Iowa Toxics Sampling 2013
Results for Benzene, Acetaldehyde, and Formaldehyde

Ambient Air Monitoring Group
Iowa Department of Natural Resources

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Summary

Scope

Section 112 of the Clean Air Act [1] contains the federal strategy for protecting the public from air toxics emissions. The Act specifies a particular list of air toxics called “hazardous air pollutants” (HAPs) for regulatory action [2]. Emitters of large amounts of these HAPs are subject to regulations that require adoption of work practices or installation of control technologies in order to reduce HAP emissions [3]. The Act requires a periodic assessment of the residual health risk posed by the HAPs [4] and adoption of additional control standards where necessary [5].

In order to establish long term trends in HAP concentrations across the nation as a component of its residual risk assessment, the Environmental Protection Agency (EPA) has funded national air toxics trends stations (NATTS) [6]. These sites contain a standard suite of samplers and analytical protocols [7]. Unlike NATTS sites, Iowa’s population-oriented air toxics sites do not have instrumentation to measure toxic metals, polycyclic aromatic hydrocarbons, or black carbon.

A review of the historical air toxics monitoring dataset [8] argues that benzene, formaldehyde, 1,3-butadiene, acrolein, arsenic, hexavalent chromium, and diesel particulate pose the greatest risk to the public health on a national level. Only two of the seven national risk drivers are discussed in this report.

Sampling Schedules

Samples were gathered on a nominal schedule of one sample every twelfth day. In calculations of average pollutant levels and cancer risks, samples collected on a more frequent schedule were averaged over the twelve day period between scheduled samples to estimate a one in twelve sampling schedule and avoid introduction of bias to the data. The monitoring schedule for formaldehyde and acetaldehyde was accelerated to one in six days during ozone season (April through October).

Data Capture

For the purpose of this report, we define a valid twelve-day average as an average constructed from one or more samples collected during the scheduled twelve-day sampling period. The data capture rate is defined as the ratio of the number of valid twelve-day averages divided by the number of scheduled twelve-day periods in the year (31). EPA data analysis guidelines usually require 75% data completeness across each sampling quarter. Each site met this requirement during 2013 with the exception of Des Moines, Public Health in Quarter 1.

Data Handling

This report characterizes only the cancer risk associated with exposure to the toxic contaminants measured, and does not quantify other “non-cancer” risks such as neurological or reproductive damage associated with the measured exposure levels. The cancer risk associated with a given exposure level was quantified only when an Air Unit Cancer Risk was available in EPA’s Integrated Risk Information System (IRIS) database. Pollutants were selected for inclusion in this report based on the screening criterion that the excess cancer risk resulting from a lifetime exposure to the average contaminant concentration was greater than the EPA benchmark of one in a million. When calculating the cancer risks and annual summary statistics for the selected pollutants, reported data values less than the method detection limit (MDL) are replaced with data values equal to half the MDL. No sites reported concentrations under the MDL in 2013.

Precision Data

Precision data are reported for the total number of collocated pairs of canisters or cartridges collected. Precision statistics shown in this report have been calculated according to 40 CFR Part 58, Appendix A (2006) using the methodology applicable to collocated fine particulate data pairs. The formulas are reproduced in Appendix A.

Results of the Analysis

Formaldehyde, acetaldehyde, and benzene concentrations were measured at levels above the EPA benchmark at all Iowa sites. Formaldehyde levels measured during the study period are associated with a much higher cancer risk than any other pollutant measured in this study.

IRIS specifies different levels of certainty associated with its cancer risk factors. Benzene is classified as a known human carcinogen (Class A). Formaldehyde is a Class B1 carcinogen, and acetaldehyde is classified as a Class B2 carcinogen.

Class B contains probable human carcinogens; Class B1 pollutants are associated with limited evidence of carcinogenicity in humans but sufficient evidence of carcinogenicity in animals, whereas a B2 classification indicates only sufficient evidence of carcinogenicity in animals. [9].

A primary contaminant is directly emitted into the ambient air from its source. A secondary contaminant is formed from a chemical reaction of other contaminants already present in the atmosphere from natural or anthropogenic sources.

Benzene is a primary contaminant, with emissions largely attributed to vehicular traffic. Formaldehyde and acetaldehyde are both primary and secondary contaminants. Motor vehicle emissions contribute to primary emissions by incomplete combustion of fuel; secondary formation results from photochemical oxidation of exhaust pipe pollutants. Secondary formation of these pollutants is enhanced in the summertime due to suitable weather conditions such as higher temperature and greater hours of sunlight. Formaldehyde is also produced in large quantities by natural events such as forest or brush fires [10]. In interpreting the results of the risk assessment contained in this type of report, EPA has encouraged States to compare the risks caused by toxic outdoor air pollution to other risks experienced in everyday life. The highest excess lifetime cancer risk identified in this report is three excess cancers per 100,000 people (3×10^{-5}), associated with average measured formaldehyde levels in the outdoor air at the urban Davenport monitoring site. Des Moines and Cedar Rapids also have similar calculated risks. For comparison, the lifetime risk of dying in a motor vehicle accident is a 8.9×10^{-3}, or approximately 300 times higher, and the lifetime risk of being killed by lightning is 7.4×10^{-6}, or approximately 4.1 times lower than developing cancer at this level of formaldehyde exposure [11].

