

Evaluation of Volatile Organic Compounds in Outdoor Air at Woodson Middle School

Woodson Middle School
HOPEWELL, VIRGINIA

Letter Health Consultation

November 23, 2015

Virginia Department of Health
Division of Environmental Epidemiology
109 Governor Street
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COMMONWEALTH of VIRGINIA

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November 23, 2015

Charles Turner
Air Monitoring Manager
Virginia Department of Environmental Quality
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Dear Charles Turner,

Thank you for the opportunity to review the air monitoring results collected 2009-2013 at Woodson Middle School in Hopewell, VA. As requested, the Virginia Department of Health (VDH) has finished *reviewing the volatile organic compounds monitoring results for public health implications*, and concludes that the volatile organic compound air monitoring results collected at Woodson Middle School from 2009-2013 are not a health hazard. VDH does not have any recommendations at this time and will evaluate any additional air monitoring results for public health implications.

BACKGROUND

In 2006, Hopewell City Public Schools permitted the Virginia Department of Environmental Quality (DEQ) to establish an ambient air sampling site on the property of Carter G. Wilson Middle school. The site was termed "Woodson" and was established as part of a Community Air Toxics Study for the Hopewell area. The project ran from July 1, 2006 to September 30, 2008. DEQ re-designated Woodson as an Urban Air Toxics Monitoring (UATM) site for the Hopewell area in October of 2008, and continues to collect data in this capacity.

In partnership with the Environmental Protection Agency (EPA), DEQ uses the designated UATM sites to monitor localized select hazardous air pollutants (HAPs). The HAPs targeted include volatile organic compounds (VOCs), carbonyls, and metals. Sampling occurs every sixth day and collocated samples for VOCs and carbonyls are collected every twelfth day.

Site description and demographics

Hopewell City is located in the southeastern part of Central Virginia and is in close proximity of the James and Appomattox Rivers. This city is located 24 miles southeast of the state capital of Richmond. Interstates I-295 and I-95 are suspected to contribute to the presence of traffic-related air pollutants in the area. The city has numerous air pollution point sources, on and off road sources, and agricultural pesticides within its boundaries.

In 2014, the estimated total population of Hopewell was 22,196, while Virginia's population was 8,326,289. In 2010, the number of persons per square mile was 2,198 in Hopewell compared to the state average of 202.6. In 2013, Caucasians represented the majority race at 56.2%. Blacks or African Americans represented 39.1%, while Hispanics or Latinos represented 6.8% of the Hopewell population in 2013. Between 2009 and 2013, the median household income in Hopewell was \$37,933, which was lower than the state (\$63,907). During this same time period, there were 8,766 households in the city, with 2.5 persons per household. Sensitive populations in 2014 include persons under the age of five, who represented 7.5% of the Hopewell population, and elderly persons over the age of 65, who represented 15.7% (U.S. Census 2013).¹

DISCUSSION

Sampling Methods

The standardized TO-15 method was used to collect air samples for VOC analysis. Whole ambient air samples were collected in an evacuated canister using a pressurized sampling mode and analyzed by GC/MS. Ambient air concentrations of carbonyl compounds were collected using the TO-11A method. In this method, carbonyl compounds were collected using adsorbent cartridges treated with DNPH and analyzed using high performance liquid chromatography. Toxic metals were collected using a high volume sampler, on a quartz filter, and were analyzed by ICP/MS using Methods IO-3.1 and IO-3.5. Carbonyl compounds and metal results are the subject of a separate consultation.

Results

The following section contains results and comparison values (CVs) for VOCs monitored in 2009-2013 at Woodson. CVs are discussed in more detail in the public health implications section. For a complete list of all VOCs monitored each year, their frequency of detection, maximum and average concentrations, refer to tables at the end of this letter.

VDH compared the yearly maximum concentration of each VOC with their CV. Out of approximately 60 VOCs analyzed, six VOCs exceeded the CVs. The maximum concentrations of the six VOCs and their CVs are shown in Table 1.

¹ <http://www.census.gov/quickfacts/table/PST045214/00,51670>: last accessed November 2015.

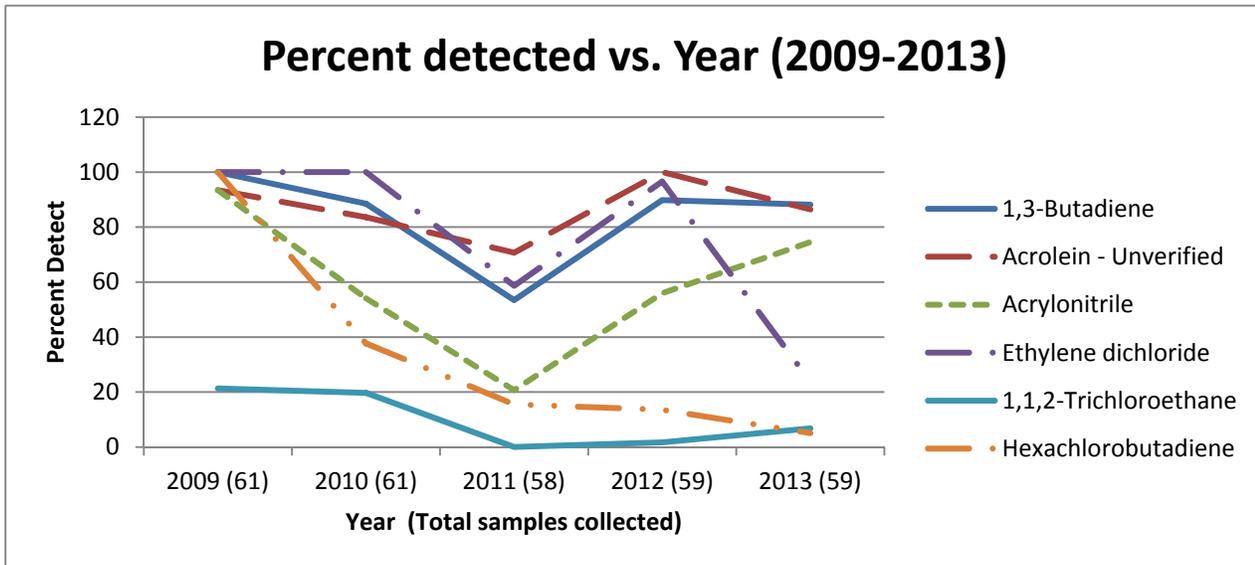
Table 1. Volatile organic compounds that exceeded one or more comparison value (2009-2013)

