Health Consultation

101 45th AVENUE NORTH PROPERTY

AIR SAMPLING RESULTS EVALUATION

NASHVILLE, DAVIDSON COUNTY, TENNESSEE

FEBRUARY 1, 2013

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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.

Please write to: Environmental Epidemiology Program
Tennessee Department of Health
1st Floor, Cordell Hull Building
425 5th Avenue North
Nashville, TN 37243

Or call us at: 615-741-7247 or 1-800-404-3006 during normal business hours

Or e-mail us at: eep.health@tn.gov

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Introduction

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) reviewed the October 2, 2012, *Vapor Intrusion Testing Report* prepared by The Breland Group, LLC and Frost Environmental Services, LLC. The report was prepared for the property located at 101 45th Avenue North, Map 103-08, Parcel 48 in Nashville, Davidson County, Tennessee. The Tennessee Department of Environment and Conservation (TDEC), Division of Remediation (DoR), State Remediation Program (SRP), asked EEP to (1) review indoor and outdoor air testing results and (2) evaluate if the levels of chemicals found in the indoor air of two separate buildings on the property could be a concern for the health of the employees working in or visitors to the buildings.

This review specifically evaluated the indoor air testing results from the testing done on September 16, 2012, inside the site buildings, by the responsible party on behalf of TDEC SRP. This health consultation documented a health evaluation of the air testing results and provided the information to TDEC and the responsible party.

Background

The 101 45th Avenue North Site land parcel contains two separate buildings (Figure 1). One of the buildings is a former restaurant. The other building is a former gas station that sold gas and provided automotive repair. The restaurant was recently vacated and closed. The gas station has been closed for 30 years and the property was used as a parking area for restaurant customers. Both the restaurant and former gas station now form one property parcel. The property is being considered for redevelopment.

The former restaurant is a single story approximate 1,200 square foot building. The floor of the restaurant is concrete slab-on-grade. The building has a kitchen area and dining area. To EEP's knowledge there has not been any environmental investigations completed inside or outside around the footprint of the former restaurant.

After the gas station closed, the underground product tanks were removed, according to TDEC (Danny Fox, personal communication, December 5, 2012). The former gas station is a single story, concrete block, approximately 1,100 square foot building. The floor of the former gas station building is concrete slab-on-grade.

The former gas station has an area that was used as service bays and a partitioned office area. The office partitions do not extend to the ceiling. There are no reported hydraulic lifts or other gas station-related materials in the building. No routine maintenance has been done inside the building.

The gas station area has been investigated previously by an environmental consultant. Soil and groundwater samples collected at the gas station site did not have any petroleum-related chemicals above State of Tennessee action levels. A nearby creek was also sampled. The creek sample had no petroleum-related chemicals.

Figure 1. 101 45th Avenue North Site Location. Residential and commercial properties surround the site. Source: Google Earth 2012

The environmental consultant for the owner contacted TDH EEP in August 2012 (Ed Breland, The Breland Group, personal communication, August 17, 2012). The consultant requested recommendations on collecting indoor air samples and to discuss general indoor air sampling procedures. After the contact with TDH EEP, the consultant initiated indoor air sampling activities. The environmental consultant did not submit an air testing workplan to TDEC before conducting the air sampling. Typically, TDEC reviews the air sampling workplans along with TDH EEP to evaluate the completeness and other features of the testing.

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 no one comes into contact with a contaminant, then no exposure occurs, and thus, 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 source could be accidental spills and leaks from past activities performed at the site. The environmental media, such as, soil, surface water, groundwater, or air, transport the contaminants. For this site, the chemicals would potentially be 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 is the way the contaminant enters the body. Routes of exposure could include the ingestion pathway, the inhalation pathway, or through dermal contact. For this site, if the indoor air has measureable levels of petroleum hydrocarbon chemicals, 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.

For this project, the people who would be exposed if vapor intrusion was occurring, the exposed population, are the future workers in and visitors to the current buildings. If the site were redeveloped, the exposed population would be the future workers and visitors to a building that would be erected on this site. It is not known how many people may work in any on-site building in the future or how many hours per day or week they would work.

