Letter Health Consultation

Public Health Implications of Residual
Contamination In Indoor Air At

DURANGO DISCOVERY MUSEUM

DURANGO, COLORADO

Prepared by the
Colorado Department of Public Health and Environment

FEBRUARY 8, 2012

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Foreword

The Colorado Department of Public Health and Environment's (CDPHE) Colorado Cooperative Program for Environmental Health Assessments has prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the United States Department of Health and Human Services and is the principal federal public health agency responsible for the health issues related to hazardous waste. This health consultation was prepared in accordance with the methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on health issues associated with specific exposures so that the state or local department of public health can respond quickly to requests from concerned citizens or agencies regarding health information on hazardous substances. The Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur in the future, reports any potential harmful effects, and then recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time this health consultation was conducted and should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding the contents of this health consultation, please contact the author.

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FROM: RAJ GOYAL, PHD, (PRINCIPAL INVESTIGATOR, COLORADO COOPERATIVE PROGRAM FOR ENVIRONMENTAL HEALTH ASSESSMENTS)

SUBJECT: DURANGO DISCOVERY MUSEUM – FOLLOW UP INDOOR AIR EVALUATION OF RESIDUAL CONTAMINATION

DATE: 2/7/2012

Summary

The Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) has conducted this health consultation at the request of the Hazardous Materials and Waste Management Division (HMWMD) of the Colorado Department of Public Health and Environment (CDPHE). The purpose of this health consultation is to evaluate the public health implications of exposures to residual contamination in the indoor air at the Durango Discovery Museum (EPA Targeted Brownfields Assessment).

This evaluation is a follow up to a previous health consultation which revealed elevated levels of radon and Volatile Organic Compounds (VOCs) in the indoor air. Specifically, the estimated cancer risks for VOCs in the indoor air for workers and visitors were above the CDPHE long-term cancer risk goal of one in a million (1E-06), and radon levels in the basement and boiler room locations exceeded the EPA recommended action level of 4.0 pCi/L.

In this follow up health consultation, CCPEHA has determined that the concentrations of radon and VOCs have significantly decreased in the indoor air after the installation of mitigation systems, but radon levels still exceed the above noted EPA action level. Thus, CCPEHA is recommending additional actions to remediate elevated levels of radon in the basement areas as well as specific main visitor/public use areas. Please note that VOC levels may need to be reduced in the basement and main visitor/public use areas only under the worst case assumption of residential use over a period of 30 years (i.e., if the future property use changes to a residential home) because of the exceedance (by 10-fold) of the CDPHE long-term cancer risk goal of one in a million (1E-06).

Purpose

The purpose of this follow up health consultation is to evaluate health risks to museum visitors and employees resulting from current and future exposures to VOCs and radon associated with residual contamination in the indoor air at the Durango Discovery Museum (EPA Targeted Brownfields Assessment).

Background

Durango's historical Power House has recently been converted to Children's Durango Discovery Museum and has been open for the public use since January 2011.

In 2003, groundwater contaminated with a variety of VOCs was identified on site, but this VOC contamination is likely attributable to an up-gradient source. A former gasoline station with a history of leaking underground storage tanks is probably the source of these VOCs. The source of the cis-1, 2-dichloroethylene is unknown but appears to be following the Animas River in a predominantly parallel fashion (CDPHE 2003). Radon, which is naturally occurring and found all over the U.S., has also been detected in the museum building. Radon is a radioactive gas without color, odor, or taste that comes from the radioactive decay of uranium in soil, rock, and groundwater. Radon gets into the indoor air primarily from soil or contaminated groundwater under homes and other buildings (EPA 2007). In addition, the uranium mill tailings were deposited immediately adjacent to this site, and under US Highway 550.

In 2008, CCPEHA evaluated the public health implications of exposures to radon and VOCs in the indoor at the Children's Discovery Museum that was under construction at that time (ATSDR, 2008). The 2008 health consultation concluded that inhalation of VOCs in indoor air was not expected to harm people's health because the estimated exposures for museum visitors and employees posed only a low theoretical cancer risk; however, the risks were above the CDPHE long-term cancer risk goal of one in a million. In addition, radon exposures in some areas could harm museum employees' health because these levels were significantly above EPA's action level of 4.0 pCi/L. Therefore, CCPEHA recommended reducing exposures to future museum employees and visitors by installing radon mitigation systems. Furthermore, CCPEHA required monitoring of air after installation of mitigation systems. This health consultation evaluates the newly collected data for the public health implications of the residual contamination.

