

Health Consultation

Public Health Implications of Exposures to Indoor Air Contaminants

TED'S CLEANERS

INDOOR AIR SAMPLING RESULTS EVALUATION

NASHVILLE, DAVIDSON COUNTY, TENNESSEE

January 11, 2018

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The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the Agency for Toxic Substances and Disease Registry or the U.S. Department of Health and Human Services. This document has not been revised or edited to conform to ATSDR standards.

Foreword

This document summarizes an environmental public health investigation performed by the Environmental Epidemiology Program of the State of Tennessee Department of Health. Our work is conducted under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry. In order for the Health Department to answer an environmental public health question, several actions are performed:

Evaluate Exposure: Tennessee health assessors begin by reviewing available information about environmental conditions at a site. We interpret environmental data, review site reports, and talk with environmental officials. Usually, we do not collect our own environmental sampling data. We rely on information provided by the Tennessee Department of Environment and Conservation, U.S. Environmental Protection Agency, and other government agencies, businesses, or the general public. We work to understand how much contamination may be present, where it is located on a site, and how people might be exposed to it. We look for evidence that people may have been exposed to, are being exposed to, or in the future could be exposed to harmful substances.

Evaluate Health Effects: If people have the potential to be exposed to contamination, then health assessors take steps to determine if it could be harmful to human health. We base our health conclusions on exposure pathways, risk assessment, toxicology, cleanup actions, and the scientific literature.

Make Recommendations: Based on our conclusions, we will recommend that any potential health hazard posed by a site be reduced or eliminated. These actions will prevent possible harmful health effects. The role of the Environmental Epidemiology Program in dealing with hazardous waste sites is to be an advisor. Often, our recommendations will be action items for other agencies. However, if there is an urgent public health hazard, the Tennessee Department of Health can issue a public health advisory warning people of the danger, and will work with other agencies to resolve the problem.

If you have questions or comments about this report, we encourage you to contact us.

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Introduction

The Tennessee Department of Environment and Conservation's (TDEC) Division of Remediation Drycleaner Environmental Response Program (DCERP) asked the Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) to evaluate indoor air within four businesses of a shopping center that are adjacent to an active drycleaner. The active drycleaner, Ted's Cleaners (Ted's), operates six days per week. Clothing from other stores is also cleaned at Ted's.

Ted's is located in a commercial area of west Nashville. The shopping center is located at 7114 Highway 70 South, Suite #111 in Nashville, Davidson County, Tennessee, 37221 (Figure 1). The shopping center was constructed in 1974. Although the cleaner has had different owners, it has been operated continuously in its current location since 1975 (TVG 2017a).

Indoor air was tested in Voodoo Gumbo (formerly Gauc Mexican restaurant), Sam's Kabab Gyro (hereafter referred to as Sam's Kabab), Ted's, T-Mobile phone store (formerly Sweet CeCe's yogurt shop), and Jersey Mike's from 2015 through 2017. Sam's Kababs and T-Mobile are the two businesses on either side of the cleaner (Figures 2 and 3). Additionally, the storerooms in Mattress King (next to Voodoo Gumbo) and CVS (next to Jersey Mike's) were tested once in May 2016.

EEP evaluated what risk site contamination may have to current and future workers of and visitors to the businesses. TDEC DCERP specifically asked TDH EEP to evaluate levels of tetrachloroethylene (PCE) and trichloroethylene (TCE) in the indoor air in businesses near the drycleaner. This Health Consultation outlines EEP's health conclusions and recommendations based on an evaluation of the indoor air sampling results in each of the businesses near the cleaner. Agency for Toxic Substances and Disease Registry (ATSDR) and U.S. Environmental Protection Agency (EPA) health screening levels of PCE and TCE were used to evaluate the involuntary inhalation exposures in the businesses near to the cleaner.

The indoor air results in the cleaner were not evaluated because employees of the cleaner should have the potential health effects of drycleaning chemicals explained to them. They would have accepted their potential exposure as part of their work environment. Levels of chemicals cleaner employees could be exposed to would be regulated by a federal agency, the Occupational Safety and Health Administration (OSHA). PCE and TCE levels would be expected to be higher in a cleaner because of drycleaned clothing being stored, from opening the door of the drycleaning machine, and from the use of spot cleaners on clothing. The cleaner was sampled nearly every time with the other four businesses to compare results.

Background and Summary of Early Site Investigations

In June 1996, as part of a refinancing of the shopping center, the property owner arranged for a Phase I Environmental Site Assessment (ESA) to be performed on the entire shopping center, and a limited Phase II ESA to be performed at Ted's. Subsurface sampling performed during the Phase II ESA found PCE in both the soil and groundwater beneath Ted's. The most contamination was found in a shallow temporary groundwater monitoring well located southeast of the entrance to the cleaner (TVG 1998).



Figure 1. Location of shopping center with Ted's Cleaners and other businesses, 7114 Highway 70 S, Nashville, TN. Note apartments, single-family residences, and other retail and commercial shops along the highways in the area. Source: Google Earth

These findings prompted the cleaner owner to enroll Ted's in DCERP in 1998 (TVG 2017a). Subsurface investigations into the nature and extent of the contamination at the site have been on-going since and have continued under different ownerships of the drycleaning business.

The extent of soil and groundwater contamination at the property is thought to have been well defined based on the numerous soil, soil-gas, and groundwater sampling investigations conducted at the site. The contamination is defined to be beneath the Ted's and T-Mobile area of the shopping center and extending to the south into the center's parking lot. There also have been five *in situ* remediation treatments of groundwater done using proprietary technologies from 2002 to 2012. These *in situ* treatments were done to reduce the contaminant mass at the site (TVG 2017a). Contaminant reduction was noted in well MW-3, mixed results in wells MW-4 and MW-13, and no impact was observed in other onsite wells (Figure 2) located outside the treatment zones (TVG 2017a).

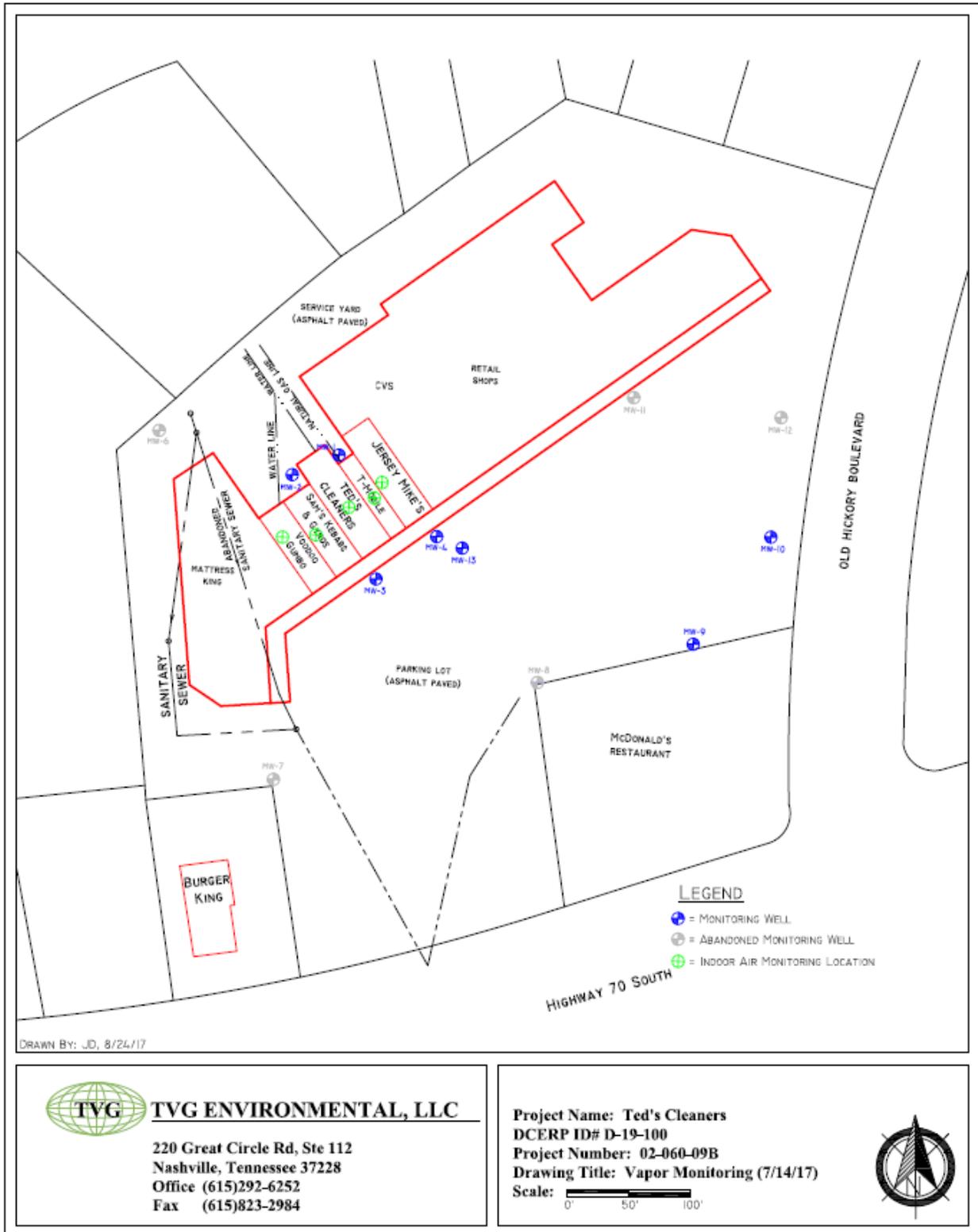


Figure 2. Location of Ted's Cleaners and adjacent businesses in the shopping center. Indoor air sampling locations and mitigation systems were installed in Ted's and in the two businesses on each side as shown in green. Site groundwater monitoring well locations are shown in blue. Utility lines as broken black lines are only partially shown. Source: TVG 2017d.



Figure 3. Photo showing locations of the businesses adjacent to Ted's Cleaners. Voodoo Gumbo and Sam's Kabab restaurants are located to the left of Ted's. Mattress King is located to the left of Voodoo Gumbo. T-Mobile is now located in the space noted by the Sweet CeCe's sign. Jersey Mike's is to the right of T-Mobile and CVS is located to the right of Jersey Mike's. Photo source: J. George, TDH, 2017.

Of note, there were increased concentrations of PCE breakdown chemicals that, along with geochemical data, showed PCE was being degraded in groundwater (TVG 2017a). Groundwater flow is toward the south at the site (TVG 2017a).

Since 2014, vapor intrusion investigations have been completed in businesses next to Ted's and inside Ted's to understand the potential for exposure of PCE and other drycleaner-related compounds to workers and customers working in and visiting those businesses. These investigations are further detailed later in this document.

Discussion

Introduction to Chemical Exposure

To determine whether persons have been or are likely to be exposed to chemicals, TDH EEP evaluates mechanisms that could lead to human exposure. Chemicals released into the environment have the potential to cause harmful health effects. Nevertheless, a release does not always result in exposure. People can only be exposed to a contaminant if they come into contact with it. If there is no contact with a contaminant, no exposure occurs. Therefore, no exposure-related health effects could occur. An exposure pathway contains five parts:

- a source of contamination,
- contaminant transport through an environmental medium,
- a point of exposure,
- a route of human exposure, and
- a receptor population.

An exposure pathway is considered complete if there is evidence that all five of these elements have been, are, or will be present at the site. An exposure pathway is considered incomplete if one of the five elements is missing.

The source is the place where the chemical was released. For this site, the potential source is spills from past activities and current operations performed at Ted's. The environmental media (such as, soil, surface water, groundwater, or air) transport the contaminants. For this site, the chemicals are potentially transported through the soil, groundwater, and indoor air. The point of exposure is the place where persons come into contact with the contaminated media. Indoor air is the potential point of exposure for this site. The route of exposure (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. For Ted's, the indoor air at several businesses has measureable levels of drycleaner solvent, thus the route of exposure would be breathing of indoor air.

Physical contact alone with a potentially harmful chemical in the environment by itself does not necessarily mean that a person will be harmed. A chemical's ability to affect health is controlled by a number of other factors, including:

- the amount of the chemical that a person is exposed to (dose),
- the length of time that a person is exposed to the chemical (duration),
- the number of times a person is exposed to the chemical (frequency),
- the person's age and health status, and
- the person's diet and nutritional habits.

The customers of the nearby businesses would be far less exposed to the chemicals in the indoor air because they would only spend a limited amount of time in the store. Business workers would have a higher likelihood of exposure based upon the amount of time spent in the leased space of the building. If it is found that there should be no harmful exposures for full-time workers, then there should not be harmful exposures for short-term workers or customers, including children.

Vapor Intrusion

Business customers and workers are the people who would be exposed if contaminated indoor air from the cleaner or from beneath the businesses was moving into the indoor air of the other businesses. Volatile and semi-volatile chemicals can evaporate from impacted subsurface soil and groundwater beneath a building and move toward areas of lower chemical levels such as in the atmosphere, utility conduits, or basements. This process is called vapor intrusion. Subsurface vapors can enter a building due to two main factors: environmental effects and building effects. Some examples of these effects are barometric pressure changes, wind load, temperature currents, or depressurization from building exhaust fans. Chemicals can migrate up and enter indoor air through foundation slabs, crawl spaces, or basements. The chemical migration depends on the construction of the building, unsealed joints or cracks in the foundation, the building's heating and ventilation characteristics, and other building design and operational elements. The amount of movement of the vapors into the building is difficult to measure and depends on soil type, chemical properties, building design and condition, and pressure differences between the outside and inside air (ITRC 2007). Upon entry into a structure, chemical vapors mix with the existing air through the natural or mechanical ventilation of the building.

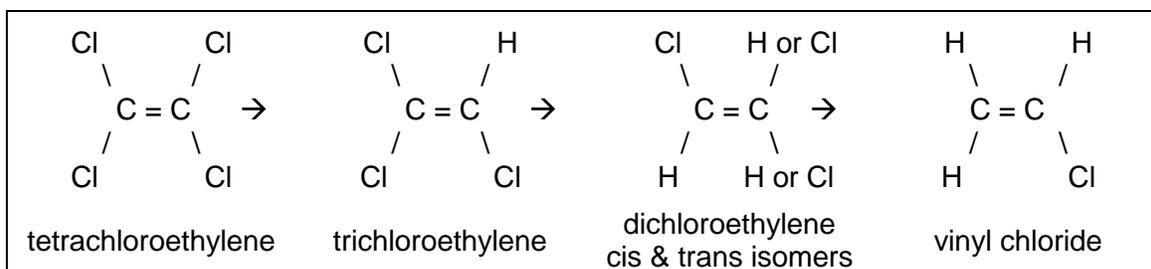
PCE and TCE can readily evaporate into air. These two chemicals are often seen at sites where vapor intrusion is occurring. PCE is the most abundant chemical found in indoor air of the businesses near the cleaner from either vapor intrusion or from infiltration from cleaner operation. TCE occurred in lesser amounts in the businesses.

