National Air Toxics Trends Study
Grand Junction, Colorado

January through December 2016

Prepared by the Air Pollution Control Division

Technical Services Program

May 24, 2018

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. EXECUTIVE SUMMARY

The Grand Junction air toxics monitors were originally established as a part of the 2001/2002 Pilot Study for the National Air Toxics Trends Sites (NATTS). The network was created by the Environmental Protection Agency (EPA) in an effort to gather data that were suitable for identifying trends in air toxics concentration levels. Grand Junction was one of the five "rural" sites selected for the study initially. Since that time, and as the population of the Grand Junction area has grown, the EPA has reconsidered, and decided that the site is more indicative of urban concentrations, and has changed the designation of the site from rural to urban.

Most of the compounds detected at Grand Junction in 2016 are found in urban air nationwide. There do not appear to be any compounds of local significance. The majority of compounds can be related to motor vehicle sources. These include formaldehyde, benzene, toluene, ethylbenzene, xylenes, and styrene. Chloroflourocarbons are also present, including chloromethane, dichlorodifluoromethane, trichlorofluoromethane, and trichlorotrifluoroethane. Polycyclic aromatic hydrocarbon compounds naphthalene, phenanthrene and acenaphthene are frequently detected.

This report has two appendices. Appendix A, "Documentation for Grand Junction Urban Air Toxics Trends Monitoring Locations – Site Maps and Photographs" provides information concerning the two air monitoring sites discussed in this report. Appendix B, "Air Toxics Summary: Compounds Contributing to Cancer and Non-cancer Risks – Overview of Sources and Health Effects," provides a brief summary of many of the compounds monitored. That document discusses the chemical formula, sources, and uses of each compound. It also profiles potential health effects, such as carcinogenicity, the compound's potential to cause birth defects, and whether it damages target organs in the body.

II. INTRODUCTION

Background

The NATTS Network collects ambient air toxics monitoring data as a part of the Urban Air Toxic Strategy (UATS). Under Section 112 of the Clean Air Act (CAA), the EPA established a list of 187 toxic air pollutants, also known as hazardous air pollutants (HAPs). These are pollutants that are known, or suspected, to cause cancer, or other major health issues. People who are exposed to these HAPs at sufficient concentration levels may have an increased chance of getting cancer, having their immune systems damaged, etc. Most air toxics originate from mobile sources (such as cars, trucks, and buses) or stationary sources (such as factories, refineries, and power plants). Some air toxics can come from indoor sources as well (for example: cleaning solvents or building materials).

Since it is not practical, or possible, to monitor for each of the 187 compounds, the EPA developed a subset of HAPs that have the greatest impact on the public and the environment. For the purposes of the NATTS Study, 62 HAPs are monitored. Thirty-three of these are on the "Urban HAP List."[1] The remaining 29 compounds were chosen based on risk factors that were developed by the EPA. From the list of 62 compounds, a "core" list of 19 toxic air pollutants that must be monitored at all times was created. These compounds are considered to be "priority compounds" because they are major health risk drivers, based on a relative ranking performed by the EPA.[2] They are referred to as the "Method Quality Objective (MQO) Core Analytes."[3] These compounds can be seen in Table 1.

---

[1] Technical Assistance Document for the National Air Toxics Trends Stations Program." US Environmental Protection Agency. Revision 3, October 2016. https://www3.epa.gov/ttnamti1/files/ambient/airtox/NATTS%20TAD%20Revision%203_FINAL%20October%202016.pdf

[2] *Ibid.*

[3] *Ibid.*

Table 1. NATTS HAPs with Mandatory Monitoring Requirements

VOCs	Carbonyls	PAHs	PM_{10} Metals	TSP Metals
1,3-Butadiene	Acetaldehyde	Benzo(a)pyrene	Arsenic	Hexavalent Chromium
Acrolein	Formaldehyde	Naphthalene	Beryllium	
Benzene			Cadmium	
Carbon Tetrachloride			Lead	
Chloroform			Manganese	
Tetrachloroethylene			Nickel	
Trichloroethylene				
Vinyl Chloride				

The Grand Junction air toxics monitoring site was established in 2004. This site measures air toxics to determine the success of the National Air Toxics Strategy in reducing the U.S. population exposure to cancer-causing substances in the air. The primary test is a comparison of mean concentrations of compounds for the first three years (2004-2006), versus the mean concentrations for successive three-year periods (2007-2009, 2010-2012, etc.), starting from 2004 and continuing to the present. Data collected beyond the initial six year study scope will be used for trending analyses.

This report presents data from January 2016 through December 2016. It is separated into sections covering the various compounds of interest. Sections 3, 4, 5, and 6 discuss the compounds monitored as a part of this study. Sections 7, 8 and 9 compare the PM_{10}, $PM_{2.5}$, and meteorological data collected as a part of the regular monitoring conducted in Grand Junction by the Colorado Department of Public Health and Environment (CDPHE) to show compliance with the national ambient air quality standards (NAAQS). Each section begins with summary statistics for the compounds analyzed followed by the percentage of samples in which each chemical was detected. Summary graphs of certain compounds are presented. It is important to note here that sampling for hexavalent chromium was discontinued in June 2013 due to an extremely low detection rate in addition to the lack of any apparent sources in the vicinity. Historical data for this compound can be found in prior years' NATTS reports.

Site Information

The NATTS Study at Grand Junction collects samples at two separate locations. These two sites (Powell and Pitkin sites) are in close proximity to one another. The Powell site is located on top of the Powell Building (approximately three stories in height) at 650 South Avenue, and the Pitkin site is located approximately 50 meters to the NNW of the Powell Building, on the roof of a small shelter, near ground level, at 645-1/4 Pitkin Avenue. The particulate/metals samplers are located on the Powell Building, and the carbon monoxide analyzer, air toxics samplers (VOC/carbonyl/PAH), and meteorological tower are located at the Pitkin site. Due to the different sampling heights, staff at Region VIII of the EPA suggested the sites be separately catalogued in the national air monitoring database [AQS IDs: 080770017 (Powell), and 080770018 (Pitkin)]. Documentation regarding these sites, including maps, photographs, and aerial views, is available as Appendix B in this document. The sites are located on the southern end of the downtown area, in an area of commercial/light industrial land use.

III. CARBONYLS

Summary Statistics

The carbonyls discussed in this section are the group of organic chemicals that contain a functional group composed of a carbon atom double bonded to an oxygen atom. The generalized symbol for the carbonyl group is R-C=O, where the "R" is some other carbon compound. Thirteen compounds were measured for this study in 2016. A listing of these compounds, as well as a summary of the collected data, is shown in Table 2. Of the thirteen carbonyl compounds analyzed for, two are included on the mandatory monitoring list of 19 core HAPs. They are shown in bold type in Table 2. In 2012, 2-butanone was added to the carbonyl analyses. It has previously been analyzed for via EPA's Method TO-15. It was moved to the Method TO-11A list because the TO-11A methodology provides better results at lower levels for this compound. The previous years' values from Method TO-15 are indicated with an asterisk.

Carbonyl sampling was attempted on an every-sixth-day basis in 2016, in accordance with the EPA's national sampling schedule. This should have yielded 61 samples during 2016. Six samples were either missed or had to be voided due to site equipment problems or operator errors. Four of those samples were made up for on alternate dates, for a total of 59 samples recovered during the year. This data recovery rate of 97% exceeds the EPA goal of over 85% sample recovery.

The annual mean concentrations for each carbonyl compound, from 2004 through 2016, are listed in Table 2. The annual means were calculated by replacing all "non-detect" values with one-half of the sample method detection limit (MDL). This is an accepted conservative technique for calculating annual values when some of the samples were less than the laboratory's ability to detect. The most prevalent carbonyls in the ambient air in Grand Junction are formaldehyde, acetone, and acetaldehyde. The other ten compounds measured in this study occurred at concentration levels significantly below those of the top three compounds. Since 2004, the annual average concentrations for many of the carbonyl compounds have dropped. The 2016 averages are similar to the 2015 averages.

All of the carbonyls, except for isovaleraldehyde and 2,5-dimethylbenzaldehyde, were present in greater than 10% of the samples taken. During the pilot phase of this study in 2001-2002, 2,5-dimethylbenzaldehyde was detected 34 percent of the time. That number dropped to 4.8 percent in 2005, and the compound has not been detected since 2006.

Isovaleraldehyde has not been detected since 2010. Note that the true annual means of 2,5-dimethylbenzaldehyde and isovaleraldehyde may be well below the numbers reported in the table due to the fact that these compounds were not detected, and one-half of the detection limit was used for the estimated concentration of the non-detects. Actual concentrations could have been at lower levels than these estimates.

It should be noted here that there was a shift in the data processing methods for this report. In previous years, data was presented for compounds that were present in at least 90% of the samples taken. In last year's report, as well as this one (and future reports), the data presented will be from compounds that were present in at least 10% of the samples taken. While this move did not have a noticeable effect on the carbonyl data (as all but 3 compounds were detected in all samples taken), it did allow for inclusion of more of the VOC compounds discussed in later sections. For purposes of consistency, this new 10% detection criterion was applied to all carbonyl, VOC, metal, and SVOC data sets.

Table 2. 2016 Sampling Statistics and Annual Averages

Compound	CAS Number	2016 # of ND's	2016 % ND	Annual Averages ($\mu g/m^3$)												
				2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
2,5-Dimethylbenzaldehyde	*5779-94-2*	*55*	*100%*	*0.08*	*0.06*	*0.02*	*0.03*	*0.03*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*
2-Butanone	78-93-3	0	0%	2.56*	0.43*	1.23*	0.99*	0.98*	1.03*	1.46*	1.08*	0.54	1.35	0.46	0.48	0.57
Acetaldehyde	**75-07-0**	**0**	**0%**	**10.53**	**5.39**	**4.25**	**5.03**	**4.48**	**2.89**	**1.95**	**2.43**	**2.85**	**3.76**	**2.76**	**1.58**	**1.76**
Acetone	67-64-1	0	0%	18.39	11.08	9.69	12.45	12.35	5.57	5.13	4.92	5.46	6.38	4.63	4.50	4.81
Benzaldehyde	100-52-7	0	0%	1.11	0.95	1.45	1.41	1.3	0.34	0.31	0.41	0.39	1.41	0.16	0.28	0.20
Butyraldehyde	123-72-8	0	0%	0.91	1.18	1	1.06	0.92	0.35	0.34	0.39	0.33	0.66	0.3	0.26	0.35
Crotonaldehyde	123-73-9	0	0%	0.67	0.62	0.5	0.57	0.55	0.22	0.2	0.16	0.16	0.24	0.16	0.19	0.21
Formaldehyde	**50-00-0**	**0**	**0%**	**3.45**	**3.83**	**4.94**	**4.94**	**5.04**	**4.01**	**2.74**	**2.74**	**2.98**	**6.41**	**3.86**	**3.08**	**2.72**
Hexaldehyde	66-25-1	0	0%	0.56	0.43	0.46	0.43	0.52	0.12	0.13	0.1	0.11	0.52	0.1	0.15	0.17
Isovaleraldehyde	*590-86-3*	*55*	*100%*	*0.04*	*0.07*	*0.15*	*0.08*	*0.08*	*0.01*	*0.01*	*0.00*	*0.01*	*0.01*	*0.00*	*0.01*	*0.01*
Propionaldehyde	123-38-6	0	0%	0.39	0.75	0.74	0.73	0.91	0.39	0.35	0.35	0.34	0.43	0.32	0.29	0.36
Tolualdehydes	NA	2	4%	0.61	0.63	1.11	0.98	0.77	0.18	0.19	0.19	0.18	0.4	0.11	0.15	0.11
Valeraldehyde	110-62-3	0	0%	0.18	0.71	0.59	0.06	0.52	0.15	0.11	0.08	0.09	0.28	0.09	0.09	0.12

ND = Not Detected

Bold = MQO Core Analyte

Italic = Less than 90% detection rate (2004-2014), less than 10% detection rate (2015 forward)

* = Results obtained by different analytical method

Graphs

The summary data for carbonyl compounds measured during 2016 are graphed in Figure 1. The compounds in these graphs are ordered by ranking their average concentrations from highest to lowest. The graphs show that acetone, formaldehyde, and acetaldehyde had the highest annual averages with values of 4.81 ± 1.80, 2.72 ± 0.61, and 1.76 ± 0.59 micrograms per cubic meter, respectively. The maxima for acetone, acetaldehyde, and formaldehyde observed in 2016 were less than their respective maxima in 2015. The error bars indicate the standard deviation of the 2016 annual average for each compound's data set.

In comparison, the national average concentrations in 2014 for acetone, formaldehyde, and acetaldehyde for all air toxics monitoring sites participating in the EPA's National Monitoring Program (NMP), were 1.12 ± 0.79, 2.25 ± 1.66, and 0.974 ± 0.618 micrograms per meter cubed, respectively.[4] The national data reports for 2015 and 2016 have not yet been released at the time this report was written.

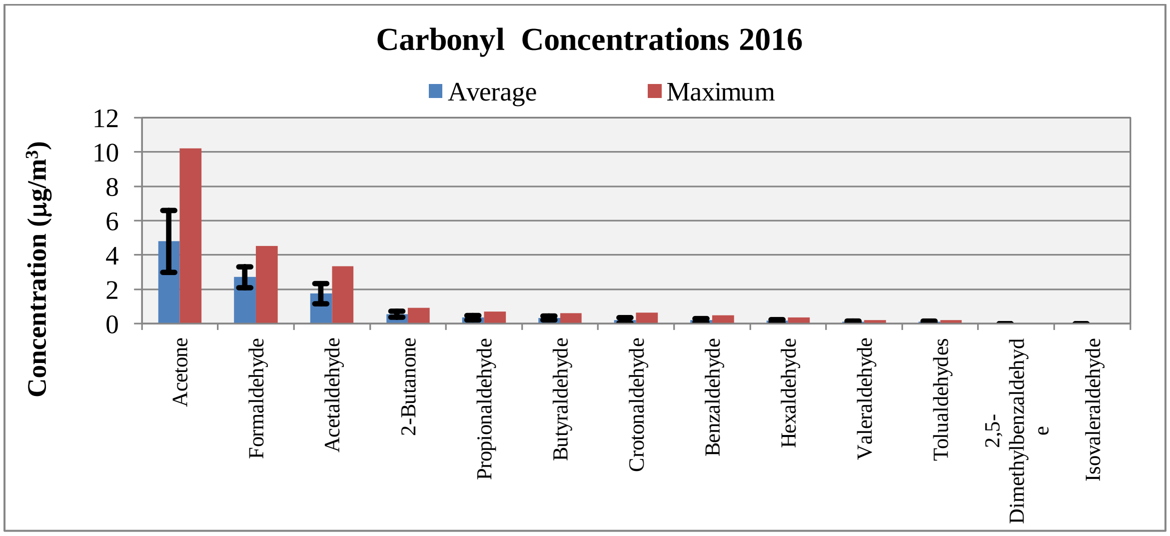


Figure 1. Annual Mean and Maximum Carbonyl Concentrations for 2016

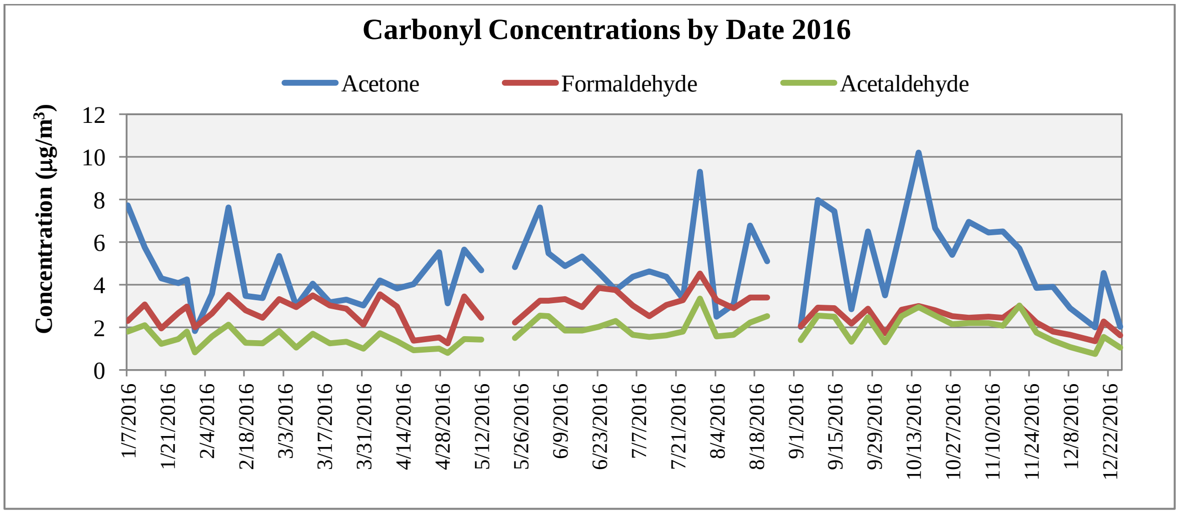


Figure 2. Carbonyl Sample Day Comparisons for 2016

---

[4] "2014 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. February 2017.

Figure 2 shows the concentrations for the acetone, formaldehyde, and acetaldehyde compounds in chronological order for 2016. It is difficult to make conclusions regarding seasonal variation at this site during the year. Generally, more formaldehyde is formed photochemically during the summer period of higher solar radiation. Formaldehyde plays a role in the formation of ozone, a chemical that usually peaks during the summer. The data does show the maximum formaldehyde concentration was observed on July 29, 2016.

Figure 3 is a graph of the weekday versus weekend average carbonyl concentrations in 2016. Each of the carbonyl compounds exhibited very similar weekday and weekend averages. 2,5-dimethylbenzaldehyde, propionaldehyde, butyraldehyde, and isovaleraldehyde, have weekday and weekend average concentrations that are equal, because their concentrations are merely half the value of their respective MDLs for the entire year, since they were non-detectable in all samples. Formaldehyde, acetone, acetaldehyde, 2-butanone, the tolualdehydes, and hexaldehyde all have weekday averages that are slightly higher than their weekend counterparts. The error bars indicate the standard deviation of the 2016 annual average data set for each compound.

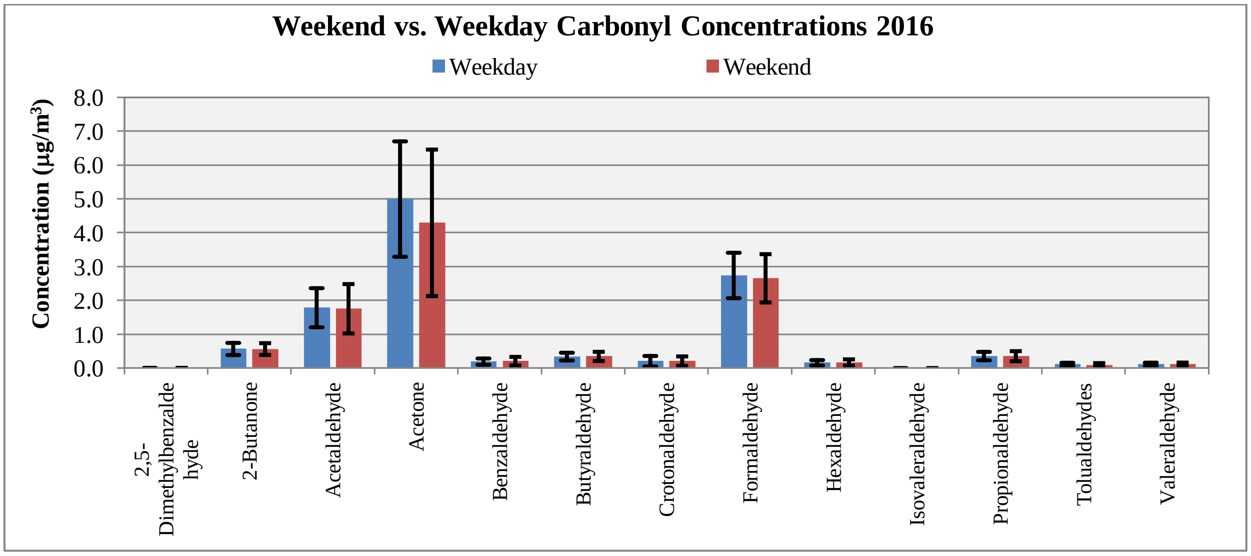


Figure 3. **Weekday vs. Weekend Carbonyl Concentrations – 2016**

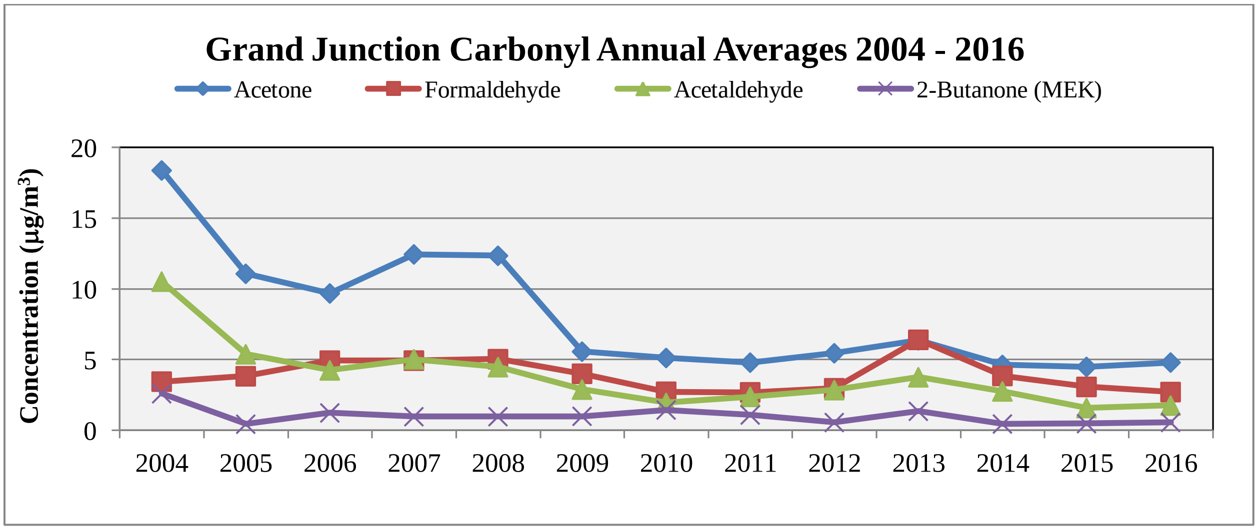


Figure 4. **Carbonyl Annual Averages 2004 – 2016**

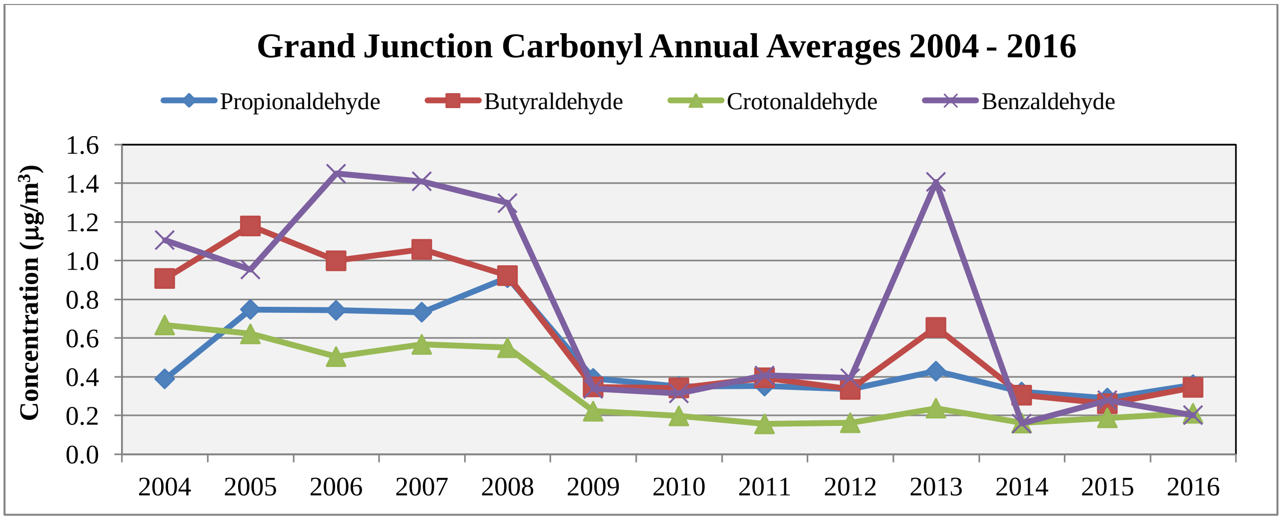


Figure 5. **Carbonyl Annual Averages 2004 – 2016, ctd.**

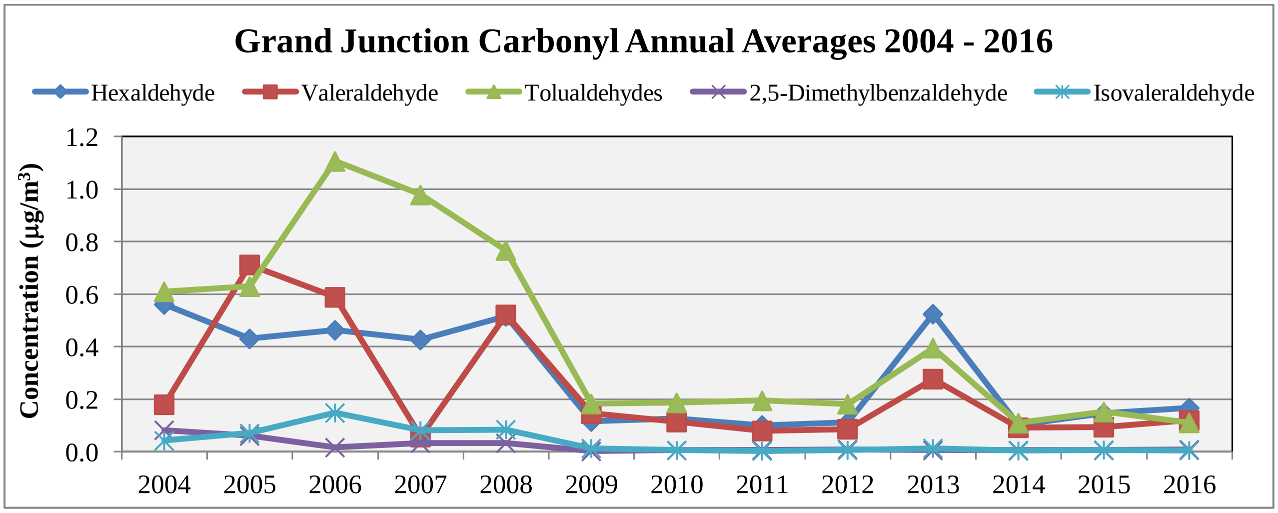


Figure 6. **Carbonyl Annual Averages 2004 – 2016, ctd.**

Figure 4 through Figure 6 are graphs of the annual average carbonyl concentrations at the Grand Junction site, for 2004 through 2016. The overall trend from 2004 through 2011 appears to be that the carbonyl concentrations are decreasing for most compounds. During 2011 and 2012 the annual average concentrations were very similar, with slight increases or decreases for some compounds. The averages in 2013 were the highest since 2009, and do not follow the overall decreasing trend of the data. This is possibly due to a large wildfire in the Grand Junction area during the summer of 2013. The 2014 and 2015 averages are lower than the 2013 averages. The 2015 averages, however, are slightly higher than their 2014 counterparts for several compounds. The 2016 averages are again slightly higher than the 2015 averages for many of the compounds.

The NATTS program was initially established to monitor the 3-year average concentrations of air toxics compounds, with the thought that successive 3-year averages would show at least a 15% drop in concentration values. Figure 7 through Figure 9 below show the 3 year average concentrations for eleven of the thirteen carbonyl compounds. 2,5-Dimethylbenzaldehye and isovaleraldehyde 3-year averages were not calculated as the compounds have not been detected for many years. The 3-year averages are taken from 2004 through 2006, 2007 through 2009, 2010 through 2012, and 2013 through 2015. The 2016 average is included on the graphs for comparative purposes. Generally, the 3-year average concentrations decreased from 2004 to 2012. The 2013 through 2015 averages decreased for only one compound, 2-butanone. The remaining averages increased, or stayed the same largely as a result of the contribution from the 2013 data which was heavily influenced by the wild fires that year.