Vapor Intrusion

Volatile and semi-volatile chemicals can evaporate from impacted subsurface soil and/or 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. Examples of these elements include 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 factors. 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.

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.

Comparison Values

To evaluate exposure to a hazardous substance, health assessors often use health comparison values (CVs). If the chemical concentrations are below the CV, then health assessors can be reasonably certain that no adverse health effects will occur in people who are exposed. If concentrations are above the CV (ATSDR 2012) for a particular chemical, then further evaluation is needed.

Comparison value levels established by the Agency for Toxic Substances and Disease Registry's (ATSDR) and U.S. Environmental Protection Agency (EPA) for residential air inhalation were used in evaluating the results of the indoor air testing. The reason for using these CVs was that there would be a potential involuntary exposure to workers and any visitors to the building to benzene and other petroleum hydrocarbon compounds. Federal Occupational Safety and Health Administration (OSHA) workplace standards were not used for this same reason. U.S.

Environmental Protection Agency (EPA) industrial air RSLs were not used for comparison of the indoor air values measured in the site buildings because of this involuntary exposure.

TDEC's Division of Underground Storage Tanks (UST) vapor intrusion CVs or guidelines were not used in this evaluation because of the change of use of the former gas station. Anyone working in the former gas station building or in a new building constructed on the property would have a secondary exposure if there were any remaining vapors from past activities conducted at the site. If there are secondary exposures at a site, CVs used are those discussed above and not those from OSHA or for an active-UST site.

ATSDR CVs

ATSDR develops Minimal Risk Levels (MRLs), using conservative assumptions. 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 2012a) and are used for comparison to the indoor air data that was collected. Exposure durations are defined as acute (14 days or less), intermediate (15–365 days), and chronic (365 days or more) exposures. ATSDR does not use serious health effects, such as irreparable damage to the liver or kidneys, 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 70-year lifetime exposure. It should be noted that chemicals found at levels that are above their respective comparison values do not necessarily represent a health threat. Instead, the results of the comparison value screening identify those chemicals that warrant a more detailed, site-specific evaluation to find out if health effects are more likely to occur (ATSDR 2012).

EPA CVs

EPA's Regional Screening Levels (RSLs) for residential air inhalation were also used in evaluating the results of the indoor air testing (EPA 2012).

Environmental Sampling

Indoor and outside air samples were collected on September 16, 2012. Because the former restaurant areas were divided by walls, two indoor air samples were collected from the former restaurant building. One sample was collected from the dining area and the other sample was collected from the kitchen area. Two samples were collected from the former gas station building. One was from the garage area and another was from the office area. One outside ambient air sample was collected. The outdoor sample was collected in the area between the two buildings (Breland Group 2012).

Indoor air samples were collected over an 8-hour time period using five laboratory-prepared 6-liter, evacuated, stainless steel Summa canisters equipped with the appropriate flow controllers. Indoor air samples were collected at floor height in the two buildings and at ground elevation for the outside air sample. Any obstructions that could prevent free airflow were cleared from the sampling locations prior to collecting the samples. No activities were conducted in either of the

two buildings during the sample collection period. The outdoor ambient air sample was collected simultaneously with the indoor air samples. All air samples were collected for a minimum of 8 hours. The air samples were analyzed by ESC Lab Sciences of Mount Juliet, Tennessee.

Results

Indoor air testing results showed very minor amounts of benzene and related petroleum hydrocarbon chemicals at all indoor air sampling locations. The two benzene measurements in the former restaurant were similar, at 0.22 and 0.25 parts per billion by volume (ppb). In the former gas station, benzene was measured at two sampling locations at the same level of 0.27 ppb. Benzene in the outside air at 0.50 ppb was about double the 2 indoor air sample concentrations in the former restaurant and the 2 indoor air sample concentrations in the former gas station. Ethylbenzene was found in the former restaurant at 1.4 and 1.9 ppb. In the former gas station, ethylbenzene was measured at 0.55 and 2.5 ppb. The ethylbenzene measurement of 2.5 ppb in the former garage portion of the former gas station was the only location where ethylbenzene was found above the 2.3 ppb level measured in the outside air sample. Table 1 shows the results of the indoor air sampling. Sample analytical detection limits were appropriately low.