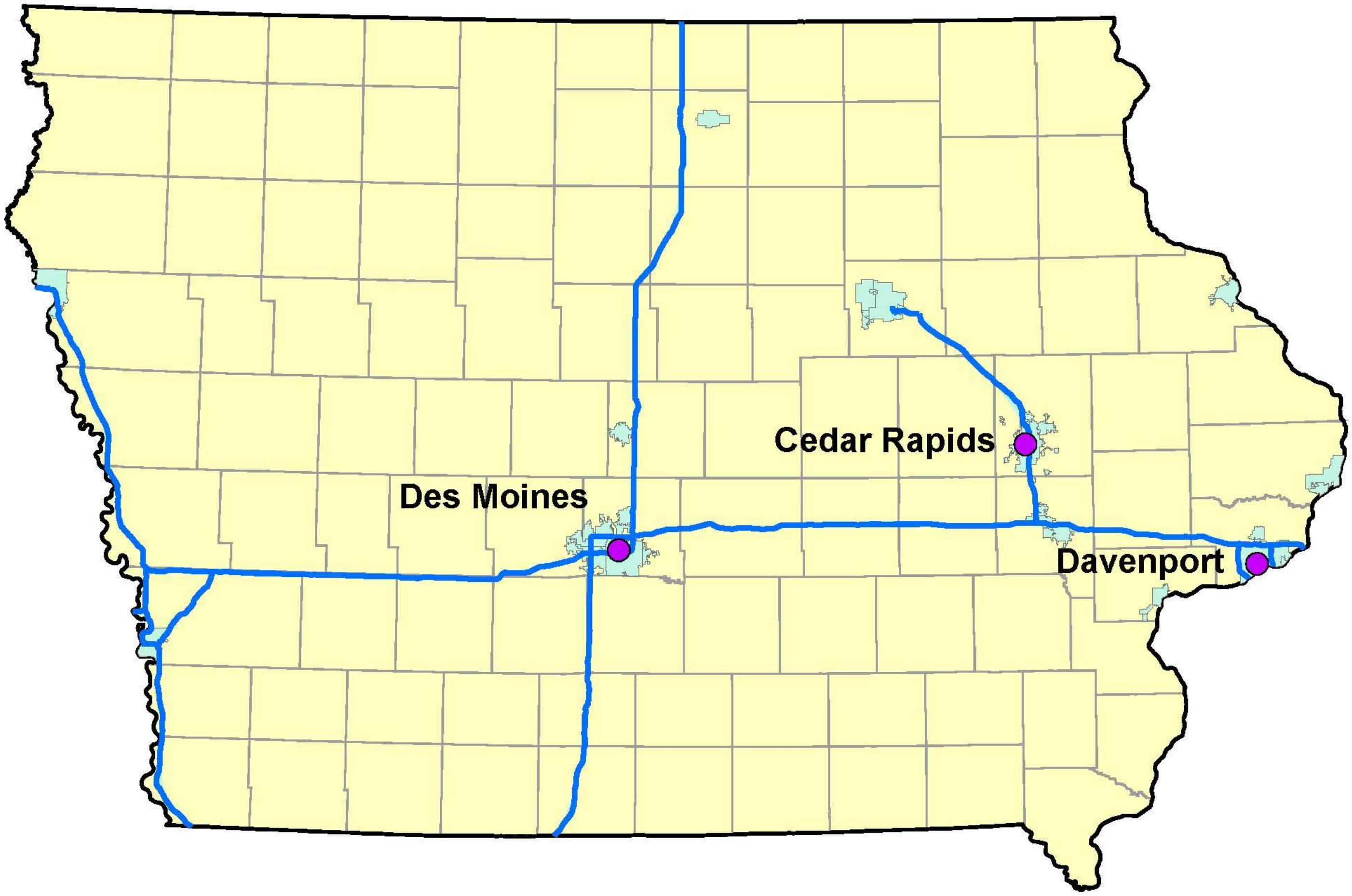
References

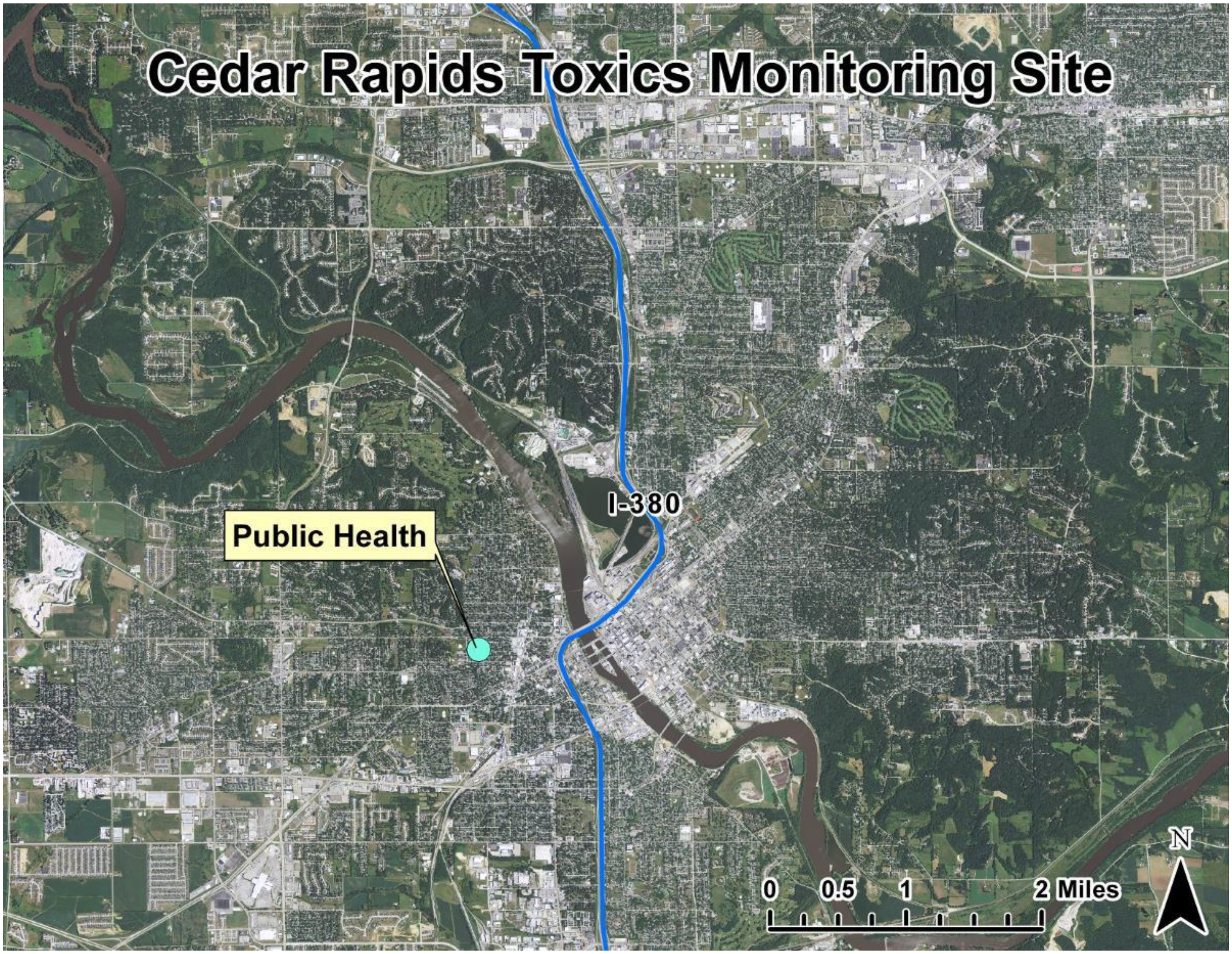
1. Federal rules regulating air toxics: http://www.epa.gov/ttn/atw/eparules.html
2. Current list of HAPs and their health effects: http://www.epa.gov/ttn/atw/hlthef/hapindex.html
3. EPA regulations limiting HAPs emissions: http://www.epa.gov/ttn/atw/mactfnlalph.html
4. EAP’s latest national assessment of health risks due to HAPs: http://www.epa.gov/ttn/atw/natamain/
5. Residual risk assessments: http://www.epa.gov/ttn/atw/rrisk/rtrpg.html
6. Current list of NATTS sites: http://www.epa.gov/ttnamti1/files/ambient/airtox/nattsite.pdf
7. Sampling protocol used to operate NATTS sites: http://www.epa.gov/ttn/amtic/files/ambient/airtox/NATTS_Model_QAPP.pdf
8. Historical review of air toxics monitoring data: http://www.ladco.org/reports/toxics/sti/
9. Integrated Risk Information System: http://www.epa.gov/iris
10. Reinhardt TE, Ottmar RD. “Baseline Measurements of Smoke Exposure Among Wildland Firefighters.” Journal of Occupational and Environmental Hygiene 2004 Sep; 1 (9):593-606. http://www.ncbi.nlm.nih.gov/pubmed?term=Baseline%20Measurements%20of%20Smoke%20Exposure%20Among%20Wildland
11. Mortality Odds: http://www.nsc.org/news_resources/injury_and_death_statistics/Documents/2014-Injury-Facts-43.pdf