Discussion

Environmental Data

This evaluation is based on the indoor air data for radon and VOCs that was collected by the CDPHE in 2009 and 2011 after the initial remedial actions were taken to reduce exposures to VOCs and radon. These actions were based on the recommendations made by CCPEHA and ATSDR in the initial health consultation (ATSDR, 2008). It should be noted that the majority of samples for radon and VOCs were collected in 2011 except one sample of VOCs from the background outdoor air and two samples of radon and VOCs from the office space area were collected in 2009 (Table A1).

To measure radon concentrations in the indoor air, a total of seven air samples were taken; two samples from the basement areas of the museum building, two samples from the main museum area used by the public, and three samples from the office space area (Table A1).

To measure concentrations of VOCs in the indoor air, a total of eight air samples were taken; three samples from the basement area, two samples from the main museum area used by the public, and three samples from the office space area (Tables A1 to A3). Indoor air contaminant values are likely to fluctuate over time depending on weather and other variables. To measure concentrations of VOCs in the background outdoor air, two samples were collected (Table A1). Although one background sample was collected in 2009 and another in 2011, the concentration of VOCs appeared to be similar in the background outdoor air in 2009 and 2011 (Table A1).

Selection of Contaminants of Potential Concern

The maximum detected concentrations of the 23 contaminants were compared with conservative health based environmental guidelines called Comparison Values (CVs) to select contaminants of potential concern (COPCs) for further evaluation of potential health effects (Table A2). These 23 contaminants did not include the following five contaminants that were analyzed previously for the 2008 health consultation: 1,2-dichloroethane, 4-ethyltoluene, propylbenzene, 1,2,4 trimethylbenzene, and 1,3,5 trimethylbenzene. However, the contaminants analyzed in 2009 and 2011 for this health consultation included the following three additional contaminants: Carbon disulfide, 1,4-dioxane, and methylene chloride. In the previous 2008 health consultation, 25 contaminants were analyzed and the following contaminants were selected as COPCs: radon, benzene, 1,2-dichloroethane, tetrachloroethene, trichloroethene, vinyl chloride, 1,2,4 trimethylbenzene, 1,3,5 trimethylbenzene, m,p-xylene, and o-xylene.

The health based environmental guidelines utilized as CVs in this evaluation are the Environmental Protection Agency's Regional Risk Values (EPA, 2011) and the ATSDR CVs for residential use (child and adult) based on daily exposures for 24 hours/day over a long period (e.g., 30 years for EPA's Regional Risk Values). In accordance with the CDPHE and EPA Region 8 protocol for the selection of COPCs (EPA, 1994), the CV values for noncarcinogens were multiplied by 0.1 to account for any additive effects from multiple chemicals.

Exposures to contaminants below the health risk-based environmental guidelines are not likely to pose significant health effects and thus were not evaluated further. No health guidelines were available for heptanes. However, the lack of health guidelines for heptanes is not likely to be a source of significant uncertainty because heptanes are not carcinogens and were measured at very low concentrations; the maximum concentration detected was $0.97 \mu g/m^3$. At low concentrations, the toxicity of alkanes is generally considered to be minimal (Sandmeyer, 1981). This contaminant is not evaluated further in this health consultation. The following nine contaminants were selected as COPCs for quantitative evaluation: radon, benzene, carbon disulfide, 1,4-dioxane, ethylbenzene, methylene chloride, tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride.

These COPCs did not include the following four COPCs that were selected previously in the 2008 health consultation: 1,2 dichloroethane, 1,2,4 trimethylbenzene, 1,3,5 trimethylbenzene, m,p-xylene, and o-xylene.; however, xylenes were analyzed as contaminants in 2009 and 2011 but were not selected as COPCs. As mentioned above, the other three 2008 COPCs (1,2 dichloroethane, 1,2,4 trimethylbenzene, and 1,3,5 trimethylbenzene) were not analyzed as contaminants in 2009 and 2011.

Pathway Analysis
Exposure to a contaminant of concern is determined by examining human exposure pathways. A complete exposure pathway consists of five elements: a source, a contaminated environmental medium and transport mechanism, a point of exposure, a route of exposure, and a receptor population. For this evaluation, the complete pathway identified is indoor air inhalation of radon and VOCs by museum visitors and employees. Incomplete exposure pathways at the Durango Discovery Museum include exposures to contaminated groundwater because of the availability of a municipal water supply.

