST, accessed 1/24/24])

PERC= Tetrachloroethylene

TCE= Trichloroethylene

Table 2. Exposure Point Concentrations for Indoor Air Contaminants, 635 East Broadway, Stratford.

Contaminant	Exposure Point Concentration: Dance Studio ($\mu\text{g}/\text{m}^3$)	Exposure Point Concentration: Dry Cleaner ($\mu\text{g}/\text{m}^3$)
Tetrachloroethylene (PERC)	33.2	514
Benzene	0.60	0.56
Trichloroethylene (TCE)	Not measured above detection limit	5.31

$\mu\text{g}/\text{m}^3$ = micrograms of contaminant per cubic meter of air

Table 3. Receptors, Selected Exposure Assumptions, Inhalation Rate Scaling and Exposure Factors, 635 East Broadway, Stratford.

Receptor Group	Frequency	Frequency Source	Inhalation Rate Scaling Factor	Exposure Factor
Elite Dancer, age 9 to <18 yrs	3 hours/day, 6 days/week, 50 weeks/year	Site specific	4.64 (heavy intensity) [#]	0.0550 (cancer) 0.4765 (chronic noncancer) 0.5797 (acute noncancer)
Very Young Dancer, age 1 to <3 yrs	1 hour/day, 1 day/week, 50 weeks/year	Site specific	6.56 (high intensity) [#]	0.00096 (cancer) 0.0375 (chronic noncancer) 0.2734 (acute noncancer)
Young Dancer, age 3 to <9	2 hours/day, 2 days/week, 50 weeks/year	Site specific	5.15 (high intensity) [#]	0.0090 (cancer) ^{&}
Adult Faculty/Admin	8.5 hours/day, 5 days/week, 50 weeks/year	ATSDR [^]	none	0.0622 (cancer) 0.2426 (chronic noncancer) 0.3542 (acute noncancer)
Adult Dry Cleaner Worker	8.5 hours/day, 5 days/week, 50 weeks/year	ATSDR [^]	none	0.0622 (cancer) 0.2426 (chronic noncancer) 0.3542 (acute noncancer)
Dry Cleaner customer with young child age <1 to <3 yrs	0.5 hours/day, 1 day/week, 50 weeks/year	Site specific	2.04 (low intensity)	0.00022 (cancer) 0.0058 (chronic noncancer) 0.0425 (acute noncancer)

[^]ATSDR Guidance for Inhalation Exposures, 2021.

[#] the average heavy intensity mean inhalation rates for the receptor age group divided by the long-term default inhalation rate for the receptor age group (Table A-2, ATSDR 2021)

[&]The Dancer aged 3 to <9 receptor group was used only for assessing total cancer risks for a dancer aged 1 to <18 years.

Table 4. Cancer Inhalation Unit Risk Values, 635 East Broadway, Stratford.

Contaminant	Inhalation Unit Risk (risk per μg per m^3) [^]
PERC	2.6E-7
Benzene	7.8E-6
TCE	2.1E-6 (NHL), 1E-6 (Liver and Kidney cancer)

μg per m^3 = micrograms of contaminant per cubic meter of air

PERC = Tetrachloroethylene, or perchloroethylene

TCE = Trichloroethylene

[^]EPA Integrated Risk Information System (IRIS), accessed via ATSDR PHAST

NHL = non-Hodgkins Lymphoma

Table 5a. Cancer Risk Estimates, Dance Studio - Indoor Air Inhalation Pathway, 635 East Broadway, Stratford.

Chemical	Elite Dancer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Young Dancer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Very Young Dancer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Adult Adj. EPC ($\mu\text{g}/\text{m}^3$)	Elite Dancer ELCR	Young Dancer ELCR	Very Young Dancer ELCR	Adult ELCR	All Dancers Combined Total ELCR for all chemicals	Adult Total ELCR for all chemicals
PERC	1.83	0.3	0.032	2.065	4.7E-7	7.8E-8	8.3E-9	5.4E-7	8.6E-7	8.3E-7
Benzene	0.033	0.005	0.001	0.037	2.6E-7	4.2E-8	4.5E-9	2.9E-7	8.6E-7	8.6E-7
TCE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	8.6E-7	8.6E-7

Adj. EPC = Adjusted Exposure Point Concentration

$\mu\text{g}/\text{m}^3$ = micrograms of contaminant per cubic meter of air

ELCR = Excess Lifetime Cancer Risk

PERC = Tetrachloroethylene, or perchloroethylene

TCE = Trichloroethylene

n/a = not assessed because TCE was not detected in the dance studio above the detection limit.