Volatile Organic Compound	2009	2009	2010	2010	2011	2011	2012	2012	2013	2013	CV	Source
	Max	Avg										
1,3-Butadiene	0.29	0.054	0.32	0.051	0.31	0.025	0.18	0.045	0.13	0.033	1.492E-02	CREG
Acrolein - Unverified	2.94	0.252	0.37	0.109	0.40	0.080	0.46	0.178	2.33	0.256	4.012E-02	EMEG(i)
Acrylonitrile	0.13	0.049	0.11	0.015	0.07	0.004	0.37	0.019	0.06	0.012	6.907E-03	CREG
Ethylene dichloride	0.12	0.022	0.03	0.017	0.02	0.007	0.02	0.011	0.14	0.007	9.388E-03	CREG
1,1,2-Trichloroethane	0.02	0.003	0.01	0.002	0.000	0.000	0.01	0.000	0.09	0.002	1.155E-02	CREG
Hexachlorobutadiene	0.07	0.013	0.03	0.004	0.12	0.003	0.03	0.002	0.02	0.001	4.219E-03	CREG

(Source: DEQ) All units parts per billion (ppb). **Max** – maximum; **Avg** – average; **CV** – comparison value; **CREG** – cancer risk evaluation guide; **EMEG(i)** – environmental medium evaluation guide (intermediate).

Except for hexachlorobutadiene, detection of these six VOCs decreased in 2010 and 2011, and then increased in 2012. Hexachlorobutadiene is the only VOC that was detected at decreasing concentrations each year of the monitoring project. However, all six VOCs were detected at lower concentrations in 2013 when compared to 2009.

Graph 1. Percent VOCs detected by year (2009-2013)



(Source: DEQ)

Public Health Implications

Contaminants in the environment can only impact human health if individuals are (1) exposed to contaminants and (2) if contaminants are present at sufficient concentrations. Residents can potentially be exposed to contaminants in ambient air whenever they spend time outdoors. Evaluation of the VOCs with air concentrations above their respective CV are discussed below.

Contaminant evaluation

VDH uses CVs to evaluate air contaminant concentrations. CVs are media-specific concentrations used to identify contaminants that often require additional evaluation. They are derived using standard default exposure assumptions and are not site-specific. For contaminants detected below their respective CVs, exposure is not anticipated to result in adverse health effects. Concentrations above CVs do not mean that adverse health effects occurred or will occur, but that further investigation is needed. Therefore, the CVs should not be used to predict the occurrence of adverse health effects. CVs used to evaluate contaminants at the sampling sites included the Agency for Toxic Substances and Disease Registry (ATSDR's) environmental media evaluation guides (EMEGs), and cancer risk evaluation guides (CREGs). EMEGs are estimated contaminant concentrations that are not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. They are based on conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight. ATSDR has developed EMEGs that apply to acute (14 days or less), intermediate (15–364 days), and chronic (365 days or more) exposures. CREGs are media-specific comparison values that are used to identify concentrations of cancer-causing substances that are unlikely to result in a significant increase of cancer rates in an exposed population. ATSDR develops CREGs using EPA's cancer slope factor or inhalation unit risk, a target risk level (10^{-6}), and default exposure assumptions. The target risk level of 10^{-6} represents an estimated risk of 1 excess cancer case in an exposed population of 1 million.

If ATSDR does not have a CV for a substance, then other federal or state guidelines are used if available. For this evaluation, VDH used EPA's regional screening levels (RSL), the National Institute for Occupational Safety and Health (NIOSH's) recommended exposure limit (REL), and the Occupational Safety and Health Administration's permissible exposure limit (PEL) to evaluate VOCs where ATSDR did not have an applicable CV. RSLs are risk-based concentrations that combine exposure assumptions and toxicity data to yield environment contaminant levels that are considered protective for humans over a lifetime was used to evaluate the air concentration of ethyl acetate. RELs and PELs are developed to be protective of workers and not necessarily the general population. Where RELs and PELs were used as CVs, the maximum concentration of VOC detected was less than 1000-fold except for isopropyl alcohol which was less than 200-fold. Therefore, VDH does not feel additional consideration is needed where occupational CVs were used.