Air Toxics Monitoring Network 2013

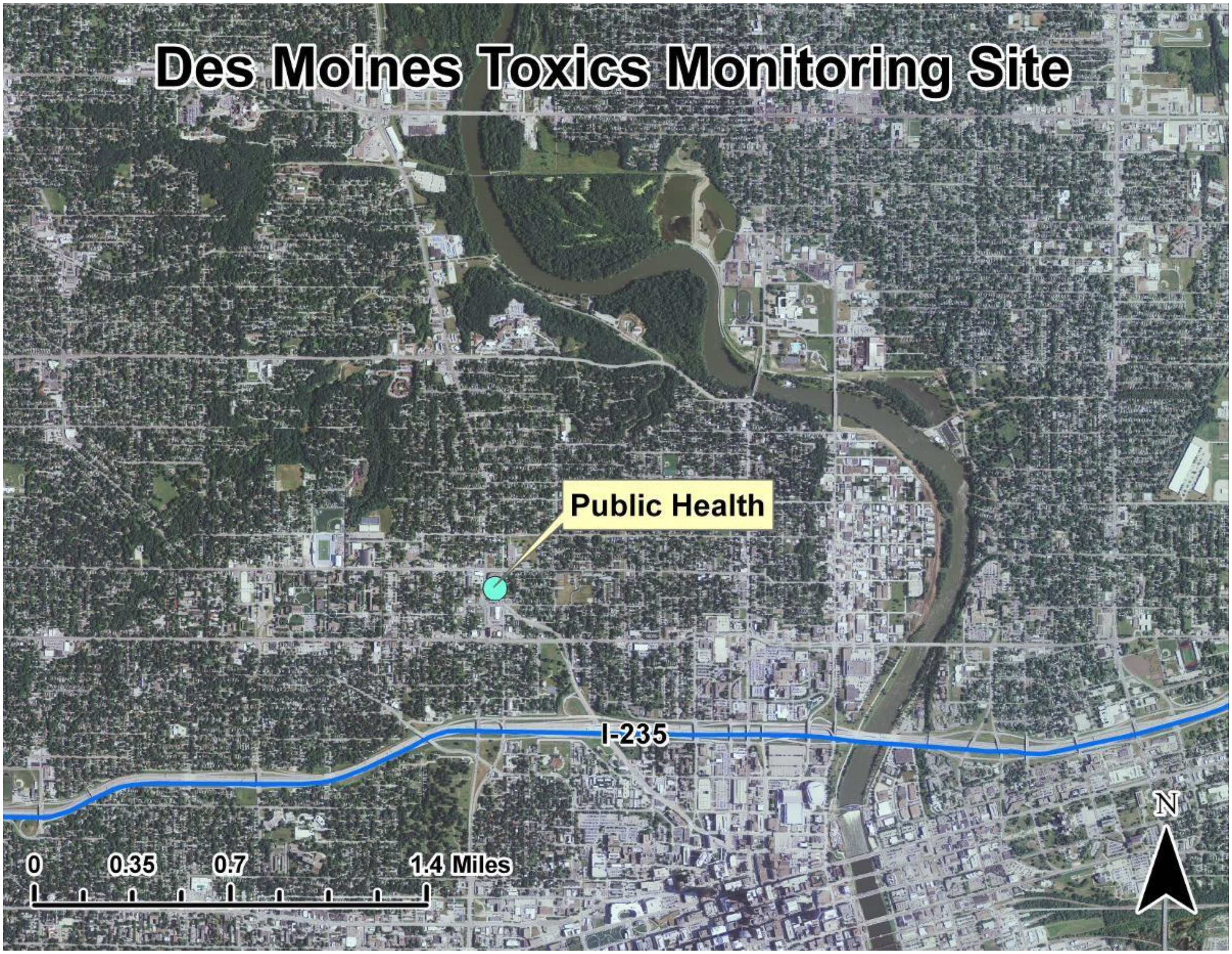
Site ID	Site Label	City	Address	County
191130040	Cedar Rapids, Public Health	Cedar Rapids	500 11th St. NW	Linn
191530030	Des Moines, Public Health	Des Moines	1907 Carpenter Ave.	Polk
191630015	Davenport, Jefferson Elementary	Davenport	10th St. & Vine St.	Scott

