STATE OF TENNESSEE
DEPARTMENT OF HEALTH
ENVIRONMENTAL EPIDEMIOLOGY PROGRAM
1ST FLOOR CORDELL HULL BUILDING
425 5TH AVENUE NORTH
NASHVILLE, TN 37243

March 17, 2011

Dr. Roy Crowder, Ph.D., Environmental Specialist
Tennessee Department of Environment and Conservation
Division of Solid and Hazardous Waste Management
State Remediation Program
5th Floor, L&C Tower
401 Church Street
Nashville, TN 37243

Dear Dr. Crowder:

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) reviewed the *Receptor and Soil Gas Survey Report* prepared by ACI Environmental Associates, Inc. (ACI) on May 4, 2010. The report was prepared for the City of Memphis, Division of Engineering, for the Pyramid Arena Site located at 1 Auction Avenue in Memphis, Shelby County, Tennessee, 38103. The Tennessee Department of Environment and Conservation (TDEC), Division of Solid and Hazardous Waste Management (DSWM), State Remediation Program (SRP), asked EEP to evaluate the results of soil-gas sampling and indoor and outdoor air sampling conducted at the arena property. The evaluation was done to better understand potentially contaminated vapors that may have migrated into the indoor air of the arena from a past solvent release(s). EEP works under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR) to identify potential health concerns for those living or working near hazardous waste sites in Tennessee.

Site Background

The site is situated along the Wolf and Mississippi Rivers in downtown Memphis, Tennessee. The property is not currently occupied. It most recently served as a public arena for the City of Memphis. Past events held in the arena were basketball games, musical concerts, tractor pulls, motocross, monster truck competitions, and other events. There are seats for over 20,000 spectators in the arena. The proposed future use of the property is a lease for a retail location for a national-chain sporting goods store. Hence, there will be a change in the potentially exposed population from that of a spectator and intermittent worker to a retail customer and commercial worker. The site is developed with one large pyramid-shaped structure, supporting utility structures, and large paved parking areas with parking attendant booths and access roads. A flood wall and railroad tracks are also located on the site (ACI 2010). Utility conduits extend

into the structure by means of vaults and by means of large piping in the east and southeastern portions of the building (ACI 2010). Adjacent properties are a mix of residential (condominiums), retail, commercial (printing, banking), and industrial (warehouses and an electrical substation).

A Phase 1 Environmental Site Assessment (ESA) was conducted on the property in 2007. According to historical research, the former occupants or lessees of the site and adjoining properties likely stored and used bulk quantities of hazardous substances. These hazardous materials were stored both underground and aboveground. Other adjacent properties were noted as having outdoor storage of electrical equipment containing polychlorinated biphenyls (PCBs). Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, and herbicides may have also been used onsite.

Because of concern about potential releases of hazardous substances to the environment by former off-site businesses, a water use survey and a soil and groundwater sampling investigation were conducted. Water use information was obtained by ACI from the Memphis and Shelby County Health Department's (MSCHD) Water Quality Branch. The survey identified 3 water wells within a one-mile radius of the site (ACI 2010). One well is 305 feet deep and used to fill ornamental ponds in a nearby residential subdivision on Mud Island; it is not used to supply drinking water to the residential subdivision nor has it been tested. Mud Island is located west and northwest of the Pyramid Arena likely upgradient from the Pyramid site. The minor amount of groundwater contamination at the Pyramid is unlikely to affect the water quality of this well. The depth of the remaining two wells was unknown. One well was abandoned in the 1960s, and the remaining well is used only as a regional water level measuring point by the U.S. Geological Survey. Its status is listed by the MSCHD as "temporarily abandoned." Soil samples were collected from a total of 27 soil borings installed across the site. Groundwater was sampled in select onsite borings during the investigation.

A review of data from the soil and groundwater investigation showed both tetrachloroethylene (PCE) and trichloroethylene (TCE) in groundwater. These two VOC compounds were considered the chemicals of concern at the site. Groundwater containing PCE and TCE was thought to migrate beneath a portion of the site. Because of these findings, TDEC wanted to sample the soil-gas directly outside the building footprint, and indoor air within the arena, to determine if vapor intrusion from impacted groundwater beneath the building would be a potential concern.