The six VOCs that exceeded their CVs are man-made chemicals. The most recent (2013) ambient air concentrations of each VOC are similar to what has been reported elsewhere (Table 2). The potential for these VOCs to cause adverse health effects depends on the length of exposure, the concentration of the VOC, and sensitivity of the individual. Table 2 summarizes ambient air concentrations reported in the literature, sources of each VOC, and their potential health effects. The average yearly concentration of 1,1,2-trichloroethane did not exceed its CV and is not discussed further.

Table 2. Air concentrations, potential sources, and health effects for six selected VOCs

Volatile Organic Compound	Reported Air Concentrations	Source	Health Effect (s)
1,3-Butadiene	0.04 to 0.9 ppb in cities and suburban areas	automobile tobacco burning rubber and plastic industrial	humans: workers studied complained of irritation to the eyes, nasal passages, throat, lungs, and fatigue and drowsiness laboratory animals: nasal inflammation, changes to lungs, heart, and reproductive tissue classified as a human carcinogen
Acrolein	0.2 ppb in urban air; 0.12 ppb in rural air Typical indoor air 0.02 to 12 ppb	automobile tobacco coal or oil power plants industrial	humans: watery eyes, nose and throat irritation not classifiable as to carcinogenicity in humans
Acrylonitrile	concentrations average less than 1 ppb near industrial source not been detected in typical ambient air	manufacturing facilities that use acrylonitrile	humans: headaches and nausea, temporary damage to blood cells and liver
Ethylene dichloride	between 0.1 to 1.5 ppb in urban locations	industrial	humans: affects multiple organs including nervous system, kidneys, liver, and lungs may reasonably be expected to cause cancer
1,1,2-Trichloroethane	0.01 to 0.05 ppb	industrial landfills	humans: can affect the nervous system, and may affect the liver, kidney, digestion tract and the body's ability to fight infection. shown to cause cancer in laboratory animals
Hexachlorobutadiene	rural and urban air average 0.002-0.003 ppb	industrial	humans: no information on human health effects animals: irritation of the nose, kidney and liver damage not classifiable as to its carcinogenicity in humans

(Source: [Agency for Toxic Substances and Disease Registry](http://www.atsdr.cdc.gov/).) Accessed online September 2015 <http://www.atsdr.cdc.gov/>

Cancer risk

The maximum and average concentrations of the carcinogens, 1,3 butadiene, acrylonitrile, and ethylene dichloride exceeded their CVs multiple times. The maximum concentration of hexachlorobutadiene detected each year also exceeded its CV, but the yearly average concentration of hexachlorobutadiene only exceeded its CV in 2009. VDH used the highest reported yearly average concentration for each of these compounds to calculate the cancer risk (see Box 1). This approach may overestimate the cancer risk because it assumes that a community member is exposed to the highest concentration of each carcinogen over their entire lifespan. The additional cancer risk for each VOC is within EPA's generally acceptable risk range (1 in 10,000 to 1 in 1,000,000) and is considered low. VDH also calculated the total excess cancer risk by adding the estimated cancer risk for each individual contaminant. The total excess cancer risk (less than 2 in a 100,000) is still considered to be low, especially considering that the background cancer rate in the United States is about one in three.

Box 1. Cancer risk calculation for carcinogens discussed

To estimate cancer risk from inhaling carcinogens discussed, the inhalation unit risk (IUR) factor in $(\mu\text{g}/\text{m}^3)^{-1}$ for each carcinogen is multiplied by the air concentration of the contaminant in $\mu\text{g}/\text{m}^3$. * See Equation 1 below.

Equation 1

$$\text{Cancer Risk} = \text{IUR} \times \text{Concentration}$$

1,3 Butadiene (2009 average concentration 0.12 $\mu\text{g}/\text{m}^3$)

$$3.6 \times 10^{-6} = 3 \times 10^{-5} (\mu\text{g}/\text{m}^3)^{-1} \times 0.12 \mu\text{g}/\text{m}^3 = \text{less than 4 additional cancers in a million}$$

Acrylonitrile (2009 average concentration 0.11 $\mu\text{g}/\text{m}^3$)

$$7.4 \times 10^{-6} = 6.8 \times 10^{-5} (\mu\text{g}/\text{m}^3)^{-1} \times 0.11 \mu\text{g}/\text{m}^3 = \text{less than 8 additional cancers in a million}$$

Ethylene dichloride (2009 average concentration 0.09 $\mu\text{g}/\text{m}^3$)

$$2.3 \times 10^{-6} = 2.6 \times 10^{-5} (\mu\text{g}/\text{m}^3)^{-1} \times 0.09 \mu\text{g}/\text{m}^3 = \text{less than 3 additional cancers in a million}$$

Hexachlorobutadiene (2009 average concentration 0.14 $\mu\text{g}/\text{m}^3$)

$$3.1 \times 10^{-6} = 2.2 \times 10^{-5} (\mu\text{g}/\text{m}^3)^{-1} \times 0.14 \mu\text{g}/\text{m}^3 = \text{less than 4 additional cancers in a million}$$

*Concentration ($\mu\text{g}/\text{m}^3$) = (Concentration (ppb) x molecular weight)/24.45

CONCLUSION

VDH concludes that the volatile organic compound air monitoring results collected at Woodson Middle School from 2009-2013 are not a health hazard.