Exposure doses via indoor air inhalation of VOCs are estimated by using the maximum detected concentration for each COPC selected above and the EPA recommended default assumptions for the reasonable maximum exposure for the residential and worker scenarios (EPA, 1991, 2002). These default exposure assumptions are as follows:

- Worker exposure assumptions to address the museum employees and visitors under the reasonable maximum exposure scenario = 8 hr/day for 250 days/year over 25 years.
- Residential exposure assumptions to address the museum visitors from the residential neighborhood under the worst case scenario = 24 hr/day for 350 days/year over 30 years. This scenario is included mainly for comparison purposes at the request of the CDPHE site managers.

Equations for estimating exposure doses and risks are provided as footnotes to Tables A3 to A5.

Public Health Implications
Overall, the levels of VOCs and radon have been reduced as a result of the implementation of vapor intrusion mitigation systems. The impact of these reductions on health is determined by estimating cancer and noncancer risks. The health risks are estimated by using exposure concentrations and toxicity values (Table A6). The public health implications of exposure to VOCs and radon are briefly discussed below.

VOCs

Cancer Risk Estimates

As shown in Tables A3 and A4, the estimated theoretical lifetime cancer risks for adults and children associated with the residual levels of VOCs, based on the residential and worker exposure scenarios, are well within EPA's acceptable cancer risk range of one excess cancer case in a million exposed to one hundred excess cases in a million exposed. Most importantly, the estimated theoretical cancer risks for young children (up to 6 years of age) in the visitor area (under the residential scenario of exposure for 24 hours/day) are at the low-end of the EPA's acceptable cancer risk range and vinyl chloride is the major risk deriving chemical because of its mutagenic mode of action for cancer (Table A4). Interestingly, the estimated cancer risks of exposure to the indoor air of the museum building are either the same as or slightly higher than the estimated cancer risks for exposure to the background outdoor air. The estimated theoretical cancer risk estimates range from the low-end to the mid-point of the acceptable cancer range and the major cancer risk driving chemicals include PCE, 1,4-dioxane, benzene, and vinyl chloride. For the background outdoor air and the office use area indoor air, the major contributors to the estimated cancer risk include benzene and 1,4-dioxane. For the visitor and basement areas, the major contributors include PCE, 1,4-dioxane, benzene, and vinyl chloride. PCE has the highest estimated cancer risk for the basement and visitor areas, and benzene has the highest risk for the office use area and the background outdoor air. Finally, it should be noted that the estimated theoretical cancer risks associated with the residual levels of VOCs in this evaluation are significantly lower than those associated with the pre-remediation levels of VOCs in the 2008 health consultation. The 2008 pre-remediation residential cancer risks were at or slightly above the high-end of the acceptable cancer risk range (ATSDR, 2008). In addition, 1,2-dichloroethane contributed the highest cancer risk for all areas of the museum building in the 2008 health consultation; however, the highest estimated residential cancer risk of twenty excess cancer cases in a million exposed was well within the acceptable cancer risk range noted above. Please note that1,2-dichloroethane is not evaluated here because air samples were not analyzed for 1,2-dichloroethane in 2009 and 2011 (i.e., the data collected for this evaluation). Other cancer risk driving carcinogens in the 2008 health consultation included benzene, vinyl chloride, TCE, and PCE. It is important to note that the lack of air data for 1,2-dichloroethane is not likely to result in significant underestimation of the total cancer risk estimated in this evaluation because the highest estimated residential cancer risk for 1,2-dichloroethane in 2008 health consultation was well within the acceptable cancer risk range (i.e., almost at the mid- point of the acceptable range).

Overall, the cancer risk estimates for all indoor and outdoor air exposure scenarios evaluated in this health consultation are associated with a low increased risk of developing cancer. The estimated cancer risks associated with the indoor air in the office use area are the same as those associated with the background outdoor air. Please note that under the worst case residential exposure scenario (i.e., 24 hours/day over 30 years), the cumulative theoretical lifetime estimated cancer risks are above the CDPHE long-term cancer risk goal of one in a million for all areas including the background outdoor air. However, under this worst case residential scenario, the estimated cumulative cancer risks are below or at the CDPHE long term cancer risk goal of one in a million for young children (0-6 years of age) in the visitor and background areas.