Data Reviewed

Groundwater

A soil and groundwater sampling investigation was conducted onsite from February 16 - 20, 2009. Four groundwater samples collected from borings installed on the east side of the pyramid building resulted in 2 detections of PCE (Table 1). TCE was also detected and co-located in 1 of the groundwater samples having PCE (ACI 2010). Groundwater measurements show groundwater is shallow at the site, less than 10 feet below the ground surface.

Table 1. Grab groundwater results from select soil borings installed at the Pyramid Arena Site, 1 Auction Avenue, Memphis, TN. All results are reported in parts per billion (ppb).

Chemical/Location	SB-9C	SB-21	SB-22	SB-23
tetrachloroethlyene	ND	1.2	44.9	ND
trichloroethylene	ND	ND	14.3	ND

Notes:
ND = Not detected above the analytical detection limit.

Soil-Gas

ACI Environmental Associates (ACI) sampled soil-gas in soil borings advanced to a total depth of 10 feet below ground surface (bgs) on the eastern, southeastern, and southern sides of the Pyramid building along the exterior footings of the structure. This investigation was done to assess the previous environmental impact for the redevelopment of the arena to retail space. The investigation was conducted without the building's heating, ventilation, and air conditioning (HVAC) system operating. The borings were located in these areas to determine if the constituents identified in site groundwater near these locations have the potential for impacting indoor air at the site. Soil-gas samples were collected from 8 borings installed on November 2 and 3, 2009. Soil-gas samples were collected in Summa canisters and analyzed by U.S. Environmental Protection Agency (EPA) method TO-15 by Environmental Science Laboratories, Inc. of Mount Juliet, Tennessee. Soil-gas results showed PCE, TCE, and 2-propanol (Table 2). PCE results ranged from below analytical detection limits (which ranged from <0.4 to <2.0 parts per billion [ppb]) to 3.2 ppb. TCE was noted from below analytical detection limits (which varied from < 0.4 to <2.1 ppb) to one detection of 0.5 ppb at one sample location. 2-Propanol detections ranged from 3.0 to 15.9 ppb. 2-Propanol was the tracer solvent used for the soil-gas testing. 2-Propanol is commonly 70% isopropyl alcohol. It is used as a tracer chemical to determine if there are leaks present in the soil-gas sampling system (TDEC 2008). Concentrations of 2-propanol in the soil-gas samples are low and their concentrations do not indicate a leak in the sampling system.

On March 4, 2010, 3 soil-gas sampling locations were sampled again along with 2 new locations. The locations sampled a second time were installed near 3 of the original 8 soil-gas sampling locations. Again, the samples were analyzed using EPA method TO-15. PCE was the only chemical measured in these samples. Two concentrations were noted. PCE was measured at 1.3 ppb in sample SP-1 and at 1.5 ppb at sample SP-9.

Table 2. Soil-gas results for the Pyramid Arena Site located at 1 Auction Avenue, Memphis, TN. All results are reported in parts per billion by volume (ppbv).

Location and Sampling Date / Chemical	Sample Depth (ft bgs)	tetrachloroethylene	trichloroethylene	2-propanol
SP-1 (11/3/09)	10	3.0	<1.6	<10.2
SP-2 (11/2/09)	10	<0.4	<0.4	5.7
SP-3 (11/02/09)	10	<2.0	<2.0	15.9
SP-5 (11/3/09)	10	3.2	<1.6	<10.2
SP-5 duplicate (11/3/09)	10	3.0	<2.0	<12.6
SP-6 (11/3/09)	10	1.0	<0.4	3.0
SP-7 (11/3/09)	10	<0.4	0.5	5.3
SP-1 (3/4/10 sample)	10	1.3	<1.2	<4.9
SP-6 (3/4/10 sample)	10	<1.0	<1.0	<4.0
SP-6 (3/4/10 sample duplicate)	10	<1.2	<1.2	<4.0
SP-9 (South Facility) (3/4/10)	3	1.5	<1.0	<4.0
SP-10 (North Facility) (3/4/10)	3	<1.0	<1.1	<4.5

Notes:
ft bgs = feet below ground surface
< = detection limit of analyte for sample
+ = retest results from boring SP-6 retest were used due to concentrations of 2-propanol tracer.