Iowa 2013 Air Toxics Monitoring Network




Cedar Rapids Toxics Monitoring Site
I-380
Public Health
0
0.5
1
2 Miles
N


Davenport Toxics Monitoring Site
Jefferson School
0
0.25
0.5
1 Miles
N

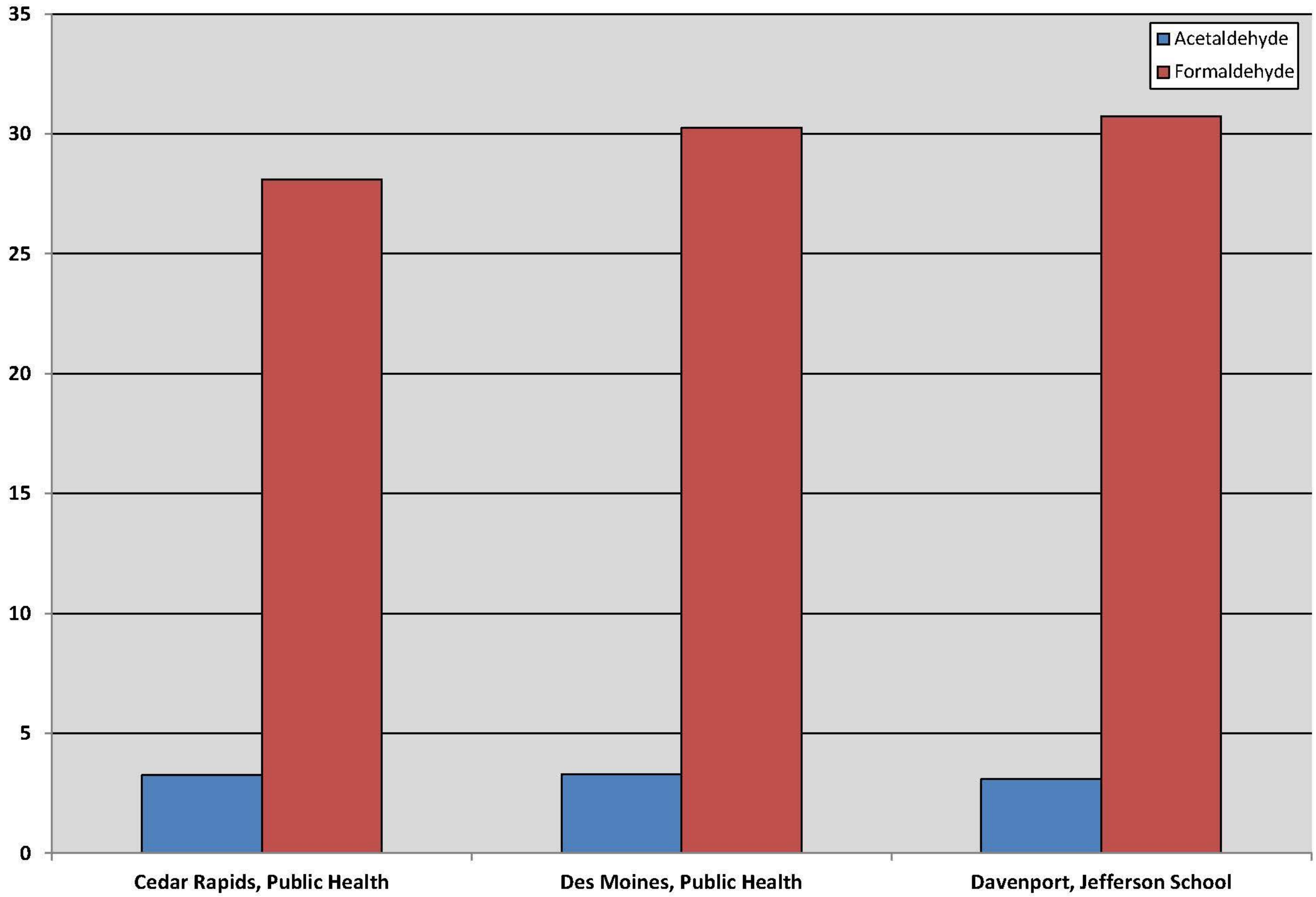


Cancer Risk Summary - Aldehydea (Excess Cancers per Million People)

Site / Pollutant	Cedar Rapids Public Health	Des Moines Public Health Building	Davenport Jefferson Elementary
Formaldehyde	28 (±5)	30 (±6)	31 (±5)
Acetaldehyde	3.3 (±0.4)	3.3 (±0.5)	3.1 (±0.3)

Values listed in parentheses represent the 95% Confidence Interval.

Excess Cancer Risk per Million People, Aldehydes – 2013



Concentration Summary – Aldehydes (ppb)

Site / Pollutant	Cedar Rapids Public Health	Des Moines Public Health Building	Davenport Jefferson Elementary
Formaldehyde	1.8 (±0.3)	1.9 (±0.4)	1.9 (±0.3)
Acetaldehyde	0.82 (±0.1)	0.83 (±0.1)	0.78 (±0.1)