<u>Noncancer Hazard Estimates</u>

As shown in Table A5, the estimated noncancer hazards for individual chemicals (Hazard Quotient; HQ) as well as multiple chemicals (Hazard Index; HI) are significantly below levels known to result in harmful health effects (i.e., below health guidelines or HQ/HI of 1.0). For the residential/visitor scenario, HIs range from 0.2 to 0.6 with trichloroethylene (HQs = 0.1 to 0.5) and benzene (HQs = 0.08 to 0.13) as the risk drivers. For the worker/employee scenario, HIs range from 0.05 to 0.13 with trichloroethylene (HQs =

0.03 to 0.12) as the risk driver. These estimates are associated with a very low risk of developing adverse health effects. Furthermore, the noncancer hazard estimates associated with the residual levels in this evaluation are significantly lower than those associated with the pre-remediation levels of VOCs in the 2008 health consultation. The 2008 pre-remediation noncancer exposure levels were above health guidelines for benzene and trimethylbenzenes (HQs of up to 3.0), Most importantly, 1,2,4-trimethylbenzene had the highest HQ of 3.0 in the visitor area of the museum; however, the estimated exposure levels were significantly lower (by about 1,000-fold) than levels known to be associated with harmful effects in animal studies Please note that 1,2,4 and 1,3,5-trimethylbenzenes are not evaluated here because air samples were not analyzed for these contaminants in 2009 and 2011. It is important to note that the lack of air data for trimethylbenzenes is not likely to result in significant underestimation of noncancer hazards because the highest estimated exposure levels for 1,2,4-trimethylbenzenne in the 2008 health consultation were significantly below levels know to be associated with harmful effects.

Radon

Radon is a known human lung carcinogen and is the largest source of radiation exposure and risk to the general public (EPA 2007). Residual radon levels detected in the basement/boiler room area (7.9 to 10.1 pCi/L) of the museum building are significantly lower than the pre-remediation levels detected in 2007 (16.3 to 19.8 pCi/L; ATSDR, 2008); however, these levels still exceed EPA's guideline of 4.0 pCi/L, and therefore need to be reduced further by implementing other types of mitigation systems. Radon levels were well below 4.0 pCi/L in other areas of the museum building except in the main visitor/public use area where one sample was at 4.4 pCi/L. It should be noted that EPA estimates that lifetime exposure to radon at a level of 4.0 pCi/L could cause approximately 7 persons out of 1,000 persons to develop lung cancer (EPA 2008a, b). Although the EPA believes that no level of exposure to radon is safe, they have set a guideline for radon in air inside homes of 4 picocuries per liter (4.0 pCi/L) of air. When a home or a building has levels of radon that exceed this guideline, EPA recommends action to lower the level of radon in indoor air regardless of the type of use (EPA 2008).

Uncertainty/Limitations

- The available data are limited because of the following: (a) Only 2 samples per location are available but this limitation was compensated for by using the maximum detected concentration; (b) Samples were collected during different time periods. For example, one sample of VOCs from the background outdoor air and two samples of radon and VOCs from the office space area indoor air were not collected in 2011 but were collected in December 2009. Again, this limitation was addressed by using the maximum detected concentration as the exposure point concentration; and (c) 1,2-dichloroethane and trimethylbenzenes were not analyzed in the 2009 and 2011 air samples and these contaminants were chemicals of potential concern in the 2008 health consultation for cancer and noncancer risks, respectively. Thus, the cancer and noncancer risks may be underestimated. It is, however, important to note that this underestimation in risk is not likely to significantly impact the conclusions reached in this evaluation because the measured concentration of these chemicals in the 2008 health consultation were below levels of health concern for both cancer and noncancer health effects.

- Indoor air contaminant values are likely to fluctuate over time depending on weather and other variables.
- The cancer risks are estimated for long-term exposures of 30 years for visitors and 25 years for employees to address current and future exposures. As a result, the current risks are likely to be significantly overestimated for the museum users since January 2011, when the museum opened for public use. The future potential risks can be over or underestimated depending upon the future changes in the indoor air concentration of VOCs
- The assumption of a residential exposure scenario to evaluate cancer risks for the museum visitors represents the worst case exposure and is highly likely to overestimate risks for a typical museum visitor. In fact, the worker exposure scenario might better approximate the exposure of those who will be visiting the museum.
- The assumption of additivity to estimate cumulative cancer and non-cancer risks is likely to over- or under-estimate risk due to synergistic and antagonistic interactions.

Conclusions

CCPEHA and ATSDR have reached two conclusions in this health consultation:

(1) Breathing in radon found in the indoor air of the basement of the museum building could harm the health of museum employees. The reason for this is that radon levels are significantly above EPA recommended action level of 4.0 pCi/L. Overall, it is necessary to reduce exposures to radon in the basement and main visitor/public areas of the museum building regardless of the type of use.

(2) Breathing in VOCs found in the indoor air of the museum building is not expected to harm the health of museum visitors and employees. The reason for this is that VOC levels are below levels of health concern. Overall, VOC levels in the indoor air are associated with a low increased risk of developing cancer and a very low risk of developing other adverse health effects. The estimated theoretical cumulative cancer risks exceed (by 10- fold) the CDPHE long-term cancer risk goal of one in a million only under the worst case assumption of residential exposures over 30 years. Please note that this scenario was included in this evaluation for comparison purposes at the request of the CDPHE site managers.