Vapors may accumulate in buildings to levels that pose safety hazards, health risks, or odor problems. Vapor intrusion has been documented in buildings with basement, crawlspace, or slab-on-grade foundation types. Vapor intrusion can be an acute health hazard. Usually, indoor vapor levels are low. Low levels of vapors, breathed over a long period of time, may or may not be a chronic health concern. But in this case the levels are relatively high. High levels breathed over a long period of time have the potential to cause health effects.

Drycleaner Solvent Explanation

The process of drycleaning is not truly dry, but it uses so little water that it has come to be known as drycleaning. Instead of water, chemical solvents are used in the cleaning process. The most commonly used solvent for drycleaning is PCE or Perc. It is a colorless liquid and has sweet smell (ATSDR 1997). PCE is a volatile organic compound. It will quickly evaporate into a gas at room temperature. This evaluation is about PCE and its chemical breakdown products.

As its name implies, PCE has four chlorine anions on a two-carbon molecule. The molecule breaks down once it enters the soil or groundwater through chemical and microbial processes into other chlorinated volatile organics. Each of these breakdown chemicals has slightly different chemical properties and toxicities. The following diagram is an example of how one chemical can break down to form another.



In this example, PCE can break down to TCE, then to dichloroethylene (DCE), and then to vinyl chloride (VC). The only way to truly know the ratio of these breakdown chemicals is to collect environmental samples. PCE appears to be the dominant chemical present in site soil-gas. PCE is known to have been used at this drycleaner for at least 30 years. TCE could have been used as a spot cleaner for the drycleaning process. The solvents, PCE and TCE were carefully considered in developing this report.

Tetrachloroethylene (PCE)

The use of PCE as a dry cleaning agent, chemical intermediate, and metal degreasing agent has led to its release to the environment. PCE enters the environment mostly by evaporating into the air during use. In air it is slow to degrade, with estimated atmospheric half-lives of approximately 100 days. Data compiled from the EPA Air Quality System indicate that the ambient atmospheric level of PCE is typically less than 1 microgram per cubic meter ($\mu\text{g}/\text{m}^3$) (ATSDR 2014a).

PCE is a volatile liquid. When PCE is released to surface water or surface soil, it tends to volatilize quickly; however, PCE is also mobile in soil and has the potential to leach below the soil surface and contaminate groundwater and the air space between soil particles. PCE can also biodegrade to TCE, DCE, VC, and ethene through a process called reductive dechlorination. People can also be exposed to the degradation products, most commonly TCE, which is often found as a contaminant in products with PCE (ATSDR 2014a).

People can be exposed to PCE from environmental and occupational sources and from consumer products. Consumer products that may contain PCE include water repellants, silicone lubricants, fabric softeners, spot removers, adhesives, and wood cleaners. When you bring clothes home from the dry cleaners, the clothes may release small amounts of PCE into the air. PCE can also be found in breast milk of mothers who have been exposed to the chemical (ATSDR 2014a).

PCE can enter your body when you breathe air, drink water, or eat food containing it. Most PCE leaves your body when you exhale. A small amount of PCE is changed by your body (especially your liver) into other chemicals that are removed from your body in urine. Most of the changed PCE leaves your body in a few days. Some of the PCE you are exposed to is found in your blood and other tissues, especially body fat (ATSDR 2014a).

Possible effects of PCE to workers at this site could potentially be issues with color vision, dizziness, or kidney, liver, or nervous system issues. Workers and customers would have to be exposed to high levels of PCE for many years to potentially have these health effects, however.

Trichloroethylene (TCE)

TCE is a colorless, volatile liquid. Liquid TCE evaporates quickly into the air. It is nonflammable and has a sweet odor. TCE is used by the textile processing industry to scour cotton, wool, and other fabrics; in dry cleaning operations; and as a component of adhesives, lubricants, paints, varnishes, paint strippers, pesticides, and cold metal cleaners (ATSDR 2014b).

People are usually exposed to TCE from breathing air or drinking water containing TCE. If you breathe the chemical, about half the amount you breathe will get into your bloodstream and organs. You will exhale the rest. Once in your blood, your liver changes much of the TCE into other chemicals. The majority of these breakdown products leave your body in the urine within a day. You will also quickly breathe out much of the TCE in your bloodstream. Some of the TCE or its breakdown products can be stored in body fat for a brief period, and thus may build up in your body if exposure continues (ATSDR 2014b).

Possible effects of exposure of TCE to workers at this site are mainly for pregnant women. One study suggests there may be development of fetal malformations during a three week window of fetal heart development from a pregnant mother's exposure to TCE. There also could be kidney, liver, or nervous system issues from exposure to high levels of TCE for many years.

Indoor Air Sampling

Details and Summary of Indoor Air Sampling Events

There have been 14 separate indoor air sampling events at Ted's since September 2014 (TVG 2014). Appendix A shows measured levels of PCE and TCE for all sampling events for the cleaner and the other businesses nearby. The same DCERP-approved contractor performed placement of all samples and the same contract laboratory analyzed all samples from all events. Samples were collected using 6-liter Summa canisters over an 8-hour time frame during all indoor air sampling events. Levels presented were gleaned from two DCERP contractor emails and two DCERP contractor reports (TVG 2014, TVG 2017a, 2017d, and 2017e). A summary of the sampling event dates, number of sampling events, range of both PCE and TCE levels pre-mitigation and post-mitigation, and date of mitigation system installation are shown in Table 1.

Indoor air was first sampled in Ted's and the Jersey Mike's Sub Shop in September 2014 (Figures 2 and 3). Elevated levels of PCE at 5,000 $\mu\text{g}/\text{m}^3$ were found in Ted's and levels of PCE at 2,400 $\mu\text{g}/\text{m}^3$ were found in Jersey Mike's. Elevated levels of TCE were also found in Ted's at 75 $\mu\text{g}/\text{m}^3$ and in Jersey Mike's at 21 $\mu\text{g}/\text{m}^3$ (TVG 2014).

In 2015, indoor air was sampled in Ted's and in the businesses on either side of the cleaner (Figures 2 and 3). Sampling which included the cleaner allowed better comparison of the results. Because high levels of PCE were again found in indoor air in Ted's (7,500 $\mu\text{g}/\text{m}^3$) and in the T-Mobile store (4,300 $\mu\text{g}/\text{m}^3$, previously Sweet CeCe's), the first sub-slab mitigation system was installed in July 2015. The benefit of this system would be to draw PCE out of the ground beneath the floor of the business and exhaust it outdoors to prevent PCE from entering the breathable air in the business.

Follow up indoor air testing in Voodoo Gumbo, Sam's Kabab, Ted's, T-Mobile, and Jersey Mike's was completed in November 2015. PCE levels in all five businesses were lower than

Table 1. Summary of measured levels of tetrachloroethylene (PCE) and trichloroethylene (TCE) during pre-mitigation timeframes (February 2015 to May 2016) and during post-mitigation timeframes (July 2016 to October 2017) in indoor air in seven businesses of a strip shopping center. Results are shown in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) for both pre- and post-mitigation investigations and were measured using 8-hour Summa canisters within the identified business.

Business Sampling Location	Pre-Mitigation				Post-Mitigation				Date Sub-slab Mitigation Systems Installed
	Sample dates	Number of samples	PCE range ($\mu\text{g}/\text{m}^3$)	TCE range ($\mu\text{g}/\text{m}^3$)	Sample dates	Number of samples	PCE range ($\mu\text{g}/\text{m}^3$)	TCE range ($\mu\text{g}/\text{m}^3$)	
Voodoo Gumbo (former Guac)	2/12/15 to 2/19/16	3	441 to 1,100	2.3 to 11	7/7/16 to 10/4/17	6	105 to 1,800	1.2 to 6.7	May 2016
Sam's Kabab	2/12/15 to 2/19/16	3	1,320 to 2,600	2.8 to 11	7/7/16 to 10/4/17	6	436 to 4,050	ND to 1.5	May 2016
Ted's Cleaners	9/22/14 to 2/19/16	4	1,190 to 7,500	4.6 to 75	7/7/16 to 10/4/17	9	55.7 to 7,440	ND to 7.3	May 2016
T-Mobile (former Sweet CeCe's)	2/12/15 to 7/2015	1	4,300	23	7/7/16 to 10/4/17	10	889 to 10,700	1.1 to 10.4	July 2015
Jersey Mike's	9/22/14 to 2/19/16	4	381 to 2,400	1.4 to 21	7/7/16 to 10/4/17	6	247 to 2,440	ND to 6.6	May 2016
Mattress King (storeroom)	5/2/16	1	9.2	105	N/A	N/A	N/A	N/A	None
CVS (storeroom)	5/2/16	1	14.3	<1.07	N/A	N/A	N/A	N/A	None

Notes:
 $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter
 ND = The chemical was not detected above method detection limits.
 N/A = not analyzed
 <1.07 = not detected with detection limit of the analysis shown.

those in February 2015. Further follow-up testing done in February 2016 showed increased levels of PCE in indoor air compared to November 2015 levels. TCE levels were noted in three of the four businesses tested.

In May 2016, businesses farthest from the cleaner were tested. Indoor air and sub-slab soil-gas samples were collected from storerooms in a Mattress King store and a CVS drug store closest to the cleaner. PCE levels in the two storerooms suggest no adverse impact to indoor air. Levels of TCE were elevated in the Mattress King storeroom in both the indoor air and sub-slab air. This

is an interesting result given only a small amount of PCE was measured. The disproportionate amount of TCE in Mattress King storeroom indoor air compared to sub-slab soil vapor samples suggest the origin of the TCE is likely from off-gassing of vapors from a source other than Ted's Cleaners, such as mattresses in the storeroom.

Active sub-slab mitigation systems similar to the system installed in T-Mobile were installed in May 2016 in Voodoo Gumbo, Sam's Kababs, Ted's, and Jersey Mike's. All four systems were tested and operational after their installation. The systems were designed such that each has a fan above the roof on a vent pipe which extends above the roof line of the building.

Levels of PCE and TCE continued to be found in the July 2016 indoor air sampling event. The future T-Mobile business continued to have the highest level of PCE of the five businesses tested suggesting there could be more mass of the chemicals beneath the T-Mobile portion of the shopping center.

In August 2016 indoor air in all five businesses were tested. Levels of PCE in the five businesses ranged between $105 \mu\text{g}/\text{m}^3$ and $1,250 \mu\text{g}/\text{m}^3$ with the T-Mobile business having the highest. Indoor air in Ted's and T-Mobile was also tested on two other days, one day after hours, and another time on a Sunday when the Ted's was not operating. Higher levels were noted in Ted's after hours of $4,750 \mu\text{g}/\text{m}^3$ than when it was tested two days before with the other four businesses. T-Mobile had lower levels of $889 \mu\text{g}/\text{m}^3$ after hours than two days before when it was co-sampled with the other four businesses. When Ted's and T-Mobile were tested on the Sunday non-operational day, both had higher levels of PCE than the after-hours sample; $7,200 \mu\text{g}/\text{m}^3$ in Ted's and $963 \mu\text{g}/\text{m}^3$ in T-Mobile. The PCE level in T-Mobile was lower on the non-operational Sunday than the level found two days before when all five businesses were co-sampled.

An inspection of the mitigation systems was performed by DCERP and their approved contractor on September 9, 2016. The mitigation system in Ted's and Sam's Kababs were found to not be operating. The electricity was turned off to both systems. The systems were restarted and the electrical switches for all were secured.

Another test of all five businesses was performed in October 2016. PCE levels in all five businesses increased over recent test levels. Ted's had the highest PCE level measured of the five locations at $7,440 \mu\text{g}/\text{m}^3$. Three additional locations were added for this investigation. Air samples were collected at two monitoring well locations in the parking area at the back of Ted's and at one location on the roof of the shopping center near the HVAC system serving T-Mobile. Samples from the monitoring well locations showed elevated PCE levels. The roof sample had low PCE levels.

At this time it was suspected that the drycleaning machine operated by the cleaner could be leaking PCE vapors. There could be PCE contributions to indoor air from the machine even when the machine is not operating as PCE is held in a tank in the machine. A manufacturer representative inspected the machine in December 2016 and found a leaking valve and a faulty door gasket (TVG 2017a). Both were replaced. It was hoped that with the replacement of these items indoor air concentrations would be lower.

Ted's and T-Mobile were sampled again in February 2017 as a follow up to the replacement of the valve and gasket on the drycleaning machine in December 2016 (TVG 2017a). Levels were lower than those of October 2016.

The drycleaning machine was inspected again in April 2017 (TVG 2017b). An air valve on the machine was discovered sticking in the open position and also a solvent drain line was clogged with lint allowing a build-up of solvent. It was thought that both issues may have contributed to elevated indoor air levels of PCE vapors during the past several monitoring events as there likely could be impact from active cleaning operations occurring in Ted's. Repairs to these two items were completed in late April 2017.

Again indoor air testing in all five businesses was completed in May 2017 as a follow up to the repair of the drycleaning machine. Levels of PCE in T-Mobile were $7,780 \mu\text{g}/\text{m}^3$, $2,440 \mu\text{g}/\text{m}^3$ in Jersey Mike's, and $4,050 \mu\text{g}/\text{m}^3$ in Sam's Kababs. These levels were the highest measured for the three individual businesses thus far. No PCE daughter product chemicals were measured during this test which likely provides some evidence that the vapors may be coming from the cleaner itself. The vapors may be migrating from the cleaner through the false ceilings, through wall penetrations between the cleaner and the adjacent spaces, or from recirculation of the ventilated exhaust air from the cleaner.

Metropolitan Nashville Public Health Department Pollution Control Division personnel conducted a drycleaning inspection of Ted's on June 13, 2017. The machine was found to have no leaks and all records for maintenance of the machine, pounds of clothing cleaned each day, amount of PCE used, receipts for purchase of PCE, and manifests for disposal of PCE were all appropriately onsite. The cleaner's leak detector was found to be operational and the cleaner operator demonstrated his ability to conduct an inspection of the drycleaning machine. All useable PCE and waste PCE were stored in solvent tanks or sealed containers.

As another effort to reduce PCE levels inside the businesses, portable air purifying units were placed in the Voodoo Gumbo, Sam's Kababs, and Jersey Mike's businesses on June 29, 2017. An air purifier was not placed in T-Mobile because of ongoing construction activities. An indoor air sampling event was conducted on July 14, 2017, in these spaces and in the T-Mobile store. On the day of the indoor air sampling, a broken pipe was replaced in the drycleaning machine (TVG 2017d). This repair was unknown at the time of sampling.

Leakage from the machine during replacement of the pipe could have contributed to the highest readings to date being found in the T-Mobile and Voodoo Gumbo businesses (TVG 2017d). Levels found were $9,950 \mu\text{g}/\text{m}^3$ and $1,800 \mu\text{g}/\text{m}^3$ respectively. Indoor air results in the other businesses were at the high end of their respective historic ranges. Measured TCE levels were within their historic ranges for all businesses except for Jersey Mike's and Voodoo Gumbo. Jersey Mike's TCE level of $6.6 \mu\text{g}/\text{m}^3$ and Voodoo Gumbo's TCE level of $6.7 \mu\text{g}/\text{m}^3$ were the highest measured in these businesses thus far.