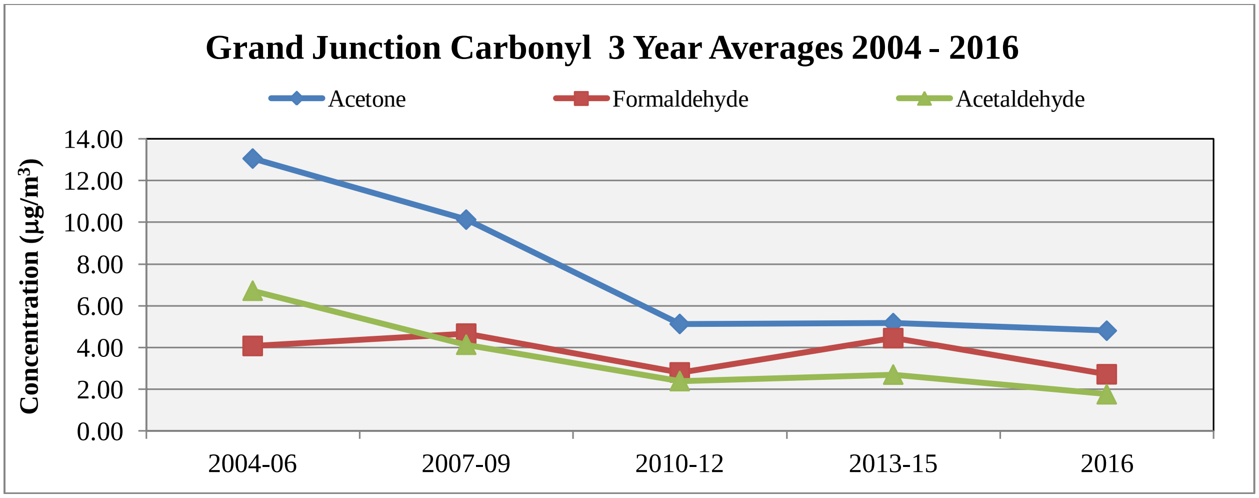


Figure 7. **Carbonyl 3-Year Averages 2004 – 2016**

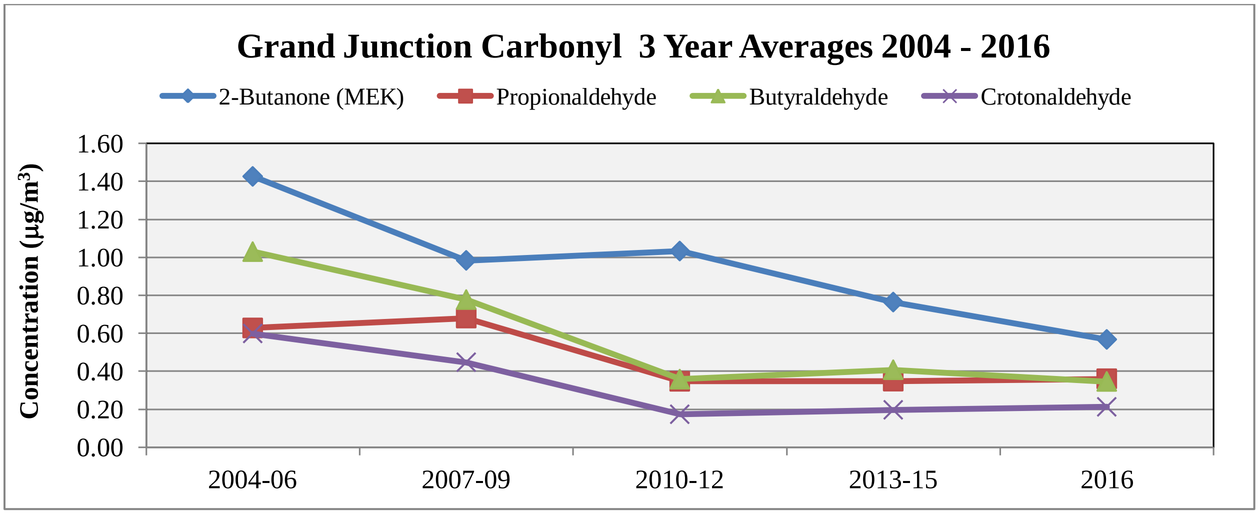


Figure 8. **Carbonyl 3-Year Averages 2004-2016, ctd.**

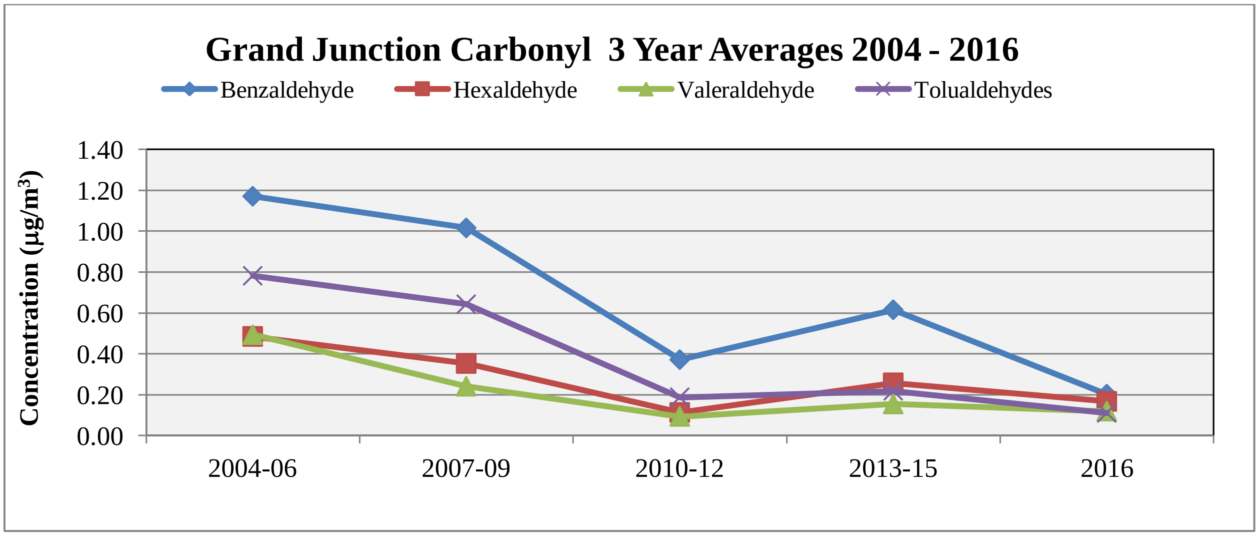


Figure 9. **Carbonyl 3-Year Averages 2004-2016, ctd.**

Quality Assurance/Quality Control

Blanks

Field blanks were collected twelve times per year by attaching a blank sample cartridge to the sampler briefly, and then removing it. The purpose of these blanks was to assess contamination that might exist in the cartridge media, sample installation, or shipping. Most cartridges had very small amounts of formaldehyde, acetaldehyde, acetone, and propionaldehyde. Detailed information regarding field blank results is available upon request.

Precision of Sample Results

This project collected precision data in order to assess both sampling and analytical procedures. Six times during the year, a second carbonyl cartridge was sampled simultaneously with the primary sample. These additional samples, or duplicates, were collected to assess the precision (repeatability) of the sampling method. In general, agreement between the two samples was excellent. Detailed information regarding precision results is available upon request.

IV. VOLATILE ORGANIC COMPOUNDS

Summary Statistics

Volatile organic compound (VOC) data collected at the Grand Junction – Powell station from January through December 2016 are presented in this section. There were 58 VOCs analyzed for this study. The list of these VOCs and the number of times each was detected in samples during the study is found in Table 3. The compounds in bold type are MQO Core Analytes. These are the same VOCs collected by all of the sites participating in the national air toxics study. VOCs are typically sampled on an every-sixth-day basis, for a total of 61 possible sample days in 2016. In all, 61 samples were attempted, with 12 samples that were missed or voided for various reasons, and 10 samples that were made up, for a 97% sample recovery rate.

Table 3. VOC List with 2016 Detection Rates

Compound	CAS Number	# of Detections in Samples	% of Time Detected in Samples
1,2,4-Trimethylbenzene	95-63-6	59	100%
1,3-Butadiene	**106-99-0**	**59**	**100%**
Acetonitrile	75-05-8	59	100%
Acetylene	74-86-2	59	100%
Benzene	**71-43-2**	**59**	**100%**
Bromomethane	74-83-9	59	100%
Carbon Disulfide	75-15-0	59	100%
Carbon Tetrachloride	**56-23-5**	**59**	**100%**
Chloroform	**67-66-3**	**59**	**100%**
Chloromethane	74-87-3	59	100%
Dichlorodifluoromethane	75-71-8	59	100%
Dichloromethane	75-09-2	59	100%
Dichlorotetrafluoroethane	76-14-2	59	100%
Ethylbenzene	100-41-4	59	100%
m,p-Xylene	100-01-6	59	100%
n-Octane	111-65-9	59	100%
o-Xylene	95-47-6	59	100%

Compound	CAS Number	# of Detections in Samples	% of Time Detected in Samples
Propylene	115-07-1	59	100%
Toluene	108-88-3	59	100%
Trichlorofluoromethane	75-69-4	59	100%
Trichlorotrifluoroethane	76-13-1	59	100%
1,3,5-Trimethylbenzene	108-67-8	58	98%
Methyl Isobutyl Ketone	108-10-1	58	98%
Styrene	100-42-5	58	98%
Acrolein	**107-02-8**	**54**	**92%**
Tetrachloroethylene	**127-18-4**	**51**	**86%**
1,2-Dichloroethane	107-06-2	49	83%
1,1,1-Trichloroethane	71-55-6	43	73%
Chloroethane	75-00-3	35	59%
Dibromochloromethane	124-48-1	25	42%
Vinyl chloride	**75-01-4**	**23**	**39%**
Bromochloromethane	74-97-5	19	32%
Ethyl tert-Butyl Ether	637-92-3	19	32%
Chlorobenzene	108-90-7	16	27%
p-Dichlorobenzene	106-46-7	16	27%
1,1-Dichloroethene	75-35-4	13	22%
Hexachloro-1,3-butadiene	87-68-3	11	19%
Methyl Methacrylate	80-62-6	11	19%
Methyl tert-Butyl Ether	1634-04-4	11	19%
Trichloroethylene	**79-01-6**	**9**	**15%**
1,2-Dichloropropane	78-87-5	7	12%
Bromodichloromethane	75-27-4	7	12%
trans-1,2-Dichloroethylene	156-60-5	7	12%
1,1,2,2-Tetrachloroethane	*79-34-5*	*5*	*8%*
o-Dichlorobenzene	*95-50-1*	*4*	*7%*
1,1-Dichloroethane	*75-34-3*	*3*	*5%*
m-Dichlorobenzene	*541-73-1*	*3*	*5%*
Bromoform	*75-25-2*	*2*	*3%*
tert-Amyl Methyl Ether	*994-05-8*	*2*	*3%*
1,2-Dibromoethane	*106-93-4*	*1*	*2%*
Ethyl Acrylate	*140-88-5*	*1*	*2%*
1,1,2-Trichloroethane	*79-00-5*	*0*	*0%*
1,2,4-Trichlorobenzene	*120-82-1*	*0*	*0%*
Acrylonitrile	*107-13-1*	*0*	*0%*
Chloroprene	*126-99-8*	*0*	*0%*
cis-1,2-Dichloroethylene	*156-59-4*	*0*	*0%*
cis-1,3-Dichloropropene	*10061-01-5*	*0*	*0%*
trans-1,3-Dichloropropene	*10061-02-6*	*0*	*0%*

ND = Not Detected,
Bold = MQO Core Analyte
Italic = Less than 10% detection rate

In 2016, there were 43 compounds detected in at least 10% of the samples taken, while in 2015, there were 38 that met the same criterion. Eight of those 43 VOC compounds are on the core list of 19 HAPs to be monitored by NATTS stations. All of the eight core compounds were detected in greater than 10% of the samples taken in 2016. Table 4 is an alphabetical listing of the 43 compounds most frequently detected in 2016. Bolded compounds are on the list of 19 core HAPs.

Table 4. VOCs Detected in Greater Than 10% of 2016 Samples

10% Detection Rate		
1,2,4-Trimethylbenzene	**Carbon Tetrachloride**	Methyl Methacrylate
1,1,1-Trichloroethane	Chlorobenzene	Methyl tert-Butyl Ether
1,1-Dichloroethene	Chloroethane	n-Octane
1,2-Dichloroethane	**Chloroform**	o-Xylene
1,2-Dichloropropane	Chloromethane	p-Dichlorobenzene
1,3,5-Trimethylbenzene	Dibromochloromethane	Propylene
1,3-Butadiene	Dichlorodifluoromethane	Styrene
Acetonitrile	Dichloromethane	**Tetrachloroethylene**
Acetylene	Dichlorotetrafluoroethane	Toluene
Acrolein	Ethyl tert-Butyl Ether	trans-1,2-Dichloroethylene
Benzene	Ethylbenzene	**Trichloroethylene**
Bromochloromethane	Hexachloro-1,3-butadiene	Trichlorofluoromethane
Bromodichloromethane	m,p-Xylene	Trichlorotrifluoroethane
Bromomethane	Methyl Isobutyl Ketone	**Vinyl chloride**
Carbon Disulfide		

Bolded compounds are on the list of 19 core HAPs

There were seven compounds that were not detected at all during 2016, which is a decrease from the ten non-detect compounds in 2015. There were 13 compounds that were detected in five percent, or less, of the samples in 2016. This is a decrease from 2015, where 19 compounds were detected in five percent, or less, of the samples. Many compounds detected less than ten percent of the time are chiefly emitted by stationary sources. It appears that these source types are not present in the immediate vicinity of the Grand Junction station.

Table 5 summarizes the annual mean concentrations for each of the 58 VOCs measured during the study, from 2004 through 2016. Compounds that have bolded values are MQO Core Analytes. Compounds with italicized values were detected in less than 10% of the samples for the year. It should be noted here that there was a shift in the data processing methods for this report. In previous years, data was presented for compounds that were present in at least 90% of the samples taken. For this (and future) reports the data presented will be from compounds that were present in at least 10% of the samples taken. This move had a noticeable effect on the VOC data by including more compounds into the discussion. For purposes of consistency, this new 10% detection criterion was applied to all carbonyl, VOC, metal, and SVOC data sets.

The annual means were calculated by replacing all “non-detect” values with one-half of the sample MDL. This is an accepted conservative technique for calculating annual values when some of the samples were less than the laboratory’s ability to measure. As a result of this technique, the average and maximum concentrations are the same if the compound was never detected. A year to year variation of the average concentrations for these non-detect compounds will be seen due to the reevaluation of the MDLs annually. The compounds are listed in alphabetical order. There are several things to note about this table. First, the acetonitrile values for all of 2004, and the first three-and-a-half months of 2005 were voided due to a contamination problem in the sampling equipment. Acrolein was not analyzed until 2005, and carbon disulfide was added to the list of analytes in 2006. Removed from this list in 2012 were the compounds of chloromethylbenzene, and methyl ethyl ketone (MEK). MEK was added to the carbonyl analysis. Chloromethylbenzene has never been detected in greater than 10% of samples.

Table 5. VOC Data Summary 2016

Analyte	Annual Average VOC Concentrations (µg/m^3)												
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
1,1,1-Trichloroethane	*0.14*	*0.15*	0.12	0.10	0.09	0.09	*0.09*	0.07	*0.05*	*0.05*	*0.05*	0.04	0.04
1,1,2,2-Tetrachloroethane	*0.17*	*0.16*	*0.05*	*0.06*	*0.03*	*0.01*	*0.03*	*0.08*	*0.06*	*0.09*	*0.05*	*0.06*	*0.10*
1,1,2-Trichloroethane	*0.22*	*0.15*	*0.02*	*0.05*	*0.02*	*0.01*	*0.04*	*0.07*	*0.06*	*0.05*	*0.06*	*0.05*	*0.05*
1,1-Dichloroethane	*0.10*	*0.07*	*0.01*	*0.03*	*0.01*	*0.01*	*0.03*	*0.02*	*0.03*	*0.03*	*0.04*	*0.03*	*0.02*
1,1-Dichloroethene	*0.10*	*0.09*	*0.03*	*0.05*	*0.01*	*0.01*	*0.02*	*0.02*	*0.03*	*0.02*	*0.03*	*0.02*	0.05
1,2,4-Trichlorobenzene	*0.67*	*0.58*	*0.06*	*0.15*	*0.11*	*0.02*	*0.07*	*0.13*	*0.08*	*0.09*	*0.20*	0.19	*0.13*
1,2,4-Trimethylbenzene	1.21	1.01	0.81	0.64	0.50	0.47	0.52	0.70	0.59	0.44	0.43	0.33	0.28
1,2-Dibromoethane	*0.19*	*0.16*	*0.07*	*0.05*	*0.03*	*0.01*	*0.04*	*0.07*	*0.07*	*0.06*	*0.06*	*0.07*	*0.08*
1,2-Dichloroethane	*0.12*	*0.10*	*0.03*	*0.04*	*0.02*	*0.02*	*0.03*	*0.04*	0.08	*0.07*	*0.08*	0.07	0.07
1,2-Dichloropropane	*0.16*	*0.12*	*0.08*	*0.05*	*0.02*	*0.01*	*0.05*	*0.05*	*0.04*	*0.04*	*0.04*	*0.04*	0.04
1,3,5-Trimethylbenzene	0.41	*0.33*	0.25	0.21	0.16	0.15	0.19	0.23	0.23	0.16	0.15	0.10	0.10
1,3-Butadiene	***0.21***	***0.20***	**0.20**	**0.16**	**0.15**	**0.17**	**0.14**	***0.14***	**0.18**	**0.15**	**0.17**	**0.13**	**0.10**
Acetonitrile	*VOID*	*17.182**	*0.59*	1.70	6.61	1.24	20.33	0.54	6.03	1.58	5.65	28.47	1.17
Acetylene	2.26	2.05	1.80	1.46	2.02	2.05	1.55	1.38	1.44	1.26	1.31	1.26	0.95
Acrolein	**----**	***0.81***	***0.62***	**0.63**	**0.68**	**1.02**	**1.37**	**0.74**	**1.09**	**0.82**	**1.13**	**1.06**	**0.81**
Acrylonitrile	*0.11*	*0.07*	*0.09*	*0.04*	*0.13*	*0.14*	*0.04*	*0.07*	*0.03*	*0.17*	*0.51*	0.06	*0.03*
Benzene	**2.25**	**1.95**	**1.85**	**1.46**	**1.62**	**1.93**	**1.41**	**1.33**	**1.28**	**0.99**	**0.99**	**0.88**	**0.69**
Bromochloromethane	*0.24*	*0.16*	*0.05*	*0.05*	*0.02*	*0.01*	*0.04*	*0.02*	*0.04*	*0.04*	*0.04*	*0.04*	0.11
Bromodichloromethane	*0.13*	*0.12*	*0.02*	*0.06*	*0.02*	*0.01*	*0.06*	*0.08*	*0.07*	*0.06*	*0.07*	*0.06*	0.06
Bromoform	*0.31*	*0.22*	*0.09*	*0.08*	*0.03*	*0.01*	*0.05*	*0.13*	*0.10*	*0.11*	*0.08*	*0.09*	*0.12*
Bromomethane	*0.11*	*0.08*	*0.04*	0.05	0.06	0.06	*0.08*	*0.04*	0.11	0.08	0.10	0.25	0.05
Carbon Disulfide	----	----	8.51	8.71	10.94	13.61	1.19	1.50	1.42	3.02	7.59	0.51	0.03
Carbon Tetrachloride	***0.52***	***0.49***	**0.59**	**0.53**	**0.68**	**0.66**	**0.53**	**0.54**	**0.67**	**0.58**	**0.58**	**0.60**	**0.61**
Chlorobenzene	*0.09*	*0.07*	*0.01*	*0.03*	*0.02*	*0.02*	*0.03*	*0.05*	*0.06*	*0.04*	*0.04*	*0.04*	0.05
Chloroethane	*0.14*	*0.09*	*0.03*	*0.03*	0.03	0.04	*0.02*	*0.02*	*0.03*	*0.02*	*0.03*	0.08	0.07
Chloroform	***0.10***	***0.11***	***0.08***	***0.09***	**0.11**	**0.12**	***0.09***	***0.09***	***0.09***	**0.11**	**0.11**	**0.10**	**0.11**
Chloromethane	1.27	1.32	1.21	1.22	1.42	1.47	1.34	1.27	1.24	1.15	1.22	1.35	1.25
Chloroprene	*0.09*	*0.07*	*0.04*	*0.03*	*0.02*	*0.01*	*0.02*	*0.01*	*0.02*	*0.02*	*0.03*	*0.02*	*0.02*
cis-1,2-Dichloroethylene	*0.12*	*0.09*	*0.03*	*0.04*	*0.01*	*0.01*	*0.07*	*0.02*	*0.04*	*0.03*	*0.03*	*0.03*	*0.03*
cis-1,3-Dichloropropene	*0.11*	*0.08*	*0.03*	*0.04*	*0.02*	*0.01*	*0.03*	*0.05*	*0.03*	*0.03*	*0.05*	*0.04*	*0.05*
Dibromochloromethane	*0.30*	*0.20*	*0.04*	*0.06*	*0.02*	*0.02*	*0.04*	*0.09*	*0.07*	*0.07*	*0.06*	0.06	0.09

Analyte	**Annual Average VOC Concentrations (µg/m^3)**												
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Dichlorodifluoromethane	3.07	3.18	2.78	2.70	2.79	3.22	2.90	2.76	2.57	2.54	2.54	2.57	2.62
Dichloromethane	*0.49*	*0.43*	0.41	0.38	3.43	1.96	91.65	1.31	40.12	15.89	40.28	83.49	0.84
Dichlorotetrafluoroethane	*0.11*	*0.12*	0.12	0.12	0.11	0.14	0.13	0.13	0.12	0.12	0.12	0.12	0.22
Ethyl Acrylate	*0.12*	*0.11*	*0.02*	*0.03*	*0.04*	*0.01*	*0.02*	*0.04*	*0.03*	*0.03*	*0.04*	*0.02*	*0.06*
Ethyl tert-Butyl Ether	*0.10*	*0.10*	*0.02*	*0.02*	*0.01*	*0.04*	*0.02*	*0.02*	*0.02*	*0.06*	0.16	0.05	0.05
Ethylbenzene	1.20	1.36	0.66	0.61	0.47	0.53	0.51	0.62	0.69	0.48	0.45	0.39	0.30
Hexachloro-1,3-butadiene	*0.85*	*0.99*	*0.07*	*0.19*	*0.09*	*0.01*	*0.06*	*0.19*	*0.12*	*0.14*	*0.15*	0.18	0.22
m,p-Xylene	3.73	4.62	2.29	2.05	1.53	1.70	1.55	1.97	2.10	1.45	1.35	1.03	0.90
m-Dichlorobenzene	*0.21*	*0.17*	*0.01*	*0.05*	*0.05*	*0.02*	*0.03*	*0.10*	*0.07*	*0.08*	*0.05*	*0.07*	*0.07*
Methyl Isobutyl Ketone	*0.27*	*0.18*	*0.21*	*0.17*	*0.17*	0.15	*0.17*	0.16	0.17	0.15	0.17	0.15	0.15
Methyl Methacrylate	*1.29*	*0.79*	*0.26*	*1.34*	*0.49*	*0.05*	*0.05*	*0.05*	*0.06*	*0.07*	*0.06*	0.06	0.06
Methyl tert-Butyl Ether	*0.13*	*0.12*	*0.01*	*0.02*	*0.01*	*0.01*	*0.02*	*0.02*	*0.02*	*0.03*	*0.05*	*0.03*	0.02
n-Octane	*0.33*	*0.34*	0.24	0.24	0.20	0.23	0.30	0.37	0.42	0.29	0.28	0.21	0.19
o-Dichlorobenzene	*0.12*	*0.15*	*0.02*	*0.05*	*0.05*	*0.02*	*0.03*	*0.10*	*0.06*	*0.07*	*0.05*	*0.07*	*0.08*
o-Xylene	1.55	1.97	0.83	0.73	0.56	0.60	0.55	0.71	0.79	0.53	0.53	0.49	0.34
p-Dichlorobenzene	*0.18*	*0.14*	*0.09*	0.07	*0.04*	*0.07*	*0.04*	*0.09*	*0.08*	*0.06*	*0.05*	0.08	0.07
Propylene	1.41	1.32	1.11	0.91	0.88	1.01	0.88	0.86	0.95	0.79	0.84	0.72	0.64
Styrene	2.19	1.05	0.37	0.58	1.26	0.63	2.57	1.45	2.96	1.91	3.47	16.47	0.87
tert-Amyl Methyl Ether	*0.15*	*0.13*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.02*	*0.04*
Tetrachloroethylene	***0.31***	***0.27***	***0.34***	**0.32**	**0.33**	**0.43**	**0.40**	***0.26***	**0.32**	**0.27**	**0.23**	**0.15**	**0.13**
Toluene	5.58	5.53	4.06	4.22	2.91	3.82	3.23	4.01	3.66	2.96	2.91	3.18	1.83
trans-1,2-Dichloroethylene	*0.10*	*0.09*	*0.04*	*0.03*	*0.01*	*0.01*	*0.03*	*0.02*	*0.03*	*0.02*	*0.03*	*0.03*	0.03
trans-1,3-Dichloropropene	*0.12*	*0.10*	*0.02*	*0.04*	*0.02*	*0.01*	*0.03*	*0.06*	*0.04*	*0.04*	*0.05*	*0.05*	*0.06*
Trichloroethylene	***0.13***	***0.12***	***0.05***	***0.06***	***0.03***	***0.11***	***0.06***	***0.09***	***0.14***	***0.05***	***0.05***	**0.05**	**0.05**
Trichlorofluoromethane	2.17	1.63	1.52	1.46	1.51	1.71	1.60	1.52	1.59	1.45	1.33	1.39	1.49
Trichlorotrifluoroethane	0.78	0.81	0.76	0.83	0.68	0.85	0.72	0.75	0.66	0.63	0.61	0.63	0.63
Vinyl chloride	***0.05***	***0.05***	***0.01***	***0.03***	***0.01***	***0.01***	***0.02***	***0.01***	***0.01***	***0.01***	***0.02***	***0.01***	**0.04**

2004 NOTE: Acetonitrile VOID due to contamination in sampler.

2005 NOTE: Acetonitrile VOID thru 4/10/2005 due to contamination in sampler.

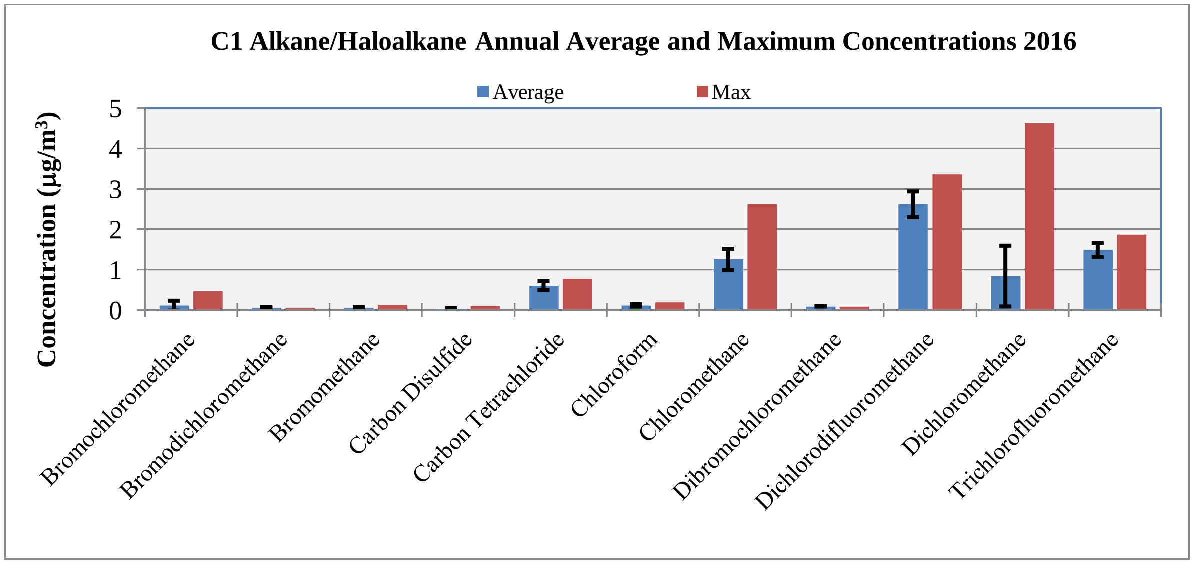
Bold = MQO Core Analyte

Italic = Less than 90% detection rate (2004-2014), less than 10% detection rate (2015 to present)

In general, the concentrations from 2016 compared well with the 2015 data. However, some compounds did show average concentrations that were significantly different than their 2015 values. For instance, dichloromethane, acetonitrile, and styrene showed much smaller annual average concentrations in 2016 than in 2015. In 2016, their respective annual average concentrations were 0.84 ± 0.75, 1.17 ± 2.43, and 0.87 ± 0.87 $\mu g/m^3$, while in 2015 they were 83.49 ± 214.8 , 28.47 ± 54.95, and 16.47 ± 4.41 $\mu g/m^3$. The 2014 National Monitoring Programs Annual report, written by Eastern Research Group for the EPA, shows the averages for these compounds to be 14.02 ± 232.1, 26.36 ± 98.22, and 0.30 ± 1.10 $\mu g/m^3$, respectively. The large change in concentrations arises from significantly elevated concentrations of these compounds on several sample days in 2015. Elevated dichloromethane concentrations were also seen in 2010 and 2012. At this point in time it has not been determined what is causing these highly variable concentrations.

Graphs

Figure 10 through Figure 13 are graphs showing the 24 hour maximum, and annual mean concentrations for each of the 43 compounds that were detected in greater than 10% of the samples in 2016. These graphs are ordered alphabetically and by the number of carbons they contain. The compounds with the five largest annual average concentrations are dichlorodifluoromethane, toluene, trichlorofluoromethane, chloromethane, and acetonitrile. Their values are 2.62 ± 0.32, 1.83 ± 0.92, 1.49 ± 0.17, 1.25 ± 0.26, and 1.17 ± 2.43 micrograms per meter cubed, respectively. In comparison, the 2013 national averages for the same compounds are 0.504 ± 0.034, 0.414 ± 0.570, 0.244 ± 0.056, 0.595 ± 0.125, and 15.7± 58.5 micrograms per meter cubed, respectively.[5]



C1 Alkane/Haloalkane Annual Average and Maximum Concentrations 2016

Figure 10. VOC Annual Average and Maximum Concentrations 2016

---

[5] "2013 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. October 2015.