Air

Also on March 4, 2010, 4 air samples were collected (Table 3). An indoor air sample, 2 indoor "background" air samples associated with the soil-gas sampling, and an outdoor air sample were collected. The indoor air sample was collected inside the closed arena at ground level near its center. The 2 indoor air "background" samples were collected from unpaved areas between the exterior façade and the occupied space at 2 corners of the arena. These two samples serve as comparison air samples to the area of the arena without a concrete floor. The outside air sample was collected on the east side of the building. These samples were collected and analyzed using EPA method TO-17 by Air Toxics Ltd., in Folsom, California. PCE was found in only one indoor air sample at a very low concentration of 0.25 ppb.

Table 3 Indoor, indoor background, and outdoor air monitoring results for the Pyramid Arena Site located at 1 Auction Avenue, Memphis, TN. All results are reported in parts per billion by volume (ppbv) in parentheses.

Chemical	Outdoor (AS-1) Sample	"Background" (AS-2) F-S Corner Sample	"Background" (AS-3) F-N Corner Sample	Indoor (AS-4) Sample	EPA RSLs[1] (10^{-6} excess cancer risk)
PCE	<0.37	<0.37	<0.37	0.25	0.06
TCE	<0.47	<0.47	<0.47	<0.47	0.22

Notes:

(<0.37) = result reported in parts per billion (ppb) by volume.
Indoor air sample AS-4 was run at a later date and had a lower detection limit for PCE of 0.18 ppb.

[1] EPA RSLs = U.S Environmental Protection Agency Region Screening Levels (2010). 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.

Discussion

Groundwater

PCE and TCE are of interest at the site and are evaluated because they are thought to "*reasonably anticipated to be human carcinogens*" (IARC 1995, NTP 2001). To be thorough, EEP evaluated the groundwater results using EPA's simplified Johnson and Ettinger (J&E) vapor intrusion model (EPA 2010). The estimated indoor air levels calculated using the J&E model were a low prediction of 0.17 ppb, a best estimate prediction of 0.23 ppb, and a high prediction of 0.24 ppb. Exposure to these estimated indoor air levels poses a theoretical cancer risk of $1.5x10^{-6}$, $1.9x10^{-6}$, and $2.0x10^{-6}$, respectively (see Appendix). The acceptable theoretical risk range is 1 excess cancer in 10,000 ($1x10^{-4}$) to 1 excess cancer in 1 million people ($1x10^{-6}$) (EPA 1991). For a concentration of TCE in groundwater of 14.3 ppb migrating to indoor air, the most conservative estimate indoor air concentration was calculated to be 0.07 ppb, a level that is estimated to pose a theoretical cancer risk of 1.6 excess cancers in 100,000 people ($1.6x10^{-5}$) (Appendix).

Modeling indicates that all concentrations of PCE and TCE detected in groundwater would result in indoor air concentrations that were within EPA's acceptable cancer risk range. The most conservative estimate of indoor air concentrations calculated using the J&E model were below ATSDR non-cancer health effects comparison values for both chemicals.

Soil-Gas

ACI's *Receptor and Soil Gas Survey Report* also presented the results of the soil-gas and the indoor/background/outdoor air sampling. The soil-gas sampling results represent a "snapshot in time" but were nevertheless valid. It is unknown if concentrations of the chemicals were different in the past or will be different in the future. Soil-gas data included PCE, TCE, and 2-propanol (Table 2). PCE soil-gas concentrations were low-ranging from <0.5 to 3.2 ppb. TCE in soil-gas was detected in only one sampling location above analytical method detection limits. The lower TCE method detection limit was 0.4 ppb. The one TCE concentration measured above the detection limit was 0.5 ppb.

Soil-gas concentrations cannot be directly compared to any established EPA or ATSDR air comparison values (ATSDR 2010, EPA 2010). However, EEP did evaluate the results by again using EPA's simplified J&E vapor intrusion model (EPA 2010). The theoretical cancer risk posed by a concentration of 3.2 ppb PCE in indoor air, would be approximately 2 excess cancers in 100 million people ($2x10^{-8}$), an acceptable excess cancer risk (Appendix). The acceptable risk range is 1 excess cancer in 10,000 ($1x10^{-4}$) to 1 excess cancer in 1 million ($1x10^{-6}$) people.