Health Risk Evaluation

There did not appear to be any physical characteristic of the building or building design (Breland Group 2012) that would trap vapors inside either of the two site buildings so that concentrations would build to high levels. Overall, there were no unexpected results.

Exposure to low levels of environmental benzene is unavoidable due to the presence of benzene everywhere in the environment from a variety of sources (ATSDR 2007). Benzene levels in indoor air inside the two on-site buildings were compared to both ATSDR non-cancer and cancer risk comparison values and non-cancer and cancer EPA RSLs. Additionally, benzene levels were compared to concentrations found in the indoor and outside air across the United States.

Benzene was of special interest at the site because it is "*known to be a human carcinogen"* (NTP 2011) based on sufficient evidence of carcinogenicity from studies in humans. Benzene was found in very small amounts in the indoor air in both the former restaurant and the former gas station.

ATSDR (2012) has a chronic EMEG for benzene in indoor air of 3 parts per billion (ppb). The EPA non-cancer RSL for a residential exposure for benzene is 9.7 ppb (EPA 2012). ATSDR's CREG for benzene is 0.04 ppb while its EPA residential cancer risk RSL is 0.1 ppb.

Other petroleum hydrocarbon-related chemicals were detected and were compared to their respective CVs, if established. The IARC (2000) has classified ethylbenzene is *"a possible human carcinogen"*. Ethylbenzene was also found in very small amounts in indoor air of the two buildings.

Table 1. Indoor and outdoor air monitoring results at a former restaurant and former gas station located at 101 45th Avenue North, Nashville, TN. All results are reported in parts per billion by volume (ppbv). Indoor and outdoor air samples were collected on September 16, 2012. The testing was done using Summa canisters for a minimum of 8 hours. The samples were tested using USEPA method TO-15 by ESC Lab Sciences. (Source: The Breland Group, LLC/Frost Environmental Services, LLC vapor intrusion testing report, October 2, 2012).

Chemical	Outdoor (ambient air) Sample	Indoor Air Former Restaurant		Indoor Air Former Gas Station		ATSDR Comparison Values		EPA RSLs	
		Dining Area Sample	Kitchen Area Sample	Garage Area Sample	Office Area Sample	Chronic EMEG[1] (non-cancer)	CREG[2] (10^{-6} excess cancer risk)	Residential Non-cancer	Residential cancer (10^{-6} excess cancer risk)
benzene	0.50	0.25	0.22	0.27	0.27	3	0.04	9.7	0.1
toluene	2.0	1.3	1.1	1.9	1.9	80	ngv	1,380	ngv
ethylbenzene	2.3	1.9	1.4	2.5	0.55	300	ngv	230	0.22
total xylenes	1.7	1.3	0.98	1.8	1.8	50	ngv	23	ngv
1,2,4-trimethylbenzene	0.54	0.40	0.32	0.66	0.59	ngv	ngv	1.5	ngv
vinyl chloride	0.34	<0.20	<0.20	<0.20	<0.20	30i	0.044	39	0.06

Notes:

[1] ATSDR MRL/EMEG = Agency for Toxic Substances and Disease Registry Minimum Risk Level / Environmental Media Evaluation Guide (ATSDR 2012). Chronic non-cancer exposure comparison values (exposure greater than 365 days) are used to determine if chemical concentrations warrant further health-based screening.

[2] ATSDR CREG = Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2012). Cancer risk comparison values are for cancer risk of 1 excess cancer in 1,000,000 people (10^{-6} risk level) and are used to determine if chemical concentrations warrant further health-based screening.

EPA RSL = Environmental Protection Agency Regional Screening Level (EPA 2012). 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 lifetime.

ngv = no guidance value available

ATSDR (2012) has a chronic EMEG for ethylbenzene of 300 ppb. The EPA non-cancer RSL for residential exposure is 230 ppb (EPA 2012). ATSDR does not have an established CREG for ethylbenzene. EPA does have a residential cancer risk RSL of 0.22 ppb.