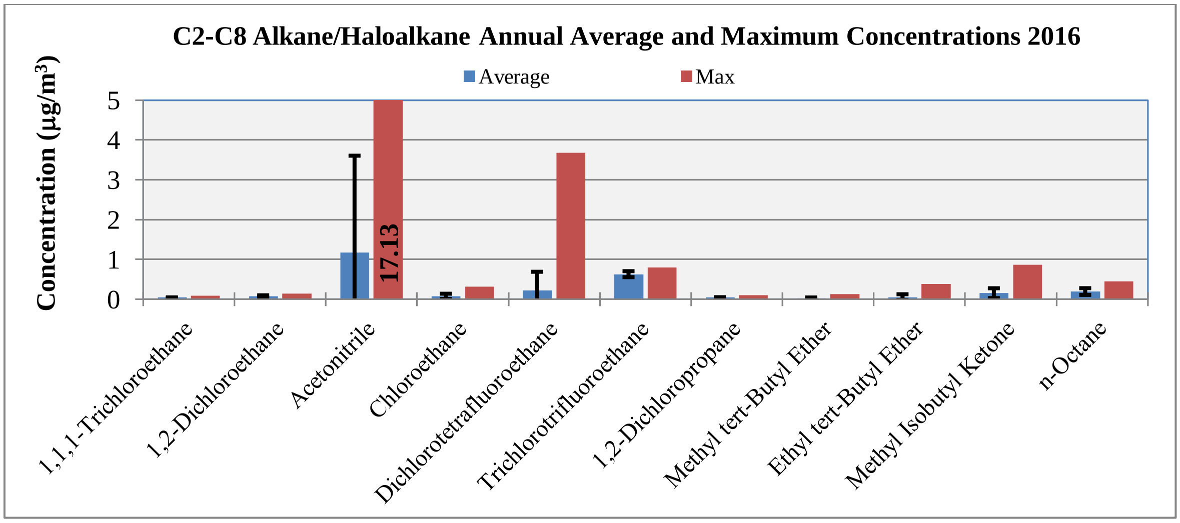


Figure 11. **VOC Annual Average and Maximum Concentrations 2016, ctd.**

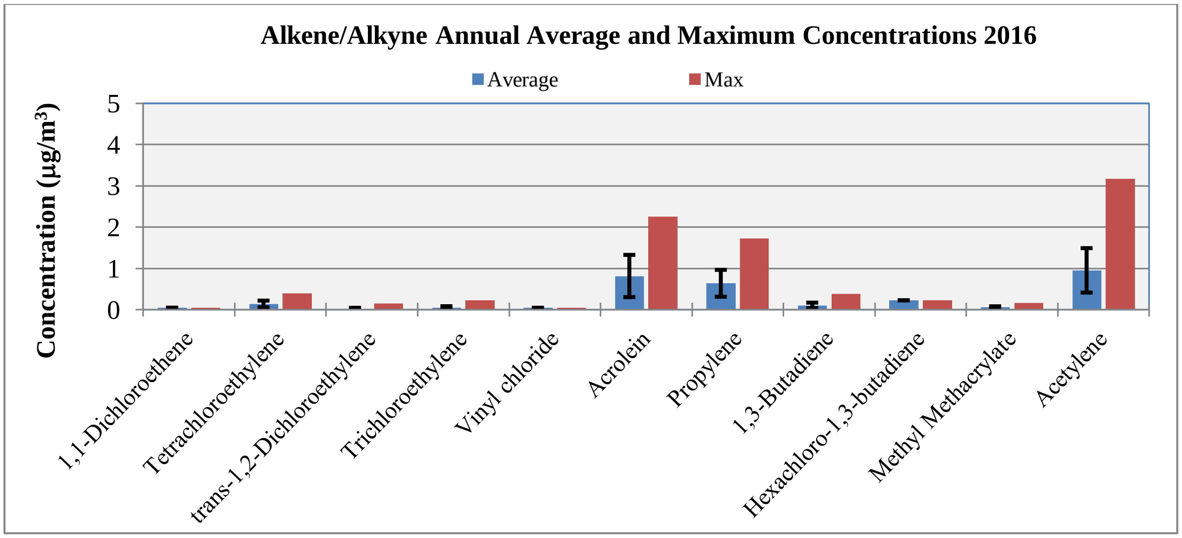


Figure 12. **VOC Annual Average and Maximum Concentrations 2016, ctd.**

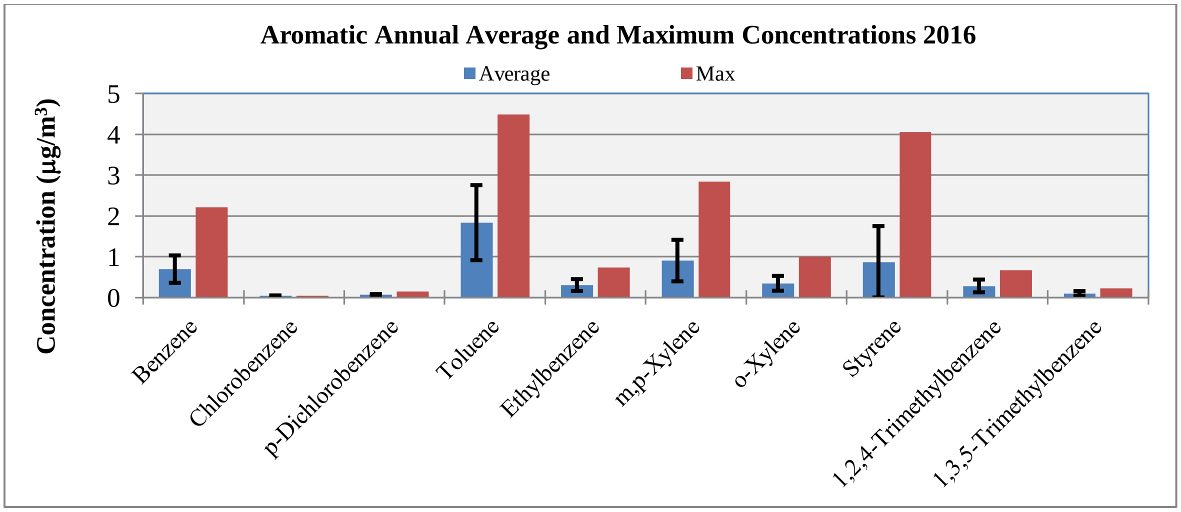


Figure 13. **VOC Annual Average and Maximum Concentrations 2016, ctd.**

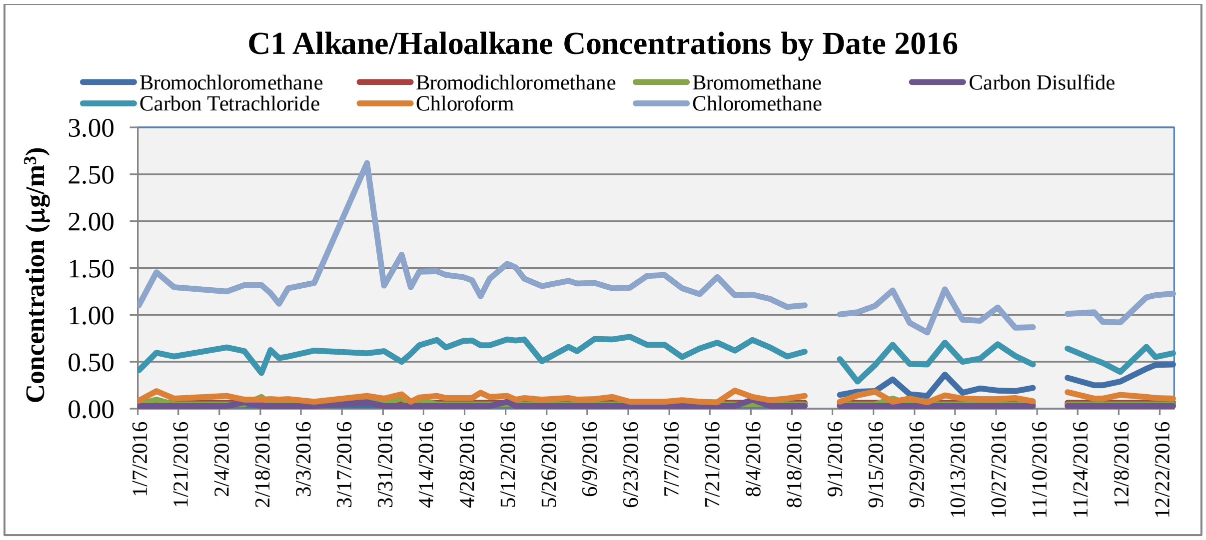


Figure 14. VOC Concentrations by Date 2016

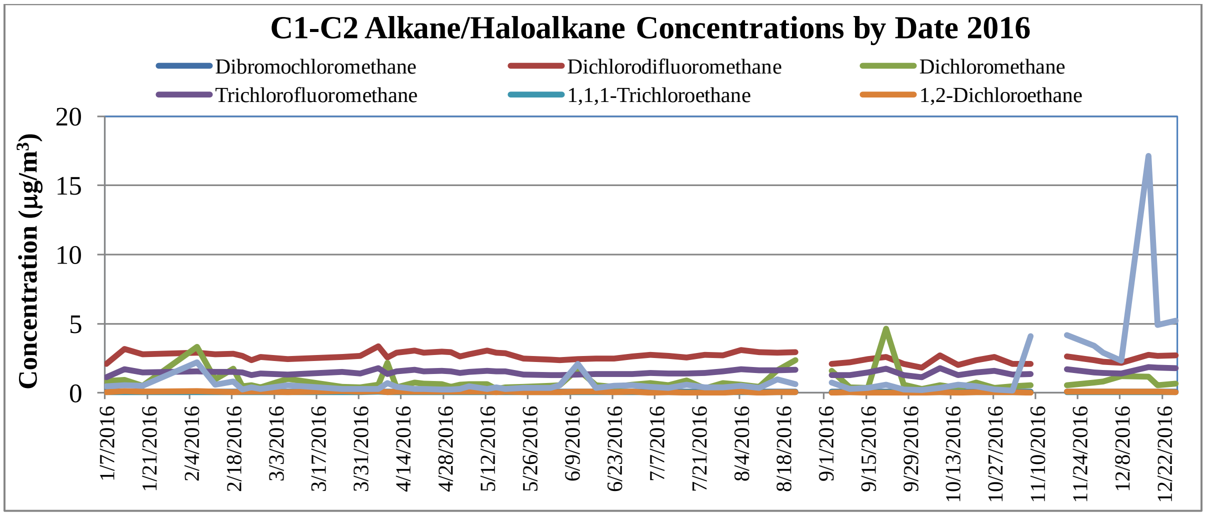


Figure 15. VOC Concentrations by Date 2016, ctd.

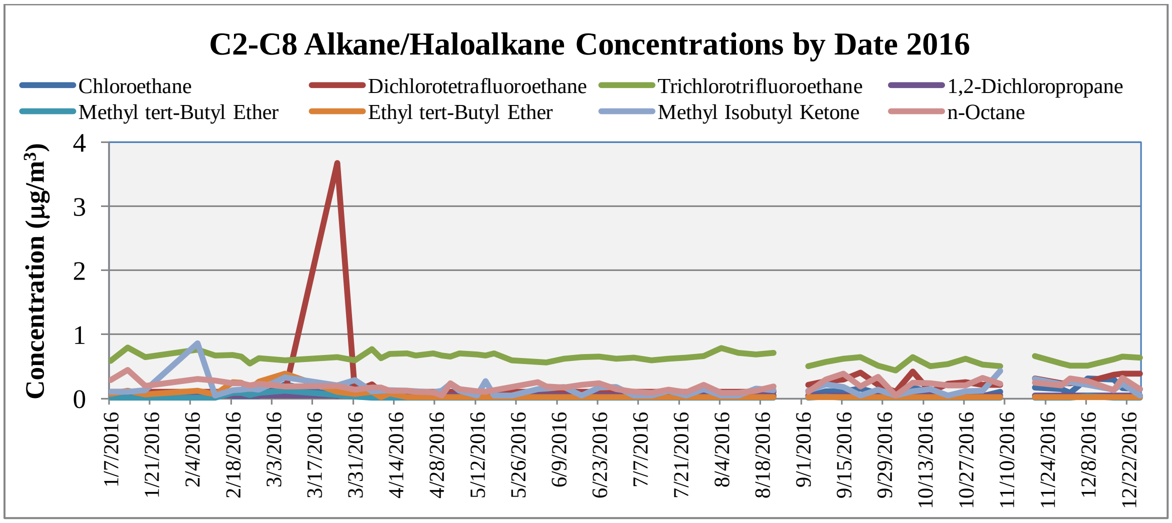


Figure 16. VOC Concentrations by Date 2016, ctd.

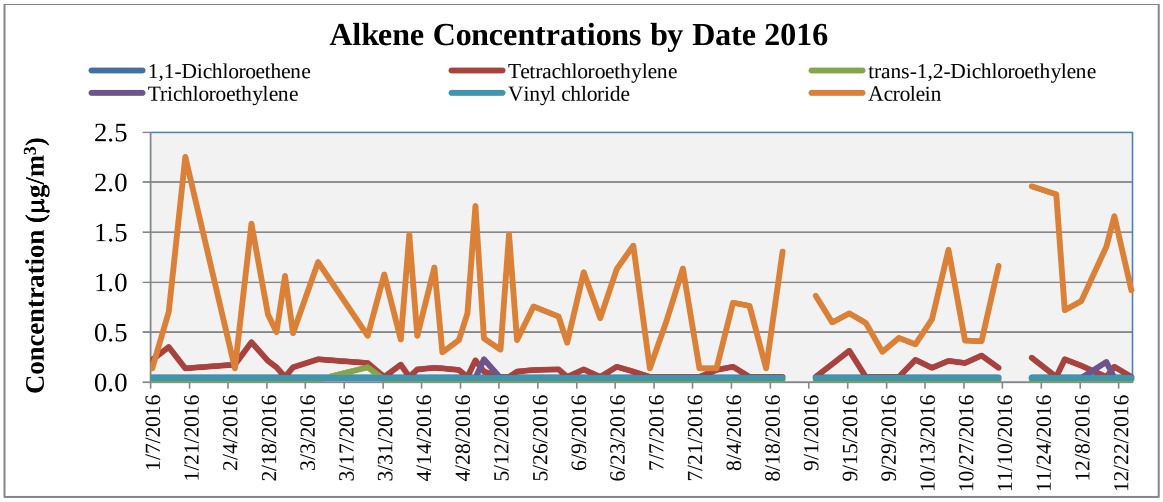


Figure 17. **VOC Concentrations by Date 2016, ctd.**

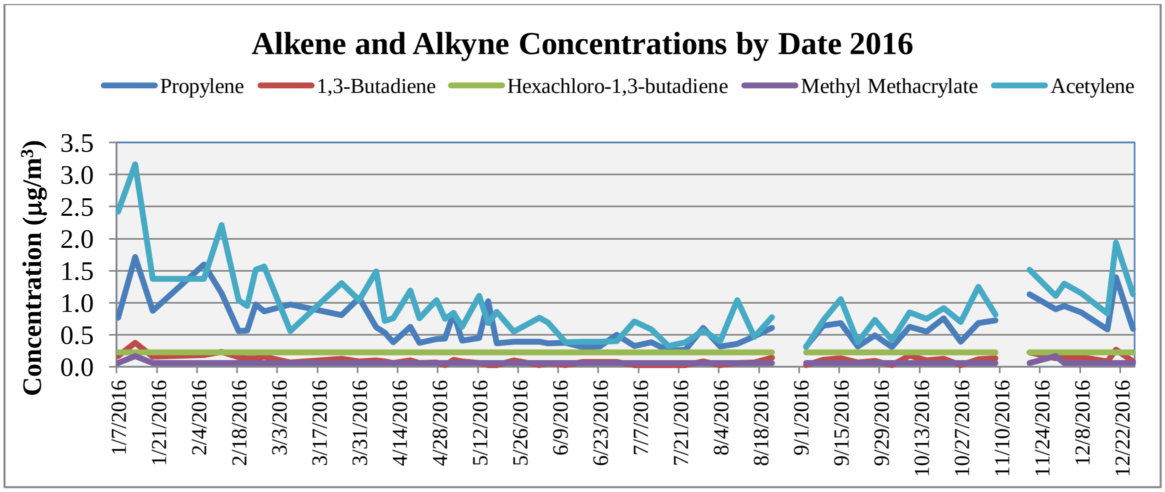


Figure 18. **VOC Concentrations by Date 2016, ctd.**

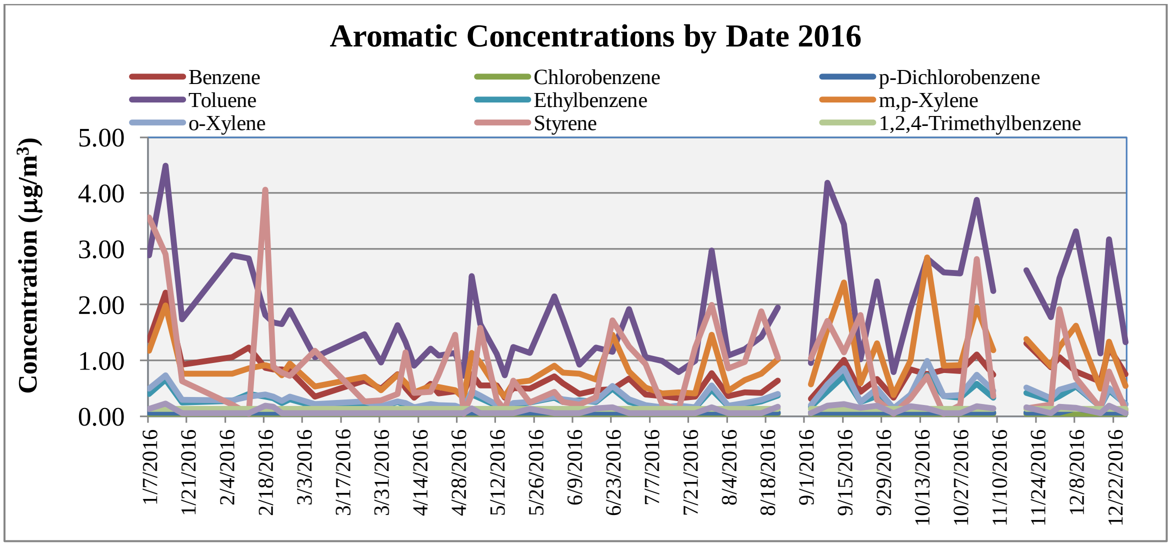


Figure 19. **VOC Concentrations by Date 2016, ctd.**

Figure 14 through Figure 19 show the concentrations of the 43 compounds detected in greater than 10% of the samples taken. The graphs are broken down by compound type (alkane, haloalkane, alkene, aromatic, etc.) and the data is listed in chronological order. There are two gaps in the 2016 data from samples that were missed or voided. The remaining sample concentrations tended to trend well with each other. Some of the compounds do show a seasonal variation in their concentrations. The variation is more evident in the alkene, alkyne, and aromatic compounds than in the alkanes. There are several compounds that show this seasonal variability in Figure 18. VOC concentrations are typically higher in the summer due to the higher temperatures, and longer availability of ultraviolet rays for the photolytic process to occur.

Figure 20 through Figure 23 graphically illustrate the weekday versus weekend VOC concentrations in 2016 for the 43 compounds. The compounds are again separated into four groups: alkanes, alkenes, alkynes, and aromatics. The alkane compounds have carbon atoms with only single bonds. The alkenes have carbon atoms with double bonds, and the alkynes have triple bonds. The aromatics are ring structures (e.g., benzene) with other substituents bonded to the ring.

In 2016, weekday concentrations for 27 of the 43 compounds were larger than concentrations captured during the weekend sampling. This is expected, as many of the compounds emitted are associated with automobile emissions, and traffic in the area usually decreases on the weekends. There were several compounds with larger weekend averages, however. Sixteen of the 43 compounds had higher weekend concentrations than weekday concentrations. The remaining compounds had weekday and weekend averages that were equal. This is most likely attributable to the practice of substituting of one-half the value of the MDL for the non-detect and less than MDL sample values.

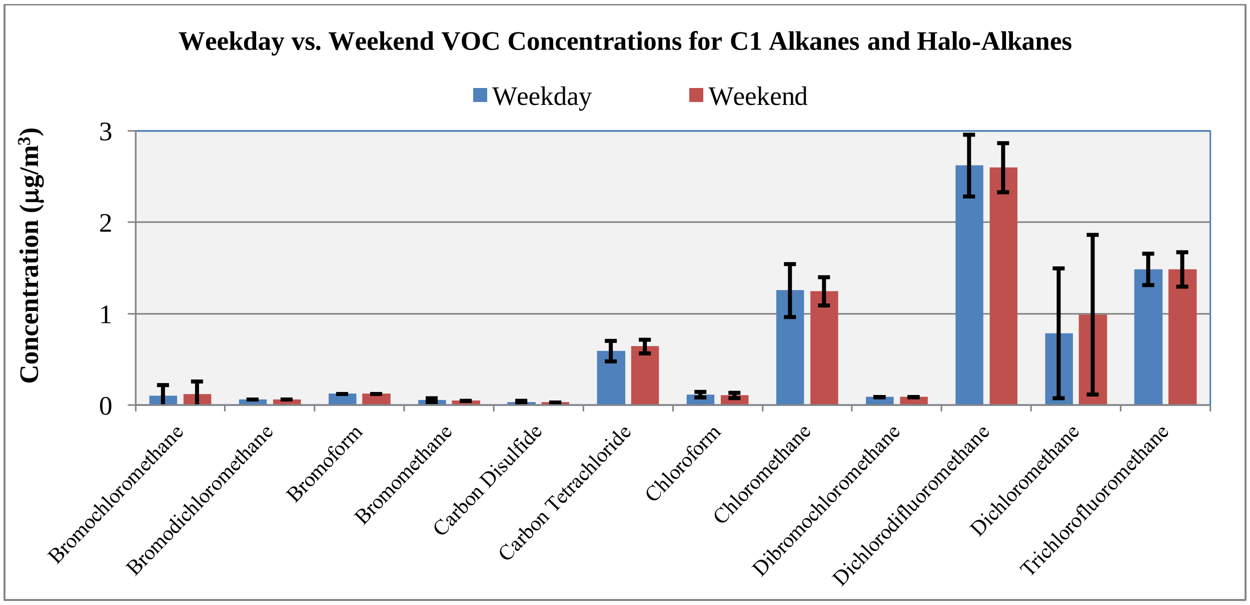


Figure 20. **VOC Weekday vs. Weekend Comparison for C1 Halo-Alkanes**

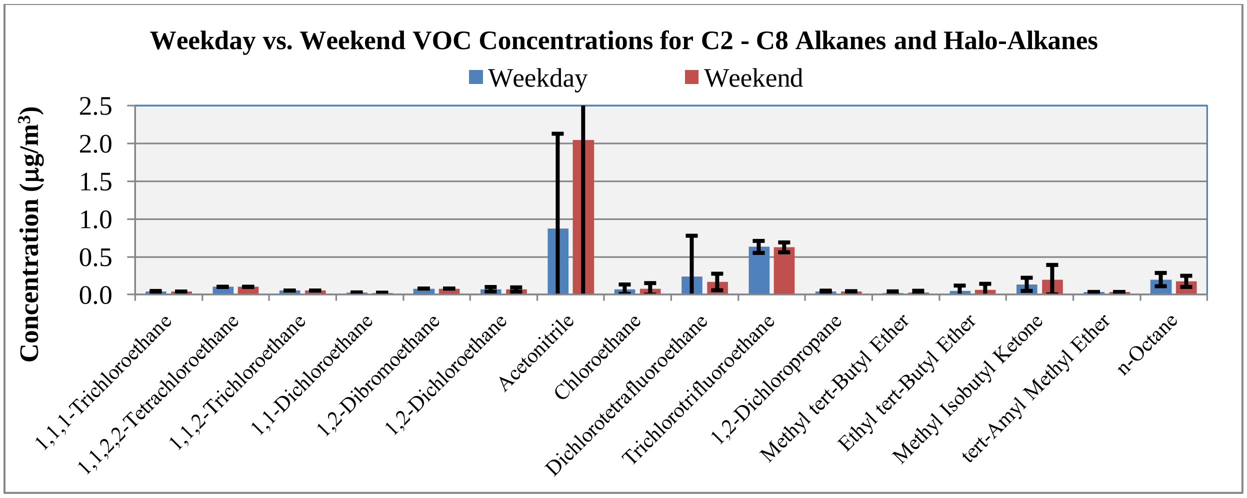


Figure 21. VOC Weekend vs. Weekday Concentrations for C2-C8 Alkanes/Haloalkanes

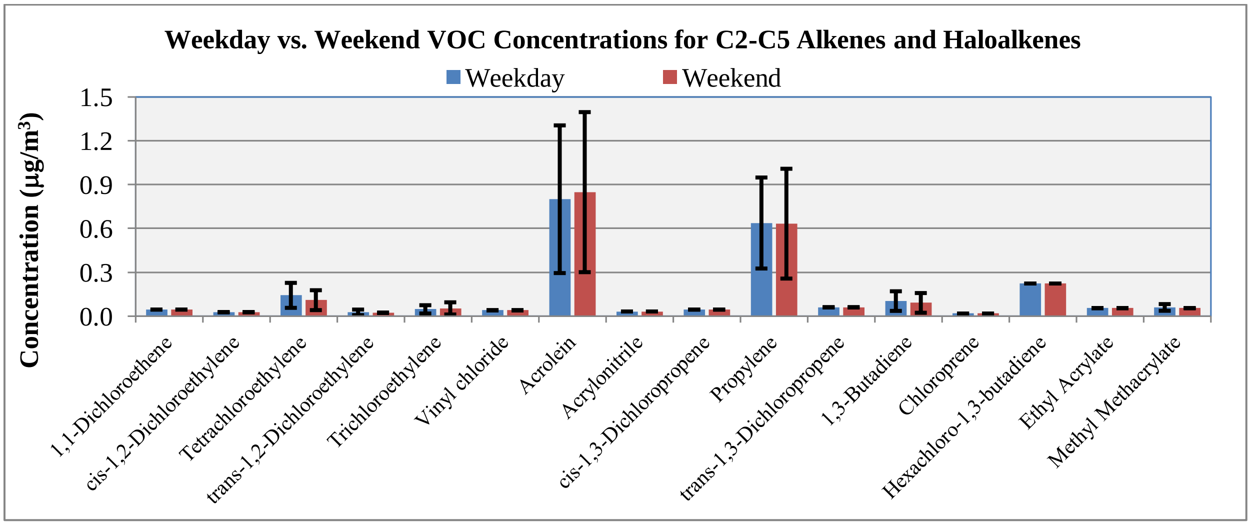


Figure 22. VOC Weekend vs. Weekday Concentrations for C2-C5 Alkenes and Haloalkenes

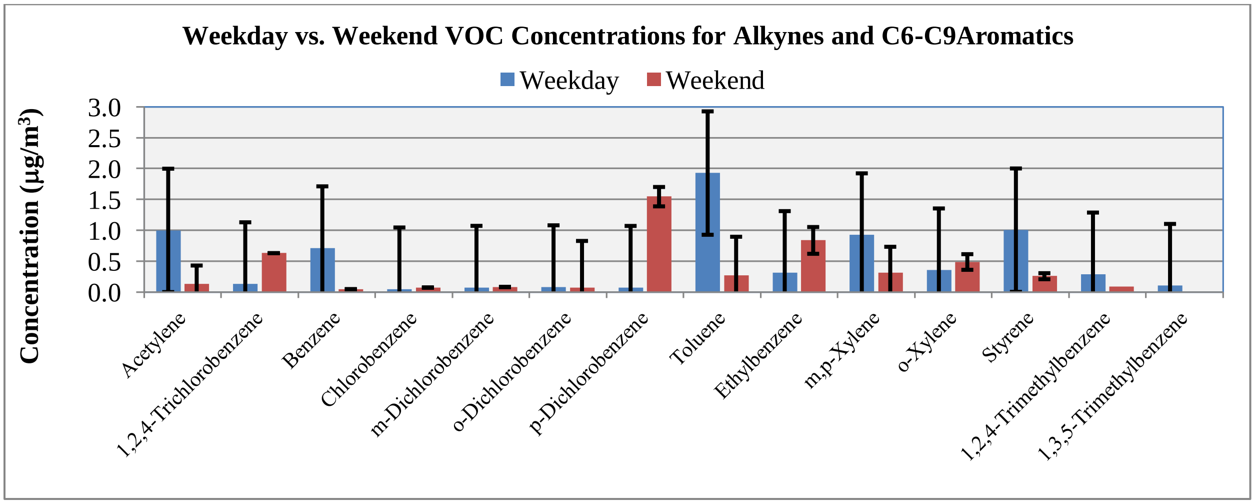


Figure 23. VOC Weekend vs. Weekday Concentrations for Alkynes and Aromatics

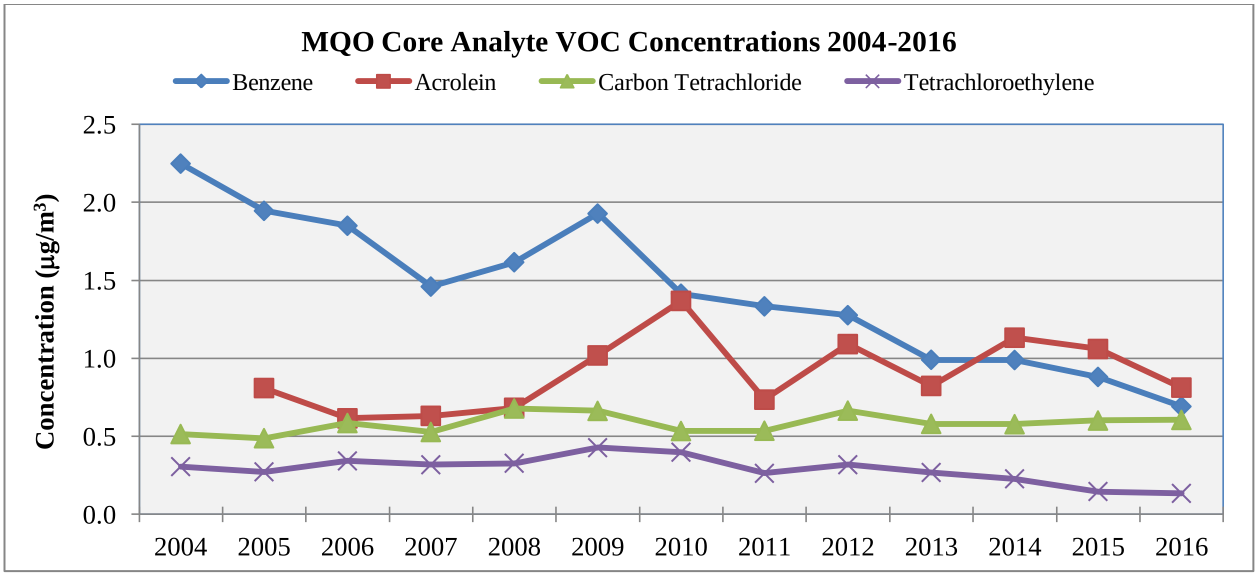


Figure 24. **MQO Core Analyte VOC Concentrations 2004 – 2016**

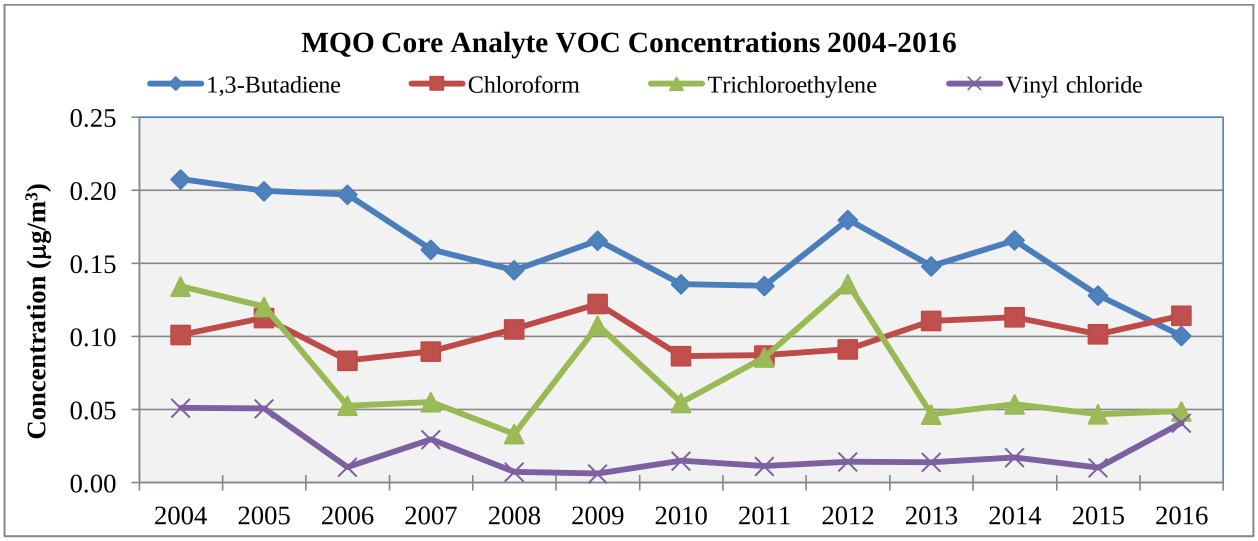


Figure 25. **MQO Core Analyte VOC Concentrations 2004 – 2016, ctd.**

Figure 24 and Figure 25 graph the annual average concentrations of the eight VOCs that are a part of the mandatory monitoring subset of 19 HAPs. The benzene and 1,3-butadiene graphs show a downward trend since 2004. The remaining graphs do not appear to indicate a general trend in concentration values since 2004. Figure 26 and Figure 27graphically illustrate how the 3-year average concentrations of the eight MQO Core Analyte VOCs have trended since the Pilot Study began in 2004. Also included in those graphs are the 2016 annual average values for comparison purposes.