RECOMMENDATION

VDH does not have any recommendations at this time and will evaluate any additional air monitoring results for public health implications.

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Attachments

Table 3. Volatile organic compounds air monitoring results and comparison values – 2009

2009	Number	detects	Max	Avg	CV	Source
Carbon disulfide	61	61	0.13	0.022	2.986E+02	Chronic EMEG
Freon 113	61	61	0.27	0.111	9.917E+05	PEL
Freon 114	61	61	0.04	0.022	1.001E+06	PEL
Ethyl Acetate	61	61	0.56	0.037	8.602E+01	RSL (Non Cancer)
1,3-Butadiene	61	61	0.29	0.054	1.492E-02	CREG
Hexane	61	61	0.95	0.161	5.958E+02	Chronic EMEG
Heptane	61	61	0.36	0.062	4.880E+05	PEL
Cyclohexane	61	59	0.17	0.052	1.743E+03	EPA RfC
Isopropyl alcohol	61	61	2.78	0.681	3.987E+02	PEL
Methyl tert-butyl ether	61	25	0.23	0.019	6.934E+02	Chronic EMEG
Acrolein - Unverified	61	57	2.94	0.252	4.012E-02	Int. EMEG
Acetone	61	61	8.01	3.353	1.305E+04	Chronic EMEG
Methyl ethyl ketone	61	61	1.18	0.254	4.747E+04	RSL (Non Cancer)
Methyl butyl ketone	61	17	0.08	0.006	1.001E+05	PEL
Methyl isobutyl ketone	61	15	0.07	0.005	7.323E+02	EPA RfC
Acetonitrile	30	28	3.82	0.592	3.574E+01	EPA RfC
Acrylonitrile	61	57	0.13	0.049	6.907E-03	CREG
Chloromethane	61	61	2.06	0.671	4.843E+01	Chronic EMEG
Dichloromethane	61	61	0.66	0.249	2.879E+01	CREG
Chloroform	61	61	0.05	0.025	2.007E+01	Chronic EMEG
Carbon tetrachloride	61	61	0.13	0.109	3.020E+01	Chronic EMEG
Bromoform	61	14	0.03	0.003	8.804E-02	CREG
Trichlorofluoromethane	61	61	0.32	0.288	5.518E+02	RSL (Non Cancer)
Chloroethane	61	42	1.20	0.043	3.790E+03	EPA RfC
1,1-Dichloroethane	61	11	0.02	0.002	1.902E+00	RSL (Cancer)
Methyl chloroform	61	61	0.06	0.015	6.965E+02	Int. EMEG
Ethylene dichloride	61	61	0.12	0.022	9.388E-03	CREG
Tetrachloroethylene	61	60	0.21	0.024	3.981E+01	Chronic EMEG
1,1,2,2-Tetrachloroethane	61	14	0.02	0.003	2.476E-01	RSL (Cancer)
Bromomethane	61	58	0.03	0.012	4.893E+00	Chronic EMEG
1,1,2-Trichloroethane	61	13	0.02	0.003	1.155E-02	CREG
Dichlorodifluoromethane	61	61	0.69	0.630	8.898E+01	RSL (Non Cancer)
Trichloroethylene	61	35	0.03	0.008	3.721E-01	Chronic EMEG
1,1-Dichloroethylene	61	23	0.03	0.005	1.993E+01	Int. EMEG
Bromodichloromethane	61	19	0.03	0.004	4.926E-02	RSL (Cancer)
1,2-Dichloropropane	61	20	0.04	0.005	4.977E+01	Acute EMEG
trans-1,3-Dichloropropene	61	11	0.07	0.003	7.051E+00	Chronic EMEG

cis-1,3-Dichloropropene	61	12	0.11	0.004	7.051E+00	Chronic EMEG
Dibromochloromethane	61	11	0.02	0.002	5.283E-02	RSL (Cancer)
trans-1,2-Dichloroethylene	61	8	0.01	0.001	1.992E+02	Int. EMEG
cis-1,2-Dichloroethene	61	9	0.02	0.002	1.992E+05	PEL
Ethylene dibromide	61	14	0.05	0.004	2.000E+04	PEL
Hexachlorobutadiene	61	61	0.07	0.013	4.219E-03	CREG
Vinyl chloride	61	12	0.02	0.002	4.303E-02	CREG
m/p Xylene	61	61	0.79	0.106	1.013E+02	RSL (Non Cancer)
Benzene	61	61	0.95	0.238	3.005E+00	Chronic EMEG
Toluene	61	61	3.52	0.338	7.961E+01	Chronic EMEG
Ethylbenzene	61	61	0.28	0.044	5.988E+01	Chronic EMEG
o-Xylene	61	60	0.32	0.042	1.013E+02	RSL (Non Cancer)
1,3,5-Trimethylbenzene	61	56	0.08	0.016	2.543E+04	REL
1,2,4-Trimethylbenzene	61	61	0.34	0.059	6.306E+00	RSL (Non Cancer)
Ethyltoluene	61	59	0.31	0.027	N/A	N/A
Styrene	61	60	0.19	0.034	1.995E+02	Chronic EMEG
Chlorobenzene	61	28	0.11	0.009	4.779E+01	RSL (Non Cancer)
1,2-Dichlorobenzene	61	29	0.09	0.008	1.464E+02	RSL (Non Cancer)
1,3-Dichlorobenzene	61	21	0.10	0.007	N/A	N/A
1,4-Dichlorobenzene	61	54	0.11	0.020	9.980E+00	Chronic EMEG
Benzyl chloride	61	20	0.07	0.007	8.499E-01	RSL (Non Cancer)
1,2,4-Trichlorobenzene	61	54	0.06	0.015	1.186E+00	RSL (Non Cancer)
tetrahydrofuran	61	22	0.07	0.010	6.781E+02	EPA RfC