Recommendations

To ensure a healthy environment inside the museum building, the following recommendations should be implemented.

- Take additional actions to remediate elevated levels of radon in the basement and main public use areas in order to meet EPA's guideline of 4.0 pCi/L. Please note that VOC levels in the basement, visitor, and main public use areas may need to be reduced only under the worst case assumption of residential exposures over 30 years in order to meet the CDPHE long term cancer risk goal of one in a million for VOCs.
- It is important to identify outdoor sources of VOCs and reduce or eliminate exposures from these sources since the estimated cancer risks for the background outdoor air, based on the residential use, are significantly above the CDPHE long term goal of one in a million.
- Analyze air monitoring samples for 1,2-dichloroethane and trimethylbenzenes which were the major risk driving chemicals in the 2008 ATSDR health consultation. This additional air monitoring data should be evaluated for public health implications.

Public Health Action Plan

CCPEHA will evaluate additional information as it becomes available.

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Report Preparation

This Health Consultation was prepared by the Colorado Department of Public Health and Environment (CDPHE) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved agency methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this health consultation and concurs with its findings based on the information presented in this report. ATSDR's approval of this document has been captured in an electronic database.

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Appendix A

Tables for Data Analysis and Risk Estimation

Table A1. Air concentrations of radon and Volatile Organic Compounds (VOCs) in the Indoor Air of the Museum Building and the Background Outdoor Air

Compound	**Indoor Air (µg/m^3) Museum Basement Storage Area**			**Indoor Air (µg/m^3) Museum Main Level Visitor/Public Area**		**Indoor Air (µg/m^3) Museum Annex Main Level Office Space**			**Outdoor Air (µg/m^3) Background**	
Sample Collection Date	2011	2011	2011	2011	2011	2011	2009	2009	2011	2009
Radon Value (pCi/L)	10.1	7.9	NA	3.0	4.4	0.8	1.2	1.0	NA	NA
Freon 12	1.9	1.9	2	1.8	2	1.7	3	3	2	3
Chloromethane	1.4	1.3	1.3	1.3	1.4	1.2	1.2	1	1.3	0.98
Ethanol	93	98	80	150	100	85	3	3.4	4.1	5.9
Acetone	20	22	19	22	26	40	3.5	6.2	4.7	12
2-Propanol	5.1	5.4	4.4	6.6	5.6	2,900 E	2.8 U	2.8 U	2.7 U	2.8 U
Carbon Disulfide	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	88	3.6 U	3.6 U	3.5 U	3.6 U
2-Butanone (MEK)	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.4	0.68 U	0.89	3.3 U	1.1
Methylene Chloride	1.5 U	1.5 U	3.8	1.5 U	1.5 U	1.5 U	1.6 U	1.6 U	1.6	1.6 U
Hexane	1.3	1.3	1	2.2	1.9	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U
Cyclohexane	1.2	1.1	0.94	1.5	1.1	0.79 U	0.79 U	0.79 U	0.9 U	0.79 U
Heptane	0.94 U	0.94 U	0.94 U	0.97	1	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
1,4-Dioxane	0.78 U	0.78 U	1.1	0.78 U	0.78 U	0.78 U	0.83 U	0.83 U	0.78 U	0.83 U
Vinyl Chloride	0.25	0.26	0.22	0.34	0.31	0.059 U	0.059 U	0.059 U	0.059 U	0.059 U
cis1,2-Dichloroethene	1.3	1.4	2	0.29	0.27	0.18 U	0.18 U	0.18 U	0.18 U	0.18 U
1,1,1-Trichloroethane	0.24 U	0.24 U	0.25	0.24 U	0.24 U	0.24 U	0.25 U	0.25 U	0.24 U	0.25 U
Benzene	0.76	0.76	0.73	0.8	0.78	1.2	1.2	1.3	0.81	1.3
Trichloroethene	0.74	0.73	1	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Toluene	12	9.6	8	12	9.3	1.9	3.6	3.5	1.6	4.2
Tetrachloroethene	4.4	4.2	5.1	1.7	1.8	0.31 U	0.31 U	0.31 U	0.31 U	0.31 U
Ethylbenzene	1.6	0.88	0.47	0.56	0.59	0.38	0.32	0.31	0.39	0.36
m,p-Xylene	4.1	1.6	1.1	1.5	1.6	1	0.97	0.9	1	1.2
o-Xylene	0.92	0.36	0.35	0.5	0.53	0.34	0.3	0.27	0.35	0.36

Note: There is no basement in the Museum Annex; NA- Not Analyzed; U – Not detected at the reporting limit

Table A2. Selection of Contaminants of Potential Concern (COPCs).