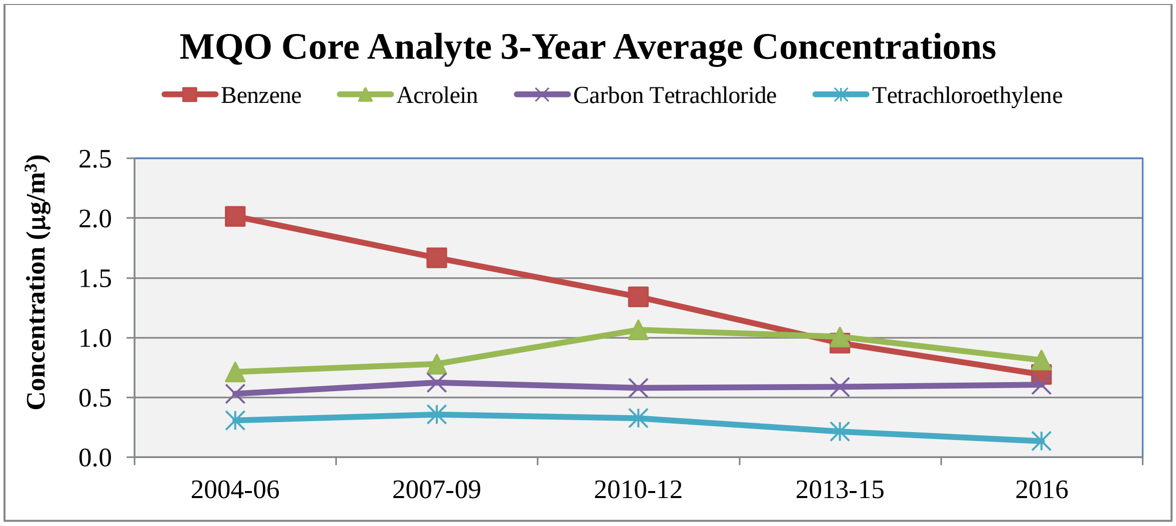


Figure 26. **MQO Core Analyte 3 year Average VOC Concentrations 2004 – 2016**

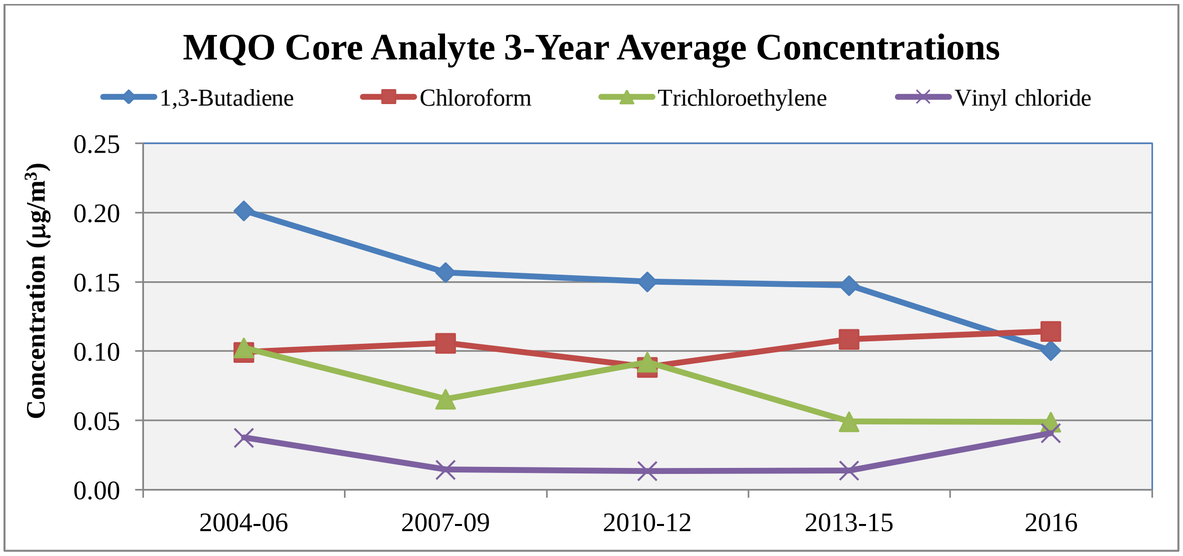


Figure 27. **MQO Core Analyte 3 Year Average VOC Concentrations 2004 – 2016**

Quality Assurance/Quality Control

Blanks

The volatile organic compound sampling method involves sampling in stainless steel canisters with specially treated interior surfaces. The canisters are re-used. After a full canister is analyzed, it is pumped out repeatedly to a high vacuum. This procedure cleans it for the next use. Periodically, one canister from each cleaning batch is tested to make sure the method is performing adequately. The test canister is filled with ultra-pure air, and then analyzed. If it shows no contamination, the batch is released for use. If contamination is found, the entire batch is sent through the cleaning process for a second time. The canisters arrive in the field closed, and under a vacuum of 20 to 30 inches of mercury. Therefore, field blanks are not used in this method. The method blank canister test is performed at the laboratory prior to shipping to the field.

Precision of Sample Results

On six random sampling dates per year, a second canister was sampled simultaneously with the primary sample. These additional samples, known as duplicates, were collected in order to assess the precision (repeatability) of the canister sampling method. In general, repeatability for the two collocated samples was acceptable. Information regarding precision and accuracy results is available upon request to the Air Pollution Control Division.

V. POLYCYCLIC AROMATIC HYDROCARBONS

Summary Statistics

In April 2008, the Grand Junction National Air Toxics Trends Site added a sampler for polycyclic aromatic hydrocarbon (PAH) compounds. A good definition of these chemicals is:

> *Polycyclic aromatic hydrocarbons (also known as polynuclear aromatic hydrocarbons) are composed of two or more aromatic (benzene) rings which are fused together when a pair of carbon atoms is shared between them. The resulting structure is a molecule where all carbon and hydrogen atoms lie in one plane. Naphthalene ($C_{10}H_8$, MW = 128.16 g), formed from two benzene rings fused together, has the lowest molecular weight of all PAHs. The environmentally significant PAHs are those molecules which contain two (e.g., naphthalene) to seven benzene rings (e.g., coronene with a chemical formula $C_{24}H_{12}$; MW = 300.36 g). In this range, there are a large number of PAHs which differ in number of aromatic rings, position at which aromatic rings are fused to one another, and number, chemistry, and position of substituents on the basic ring system.* (Source: Ambient Water Quality Criteria for Polycyclic Aromatic Hydrocarbons (PAHs) Ministry of Environment, Lands and Parks, Province of British Columbia. By N. K. Nagpal, Ph.D., Water Quality Branch, Water Management Division, British Columbia, Canada, Ministry of Environment, February, 1993).

In 2016, 61 PAH samples were possible. Of those 61, three were either missed or invalidated by the lab for errors during the analytical process. All three were made up, for a total of 61 out of 61 samples (100% sample recovery rate). Twenty-two compounds were measured for this study. The list of these compounds and the summary of the collected data are shown in Table 6 and Table 7. All of the 22 compounds analyzed for were detected in more than 10% of the samples taken. Benzo(k)fluoranthene was found to have the lowest detection rate, with only 52% of the samples taken showing levels above the compound's MDL. Fourteen compounds were detected in every sample taken. This is an increase from the 2015, where only thirteen compounds were present in all samples taken.

Table 6. PAH Sample Summary Data 2016

Compound	CAS Number	# Detections in Samples	% of Time Detected in Samples
9-Fluorenone	486-25-9	61	100%
Acenaphthene	83-32-9	58	95%
Acenaphthylene	208-96-8	53	87%
Anthracene	120-12-7	61	100%
Benzo (a) anthracene	56-55-3	61	100%
Benzo (a) pyrene	**50-32-8**	**61**	**100%**
Benzo (b) fluoranthene	205-99-2	61	100%
Benzo (e) pyrene	192-97-2	61	100%
Benzo (g,h,i) perylene	191-24-2	61	100%

Compound	CAS Number	# Detections in Samples	% of Time Detected in Samples
Benzo (k) fluoranthene	207-08-9	32	52%
Chrysene	218-01-9	61	100%
Coronene	191-07-1	61	100%
Cyclopenta[cd]pyrene	27208-37-3	46	75%
Dibenz (a,h) anthracene	53-70-3	45	74%
Fluoranthene	206-44-0	61	100%
Fluorene	86-73-7	52	85%
Indeno(1,2,3-cd)pyrene	193-39-5	59	97%
Naphthalene	**91-20-3**	**61**	**100%**
Perylene	198-55-0	48	79%
Phenanthrene	85-01-8	61	100%
Pyrene	129-00-0	61	100%
Retene	483-65-8	61	100%

ND = Not Detected
Bold = MQO Core Analyte

Table 7 summarizes the annual mean concentrations for each PAH measured during the study, from 2008 through 2016. Any compounds that were detected in less than 10% of the samples taken since 2015 are italicized to show that their averages are dependent on their respective MDL values. From 2008 through 2014 the italicized results indicate compounds that were detected in less than 90% of the samples taken. It should be noted here that there was a shift in the data processing methods for this report. In previous years, data was presented for compounds that were present in at least 90% of the samples taken. For this (and future) reports the data presented will be from compounds that were present in at least 10% of the samples taken. While this move did not have a noticeable effect on the carbonyl or PAH data, it did allow for inclusion of more of the VOC compounds discussed in earlier sections. For purposes of consistency, this new 10% detection criterion was applied to all carbonyl, VOC, metal, and SVOC data sets.

Bolded compounds are listed among those on the list of 19 core HAPs to be monitored. The annual means were calculated by replacing all "non-detect" values with one-half of the sample MDL. This is an accepted conservative technique for calculating annual values when some of the samples were less than the laboratory's ability to detect. Naphthalene had the largest annual average of the PAH compounds with a value of just over 73 nanograms per meter cubed in 2016. This is more than seven times greater than the next closest average concentration, which is phenanthrene, at 10.5 nanograms per meter cubed.

Table 7. PAH Annual Average Values 2008 - 2016

Analyte	2008 Average (ng/m^3)	2009 Average (ng/m^3)	2010 Average (ng/m^3)	2011 Average (ng/m^3)	2012 Average (ng/m^3)	2013 Average (ng/m^3)	2014 Average (ng/m^3)	2015 Average (ng/m^3)	2016 Average (ng/m^3)
9-Fluorenone	*1.53*	2.67	2.34	2.13	2.74	2.42	2.09	2.26	1.68
Acenaphthene	8.41	11.34	7.30	10.54	20.5	8.07	7.17	8.29	5.67
Acenaphthylene	*2.12*	*3.68*	*2.50*	*2.22*	*2.28*	*2.51*	*1.33*	1.17	0.99
Anthracene	*0.63*	1.65	0.89	0.77	0.83	0.82	0.66	1.28	0.46
Benzo (a) anthracene	*0.20*	*0.39*	*0.25*	0.26	0.22	*0.31*	0.22	0.26	0.18
Benzo (a) pyrene	***0.18***	***0.33***	***0.20***	***0.22***	***0.18***	***0.24***	***0.19***	**0.24**	**0.17**
Benzo (b) fluoranthene	0.36	0.72	0.50	0.48	0.41	0.56	0.44	0.31	0.32
Benzo (e) pyrene	*0.19*	*0.39*	*0.24*	0.23	0.19	0.25	0.22	0.22	0.19
Benzo (g,h,i) perylene	*0.26*	0.43	0.28	0.25	0.21	0.26	0.25	0.23	0.20

Analyte	**2008 Average (ng/m^3)**	**2009 Average (ng/m^3)**	**2010 Average (ng/m^3)**	**2011 Average (ng/m^3)**	**2012 Average (ng/m^3)**	**2013 Average (ng/m^3)**	**2014 Average (ng/m^3)**	**2015 Average (ng/m^3)**	**2016 Average (ng/m^3)**
Benzo (k) fluoranthene	*0.10*	*0.21*	*0.14*	*0.14*	*0.12*	*0.14*	*0.12*	0.09	0.07
Chrysene	0.35	0.68	0.49	0.48	0.42	0.54	0.41	0.48	0.42
Coronene	*0.15*	*0.23*	*0.13*	*0.11*	*0.09*	*0.10*	0.12	0.12	0.11
Cyclopenta[cd]pyrene	*0.16*	*0.19*	*0.10*	*0.13*	*0.12*	*0.11*	*0.07*	0.18	0.11
Dibenz (a,h) anthracene	*0.06*	*0.06*	*0.03*	*0.05*	*0.04*	*0.03*	*0.02*	0.05	0.03
Fluoranthene	2.52	3.79	3.30	3.35	3.55	3.36	2.60	5.48	4.11
Fluorene	5.15	9.20	6.44	7.67	12.6	6.89	5.75	7.34	4.58
Indeno(1,2,3-cd)pyrene	*0.21*	*0.37*	*0.24*	*0.23*	*0.19*	*0.25*	0.25	0.20	0.17
Naphthalene	**112**	**189**	**147**	**158**	**204**	**137**	**100**	**90.3**	**73.6**
Perylene	*0.07*	*0.08*	*0.09*	*0.07*	*0.06*	*0.04*	*0.03*	0.04	0.03
Phenanthrene	12.0	17.9	13.9	14.0	18.7	13.3	11.1	22.1	10.5
Pyrene	1.81	2.87	2.28	2.19	2.20	2.30	1.79	3.01	2.12
Retene	0.67	1.37	1.04	0.85	0.77	1.06	0.74	0.71	0.62

Bold = MQO Core Analyte

Italic = less than 90% detection rate 2008 – 2014

Graphs

Chronological graphs of the concentration data for the PAH compounds are shown in Figure 28 through Figure 31. Naphthalene is the most variable, with concentrations ranging from 17.2 to 247 nanograms per meter cubed. Naphthalene had the largest annual average concentration, followed by phenanthrene, with values of 73.6 ± 37.6, and 10.5 ± 5.76 nanograms per meter cubed, respectively. In comparison, the National Monitoring Program (NMP) national averages for these compounds in 2014 were 66.5 ± 56.65, and 9.51 ± 14.68 nanograms per meter cubed, respectively.[6]

Overall, the PAH compound concentrations tended to follow the same general trend. Many of the compounds showed larger concentrations during the summer months. This is likely due to smoke in the area caused by regional forest fires, as well as mobile source emissions from the incomplete combustion products of motor vehicles. Several other PAH compounds exhibited a different variation, with larger concentrations in the winter months, and lower concentrations in the summer months. This also makes sense, since the primary source of many PAHs in air is the incomplete combustion of wood and fuel.[7] PAHs are a product of combustion from common sources like automobiles, wood-burning stoves and furnaces, cigarette smoke, etc. The natural sources of PAHs include volcanoes, forest fires, crude oil, and shale oil.[8]

---

[6] "2014 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. February 2017.

[7] "Toxicological Profile for Polycyclic Aromatic Hydrocabons." US Department of Health and Human Services, Agency for Toxic Substances and Disease Resigtry. August 1995. http://www.atsdr.cdc.gov/ToxProfiles/tp69.pdf

[8] *Ibid.*

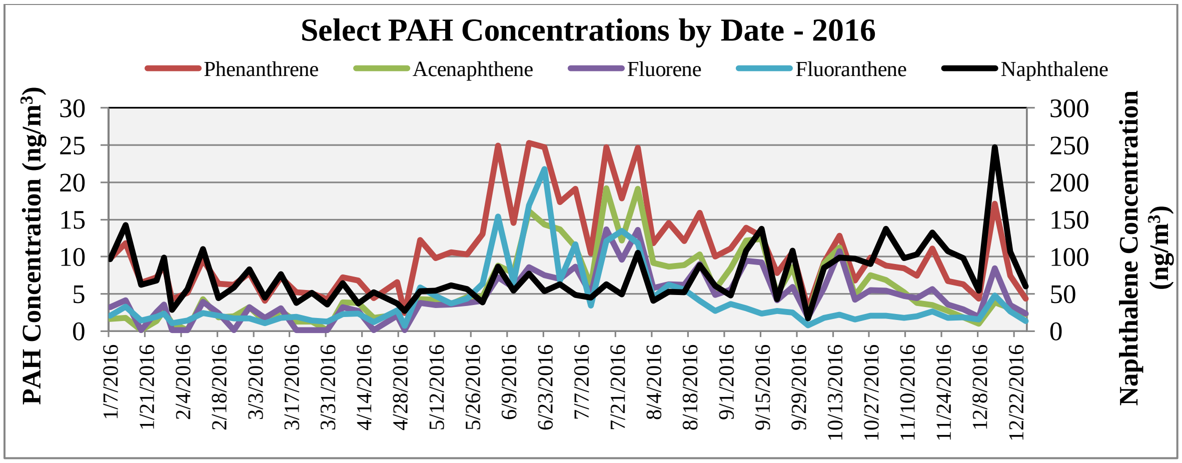


Figure 28. **PAH Concentrations by Date 2016**

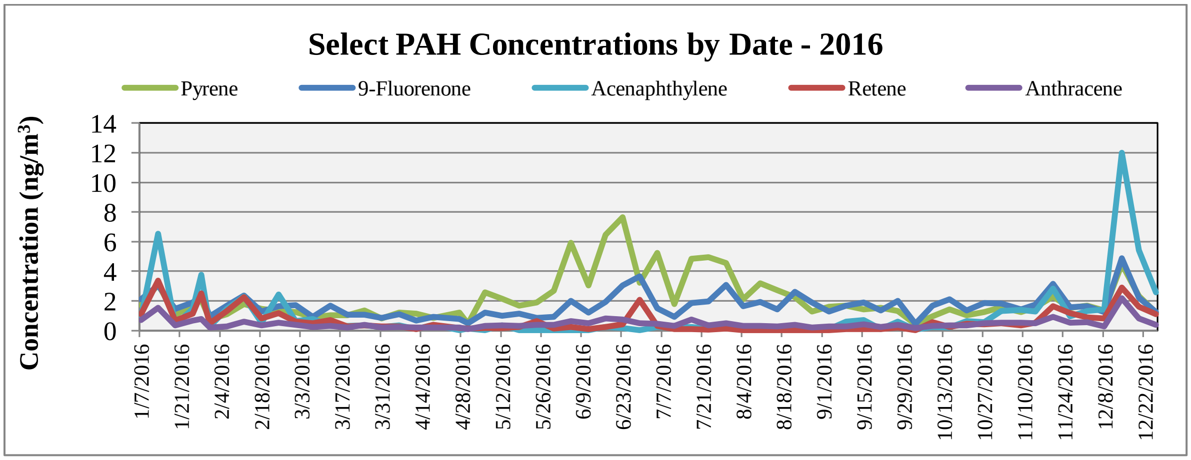


Figure 29. **PAH Concentrations by Date 2016, ctd.**

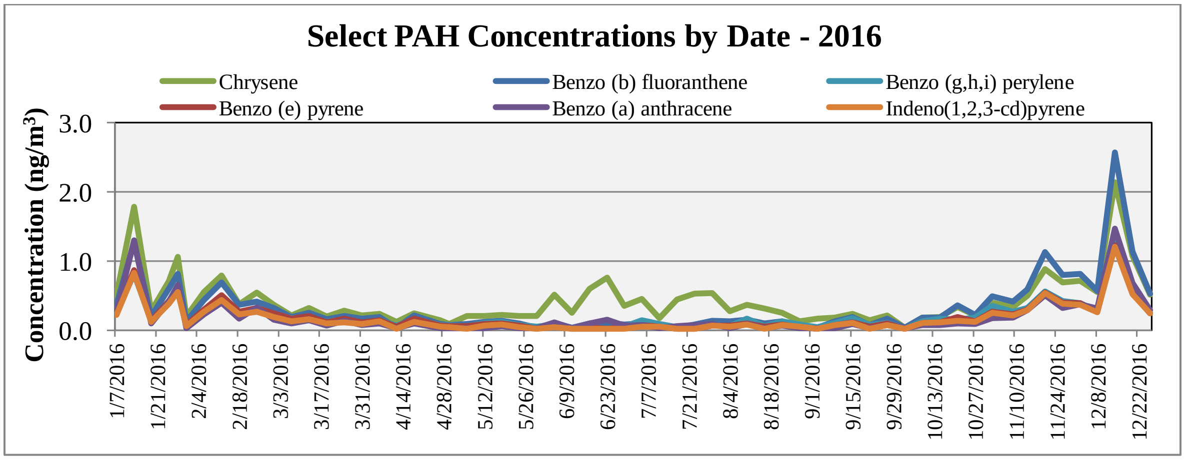


Figure 30. **PAH Concentrations by Date 2016, ctd.**

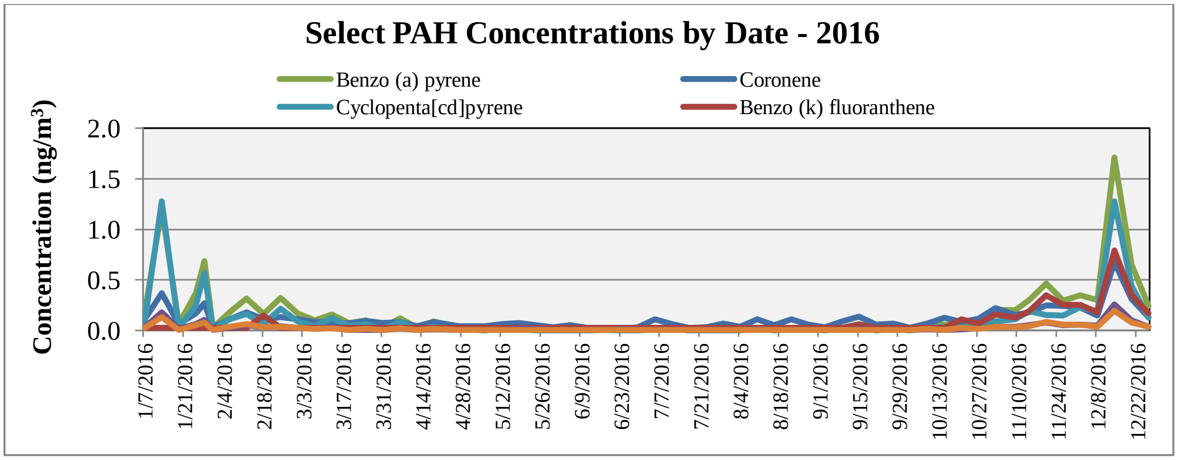


Figure 31. Select PAH Concentrations by Date 2016, ctd.

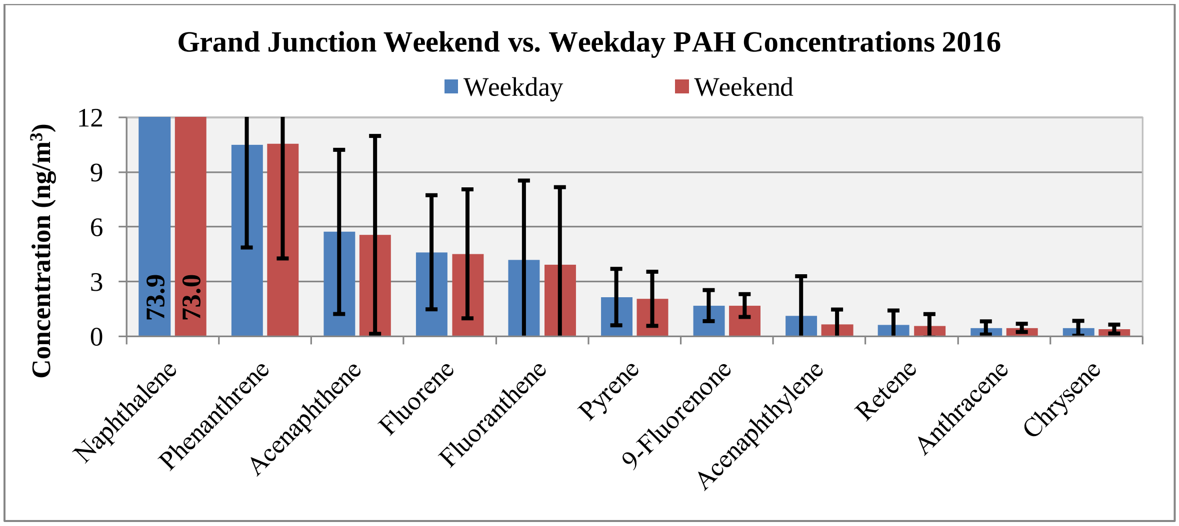


Figure 32. PAH Weekend vs. Weekday Concentrations 2016

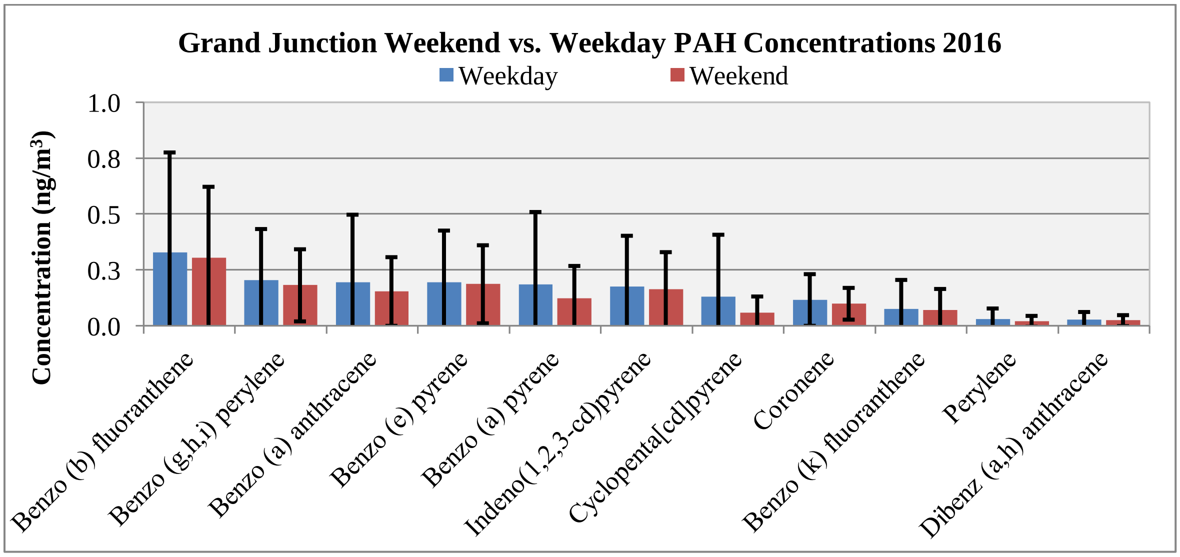


Figure 33. PAH Weekend vs. Weekday Concentrations 2016, ctd.