Measured toluene and xylenes levels in indoor air were all well below their corresponding ATSDR and/or EPA CVs. 1,2,4-trimethylbenzene was below its EPA RSL. These chemicals found in very low levels in indoor air will not be discussed further in this document.

A full suite of chemical analysis was run as part of the analysis of the indoor air in both the former restaurant and former gas station. A chemical not related to petroleum hydrocarbons, vinyl chloride, was found in outside air (Table 1). Test detection levels were very low and would have detected vinyl chloride if it were present in the indoor air. Since the measured amount of vinyl chloride was only found in the outside air, it will not be discussed further.

For this site, we are concerned with the inhalation of petroleum hydrocarbons from vapor intrusion into indoor air. Both benzene and ethylbenzene are readily absorbed following inhalation and oral exposure as well as from direct exposure to the skin. About half of the benzene breathed by a person passes through the lining of the lungs and enters the bloodstream (ATSDR 2007).

Benzene levels in the outside air sample were higher than indoor air benzene levels (Table 1). This is likely due to the site being near a major urban intersection. Indoor air benzene levels ranged from 0.22 to 0.25 ppb in the former restaurant, for an average of 0.24 ppb. Benzene was 0.27 ppb at both sampling locations in the former gas station, for an average of 0.27 ppb. The benzene level measured in outside air was 0.50 ppb.

Non-Cancer Evaluation

Former Restaurant

Benzene levels measured in the indoor air of the former restaurant were much lower than its non-cancer CVs (Table 1). Measured ethylbenzene levels were also much lower than its non-cancer CVs (Table 1). There should not be any non-cancer health issues from breathing air containing the measured benzene and ethylbenzene levels inside the building.

Former Gas Station

Benzene levels in the former gas station were similar to those in the former restaurant. Levels were much lower than their ATSDR and EPA non-cancer CVs (Table 1). The measured levels of ethylbenzene in the former gas station were much lower than its ATSDR and EPA non-cancer CVs. There should not be any non-cancer health issues from breathing air containing the levels of benzene and ethylbenzene measured inside the former gas station.

Cancer Risk Evaluation

Benzene's ATSDR CREG is 0.04 ppb (ATSDR 2012b). EPA's residential RSL is 0.1 ppb (EPA 2012). ATSDR has not established a CREG for ethylbenzene. The EPA cancer RSL for

ethylbenzene is 0.23 ppb (EPA 2012). These CVs are established for a 1 excess cancer in 1,000,000, or a $1x10^{-6}$ excess cancer risk.

Benzene – Former Restaurant

Measured benzene levels ranged from 0.22 to 0.25 ppb in the indoor air samples. The former gas station would be the expected source area for any vapors that could migrate into the indoor air of the former restaurant or surrounding buildings. The benzene results in the former restaurant were roughly in the range between an excess lifetime cancer risk (ELCR) of 1 in 1,000,000 and 1 in 100,000. To further understand the estimated ELCR, further evaluation was done using the inhalation unit risk value for benzene.

An estimated risk was calculated using the measured benzene levels and EPA's inhalation unit risk (IUR). Benzene has an IUR range from $2.2x10^{-6}$ to $7.8x10^{-6}$. The benzene results from each building were averaged and evaluated. Using the average measured benzene level for the former restaurant of 0.24 ppb or 0.77 $\mu g/m^3$, an estimated ELCR ranging from $1.7x10^{-6}$ to $6.0x10^{-6}$ was calculated. This additional risk is based on a 24 hour per day, 7 day per week, 365 day per year, 70 year lifetime exposure, which is not realistic at this site. This means that there is an approximate $2x10^{-6}$ to $6x10^{-6}$ ELCR in addition to the background cancer risk. The normal every day background risk of having cancer in the U.S. is 1 in 2 for men and 1 in 3 for women (NTP 2011). Overall there would be a negligible increase in cancer risk to the normal every day risk by breathing indoor air in the former restaurant. There should not be any cancer health issues from breathing air containing the measured benzene levels inside the building.