TCE soil-gas concentrations were also modeled to breathable air concentrations using the EPA J&E model. Using the single measured concentration and the lowest detection limit concentration, the most conservative estimated indoor air TCE concentration resulted in a theoretical excess cancer risk of 2 in 10 million people ($2x10^{-7}$), a very low risk (Appendix).

Air

PCE was detected in 1 of 4 air samples (Table 3). The indoor air sample corresponding to the area in question had 0.25 ppb of PCE. This result was compared to cancer and non-cancer comparison values (ATSDR 2010, EPA 2010). ATSDR does not presently have cancer comparison values; therefore, EPA comparison values are used. The EPA lifetime cancer comparison values are 0.06 ppb for PCE, and 0.22 ppb for TCE. These values are based on a lifetime exposure theoretical cancer risk of 1 additional cancer in 1 million people (10^{-6} risk).

The 0.25 ppb of PCE measured in the AS-4 indoor air sample would not be a cause for concern. This concentration is within a comparison value range from 0.6 to 0.06 ppb, which corresponds to an acceptable excess cancer risk of 1 excess cancer in 100,000 to 1 excess cancer in 1 million (EPA 1991). Moreover, workers and visitors to the Pyramid Arena would not be exposed 24 hours per day, 7 days per week, 52 weeks per year, for a 70 year lifetime. The comparison values used above are calculated for this exposure time frame.

The indoor/background/outdoor air results represent a "snapshot in time," but were nevertheless valid. It is unknown if the concentration of the chemicals were different in the past or will be different in the future.

Building HVAC System

EEP inquired as to the design of the air handling equipment at the site and the number of times the air within the building was refreshed during the day. Personal communication with Dr. Roy Crowder with TDEC, who conferred with Mr. George A. Parks of ACI, the City of Memphis' environmental consultant for the project (May 13, 2010) indicated that "*It is important to note that the building was designed not only for basketball and musical concerts but also for tractor pulls, motor cross, monster trucks, etc. which increase the importance of air changes. …air changes [were calculated] based on two different volumes of air. One calculation was made based on the volume from ground level, the other on the volume from the concourse level. …the volume from ground level includes certain areas which are not in the occupied space, so [the volume of air was] also calculated from the concourse level. In both cases, the volume of air in the entire building was used with a maximum seating capacity of 20,142. The calculated number of total air changes ranged from 4.7 to 7.6 air changes per day. The engineer cautioned that the design engineer may have gotten some reduction in make-up outside air but he felt 5 air changes per day was reasonable.*"

The number of air changes per day for a fully occupied Pyramid Arena appeared to be a very reasonable amount and would further reduce any already minor exposure from the chemicals of concern at the site. The existing system handled emissions from previous events held within the arena and supplied breathing air for over 20,000 spectators. Therefore, the minor amounts of chemicals found in the indoor air of the arena would be diluted from the make-up outside air.

EEP Concludes:

- EEP concludes that there should not be any harm to workers or the general public who would breathe the indoor air in the arena containing the very minor amount of PCE and TCE in the air. The concentrations of constituents detected were below the EPA comparison value for cancer effects and the ATSDR comparison value for non-cancer effects that are protective of human health. Soil-gas results for these chemicals were also very low. Overall, the health risk from breathing the indoor air at the site is very low. The HVAC system of the arena and hence the redeveloped retail space is designed to handle up to 5 air changes per day. It is likely that chemicals present in the indoor air of the arena will be very diluted by make-up air from the HVAC system of the building.

EEP Recommends:

EEP has no recommendations at this time.

Should you have any further questions or concerns please contact me at 615-741-7247 or via email at joseph.george@tn.gov.

Regards,

Joseph P. George, MS, PG
Environmental Health Assessor
Tennessee Department of Health
Environmental Epidemiology Program

References

ACI Environmental Consultants Inc. 2010. Receptor and soil gas survey report, Pyramid Arena Property Project, 1 Auction Avenue, Memphis, Tennessee. Memphis, TN.

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[NTP] 2001. Ninth report on carcinogens. Revised January 2001. U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.