On August 8, 2017, indoor air was sampled again in Voodoo Gumbo, Sam's Kababs, Ted's, T-Mobile, and Jersey Mike's. The sampling device malfunctioned in Sam's Kababs and indoor air was sampled again in that business on August 11, 2017 (TVG 2017d). Levels of PCE found were near the high end of the range of PCE levels for each individual business. The air purifying units appeared to have minimal effect in lowering the levels of PCE. TCE levels were non-

detect in all five businesses. In addition, monitoring near the mitigation system exhaust standpipes was done on August 8.

Levels of indoor air in all five businesses were close to the highest levels recorded for each. Monitoring of PCE levels emitted from the mitigation system's exhaust piping showed relatively low amounts of PCE emitted. PCE exhaust levels ranged from 2.89 $\mu\text{g}/\text{m}^3$ for Jersey Mike's to 192 $\mu\text{g}/\text{m}^3$ for Ted's. T-Mobile was second highest at 157 $\mu\text{g}/\text{m}^3$. TCE levels near the exhaust pipes ranged from 1.3 $\mu\text{g}/\text{m}^3$ for Sam's Kababs to 41.6 $\mu\text{g}/\text{m}^3$ for Jersey Mike's.

Indoor air was sampled again on October 4, 2017, in all five businesses. Both PCE and TCE levels were within historic ranges for each business except the T-Mobile result. A PCE level of 10,700 $\mu\text{g}/\text{m}^3$ found in T-Mobile was the highest value found to date in any of the five businesses, including the cleaner. The mitigation systems and the portable air purifiers together have not been enough to reduce PCE levels and solve the vapor issues inside the businesses.

On October 5, sub-slab soil-gas beneath the five businesses was extensively sampled. Elevated levels of PCE were found beneath the rear portion of Ted's Cleaners and beneath the entirety of the T-Mobile business. Lower levels of PCE, although elevated, were also found beneath Jersey Mike's and Voodoo Gumbo (TVG 2017e). It is not clear whether there is a mixture of vapors from drycleaner operations and sub-slab vapor intrusion entering the businesses or if one of the two sources is dominant over the other.

The highest level measured, the average level measured, the average pre-mitigation level, and the average post-mitigation level for both PCE and TCE in all locations where indoor air samples were collected are shown in Table 2. Table 2 shows there are higher PCE levels found in the T-Mobile business than the operating drycleaner, PCE levels measured before the mitigation systems were installed were slightly lower than post-mitigation PCE levels, and PCE levels remain elevated. PCE levels have not decreased appreciably with the installation of the sub-slab mitigation systems or the portable air purifying units.

Table 2. Highest levels measured calculated average levels, pre-mitigation average levels, and post-mitigation average levels of tetrachloroethylene (PCE) and trichloroethylene (TCE) for September 2014 to October 2017. All results are shown in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) and were measured using 8-hour Summa canisters within the identified leased space.

Business Sampling Location	Maximum Level Measured (all events)		Average Level Measured (all events)		Calculated Average Pre-Mitigation Level		Calculated Average Post-Mitigation Level	
	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE
Voodoo Gumbo	1,800	11	911	3.4	870	5.9	928	2.2
Sam's Kabab	4,050	11	2,393	2.6	2,010	5.9	2,558	1.2

Table 2. Highest levels measured calculated average levels, pre-mitigation average levels, and post-mitigation average levels of tetrachloroethylene (PCE) and trichloroethylene (TCE) for September 2014 to October 2017. All results are shown in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) and were measured using 8-hour Summa canisters within the identified leased space.

Business Sampling Location	Maximum Level Measured (all events)		Average Level Measured (all events)		Calculated Average Pre-Mitigation Level		Calculated Average Post-Mitigation Level	
	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE
Ted's Cleaners	7,500	75	3,669	9.5	3,785	27.3	3,623	2.3
T-Mobile	10,700	23	4,640	4.6	4,300	23	4,987	2.4
Jersey Mike's	2,440	21	1,482	4.1	1,740	7.9	1,334	1.9

Notes:

All results are shown in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$)

PCE = tetrachloroethylene

TCE = trichloroethylene

N/A = Not Analyzed. Samples only collected once at these locations.

<1.07 = not detected with detection limit of the analysis shown.

Comparison Values

To evaluate exposure to a hazardous substance, health assessors often use health comparison values established by the ATSDR. If the chemical concentrations are below the comparison value, then health assessors can be reasonably certain that no adverse health effects will occur in people who are exposed. If concentrations are above the comparison values (ATSDR 2017) for a particular chemical, then further evaluation is needed. It should be noted chemicals found at levels above their respective comparison values do not necessarily represent a health threat. Instead the results of the comparison value screening identify those chemicals that need a more detailed, site-specific evaluation (ATSDR 2017).

ATSDR develops Minimal Risk Levels (MRLs) using conservative assumptions to assess non-cancer health effects. ATSDR uses the term 'conservative' to refer to values that are protective of public health in essentially all situations. Environmental Media Evaluation Guidelines (EMEGs) are calculated by ATSDR from their MRLs. EMEGs consider non-cancer adverse health effects (ATSDR 2017) and are used for comparison to the indoor air data. Exposure durations are defined as acute (14 days or less), intermediate (15–364 days), and chronic (365 days or more) exposures. ATSDR does not use serious health effects, such as irreparable damage to organs or birth defects, as a basis for establishing EMEGs. Chronic EMEGs assume exposure for 24 hours per day, 7 days per week, 52 weeks, 365 days per year, over a 78-year lifetime exposure. A reference concentration, or RfC, is an estimate of a daily inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of negative health effects during a lifetime of exposure. In January 2013,

ATSDR adopted the EPA's RfC for TCE as their chronic inhalation MRL. In addition to non-cancer health effects comparison values, ATSDR has cancer risk evaluation guides (CREGs) for cancer health effects evaluation. ATSDR residential indoor air comparison values are shown in Table 3.

Table 3. ATSDR and EPA inhalation comparison values in milligrams per cubic meter ($\mu\text{g}/\text{m}^3$) for chemicals found in the indoor air at the Ted's Cleaners and adjacent businesses at 7114 Highway 70 S, Nashville, TN.

Chemical	Acronym	ATSDR Chronic EMEG (non-cancer) ($\mu\text{g}/\text{m}^3$)	ATSDR CREG (10^{-6} excess cancer risk) ($\mu\text{g}/\text{m}^3$)	EPA Residential RSL non-cancer health effects ($\mu\text{g}/\text{m}^3$) HI = 1	EPA Residential RSL (10^{-6} excess cancer risk) ($\mu\text{g}/\text{m}^3$)
tetrachloroethylene	PCE	41	3.8	42	11
trichloroethylene	TCE	2.1	0.22	2.1	0.48

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2017). Chronic non-cancer exposure comparison values (exposure greater than 365 days) used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2017). Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people (10^{-6} risk) over a 78-year lifetime.

EPA Residential RSLs = Environmental Protection Agency Regional Screening Level (EPA 2017a). The screening levels were developed using risk assessment guidance from the EPA Superfund Program. RSLs are considered by EPA to be protective for humans (including sensitive groups) over a 70-year lifetime. The non-cancer screening level is for a Hazard Index of 1 and the cancer screening level is for a 1×10^{-6} risk.

EPA's Regional Screening Levels (RSLs) for residential air inhalation were also used in evaluating the results of the indoor air testing (EPA 2017a). EPA residential indoor air comparison values are also shown in Table 3 for the chemicals found in the indoor air related to the former drycleaning operations. They are developed based on a 70-year lifetime exposure.

Other breakdown chemicals of PCE, such as TCE and cis-1,2-dichloroethylene (cis-1,2-DCE), were intermittently found at very low levels in all previous sampling events. Cis-1,2-DCE is not considered a chemical of concern at this site.

Health Risk Evaluation

For this health consultation, the evaluation of the health risk at the site will consider the chemicals that have been confirmed to be present in the indoor air potentially related to the cleaning operations and have potential health risks. This included PCE and TCE. PCE was considered because of its use in Ted's as a drycleaning solvent and because it was the most abundant drycleaner-related chemical found in the adjacent businesses. TCE was considered because its comparison values are very low to account for the potential of heart malformations early in pregnancy, as identified with animal testing (ATSDR 2014b) and because it was also found with the PCE in indoor air in many of the sampling events.

It appears PCE and minor amounts of TCE contamination remains in soil, soil vapor, and groundwater beneath the cleaner. These media are the source areas for the process of vapor intrusion that seems to be occurring at the site. Both chemicals are present in indoor air in the cleaner and in the nearby businesses.

Our evaluation of site-related environmental contamination followed a two-tiered approach:

- 1) a screening analysis, and
- 2) a further, more in-depth analysis to determine public health implications of site-specific exposures.

First, concentrations of PCE and TCE were compared with environmental media-specific health-based comparison values. Second, if concentrations exceed the environmental comparison value, these substances, referred to as contaminants of concern, are selected for further evaluation. Third, contaminant levels above environmental comparison values do not mean that adverse health effects are likely, but that further evaluation is needed. After exposure doses are estimated, they were further evaluated to determine the likelihood of adverse health effects.

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

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

A NOAEL is the highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals. LOAEL is the lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals. In order to provide additional perspective on these health effects, the calculated exposure doses were then compared to observed effect levels (e.g., NOAEL, LOAEL). As the exposure dose increases beyond the MRL to the level of the NOAEL and/or LOAEL, the likelihood of adverse health effects increases. A point-of-departure (POD) dose may be used in the health assessment process in examining the potential for health effects to occur. A point-of-departure is defined as the dose-response point that marks the beginning of a low-dose extrapolation.

This point is most often the upper bound on an observed incidence or on an estimated incidence from a dose-response model.

When MRLs for specific contaminants are unavailable, other health based comparison values such as the EPA's Reference Dose (RfD) and Reference Concentrations (RfC) are used. The RfD is an estimate of a daily oral exposure and the RfC is an estimate of a daily inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure.

For understanding the potential cancer effects of exposure to chemicals, a site-specific lifetime excess cancer risk (LECR) is calculated. LECR estimates are usually expressed in terms of excess cancer cases in an exposed population in addition to the background rate of cancer. For perspective, the lifetime risk of being diagnosed with cancer in the United States is 46 per 100 individuals for males, and 38 per 100 for females; the lifetime risk of being diagnosed with any of several common types of cancer ranges between 1 in 10 and 1 in 100 (ACS 2011). Typically, health guideline comparison values developed for carcinogens are based on one excess cancer case per one million people. EPA considers estimated cancer risks of less than one additional cancer case among one million persons exposed as insignificant or no increased risk (expressed exponentially as 10^{-6}). EPA considers one additional cancer case among 10,000 people to one additional cancer in one million people no apparent increase in risk.

PCE Toxicity — *Non-Cancer*

ATSDR suggests PCE inhalation exposure may harm the nervous system, liver, kidneys, and reproductive system, and may be harmful to unborn children. If you breathe in air containing a lot of PCE, you may become dizzy or sleepy, develop headaches, and become uncoordinated; exposure to very large amounts in the air can cause unconsciousness.

People who are exposed for longer periods of time to lower levels of PCE in air may have changes in mood, memory, attention, reaction time, or vision. Studies in animals exposed to PCE have shown liver and kidney effects, and changes in brain chemistry, but it is not clear what these findings mean for humans. PCE may have effects on pregnancy and unborn children. Studies in people are not clear on this subject, but studies in animals show problems with pregnancy (such as miscarriage, birth defects, and slowed growth of the baby) after inhalation exposure (ATSDR 2014a).

Available human and animal studies have shown that exposure to PCE has been associated with toxicity to the central nervous system, the kidney, liver, immune and hematologic (blood or circulatory) systems, and to development and reproduction toxicity. Neurotoxic effects have been characterized in human controlled exposure, occupational and residential studies, as well as in experimental animal studies. The studies provide evidence of an association between PCE exposure and neurological deficits. PCE exposure primarily results in visual changes, decreased reaction time, and cognitive decrements in humans.

Animal studies found effects on vision, visual-spatial function, and reaction time, as well as brain weight changes. An animal study (Chen et. al. 2002) showed neurological impacts at a Human Equivalent Dose of 1.8 mg/kg-day, based on physiologically based pharmacokinetic

(PBPK) modeling. Numerous animal studies have reported adverse effects on the kidney in the form of tubular toxicity. Although human studies have not systematically investigated nephrotoxicity, measurement of urinary excretion of renal proteins and end-stage renal disease support an association between PCE exposure via inhalation and chronic kidney disease. A study of dry cleaning workers (Mutti et. al. 1992) showed the inhalation dose associated with kidney toxicity was 34 ppm or 230,630 $\mu\text{g}/\text{m}^3$ (as derived in USEPA 2012a). The equivalent ingestion dose from the Mutti, 1992 study was calculated to be 5.4 mg/kg-day, based on route-to-route extrapolation using PBPK modeling (USEPA 2012a). Another study of dry cleaners showed hematologic effects (Emara et. al. 2010) at an inhalation dose of 43 ppm or 291,680 $\mu\text{g}/\text{m}^3$ (as derived in USEPA 2012a). The equivalent ingestion dose from Emara, 2010 study was calculated to be 6.8 mg/kg-day, based on route-to-route extrapolation using PBPK modeling (USEPA 2012a). The developmental and reproductive toxicity database for PCE includes a range of data from appropriate, well-conducted studies in several laboratory animal species plus limited human data. The developmental effects include fetal malformations of bone and soft tissue, delayed ossification, and decreased fetal weight. Reproductive effects include increased incidence of fetal resorptions and preimplantation losses. Evidence of liver toxicity is primarily from several well-conducted rodent studies, including chronic bioassays (ATSDR 2014; USEPA 2012a).

The EPA RfC incorporates neurotoxic effects found in studies of workers exposed to PCE vapors (Echeverria et al. 1995; Cavalleri et al. 1994). The LOAEL in these studies was 15–56 mg/m^3 (2.2 to 8.3 ppm). With the application of an uncertainty factor of 1,000 (10x for use of LOAEL; 10x for human variability; 10x for database deficiencies), the resulting EPA RfC is 0.04 mg/m^3 (0.006 ppm).

ATSDR has an inhalation MRL for assessment of both short-term and chronic exposures. It draws on an epidemiological study of drycleaner workers exposed to PCE for an average of 2 years, showing a loss of color vision resulting from PCE exposure (Cavalleri et al. 1994; Gobba et al. 1998). The exposure time-adjusted LOAEL in the study was 1.7 ppm or 11,530 $\mu\text{g}/\text{m}^3$. With the application of an uncertainty factor of 300 (10x for use of LOAEL; 10x for human variability; 3x for database deficiencies), the resulting MRL is ATSDR's acute, intermediate, and chronic inhalation MRL for PCE of 41 $\mu\text{g}/\text{m}^3$ (0.006 ppm).