Figure 32 and Figure 33 are graphs of the weekend versus weekday concentrations for all the PAH compounds in 2016. The weekday averages were larger than the weekend values for all but three compounds: phenanthrene, 9-Fluorenone, and anthracene. All three of those compounds were detected in all samples taken. The values for naphthalene are off the chart with a weekday average of 73.9 nanograms per meter cubed, and a weekend average of 73.0 nanograms per meter cubed, which are both lower than their respective 2015 values. Figure 34 through Figure 37 are graphs of the annual average concentrations for all the PAH compounds. The graphs show that several of the annual average compound concentrations have increased since 2012, while others have decreased or remained fairly constant.

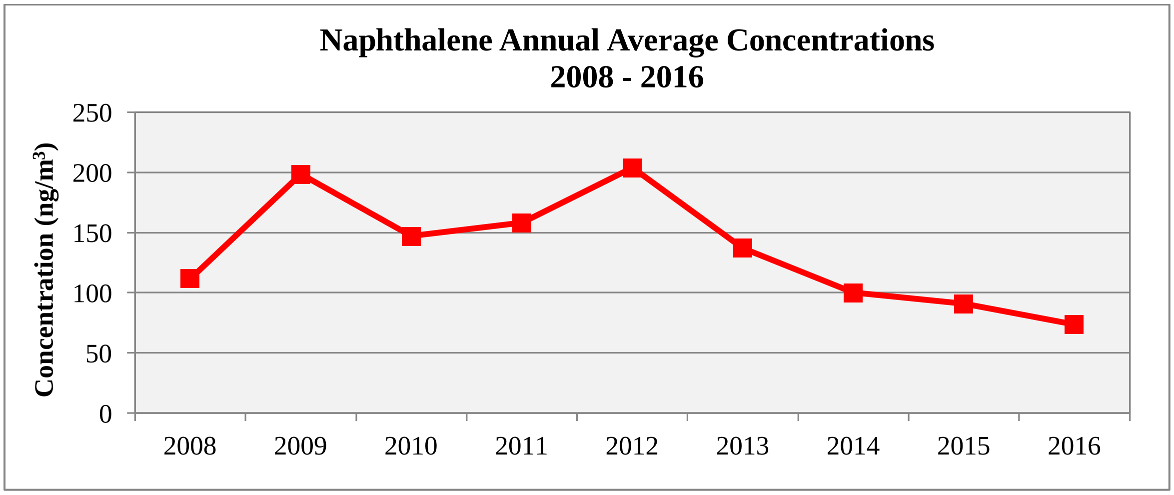


Figure 34. Naphthalene Annual Average Concentrations 2008 – 2016

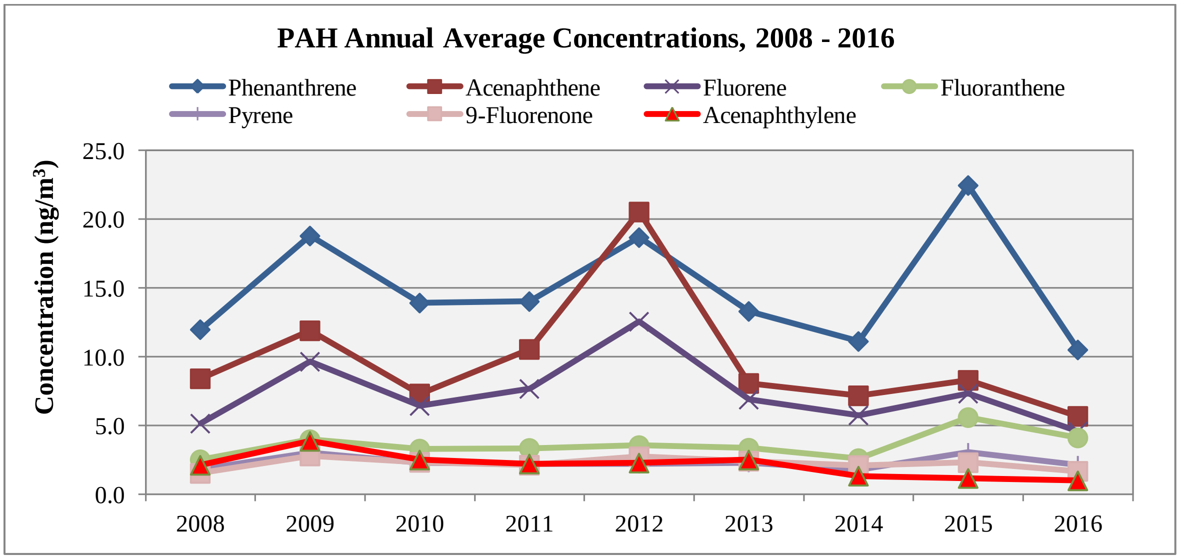


Figure 35. PAH Annual Average Concentrations 2008 – 2016

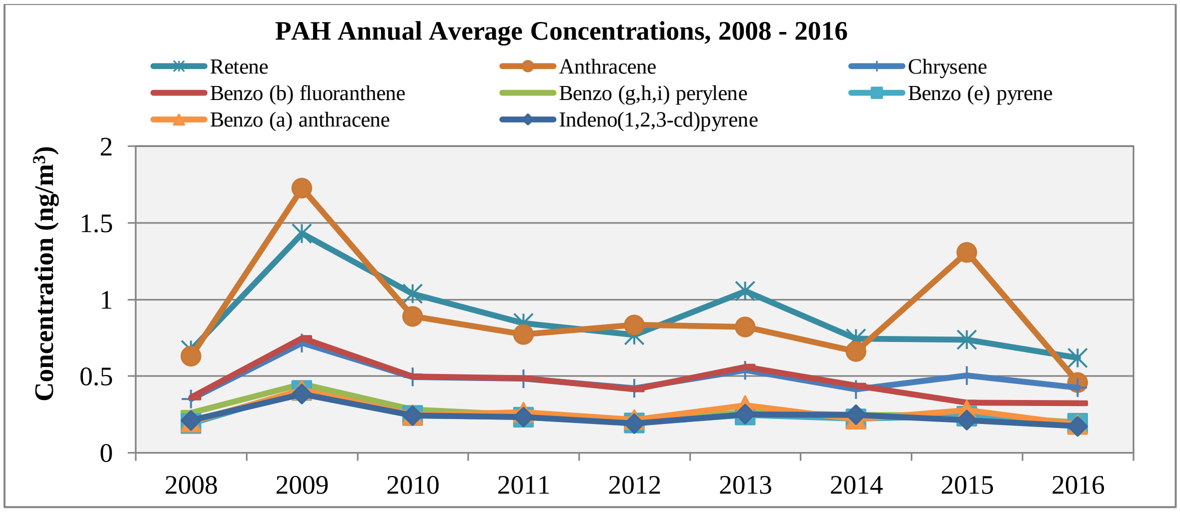


Figure 36. **PAH Annual Average Concentrations 2008 – 2016, ctd.**

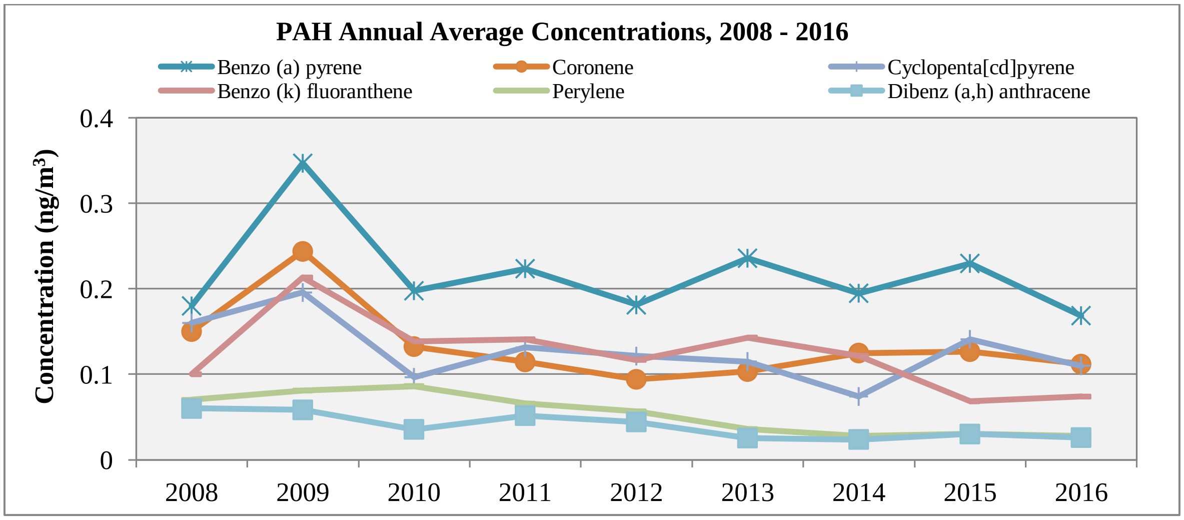


Figure 37. **PAH Annual Average Concentrations 2008 - 2016, ctd.**

Figure 38 shows the 3-year average concentrations for the metals compounds that are on the MQO Core Analyte list, naphthalene and benzo(a)pyrene. The data indicate a downward trend from the start of sampling. As mentioned previously, PAH sampling began four years after the start of the NATTS project, so the 3-year averages are calculated using different years than the VOCs, carbonyls, etc.

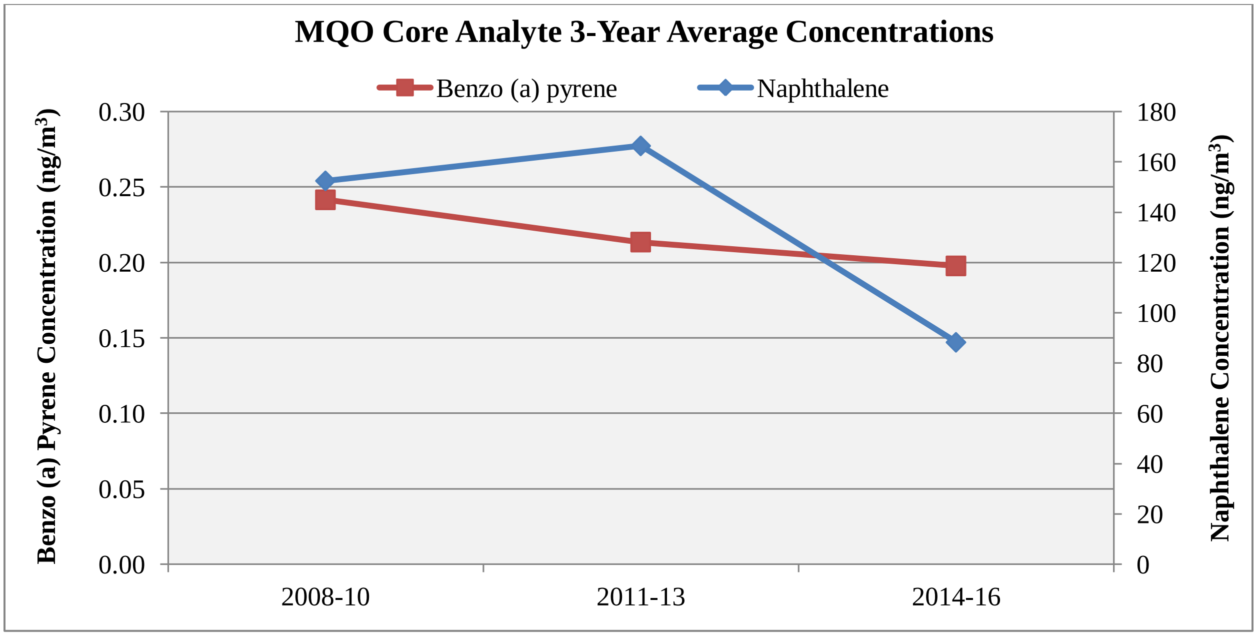


Figure 38. MQO Core Analyte 3-Year Average Concentrations

Quality Assurance/Quality Control

Blanks

Periodically, the laboratory analyzes a “blank,” or unused, filter for PAH compounds. The purpose of this extra analysis is to determine if there was any contamination of the filter during manufacturing, or during laboratory processing. In 2016, the laboratory analyzed 11 “filter blanks,” filters which never left the lab. Several compounds were detected at very low levels in many of the filter blanks. The blank concentrations were averaged, and subtracted from the sample concentrations before annual averages were calculated. Results of the blank filters are available upon request from CDPHE.

Precision of Sample Results

Precision air samples were not run at this site in 2016. Assessing precision requires a collocated sampler at the site, and the NATTS group chose to take precision samples at other locations in the nationwide network.

VI. PM$_{10}$ METALS

In 2014, CDPHE switched to a different contract lab for metals analyses, as previous years’ data were found to have various errors due to the contracted laboratory not following correct procedures for establishing the method detection limits (MDLs). The reported concentrations for some of the metals rely heavily on the MDL values, as one-half the value of the MDL is substituted for the concentration in instances where the metal is not detected during the analysis, or is detected but it’s value is less than the MDL. Because it was impossible to go back and calculate the MDLs being used for the previous data, a new MDL study was performed by the lab in 2014. The values obtained as a result of that study are used for the analysis of 2010-2013 metals data, in an effort to keep from losing several years’ worth of valuable data.

In previous years, antimony and total chromium were also a part of the suite of compounds CDPHE had the lab analyze for. These two compounds are not required as a part of the NATTS program. As such, when the new MDL study was performed they were dropped from the list of compounds to be recalculated. Any data associated with those two compounds for the years 2010 through 2013 has consequently been removed.

Summary Statistics

In 2016, as in past years, metals were sampled on the every sixth day schedule, for a total of 61 samples attempted. Of those 61 samples, one was missed or voided, leaving a total of 60 samples collected (98.4% sample recovery). Table 8 shows the percentage of the samples in which each metal was detected, including those that were detected but had a concentration value that was below the MDL value for that compound. Some compounds were detected on many of the sample dates, but at concentrations that were less than their respective MDL. For instance, chromium was detected in all of the samples taken, having an average of 2.55 ng/m^3 (using the raw data). However, the MDL for chromium is 4.63 ng/m^3. Therefore, a value equal to one-half the MDL (2.32 ng/m^3) was substituted in place of the listed raw value as a conservative, reliable estimate of the compound's concentration. Since the actual raw value is under the MDL, it is difficult to use it with any certainty. Although there is a peak on the graph at the proper time indicating that it is chromium, it could also be attributed to instrument noise as it is less than the instrument's ability to accurately determine the compound. The fact that the chromium average in the blank samples taken throughout the year was near the raw average of the samples (2.08 ng/m^3 for blanks versus 2.55 ng/m^3 for samples) supports this.

There were a total of 40 actual non-detect values for the entire metals data set in 2016. These non-detect values are attributable to three compounds: beryllium, cobalt, and nickel. Beryllium was listed as non-detect for one of those 40 samples, cobalt for 35, and nickel for four. Both mercury and chromium were detected in all samples taken, but at levels below their respective MDLs. Mercury, however, did meet the minimum 10% sample detection rate with seven values that were measured above the MDL.

Table 8. Metals Detection Rates, 2016

Compound	CAS Number	# of Times Detected in Samples	% of Time Detected in Samples
Antimony	7440-36-0	60	100%
Arsenic	**7440-38-2**	**60**	**100%**
Beryllium	**7440-41-7**	**59**	**98%**
Cadmium	**7440-43-9**	**60**	**100%**
Chromium	7440-47-3	0	0%
Cobalt	7440-48-4	25	42%
Lead	**7439-92-1**	**60**	**100%**
Manganese	**7439-96-5**	**60**	**100%**
Mercury	7439-97-6	7	12%
Nickel	**7440-02-0**	**56**	**93%**
Selenium	7782-49-2	60	100%

Bold = MQO Core Analyte

Table 9 summarizes the annual mean concentrations for each of the metals measured during the study, from 2004 through 2016. The compounds that are listed in bold type are on the list of 19 core HAPs. The italicized compounds are those that were detected in less than 10% of the samples taken. Annual means were calculated by using one-half of the detection limits in place of the non-detect and less than MDL samples. In instances where subtracting the blank value made the resulting concentration less than zero the data were treated as non-detect samples. Non-detect sample values are those that were listed as "ND" by the lab, or those mentioned above. Results show that manganese was the compound with the highest annual average. The other metals were present at lower concentrations. The data for antimony and chromium from 2010 through 2013 has been removed due to lab issues discussed previously. CDPHE's new contract lab analyzes for more compounds than are required by the NATTS technical assistance document. As such, there are new compounds that have been added to the analytical suite. CDPHE has no data for these compounds prior to 2014.

Table 9. Metals Data Summary 2016

Year	**Antimony (ng/m^3)**	***Arsenic* (ng/m^3)**	***Beryllium* (ng/m^3)**	**Cadmium (ng/m^3)**	***Chromium* (ng/m^3)**	**Cobalt (ng/m^3)**	**Lead (ng/m^3)**	**Manganese (ng/m^3)**	***Mercury* (ng/m^3)**	***Nickel* (ng/m^3)**	***Selenium* (ng/m^3)**
2004	0.36	***0.27***	***0.08***	0.05	*1.86*	----	**4.91**	**13.0**	----	***0.63***	----
2005	1.34	***2.13***	***0.91***	0.35	*31.7*	----	**4.01**	**12.0**	----	***0.91***	----
2006	1.47	***2.88***	***0.59***	0.26	*13.1*	----	**4.33**	**15.0**	----	***1.19***	----
2007	0.99	***4.22***	***0.68***	0.24	*16.8*	----	**4.26**	**15.2**	----	***1.44***	----
2008	1.08	***2.43***	***0.19***	0.14	*8.75*	----	**2.48**	**14.7**	----	***1.43***	----
2009	0.54	***0.87***	***0.13***	0.23	*8.83*	----	**2.09**	**8.70**	----	***0.88***	----
2010	----	***1.32***	***0.14***	0.20	----	----	**2.05**	**8.34**	----	***1.80***	----
2011	----	***0.67***	***0.14***	0.21	----	----	**2.79**	**8.82**	----	***2.11***	----
2012	----	***0.57***	***0.13***	0.13	----	----	**3.03**	**10.8**	----	***2.26***	----
2013	----	***0.37***	***0.08***	0.11	----	----	**2.75**	**7.89**	----	***2.64***	----
2014	0.96	***0.30***	**0.02**	**0.08**	*7.86*	0.17	**2.64**	**9.39**	*0.02*	**0.57**	0.71
2015	0.73	**0.31**	**0.01**	**0.06**	*5.96*	0.12	**2.09**	**7.09**	*0.01*	**0.55**	0.68
2016	0.83	**0.36**	**0.01**	**0.06**	*2.32*	0.10	**1.65**	**7.04**	*0.01*	**0.54**	0.63

Bold = MQO Core Analyte

Italic = less than 90% detection rate 2004-2014, less than 10% detection rate 2015 to present.

Graph

The annual average metals concentrations are graphed in Figure 39. The figure shows that manganese and lead were the metals with the largest average concentrations, having values of 7.04 and 2.32 nanograms per meter cubed, respectively. While the concentrations for chromium, beryllium, and mercury are shown for comparative purposes, it is important to note that their values are dependent only on their respective MDLs, as they were rarely, if ever, detected at levels higher than that. In comparison, the NMP national average concentrations for manganese and lead in 2014 were 8.02 ± 9.10 and 2.93 ± 3.15 nanograms per meter cubed, respectively.[9] Figure 39 and Figure 40 indicate that most of the metals were at low concentration levels throughout the year. There does not appear to be any seasonal trending in the metals values based on the 2016 data. Manganese has the largest amount of variability in the concentration values recorded, with values ranging from 0.57 to over 19.8 nanograms per meter cubed.

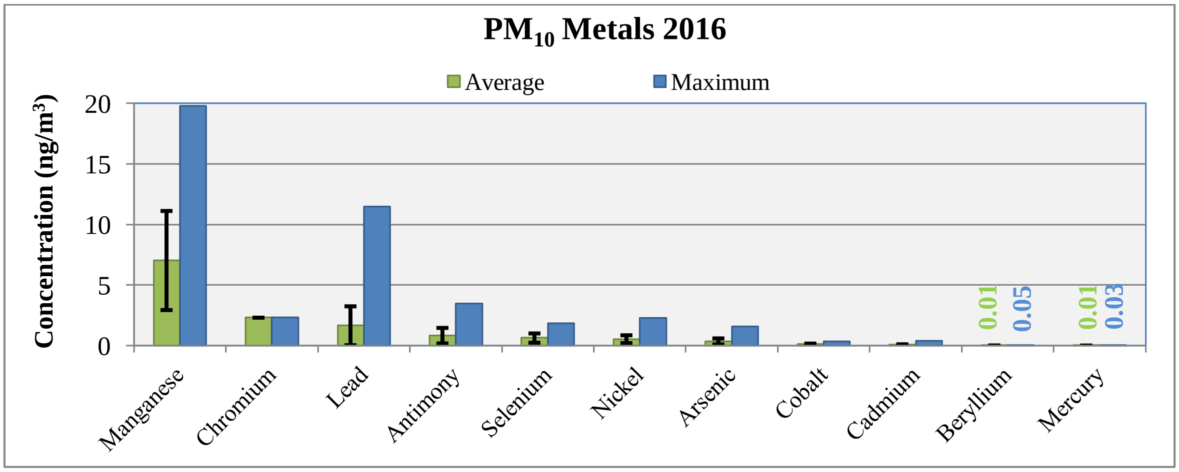


Figure 39. PM$_{10}$ Metals Average and Maximum Concentrations 2016

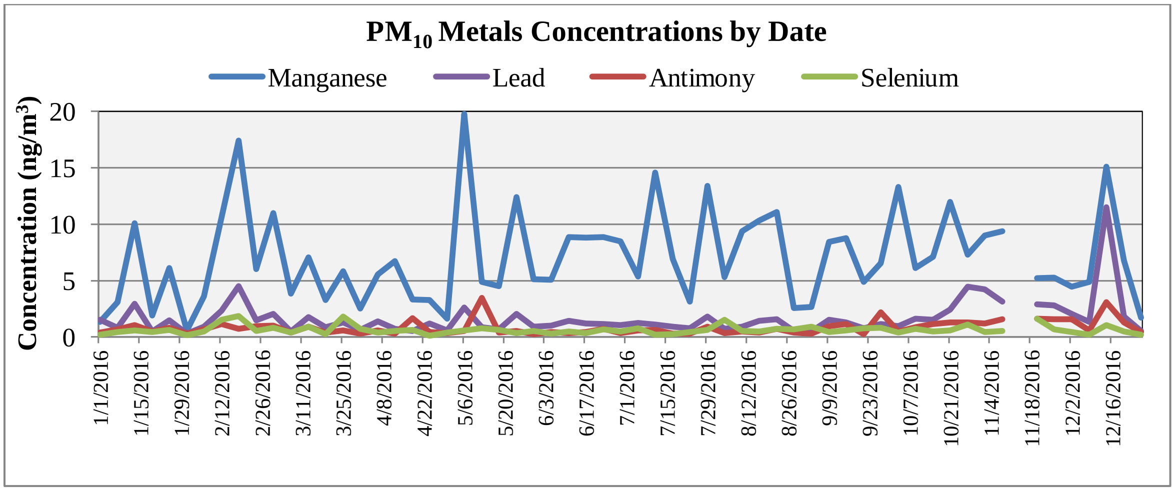


Figure 40. PM$_{10}$ Metals Concentrations by Date 2016

---

[9] "2014 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM). US EPA. February 2017.

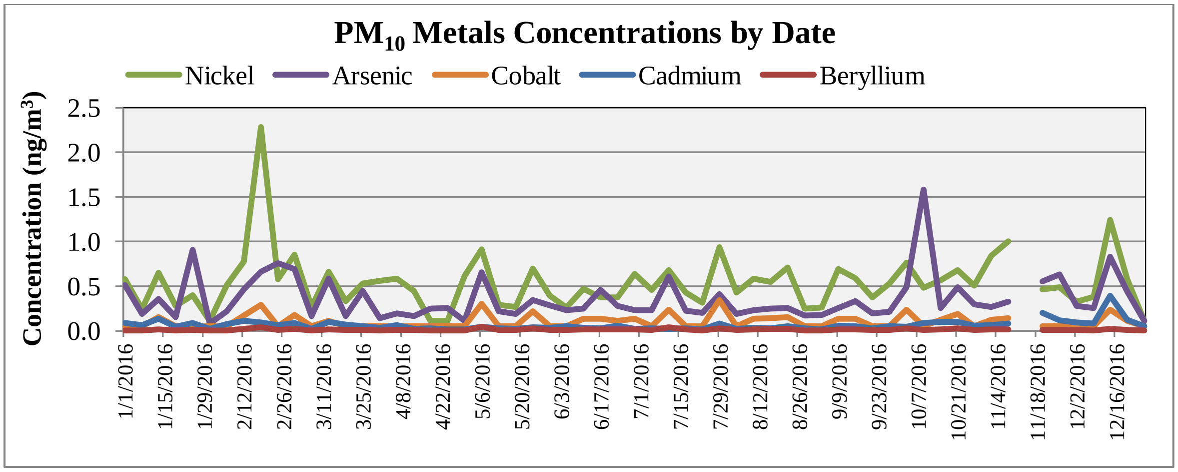


Figure 41. PM$_{10}$ Metals Concentrations by Date 2016, ctd.