Table 5b. Cancer Risk Estimates, Dry Cleaners - Indoor Air Inhalation Pathway, 635 East Broadway, Stratford.

Chemical	Adult Worker Adj. EPC ($\mu\text{g}/\text{m}^3$)	Young Child Customer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Adult Worker ELCR	Young Child Customer ELCR	Adult Worker Total ELCR-all chemicals	Young Child Customer Total ELCR-all chemicals
PERC	31.97	0.115	8.3E-6*	3.0E-8	1.0E-5*	8.0E-8
Benzene	0.035	0.0001	2.7E-7	9.8E-10	1.0E-5*	8.0E-8
TCE	0.33	0.001	1.35E-6*	4.9E-8	1.0E-5*	8.0E-8

Adj. EPC = Adjusted Exposure Point Concentration

$\mu\text{g}/\text{m}^3$ = micrograms of contaminant per cubic meter of air

ELCR = Excess Lifetime Cancer Risk

PERC = Tetrachloroethylene, or perchloroethylene

TCE = Trichloroethylene

n/a = not applicable (TCE was not detected in the dance studio at levels above the detection limit).

*Cancer risk exceeds one in one million (1E-6).

Table 6. Minimal Risk Levels (MRL) used in Noncancer Risk Calculations, 635 E. Broadway, Stratford.

Contaminant	Chronic Inhalation MRL ($\mu\text{g}/\text{m}^3$) [^]	Acute Inhalation MRL ($\mu\text{g}/\text{m}^3$) [^]
PERC	41	41
Benzene	9.6	29
TCE	2.1	---

$\mu\text{g}/\text{m}^3$ = micrograms of contaminant per cubic meter of air

PERC = Tetrachloroethylene, or perchloroethylene

TCE = Trichloroethylene

[^]Chronic and Acute Inhalation Minimal Risk Levels (MRLs) from ATSDR PHAST.

Table 7a. Chronic Noncancer Risk Estimates - Indoor Air Inhalation Pathway, 635 East Broadway, Stratford.

Location	Chemical	Elite Dancer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Young Dancer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Adult Faculty/Admin Adj. EPC ($\mu\text{g}/\text{m}^3$)	Elite Dancer Chronic HQ	Young Dancer Chronic HQ	Adult Faculty/Admin Chronic HQ
Dance Studio	PERC	15.82	1.24	8.05	0.39	0.03	0.20
	Benzene	0.29	0.02	0.15	0.03	0.002	0.02
	TCE	n/a	n/a	n/a	n/a	n/a	n/a

Location	Chemical	Adult Worker Adj. EPC ($\mu\text{g}/\text{m}^3$)	Young Child Customer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Adult Worker Chronic HQ	Young Child Customer Chronic HQ
Dry Cleaner	PERC	124.7	2.99	3.0*	0.07
	Benzene	0.14	0.003	0.01	0.0003
	TCE	1.29	0.03	0.61	0.01

Adj. EPC = Adjusted Exposure Point Concentration

Chronic HQ = Chronic Hazard Quotient

$\mu\text{g}/\text{m}^3$ = micrograms of contaminant per cubic meter of air

PERC = Tetrachloroethylene, or perchloroethylene

TCE = Trichloroethylene

n/a = not applicable (TCE was not detected in the dance studio at levels above the detection limit).

*HQ exceeds 1.0

Table 7b. Acute Noncancer Risk Estimates - Indoor Air Inhalation Pathway, 635 East Broadway, Stratford.

Location	Chemical	Elite Dancer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Young Dancer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Adult Faculty/Admin Adj. EPC ($\mu\text{g}/\text{m}^3$)	Elite Dancer Acute HQ	Young Dancer Acute HQ	Adult Faculty/Admin Acute HQ
Dance Studio	PERC	19.24	9.08	8.05	0.47	0.22	0.29
	Benzene	0.35	0.16	0.21	0.01	0.006	0.007
	TCE	n/a	n/a	n/a	NC	NC	NC

Location	Chemical	Adult Worker Adj. EPC ($\mu\text{g}/\text{m}^3$)	Young Child Customer Adj. EPC ($\mu\text{g}/\text{m}^3$)	Adult Worker Acute HQ	Young Child Customer Acute HQ
Dry Cleaner	PERC	182	21.8	4.4*	0.53
	Benzene	0.2	0.024	0.007	0.0008
	TCE	1.88	0.23	NC	NC

Adj. EPC = Adjusted Exposure Point Concentration

Acute HQ = Acute Hazard Quotient

$\mu\text{g}/\text{m}^3$ = micrograms of contaminant per cubic meter of air

PERC = Tetrachloroethylene, or perchloroethylene

TCE = Trichloroethylene

n/a = not assessed because TCE was not detected in the dance studio at levels above the detection limit.