PCE Toxicity – Cancer

Exposure to PCE for a long time may lead to a higher risk of getting cancer, but the type of cancer that may occur is not well-understood. Studies in humans suggest that exposure to PCE might lead to a higher risk of getting bladder cancer, multiple myeloma, or non-Hodgkin's lymphoma, but the evidence is not very strong. In animals, PCE has been shown to cause cancers of the liver, kidney, and blood system. It is not clear whether these effects might also occur in humans, because humans and animals differ in how their bodies handle PCE. The EPA considers PCE to be “likely to be carcinogenic to humans by all routes of exposure” based on suggestive evidence in human studies and clear evidence of mononuclear cell leukemia in rats and liver tumors in mice exposed for 2 years by inhalation or stomach tube (ATSDR 2014a). The International Agency for Research on Cancer (IARC) considers PCE “probably carcinogenic to humans” based on limited evidence in humans and sufficient evidence in animals. The National Toxicology Program considers PCE to be “reasonably anticipated to be a human carcinogen” (NTP 2016).

Regarding cancer, PCE is associated with tumors of liver, kidney, brain, and testes, and in laboratory animal studies, leukemia and hemangiosarcomas (USEPA 2012a). Occupational studies show an association with several types of cancer, specifically bladder cancer, non-Hodgkin lymphoma, and multiple myeloma (USEPA 2012a).

EPAs Inhalation Unit Risk value (IUR) is based on a study of rats exposed to PCE via inhalation, resulting in the induction of hepatocellular adenomas or carcinomas. The IUR for PCE is 2.6E-07 per $\mu\text{g}/\text{m}^3$ (ATSDR 2014a).

TCE Toxicity — *Non-cancer*

People who are overexposed to moderate amounts of TCE may experience headaches, dizziness, and sleepiness. Some people who breathe high levels of TCE may develop damage to some of the nerves in the face. Other effects seen in people exposed to elevated levels of TCE include evidence of nervous system effects related to hearing, seeing, and balance, changes in the rhythm of the heartbeat, liver damage, and evidence of kidney damage. Relatively short-term exposure of animals to TCE resulted in harmful effects on the nervous system, liver, respiratory system, kidneys, blood, immune system, heart, and body weight.

ATSDR and EPA have concluded that TCE poses a potential human health hazard to the central nervous system, the immune system, the kidney, the liver, the male reproductive system, and the developing fetus (ATSDR 2014b). The immune system and the developing fetus are most sensitive to the toxic effects of TCE, as reductions in thymus weight (Kiel et. al. 2009) and the development of fetal malformations during a three week window of fetal heart development (Johnson et. al. 2003) are the earliest observed health effects following low level exposures. Although these studies were conducted in rats and mice exposed to TCE in drinking water, PBPK modeling was used to extrapolate oral dose in animals to Human Equivalent Concentrations (HECs) in air. The EPA RSL for TCE in residential air ($2.1 \mu\text{g}/\text{m}^3$) is based on the EPA RfC derived from the Keil and Johnson studies. This inhalation RfC was conservatively chosen because it is below the candidate RfCs derived from the lowest concentrations associated with adverse health effects from TCE inhalation studies. The RfC was adopted by ATSDR as both the intermediate and chronic inhalation MRL for TCE exposure of 0.004 ppm or $2.1 \mu\text{g}/\text{m}^3$ (ATSDR 2014b).

The HEC for a 1 percent extra risk of fetal cardiac malformations is $21 \mu\text{g}/\text{m}^3$, while the HEC for decreased thymus weight is $190 \mu\text{g}/\text{m}^3$. For fetal heart malformations, EPA used an uncertainty factor of 10 times to account for human variation and species differences. For decreased thymus weight, EPA used an uncertainty factor of 100 times to account for the use of the LOAEL, as well as human variation and species differences. The midpoint between the candidate RfC for the two critical effects (rounding to one significant digit) was used to derive the TCE RfC of $2.0 \mu\text{g}/\text{m}^3$. Exposure of pregnant women to TCE levels above the EPA RSL does not mean that fetal heart development will be impaired. However, breathing air exceeding the TCE RSL begins to introduce a small amount of risk to proper fetal development and should be avoided.

TCE Toxicity – Cancer

There is strong evidence TCE can cause kidney cancer in people and some evidence TCE can cause liver cancer and malignant lymphoma (a blood cancer). Lifetime exposure to TCE resulted in increased liver cancer in mice and increased kidney cancer in rats at relatively high exposure levels. There is some evidence for TCE-induced testicular cancer and leukemia in rats and lymphomas and lung tumors in mice. The IARC and the EPA determined that there is convincing evidence that TCE exposure can cause kidney cancer in humans. IARC considers TCE to be a multisite carcinogen (liver, kidney, lung, testes, and blood-producing system) in rats and mice by inhalation exposure routes. TCE is listed in the 14th Report on Carcinogens (RoC 2016) as reasonably anticipated to be a human carcinogen. The National Research Council (NRC 2006) concluded that there is “limited/suggestive evidence of an association” between exposure to TCE and risk of kidney cancer and “inadequate/insufficient evidence to determine whether an association exists” between exposure to TCE and risk of cancer at other organs. Long-term inhalation of TCE can also increase one’s risk of developing certain cancers. The EPA recently released an extensive toxicological review of TCE, in which they reclassified it as “*carcinogenic to humans by all routes of exposure*” (EPA 2012a). The National Toxicology Program has also determined that TCE is “*reasonably anticipated to be a human carcinogen*”. The most consistent and convincing evidence of an association between TCE exposure in humans and cancer is that for cancer of the kidney. However, there are also compelling links between TCE exposure and cancers of the lymphoid tissues (lymphoma) and liver (EPA 2012a).

EPAs IUR is based on a study of rats exposed to TCE via inhalation, resulting in the induction of hepatocellular adenomas or carcinomas. The IUR for TCE is $4.1E-06$ per $\mu\text{g}/\text{m}^3$ (ATSDR 2014b).

Mixtures Considerations

In the past, workers in and visitors to the businesses were exposed to both PCE and TCE through inhalation of indoor air. This consultation will focus on evaluating chemical-specific and pathway-specific exposures. However, the ATSDR and EEP recognize that exposures can involve multiple chemicals through more than one exposure pathway. ATSDR has developed guidance for evaluating exposures to chemical mixtures (ATSDR 2004).

PCE and TCE frequently occur together in air samples collected from sites. A potential limitation of this health consultation is that each chemical found above an EPA RSL, RfC, or MRL is treated individually and conclusions are derived from individual components. It is not entirely accurate to assess risk without considering joint toxicity of chemicals that have similar toxicity endpoints.

To carry out exposure-based assessments of possible health hazards associated with inhalation exposure scenarios involving indoor air exposures to mixtures of PCE and TCE, component-based approaches that assume additive joint action of the components are recommended for exposure based screening assessments (ATSDR 2004). Applying the additivity assumption appears to be in the interest of public health since the components have several shared toxicity targets. This approach is recommended because of the lack of studies that examine relevant endpoints and describe dose-response relationships for inhalation exposures that contain mixtures of the components of concern. For non-cancer endpoints (nervous system effects, liver

or kidney effects), a target-organ toxicity dose modification of the HI approach is recommended by ATSDR given that a wide range of overlapping toxicity targets can be affected by the components.

Because PCE and TCE have similar metabolic pathways, evidence suggests that they may interfere with each other's metabolism in the body (Seiji et. al. 1989). Occupational studies indicated that workers exposed to both PCE and TCE had lower levels of TCE metabolites in the urine than workers exposed only to TCE at about the same concentrations that occurred in the mixture. The metabolites of PCE and TCE are considered to be responsible for the chemical's toxicity to the liver and kidneys; however, it is unclear whether the parent compounds or their metabolites (particularly TCE metabolites) have the greater impact on neurological effects. Overall, the available weight-of-evidence suggests that co-exposure of humans to PCE and TCE may inhibit the metabolism of TCE and thereby may inhibit carcinogenic and non-carcinogenic responses in the liver and kidney to TCE metabolites. ATSDR scientists concluded that PCE had a less-than-additive effect on TCE whereas TCE had an additive effect on PCE (ATSDR 2004).

Data Evaluation

Even though there were 14 indoor air sampling events conducted at the Ted's Cleaners Site since September 2014, indoor air samples were not collected in all businesses in each event. Indoor air results were first evaluated using the highest PCE and TCE levels found in each business, the average pre-mitigation PCE and TCE levels for each business, and the average post-mitigation PCE and TCE levels. The calculated hazard index (HI) and Lifetime Excess Cancer Risk (LECR) for the highest PCE and TCE levels, the averaged PCE and TCE levels, the average pre-mitigation PCE and TCE levels, and the average post-mitigation PCE and TCE levels are shown in Tables 4 and 5 below. The LECR is a calculated cancer risk in addition to the normal everyday risk of men getting cancer of 1 in 2 and women of 1 in 3 (ACS 2016).

Non-Cancer Evaluation

Levels of PCE detected in indoor air over the numerous sampling events at all of the sampling locations were above their respective ATSDR indoor air health comparison values and EPA's non-cancer residential Regional Screening Level (RSL) shown in Table 3 (ATSDR 2017, EPA 2017a). ATSDR's non-cancer comparison value for PCE is $41 \mu\text{g}/\text{m}^3$. EPA's non-cancer residential RSL for PCE is $42 \mu\text{g}/\text{m}^3$. Residential screening values were used for comparison because the exposures of these two chemicals to workers and visitors of the four other businesses are involuntary. The exposures were considered secondary in nature because the owners of the businesses, the workers working in the businesses, and the visitors to the businesses may not know they are being exposed to chemical vapors (ATSDR 2006). The EPA commercial exposure scenario and the industrial worker RSLs were not used.

Levels of TCE were also found above both its ATSDR non-cancer health comparison value and its EPA non-cancer screening value (Table 3). ATSDR's non-cancer comparison value is $2.1 \mu\text{g}/\text{m}^3$ (ATSDR 2017) and EPA's non-cancer screening level is $2.1 \mu\text{g}/\text{m}^3$ for an HI of 1 (EPA 2017).

Hazard indexes for the individual businesses were calculated to understand the non-cancer health risks to individuals. The highest measured PCE levels in each of the four businesses near Ted's,

equate to a HI ranging from 43 for Voodoo Gumbo to 260 for T-Mobile (Table 4). Using the average PCE levels measured before mitigation systems were installed in each leased space results in a HI ranging from 21 for Voodoo Gumbo to 100 for T-Mobile (Table 4). Using the average PCE levels measured after mitigation systems were installed, the HIs were calculated to be 22 for Voodoo Gumbo to 120 for T-Mobile (Table 4). These non-cancer HIs are very high for the highest PCE level measured. The HIs indicate there are possible adverse exposures for those who spend many hours in these businesses, mainly the workers.

HIs were also elevated for the highest TCE level measured. The highest measured TCE levels were measured during the pre-mitigation time frame. HIs ranged from 5.3 for both Voodoo Gumbo and Sam's Kabab to 11 for T-Mobile (Table 4). Using the highest levels measured after the mitigation systems were installed, the HIs were calculated to be 0.58 for Sam's Kababs to 1.2 for T-Mobile (Table 4). These HIs should not indicate an adverse exposure to those spending many hours in the businesses.

Table 4. Tetrachloroethylene (PCE) and trichloroethylene (TCE) hazard indexes (HI) calculated using the highest PCE and TCE levels (September 2014 to October 2017), average levels measured (September 2014 to October 2017), average pre-mitigation levels (February 2014 to May 2016), and the average post-mitigation levels (July 2016 to October 2017). HIs are calculated to show potential non-cancer health effects. An HI above 1 is to be evaluated further.

Business Sampled	Maximum Level Measured		Average Level Measured (all events)		Average Pre-Mitigation Level		Average Post-Mitigation Level	
	PCE HI	TCE HI	PCE HI	TCE HI	PCE HI	TCE HI	PCE HI	TCE HI
Voodoo Gumbo	43	5.3	22	1.6	21	2.8	22	1.1
Sam's Kabab	97	5.3	57	1.2	48	2.8	61	0.58
T-Mobile	260	11	110	2.2	100	11	120	1.2
Jersey Mike's	58	10	36	2.0	42	3.8	32	0.91

Notes:

HI = Hazard Index – unit less values used to understand if non-cancer health effects are probable based on the measured levels.

BOLD = indicates elevated HIs which could potentially lead to non-cancer health effects.

Cancer Evaluation

The highest PCE values for the four businesses around Ted's ranged from 1,800 µg/m³ in Voodoo Gumbo to 10,700 µg/m³ in T-Mobile (Table 2). These levels accounted for LECRs ranging from 4.7x10⁻⁴ or about 5 excess cancers in 10,000 people to 2.8x10⁻³ or about 3 excess

cancers in 1,000 people (Table 5). These LECRs were all greater than EPA's acceptable range of risk of excess cancer of one in one million to one in 10,000 people (1×10^{-6} to 1×10^{-4}). The average pre-mitigation PCE levels ranged from $870 \mu\text{g}/\text{m}^3$ in Voodoo Gumbo to $4,300 \mu\text{g}/\text{m}^3$ in T-Mobile. These levels correspond to 2.3×10^{-4} or about 2 excess cancers in 10,000 people to 1.1×10^{-3} or about 1 excess cancer in 1,000 people (Table 5). These average post-mitigation PCE levels ranged from $928 \mu\text{g}/\text{m}^3$ in Voodoo Gumbo to $4,987 \mu\text{g}/\text{m}^3$ in T-Mobile which correspond to 2.4×10^{-4} or about 2 excess cancers in 10,000 people to 1.3×10^{-3} or about 1 excess cancer in 1,000 people (Table 5). The increased cancer risk from these exposures is considered low however; they are above levels which indicate remedial actions should be taken to lower PCE levels. These other actions are discussed later in this document.

Table 5. Tetrachloroethylene (PCE) and trichloroethylene (TCE) lifetime excess cancer risk (LECR) calculated using the highest PCE and TCE levels (September 2014 to October 2017), average levels from all events (September 2014 to October 2017), average pre-mitigation levels (September 2014 to May 2016), and average post-mitigation levels (July 2016 to October 2017). LECRs have not been adjusted for time spent in the businesses by workers or visitors. Exposure is assumed to be for a lifetime of 24 hours per day, 7 days per week, 365 days per year for 78 years. Non-adjusted levels are consistently outside of EPA's acceptable risk range in all 4 businesses.

Business Sampled	Maximum Level Measured		Average Level Measured (all events)		Average Pre-Mitigation Level		Average Post-Mitigation Level	
	PCE	TCE	PCE	TCE	PCE	TCE	PCE	TCE
T-Mobile	2.8×10^{-3}	9.4×10^{-5}	1.2×10^{-3}	1.9×10^{-5}	1.1×10^{-3}	9.4×10^{-5}	1.3×10^{-3}	9.8×10^{-6}
Jersey Mike's	6.3×10^{-4}	8.6×10^{-5}	3.9×10^{-4}	1.7×10^{-5}	4.5×10^{-4}	3.2×10^{-5}	3.5×10^{-4}	7.8×10^{-6}
Voodoo Gumbo	4.7×10^{-4}	2.7×10^{-5}	2.4×10^{-4}	1.4×10^{-5}	2.3×10^{-4}	2.4×10^{-5}	2.4×10^{-4}	9×10^{-6}
Sam's Kabab	1.1×10^{-3}	1.1×10^{-5}	6.2×10^{-4}	1.1×10^{-5}	5.2×10^{-4}	2.4×10^{-5}	6.7×10^{-4}	5×10^{-6}

Notes:

Lifetime Excess Cancer Risk (LECR) was calculated by multiplying the measured concentrations of both PCE and TCE by their respective inhalation Unit Risk values. The LECR is unit less and represents the added cancer risk in addition to the average risk today of developing cancer which is estimated to be 1 in 2 for men and 1 in 3 for women (NTP 2016).