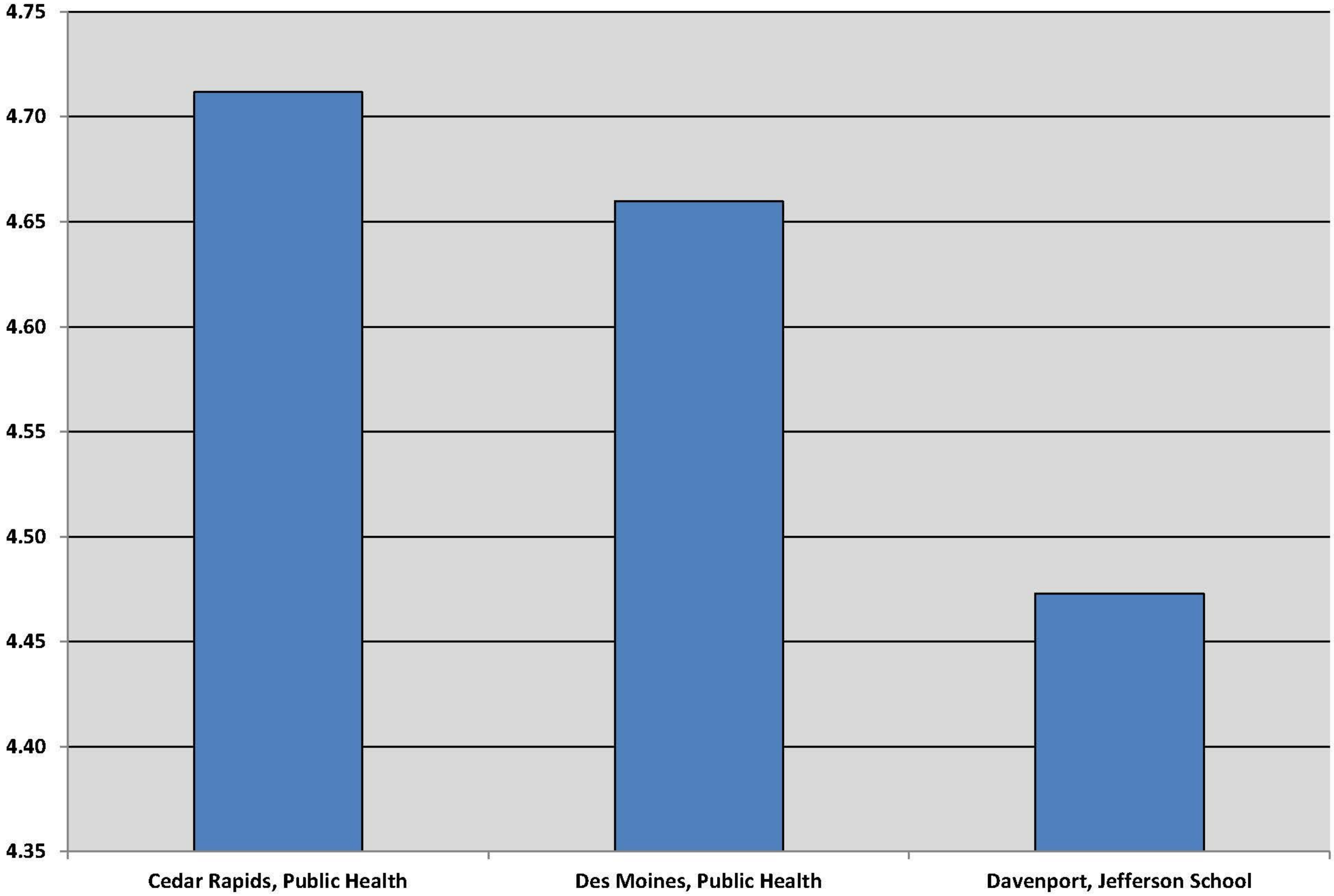
Note: Values indicated are the average concentrations in parts per billion measured at each site in 2013.
Data from enhanced summer monitoring at the site were averaged to prevent seasonal bias.
Values listed in parentheses represent the 95% Confidence Interval for the mean.

Excess Cancer Risk* per Million People, Benzene – 2013

Site / Pollutant	Cedar Rapids Public Health	Des Moines Public Health Building	Davenport Jefferson Elementary
Benzene	4.7 (±0.9)	4.7 (±0.9)	4.5 (±0.5)

*IRIS lists two cancer risk estimates for Benzene, and the higher risk estimate is used for the statistics in this report.
Values listed in parentheses represent the 95% Confidence Interval.

Excess Cancer Risk per Million People, Benzene – 2013



Concentration Summary – Benzene (ppb)

Site / Pollutant	Cedar Rapids Public Health	Des Moines Public Health Building	Davenport Jefferson Elementary
Benzene	0.19 (±0.03)	0.19 (±0.04)	0.18 (±0.02)

Note: Values indicated are the average concentrations in parts per billion measured at each site in 2013. Values listed in parentheses represent the 95% Confidence Interval for the mean.

Percent Data Capture

Site / Pollutant	Cedar Rapids Public Health	Des Moines Public Health Building	Davenport Jefferson Elementary
Formaldehyde	100%	81%*	100%
Acetaldehyde	100%	81%*	100%
Benzene*	94%	81%*	94%