[TDEC] Tennessee Department of Environment and Conservation. 2007. General Water Quality Criteria. Tennessee Code Annotated Chapter 1200-4-3-.07. Ground Water Classification. October 2007

[TDEC] Tennessee Department of Environment and Conservation, Division of Underground Storage Tanks. 2008. Technical Guidance Document TGD-018, Requirements for conducting soil gas surveys. January 1, 2008. Available from: http://tn.gov/environment/ust/guidance/tgd018.pdf

[TDEC] Dr. Roy Crowder, Tennessee Department of Environment and Conservation, Division Solid and Hazardous Waste Management, State Remediation Program, Central Office, personal communication, May 13, 2010.

Certification

This Letter Public Health Consultation: *Review of Soil-gas and Air Testing Data at the Pyramid Arena Site, Memphis, Shelby 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.

Director of EEP, CEDS, TDH

APPENDIX

Johnson & Ettinger simplified vapor intrusion model results

for site groundwater and soil-gas concentrations

INDOOR AIR SIMULATION RESULTS

Screening-Level Johnson and Ettinger Model

Site Name: Pyramid Arena
Report Date: Tue May 11 10:40:25 CDT 2010
Report Generated From: http://www.epa.gov/athens/learn2model/part-two/onsite/JnE_lite_forward.htm
Type of sample: GROUND WATER Concentration = 44.9[µg/L]
Depth to ground water table: 10ft +/- 0.5ft
Average soil/ground water temperature: 55F

CHEMICAL PROPERTIES
Chemical of Concern: Tetrachloroethylene CAS Number: 127184
Molecular Weight: 165.83 [g/mole] Henrys Constant: 0.3934997 [unitless]
Diffusivity in Air: 7.200e-2 [cm^2/sec] Diffusivity in Water: 8.200e-6 [cm^2/sec]
Unit Risk Factor: 0.000003 [$(\mu g/m^3)^{-1}$] Reference Concentration: 0 [mg/m^3]

SOIL PROPERTIES
Soil Type: Loam Total Porosity: 0.399
Unsaturated Zone Moisture Content:
low= 0.061 best estimate= 0.148 high= 0.24
Capillary Zone Moisture Content: 0.332 Height of Capillary Rise: 0.375 [m]
Soil-Gas Flow Rate into Building: 5 [L/min]

BUILDING PROPERTIES
Building Type: Slab-on-Grade Air Exchange Rate: 0.25[hr^{-1}]
Building Mixing Height: 2.44[m] Building Footprint Area: 100[m^2]
Subsurface Foundation Area: 106[m^2] Building Crack Ratio: 0.00038[unitless]
Foundation Slab Thickness: 0.1[m]

EXPOSURE PARAMETERS
Exposure Duration: carcinogens 30 [years] non-carcinogens: 30 [years]
Exposure Frequency: carcinogens 350 [days/year] non-carcinogens: 365 [days/year]
Averaging Time: carcinogens 70 [years] non-carcinogens: 30 [years]

JOHNSON & ETTINGER SIMULATION RESULTS
Effective Diffusion Coefficient (D^T_{eff}): 0.0004393[cm^2/s]
Ground Water to Indoor Air Attenuation Factor (α_{GW}) = 0.00008855

[1]Low Indoor Air Prediction: 1.186 [$\mu g/m^3$] or 0.1749 [ppbv]
Cancer Risk of this concentration: 1.462e-6 Hazard Risk of this concentration: 0.

Best Estimate Indoor Air Prediction: 1.564[$\mu g/m^3$] or 0.2308 [ppbv]
Cancer Risk of this concentration: 1.929e-6 Hazard Risk of this concentration: 0.

[2]High Indoor Air Prediction: 1.654[$\mu g/m^3$] or 0.2441 [ppbv]
Cancer Risk of this concentration: 2.039e-6 Hazard Risk of this concentration: 0.

Based on parameter analysis: Advection is the dominant mechanism across foundation. Diffusion through soil is the overall rate-limiting process for the subsurface to indoor-air pathway.

[1]"Low Prediction" concentrations produced with HIGHEST moisture content and DEEPEST depth to contamination.
[2]"High Prediction" concentrations produced with LOWEST moisture content and SHALLOWEST depth to contamination.