PCE = tetrachloroethylene

TCE = trichloroethylene

BOLD = calculated lifetime excess cancer risk is greater than EPA's acceptable risk range.

Average TCE levels ranged from $2.6 \mu\text{g}/\text{m}^3$ in Sam's Kabab to $4.6 \mu\text{g}/\text{m}^3$ in T-Mobile (Table 5). These average results were compared to ATSDR's CREG for one excess cancer in one million people health risk comparison value of $0.22 \mu\text{g}/\text{m}^3$ (ATSDR 2017) and EPA's residential RSL for a LECR of one in a million of $0.48 \mu\text{g}/\text{m}^3$ (EPA 2017). Average TCE results were 11 to 11

times higher than its ATSDR CREG and from about 5 to 10 times greater than its EPA residential cancer health effects RSL. The highest, average, average pre-mitigation and average post-mitigation TCE LECRs were within EPA's acceptable range of risk of excess cancer of one in one million to one in 10,000 people (1×10^{-6} to 1×10^{-4}).

Work-Time Adjusted Non-Cancer Evaluation

To further evaluate the potential exposure to workers and visitors to the businesses in the shopping center near the cleaner, a more in-depth evaluation was done. Estimates were made for the amount of time full-time and part-time workers would be in any of the four businesses. Another estimate was made for a potential visitor of one of the businesses. These estimates are not based on a 24 hours per day 7 days a week exposure. Instead, the scenario for a full-time worker was one where the worker would be working 10 hours per day for five days a week for 1 year. For the part-time worker, a scenario of 4 hours per day for 5 days per week for 50 weeks was used. For a visitor of one of the businesses, a scenario of one and one half hour visit to one of the businesses every two weeks during the year was used. The HIs and the LECRs were calculated for a pre-mitigation exposure (Table 6) and a post-mitigation exposure (Table 7).

The adjusted pre-mitigation indoor air PCE HIs in all four businesses are 6 or above for a worker working 10 hours a day, 5 days per week for 50 weeks per year. The highest time-adjusted HI was for T-Mobile at 29. However, the PCE level in all four businesses for a worker working 10 hours a day, 5 days per week for 50 weeks per year were below ATSDR's LOAEL of 1.7 parts per million (ppm) or $11,530 \mu\text{g}/\text{m}^3$ for PCE. Additionally, the adjusted pre-mitigation indoor air PCE HIs for an employee working 4 hours per day, 5 days per week, for 1 year are also below ATSDR's LOAEL. Adjusted non-cancer PCE HIs for a part-time worker exceeded 2 in all four businesses. Again, adjusted levels of PCE were below ATSDR's LOAEL for PCE. Pre-mitigation adjusted PCE levels for a visitor of the business for 1.5 hours, 1 day every two weeks, were below 1, meaning there should not have been non-cancer health effects from visiting any of the four businesses before the mitigation systems were installed.

Adjusted pre-mitigation HIs for TCE for a full-time worker in all four businesses were either below 1 or just above (Jersey Mike's). For HIs of 1 or less, there should not have been non-cancer health effects from visiting any of the four businesses before the mitigation systems were installed. Additionally, the adjusted pre-mitigation TCE levels for the three scenarios are well below ATSDR's TCE LOAEL (ATSDR 2014b) meaning there should not be potential harmful exposures from breathing in the adjusted TCE levels in the businesses for those working extended periods of time and there should not be harmful exposures to visitors of the businesses for any of the three scenarios shown.

The same calculations were done for average measured post-mitigation PCE and TCE levels. These adjusted PCE and TCE levels are found in Table 7.

Table 6. Pre-mitigation tetrachloroethylene (PCE) and trichloroethylene (TCE) adjusted exposure levels for three scenarios and calculated lifetime excess cancer risk (LECR) for 50 weeks per year. Adjusted exposure values were calculated using September 2014 to May 2016 PCE and TCE levels. LECRs have been adjusted for time spent in the businesses by workers or visitors. Adjusted exposure values are reported in micrograms per cubic meter (top value) and in parts per million (lower value). Hazard Index (HI) values indicate level of non-cancer health hazard.

Business Sampling Location	Adjusted Exposure for Worker - 10 hr. shift, 5 days/week in $\mu\text{g}/\text{m}^3$ and in (ppm)		Adjusted Exposure for Worker – 4 hr. shift, 5 days/week in $\mu\text{g}/\text{m}^3$ and in (ppm)		Adjusted Exposure for Visitor – 1.5 hr., 1 day/week, every other week in $\mu\text{g}/\text{m}^3$ and in (ppm)	
	PCE	TCE	PCE	TCE	PCE	TCE
Voodoo Gumbo	249 (0.037)	1.7 (0.0003)	100 (0.015)	0.7 (0.0001)	3.9 (0.0006)	0.03 (0.000006)
Calculated LECR	6.5×10^{-5}	7.0×10^{-6}	2.6×10^{-5}	2.9×10^{-6}	1.0×10^{-6}	1.2×10^{-7}
HI	6	0.82	2.4	0.34	0.093	0.014
Sam's Kabab	575 (0.091)	1.7 (0.0003)	230 (0.04)	0.7 (0.0003)	9 (0.0013)	0.03 (0.000006)
Calculated LECR	1.5×10^{-4}	7.0×10^{-6}	6×10^{-5}	2.9×10^{-6}	2.3×10^{-6}	1.2×10^{-7}
HI	14	0.82	5.5	0.34	0.22	0.014
T-Mobile	1,229 (0.18)	0.66 (0.0001)	492 (0.07)	0.27 (0.00005)	19.2 (0.003)	0.01 (0.000002)
Calculated LECR	3.2×10^{-4}	2.7×10^{-6}	1.3×10^{-4}	1.1×10^{-6}	5×10^{-6}	4.1×10^{-8}
HI	29	0.32	12	0.13	0.46	0.005
Jersey Mike's	497 (0.07)	2.3 (0.0004)	199 (0.03)	0.90 (0.0002)	7.8 (0.001)	0.04 (0.000007)
Calculated LECR	1.3×10^{-4}	9.4×10^{-6}	5.2×10^{-5}	3.7×10^{-6}	2×10^{-6}	1.6×10^{-7}
HI	12	1.1	4.8	0.43	0.19	0.02

Notes:

Lifetime Excess Lifetime Cancer Risk (LECR) was calculated by multiplying the measured concentrations of both PCE and TCE by their respective inhalation Unit Risk values. The LECR is unit less and represents the added cancer risk in addition to the average risk today of developing cancer which is estimated to be 1 in 2 for men and 1 in 3 for women (NTP 2016).

BOLD = calculated lifetime excess cancer risk is greater than EPA's acceptable risk range and non-cancer HIs could potentially lead to non-cancer health effects..

The HIs for adjusted post-mitigation PCE levels for a person working 10 hours a day, 5 days per week, for 1 year in all four businesses are above 6 meaning there is a potential for non-cancer health effects (Table 7). However, adjusted levels were below ATSDR's LOAEL of 1.7 ppm indicating there should not be observable non-cancer health effects in an otherwise healthy person. The highest adjusted post-mitigation levels were found in the T-Mobile business. HIs for adjusted post-mitigation PCE levels for a part-time worker were above 2, but again below ATSDR's LOAEL. HIs for adjusted PCE levels for a visitor to the business for 1.5 hours, 1 day every two weeks, are all less than 1 indicating there should not be non-cancer health effects from visiting any of the four businesses.

Adjusted non-cancer TCE HIs for a visitor to one of the businesses were all below 1. For post-mitigation levels of TCE, adjusted TCE levels for the three scenarios are well below ATSDR's TCE NOAEL and LOAEL (ATSDR 2014b). There should not be potential harmful exposures from breathing in the calculated TCE levels in the businesses for those working extended periods of time and there should not be harmful exposures to visitors to the businesses for any of the three scenarios shown.

Work-Time Adjusted Cancer Evaluation

The highest PCE values for the four businesses adjacent to Ted's ranged from 1,800 $\mu\text{g}/\text{m}^3$ in Voodoo Gumbo to 10,700 $\mu\text{g}/\text{m}^3$ in T-Mobile (Table 2). The average pre-mitigation PCE levels ranged from 870 $\mu\text{g}/\text{m}^3$ in Voodoo Gumbo to 4,300 $\mu\text{g}/\text{m}^3$ in T-Mobile. The average post-mitigation PCE levels ranged from 928 $\mu\text{g}/\text{m}^3$ in Voodoo Gumbo to 4,987 $\mu\text{g}/\text{m}^3$ in T-Mobile. PCE indoor air concentrations were compared to ATSDR's CREG for one excess cancer in one million people health risk comparison value of 3.8 $\mu\text{g}/\text{m}^3$ (ATSDR 2017) and EPA's residential RSL for an LECR of one in a million of 11 $\mu\text{g}/\text{m}^3$ (EPA 2017). The highest PCE results were about 473 to 2,816 times higher than its ATSDR CREG and from about 164 to 973 times greater than its EPA residential cancer health affects RSL. Average post-mitigation PCE results ranged from 244 to 1,312 times higher than the ATSDR CREG and from about 84 to 453 times higher than the EPA residential cancer health affects RSL.

Average TCE levels ranged from 2.6 $\mu\text{g}/\text{m}^3$ in Sam's Kabab to 4.6 $\mu\text{g}/\text{m}^3$ in T-Mobile. These average results were also compared to ATSDR's CREG for one excess cancer in one million people health risk comparison value of 0.22 $\mu\text{g}/\text{m}^3$ (ATSDR 2017) and EPA's residential RSL for an lifetime excess cancer risk (LECR) of one in a million of 0.48 $\mu\text{g}/\text{m}^3$ (EPA 2017). Average TCE results were about 11 to 21 times higher than its ATSDR CREG and from about 5 to 10 times greater than its EPA residential cancer health affects RSL. Therefore, further analysis was done using the inhalation unit risk value for PCE and adjusting the exposure time for a potential worker work day and a potential visitor to the businesses.

An estimated risk was calculated using the average measured PCE and TCE levels measured in all sampling events and EPA's inhalation unit risk (IUR) values for both chemicals (2.6×10^{-7} for PCE and 4.1×10^{-6} for TCE). The IUR was calculated based on exposure to a chemical 24 hours per day, 7 days per week, for 365 days per year. Appendices B and C show how the LECRs were calculated using pre-mitigation and post-mitigation levels. These LECRs are in addition to the normal background cancer risk to men and women in the U.S. The normal every day risk of having cancer in the U.S. is 1 in 2 for men and 1 in 3 for women (ACS 2016).

Table 7. Post-mitigation tetrachloroethylene (PCE) and trichloroethylene (TCE) adjusted exposure levels for three scenarios and calculated lifetime excess cancer risk (LECR) for 50 weeks. Adjusted exposure values were calculated using averaged post-mitigation (July 2016 to August 2017) PCE and TCE levels. LECRs have been adjusted for time spent in the businesses by workers or visitors. Adjusted lifetime exposure values are reported in micrograms per cubic meter (top value) and in parts per million (lower value). Exposure in the T-Mobile phone store is greater than EPA's acceptable cancer risk range. Hazard Index (HI) values indicate level of non-cancer health hazard.

Business Sampling Location	Adjusted Exposure for Worker - 10 hr. shift, 5 days/week in $\mu\text{g}/\text{m}^3$ and in (ppm)		Adjusted Exposure for Worker – 4 hr. shift, 5 days/week in $\mu\text{g}/\text{m}^3$ and in (ppm)		Adjusted Exposure for Visitor – 1.5 hr., 1 day/week, every other week in $\mu\text{g}/\text{m}^3$ and in (ppm)	
	PCE	TCE	PCE	TCE	PCE	TCE
Voodoo Gumbo	265 (0.04)	0.63 (0.0001)	106 (0.016)	0.25 (0.00005)	4.1 (0.0006)	0.01 (0.000002)
Calculated LECR	6.9×10^{-5}	2.6×10^{-6}	2.8×10^{-5}	1.0×10^{-6}	1.1×10^{-6}	4.1×10^{-8}
HI	6.4	0.30	2.5	0.12	0.1	0.0058
Sam's Kabab	731 (0.11)	0.34 (0.00006)	293 (0.04)	0.14 (0.00003)	11.4 (0.002)	0.005 (0.0000009)
Calculated LECR	1.9×10^{-4}	1.4×10^{-6}	7.6×10^{-5}	5.7×10^{-7}	3.0×10^{-6}	2.1×10^{-8}
HI	18	0.16	7.0	0.07	0.27	0.002
T-Mobile	1,425 (0.21)	0.68 (0.0001)	571 (0.08)	0.27 (0.00005)	22.3 (0.002)	0.01 (0.000002)
Calculated LECR	3.7×10^{-4}	2.8×10^{-6}	1.5×10^{-4}	1.1×10^{-6}	5.6×10^{-6}	4.1×10^{-8}
HI	34	0.33	14	0.13	0.53	0.005
Jersey Mike's	381 (0.06)	0.54 (0.0001)	153 (0.02)	0.22 (0.00004)	6 (0.001)	0.009 (0.000002)
Calculated LECR	1.0×10^{-4}	2.2×10^{-6}	4.0×10^{-5}	9×10^{-7}	1.6×10^{-6}	1.9×10^{-8}
HI	9.1	0.26	3.7	0.11	0.14	0.004

Notes:

Lifetime Excess Cancer Risk (LECR) was calculated by multiplying the measured concentrations of both PCE and TCE by their respective inhalation Unit Risk values. The LECR is unit less and represents the added cancer risk in addition to the average risk today of developing cancer which is estimated to be 1 in 2 for men and 1 in 3 for women (NTP 2016).

BOLD = calculated lifetime excess cancer risk is greater than EPA's acceptable risk range and non-cancer HIs could potentially lead to non-cancer health effects.

For a full-time worker working 10 hours per day for five days per week for 50 weeks per year in T-Mobile, Jersey Mike's, and Sam's Kabab, the adjusted pre-mitigation levels of PCE equate to an LECR greater than EPA's acceptable excess risk range of one excess cancer in one million to one excess cancer in 10,000 people (1×10^{-6} to 1×10^{-4}). Work-time adjusted pre-mitigation PCE LECRs for Voodoo Gumbo, the Mattress King storeroom, and the CVS storeroom are within EPA's acceptable excess risk range. Adjusted pre-mitigation PCE LECRs in T-Mobile for a part-time worker working four hours per day, five days per week, for 50 weeks per year would be outside of EPA's acceptable excess risk range. Adjusted pre-mitigation PCE LECR's for the part-time worker scenario for all other businesses would be within the excess risk range EPA considers acceptable. Adjusted visitor LECR's are within EPA's acceptable excess cancer risk range for all four businesses and therefore, visitors to the businesses should not have harmful exposures.