Benzene – Former Gas Station

For the former gas station, the estimated risk was also calculated by using the average measured benzene level of 0.27 ppb or 0.86 $\mu g/m^3$. Multiplying this average by the benzene IUR range of $2.2x10^{-6}$ to $7.8x10^{-6}$, results in a calculated estimated ELCR ranging from $1.9x10^{-6}$ to $6.7x10^{-6}$. Like in the restaurant, this means that there is an approximate $2x10^{-6}$ to $7x10^{-6}$ ELCR in addition to the background cancer risk. This additional risk is based on a 24 hour per day, 7 day per week, 365 day per year, 70 year lifetime exposure, which is not realistic at this site. The normal every day risk of having cancer in the U.S. is 1 in 2 for men and 1 in 3 for women (NTP 2011). Similar to the restaurant, there would be a negligible increase in cancer risk to the normal every day risk by breathing indoor air in the former gas station building. There should not be any cancer health issues from breathing air containing the measured benzene levels inside the former gas station.

Furthermore, Schuver (2004) published a memorandum listing benzene levels in both indoor and ambient air. For indoor air, a best estimate of background levels ranged from 1.5 to 2.0 ppb. EPA (1998) published a value of 1.6 ppb for average benzene levels for U.S. homes. Benzene levels in the ambient air of urban environments of the U.S. referenced in this EPA document ranged from 4 to 160 ppb. In remote and rural areas of the U.S., ambient air benzene levels ranged from 0.35 to 1.6 ppb. A best estimate of benzene levels in ambient urban air ranged from 0.5 to 1.0 ppb. The measured levels of benzene at 0.50 (outside) and an average of 0.24 found in the indoor air of the former restaurant and an average of 0.27 ppb found in the indoor air of the former gas station were within and actually below these ranges. The higher

benzene level in the outside sample may be associated with traffic exhaust. The site is along a busy urban street and near an intersection.

Ethylbenzene – Former Restaurant

Measured ethylbenzene levels ranged from 1.4 to 1.9 ppb in the indoor air samples. These results were roughly in the range between an excess lifetime cancer risk (ELCR) of 1 in 1,000,000 and 1 in 100,000. Similar to the further evaluation for benzene above, further evaluation was done using the inhalation unit risk value for ethylbenzene.

An estimated risk was calculated using the measured benzene levels and EPA's inhalation unit risk (IUR). Ethylbenzene has an IUR of $2.5x10^{-6}$. The benzene results from each building were averaged and evaluated. Using the average measured benzene level for the former restaurant of 1.7 ppb or 6.5 $\mu g/m^3$, an estimated ELCR of $1.6x10^{-5}$ was calculated. This means that there is an approximate $2x10^{-5}$ ELCR in addition to the background cancer risk for a 24 hour per day, 7 day per week, 365 day per year exposure. The normal every day risk of having cancer in the U.S. is 1 in 2 for men and 1 in 3 for women (NTP 2011). Overall, there would be a negligible increase in cancer risk to the normal every day risk by breathing indoor air in the former restaurant. There should not be any cancer health issues from breathing air containing the measured ethylbenzene levels inside the former restaurant.

Ethylbenzene – Former Gas Station

For the former gas station, the estimated risk was also calculated by using the average measured ethylbenzene level of 1.5 ppb or 6.5 $\mu g/m^3$. Multiplying this average by the ethylbenzene IUR of $2.5x10^{-6}$, results in a calculated estimated ELCR of $1.6x10^{-5}$. Like the former restaurant, this means that there is an approximate $2x10^{-5}$ ELCR in addition to the background cancer risk. The normal every day risk of having cancer in the U.S. is 1 in 2 for men and 1 in 3 for women (NTP 2011). Similar to the former restaurant building, there would be a negligible increase in cancer risk to the normal every-day risk by breathing indoor air in the former gas station building. There should not be any cancer health issues from breathing air containing the measured ethylbenzene levels inside the former gas station.