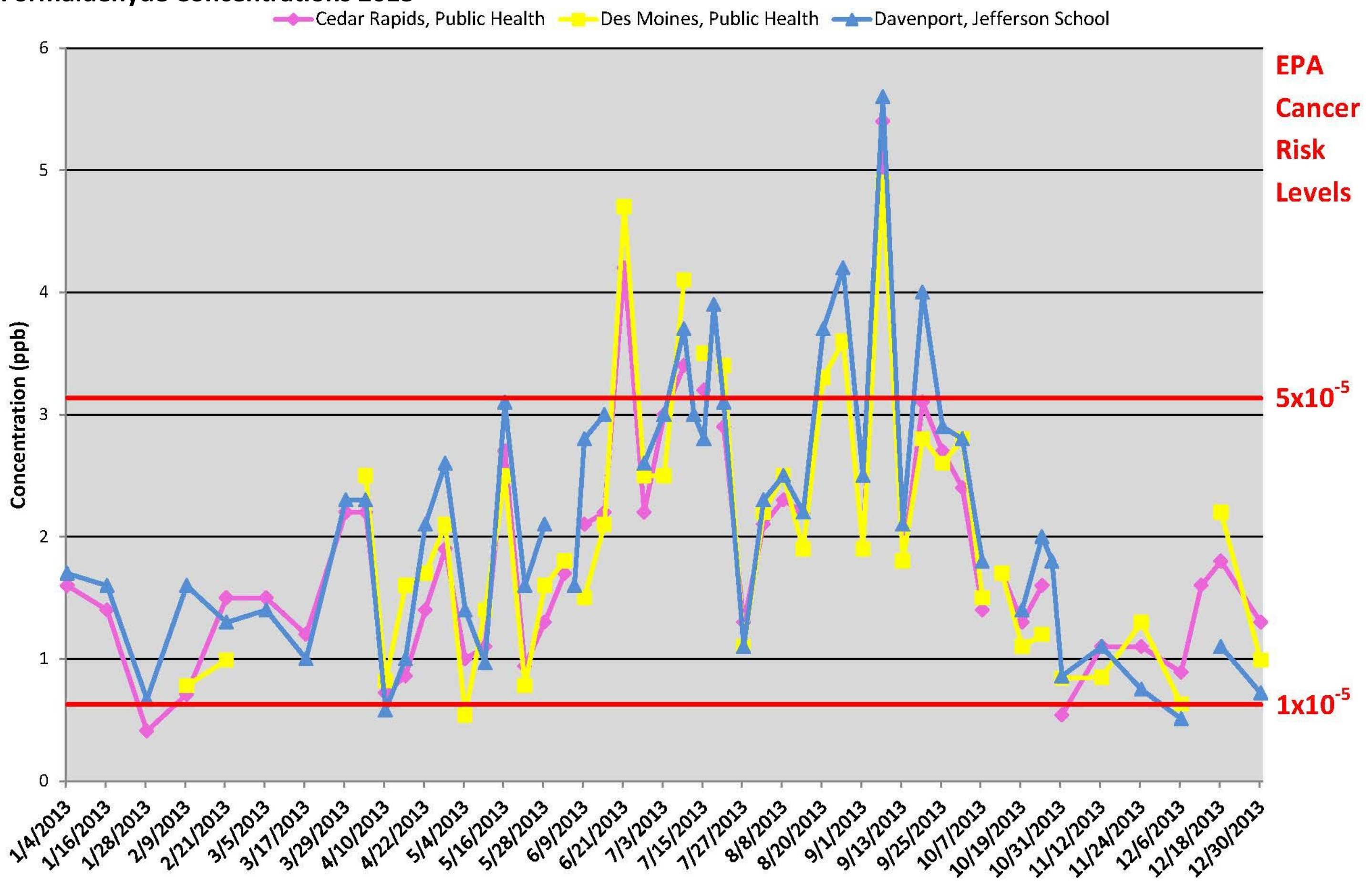
Note: Values indicated represent the number of valid samples taken relative to the scheduled number of samples at each site in 2013. *Des Moines, Public Health did not meet quarterly completeness requirements (75%) for Quarter 1.

Annual Toxics Precision Statistics

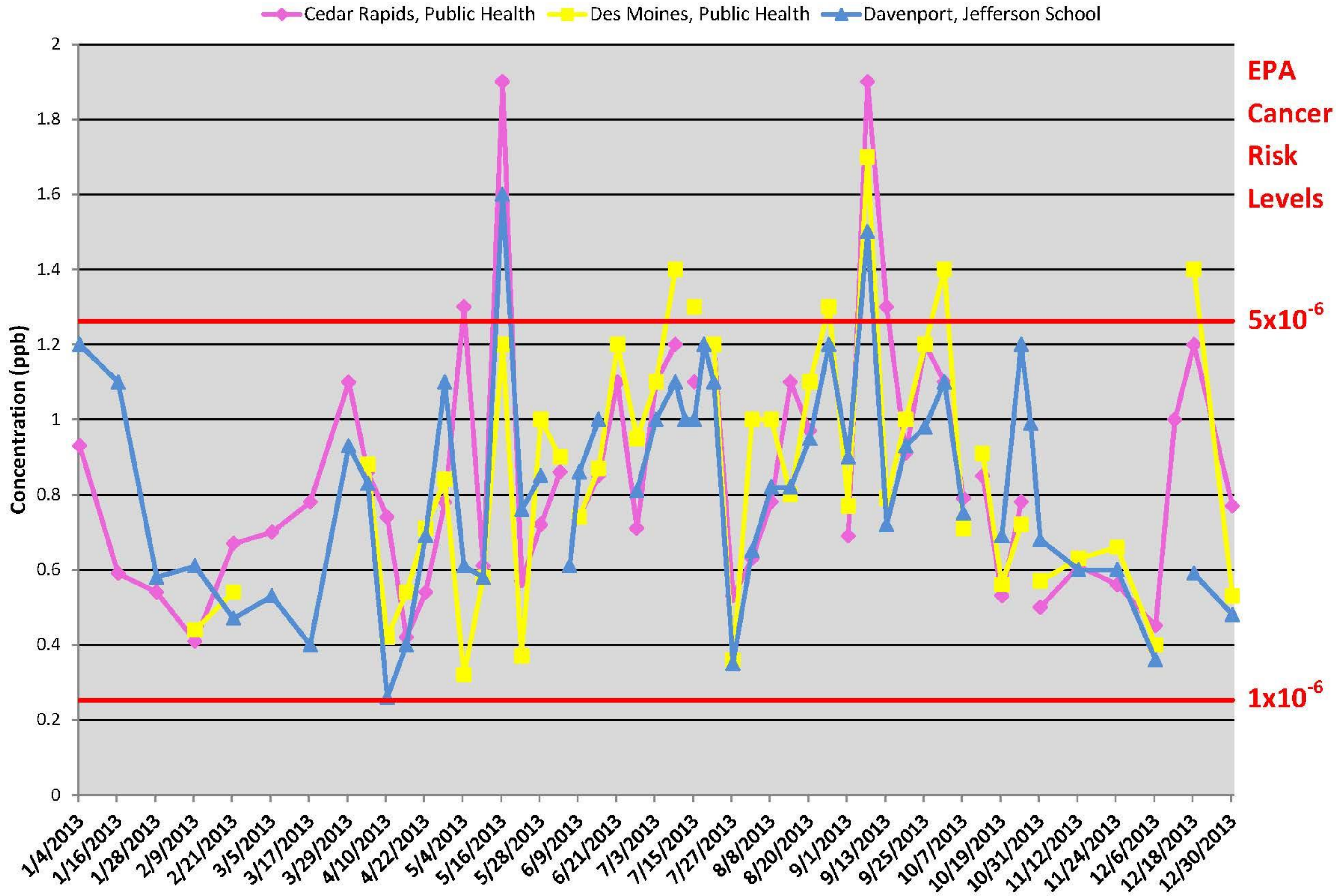
Statistic/ Pollutant	Number of Pairs	Coefficient of Variation	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Formaldehyde	39	4.24%	3.59%	5.23%
Acetaldehyde	39	10.10%	8.54%	12.44%
Benzene	25	15.94%	12.99%	20.85%

Note: Statistics generated from collocated sample pairs. Coefficient of variation and confidence limits were calculated according to 2006 methods in Appendix A.