The same calculations were done for average measured post-mitigation PCE and TCE levels. These work-time adjusted LECR's are found in Table 7. For a full-time worker working 10 hours per day for five days per week for one year in T-Mobile, Jersey Mike's, and Sam's Kabab, the adjusted post-mitigation levels of PCE equate to an LECR greater than EPA's acceptable excess risk range. Adjusted post-mitigation PCE levels in T-Mobile for a part-time worker working four hours per day, five days per week, for 50 weeks per year would also have an LECR outside of EPA's acceptable excess risk range. LECR's for TCE are within EPA's acceptable risk range.

Mattress King and CVS Stores

Indoor air in storerooms in the Mattress King and CVS was sampled once in May 2016. The indoor air sampling was completed in areas of each store that were closest to the cleaner. Both PCE and TCE were noted in the indoor air of each storeroom and the levels are discussed in detail below.

Mattress King

The PCE level measured in Mattress King storeroom was low at $9.2 \mu\text{g}/\text{m}^3$. This was below ATSDR's non-cancer chronic EMEG. The level was about 2.5 times higher than ATSDR's CREG. EEP calculated an HI of 0.22 and an LECR of 2.4×10^{-6} which was not adjusted for any work hours. Breathing the level of PCE measured in the Mattress King storeroom should not be a health concern.

The TCE level of $105 \mu\text{g}/\text{m}^3$ measured in the Mattress King storeroom was above ATSDR and EPA comparison values. EEP calculated an HI of 50 and an LECR of 4.3×10^{-4} . This LECR was not adjusted for how long a person would work in the storeroom. Even when adjusting the exposure level for a ten hour work day, five days per week, for one year, the LECR remains outside of EPA's acceptable cancer risk range, at 1.2×10^{-4} or about one additional cancer in 10,000 people. This calculated exposure time was likely not representative of the amount of time an employee would spend in the store room. If the employee spent four hours each day for a five day work week for one year, the LECR lowers to 5×10^{-5} which would be in EPA's acceptable risk range. The TCE was likely from a source different than the cleaner as there were no comparable TCE levels measured in any of the other businesses located much closer to the

cleaner. TCE was found at a level of $123 \mu\text{g}/\text{m}^3$ in a sub-slab sample collected beneath the storeroom floor.

It should be pointed out that recent studies have led to a re-evaluation of TCE non-carcinogenic effects. Using the recent study data, the EPA predicts that there is a small risk of fetal heart malformations for pregnant women exposed to TCE at $21 \mu\text{g}/\text{m}^3$ or more TCE in air. The EPA used an uncertainty factor of 10 to obtain the RfC of $2 \mu\text{g}/\text{m}^3$ (ATSDR 2014a U.S. EPA 2013), or 0.37 ppb. There was also a 1988 study by the NTP (2011) that determined humans exposed to $30 \mu\text{g}/\text{m}^3$ of TCE in air are at risk of developing kidney damage from inhalation of air with TCE (EPA 2011). The TCE levels within the Mattress King storeroom were above both EPA's RfC level and the NTP study level.

Calculated TCE levels in the storeroom of Mattress King could be a potential health hazard for pregnant women employees if they spent their entire work time in the store room area. This is likely not the case and therefore, it is not likely that Mattress King employees would be harmed by the levels of TCE measured in the indoor air of the storeroom area.

CVS

The PCE level measured in CVS was $14.3 \mu\text{g}/\text{m}^3$. EEP calculated an HI of 0.34 and an LECR of 3.7×10^{-6} which was not adjusted for time spent in the storeroom. Both the calculated HI and LECR were within EPA's acceptable risk range. TCE was not detected in the storeroom above its detection limit of $1.07 \mu\text{g}/\text{m}^3$ and therefore no further evaluation was completed. There should not be a health concern from inhaling the levels of PCE or TCE measured in the CVS storeroom.

Health Education Activities

EEP and TDEC held a joint health education session for the businesses surrounding and including the cleaner on May 4, 2016. Managers of the cleaner as well as Jersey Mike's attended the session. The shopping center owner and the center's property manager also attended the meeting. Managers from Sam's Kabab and the Gauc restaurant (where Voodoo Gumbo is now located) did not attend. The T-Mobile business was vacant at the time which is where the session was held. TDEC and EEP discussed the fact that there is an indoor air issue in the various businesses that TDEC has been trying to address with the mitigation systems. The manager for Jersey Mike's asked several pointed health questions. The property owner, property manager, and managers of the cleaner and Jersey Mike's were given fact sheets on PCE and vapor intrusion, and were given information on our program and our contact number. EEP did not receive any further inquiries after the session.

During the deployment of the portable air purifying units on June 29, 2017, EEP again visited the site with TDEC and TDEC's contractor. EEP spoke to the Jersey Mike's manager again regarding the indoor air issues in the business. EEP also spoke to the Sam's Kabab and Voodoo Gumbo managers regarding why the units were being placed in their businesses and the associated indoor air issues. EEP also provided information about our program and PCE fact sheets for these two managers. The business that was Sweet CeCe's was being remodeled into

T-Mobile at the time. EEP spoke to the workers performing the remodeling encouraging them to provide as much ventilation in the space as possible. The portable air purifying unit was placed in T-Mobile several weeks later after the business opened. EEP did not speak to the T-Mobile manager or workers at the time of placement of the unit.

Child Health Considerations

Children would be unlikely to spend a great deal of time in any of the businesses surrounding the drycleaner. They are more likely to be visitors, to the businesses with their parents. Sometimes the children of the restaurant owners could spend time in the businesses after school or on school holidays. Children may be more sensitive to the carcinogenic effects of PCE and TCE than adults (ATSDR 2004). However, children's exposure time would be much less as they would likely not be part of the population that would normally be present inside the building for long periods of time.

To protect public health, it would be prudent to limit the amount of time children would spend in the drycleaner or the four businesses. If parents worked in any of these five businesses and brought their child to work, it would not be advisable for children to spend the day, given levels of PCE in the indoor air. It also would be advisable not to establish a future child care facility in the shopping center in the area of the cleaner where the populations would be exposed to the measured levels of PCE and TCE from the cleaner unless additional mitigation measures were used to make the building safe for this type of occupancy.

Limitations and Uncertainties in Vapor Intrusion

Having and following an accepted protocol for conducting indoor air investigations is important. A general protocol was developed for this investigation. Still, even a good protocol cannot remove all limitations and uncertainties related to vapor intrusion investigations (EPA 2012).

What happened in the past at the cleaner or other nearby sites is another uncertainty. The amounts and locations of any or all spills from the drycleaner were likely undocumented. Basic handling practices of drycleaning chemicals were different over the 40 years the drycleaner has operated in the shopping center. There appear to have been sumps located on the interior of the drycleaner. Drums of stored chemicals have been and are being stored inside the drycleaner. Several characteristics of buildings may influence the indoor air results. Some examples of limitations and uncertainties include the unavailability of "as built" construction diagrams for this building. The number of breaks in floor slabs or utility perforations entering the building were also variables that can influence test results (ITRC 2007). For example, the exact amount of contamination under the cleaner is an unknown. The amount and frequency of vapor off-gassing is likely not constant. It is unknown if there is migration of contaminated indoor air from the cleaner into the indoor air of the other businesses. The number of penetrations of the walls between the cleaner and the businesses on either side are also unknown.

Off-gassing from drycleaned clothing inside the cleaner may be influencing the results of the testing. Leaks from the drycleaning machine which have been repeatedly found and repaired in 2016 and 2017 have likely affected levels found in previous sampling events. Levels of chemicals in the indoor air of the cleaner and other businesses could vary depending on the

amount of drycleaning occurring in the cleaner, vapor flux, precipitation events, and seasonal effects. Off-gassing of chemicals from stored mattresses is likely influencing the measured TCE levels in the Mattress King.

Summary of Risk

Non-Cancer Risk: For the highest PCE levels found and for the average adjusted pre-mitigation and average adjusted post-mitigation levels of PCE, there could be non-cancer health effects if workers work long hours in the T-Mobile, Jersey Mikes, Sam's Kabab, and Voodoo Gumbo. These workers could experience neurological health effects such as color vision changes and cognitive and reaction time changes based on previous studies of drycleaning workers. It appears, based on the indoor air sampling results that workers in T-Mobile may at times be exposed to higher levels of PCE in the indoor air than the drycleaner workers in Ted's.

The highest levels of TCE found in the indoor air of the T-Mobile business would be considered a health hazard. However, since the installation of the mitigation systems in the businesses, TCE levels have decreased. Current levels of TCE in the businesses should not harm the health of those working or visiting any of the four businesses.

Cancer Risk: For the highest PCE levels found and for average adjusted pre-mitigation and average adjusted post-mitigation levels of PCE, LECRs of 10^{-4} to 10^{-3} or one in 10,000 people to one in 1,000 people were calculated. These LECRs suggest there is a low increase for additional cancer for an individual working in any of the four businesses. This low increase is in addition to the normal cancer rate of 1 in 2 for men and 1 in 3 for women.

The initial level of TCE found in the T-Mobile business would indicate an additional low risk of additional cancer and therefore indicate a health concern. Similar to that for non-cancer risk, post-mitigation work-time adjusted average levels of TCE should not be a health concern to those working or visiting any of the four businesses.

There was not a large difference between pre-mitigation and post-mitigation LECRs. It appears there may have been an additional low risk of increased cancer in the past and there continues to be the same risk, despite the mitigation efforts performed to date, in the future, especially in the T-Mobile business.

Conclusions

Conclusions and recommendations presented in this Health Consultation were based on the results of the indoor air testing performed between September 22, 2014 and October 4, 2017.

Conclusion 1: *TDH EEP concluded there could have been enough tetrachloroethylene (PCE) vapors in indoor air for the past two years in businesses surrounding Ted's Cleaners to harm people's health. EEP concluded that full-time workers health could be affected by inhaling measured levels of PCE over time. Levels in Voodoo Gumbo, Sam's Kabab, and Jersey Mike's may have been public health hazards from inhaling PCE in the past as documented by pre-mitigation levels of PCE in indoor air. Levels of PCE in the T-Mobile phone store, Sam's Kabab, and Jersey Mike's are an on-going public health hazard from inhaling indoor air for workers of these businesses who work long hours.*

Basis for Conclusion

PCE indoor air levels over the past two years were above both non-cancer and cancer comparison levels. Workers of and visitors to the businesses near Ted's Cleaners are being exposed to elevated levels of PCE. Sub-slab venting of vapors beneath the businesses and placement of portable air purifying units in the four businesses have not sufficiently reduced the indoor air levels of PCE. Vapors may also be coming from the operation of the drycleaner itself.

The highest level of PCE measured in T-Mobile at $10,700 \mu\text{g}/\text{m}^3$ was 261 times higher than the Agency for Toxic Substances and Disease Registry's (ATSDRs) chronic environmental media evaluation guide (EMEG) of $41 \mu\text{g}/\text{m}^3$. The average adjusted post-mitigation PCE level of $1,425 \mu\text{g}/\text{m}^3$ was nearly 35 times higher than its EMEG. Work-time adjusted average exposure levels of PCE in T-Mobile are 8 times lower than the LOAEL of 1.7 parts per million (ppm) or $11,530 \mu\text{g}/\text{m}^3$ for PCE. Work-time adjusted exposure levels of PCE in Sam's Kababs are 15 times lower than the PCE LOAEL of 1.7 ppm. However, levels of PCE in indoor air in T-Mobile, Sam's Kabab, Jersey Mike's, and Voodoo Gumbo are variable. There may be times when PCE levels are greater than its LOAEL, especially in the T-Mobile business. The variability suggests there could be a potential for non-cancer health effects, most likely neurological effects such as color vision changes. Post-mitigation adjusted PCE levels suggest there could also be a low increase in risk of cancer when compared to the background risk of cancer in T-Mobile, Sam's Kabab, and Jersey Mike's. Lifetime excess cancer risk for average adjusted PCE levels ranged from 6.9×10^{-5} in Voodoo Gumbo which is within EPA's acceptable risk range to 3.7×10^{-4} in T-Mobile which is outside EPA's acceptable range of risk for a full-time worker working 10 hours per day, 5 days per week, for 50 weeks per year in the four businesses.

Next Steps

Reducing levels of PCE in the four businesses surrounding Ted's is imperative. As mentioned, there likely are vapors coming from the operation of the cleaner as well as from sub-slab vapor intrusion entering the businesses adjacent to the cleaner. The sub-slab venting systems in the businesses have been in operation for over a year and a half. There has not been a noticeable decrease in PCE levels due to its operation. Portable air purifying units were also placed in each

of the four businesses. The air purifying units have not had an effect on PCE levels. Elevated PCE levels remain in all four businesses. Inside T-Mobile PCE levels have been higher than the active drycleaner (Ted's).

One option to reduce PCE levels in indoor air is through adjustment of the current heating, ventilation, and air conditioning (HVAC) systems in the individual businesses to have more air turnover per hour, to use or maximize the amount of make-up air pulled in from the outdoors, or if the current HVAC systems do not use make-up air, installing new HVAC systems that use make-up air. Another option to reduce PCE levels in indoor air is to remediate soil contamination by performing a source removal beneath both Ted's Cleaners and T-Mobile. The recent sub-slab vapor sampling indicates a mass of PCE vapor beneath these businesses and hence an underground PCE source area. It is also likely that drycleaner operations are contributing to the elevated levels found in the indoor air of the businesses. Therefore, ceasing drycleaning operations may help reduce indoor air levels of PCE.

Indoor air testing should continue to be performed in all the businesses to monitor current indoor air PCE levels and should continue after any interim or permanent remedial actions to prove the effectiveness of the action in lowering these levels.

Conclusion 2: *TDH EEP concluded past inhalation exposures to trichloroethylene (TCE) in the four businesses may have harmed full and part-time workers' health. With less TCE being measured, it appears the mitigation systems have reduced TCE levels indoors. It appears as long as the sub-slab mitigation systems continue to operate in the four businesses, there should not be harmful inhalation exposures to full- and part-time workers or visitors of the businesses.*

Basis for Conclusion

TCE indoor air levels were above both non-cancer and cancer comparison levels. Workers and customers of the businesses would be exposed to these levels. The highest measured TCE levels, the average TCE level measured, and pre-mitigation adjusted work-time exposure levels were above or near EPA's RfC for TCE of $2 \mu\text{g}/\text{m}^3$, suggesting past harmful health effects to workers were possible. Post-mitigation levels adjusted for work times were below the RfC suggesting these levels should not harm the health of workers or visitors of the businesses. They are also well below the level EPA predicts that there is a small risk of fetal heart malformations for pregnant women exposed to TCE of $21 \mu\text{g}/\text{m}^3$. The sub-slab mitigation systems and the portable air purifiers appear to have reduced and continue to reduce levels of TCE in the indoor air of the businesses. Cancer health effects likely did not occur as calculated LECRs for the highest TCE levels measured in each business, the average of measured TCE levels, and the work-time adjusted exposure levels of TCE were all within EPA's acceptable risk range.