Compound	Maximum detected air concentration ($\mu g/m^3$) [a]			COPC selected Y/N
		$\mu g/m^3$	Source	
Radon Value (pCi/L)	10.1	4.0 pCi/L	EPA	Y
Freon 12	2.0	180	[d]	N
Chloromethane	1.4	94 nc	EPA RSL	N
Ethanol	150.0	100,000 nc	Cal EPA	N
Acetone	40.0	30,000 nc	ATSDR chronic EMEG	N
2-Propanol	2,900.0E	7,300	EPA RSL	N
Carbon Disulfide	88.0	730 nc	EPA RSL	Y
2-Butanone (MEK)	3.4	5,200 nc	EPA RSL	N
Methylene Chloride	3.8	5.20 c	EPA RSL	N
Hexane	0.81	730 nc	EPA RSL	N
Cyclohexane	1.2	6,300 nc	EPA RSL	N
Heptane [c]	0.94	NA		Y
1,4-Dioxane	1.1	0.32 c	EPA RSL	Y
Vinyl Chloride	0.34	0.16 c	EPA RSL	Y
cis-1,2-Dichloroethene	1.4	37	[d]	N
1,1,1-Trichloroethane	0.25	4,000.0 nc	ATSDR intermediate EMEG	N
Benzene	1.3	0.31 c	EPA RSL	Y
Trichloroethene	1.0	0.20 c	ATSDR CREG	Y
Toluene	12.0	300.0 nc	ATSDR chronic EMEG	N
Tetrachloroethene	5.1	0.41 c	EPA RSL	Y
Ethylbenzene	1.6	0.97 c	EPA RSL	Y
m,p-Xylene	4.1	100 nc	EPA RSL	N
o-Xylene	0.92	100 nc	EPA RSL	N

NA- Not available; c = carcinogen; nc = noncarcinogen ; CREG= Cancer Risk Evaluation Guide; E= Estimated value
EMEG- Environmental Media Evaluation Guide; EPA – Environmental Protection Agency ; RSL = Regional Screening Level; ATSDR = Agency for Toxic Substances and Disease Registry; Cal EPA = California EPA

[a] Represents the highest concentration detected among all areas of investigation

[b] Represents the most conservative value of all available sources. For noncarcinogens, CV was multiplied by 0.1 (during COPC selection) to account for the additive effects of multiple chemicals

[c] COPCs with no health guidelines were not carried forward for quantitative risk evaluation

[d] no current CVs are available for these chemicals so old EPA Region 3 screening levels are used from the previous ATSDR health consultation for this site (ATSDR 2008).

Table A3. Theoretical Lifetime Cancer Risk Estimates for the Indoor Use Areas and Outdoor Background Area for the Residential/Visitor and Worker/Employee Exposure Scenarios.

Location	COPC	Max Value ($\mu g/m^3$)	Cancer Risk Estimates		Total Cancer Risk	
			Resident	Worker		Worker
Basement Area (Indoor air)	Methylene Chloride	3.80	7.30E-07	1.46E-07	2.29E-05	4.53E-06
	1,4-Dioxane	1.10	3.44E-06	6.90E-07		
	Vinyl Chloride	0.26	1.63E-06	9.33E-08		
	Benzene	0.76	2.44E-06	4.83E-07		
	Trichloroethene	1.00	2.32E-06	3.34E-07		
	Tetrachloroethene	5.10	1.24E-05	2.45E-06		
	Ethylbenzene	1.60	1.64E-06	3.26E-07		
Visitor/Public Use Area (Indoor air)	Methylene Chloride	1.50	2.90E-07	5.75E-08	1.30E-05	2.25E-06
	1,4-Dioxane	0.78	2.44E-06	4.90E-07		
	Vinyl Chloride	0.34	2.12E-06	1.22E-07		
	Benzene	0.80	2.58E-06	5.09E-07		
	Trichloroethene	0.25	5.81E-07	8.36E-08		
	Tetrachloroethene	1.80	4.40E-06	8.66E-07		
	Ethylbenzene	0.59	6.10E-07	1.20E-07		
Office Space (Indoor air)	Methylene Chloride	1.60	3.07E-07	6.13E-08	9.18E-06	1.74E-06
	1,4-Dioxane	0.83	2.59E-06	5.21E-07		
	Vinyl Chloride	0.06	3.68E-07	2.15E-08		
	Benzene	1.30	4.19E-06	8.27E-07		
	Trichloroethene	0.25	5.81E-07	8.36E-08		
	Tetrachloroethene	0.31	7.56E-07	1.49E-07		
	Ethylbenzene	0.38	3.91E-07	7.75E-08		
Background (Outdoor air)	Methylene Chloride	1.60	3.07E-07	6.13E-08	9.18E-06	1.74E-06
	1,4-Dioxane	0.83	2.59E-06	5.21E-07		
	Vinyl Chloride	0.06	3.69E-07	2.15E-08		
	Benzene	1.30	4.19E-06	8.27E-07		
	Trichloroethene	0.25	5.81E-07	8.36E-08		
	Tetrachloroethene	0.31	7.56E-07	1.49E-07		
	Ethylbenzene	0.39	4.02E-07	7.95E-08		