(Source: DEQ) All units are in parts per billion (ppb). **REL**-Recommended Exposure Limit, **RSL**-Regional Screening Level, **N/A**-Not Available, **PEL**-Permissible Exposure Limit, **EMEG**-Environmental Media Exposure Guideline, **CREG**-Cancer Risk Exposure Guideline, **Int.**-Intermediate, **RfC**-Reference Concentration, **Num**-number of samples collected, **Max**- maximum concentration, **Avg**- average concentration, **CV**-comparison value

Table 4. Volatile organic compounds air monitoring results and comparison values - 2010

2010	Num	Detects	Max	Avg	CV	Source
Carbon disulfide	61	60	0.16	0.023	2.986E+02	Chronic EMEG
Freon 113	61	61	0.18	0.102	9.917E+05	PEL
Freon 114	61	61	0.03	0.022	1.001E+06	PEL
Ethyl Acetate	61	40	0.23	0.030	8.602E+01	RSL (Non Cancer)
1,3-Butadiene	61	54	0.32	0.051	1.492E-02	CREG
Hexane	61	61	0.72	0.156	5.958E+02	Chronic EMEG
Heptane	61	61	0.49	0.071	4.880E+05	PEL
Cyclohexane	61	59	0.14	0.031	1.743E+03	EPA RfC
Isopropyl alcohol	61	61	11.23	0.915	3.987E+02	PEL
Methyl tert-butyl ether	61	14	0.03	0.003	6.934E+02	Chronic EMEG
Acrolein - Unverified	61	51	0.37	0.109	4.012E-02	Int. EMEG
Acetone	61	61	8.01	3.117	1.305E+04	Chronic EMEG

Methyl ethyl ketone	61	61	0.64	0.252	4.747E+04	RSL (Non Cancer)
Methyl Butyl Ketone	61	16	0.05	0.004	1.001E+05	PEL
Methyl isobutyl ketone	61	7	0.02	0.001	7.323E+02	EPA RfC
Acetonitrile	61	58	11.58	2.614	3.574E+01	EPA RfC
Acrylonitrile	61	33	0.11	0.015	6.907E-03	CREG
Chloromethane	61	61	0.74	0.619	4.843E+01	Chronic EMEG
Dichloromethane	61	61	0.35	0.177	2.879E+01	CREG
Chloroform	61	61	0.05	0.025	2.007E+01	Chronic EMEG
Carbon tetrachloride	61	61	0.12	0.098	3.020E+01	Chronic EMEG
Bromoform	61	13	0.01	0.002	8.804E-02	CREG
Trichlorofluoromethane	61	61	0.31	0.276	5.518E+02	RSL (Non Cancer)
Chloroethane	61	58	0.4	0.113	3.790E+03	EPA RfC
1,1-Dichloroethane	61	12	0.01	0.002	1.902E+00	RSL (Cancer)
Methyl chloroform	61	61	0.02	0.012	6.965E+02	Int. EMEG
Ethylene dichloride	61	61	0.03	0.017	9.388E-03	CREG
Tetrachloroethylene	61	58	0.05	0.017	3.981E+01	Chronic EMEG
1,1,2,2-Tetrachloroethane	61	17	0.01	0.003	2.476E-01	RSL (Cancer)
Bromomethane	61	59	0.03	0.011	4.893E+00	Chronic EMEG
1,1,2-Trichloroethane	61	12	0.01	0.002	1.155E-02	CREG
Dichlorodifluoromethane	61	61	0.68	0.572	8.898E+01	RSL (Non Cancer)
Trichloroethylene	61	29	0.02	0.006	3.721E-01	Chronic EMEG
1,1-Dichloroethylene	61	15	0.03	0.003	1.993E+01	Int. EMEG
Bromodichloromethane	61	24	0.04	0.005	4.926E-02	RSL (Cancer)
1,2-Dichloropropane	61	24	0.02	0.005	4.977E+01	Acute EMEG
trans-1,3-Dichloropropene	61	7	0.03	0.002	7.051E+00	Chronic EMEG
cis-1,3-Dichloropropene	61	8	0.06	0.003	7.051E+00	Chronic EMEG
Dibromochloromethane	61	10	0.01	0.002	5.283E-02	RSL (Cancer)
trans-1,2-Dichloroethylene	61	9	0.04	0.002	1.992E+02	Int. EMEG
cis-1,2-Dichloroethene	61	5	0.01	0.001	1.992E+05	PEL
Ethylene dibromide	61	10	0.04	0.002	2.000E+04	PEL
Hexachlorobutadiene	61	23	0.03	0.004	4.219E-03	CREG
Vinyl chloride	61	10	0.02	0.002	4.303E-02	CREG
m/p Xylene	61	61	0.43	0.097	1.013E+02	RSL (Non Cancer)
Benzene	61	61	0.92	0.225	3.005E+00	Chronic EMEG
Toluene	61	61	1.07	0.252	7.961E+01	Chronic EMEG
Ethylbenzene	61	61	0.16	0.040	5.988E+01	Chronic EMEG
o-Xylene	61	60	0.17	0.039	1.013E+02	RSL (Non Cancer)
1,3,5-Trimethylbenzene	61	49	5.91	0.219	2.543E+04	REL
1,2,4-Trimethylbenzene	61	61	0.22	0.050	6.306E+00	RSL (Non Cancer)
Ethyltoluene	61	57	0.12	0.021	N/A	N/A