INDOOR AIR SIMULATION RESULTS

Screening-Level Johnson and Ettinger Model

Site Name: Pyramid Arena
Report Date: Tue May 11 10:03:25 CDT 2010
Report Generated From: http://www.epa.gov/athens/learn2model/part-two/onsite/JnE_lite_forward.htm
Type of sample: GROUND WATER Concentration = 14.3[µg/L]
Depth to ground water table: 10ft +/- 0.5ft
Average soil/ground water temperature: 55F

CHEMICAL PROPERTIES
Chemical of Concern: Trichloroethylene CAS Number: 79016
Molecular Weight: 131.39 [g/mole] Henrys Constant: 0.2367947 [unitless]
Diffusivity in Air: 7.900e-2 [cm^2/sec] Diffusivity in Water: 9.100e-6 [cm^2/sec]
Unit Risk Factor: 0.00011 [$(\mu g/m^3)^{-1}$] Reference Concentration: 0.04 [mg/m^3]

SOIL PROPERTIES
Soil Type: Loam Total Porosity: 0.399
Unsaturated Zone Moisture Content:
low= 0.061 best estimate= 0.148 high= 0.24
Capillary Zone Moisture Content: 0.332 Height of Capillary Rise: 0.375 [m]
Soil-Gas Flow Rate into Building: 5 [L/min]

BUILDING PROPERTIES
Building Type: Slab-on-Grade Air Exchange Rate: 0.25[hr^{-1}]
Building Mixing Height: 2.44[m] Building Footprint Area: 100[m^2]
Subsurface Foundation Area: 106[m^2] Building Crack Ratio: 0.00038[unitless]
Foundation Slab Thickness: 0.1[m]

EXPOSURE PARAMETERS
Exposure Duration: carcinogens 30 [years] non-carcinogens: 30 [years]
Exposure Frequency: carcinogens 350 [days/year] non-carcinogens: 365 [days/year]
Averaging Time: carcinogens 70 [years] non-carcinogens: 30 [years]

JOHNSON & ETTINGER SIMULATION RESULTS
Effective Diffusion Coefficient (D^T_{eff}): 0.0004989[cm^2/s]
Ground Water to Indoor Air Attenuation Factor (α_{GW}) = 0.0001003

[1]Low Indoor Air Prediction: 0.2554 [$\mu g/m^3$] or 0.04757 [ppbv]
Cancer Risk of this concentration: 1.155e-5 Hazard Risk of this concentration: 0.006386

Best Estimate Indoor Air Prediction: 0.3397[$\mu g/m^3$] or 0.06325 [ppbv]
Cancer Risk of this concentration: 1.535e-5 Hazard Risk of this concentration: 0.008492

[2]High Indoor Air Prediction: 0.3598[$\mu g/m^3$] or 0.06700 [ppbv]
Cancer Risk of this concentration: 1.627e-5 Hazard Risk of this concentration:

0.008996

Based on parameter analysis: Advection is the dominant mechanism across foundation. Diffusion through soil is the overall rate-limiting process for the subsurface to indoor-air pathway.

[1]"Low Prediction" concentrations produced with HIGHEST moisture content and DEEPEST depth to contamination.
[2]"High Prediction" concentrations produced with LOWEST moisture content and SHALLOWEST depth to contamination.

INDOOR AIR SIMULATION RESULTS

Screening-Level Johnson and Ettinger Model

Site Name: Pyramid Arena
Report Date: Tue May 11 10:41:41 CDT 2010
Report Generated From: http://www.epa.gov/athens/learn2model/part-two/onsite/JnE_lite_forward.htm
Type of sample: SOIL GAS Concentration = 22[$\mu g/m^3$]
Depth of soil gas sample: 10ft +/- 0.5ft
Average soil/ground water temperature: 55F

CHEMICAL PROPERTIES
Chemical of Concern: Tetrachloroethylene CAS Number: 127184
Molecular Weight: 165.83 [g/mole] Henrys Constant: 0.3934997 [unitless]
Diffusivity in Air: 7.200e-2 [cm^2/sec] Diffusivity in Water: 8.200e-6 [cm^2/sec]
Unit Risk Factor: 0.000003 [$(\mu g/m^3)^{-1}$] Reference Concentration: 0 [mg/m^3]