Next Steps

It would be a prudent public health action to continue to lower TCE levels in the businesses even though they are currently low and should not cause harm to those working and visiting the businesses. Whatever method is used to mitigate the bigger PCE problem should also mitigate

TCE levels in indoor air. Further indoor air testing should include monitoring for TCE in all four businesses.

Conclusion 3: *TDH EEP concluded TCE vapors may pose a public health hazard for pregnant women who spend long hours in the Mattress King storeroom. The TCE in the Mattress King storeroom may be unrelated to the drycleaning activities carried out at Ted's as the PCE level in indoor air was low. A sub-slab sample collected did show elevated levels of TCE. The TCE is also likely off-gassing from materials and mattresses in the storeroom.*

Basis for Conclusion

TCE indoor air levels in the Mattress King storeroom were elevated and above both non-cancer and cancer comparison levels. For the one test conducted in 2016, the level of TCE was at a level of 105 $\mu\text{g}/\text{m}^3$, above the 21 $\mu\text{g}/\text{m}^3$ level which EPA predicts there is a small risk of fetal heart malformations for pregnant women. The level found is also above a study level of 30 $\mu\text{g}/\text{m}^3$ where it was found that humans are at risk of developing kidney damage from inhalation of air with TCE. For pregnant women, inhalation of TCE levels found is a cause for concern.

Next Steps

It would be a prudent public health action not to allow pregnant women to work in the Mattress King storeroom for long periods of time.

Recommendations

This Health Consultation was prepared to make sure the indoor air breathed by workers and visitors to the shopping center where Ted's Cleaners is located will not lead to harmful health effects. Based on the results of two years of indoor air sampling, TDH EEP has the following recommendations:

1. TDH EEP recommends a permanent solution to reduce PCE from indoor air in the businesses adjacent to Ted's Cleaners. The installation of sub-slab mitigation systems and use of indoor air purifiers have both failed to significantly reduce indoor PCE levels. Workers continue to be exposed to too much PCE over their work week.
2. TDH EEP recommends reducing levels of PCE in indoor air through adjustment of the current HVAC systems in the individual businesses to have more air turnover per hour, to use or maximize the amount of make-up air pulled in from the outdoors or if the current HVAC systems do not use make-up air, or installing new HVAC systems that use make-up air. Additionally, the best option to reduce PCE levels in indoor air would be to discontinue drycleaning operations and remediate soil contamination. Drycleaner operations are likely contributing to the elevated PCE levels in indoor air of the businesses. Ceasing cleaning operations could lower indoor air levels of PCE. Soil remediation could be accomplished by ceasing cleaning operations, removing the drycleaning machine within Ted's, and performing a source removal beneath both Ted's

Cleaners and T-Mobile. Sub-slab vapor sampling shows a mass of PCE beneath these businesses.

3. TDH EEP recommends continuing indoor air monitoring until enough data is available to verify the levels of PCE in indoor air in the businesses have been effectively reduced *below a level of health concern*.
4. EEP recommends the property not have a child care facility, senior center, medical clinic or other use that would expose potentially sensitive populations to PCE and TCE.

Public Health Action Plan

The public health action plan for the Ted's Cleaners Site contains a list of actions that have been or will be taken by TDH EEP and other agencies. The purpose of the public health action plan is to ensure that this health consultation identifies public health concerns and offers a plan of action designed to mitigate and prevent harmful health effects that result from breathing, eating, drinking, or touching hazardous substances in the environment. Included is a commitment on the part of EEP to follow up on this plan to ensure that it is implemented.

Public health actions that have already been taken by TDH EEP included:

- Reviewed data collected from 14 indoor air sampling events done in the cleaner and four adjacent businesses over the past two and one-half years.
- Performed four site visits to the cleaners. One was to provide health information to nearby leased space managers about the health effects of drycleaning chemicals. One visit was to observe a DCERP contractor verifying the operation of the sub-slab mitigation system. The third visit was to observe Metropolitan Nashville Department of Health's Air Quality Program inspect the drycleaning machine. The fourth visit was to accompany DCERP and DCERP's contractor to install the portable air purifier units in each of the businesses surrounding Ted's, and to speak with the owners of the businesses about the actions to fix the indoor air issue.
- Conferred with TDEC DCERP personnel and TDEC's Risk Assessor regarding the elevated levels of chemicals identified in the indoor air. All concluded it would be prudent to install temporary air purifiers in the four businesses. The air purifiers were installed but they have not lowered the levels of PCE in the businesses enough.
- Prepared this Health Consultation.

Public health actions that will be taken include:

- TDH EEP will provide a copy of this health consultation to the shopping center owner, the property management company, and the owners of the four businesses next to the cleaner. This health consultation will also be given to any employees of any of the four businesses who request it.
- Answer any questions the businesses owners and their employees have about their current and past exposures.
- TDH EEP will provide fact sheets about vapor intrusion and health effects of inhaling air containing PCE and TCE to the four business owners and operators and their employees. EEP will also provide a TCE fact sheet to the business owner and operator of the Mattress King store.
- TDH EEP will follow up with TDEC to make sure progress is being made on a solution to permanently reduce PCE from indoor air in the businesses.
- TDH EEP will maintain dialogue with ATSDR, TDEC, the Metropolitan Nashville Department of Health, and other interested stakeholders to safeguard public health.
- TDH EEP staff will be available to answer questions regarding the interpretation of the indoor air results and to review additional environmental data, as requested.

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Glossary of Terms and Acronyms

acute exposure: Contact with a substance that occurs once or for only a short time (up to 14 days).

adverse health effect: A change in body function or cell structure that might lead to disease or health problems.

ATSDR: Agency for Toxic Substances and Disease Registry.

cancer: Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

cancer risk: The theoretical excess risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower. The excess cancer risk is often expressed as 1×10^{-6} for one excess cancer in 1 million people.

carcinogen: A substance that may cause cancer.

chronic exposure: Contact with a substance that occurs over a long time (more than 1 year).

Comparison Value (CV): Calculated concentration of a substance in air, water, food, or soil unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Cancer Risk Evaluation Guide (CREG): soil, water, or air comparison values prepared by ATSDR used to identify concentrations of cancer-causing substances unlikely to result in an increase of cancer rates in an exposed population.

contaminant: A substance that is present in an environment where it does not belong.

DCERP: Tennessee Department of Environment and Conservation's Drycleaner Environmental Response Program

detection limit: The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

DoR: Tennessee Department of Environment and Conservation's Division of Remediation.

Excess Lifetime Cancer Risk (ECLR): The additional risk that someone may have of getting cancer if that person is exposed to cancer-causing chemicals.

EEP: Environmental Epidemiology Program of the Tennessee Department of Health.

Environmental Media Evaluation Guide (EMEG): Concentrations of substances in water, soil, or air developed by ATSDR to which humans may be exposed during a specified period of time (acute, intermediate, chronic) without experiencing adverse non-cancer health effects.

EPA: United States Environmental Protection Agency.

exposure: Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).

exposure pathway: The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: 1. a source of contamination (such as an abandoned business), 2. an environmental media and transport mechanism (such as movement through groundwater), 3. a point of exposure (such as a private well), 4. a route of exposure (eating, drinking, breathing, or touching), and 5. a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

hazard: A source of potential harm from past, current, or future exposures.

Health Consultation: A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health Consultations are focused on a specific exposure issue. Health Consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical.

Hazard Index: The sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The HI is calculated separately for chronic, subchronic, and shorter-duration exposures.

inhalation: The act of breathing. Inhalation is a pathway of concern for the Ted's Cleaners Site.

Inhalation Unit Risk (IUR): The excess lifetime cancer risk estimated to result from continuous (24-hour per day, 7 days per week, 365 days per year) exposure to a chemical at a concentration of 1 microgram per cubic meter ($\mu\text{g}/\text{m}^3$) in air.

intermediate duration exposure: Contact with a substance that occurs for more than 14 days and less than a year.

Lowest Observed Adverse Effect Level (LOAEL): The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Minimal Risk Level (MRL): An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.

No Observed Adverse Effect Level (NOAEL): The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

Occupational Safety and Health Administration (OSHA): The Williams-Steiger Occupational Safety and Health Act of 1970 (OSHA) is a law designed to protect the health and safety of industrial workers and also the operators of water supply systems and treatment plants..

ppm: parts per million

reference dose: A USEPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause non-cancer health effects in humans.

Regional Screening Level (RSL): comparison levels prepared by the U.S. EPA that are chemical-specific concentrations for individual contaminants in air, drinking water, and soil that may warrant further investigation or site cleanup.

remediation: Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a site.

risk: The probability that something will cause injury or harm. For non-carcinogen health effects, it is evaluated by comparing an exposure level over a period to a reference dose derived from experiments on animals. For carcinogenic health effects, risk is estimated as the incremental probability of an individual developing cancer over a lifetime (70 years) as a result of exposure to a potential carcinogen.

route of exposure: How people come into contact with a hazardous substance. Three routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact).

sample: An environmental sample, such as a small amount of soil, water, or air collected to measure contamination in the environment.

TDEC: State of Tennessee Department of Environment and Conservation

TDH: State of Tennessee Department of Health

tetrachloroethylene (PCE or Perc): A chemical this is a nonflammable liquid at room temperature. It is a colorless liquid and has a sweet smell. It is widely used as a solvent and is the most common chemical used in drycleaning garments.

toxicological profile: An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

trichloroethylene (TCE): A chemical that is a nonflammable liquid at room temperature. It is also called TCE. It is a manufactured chemical that is widely used to remove grease from metal

parts. Trichloroethylene is also an ingredient in other consumer products. It evaporates easily into the air from surface water and has a somewhat sweet odor.

µg/m³: micrograms per cubic meter. Air results are usually measured in either µg/m³ or ppb.

vapor intrusion: The process by which volatile chemicals migrate from an underground source into the indoor air of buildings.

Appendix A. Measured Tetrachloroethylene and Trichloroethylene Levels in Cleaners and Businesses: 2014-2017

Measured indoor air PCE levels Sept 2014 – Oct 2017 (in micrograms per cubic meter - $\mu\text{g}/\text{m}^3$)

	Ted's Cleaners	T-Mobile	Jersey Mike's	Voodoo Gumbo	Sam's Kababs	
Sept 22 2014	5000		2400			
Feb 12 2015	7500	4300	1800	1100	2600	
Nov 18 2015	1190	1510	381	441	1320	* T-Mob. Mitigated
Feb 10, 19 2016	1450		2380	1070	2110	
July 7 2016	55.7	1960	467	262	1250	*Others mitigated
Aug 12 2016	432	1250	247	105	436	
Aug 12 2016	4750	889				
Aug 14 2016	7200	963				
Oct 26 2016	7440	6730	1820	1100	2030	
Feb 16 2017	1180	1200				
May 15 2017	2530	7780	2440	362	4050	
July 14 2017	5730	9950	1700	1800	3300	
August 8-11 2017	4140	8450	1440	1760	3890	
October 4 2017	2780	10700	1230	1110	2950	
Average of All Events	3669.84	4640.17	1482.27	911	2393.6	
Average of Pre-Mitigation Levels	3785	4300	1740.25	870.33	2010	
Average of Post-Mitigation Levels	3623.77	4987.2	1334.86	928.43	2558	

Measured indoor air TCE levels Sept 2014 – Oct 2017 (in micrograms per cubic meter - $\mu\text{g}/\text{m}^3$)

	Ted's Cleaners	T-Mobile	Jersey Mike's	Voodoo Gumbo	Sam's Kababs	
Sept 22, 2014	75		21			
Feb 12 2015	28	23	5.1	11	11	
Nov 18 2015	4.6	7.8	1.4	2.3	2.8	* T-Mob. Mitigated
Feb 10, 19 2016	1.4		4.1	4.5	4	
July 7 2016	1.1	1.6	1.1	2.5	1.3	*remainder mitigated
Aug 12 2016	1.1	1.1	1.1	1.2	1.1	
Aug 12 2016	2.6	1.1				
Aug 14 2016	5.6	1.1				
Oct 26 2016	7.3	2.4	1.1	2	1.3	
Feb 16 2017	1.1	2.8				
May 15 2017	1.1	1.1	1.1	1.1	1.1	
July 14 2017	1.33	10.4	6.55	6.73	1.51	
August 8-11 2017	1.1	1.1	1.1	1.1	1.1	
October 4 2017	1.1	1.1	1.1	1.09	1.1	
Average of All Events	9.46	4.55	4.07	3.35	2.63	
Average Pre-Mitigation Levels	27.25	23	7.9	5.93	5.93	
Average Post-Mitigation Levels	2.34	2.38	1.88	2.24	1.22	

Appendix B. Pre-Mitigation Estimated Exposure Levels for Individual Businesses

Exposure Calculations for T-Mobile

1. Calculation for 10 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 10 hour shift for 5 days per week for 50 weeks per year in T-Mobile:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 4,300 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **1,229 $\mu\text{g}/\text{m}^3$**
= **0.18 ppm = 180 ppb**

Average Pre-Mitigation TCE Conc._{adjusted} = 2.3 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.66 $\mu\text{g}/\text{m}^3$**
= **0.0001 ppm = 0.1 ppb**

2. Calculation for 4 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 4 hour shift for 5 days per week for 50 weeks per year in T-Mobile:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 4,300 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **492 $\mu\text{g}/\text{m}^3$**
= **0.07 ppm = 70 ppb**

Average Pre-Mitigation Maximum TCE Conc._{adjusted} = 2.3 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.26 $\mu\text{g}/\text{m}^3$**
= **0.00005 ppm = 0.05 ppb**

3. Calculation for 1.5 hour/day Visitor – Average Level – Pre-Mitigation:

In this case we will calculate the level for a visitor who is in T-Mobile for 1.5 hours 1 day per week for 26 weeks per year:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

*Average Pre-Mitigation PCE Conc._{adjusted} = 4,300 µg/m³ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = **19.2 µg/m³**
= **0.003 ppm = 3.0 ppb***

*Average Pre-Mitigation TCE Conc._{adjusted} = 2.3 µg/m³ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = **0.01 µg/m³**
= **0.000002 ppm = 0.002 ppb***

Exposure Calculations for Jersey Mike's

1. Calculation for 10 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 10 hour shift for 5 days per week for 50 weeks per year in Jersey Mike's:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

*Average Pre-Mitigation PCE Conc._{adjusted} = 1,740 µg/m³ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **497 µg/m³**
= **0.07 ppm = 70 ppb***

*Average Pre-Mitigation TCE Conc._{adjusted} = 7.9 µg/m³ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **2.3 µg/m³** =
0.0004 ppm = 0.4 ppb*

2. Calculation for 4 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 4 hour shift for 5 days per week for 50 weeks per year in Jersey Mike's:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 1,740 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 199 $\mu\text{g}/\text{m}^3$ = 0.03 ppm = 30 ppb

Average Pre-Mitigation Maximum TCE Conc._{adjusted} = 7.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 0.90 $\mu\text{g}/\text{m}^3$ = 0.0002 ppm = 0.2 ppb

3. Calculation for 1.5 hour/day Visitor – Average Level – Pre-Mitigation:

In this case we will calculate the level for a visitor who is in Jersey Mike's for 1.5 hours 1 day every other week for 26 weeks per year:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 1,740 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = 7.8 $\mu\text{g}/\text{m}^3$ = 0.001 ppm = 1.0 ppb