Styrene	61	55	0.23	0.027	1.995E+02	Chronic EMEG
Chlorobenzene	61	30	0.05	0.007	4.779E+01	RSL (Non Cancer)
1,2-Dichlorobenzene	61	28	0.06	0.007	1.464E+02	RSL (Non Cancer)
1,3-Dichlorobenzene	61	21	0.06	0.006	N/A	N/A
1,4-Dichlorobenzene	61	57	0.1	0.021	9.980E+00	Chronic EMEG
Benzyl chloride	61	23	0.24	0.014	8.499E-01	RSL (Non Cancer)
1,2,4-Trichlorobenzene	61	27	0.1	0.008	1.186E+00	RSL (Non Cancer)
Tetrahydrofuran	61	23	0.19	0.013	6.781E+02	EPA RfC

(Source: DEQ) All units are in parts per billion (ppb). **REL**-Recommended Exposure Limit, **RSL**-Regional Screening Level, **N/A**-Not Available, **PEL**-Permissible Exposure Limit, **EMEG**-Environmental Media Exposure Guideline, **CREG**-Cancer Risk Exposure Guideline, **Int.**-Intermediate, **RfC**-Reference Concentration, **Num**-number of samples collected, **Max**- maximum concentration, **Avg**- average concentration, **CV**-comparison value

Table 5. Volatile organic compounds air monitoring results and comparison values - 2011

2011	Num	Detects	Max	Avg	CV	Source
Carbon disulfide	58	58	0.21	0.055	2.986E+02	Chronic EMEG
Freon 113	58	58	0.62	0.096	9.917E+05	PEL
Freon 114	58	58	0.02	0.015	1.001E+06	PEL
1,3-Butadiene	58	31	0.31	0.025	1.492E-02	CREG
Hexane	58	45	0.42	0.068	5.958E+02	Chronic EMEG
Heptane	58	50	0.21	0.053	4.880E+05	PEL
Cyclohexane	58	51	0.28	0.049	1.743E+03	EPA RfC
Methyl tert-butyl ether	58	11	0.34	0.014	6.934E+02	Chronic EMEG
Acrolein - Unverified	58	41	0.4	0.080	4.012E-02	Int. EMEG
Acetone	58	58	6.79	2.679	1.305E+04	Chronic EMEG
Acetonitrile	58	58	7.41	3.178	3.574E+01	EPA RfC
Acrylonitrile	58	12	0.07	0.004	6.907E-03	CREG
Chloromethane	58	58	0.66	0.543	4.843E+01	Chronic EMEG
Dichloromethane	58	58	0.87	0.116	2.879E+01	CREG
Chloroform	58	55	0.03	0.016	2.007E+01	Chronic EMEG
Carbon tetrachloride	58	58	0.12	0.076	3.020E+01	Chronic EMEG
Trichlorofluoromethane	58	58	0.36	0.252	5.518E+02	RSL (Non Cancer)
Methyl chloroform	58	19	0.02	0.004	6.965E+02	Int. EMEG
Ethylene dichloride	58	34	0.02	0.007	9.388E-03	CREG
Tetrachloroethylene	58	33	0.06	0.010	3.981E+01	Chronic EMEG
1,1,2,2-Tetrachloroethane	58	1	0.01	0.000	2.476E-01	RSL (Cancer)
Bromomethane	58	30	0.04	0.007	4.893E+00	Chronic EMEG
1,1,2-Trichloroethane	58	0	0	0.000	1.155E-02	CREG
Dichlorodifluoromethane	58	58	0.63	0.522	8.898E+01	RSL (Non Cancer)
Trichloroethylene	58	3	0.01	0.001	3.721E-01	Chronic EMEG
1,2-Dichloropropane	58	0	0	0.000	4.977E+01	Acute EMEG