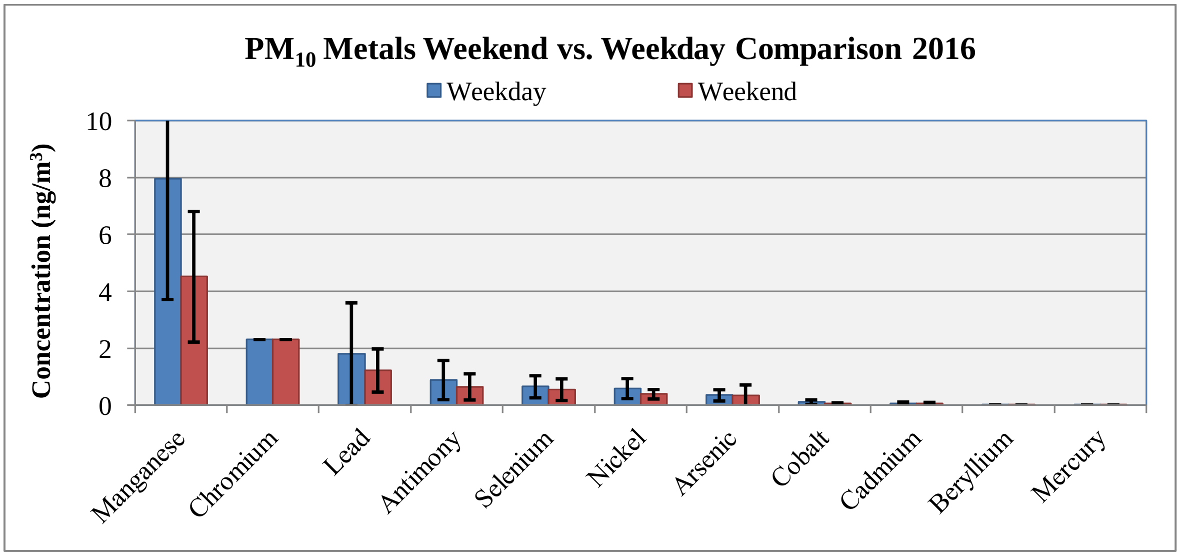


Figure 42. PM$_{10}$ Metals Weekend versus Weekday Comparison 2016

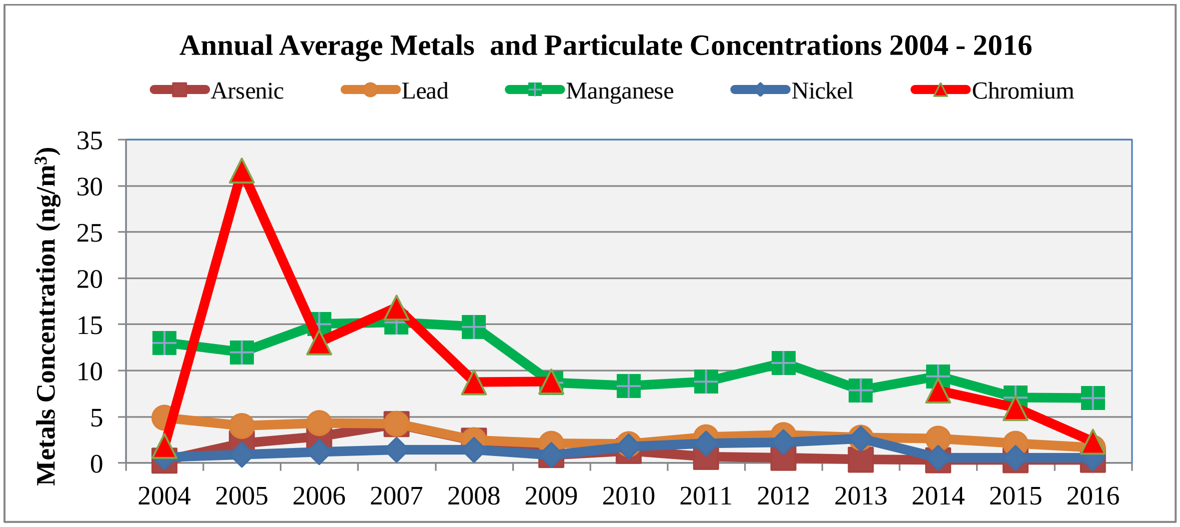


Figure 43. PM$_{10}$ Metals Annual Average Concentrations 2004 – 2016

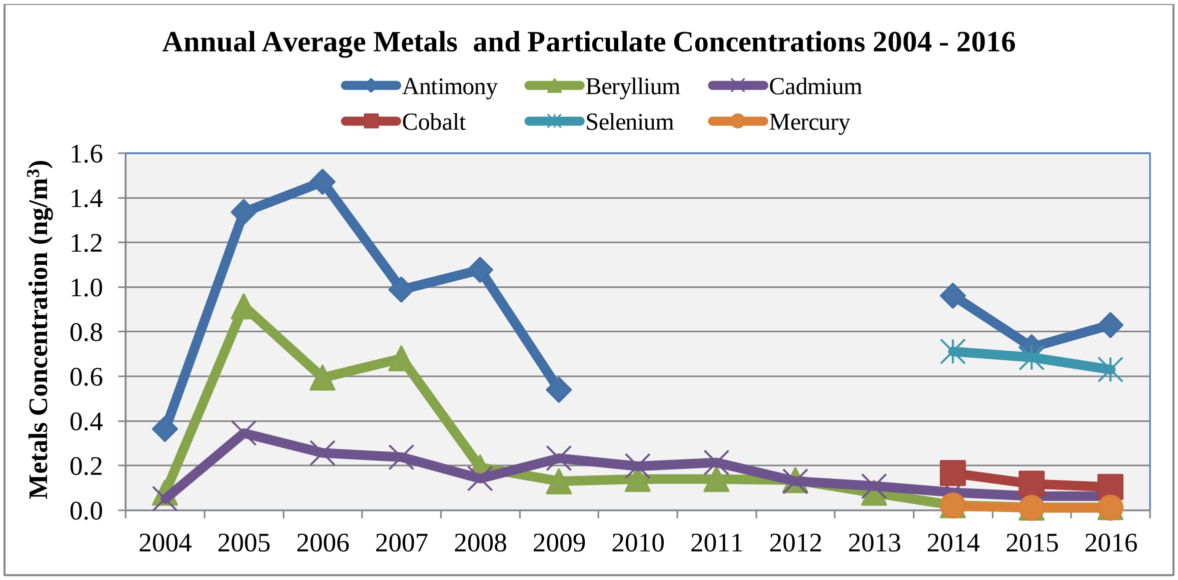


Figure 44. PM_{10} Metals Annual Average Concentrations, 2004 – 2016, ctd.

Figure 42 is a chart of the weekend versus weekday concentrations for the PM_{10} metals. All of the compounds had weekend averages that were equal to or less than the weekday averages. Chromium and mercury were not detected often, meaning the concentration values are heavily dependent on their MDL values, resulting in equal weekend and weekday concentrations. Figure 43 and Figure 44 are graphs of the annual average concentrations (2004 – 2016) for each of the PM_{10} metals. The graphs appear to show a general downward trend in the concentration values for many of the metals. A calculation of the 3-year averages from 2004 to 2006, 2007 to 2009, 2010 to 2012, and 2013 to 2015 shows a decrease in concentrations (going from the first 3-year average to the last 3-year average) for most compounds. These can be seen in Figure 45 and Figure 46. Also included in those figures are the 2016 annual averages for comparison purposes.

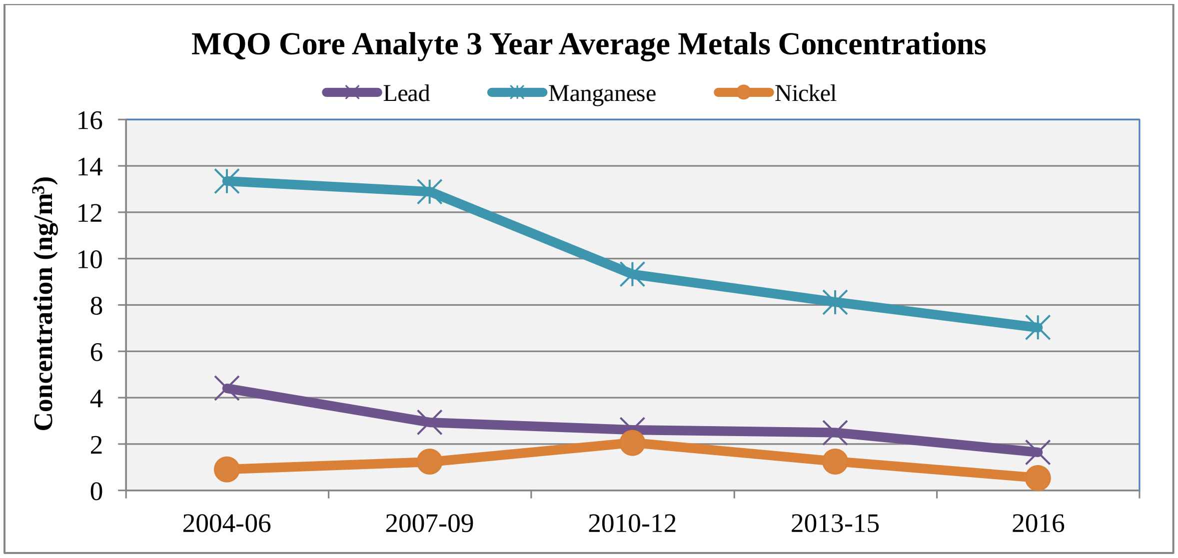


Figure 45. 3-Year Average Metals Concentrations

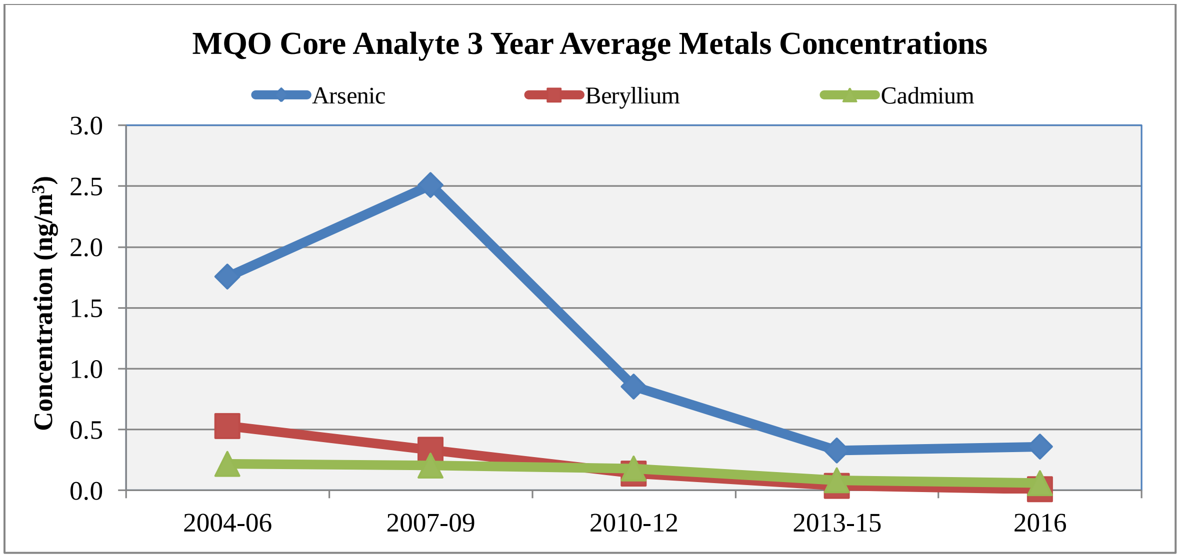


Figure 46. **3-Year Average Metals Concentrations (ctd.)**

Quality Assurance/Quality Control

Blanks

Periodically, the laboratory analyzes a "blank" or unused, filter for metals. The purpose of this extra analysis is to determine if there was any contamination of the filter during manufacturing, the sample setup/tear down or transport processes, or during laboratory processing. In 2016, there were six blank samples taken and analyzed by the lab. The concentration values seen in the blank samples were found to be less than their respective MDL values, so no blank corrections were made to the data set.

Precision of Sample Results

Once per month a secondary sampler was run simultaneously with the primary sampler. These additional samples, known as duplicates, were collected in order to assess the precision (repeatability) of the metals sampling method. In general, repeatability for the two collocated samples was acceptable for the compounds that were detected in greater than 10% of the samples taken. Information regarding precision and accuracy results is available upon request to the Air Pollution Control Division.

VII. PM$_{10}$

Sample Statistics Summary

The Colorado Department of Public Health and Environment operates samplers for particulate matter 10 microns or less in diameter (PM$_{10}$) at the Grand Junction – Powell station. These samplers serve to indicate the status of Grand Junction regarding the National Ambient Air Quality Standards (NAAQS) for PM$_{10}$. Results of the statewide particulate matter monitoring network are discussed in "Colorado: 2016 Air Quality Data Report" by the Air Pollution Control Division. In 2016, 124 samples were attempted, and 122 were collected on the primary sampler, bringing the final data recovery rate to 98%. The duplicate sampler was in operation for four of the missed samples.

Table 10. **PM_{10} Average and Maximum Concentrations 2004 – 2016**

Year	PM_{10} Concentrations			
	3rd Day		6th day	
	Average (µg/m^3)	Maximum (µg/m^3)	Average (µg/m^3)	Maximum (µg/m^3)
2004	29	102	29	102
2005	26	198	25	62
2006	30	98	30	66
2007	30	85	29	69
2008	30	116	30	84
2009	25	68	26	68
2010	22	155	19	57
2011	18	41	18	39
2012	22	77	20	44
2013	19	55	20	48
2014	18	46	19	46
2015	15	37	14	34
2016	15	37	15	35

Table 10 lists the average and maximum concentrations observed at the Grand Junction site from 2004 through 2016, for both the every third day and every sixth day samples. The averages are similar for the third and sixth day sampling, and are far lower than the 24-hour standard level of 150 micrograms per meter cubed. The maximum value observed in 2016 was 37 micrograms per meter cubed. The maximums are similar for some years, but quite different for others. To date, the highest concentration observed was 198 micrograms per meter cubed in 2005.

Graphs

The graphs in this section will cover data for the NATTS sampling calendar (every sixth day). Any data discussed will be derived from the every sixth day values. Figure 47 is a graph of the PM_{10} concentration data recorded every sixth sampling day. The graph does not appear to indicate any seasonal variation in 2016.

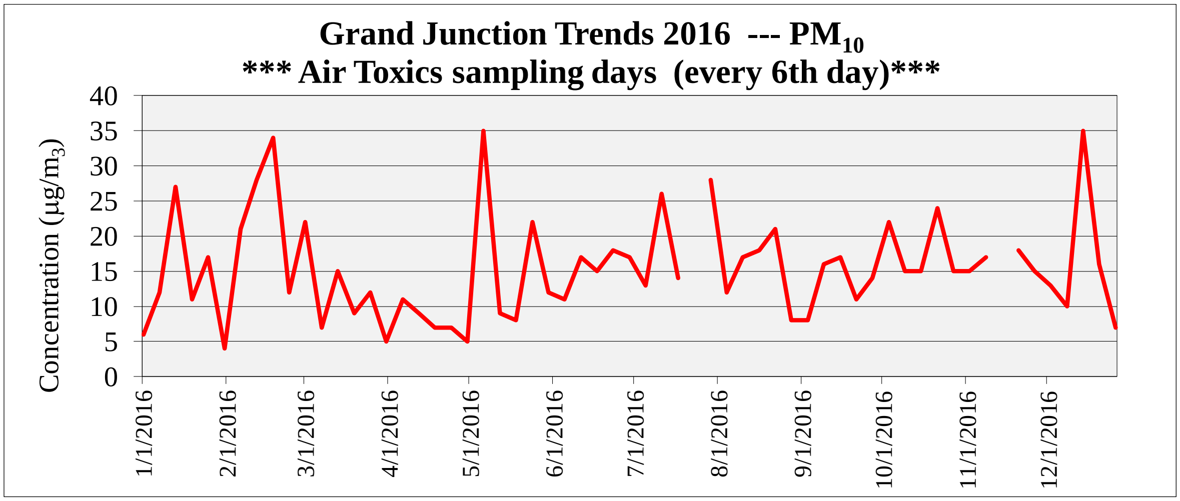


Figure 47. **PM_{10} Concentrations by Date, 2016 (every 6th Day)**

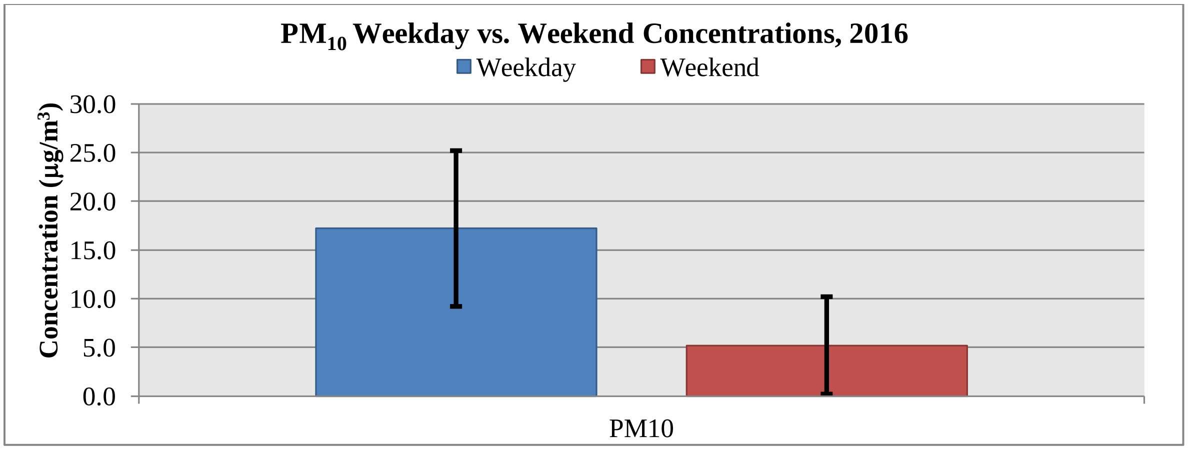


Figure 48. **PM_{10} Weekend vs. Weekday Comparison, 2016 (every 6th day)**

Figure 48 is a graph of the weekend versus weekday concentrations for PM_{10} on the every sixth day sampling schedule. The weekday average is larger than the weekend average. PM_{10} is dominated by surface disturbance of earth materials (e.g., street sand, windblown dust, etc.). The PM_{10} levels are subject to change due to daily weather conditions. Figure 49 is a graph of the annual average PM_{10} concentrations from 2004 through 2016, for the every sixth day sampling period. Figure 50 is a graph of the 24-hour maximum PM_{10} concentrations from 2004 through 2016, for the every sixth day sampling period. The maximum PM_{10} concentrations observed in each year are used for comparison to the NAAQS in this graph.

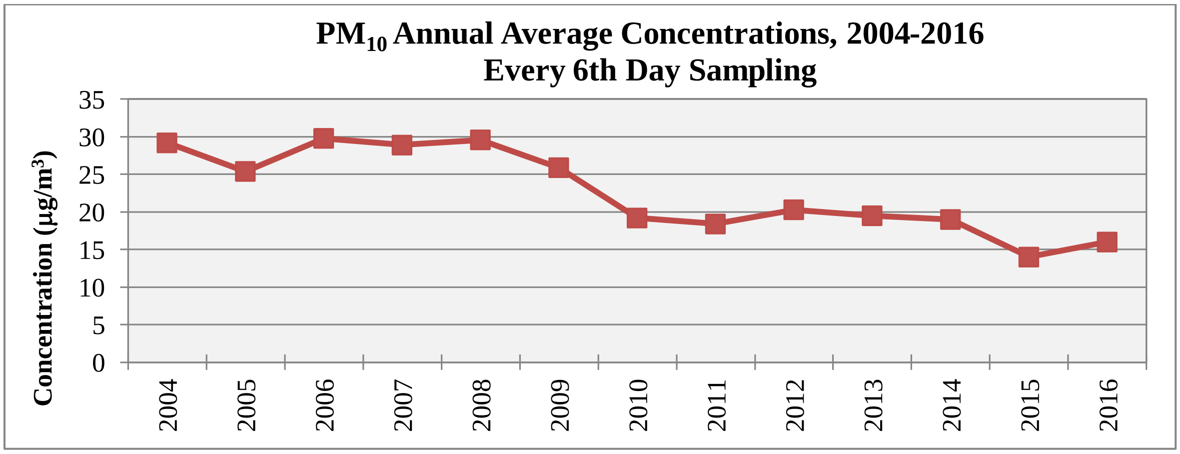


Figure 49. **PM_{10} Annual Average Concentrations 2004 – 2016**

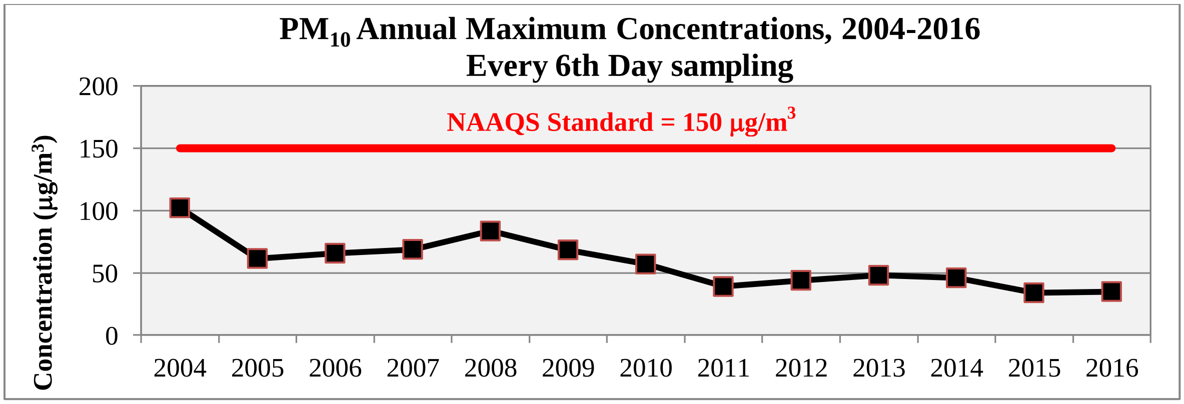


Figure 50. **PM_{10} Annual Maximum Concentrations 2004 – 2016**

Quality Assurance/Quality Control

Blanks

Blank filters are collected for the purposes of determining any bias in the sampling setup, removal, transport, or laboratory weighing processes. Data from these field blanks is available on request.

Precision of Sample Results

Collocated samples were run once every sixth day, half as frequently as the primary samples were run. This is done in an effort to validate the collected data. There is good agreement between the primary and collocated sampler concentrations. Information regarding precision and accuracy results is available upon request to the Air Pollution Control Division.

VIII. $PM_{2.5}$

Sample Statistics Summary

The Colorado Department of Public Health and Environment operates samplers for particulate matter 2.5 microns or less in diameter ($PM_{2.5}$) at the Grand Junction – Powell station. This sampler serves to indicate the status of Grand Junction regarding the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$. Results of the statewide particulate matter monitoring network are discussed in "Colorado: 2016 Air Quality Data Report" by the Air Pollution Control Division. The National Air Toxics Trends Study chose to monitor air toxics in Grand Junction due to the availability of a $PM_{2.5}$ speciation sampler, which gives insight into air toxics in particulate matter. It should be noted here, however, that the speciation sampler previously located in Grand Junction was removed, and relocated to the state's NCore site in Denver at the end of 2009. In addition, the filter-based monitor was removed in May of 2016 due to the addition of a continuous particulate monitor, the GRIMM. The $PM_{2.5}$ data discussed in this section is based on the gravimetric filter data from 2004 through 2015, and the continuous data generated in 2016. The data does not include any speciated results. In 2016, 366 daily averages were possible, and 363 were calculated on the daily sampling schedule, giving a 99% sampling rate.

Table 11. $PM_{2.5}$ Average Concentrations 2004-2016

Year	3rd day		6th day		98th %ile
	Average (µg/m^3)	1st Max (µg/m^3)	Average (µg/m^3)	1st Max (µg/m^3)	Max (µg/m^3)
2004	10.4	36.3	10.4	31.6	31.6
2005	8.4	19.0	7.9	18.2	18.0
2006	9.7	28.5	9.8	28.5	24.0
2007	9.5	30.7	9.0	30.7	26.0
2008	9.1	27.8	8.9	27.8	25.0
2009	9.8	59.1	10.5	59.1	41.0
2010	9.0	43.3	8.4	43.3	37.0
2011	7.1	23.9	6.8	23.9	22.0
2012	7.3	28.3	7.2	28.3	24.0
2013	8.8	42.2	8.6	40.3	40.0
2014	6.3	21.7	6.3	20.9	16.0
2015	5.4	22.2	5.5	22.2	19.0
2016	6.4	35.9	6.4	22.0	21.0

Table 11 lists the annual average and first maximum $PM_{2.5}$ concentrations at the Grand Junction sites for 2004 through 2016, for both every third day and every sixth day sampling. There is very little difference between the averages for the two sampling schedules, and they are less than the current annual standard level of 12 micrograms per cubic meter. $PM_{2.5}$ emissions are generated by agriculture, and the combustion of automobile fuels, coal, wood, etc., as well as by secondary formation from other available atmospheric compounds. Table 11 also lists the 98th percentile maximum values for 2004 through 2016.

To meet the primary $PM_{2.5}$ national standard, the three year average of the annual mean concentrations must be less than 12 micrograms per cubic meter. The design value for this site is 6.4 micrograms per meter cubed, thus the primary standard is met. To meet the secondary $PM_{2.5}$ national standards, the three year average of the annual mean must be less than 15 micrograms per cubic meter, and the 3 year average of the 98th percentile value must be less than 35 micrograms per meter cubed. Those values for this site are 6.4 and 19 micrograms per meter cubed, respectively. Therefore, the secondary standards are met.

Graphs

A graph of the daily concentration values for the every sixth day sampling subset is shown in Figure 51. The data appear to indicate that the $PM_{2.5}$ concentrations were seasonably variable. Concentrations appear to be more consistent during the summer months and vary more during the winter months when there is more smoke in the air from agricultural and household wood burning.

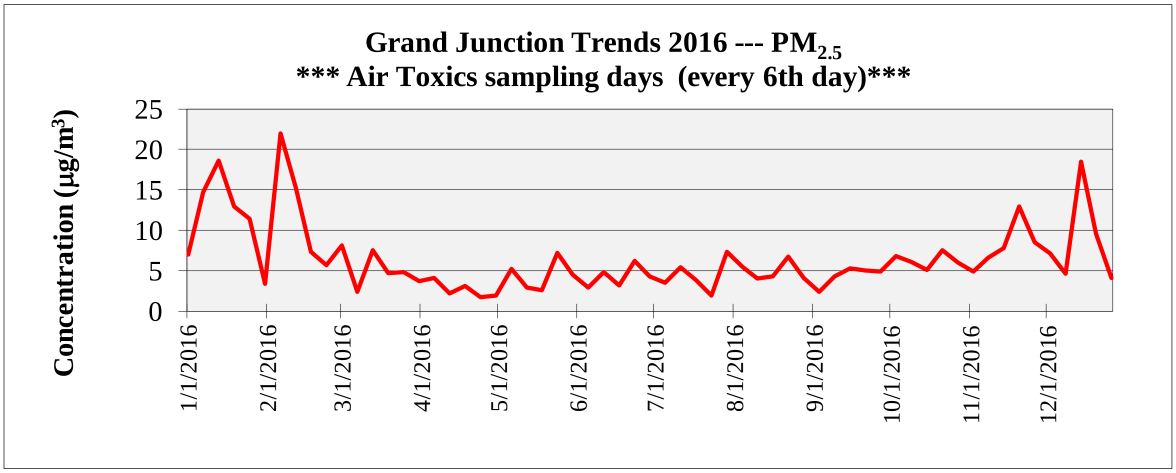


Figure 51. $PM_{2.5}$ Concentration by Date, 2016 (every 6th day)

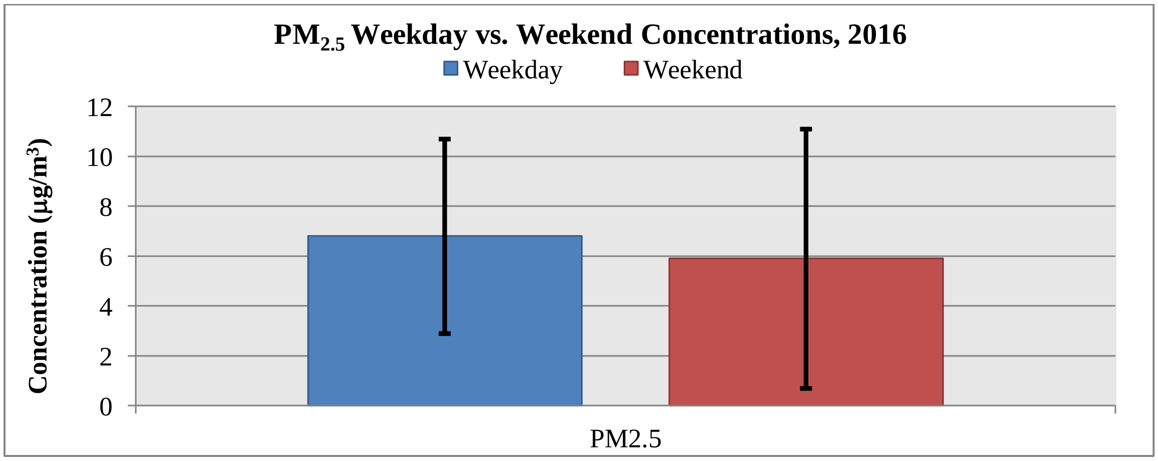


Figure 52. $PM_{2.5}$ Weekend vs. Weekday Comparison, 2004-2016 (every 6th day)

Figure 52 shows how the weekend versus weekday average concentrations compare for 2016, on the every 6th day sampling schedule. Figure 53 shows the annual average concentrations for $PM_{2.5}$ for 2004 through 2016. Overall, the average trend appears to be decreasing.

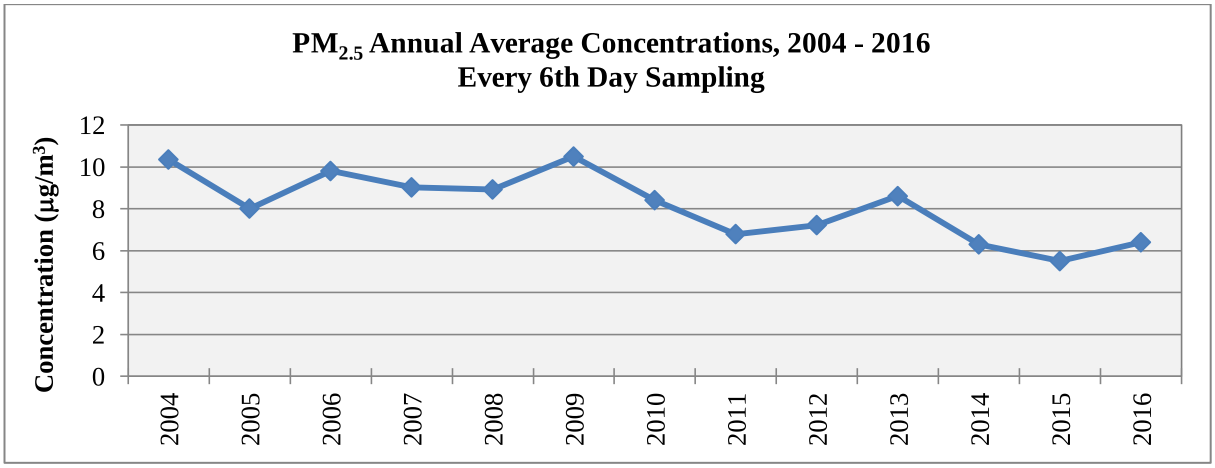


Figure 53. **$PM_{2.5}$ Annual Average Concentrations 2004 – 2016**

Quality Assurance/Quality Control

Precision of Sample Results

No collocated samples were run for $PM_{2.5}$, as there is currently only one $PM_{2.5}$ instrument available to place at the Grand Junction site.

IX. METEOROLOGY

A meteorological tower at the Pitkin shelter site measures wind speed, wind direction, relative humidity, and temperature. The 2016 wind rose is shown below in Figure 54. The “arms” of this diagram show the percentage of the time that the wind blew from each direction. The shading on each arm indicates the wind speeds associated with each direction. Each of the concentric rings, moving outward, signifies an additional 1.6 percent of the time. For example, about 7 to 8% of the winds are from the east. Wind speeds in the ranges of 0.5 to 2.1 meters per second (m/s) are the most frequent.