NC = not calculated because there is no acute MRL for TCE.

*HQ exceeds 1.0

Inhalation Risk Assessment Equations (from ATSDR 2021)

Cancer:

$$\text{ELCR} = \text{IUR} * \text{EPC} * \text{Exp. Fctr} * \text{ADAF}$$

$$\text{Exp Fctr} = \text{site exp}/24 \text{ hours} * \text{site exp}/7 \text{ days} * \text{site exp}/52.14 \text{ weeks} * \text{ED}/\text{AT} * \text{InhScale}$$

$$\text{InhScale} = \text{site IR}/\text{default IR}$$

Where:

ELCR = Excess Lifetime Cancer Risk

IUR = inhalation Unit Risk (risk per $\mu\text{g}/\text{m}^3$, chemical-dependent)

EPC = exposure point concentration at the site ($\mu\text{g}/\text{m}^3$, chemical-dependent)

Exp Fctr = Exposure Adjustment Factor (unitless)

ADAF = age-dependent adjustment factor (unitless)

Site Exp = hours, days or weeks of exposure at the site (receptor-dependent)

ED = exposure duration in years (receptor-dependent)

AT = averaging time (78 years)

InhScale = inhalation scaling factor (unitless)

Site IR = inhalation rate at the site (m^3/day , receptor-dependent)

Default IR = long term default inhalation rate (m^3/day , receptor-dependent)

Term	Value
IUR (risk per $\mu\text{g}/\text{m}^3$)	Tetrachloroethylene = $2.6\text{E}-7^{\wedge}$ Benzene = $7.8\text{E}-6^{\wedge}$ Trichloroethylene = $2.1\text{E}-6^{\wedge}$ (non-Hodgkins Lymphoma), $1\text{E}-6$ (Liver and Kidney)
EPC ($\mu\text{g}/\text{m}^3$)	Tetrachloroethylene = 33.2 (Dance Studio), 514 (Dry Cleaner) Benzene = 0.60 (Dance Studio), 0.56 (Dry Cleaner) Trichloroethylene = 5.31 (Dry Cleaner)
ADAF	Tetrachloroethylene = 1 Benzene = 1 Trichloroethylene = 1 (adult worker), 3 (Elite Dancer), 10 (Very Young Dancer and young dry cleaner customer)
Site Exp	Elite Dancer = 3 hours/day, 6 days/week, 50 weeks/year Young Dancer = 2 hours/day, 2 days/week, 50 week/year Very Young Dancer = 1 hour/day, 1 day/week, 50 weeks/year Adult Faculty and Dry Cleaner Worker = 8.5 hours/day, 5 days/week, 50 weeks/year Dry Cleaner Customer = 0.5 hours/day, 1 day/week, 50 weeks/year
ED	Elite Dancer = 9 years Young Dancer = 6 years Very Young Dancer = 2 years Adult Faculty and Dry Cleaner Worker = 20 years

	Dry Cleaner Customer = 3 years
AT	78 years
Site IR (m ³ /d)	Elite Dancer = 68.32 ⁺ Young Dancer = 56.88 ⁺ Very Young Dancer = 55.44 ⁺ Young Dry Cleaner Customer = 15.167 ^{&}
Default IR (m ³ /d)	Elite Dancer = 14.733 [*] Young Dancer = 11.050 [*] Very Young Dancer = 8.450 [*] Young Dry Cleaner Customer = 7.433 [*]

[^]EPA Integrated Risk Information System (IRIS), accessed via ATSDR PHAST

⁺Average Heavy Intensity Inhalation Rate for age group (ATSDR 2021)

[&]Average Light Intensity Inhalation Rate for age group (ATSDR 2021)

^{*}Average Long-term Default Inhalation Rate for age group (ATSDR 2021)

Chronic Noncancer:

$$\text{HQ} = \text{EPC} * \text{Exp Fctr} * 1/\text{Inhal MRL}$$

$$\text{Exp Fctr} = \text{site exp}/24 \text{ hours} * \text{site exp}/7 \text{ days} * \text{site exp}/52.14 \text{ weeks} * \text{ED}/\text{AT} * \text{InhScale}$$

$$\text{InhScale} = \text{site IR}/\text{default IR}$$

Where:

HQ = Hazard Quotient

EPC = exposure point concentration at the site (µg/m³, chemical-dependent)

Inhal MRL = inhalation Minimum Risk Level (µg/m³, chemical-dependent)

Exp Fctr = Exposure Adjustment Factor (unitless)

Site Exp = hours, days or weeks of exposure at the site (receptor-dependent)