SOIL PROPERTIES
Soil Type: Loam Total Porosity: 0.399
Unsaturated Zone Moisture Content:
low= 0.061 best estimate= 0.148 high= 0.24
Capillary Zone Moisture Content: 0.332 Height of Capillary Rise: 0.375 [m]
Soil-Gas Flow Rate into Building: 5 [L/min]

BUILDING PROPERTIES
Building Type: Slab-on-Grade Air Exchange Rate: 0.25[hr^{-1}]
Building Mixing Height: 2.44[m] Building Footprint Area: 100[m^2]
Subsurface Foundation Area: 106[m^2] Building Crack Ratio: 0.00038[unitless]
Foundation Slab Thickness: 0.1[m]

EXPOSURE PARAMETERS
Exposure Duration: carcinogens 30 [years] non-carcinogens: 30 [years]
Exposure Frequency: carcinogens 350 [days/year] non-carcinogens: 365 [days/year]
Averaging Time: carcinogens 70 [years] non-carcinogens: 30 [years]

JOHNSON & ETTINGER SIMULATION RESULTS
Effective Diffusion Coefficient (D_{eff}): 0.004532[cm^2/s]
Soil Gas to Indoor Air Attenuation Factor (α_{SG}) = 0.0007823

[1]Low Indoor Air Prediction: 0.004104 [$\mu g/m^3$] or 6.055e-4 [ppbv]
Cancer Risk of this concentration: 5.060e-9 Hazard Risk of this concentration: 0.

Best Estimate Indoor Air Prediction: 0.01721[$\mu g/m^3$] or 0.002539 [ppbv]
Cancer Risk of this concentration: 2.122e-8 Hazard Risk of this concentration: 0.

[2]High Indoor Air Prediction: 0.03777[$\mu g/m^3$] or 0.005573 [ppbv]
Cancer Risk of this concentration: 4.657e-8 Hazard Risk of this concentration: 0.

Based on parameter analysis: Advection is the dominant mechanism across foundation.

[1]"Low Prediction" concentrations produced with HIGHEST moisture content and DEEPEST depth to contamination.
[2]"High Prediction" concentrations produced with LOWEST moisture content and SHALLOWEST depth to contamination.

INDOOR AIR SIMULATION RESULTS

Screening-Level Johnson and Ettinger Model

Site Name: Pyramid Arena
Report Date: Wed May 12 10:00:50 CDT 2010
Report Generated From: http://www.epa.gov/athens/learn2model/part-two/onsite/JnE_lite_forward.htm
Type of sample: SOIL GAS Concentration = 2.7[$\mu g/m^3$]
Depth of soil gas sample: 10ft +/- 0.5ft
Average soil/ground water temperature: 55F

CHEMICAL PROPERTIES
Chemical of Concern: Trichloroethylene CAS Number: 79016
Molecular Weight: 131.39 [g/mole] Henrys Constant: 0.2367947 [unitless]
Diffusivity in Air: 7.900e-2 [cm^2/sec] Diffusivity in Water: 9.100e-6 [cm^2/sec]
Unit Risk Factor: 0.00011 [$(\mu g/m^3)^{-1}$] Reference Concentration: 0.04 [mg/m^3]

SOIL PROPERTIES
Soil Type: Loam Total Porosity: 0.399
Unsaturated Zone Moisture Content:
low= 0.061 best estimate= 0.148 high= 0.24
Capillary Zone Moisture Content: 0.332 Height of Capillary Rise: 0.375 [m]
Soil-Gas Flow Rate into Building: 5 [L/min]

BUILDING PROPERTIES
Building Type: Slab-on-Grade Air Exchange Rate: 0.25[hr^{-1}]
Building Mixing Height: 2.44[m] Building Footprint Area: 100[m^2]
Subsurface Foundation Area: 106[m^2] Building Crack Ratio: 0.00038[unitless]
Foundation Slab Thickness: 0.1[m]

EXPOSURE PARAMETERS
Exposure Duration: carcinogens 30 [years] non-carcinogens: 30 [years]
Exposure Frequency: carcinogens 350 [days/year] non-carcinogens: 365 [days/year]
Averaging Time: carcinogens 70 [years] non-carcinogens: 30 [years]

JOHNSON & ETTINGER SIMULATION RESULTS
Effective Diffusion Coefficient (D_{eff}): 0.004973[cm^2/s]
Soil Gas to Indoor Air Attenuation Factor (α_{SG}) = 0.0008453