The wind rose shows that winds follow a daily pattern typical of river valleys. At night, the winds come from the southeast quarter, flowing down river. During the day, heating of the air causes flow reversals, and flow comes from the northwest.

A look at the highest concentrations days for each pollutant indicated that some days showed maxima for more than one air pollutant. Many of these dates are in the fall or winter period, which indicates possible local temperature inversions and limited air mixing, thus allowing pollutants of all types to build up in the area.

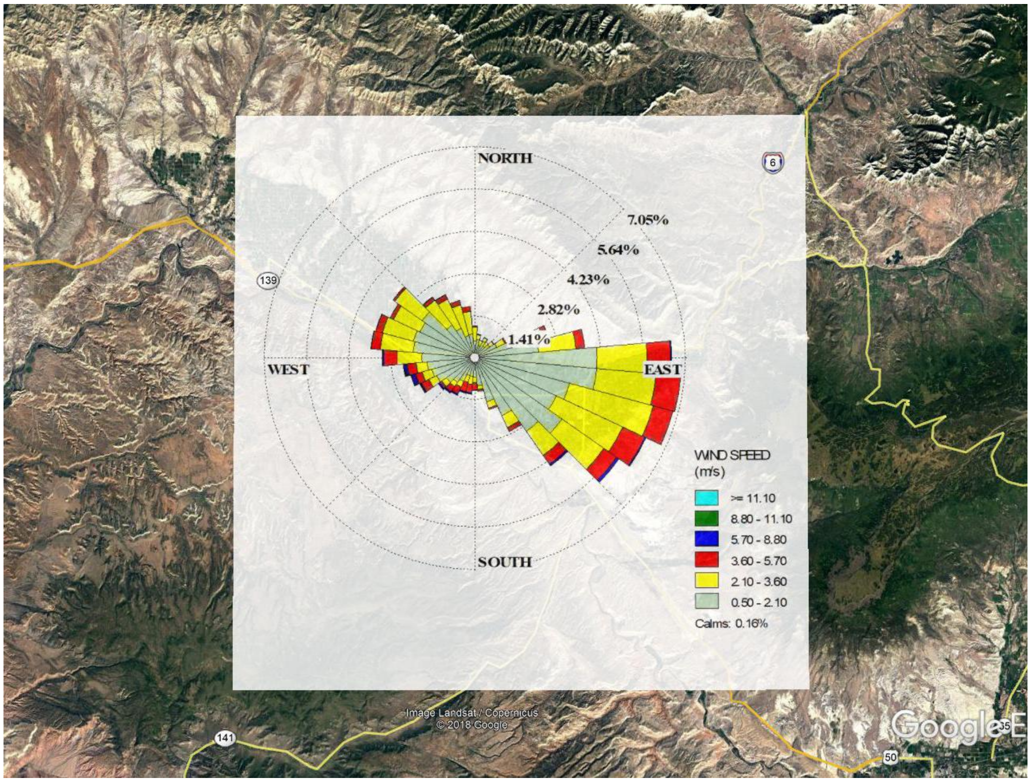


Figure 54. Wind Rose for Grand Junction 2016

X. DATA CORRELATIONS AND DISCUSSION

The data presented below are the results of several correlation comparisons between the particulate concentrations and various other air toxics compound concentrations.

Carbonyl Correlations and Sample Composition

Carbonyl compounds are known to have adverse effects on human health. They can be emitted directly from primary sources (motor vehicle emissions, and incomplete combustion), or can be formed secondarily via atmospheric photo-oxidation reactions.[10] They play an important role in the formation of ozone in the atmosphere, and are of great interest to atmospheric researchers, as is particulate matter. Particulates are a mixture of solid particles and liquid droplets found in the air. Of interest to researchers are two different classes of particulates: coarse (having a diameter of 10 micrometers or less), and fine (having a diameter of 2.5 micrometers or less). Fine particles are small enough to be inhaled deep into the lungs, and cause serious health problems. Fine particulates are the major cause of visibility issues in many parts of the U.S. A correlation of the annual average carbonyl concentration data was performed with both the PM_{10}, and $PM_{2.5}$ annual average data sets for 2004 through 2016. The results of the correlation are presented in Table 12.

---

[10] Wang et al., “Seasonal Variation and Source Apportionment of Atmospheric Carbonyl Compounds in Urban Kaohsiung, Taiwan.” *Aerosol and Air Quality Research,* 10: 559–570, 2010. http://aaqr.org/VOL10_No6_December2010/5_AAQR-10-07-OA-0059_559-570.pdf

Table 12. Correlation Coefficient Values for Carbonyls-Particulates

Analyte	r - PM_{10}	r-$PM_{2.5}$
2,5-Dimethylbenzaldehyde	0.62	0.42
2-Butanone (MEK)	0.45	0.65
Acetaldehyde	**0.71**	**0.63**
Acetone	0.81	0.62
Benzaldehyde	0.74	0.58
Butyraldehyde	0.81	0.53
Crotonaldehyde	0.83	0.57
Formaldehyde	**0.49**	**0.50**
Hexaldehyde	0.70	0.56
Isovaleraldehyde	0.79	0.51
Propionaldehyde	0.75	0.42
Tolualdehydes	0.84	0.57
Valeraldehyde	0.52	0.31

Bold = MQO Core Analyte

Nine of the thirteen carbonyl compounds tended to correlate well with the PM_{10} data, having "r" values of 0.7 or larger. The tolualdehydes show the strongest correlation with an "r" value of 0.84. One of the two MQO Core Analyte carbonyls, acetaldehyde, did show some correlation with the course particulate concentrations. There was little correlation between any of the carbonyls and the fine particulate concentrations. 2-Butanone had the highest "r" value of the group at 0.65. A graph of the four carbonyls with "r" values greater than or equal to 0.80 for the PM_{10} correlation is shown in Figure 55.

The final graph presented in this section is a snapshot of the chemical make-up of the carbonyls group from 2004 through 2016. Figure 56 shows the percentage each carbonyl compound contributed to the overall total carbonyl concentration from year to year. Acetone, acetaldehyde, and formaldehyde clearly dominate the carbonyl concentrations, comprising nearly 80% of the overall concentrations from year to year.

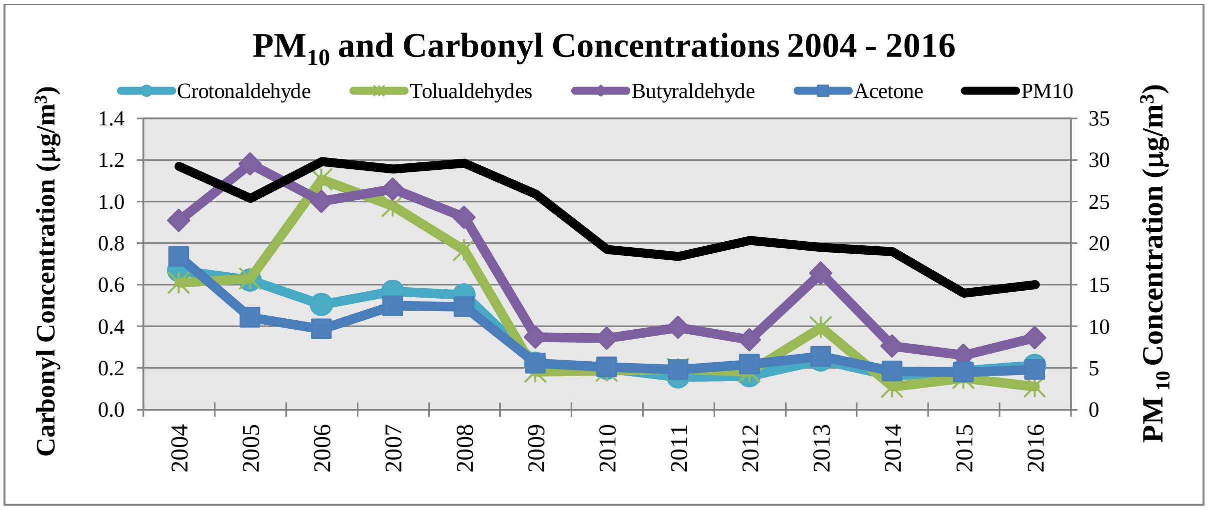


Figure 55. PM_{10} – Carbonyl Concentration Comparison

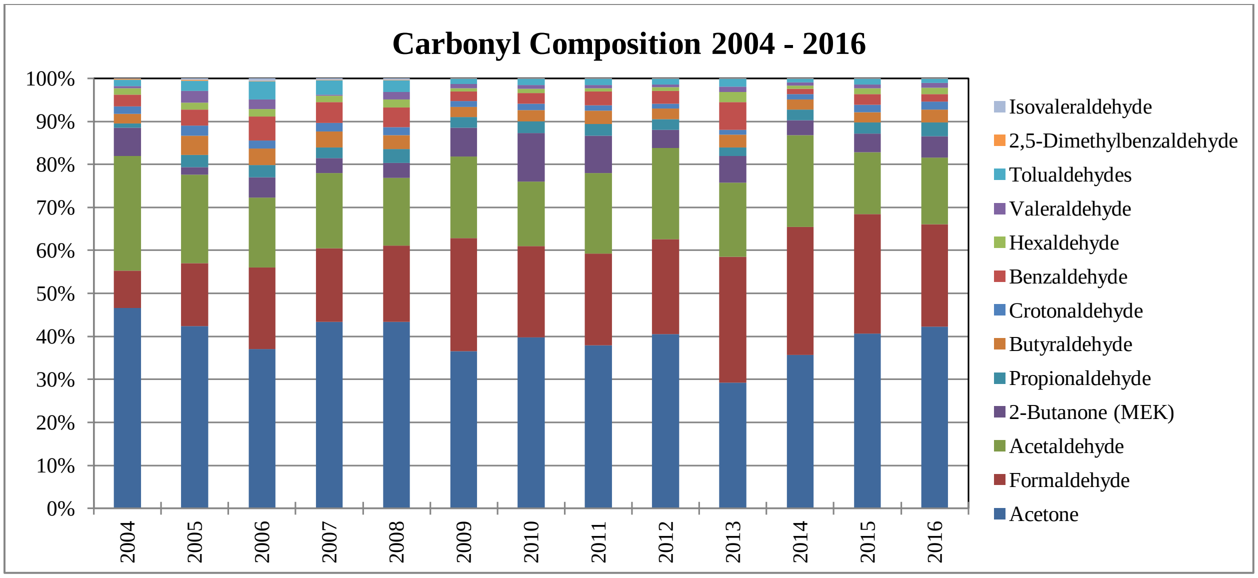


Figure 56. Annual Carbonyl Composition

VOC Correlations and Sample Composition

VOCs are organic compounds which have a high vapor pressure at room temperature. Because of this high vapor pressure, which is the result of a low boiling point, large numbers of VOC molecules can evaporate or sublimate from a liquid or solid form and enter the ambient air. The NATTS program monitors for 60 of these compounds, many of which are never detected in any samples. The VOC correlation data used and discussed in this section is based upon a subset of 37compounds that were detected in greater than 10% of the samples taken since 2004, and the MQO Core Analytes that did not meet that criterion. The MQO Core Analytes are bolded in the table below.

Table 13 is a listing of the correlation coefficients (r) for each of the 37 VOC compound data sets, with both $PM_{2.5}$, and PM_{10} data sets for 2016. For the VOC - PM_{10} correlation, 1,1,1-Trichloroethane, acetylene, benzene, and carbon disulfide correlated fairly well with the coarse particulate concentrations with correlation coefficient values of 0.81, 0.81, 0.84, and 0.83, respectively. Figure 57 is a graph of the carbon disulfide, benzene, acetylene, and PM_{10} annual average concentrations from 2004 through 2016. The 1,1,1-trichloroethane concentrations were not included in the graph as the values were so low compared to the other compounds that the graph shows up as a straight line at the bottom of the graph.

Table 13. VOC – Particulate Correlation Coefficient Values

Compound	**PM_{10}**	**$PM_{2.5}$**
1,1,1-Trichloroethane	0.81	0.71
1,2,4-Trimethylbenzene	0.63	0.52
1,2-Dichloroethane	-0.17	-0.22
1,3,5-Trimethylbenzene	0.58	0.49
1,3-Butadiene	**0.69**	**0.57**
Acetonitrile	-0.45	-0.43
Acetylene	0.81	0.76
Acrolein	**-0.54**	**-0.29**
Acrylonitrile	-0.06	-0.14
Benzene	**0.84**	**0.81**
Bromomethane	-0.48	-0.50
Carbon Disulfide	0.83	0.73

Compound	**PM_{10}**	**$PM_{2.5}$**
Carbon Tetrachloride	**-0.06**	**-0.02**
Chloroethane	0.14	0.11
Chloroform	**-0.13**	**-0.02**
Chloromethane	0.16	0.19
Dibromochloromethane	0.22	0.17
Dichlorodifluoromethane	0.54	0.65
Dichloromethane	-0.58	-0.47
Dichlorotetrafluoroethane	-0.46	-0.32
Ethyl tert-Butyl Ether	-0.16	-0.23
Ethylbenzene	0.50	0.38
Hexachloro-1,3-butadiene	0.25	0.12
m,p-Xylene	0.54	0.40
Methyl Isobutyl Ketone	0.61	0.54
Methyl Methacrylate	0.69	0.48
n-Octane	-0.07	-0.07
o-Xylene	0.47	0.33
p-Dichlorobenzene	0.33	0.27
Propylene	0.70	0.63
Styrene	-0.53	-0.57
Tetrachloroethylene	**0.64**	**0.79**
Toluene	0.59	0.49
Trichloroethylene	**0.21**	**0.26**
Trichlorofluoromethane	0.46	0.62
Trichlorotrifluoroethane	0.68	0.70
Vinyl chloride	***0.62***	***0.49***

Bold = MQO Core Analyte
Italic = Did not meet detection requirements

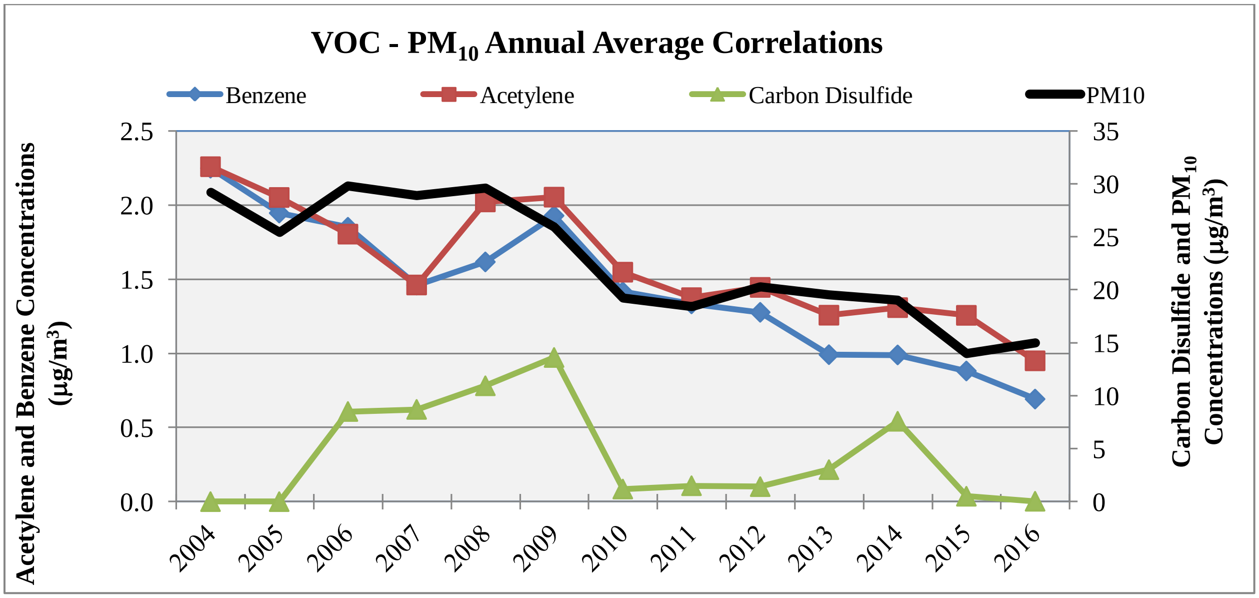


Figure 57. VOC – PM_{10} Concentration Comparison

The VOC – $PM_{2.5}$ correlation also showed several compounds with relatively strong correlations. Benzene correlated well with the fine particulate matter concentrations, showing a positive r-value of 0.81. Acetylene and carbon disulfide also showed some correlation with the fine particulate matter, with r-values of 0.76, and 0.73, respectively. In addition, 1,1,1-trichloroethane, tetrachloroethylene, and trichlorotrifluoroethane also showed a slight correlation with PM2.5 having r-values of 0.71, 0.79, and 0.70, respectively. Those compounds are not included in Figure 56 as their concentration values were so low that they appear as straight lines when graphed with benzene, acetylene, and carbon disulfide. Figure 58 shows the annual average concentrations for benzene, acetylene, carbon disulfide, and $PM_{2.5}$.

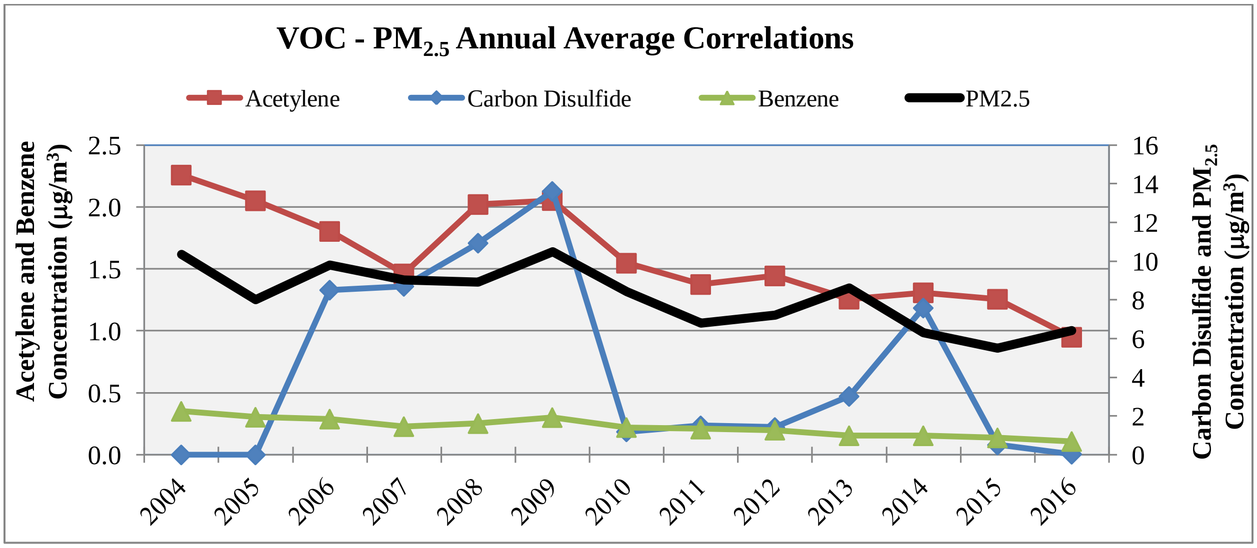
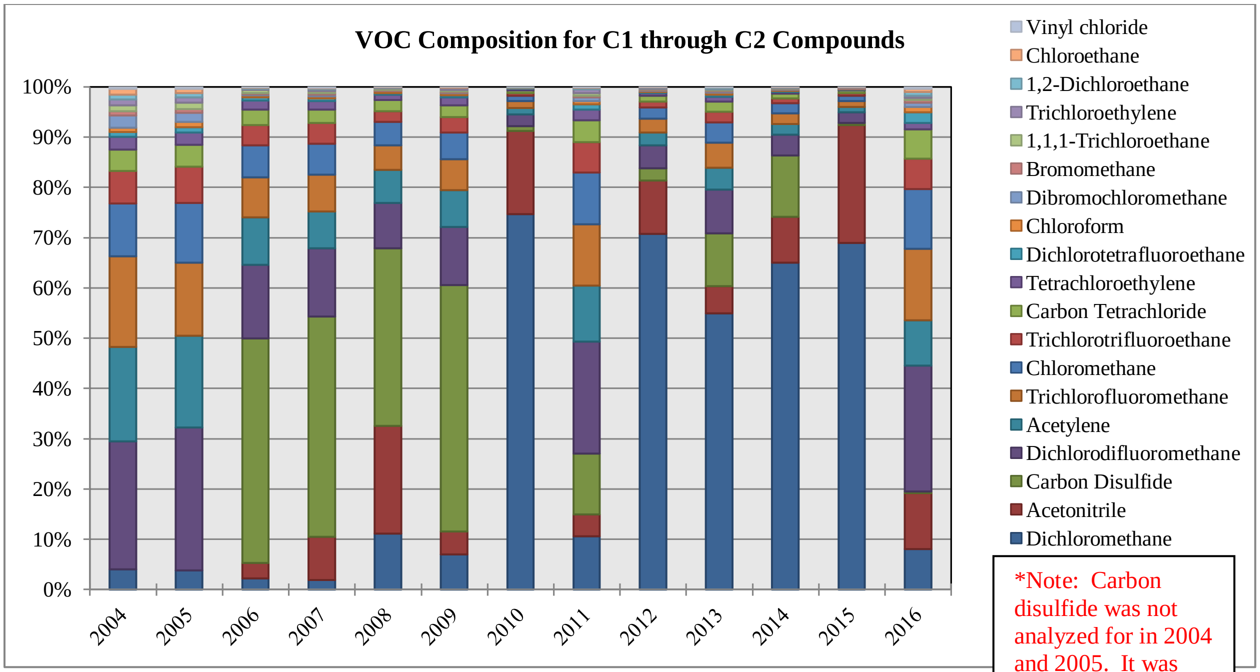


Figure 58. VOC – $PM_{2.5}$ Concentration Comparison

The chemical make-up of the VOC compounds tends to be much more variable from year to year than the carbonyl compounds. This is especially true for the C1 through C2 carbon chains of the VOCs, which can be seen in Figure 59. The graph shows data from 2004 through 2016. The year to year variability is easily seen. Carbon disulfide was not sampled for during the 2004 and 2005 campaigns, but was added in 2006. It was a major component of the VOCs for 2006 through 2009, but has not been a major contributor since 2009. The data from 2010, 2012, 2013, 2014, and 2015 show a shift to dichloromethane as a large component of this VOC group, comprising 50 to 75 percent of the C1through C2 VOC composition.



*Note: Carbon disulfide was not analyzed for in 2004 and 2005. It was added to the analysis in 2006.

Figure 59. **Total VOC Composition for C1 through C2 Compounds**

Figure 60 shows the chemical composition of the C3 though C9 carbon chain compounds. These compounds tend to show a more consistent make-up from year to year, as opposed to the lighter end alkanes of the C1 and C2 chains. It should be noted that this grouping contains straight chain alkanes, as well as aromatic compounds. It seems likely that the major source for these C3 through C9 compounds is from motor vehicle traffic, due to the consistent nature of the chemical makeup, and the site's nearness to a major road. In 2015, styrene concentrations dominated the mix, comprising more than 60% of the matrix. This is a large jump from previous years.

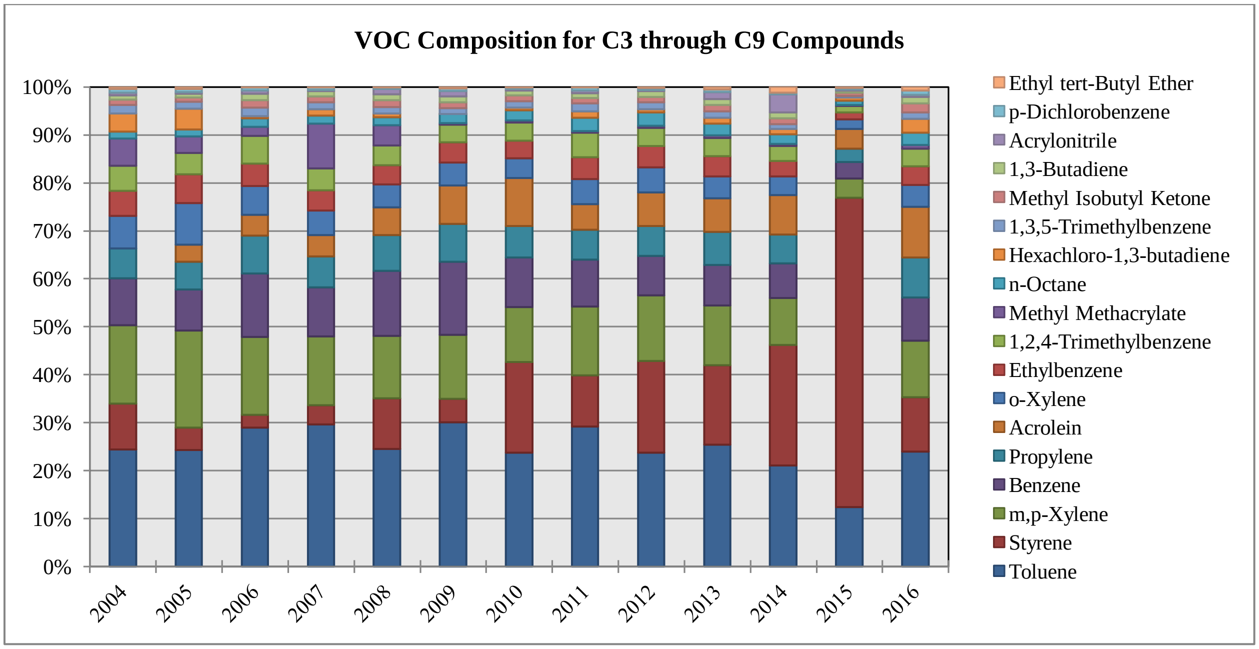


Figure 60. **Total VOC Composition for C3 through C9 Compounds**

PAH Correlations and Sample Composition

Polycyclic Aromatic Hydrocarbons are often found naturally in the environment, but are also man-made. They can enter the air through the incomplete combustion of fuels and garbage. They are a concern because of their toxicity and persistence in the environment. Table 14 lists the correlation coefficient values for each of the PAH compounds with $PM_{2.5}$ and PM_{10} data sets for 2016. All but one of the compounds show little to no correlation with the PM_{10} values. This is reasonable, since PM_{10} is largely from geologic sources.

This particular set of compounds did tend to trend better with the fine particulate matter concentrations. All but two compounds showed positive correlations with the $PM_{2.5}$ concentrations. The strongest correlation between the PAH and $PM_{2.5}$ concentrations was seen with acenapthylene. A correlation coefficient of 0.90 was obtained for this compound. PAHs can exist in liquid or solid phases, so their positive relationship with the smallest diameter particles, which develop from gaseous condensation, is easily explained. PAHs and $PM_{2.5}$ are also both direct combustion products. The compounds with correlation coefficient values that are greater than 0.75 are graphed in Figure 61.

Table 14. PAH – Particulate Correlation Coefficient Values

PAH correlations	r - PM_{10}	r - $PM_{2.5}$
9-Fluorenone	-0.04	0.29
Acenaphthene	0.21	0.13
Acenaphthylene	0.65	0.90
Anthracene	0.17	0.42
Benzo (a) anthracene	0.23	0.59
Benzo (a) pyrene	0.28	0.59
Benzo (b) fluoranthene	0.41	0.77
Benzo (e) pyrene	0.30	0.64
Benzo (g,h,i) perylene	0.53	0.78
Benzo (k) fluoranthene	0.49	0.78
Chrysene	0.08	0.54
Coronene	0.57	0.70
Cyclopenta[cd]pyrene	0.58	0.58
Dibenz (a,h) anthracene	0.77	0.59
Fluoranthene	-0.57	-0.35
Fluorene	0.11	0.18
Indeno(1,2,3-cd)pyrene	0.44	0.71
Naphthalene	0.41	0.57
Perylene	0.63	0.71
Phenanthrene	-0.12	-0.03
Pyrene	-0.19	0.14
Retene	0.35	0.77

Bold = MQO Core Analyte
Italic = Detected in less than 10% of samples taken

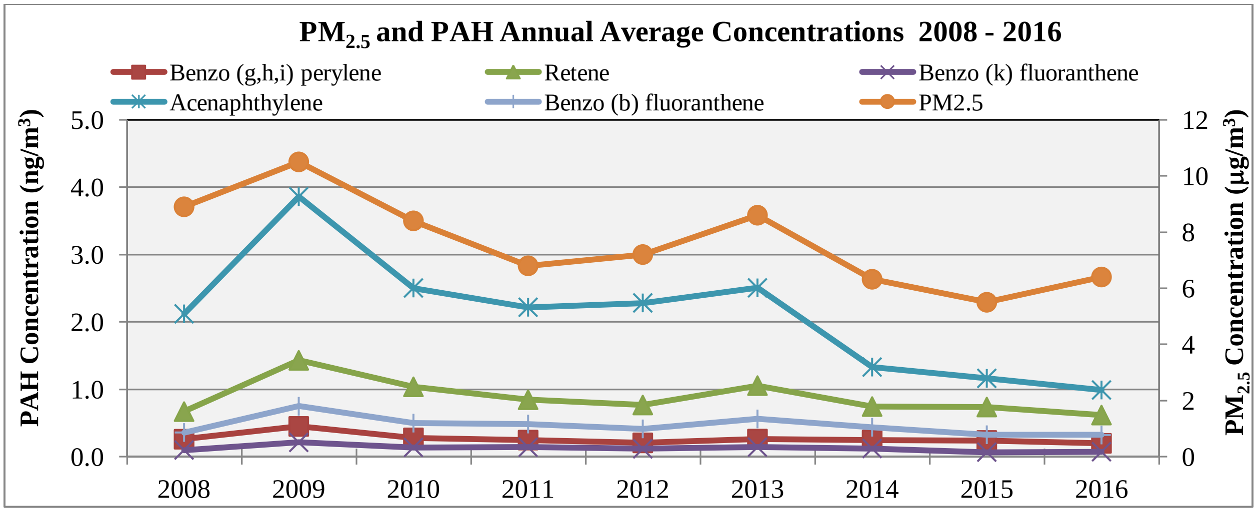


Figure 61. PAH – $PM_{2.5}$ Concentration Comparison

Figure 62 is a graph showing the percentage contribution each of the PAH compounds to the total PAH concentration. Clearly, naphthalene is the dominant compound of the group, consistently making up more than 60% of the PAH composition. The composition of the PAH group does not appear to vary much from year to year. This may imply that PAH sources are consistent over time.