Chemical Mixture

When you have more than one chemical found at a sampling location, there could be potential additive, synergistic, or inhibitive health effects to an exposed population (ATSDR 2004). There also could be no different health effects from the presence of two different chemicals. Since benzene, toluene, ethylbenzene, and xylenes are commonly found together in soil, water, and air samples collected from former gasoline stations, the health effects are often considered as a group. There is limited data for interaction effects for these chemicals. Results of physiologically-based pharmacokinetic (PBPK) model simulations and experimental exposures with BTEX and mixtures of its components strongly suggest that joint neurotoxic action is expected to be additive at BTEX concentrations below approximately 20 ppm of each component. There is no evidence to indicate that greater-than-additive interactions among benzene, toluene, ethylbenzene, or total xylenes.

Only the benzene and ethylbenzene levels in indoor air were found to be elevated above ATSDR and EPA RSL cancer risk comparison values. Toluene and xylenes levels in indoor air were below ATSDR and EPA RSL comparison values. 1,2,4-trimethylbenzene levels were below its EPA RSL. In evaluating the total estimated ELCRs for the two buildings, each would result in a total estimated ECLR of about 2 in 100,000. This level is based on a 24-hour a day, 7 days per week, 365 day per year, 70 year lifetime exposure. This exposure time frame is a worst-case scenario. People working in and visitors to the buildings or any future newly constructed on-site building would have a much shorter exposure as work days are shorter and there likely would not be employees working for many consecutive years. It is unlikely that the presence of very low levels of benzene and ethylbenzene in the indoor air would create any increased health effects to those who breathe the indoor air by working in or visiting either of the two buildings or doing so in any new building constructed on the site.

Limitations and Uncertainties in Vapor Intrusion

Having and following an accepted protocol for conducting indoor air investigations is important. Still, even a good protocol cannot remove all limitations and uncertainties related to vapor intrusion investigations.

Several characteristics of buildings may influence the indoor air testing. Some examples of limitations and uncertainties include the number of breaks in floor slabs or utility perforations entering the buildings. According to the environmental consultant there could have been background sources of chemicals in the former restaurant. There were typical cleaning supplies and chemicals located in the former restaurant building. There did not appear to be any background sources of the chemicals in the former gas station building.

Neither a building inventory of potential sources or a measurement of background sources were done before the testing began. The use of cleaning products that sometimes contain many of the same chemicals that are tested for could influence the results of the testing. This can be the case especially if cleaning products were recently used inside the building. It is unknown if the HVAC system was operating in the former restaurant during the testing. Levels were low without removing potential confounding sources inside the building.

Exactly what has happened in the past at the site is another uncertainty. The amounts and locations of any or all spills at the former gas station may not have all been documented. Basic handling practices of chemicals were also different during the time period that the gas station operated.

As a prudent public health action, even though indoor air levels of benzene and ethylbenzene are low, engineering controls should be considered to prevent the potential for future vapor intrusion in any new construction planned for the site.

Child Health Considerations

The health of children was considered as part of this health consultation. The many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances. Children have lower body weights than adults. Although children's lungs are usually smaller than adults, children breathe a greater relative volume of air compared to adults. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage.

Children can be subjected to increased benzene and ethylbenzene exposure by inhalation of second-hand smoke and may have higher exposure to benzene than adults. For all infants and children, benzene exposure predominantly comes from the indoors (ATSDR 2007). There is no indication that benzene, affects children's bodies differently than adults (ATSDR 1997). Children may be more sensitive to the carcinogenic effects of benzene than adults (IRIS 2011). ATSDR considered this increased sensitivity when they developed their CREG value. The same holds true with ethylbenzene.

It is unknown what type of redevelopment may be done on the site. Future site workers may be all adults or there may be children visitors to the property. Investigation results do not suggest there is a major amount of contamination left in place at the site. Any children who visit the site would likely have no adverse health effects from breathing the indoor air.

Conclusion

Based on the results of the September 2012, indoor air sampling, it does not appear that vapor intrusion was happening in either the former restaurant or the former gas station buildings. Levels of benzene and ethylbenzene present in the indoor air of either building did not suggest there would be adverse health effects from breathing the indoor air in either of the two buildings. Calculated assessments of risk were within EPA's target excess lifetime cancer risk range.