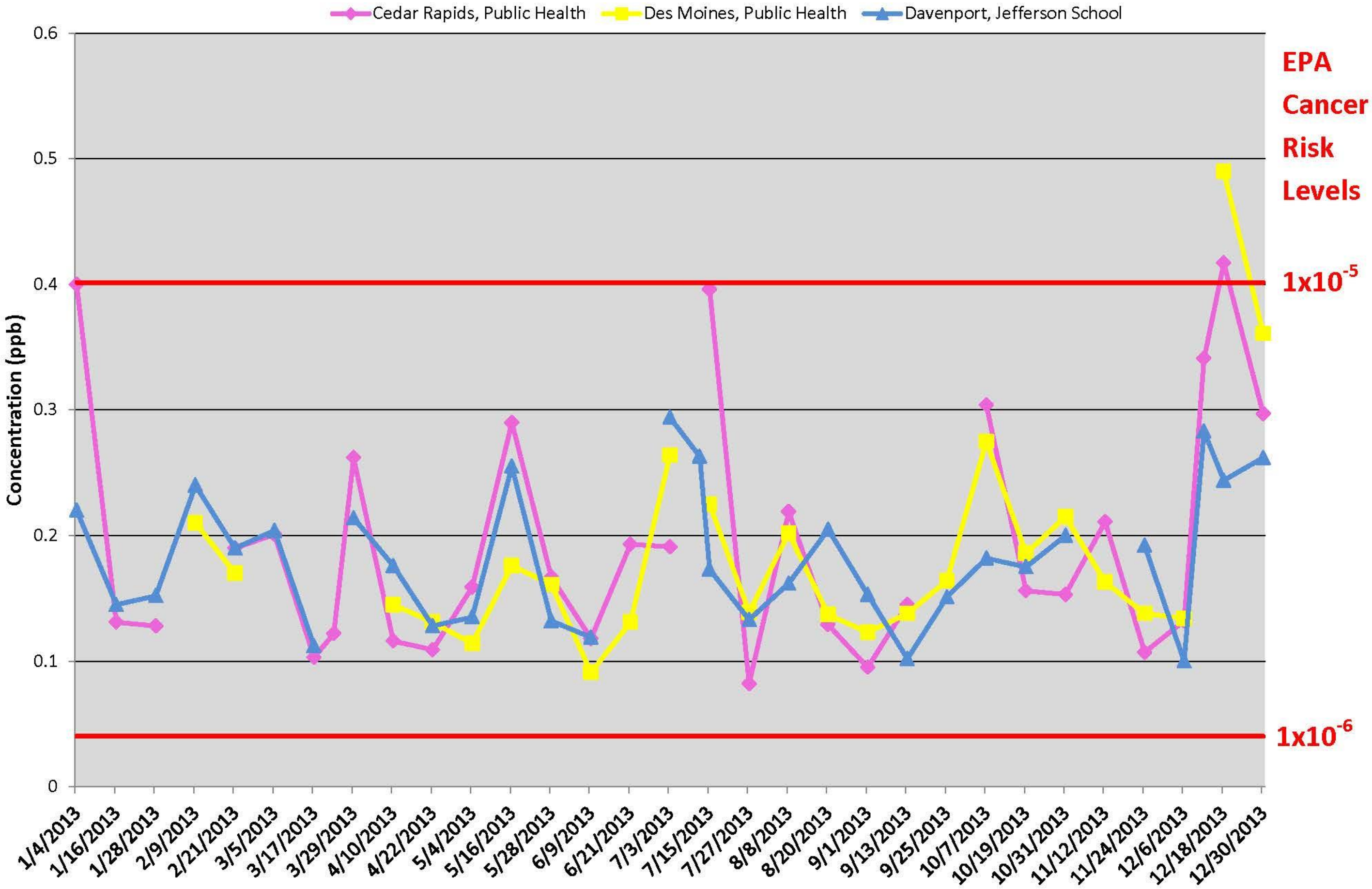
Formaldehyde Concentrations 2013



Acetaldehyde Concentrations 2013



Benzene Concentrations 2013



Raw Data – Formaldehyde Concentration (ppb)

Date	Cedar Rapids, Public Health	Des Moines, Public Health	Davenport, Jefferson School
1/4/2013	1.6		1.7
1/16/2013	1.4		1.6
1/28/2013	0.41		0.67
2/9/2013	0.71	0.78	1.6
2/21/2013	1.5	0.99	1.3
3/5/2013	1.5		1.4
3/17/2013	1.2		1
3/29/2013	2.2		2.3
4/4/2013	2.2	2.5	2.3
4/10/2013	0.72	0.82	0.58
4/16/2013	0.86	1.6	1
4/22/2013	1.4	1.7	2.1
4/28/2013	1.9	2.1	2.6
5/4/2013	1	0.54	1.4
5/10/2013	1.1	1.4	0.97
5/16/2013	2.7	2.5	3.1
5/22/2013	0.94	0.78	1.6

Date	Cedar Rapids, Public Health	Des Moines, Public Health	Davenport, Jefferson School
5/28/2013	1.3	1.6	2.1
6/3/2013	1.7	1.8	
6/6/2013			1.6
6/9/2013	2.1	1.5	2.8
6/15/2013	2.2	2.1	3
6/21/2013	4.2	4.7	
6/27/2013	2.2	2.5	2.6
7/3/2013	3	2.5	3
7/9/2013	3.4	4.1	3.7
7/12/2013			3
7/15/2013	3.2	3.5	2.8
7/18/2013			3.9
7/21/2013	2.9	3.4	3.1
7/27/2013	1.3	1.1	1.1
8/2/2013	2.1	2.2	2.3
8/8/2013	2.3	2.5	2.5
8/14/2013	2.2	1.9	2.2
8/20/2013	3.3	3.3	3.7
8/26/2013		3.6	4.2
9/1/2013	1.9	1.9	2.5
9/7/2013	5.4	4.9	5.6
9/13/2013	1.8	1.8	2.1
9/19/2013	3.1	2.8	4
9/25/2013	2.7	2.6	2.9
10/1/2013	2.4	2.8	2.8
10/7/2013	1.4	1.5	1.8
10/12/2013			
10/13/2013	1.7	1.7	
10/19/2013	1.3	1.1	1.4
10/25/2013	1.6	1.2	2
10/28/2013			1.8
10/31/2013	0.54	0.84	0.86
11/12/2013	1.1	0.85	1.1
11/24/2013	1.1	1.3	0.75
12/6/2013	0.89	0.63	0.51
12/12/2013	1.6		
12/18/2013	1.8	2.2	1.1
12/30/2013	1.3	0.99	0.72