Cancer Risk = EC x Inhalation Unit Risk (Chemical –specific values provided in Table A8)
EC = (CA x ET x EF x ED)/AT (Per USEPA, 2009 and ATSDR, 2005)
EC ($\mu g/m^3$) = Chemical specific exposure concentration;
CA ($\mu g/m^3$) = contaminant concentration in air;
ET (hours/day) = exposure time = 8 hrs/day for workers and 24 hrs/day for residents;
EF (days/year) = exposure frequency= 250 days/year for workers and 350 days/year for residents;
ED (years) = exposure duration = 25 years for workers and 30 years for residents (child+adult); a
AT = averaging time = (lifetime of 70 years x 365 days/year x 24 hours/day)
Note: Cancer risks for trichloroethene and vinyl chloride were calculated using the mutagenic mode of action

Table A4. Theoretical Child Cancer Risk Estimates for the Indoor Visitor/Public Use Area and Outdoor Background Area for the Residential/Visitor Exposure Scenario.

Location	COPC	Max Value (µg/m³)	Child Cancer Risk - age groups			
			0-2 year	2-6 year	6-16 year	0-16 year
Visitor/Public Use Area (Indoor air)	Methylene Chloride	1.50	1.93E-08	3.86E-08	9.66E-08	1.55E-07
	1,4-Dioxane	0.78	1.65E-07	3.29E-07	8.23E-07	1.32E-06
	Vinyl Chloride	0.34	1.54E-06	1.58E-06	1.70E-06	1.82E-06
	Benzene	0.80	1.71E-07	3.42E-07	8.55E-07	1.37E-06
	Trichloroethene	0.25	9.00E-08	8.36E-08	2.09E-07	3.83E-07
	Tetrachloroethene	1.80	2.91E-07	5.82E-07	1.45E-06	2.33E-06
	Ethylbenzene	0.59	4.04E-08	8.08E-08	2.02E-07	3.23E-07
	Total Cancer Risk		2.32E-06	3.04E-06	5.34E-06	7.70E-06
Background (Outdoor air)	Methylene Chloride	1.60	2.06E-08	4.12E-08	1.03E-07	1.65E-07
	1,4-Dioxane	0.83	1.75E-07	3.50E-07	8.75E-07	1.40E-06
	Vinyl Chloride	0.06	2.71E-07	2.78E-07	3.00E-07	3.22E-07
	Benzene	1.30	2.78E-07	5.56E-07	1.39E-06	2.22E-06
	Trichloroethene	0.25	9.00E-08	8.36E-08	2.09E-07	3.83E-07
	Tetrachloroethene	0.31	5.01E-08	1.00E-07	2.51E-07	4.01E-07
	Ethylbenzene	0.39	2.67E-08	5.34E-08	1.34E-07	2.14E-07
	Total Cancer Risk		9.12E-07	1.46E-06	3.26E-06	5.10E-06

Cancer Risk = EC x Inhalation Unit Risk (Chemical –specific values provided in Table A9)
EC = (CA x ET x EF x ED)/AT (Per USEPA, 2009 and ATSDR, 2005)
EC (µg/m³) = Chemical specific exposure concentration;
CA (µg/m³) = contaminant concentration in air;
ET (hours/day) = exposure time = 24 hrs/day
EF (days/year) = exposure frequency= 350 days/year for residents;
ED (years) = exposure duration = 2 years; 4 years; 10 years; 16 years
AT = averaging time = (lifetime of 70 years x 365 days/year x 24 hours/day)
Note: Cancer risk for trichloroethene and vinyl chloride are estimated using the mutagenic mode of action for cancer as recommended by EPA IRIS.

Table A5. Non Cancer Hazard Quotient (HQs) Estimates for the Indoor Use Areas and Outdoor Background Area for the Residential/Visitor and Worker/Employee Exposure Scenarios.