Average Pre-Mitigation TCE Conc._{adjusted} = 7.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = 0.04 $\mu\text{g}/\text{m}^3$ = 0.000007 ppm = 0.007 ppb

Exposure Calculations for Voodoo Gumbo

1. Calculation for 10 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 10 hour shift for 5 days per week for 50 weeks per year in Voodoo Gumbo:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 870 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **249 $\mu\text{g}/\text{m}^3$**
= **0.038 ppm = 38 ppb**

Average Pre-Mitigation TCE Conc._{adjusted} = 5.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **1.7 $\mu\text{g}/\text{m}^3$** = **0.0003 ppm = 0.3 ppb**

2. Calculation for 4 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 4 hour shift for 5 days per week for 50 weeks per year in Voodoo Gumbo:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 870 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **100 $\mu\text{g}/\text{m}^3$**
= **0.015 ppm = 15 ppb**

Average Pre-Mitigation Maximum TCE Conc._{adjusted} = 5.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.7 $\mu\text{g}/\text{m}^3$** = **0.0001 ppm = 0.1 ppb**

3. Calculation for 1.5 hour/day Visitor – Average Level – Pre-Mitigation:

In this case we will calculate the level for a visitor who is in Voodoo Gumbo for 1.5 hours 1 day every other week for 26 weeks per year:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

*Average Pre-Mitigation PCE Conc._{adjusted} = 870 µg/m³ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = 3.9 µg/m³
= 0.006 ppm = 6 ppb*

*Average Pre-Mitigation TCE Conc._{adjusted} = 5.9 µg/m³ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = 0.03 µg/m³
= 0.000006 ppm = 0.006 ppb*

Exposure Calculations for Sam's Kabab

1. Calculation for 10 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 10 hour shift for 5 days per week for 50 weeks per year in Sam's Kabab:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

*Average Pre-Mitigation PCE Conc._{adjusted} = 2,167 µg/m³ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 619 µg/m³
= 0.091 ppm = 91 ppb*

Average Pre-Mitigation TCE Conc._{adjusted} = 5.9 µg/m³ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 1.7 µg/m³ = 0.0003 ppm = 0.1 ppb

2. Calculation for 4 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 4 hour shift for 5 days per week for 50 weeks per year in Sam's Kabab:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 2,167 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 248 $\mu\text{g}/\text{m}^3$ = 0.04 ppm = 40 ppb

Average Pre-Mitigation Maximum TCE Conc._{adjusted} = 5.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 0.7 $\mu\text{g}/\text{m}^3$ = 0.0003 ppm = 0.3 ppb

3. Calculation for 1.5 hour/day Visitor – Average Level – Pre-Mitigation:

In this case we will calculate the level for a visitor who is in Sam's Kabab for 1.5 hours 1 day every other week for 26 weeks per year:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 2,167 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = 9.7 $\mu\text{g}/\text{m}^3$ = 0.0014 ppm = 14 ppb

Average Pre-Mitigation TCE Conc._{adjusted} = 5.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = 0.03 $\mu\text{g}/\text{m}^3$ = 0.000006 ppm = 0.006 ppb

Exposure Calculations for the Mattress King Store Room Area

1. Calculation for 10 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 2 hours for 5 days per week for 50 weeks per year in the Mattress King Store Room Area:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted}* = 9.2 µg/m³ average indoor air level x 2 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.5 µg/m³ = 0.001 ppm = 1 ppb*

Average Pre-Mitigation TCE Conc._{adjusted}* = 105 µg/m³ average indoor air level x 2 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **6 µg/m³ = 0.0009 ppm = 0.9 ppb*

2. Calculation for 4 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working 1hour for 5 days per week for 50 weeks per year in the Mattress King Store Room Area:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted}* = 9.2 µg/m³ average indoor air level x 1 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.26 µg/m³ = 0.00004 ppm = 0.04 ppb*

Average Pre-Mitigation Maximum TCE Conc._{adjusted}* = 105 µg/m³ average indoor air level x 1 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **3.0 µg/m³ = 0.0006 ppm = 0.6 ppb*

3. Calculation for 1.5 hour/day Visitor – Average Level – Pre-Mitigation:

In this case we will calculate the level for a visitor who is in the Mattress King Store Room Area for 0.5 hours 1 day per week for 2 weeks per year:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 9.2 µg/m³ average indoor air level x 0.5 hours/24 hour day x 1 days/7 days per week x 2 weeks/52 weeks per year = **0.001 µg/m³**
= **0.0000001 ppm = 0.0001 ppb**

Average Pre-Mitigation TCE Conc._{adjusted} = 105 µg/m³ average indoor air level x 0.5 hours/24 hour day x 1 days/7 days per week x 2 weeks/52 weeks per year = **0.01 µg/m³** = **0.000002 ppm = 0.002 ppb**

Exposure Calculations for the CVS Store Room Area

1. Calculation for 10 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working a 2 hours for 5 days per week for 50 weeks per year in the CVS Store Room Area:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted} = 14.3 µg/m³ average indoor air level x 2 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.8 µg/m³** = **0.001 ppm = 1 ppb**

Average Pre-Mitigation TCE Conc._{adjusted} = 1.1 µg/m³ average indoor air level x 2 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.06 µg/m³** = **0.0002 ppm = 0.2 ppb**

2. Calculation for 4 hour/day Worker – Average Level – Pre-Mitigation:

In this case we will calculate the level for a worker working 1hour for 5 days per week for 50 weeks per year in the CVS Store Room Area:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted}* = 14.3 µg/m³ average indoor air level x 1 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.4 µg/m³ = 0.00004 ppm = 0.04 ppb*

Average Pre-Mitigation Maximum TCE Conc._{adjusted}* = 1.1 µg/m³ average indoor air level x 1 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **0.03 µg/m³ = 0.00006 ppm = 0.06 ppb*

3. Calculation for 1.5 hour/day Visitor – Average Level – Pre-Mitigation:

In this case we will calculate the level for a visitor who is in the CVS Store Room Area for 0.5 hours 1 day per week for 2 weeks per year:

Average Pre-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Pre-Mitigation PCE Conc._{adjusted}* = 14.3 µg/m³ average indoor air level x 0.5 hours/24 hour day x 1 days/7 days per week x 2 weeks/52 weeks per year = **0.002 µg/m³ = 0.0000001 ppm = 0.0001 ppb*

Average Pre-Mitigation TCE Conc._{adjusted}* = 1.1 µg/m³ average indoor air level x 0.5 hours/24 hour day x 1 days/7 days per week x 2 weeks/52 weeks per year = **0.0001 µg/m³ = 2x10⁻⁸ ppm = 0.00002 ppb*

Appendix C. Post-Mitigation Estimated Exposure Levels for Individual Businesses

Exposure Calculations for T-Mobile

1. Calculation for 10 hour/day Worker – Average Level – Post–Mitigation:

In this case we will calculate the level for a worker working a 10 hour shift for 5 days per week for 50 weeks per year in T-Mobile:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and
EF = exposure frequency (days/week)

Average Post-Mitigation PCE Conc._{adjusted} = 4,987 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 1,425 $\mu\text{g}/\text{m}^3$ = 0.21 ppm = 210 ppb

Average Post- Mitigation TCE Conc._{adjusted} = 2.4 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks / 52 weeks per year = 0.68 $\mu\text{g}/\text{m}^3$ = 0.0001 ppm = 0.1 ppb

2. Calculation for 4 hour/day Worker – Average Level – Post–Mitigation:

In this case we will calculate the level for a worker working a 4 hour shift for 5 days per week for 50 weeks per year in T-Mobile:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and
EF = exposure frequency (days/week)

Average Post-Mitigation PCE Conc._{adjusted} = 4,987 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 571 $\mu\text{g}/\text{m}^3$ = 0.08 ppm = 80 ppb

Average Post-Mitigation Maximum TCE Conc._{adjusted} = 2.4 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks / 52 weeks per year = 0.27 $\mu\text{g}/\text{m}^3$ = 0.00005 ppm = 0.05 ppb

3. Calculation for 1.5 hour/day Visitor – Average Level – Post–Mitigation:

In this case we will calculate the level for a visitor who is in T-Mobile for 1.5 hours 1 day every other week for 26 weeks per year:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

***Average Post-Mitigation PCE Conc._{adjusted}* = 4.987 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = 22 $\mu\text{g}/\text{m}^3$
= **0.002 ppm = 2 ppb****

***Average Post-Mitigation TCE Conc._{adjusted}* = 2.4 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks / 52 weeks per year = **0.01 $\mu\text{g}/\text{m}^3$**
= **0.000002 ppm = 0.002 ppb****

Exposure Calculations for Jersey Mike's

1. Calculation for 10 hour/day Worker – Average Level – Post–Mitigation:

In this case we will calculate the level for a worker working a 10 hour shift for 5 days per week for 50 weeks per year in Jersey Mike's:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

***Average Post-Mitigation PCE Conc._{adjusted}* = 1,335 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **381 $\mu\text{g}/\text{m}^3$**
= **0.06 ppm = 60 ppb****

***Average Post-Mitigation TCE Conc._{adjusted}* = 1.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks / 52 weeks per year = **0.54 $\mu\text{g}/\text{m}^3$**
= **0.0001 ppm = 0.1 ppb****

2. Calculation for 4 hour/day Worker – Average Level – Post-Mitigation:

In this case we will calculate the level for a worker working a 4 hour shift for 5 days per week for 50 weeks per year in Jersey Mike's:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Post-Mitigation PCE Conc._{adjusted} = 1,335 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **153 $\mu\text{g}/\text{m}^3$**
= **0.02 ppm = 20 ppb**

Average Post-Mitigation Maximum TCE Conc._{adjusted} = 1.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks / 52 weeks per year = **0.22 $\mu\text{g}/\text{m}^3$** = **0.00004 ppm = 0.04 ppb**

3. Calculation for 1.5 hour/day Visitor – Average Level – Post-Mitigation:

In this case we will calculate the level for a visitor who is in Jersey Mike's for 1.5 hours 1 day every other week for 26 weeks per year:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Post-Mitigation PCE Conc._{adjusted} = 1,335 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = **6 $\mu\text{g}/\text{m}^3$**
= **0.001 ppm = 1 ppb**

Average Post-Mitigation TCE Conc._{adjusted} = 1.9 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks / 52 weeks per year = **0.009 $\mu\text{g}/\text{m}^3$** = **0.000004 ppm = 0.004 ppb**

Exposure Calculations for Voodoo Gumbo

1. Calculation for 10 hour/day Worker – Average Level – Post–Mitigation:

In this case we will calculate the level for a worker working a 10 hour shift for 5 days per week for 50 weeks per year in Voodoo Gumbo:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Post-Mitigation PCE Conc._{adjusted} = 928 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 265 $\mu\text{g}/\text{m}^3$ = 0.04 ppm = 40 ppb

Average Post-Mitigation TCE Conc._{adjusted} = 2.2 $\mu\text{g}/\text{m}^3$ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks / 52 weeks per year = 0.63 $\mu\text{g}/\text{m}^3$ = 0.0001 ppm = 0.1 ppb

2. Calculation for 4 hour/day Worker – Average Level – Post–Mitigation:

In this case we will calculate the level for a worker working a 4 hour shift for 5 days per week for 50 weeks per year in Voodoo Gumbo:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

Average Post-Mitigation PCE Conc._{adjusted} = 928 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = 106 $\mu\text{g}/\text{m}^3$ = 0.016 ppm = 16 ppb

Average Post-Mitigation Maximum TCE Conc._{adjusted} = 2.2 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks / 52 weeks per year = 0.25 $\mu\text{g}/\text{m}^3$ = 0.00005 ppm = 0.05 ppb

3. Calculation for 1.5 hour/day Visitor – Average Level – Post–Mitigation:

In this case we will calculate the level for a visitor who is in Voodoo Gumbo for 1.5 hours 1 day every other week for 26 weeks per year:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

*Average Post-Mitigation PCE Conc._{adjusted} = 928 µg/m³ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = **4.1 µg/m³**
= **0.006 ppm = 6 ppb***

*Average Post-Mitigation TCE Conc._{adjusted} = 2.2 µg/m³ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks / 52 weeks per year = **0.01 µg/m³**
= **0.000002 ppm = 0.002 ppb***

Exposure Calculations for Sam's Kabab

1. Calculation for 10 hour/day Worker – Average Level – Post–Mitigation:

In this case we will calculate the level for a worker working a 10 hour shift for 5 days per week for 50 weeks per year in Sam's Kabab:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

*Average Post-Mitigation PCE Conc._{adjusted} = 2,558 µg/m³ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **731 µg/m³**
= **0.11 ppm = 11 ppb***

*Average Post-Mitigation TCE Conc._{adjusted} = 1.2 µg/m³ average indoor air level x 10 hours/24 hour day x 5 days/7 days per week x 50 weeks / 52 weeks per year = **0.34 µg/m³**
= **0.00006 ppm = 0.06 ppb***

2. Calculation for 4 hour/day Worker – Average Level – Post-Mitigation:

In this case we will calculate the level for a worker working a 4 hour shift for 5 days per week for 50 weeks per year in Sam's Kabab:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

***Average Post-Mitigation PCE Conc._{adjusted}* = 2,558 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks/52 weeks per year = **293 $\mu\text{g}/\text{m}^3$**
= 0.04 ppm = 40 ppb**

Average Post-Mitigation Maximum TCE Conc._{adjusted}* = 1.2 $\mu\text{g}/\text{m}^3$ average indoor air level x 4 hours/24 hour day x 5 days/7 days per week x 50 weeks / 52 weeks per year = **0.14 $\mu\text{g}/\text{m}^3$** = **0.00002 ppm = 0.02 ppb*

3. Calculation for 1.5 hour/day Visitor – Average Level – Post-Mitigation:

In this case we will calculate the level for a visitor who is in Sam's Kabab for 1.5 hours 1 day every other week for 26 weeks per year:

Average Post-Mitigation PCE or TCE Concentration_{adjusted} = Maximum PCE or TCE Concentration x ET x EF

where:

ET = exposure time (hours [hrs.]/day); and

EF = exposure frequency (days/week)

***Average Post-Mitigation PCE Conc._{adjusted}* = 2,558 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks/52 weeks per year = **11.4 $\mu\text{g}/\text{m}^3$**
= 0.00002 ppm = 0.02 ppb**

Average Post-Mitigation TCE Conc._{adjusted}* = 1.2 $\mu\text{g}/\text{m}^3$ average indoor air level x 1.5 hours/24 hour day x 1 days/7 days per week x 26 weeks / 52 weeks per year = **0.005 $\mu\text{g}/\text{m}^3$** = **0.0000009 ppm = 0.0009 ppb*

Certification

This Health Consultation: *Ted's Cleaners Air Sampling Results Evaluation, Nashville, Davidson County, Tennessee*, was prepared by the Tennessee Department of Health's Environmental Epidemiology Program. It was prepared in accordance with the approved methodology and procedures that existed at the time the health consultation was prepared.



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