Raw Data – Acetaldehyde Concentration (ppb)

Date	Cedar Rapids, Public Health	Des Moines, Public Health	Davenport, Jefferson School
1/4/2013	0.93		1.2
1/16/2013	0.59		1.1
1/28/2013	0.54		0.58
2/9/2013	0.41	0.44	0.61
2/21/2013	0.67	0.54	0.47
3/5/2013	0.7		0.53
3/17/2013	0.78		0.4
3/29/2013	1.1		0.93
4/4/2013	0.86	0.88	0.83
4/10/2013	0.74	0.42	0.26
4/16/2013	0.42	0.54	0.4
4/22/2013	0.54	0.71	0.69
4/28/2013	0.78	0.84	1.1
5/4/2013	1.3	0.32	0.61
5/10/2013	0.61	0.58	0.58
5/16/2013	1.9	1.2	1.6
5/22/2013	0.57	0.37	0.76
5/28/2013	0.72	1	0.85
6/3/2013	0.86	0.9	
6/6/2013			0.61
6/9/2013	0.74	0.74	0.86
6/15/2013	0.85	0.87	1
6/21/2013	1.1	1.2	
6/27/2013	0.71	0.95	0.81
7/3/2013	1.1	1.1	1
7/9/2013	1.2	1.4	1.1
7/12/2013			1
7/15/2013	1.1	1.3	1
7/18/2013			1.2
7/21/2013	1.2	1.2	1.1
7/27/2013	0.53	0.36	0.35
8/2/2013	0.63	1	0.65
8/8/2013	0.78	1	0.82
8/14/2013	1.1	0.8	0.82
8/20/2013	0.97	1.1	0.95
8/26/2013		1.3	1.2
9/1/2013	0.69	0.77	0.9
9/7/2013	1.9	1.7	1.5
9/13/2013	1.3	0.79	0.72
9/19/2013	0.91	1	0.93
9/25/2013	1.2	1.2	0.98

Date	Cedar Rapids, Public Health	Des Moines, Public Health	Davenport, Jefferson School
10/1/2013	1.1	1.4	1.1
10/7/2013	0.79	0.71	0.75
10/12/2013			
10/13/2013	0.85	0.91	
10/19/2013	0.53	0.56	0.69
10/25/2013	0.78	0.72	1.2
10/28/2013			0.99
10/31/2013	0.5	0.57	0.68
11/12/2013	0.61	0.63	0.6
11/24/2013	0.56	0.66	0.6
12/6/2013	0.45	0.4	0.36
12/12/2013	1		
12/18/2013	1.2	1.4	0.59
12/30/2013	0.77	0.53	0.48

Raw Data – Benzene Concentration (ppb)

Date	Cedar Rapids, Public Health	Des Moines, Public Health	Davenport, Jefferson School
1/4/2013	0.4		0.22
1/16/2013	0.131		0.145
1/28/2013	0.128		0.152
2/9/2013		0.21	0.24
2/21/2013	0.19	0.17	0.19
3/5/2013	0.201		0.204
3/17/2013	0.103		0.112
3/23/2013	0.122		
3/29/2013	0.262		0.214
4/10/2013	0.116	0.145	0.176
4/22/2013	0.109	0.131	0.128
5/4/2013	0.159	0.114	0.135
5/16/2013	0.29	0.176	0.255
5/28/2013	0.167	0.161	0.132
6/9/2013	0.118	0.091	0.119
6/21/2013	0.193	0.131	
7/3/2013	0.191	0.264	0.294
7/12/2013			0.263
7/15/2013	0.396	0.225	0.173
7/27/2013	0.082	0.139	0.133
8/8/2013	0.219	0.202	0.162
8/20/2013	0.129	0.137	0.205
9/1/2013	0.095	0.123	0.153

Date	Cedar Rapids, Public Health	Des Moines, Public Health	Davenport, Jefferson School
9/13/2013	0.145	0.138	0.102
9/25/2013		0.164	0.151
10/7/2013	0.304	0.275	0.182
10/19/2013	0.156	0.186	0.175
10/31/2013	0.153	0.215	0.2
11/12/2013	0.211	0.163	
11/24/2013	0.107	0.138	0.192
12/6/2013	0.132	0.134	0.1
12/12/2013	0.341		0.283
12/18/2013	0.417	0.49	0.244
12/30/2013	0.297	0.361	0.262

*Indicates sample value reported is less than or equal to the minimum detectable limit.

Appendix A. Precision Calculations

Let c_i^1 and c_i^2 represent two concentrations from a particular monitoring location taken on the same day. If both are greater than the MDL, then they may be used to estimate the precision of the data at the sampling location as follows:

First compute the average:

$$\overline{c_i} = \frac{c_i^1 + c_i^2}{2}$$

And the mean difference:

$$d_i = \frac{c_i^1 - c_i^2}{c_i}$$

Define the coefficient of variation for the pair of samples as:

$$CV_i = \frac{d_i}{\sqrt{2}}$$

Compute the root mean square of the individual coefficients of variation to determine the coefficient of variation of the data at the site for the entire year:

$$CV = \sqrt{\frac{\sum_{i=1}^{n} CV_i^2}{n}}$$

Finally, compute confidence limits in the usual way:

$$Lower\ Confidence\ Limit = CV = \sqrt{\frac{n}{X^{-1}_{(.05,n)}}}$$

$$Upper\ Confidence\ Limit = CV = \sqrt{\frac{n}{X^{-1}_{(.95,n)}}}$$

Where X^{-1} represents the inverse of the chi-squared distribution.