Location	COPC	Max Value (µg/m³)	Noncancer HQ		Noncancer HI (Total HQ)	
			Resident	Worker	Resident	Worker
Basement Area (Indoor air)	Methylene Chloride	3.80	0.0040	0.0009	0.62	0.13
	1,4-Dioxane	1.10	0.0004	0.00008		
	Vinyl Chloride	0.26	0.0030	0.0006		
	Benzene	0.76	0.0760	0.0170		
	Trichloroethene	1.00	0.5000	0.1142		
	Tetrachloroethene	5.10	0.0190	0.0040		
	Ethylbenzene	1.60	0.0160	0.0004		
	Carbon disulfide	3.50	0.0050	0.0010		
Visitor/Public Use Area (Indoor air)	Methylene Chloride	1.50	0.0020	0.0003	0.22	0.05
	1,4-Dioxane	0.78	0.0003	0.00006		
	Vinyl Chloride	0.34	0.0030	0.0008		
	Benzene	0.80	0.0800	0.0180		
	Trichloroethene	0.25	0.1250	0.0285		
	Tetrachloroethene	1.80	0.0070	0.0015		
	Ethylbenzene	0.59	0.0006	0.0001		
	Carbon disulfide	3.50	0.0050	0.0011		
Office Space (Indoor air)	Methylene Chloride	1.60	0.0020	0.0004	0.39	0.09
	1,4-Dioxane	0.83	0.0003	0.00006		
	Vinyl Chloride	0.06	0.0006	0.0001		
	Benzene	1.30	0.1300	0.029		
	Trichloroethene	0.25	0.1250	0.0285		
	Tetrachloroethene	0.31	0.0010	0.0003		
	Ethylbenzene	0.38	0.0004	0.00009		
	Carbon disulfide	88.0	0.1260	0.0280		
Background (Outdoor air)	Methylene Chloride	1.60	0.0020	0.0004	0.26	0.06
	1,4-Dioxane	0.83	0.0003	0.00006		
	Vinyl Chloride	0.06	0.0006	0.0001		
	Benzene	1.30	0.1300	0.0290		
	Trichloroethene	0.25	0.1250	0.0285		
	Tetrachloroethene	0.31	0.0010	0.0003		
	Ethylbenzene	0.39	0.0004	0.00009		
	Carbon disulfide	3.60	0.0050	0.0010		

Hazard Quotient (HQ) = EC/Health Guideline; Hazard Index (HI) = Sum of all HQs
EC = (CA x ET x EF x ED)/AT (USEPA, 2009)
EC (µg/m^3) = exposure concentration; CA (µg/m^3) = contaminant concentration in air;
ET (hours/day) = exposure time = 8 hrs/day for workers and 24 hrs/day for residents;
EF (days/year) = exposure frequency=250 days/year for workers and 350 days/year for residents;
ED (years) = exposure duration=25 years for workers and 30 years for residents; and
AT =Averaging Time (ED in years x 365 days/year x 24 hours/day)

Table A6. Cancer and Noncancer Toxictiy Values for COPCs

COPC	Inhalation Unit Risk (IUR) $(\mu g/m^3)^{-1}$	Noncancer Health guideline $(\mu g/m^3)$
Methylene Chloride	4.7E-07 (EPA IRIS)	1000.0 (ATSDR MRL)
1,4-Dioxane	7.7E-06 (EPA IRIS)	3000.0 (Cal EPA)
Vinyl Chloride	4.4E-06 (EPA IRIS)	100.0 (EPA IRIS)
Benzene	7.8E-06 (EPA IRIS)	10.0 (ATSDR MRL)
Trichloroethene	4.1E-06 (EPA IRIS) [a]	2.0 (EPA IRIS)
Tetrachloroethene	5.9E-06 (OSWER)	270.0 (ATSDR MRL)
Ethylbenzene	2.5E-06 (EPA IRIS)	1000.0 (EPA IRIS)
Carbon disulfide	Noncarcinogen	700.0 (EPA IRIS)

EPA= Environmental Protection Agency
IRIS = Integrated Risk Information System
OSWER = EPA's Office of Solid Waste and Emergency Response
Cal EPA = California EPA
[a] This value was applied for risk calculation for workers. For the residential scenario, risks were estimated by taking into consideration the mutagenic mode of action for children for kidney cancer using the IUR of 1.0E-06 $(\mu g/m^3)^{-1}$ and no mutagenic mode of action was considered for the lymphoma and liver cancer using the IUR of 3.1E-06 $(\mu g/m^3)^{-1}$.