trans-1,3-Dichloropropene	58	0	0	0.000	7.051E+00	Chronic EMEG
cis-1,3-Dichloropropene	58	0	0	0.000	7.051E+00	Chronic EMEG
Ethylene dibromide	58	2	0.01	0.000	0	PEL
Hexachlorobutadiene	58	9	0.12	0.003	4.219E-03	CREG
Vinyl chloride	58	2	0.01	0.000	4.303E-02	CREG
m/p Xylene	58	58	0.39	0.074	1.013E+02	RSL (Non Cancer)
Benzene	58	58	0.61	0.177	3.005E+00	Chronic EMEG
Toluene	58	58	0.99	0.198	7.961E+01	Chronic EMEG
Ethylbenzene	58	58	0.13	0.029	5.988E+01	Chronic EMEG
o-Xylene	58	58	0.14	0.032	1.013E+02	RSL (Non Cancer)
1,3,5-Trimethylbenzene	58	30	0.05	0.008	2.543E+04	REL
1,2,4-Trimethylbenzene	58	58	0.14	0.030	6.306E+00	RSL (Non Cancer)
Ethyltoluene	58	41	0.07	0.015	N/A	N/A
Styrene	58	40	0.05	0.013	1.995E+02	Chronic EMEG
Chlorobenzene	58	8	0.03	0.002	4.779E+01	RSL (Non Cancer)
1,4-Dichlorobenzene	58	26	0.02	0.005	9.980E+00	Chronic EMEG
Benzyl chloride	58	17	0.05	0.007	8.499E-01	RSL (Non Cancer)
Tetrahydrofuran	58	17	0.12	0.011	6.781E+02	EPA RfC

(Source: DEQ) All units are in parts per billion (ppb). **REL**-Recommended Exposure Limit, **RSL**-Regional Screening Level, **N/A**-Not Available, **PEL**-Permissible Exposure Limit, **EMEG**-Environmental Media Exposure Guideline, **CREG**-Cancer Risk Exposure Guideline, **Int.**-Intermediate, **RfC**-Reference Concentration, **Num**-number of samples collected, **Max**- maximum concentration, **Avg**- average concentration, **CV**-comparison value

Table 6. Volatile organic compounds air monitoring results and comparison values - 2012

2012	Num	Detects	Max	Avg	CV	Source
Carbon disulfide	59	59	0.08	0.023	2.986E+02	Chronic EMEG
Freon 113	59	59	0.31	0.080	9.917E+05	PEL
Freon 114	59	48	0.02	0.013	1.001E+06	PEL
1,3-Butadiene	59	53	0.18	0.045	1.492E-02	CREG
Hexane	59	51	0.44	0.099	5.958E+02	Chronic EMEG
Heptane	59	59	0.35	0.101	4.880E+05	PEL
Cyclohexane	59	57	0.15	0.044	1.743E+03	EPA RfC
Methyl tert-butyl ether	59	17	0.08	0.008	6.934E+02	Chronic EMEG
Acrolein - Unverified	59	59	0.46	0.178	4.012E-02	Int. EMEG
Acetone	59	59	7.6	3.097	1.305E+04	Chronic EMEG
Acetonitrile	59	59	8.17	2.554	3.574E+01	EPA RfC
Acrylonitrile	59	33	0.37	0.019	6.907E-03	CREG
Chloromethane	59	59	0.75	0.547	4.843E+01	Chronic EMEG
Dichloromethane	59	59	0.5	0.092	2.879E+01	CREG
Chloroform	59	59	0.03	0.018	2.007E+01	Chronic EMEG
Carbon tetrachloride	59	59	0.1	0.078	3.020E+01	Chronic EMEG

Trichlorofluoromethane	59	59	0.3	0.230	5.518E+02	RSL (Non Cancer)
Methyl chloroform	59	33	0.04	0.009	6.965E+02	Int. EMEG
Ethylene dichloride	59	57	0.02	0.011	9.388E-03	CREG
Tetrachloroethylene	59	52	0.09	0.022	3.981E+01	Chronic EMEG
1,1,2,2-Tetrachloroethane	59	2	0.01	0.000	2.476E-01	RSL (Cancer)
Bromomethane	59	27	0.02	0.006	4.893E+00	Chronic EMEG
1,1,2-Trichloroethane	59	1	0.01	0.000	1.155E-02	CREG
Dichlorodifluoromethane	59	59	0.59	0.447	8.898E+01	RSL (Non Cancer)
Trichloroethylene	59	10	0.02	0.002	3.721E-01	Chronic EMEG
1,2-Dichloropropane	59	2	0.02	0.001	4.977E+01	Acute EMEG
trans-1,3-Dichloropropene	59	4	0.03	0.001	7.051E+00	Chronic EMEG
cis-1,3-Dichloropropene	59	2	0.02	0.001	7.051E+00	Chronic EMEG
Ethylene dibromide	59	2	0.02	0.001	0	PEL
Hexachlorobutadiene	59	8	0.03	0.002	4.219E-03	CREG
Vinyl chloride	59	10	0.05	0.006	4.303E-02	CREG
m/p Xylene	59	59	0.3	0.078	1.013E+02	RSL (Non Cancer)
Benzene	59	59	0.67	0.180	3.005E+00	Chronic EMEG
Toluene	59	59	0.8	0.227	7.961E+01	Chronic EMEG
Ethylbenzene	59	59	0.12	0.031	5.988E+01	Chronic EMEG
o-Xylene	59	59	0.09	0.030	1.013E+02	RSL (Non Cancer)
1,3,5-Trimethylbenzene	59	30	0.03	0.006	2.543E+04	REL
1,2,4-Trimethylbenzene	59	55	0.08	0.021	6.306E+00	RSL (Non Cancer)
Ethyltoluene	59	42	0.18	0.020	N/A	N/A
Styrene	59	51	0.15	0.026	1.995E+02	Chronic EMEG
Chlorobenzene	59	16	0.33	0.014	4.779E+01	RSL (Non Cancer)
1,4-Dichlorobenzene	59	25	0.11	0.008	9.980E+00	Chronic EMEG
Benzyl chloride	59	2	0.02	0.001	8.499E-01	RSL (Non Cancer)
Tetrahydrofuran	59	53	0.05	0.024	6.781E+02	EPA RfC