[1]Low Indoor Air Prediction: 5.511e-4 [$\mu g/m^3$] or 1.026e-4 [ppbv]
Cancer Risk of this concentration: 2.491e-8 Hazard Risk of this concentration: 1.378e-5

Best Estimate Indoor Air Prediction: 0.002282[$\mu g/m^3$] or 4.250e-4 [ppbv]
Cancer Risk of this concentration: 1.032e-7 Hazard Risk of this concentration: 5.706e-5

[2]High Indoor Air Prediction: 0.004919[$\mu g/m^3$] or 9.160e-4 [ppbv]
Cancer Risk of this concentration: 2.224e-7 Hazard Risk of this concentration:

1.230e-4

Based on parameter analysis: Advection is the dominant mechanism across foundation.

[1]"Low Prediction" concentrations produced with HIGHEST moisture content and DEEPEST depth to contamination.
[2]"High Prediction" concentrations produced with LOWEST moisture content and SHALLOWEST depth to contamination.

INDOOR AIR SIMULATION RESULTS

Screening-Level Johnson and Ettinger Model

Site Name: Pyramid Arena
Report Date: Wed May 12 10:01:41 CDT 2010
Report Generated From: http://www.epa.gov/athens/learn2model/part-two/onsite/JnE_lite_forward.htm
Type of sample: SOIL GAS Concentration = 11[$\mu g/m^3$]
Depth of soil gas sample: 10ft +/- 0.5ft
Average soil/ground water temperature: 55F

CHEMICAL PROPERTIES
Chemical of Concern: Trichloroethylene CAS Number: 79016
Molecular Weight: 131.39 [g/mole] Henrys Constant: 0.2367947 [unitless]
Diffusivity in Air: 7.900e-2 [cm^2/sec] Diffusivity in Water: 9.100e-6 [cm^2/sec]
Unit Risk Factor: 0.00011 [$(\mu g/m^3)^{-1}$] Reference Concentration: 0.04 [mg/m^3]

SOIL PROPERTIES
Soil Type: Loam Total Porosity: 0.399
Unsaturated Zone Moisture Content:
low= 0.061 best estimate= 0.148 high= 0.24
Capillary Zone Moisture Content: 0.332 Height of Capillary Rise: 0.375 [m]
Soil-Gas Flow Rate into Building: 5 [L/min]

BUILDING PROPERTIES
Building Type: Slab-on-Grade Air Exchange Rate: 0.25[hr^{-1}]
Building Mixing Height: 2.44[m] Building Footprint Area: 100[m^2]
Subsurface Foundation Area: 106[m^2] Building Crack Ratio: 0.00038[unitless]
Foundation Slab Thickness: 0.1[m]

EXPOSURE PARAMETERS
Exposure Duration: carcinogens 30 [years] non-carcinogens: 30 [years]
Exposure Frequency: carcinogens 350 [days/year] non-carcinogens: 365 [days/year]
Averaging Time: carcinogens 70 [years] non-carcinogens: 30 [years]

JOHNSON & ETTINGER SIMULATION RESULTS
Effective Diffusion Coefficient (D_{eff}): 0.004973[cm^2/s]
Soil Gas to Indoor Air Attenuation Factor (α_{SG}) = 0.0008453

[1]Low Indoor Air Prediction: 0.002245 [$\mu g/m^3$] or 4.180e-4 [ppbv]
Cancer Risk of this concentration: 1.015e-7 Hazard Risk of this concentration: 5.613e-5

Best Estimate Indoor Air Prediction: 0.009298[$\mu g/m^3$] or 0.001731 [ppbv]
Cancer Risk of this concentration: 4.203e-7 Hazard Risk of this concentration: 2.324e-4

[2]High Indoor Air Prediction: 0.02004[$\mu g/m^3$] or 0.003732 [ppbv]
Cancer Risk of this concentration: 9.060e-7 Hazard Risk of this concentration:

5.010e-4

Based on parameter analysis: Advection is the dominant mechanism across foundation.

[1]"Low Prediction" concentrations produced with HIGHEST moisture content and DEEPEST depth to contamination.
[2]"High Prediction" concentrations produced with LOWEST moisture content and SHALLOWEST depth to contamination.