Recommendations

TDH EEP recommends that if the site is redeveloped that engineering controls to prevent vapor intrusion should be considered for new buildings constructed on the site.

Public Health Action Plan

The public health action plan for the 101 45th Avenue North 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 been taken by TDH's EEP include:

- Reviewed indoor air data from the 101 45th Avenue North Site.
- Prepared this Health Consultation.

Public health actions that will be taken include:

- TDH EEP will provide copies of this health consultation to state and federal government agencies interested in the site.
- TDH EEP will provide copies of this health consultation to the environmental contractor for the site.
- TDH EEP will maintain dialogue with ATSDR, TDEC, EPA, 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.
- TDH EEP will be available to review additional environmental data, and provide interpretation of the data, as requested.

Preparer of Report

Joseph P. George, PG, MS
Environmental Health Assessor
Tennessee Department of Health (TDH)
Environmental Epidemiology Program (EEP)
Communicable and Environmental Diseases and Emergency Preparedness (CEDEP)
1st Floor, Cordell Hull Building
425 5th Avenue North
Nashville TN 37243

Reviewers of Report

Internal

David M. Borowski, MS
Interim Director, Environmental Epidemiology Program
Tennessee Department of Health

External

Danny Fox
Geologist, Division of Remediation, State Remediation Program
Tennessee Department of Environment and Conservation

References

[ATSDR] Agency for Toxic Substances and Disease Registry. 1997. Healthy children - toxic environments. Report of the Child Health Workgroup presented to the Board of Scientific Counselors. Atlanta, GA: U.S. Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2004. Interaction Profile for benzene, Toluene, Ethylbenzene, and Xylenes (BTEX) (May 2004). U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. Available online at: http://atsdr.cdc.gov/interactionprofiles/IP-btex/ip05.pdf

[ATSDR] Agency for Toxic Substances and Disease Registry. 2007. Toxicological Profile for Benzene (August 2007). U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. Available online at: http:// atsdr.cdc.gov/toxprofiles/tp3.html

[ATSDR] Agency for Toxic Substances and Disease Registry. 2010. Toxicological Profile for Ethylbenzene (November 2010). U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. Available online at: http:// atsdr.cdc.gov/toxprofiles/tp110.html

[ATSDR] Agency for Toxic Substances and Disease Registry. 2012. Indoor air health comparison values. Atlanta, GA: U.S. Department of Health and Human Services. August 2012.

[Breland] The Breland Group LLC. 2012. Vapor intrusion testing, 101 45th Avenue North, Map103-08, Parcel 48, Nashville, Tennessee. Nashville, TN.

[EPA] U.S. Environmental Protection Agency. 1991. Role of the baseline risk assessment in superfund remedy selection determination. OSWER Directive 9355.0-30. Washington, D.C.

[EPA] U.S. Environmental Protection Agency. 2012. Regional Screening Levels (RSL) for chemical contaminants at superfund sites. Oak Ridge National Laboratory: Oak Ridge, TN. Last accessed: December 14, 2012. Available online at: http://epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

[IARC] International Agency for Research on Cancer, Summaries and Evaluations, Ethylbenzene. 2000. vol. 77. Available online at: http://monographs.iarc.fr/ENG/Monographs/vol77/mono77-10.pdf. August 21, 2000.

[ITRC] Interstate Technology and Regulatory Council. 2007. Vapor intrusion pathway a practical guideline. Washington, D.C. The Interstate Technology & Regulatory Council Vapor Intrusion Team. January 2007.

[NTP] National Toxicology Program. 2011. Report on carcinogens, 12th ed. Research Triangle Park, NC. Available online at: http://ntp.niehs.nih.gov/ntp/roc/twelfth/roc12.pdf

Schuver, H. 2004. Memorandum – typical benzene concentrations in ambient and indoor air. Available online at: https://iavi.rti.org/attachments/OtherDocuments/Benzene_concentrations_in_air_11-2004.pdf

Certification

This Public Health Consultation: *101 45th Avenue North Property, 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 begun.

David M. Borowski

Interim Director of EEP, CEDEP, TDH