(Source: DEQ) All units are in parts per billion (ppb). **REL**-Recommended Exposure Limit, **RSL**-Regional Screening Level, **N/A**-Not Available, **PEL**-Permissible Exposure Limit, **EMEG**-Environmental Media Exposure Guideline, **CREG**-Cancer Risk Exposure Guideline, **Int.**-Intermediate, **RfC**-Reference Concentration, **Num**-number of samples collected, **Max**- maximum concentration, **Avg**- average concentration, **CV**-comparison value

Table 7. Volatile organic compounds air monitoring results and comparison values - 2013

2013	Num	Detects	Max	Avg	CV	Source
Carbon disulfide	59	54	0.32	0.046	2.986E+02	Chronic EMEG
Freon 113	59	59	0.19	0.079	9.917E+05	PEL
Freon 114	59	59	0.04	0.020	1.001E+06	PEL
1,3-Butadiene	59	52	0.13	0.033	1.492E-02	CREG
Hexane	59	54	0.71	0.089	5.958E+02	Chronic EMEG
Heptane	59	54	0.16	0.053	4.880E+05	PEL
Cyclohexane	59	57	0.14	0.035	1.743E+03	EPA RfC

Methyl tert-butyl ether	59	9	0.05	0.002	6.934E+02	Chronic EMEG
Acrolein - Unverified	59	51	2.33	0.256	4.012E-02	Int. EMEG
Acetone	59	59	18.15	4.248	1.305E+04	Chronic EMEG
Acetonitrile	59	59	4.49	0.921	3.574E+01	EPA RfC
Acrylonitrile	59	44	0.06	0.012	6.907E-03	CREG
Chloromethane	59	59	0.9	0.594	4.843E+01	Chronic EMEG
Dichloromethane	59	56	4.23	0.259	2.879E+01	CREG
Chloroform	59	56	0.03	0.019	2.007E+01	Chronic EMEG
Carbon tetrachloride	59	59	0.14	0.084	3.020E+01	Chronic EMEG
Trichlorofluoromethane	59	59	0.38	0.223	5.518E+02	RSL (Non Cancer)
Methyl chloroform	59	32	0.04	0.007	6.965E+02	Int. EMEG
Ethylene dichloride	59	14	0.14	0.007	9.388E-03	CREG
Tetrachloroethylene	59	47	0.07	0.017	3.981E+01	Chronic EMEG
1,1,2,2-Tetrachloroethane	59	6	0.08	0.002	2.476E-01	RSL (Cancer)
Bromomethane	59	37	0.05	0.011	4.893E+00	Chronic EMEG
1,1,2-Trichloroethane	59	4	0.09	0.002	1.155E-02	CREG
Dichlorodifluoromethane	59	59	0.89	0.449	8.898E+01	RSL (Non Cancer)
Trichloroethylene	59	5	0.09	0.005	3.721E-01	Chronic EMEG
1,2-Dichloropropane	59	18	0.03	0.004	4.977E+01	Acute EMEG
trans-1,3-Dichloropropene	59	2	0.09	0.003	7.051E+00	Chronic EMEG
cis-1,3-Dichloropropene	59	3	0.06	0.002	7.051E+00	Chronic EMEG
Ethylene dibromide	59	3	0.27	0.006	0	PEL
Hexachlorobutadiene	59	3	0.02	0.001	4.219E-03	CREG
Vinyl chloride	59	18	0.06	0.007	4.303E-02	CREG
m/p Xylene	59	57	0.52	0.092	1.013E+02	RSL (Non Cancer)
Benzene	59	59	0.45	0.188	3.005E+00	Chronic EMEG
Toluene	59	59	2.27	0.285	7.961E+01	Chronic EMEG
Ethylbenzene	59	58	0.17	0.043	5.988E+01	Chronic EMEG
o-Xylene	59	55	0.16	0.036	1.013E+02	RSL (Non Cancer)
1,3,5-Trimethylbenzene	59	33	0.09	0.009	2.543E+04	REL
1,2,4-Trimethylbenzene	59	55	0.17	0.035	6.306E+00	RSL (Non Cancer)
Ethyltoluene	59	41	0.22	0.016	N/A	N/A
Styrene	59	54	0.42	0.043	1.995E+02	Chronic EMEG
Chlorobenzene	59	12	0.33	0.010	4.779E+01	RSL (Non Cancer)
1,4-Dichlorobenzene	59	31	0.33	0.014	9.980E+00	Chronic EMEG
Benzyl chloride	59	17	0.11	0.006	8.499E-01	RSL (Non Cancer)
Tetrahydrofuran	59	48	0.08	0.021	6.781E+02	EPA RfC

(Source: DEQ) All units are in parts per billion (ppb). **REL**-Recommended Exposure Limit, **RSL**-Regional Screening Level, **N/A**-Not Available, **PEL**-Permissible Exposure Limit, **EMEG**-Environmental Media Exposure Guideline, **CREG**-Cancer Risk Exposure Guideline, **Int.**-Intermediate, **RfC**-Reference Concentration, **Num**-number of samples collected, **Max**- maximum concentration, **Avg**- average concentration, **CV**-comparison value