ED = exposure duration in years (receptor-dependent)

AT = averaging time (years, scenario-dependent)

InhScale = inhalation scaling factor (unitless)

Site IR = inhalation rate at the site (m³/day, receptor-dependent)

Default IR = long term default inhalation rate (m³/day, receptor-dependent)

Term	Value
Inhal MRL ($\mu\text{g}/\text{m}^3$)	Tetrachloroethylene = 41 [^] Benzene = 9.6 [^] Trichloroethylene = 2.1 [^]
EPC ($\mu\text{g}/\text{m}^3$)	Tetrachloroethylene = 33.2 (Dance Studio), 514 (Dry Cleaner) Benzene = 0.60 (Dance Studio), 0.56 (Dry Cleaner) Trichloroethylene = 5.31 (Dry Cleaner)
Site Exp	Elite Dancer = 3 hours/day, 6 days/week, 50 weeks/year Young Dancer = 2 hours/day, 2 days/week, 50 weeks/year Very Young Dancer = 1 hour/day, 1 day/week, 50 weeks/year Adult Faculty and Dry Cleaner Worker = 8.5 hours/day, 5 days/week, 50 weeks/year Dry Cleaner Customer = 0.5 hours/day, 1 day/week, 50 weeks/year
ED	Elite Dancer = 9 years Young Dancer = 6 years Very Young Dancer = 2 years Adult Faculty and Dry Cleaner Worker = 20 yrs Dry Cleaner Customer = 3 yrs
AT	Elite Dancer = 9 years Young Dancer = 6 years Very Young Dancer = 2 years Adult Faculty and Dry Cleaner Worker = 20 years Dry Cleaner Customer = 3 years
Site IR (m^3/d)	Elite Dancer = 68.32 ⁺ Very Young Dancer = 55.44 ⁺ Young Dry Cleaner Customer = 15.167 ^{&}
Default IR (m^3/d)	Elite Dancer = 14.733 [*] Very Young Dancer = 8.450 [*] Young Dry Cleaner Customer = 7.433 [*]

[^]Chronic Inhalation Minimal Risk Levels from ATSDR PHAST.

⁺Average Heavy Intensity Inhalation Rate for age group (ATSDR 2021)

[&]Average Light Intensity Inhalation Rate for age group (ATSDR 2021)

^{*}Average Long-term Default Inhalation Rate for age group (ATSDR 2021)

Acute Noncancer:

$$\text{HQ} = \text{EPC} * \text{Exp Fctr} * 1/\text{Inhal MRL}$$

$$\text{Exp Fctr} = \text{site exp}/24 \text{ hours} * \text{InhScale}$$

$$\text{InhScale} = \text{site IR}/\text{default IR}$$

Where:

HQ = Hazard Quotient

EPC = exposure point concentration at the site ($\mu\text{g}/\text{m}^3$, chemical-dependent)

Inhal MRL = inhalation Minimum Risk Level ($\mu\text{g}/\text{m}^3$, chemical-dependent)

Exp Fctr = Exposure Adjustment Factor (unitless)

Site Exp = hours, days or weeks of exposure at the site (receptor-dependent)

InhalScale = inhalation scaling factor (unitless)

Site IR = inhalation rate at the site (m^3/day , receptor-dependent)

Default IR = long term default inhalation rate (m^3/day , receptor-dependent)

Term	Value
Inhal MRL ($\mu\text{g}/\text{m}^3$)	Tetrachloroethylene = 41 [^] Benzene = 29 [^]
EPC ($\mu\text{g}/\text{m}^3$)	Tetrachloroethylene = 33.2 (Dance Studio), 514 (Dry Cleaner) Benzene = 0.60 (Dance Studio), 0.56 (Dry Cleaner)
Site Exp	Elite Dancer = 3 hours/day Young Dancer = 2 hours/day Very Young Dancer = 1 hours/day Adult Faculty and Dry Cleaner Worker = 8.5 hours/day Dry Cleaner Customer = 0.5 hours/day
Site IR (m^3/d)	Elite Dancer = 68.32 ⁺ Very Young Dancer = 55.44 ⁺ Young Dry Cleaner Customer = 15.167 ^{&}
Default IR (m^3/d)	Elite Dancer = 14.733 [*] Very Young Dancer = 8.450 [*] Young Dry Cleaner Customer = 7.433 [*]

[^]Acute Inhalation Minimal Risk Levels from ATSDR PHAST.

⁺Average Heavy Intensity Inhalation Rate for age group (ATSDR 2021)

[&]Average Light Intensity Inhalation Rate for age group (ATSDR 2021)

^{*}Average Long-term Default Inhalation Rate for age group (ATSDR 2021)