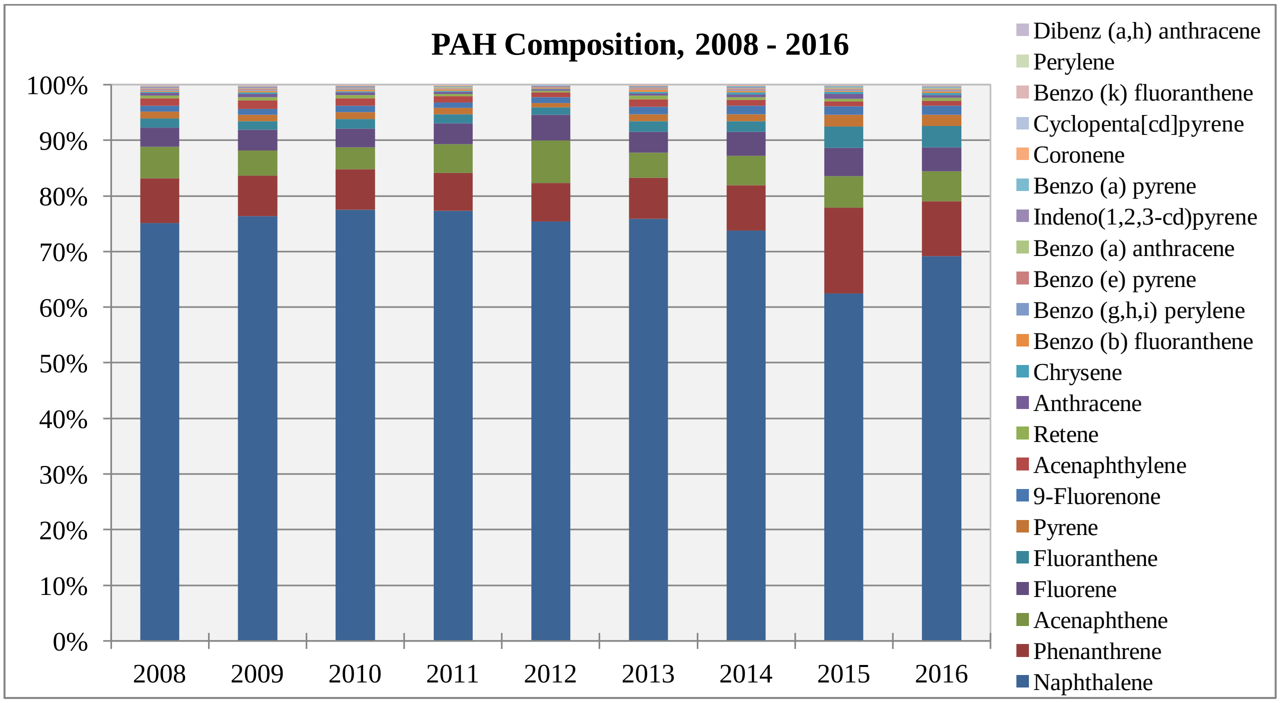


Figure 62. PAH Chemical Composition 2008 – 2016

Metals Correlations and Sample Composition

The metals in this group are sampled via a PM_{10} filter based monitor. Six of the metals sampled for are listed as MQO Core Analytes. The correlation coefficients for the metals compounds (having enough data to correlate) with the two different particulate classes are shown in Table 15 for 2016. Manganese and lead concentrations correlated well with the PM$_{10}$ concentrations, having r-values of 0.90 and 0.71, respectively. There were no significant correlations between any of the metals compounds and the PM$_{2.5}$ concentrations. This suggests that select metals may be coming from geologic crustal, rather than combustion or secondary formation, sources. Nickel sources include various metal alloys, electroplating, motor vehicle exhaust, and geologic crustal material.[11] A graph of the PM$_{10}$, lead, and manganese concentrations is seen in Figure 63.

Table 15. Metals – Particulates Correlation Coefficients

Analyte	**r-PM$_{10}$**	**r-PM$_{2.5}$**
Antimony	0.21	-0.09
Arsenic	**0.68**	**0.41**
Beryllium	**0.57**	**0.31**
Cadmium	**0.46**	**0.36**
Chromium	0.32	0.10
Cobalt	----	----
Lead	**0.71**	**0.51**
Manganese	**0.90**	**0.57**
Mercury	----	----
Nickel	**-0.04**	**0.08**
Selenium	----	----

Bold = MQO Core Analyte

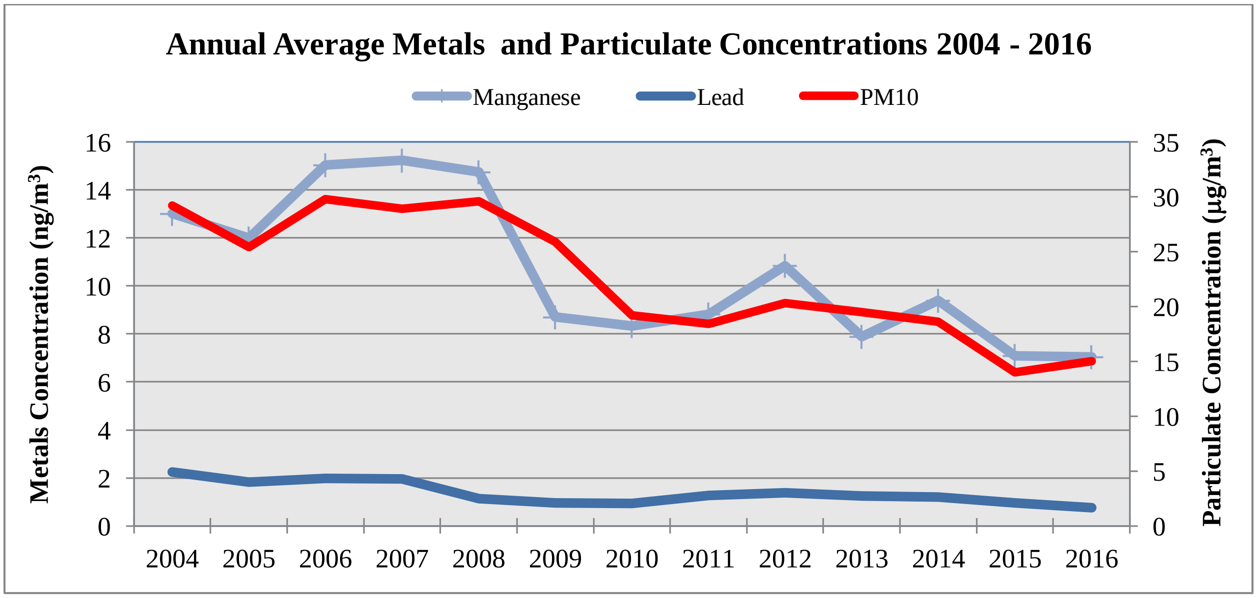


Figure 63. Metals – PM$_{10}$ Concentration Comparison

Figure 64 is a graph showing the percentage contribution of each of the individual metals compounds to the overall total. The concentrations vary somewhat from year to year, but not as much as the C1 through C2 compounds of the VOC section. It should be noted here that although the chromium concentrations appear to make up a large portion of the metals composition, the compound was never detected at levels above the MDL in 2016.

---

[11] http://scorecard.goodguide.com/chemical-profiles/html/nickel.html

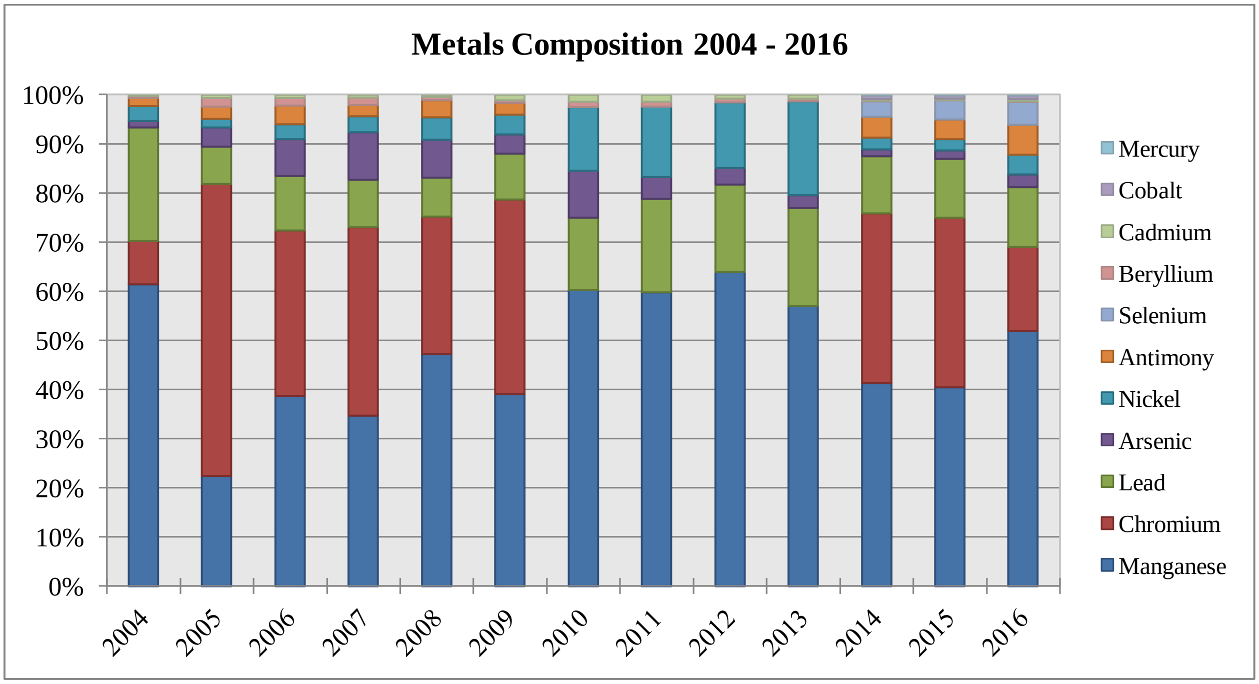


Figure 64. Metals Chemical Composition 2004 – 2016

XI. SUMMARY AND CONCLUSIONS

The National Air Toxics Trends Study in Grand Junction for 2016 showed similar results to prior years. The highest carbonyls in air were formaldehyde, acetaldehyde, and acetone. A correlation analysis was run between the particulate concentrations and the carbonyl concentrations. PM_{10} concentrations tended to correlate with many of the carbonyl compounds. A correlation value (r) of 0.84 was obtained when comparing annual average PM_{10} to the tolualdehydes concentrations. This value was the highest obtained for the PM_{10}-carbonyl correlation. A comparison of the $PM_{2.5}$ concentrations with the carbonyls showed that 2-butanone correlated the best, but had a moderate correlation coefficient value of 0.65. Many of the carbonyls showed no correlation at all with the $PM_{2.5}$ values.

Thirty-seven volatile organic compounds are ubiquitous, having been detected in at least 10% of the air samples taken in 2016. From 2004 to 2016, the makeup of the C1 to C2 group was highly variable, with large concentrations of carbon disulfide from 2006 through 2009, and moderate concentrations in 2011, 2013, and 2014. There were also large concentrations of dichloromethane in 2010, 2012, 2013, 2014 and 2015. The C3 through C9 group showed more consistency in the constituent concentrations from 2004 to 2016, with the exception of styrene, which showed a marked increase in concentration from 2014 to 2015, but then dropped again in 2016. Correlations with particulate data showed that carbon disulfide, benzene, and acetylene tracked most closely with the PM_{10} concentrations, with r-values of 0.83, 0.84, and 0.81, respectively. Benzene correlated best with the fine particulate concentrations, having an r-value of 0.81.

The highest polycyclic aromatic hydrocarbons concentrations were naphthalene, acenaphthyene, and phenanthrene, none of which correlated well with PM_{10} concentrations. The compounds that did correlate well with the fine particulate matter were acenaphthylene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, and retene, with r-values of 0.90, 0.77, 0.78, 0.78, and 0.77, respectively. Several of the other PAH compounds also correlated somewhat with $PM_{2.5}$ values. Their r-values were at or near the 0.70 cutoff.

For the metals, lead and manganese showed the highest average concentrations. Manganese had the highest correlation value with the coarse particulate matter at 0.90. It is important to note here that many of the metals concentrations rely heavily on their respective MDLs. None of the metal compounds showed any correlation with fine particulate matter.

In general, it appears that the concentrations of many of the compounds of interest are dropping since the inception of the NATTS program in Grand Junction. The study will continue in 2017, as one of the major goals is to run the site long term, for comparison of the mean concentrations for each pollutant during the first three years to the means for successive three year intervals. Calculation of the three year average concentrations to date has shown a decrease in the majority of the concentrations of the compounds of interest.

Appendix A: Compounds Contributing to Cancer and Non-cancer Risks - Overview of Sources and Health Effects

Chemicals can be released to the environment as a result of their use and manufacture. Some chemicals may also form, as other chemicals react with sunlight and one another in outdoor air. A brief summary of the potential sources and health effects of some prevalent chemicals in the ambient air is provided below. This information is adopted from the following main sources: EPA Air Toxic Website, EPA Office of Pollution Prevention and Toxics (OPPT), EPA Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry (ATSDR), New Jersey Department of Health and Senior Services, Occupational Safety and Health Administration (OSHA), National Institute of Occupational Safety and Health (NIOSH), and the California Air Resources Board (CARB).

CARBONYLS

Three of the twelve carbonyl compounds sampled are discussed below. These three are believed to be significant health risk drivers, at the national level.

ACETALDEHYDE

Acetaldehyde is a hydrocarbon with the formula CH_3CHO. It is thus closely related to formaldehyde, HCHO. Like formaldehyde, it exists in the atmosphere as a gas with a pungent odor. Acetaldehyde is ubiquitous in the ambient environment. It is mainly used as an intermediate in the synthesis of other chemicals, such as acetic acid, acetic anhydride, chloral, and glyoxal. It is employed in the food processing industry as a food and fish preservative, a flavoring agent, and in gelatin fibers. The tanning and paper industries use acetaldehyde, as do the perfume and dye manufacturers (CARB Acetaldehyde Fact Sheet).

Acetaldehyde can be released to the environment as a product of incomplete combustion in fireplaces and wood stoves, forest and wild fires, pulp and paper production, stationary internal combustion engines and turbines, vehicle exhaust, and petroleum refineries. Waste water processing is also a source. It is important to note that residential fireplaces and woodstoves are the two highest sources of emissions, followed by various industrial emissions.

Although it is used in industry, the California Air Resource Board believes that the largest sources of acetaldehyde in outdoor air are combustion and production from photochemical reactions (CARB Acetaldehyde Fact Sheet). Acetaldehyde itself can break down in these complex reactions between air pollutants and sunlight, forming formaldehyde.

The health effects of acetaldehyde are very similar to those of its chemical relative formaldehyde. It irritates the eyes and mucous membranes. It can paralyze the respiratory muscles, act as a narcotic to prevent coughing, and speed up pumping of the heart. Exposure can lead to headaches and sore throat. (Kirk Othmer, Vol 1, page 107). It should be noted that most of these health effects have been observed in factory workers, who are exposed to acetaldehyde concentrations thousands of times greater than those occurring in outdoor air. Acetaldehyde is believed to be a probable human carcinogen, leading to cancer of the nose and throat. Acetaldehyde has been shown to cause birth defects in animals, but no human research is available. (CARB Acetaldehyde Fact Sheet).

EPA's Technology Transfer Network Air Toxic Website provides information on the potential health effects of acetaldehyde. According to this source, the primary acute effects of acetaldehyde are irritation of the eyes, skin, and respiratory tract in humans. At higher exposure levels erythema, coughing, pulmonary edema, and necrosis may happen. Chronic toxicity symptoms in humans resemble those of alcoholism.

The EPA has established a Reference Concentration (RfC) for inhalation exposure to acetaldehyde based on degeneration of the olfactory epithelium in rats. No information is available on the reproductive and developmental effects of acetaldehyde in humans. Animal studies data indicate that acetaldehyde may be a potential developmental toxin. EPA has classified acetaldehyde as a Group B2, probable human carcinogen, based on increased incidence of nasal tumors in male and female rats and laryngeal tumors in male and female hamsters after inhalation exposure.

The California Air Resources Board observed an annual mean of 1.33 ppb acetaldehyde in its state-wide network during 1996 (CARB Acetaldehyde Fact Sheet). The mean observed in this Grand Junction study, 3.2 ppb, is a bit above the California data, but acetaldehyde in Grand Junction occurs at levels typical of large urban areas. Acetaldehyde levels are a national problem related primarily to the use of motor vehicles.

CROTONALDEHYDE

Crotonaldehyde with the chemical formula of C_4H_6O is also known as propylene aldehyde, betamethyl-acrolein, crotinin aldehyde and butenal. Crotonaldehyde is a colorless liquid with a pungent, suffocating odor.

Crotonaldehyde can be emitted to the environment from the combustion of gasoline, the burning of wood, paper, cotton, plastic, and tobacco. It can also be released through industrial use. It is found naturally in emissions of some vegetables and volcanoes.

According to the ATSDR Medical Management Guidelines, inhaled crotonaldehyde is highly toxic. It is irritating to the upper respiratory tract even at low concentrations. Crotonaldehyde vapor is heavier than air. Therefore, higher levels of crotonaldehyde vapors would be found nearer to the ground. The mechanism of toxicity of crotonaldehyde is not known, but it is highly reactive. Crotonaldehyde is also a skin irritant and can cause eye irritation and damage to the cornea. After an acute, relatively high concentration exposure, people may become sensitized to crotonaldehyde. Except for rare cases of sensitization, no health effects have been reported in humans exposed to relatively low concentrations of crotonaldehyde. No studies have been found that address reproductive or developmental effects of crotonaldehyde in humans. The compound has been shown to cause degeneration of spermatocytes in mice. No teratogenic effects from acute exposures have been reported.

The Department of Health and Human Services has determined that crotonaldehyde may be a possible carcinogen. The EPA IRIS has classified crotonaldehyde as a possible carcinogen based on the fact that there is no human data, but an increased incidence of hepatic tumors in male rats. The possible carcinogenicity of crotonaldehyde is supported by genotoxic activity and the expected reactivity of croton oil and aldehyde. The EPA IRIS, however, has not derived a cancer toxicity value for the compound. The EPA HEAST (Health Effects Summary Tables) has established an oral cancer toxicity value for crotonaldehyde. The Agency for Research on Cancer has determined that crotonaldehyde is not classifiable as to its carcinogenicity to humans.

Information concerning typical concentrations of crotonaldehydes in air could not be located.

FORMALDEHYDE

Formaldehyde is a hydrocarbon compound with the formula HCHO. It exists in the atmosphere as a colorless gas with a pungent odor. It is used in the manufacture of urea-formaldehyde resins which are used in particleboard and plywood products. Therefore, high levels of airborne formaldehyde can also be found in indoor air as a result of release from various consumer products such as building materials and home furnishings. Another source of formaldehyde in indoor air is smoking. It is also employed in chemical manufacturing of pharmaceuticals, herbicides, and sealants. Textile finishes, such as used for “permanent press” clothes, contain formaldehyde (Kirk-Othmer, Vol 11, pages 245 - 246).

EPA’s Technology Transfer Network Air Toxic Website provides information on the potential sources and health effects of formaldehyde. According to this source, the major sources of formaldehyde emissions to the ambient air include power plants, manufacturing facilities, incinerators, forest and wild fires, stationary internal combustion engines and turbines, pulp and paper plants, petroleum refineries, and automobile traffic. In urban areas, combustion of automotive fuel is the dominant source for much of the year. However, formaldehyde can also form photochemically in the air, as other hydrocarbons and oxides of nitrogen from automobile traffic break down to form ozone. Complicating the situation is the fact that the complex ozone-producing atmospheric reactions may both create and destroy formaldehyde, as the chains of chemical reactions proceed along various pathways.

The Agency for Toxic Substances and Disease Registry (ATSDR), lists a number of possible health effects that may occur from inhalation of formaldehyde. Formaldehyde is an irritant. The major acute toxic effects via inhalation exposure are eye, nose, and throat irritation and effects on the nasal cavity. At 0.4 – 3 ppm, it may cause the eyes to tear. Other effects observed in humans from exposure to high levels of formaldehyde are coughing, wheezing, chest pain, and bronchitis (EPA's Technology Transfer Network Air Toxic Website). Formaldehyde is believed to be carcinogenic to humans. However, the body can quickly break down formaldehyde, so it does not accumulate in fatty tissue. Currently, ATSDR believes that formaldehyde does not cause birth defects in humans (ATSDR Toxicological Profile for Formaldehyde). Thus, the main concerns with this compound are its irritant properties and its potential ability to cause cancer of the nose and throat.

Chronic inhalation exposure to formaldehyde in humans has been associated with respiratory symptoms and eye, nose, and throat irritation. EPA has not established an inhalation Reference Concentration (RfC) for formaldehyde. However, the ATSDR has established an inhalation reference concentration called a Minimal Risk Level (MRL) for formaldehyde based on respiratory effects in humans. Developmental effects, such as birth defects, have not been observed in animal studies. EPA has classified formaldehyde as a Group B1, probable human carcinogen, based on limited evidence in humans and sufficient evidence in animals. Occupational studies have shown statistically significant increases in incidence of lung and nasopharyngeal cancer. This evidence is considered limited because of possible exposure to other agents. Animal studies have reported an increased incidence of nasal squamous cell carcinoma by inhalation exposure. Please see EPA IRIS for a detailed discussion on the carcinogenicity of formaldehyde.

ATSDR states that typical levels of formaldehyde in urban air are 10 – 20 ppb. ATSDR cites concentrations of 0.2 ppb for rural areas, and 2-6 ppb for suburban areas (ATSDR Toxicological Profile for Formaldehyde). The mean level observed in Grand Junction during this study, 2.3 ppb, is within the "suburban" range.

VOLATILE ORGANIC COMPOUNDS

Volatile organic compounds commonly present included 1,3 – butadiene, benzene, carbon tetrachloride, tetrachloroethylene, 1,3,5 – trimethylbenzene and 1,2,4 - trimethylbenzene. Some health summary and source information regarding these compounds is given below.

BENZENE

Benzene is a hydrocarbon compound with the formula C_6H_6. It exists in the atmosphere as a colorless gas with a sweet odor. It is used in chemical manufacturing of medicines, detergents, explosives, shoes, dyes, leather, resins, paints, plastics and inks (CARB Fact Sheet on Benzene). It is also present in gasoline.

The largest sources of benzene in ambient air are automobiles, gasoline service stations, refineries, and chemical plants. Burning of vegetative matter in forest fires and woodstoves is also a source. In ambient air, benzene reacts with hydroxyl (OH^-) radicals within a few hours. Since hydroxyl radicals are common in outdoor air, this chemical transformation prevents the build-up of large concentrations of benzene.

Benzene is a serious concern from a toxicological standpoint. Unlike many of the compounds discussed here, benzene is a proven human carcinogen. It damages the blood-forming capacity of the body, leading to anemia or leukemia. Like the other volatile organic compounds, breathing large amounts can cause lightheadedness, headache, vomiting, convulsions, coma and death. It also irritates the skin and eyes, exerting a drying effect.

However, these health effects are usually seen in workplaces, where levels are thousands of times higher than those in outdoor air. Experiments with laboratory animals suggest that benzene exposure may be associated with numerous cancers. It may cause bone marrow damage and bone formation problems for a developing fetus (ATSDR Toxicological Profile for Benzene). Thus, EPA has had concern about whether levels of benzene in outdoor air are associated with cancer and leukemia. While no link with outdoor air concentrations has been unequivocally proven, EPA has acted to reduce air concentrations of this pollutant.

The EPA has established a Reference Concentration for inhalation exposure to benzene based on decreased lymphocyte count in an occupational epidemiologic study. Benzene is classified as a “known” human carcinogen for all routes of exposure by the EPA IRIS based on the increased incidence of leukemia in epidemiologic and case studies.

The Agency for Toxic Substances and Disease Registry (ATSDR) cites national 1984 to 1986 data from 300 cities, which indicate an average benzene level of 1.8 ppb for urban and suburban areas (ATSDR Toxicological Profile for Benzene). The Grand Junction – Powell site mean of 0.7 ppb observed in this study is somewhat lower.

1,3-BUTADIENE

1,3-Butadiene is a hydrocarbon compound with the formula C_4H_6. It exists in the atmosphere as a colorless gas with an odor similar to gasoline. It is used in making rubber and plastics. The most important use is in tire production. It is also used in the production of chemicals such as 1,4-hexadiene (NIOSH Current Intelligence Bulletin 41).

According to the California Air Resources Board, most emissions of 1,3-butadiene come from combustion of fuels in diesel and gas-powered motor vehicles. Other sources that they list include petroleum refining, tire wear, residential wood heating, and forest fires. Rubber and chemical production plants also have emissions. Breathing of cigarette smoke is another source of 1,3-butadiene exposure (ATSDR Fact Sheet)

1,3-Butadiene is of concern toxicologically because it is characterized as carcinogenic to humans based on the new EPA guidelines for cancer risk assessment and it also has adverse effects on reproduction and fetal development. Exposure to high concentrations can cause irritation and central nervous system effects such as eye irritation, cough, sore throat, headache, drowsiness, nausea, unconsciousness, and death. Rats and mice exposed to this compound in laboratory tests developed multiple cancers within single individuals. The animals had damaged testes and ovaries, and offspring of the animals had skeletal problems. Other effects seen in animals at low levels of inhalation exposure for one year include kidney and liver disease, and damaged lungs (ATSDR Fact Sheet). Generally, the acute health effects have not been seen at concentrations existing in outdoor air. However, EPA considers that the levels of 1,3-butadiene in air may represent a significant portion of the cancer risk related to ambient airborne chemicals.

The EPA has established a Reference Concentration for inhalation exposure to 1,3-butadiene based on ovarian atrophy in mice. The EPA has characterized 1,3-butadiene as carcinogenic to humans by inhalation based on the following total evidence: sufficient evidence from epidemiologic studies showing increased lymphohematopoietic cancers and leukemia; tumors at multiple sites in animal studies, and strong evidence suggesting that the carcinogenic effects are mediated by genotoxic metabolites of 1,3-butadiene.

ATSDR estimates that urban and suburban areas have an average concentration of 0.3 ppb 1,3-butadiene, while rural areas have 0.1 ppb (ATSDR Toxicological Profile for 1,3-Butadiene). The annual average at Grand Junction - Powell is 0.09 ppb.

CARBON TETRACHLORIDE

Carbon tetrachloride, also known as tetrachloromethane or methane tetrachloride, is a chlorinated hydrocarbon with the formula CCl_4. It exists in the atmosphere as a gas. It has a sweet odor. The primary uses of carbon tetrachloride were as a dry cleaning solvent, a grain fumigant, as a refrigerant, and as an aerosol propellant. Carbon tetrachloride has a long atmospheric half-life, so it can travel to the higher reaches of the atmosphere and damage the earth's ozone layer. Due to its toxicity and ozone-damaging qualities, most uses of carbon tetrachloride have been banned. It is still in use in industrial settings for producing refrigerants.

Carbon tetrachloride is emitted to the air from industrial sources and from petroleum refineries (California Air Resources Board Toxic Air Contaminant Identification List Summary for Carbon Tetrachloride). Carbon tetrachloride is also a common indoor air contaminant due to releases from building materials and products, such as cleaning agents used in homes (Air Toxic Website). There are no natural sources of carbon tetrachloride; it is produced by man (ATSDR Toxicological Profile for Carbon Tetrachloride).

As is true for many of the chlorinated hydrocarbons, breathing large concentrations of carbon tetrachloride has central nervous system effects including lightheadedness, coma, convulsions, double vision, intoxication, and death. It can also cause vomiting. In animal studies, it had effects on the liver and kidney. Male rats exposed to carbon tetrachloride had lower sperm production. Female rats exposed to it had stunted offspring with birth defects. These health effects are generally observed in occupational settings, where people had exposure to very high levels over a number of years.

EPA has not established a Reference Concentration for carbon tetrachloride. The CalEPA has established a Reference Exposure Level for carbon tetrachloride based on liver effects in guinea pigs. Carbon tetrachloride has been associated with liver and kidney cancer in animals. EPA considers it a Class B2 Carcinogen (probable human carcinogen) based on liver tumors in animals.

The California Air Resources Board has monitored carbon tetrachloride at a number of locations, and found a mean value of 0.078 ppb (California Air Resources Board Toxic Air Contaminant Identification List Summary for Carbon Tetrachloride). The 0.08 ppb annual mean observed at Grand Junction – Powell is at the same level.

TETRACHLOROETHYLENE

Tetrachloroethylene, also known as perchloroethylene, is a chlorinated hydrocarbon with the formula C_2Cl_4. It exists in the atmosphere as a gas. It has a "chloroform-like" odor (NIOSH Pocket Guide to Chemical Hazards, Tetrachloroethylene). The primary uses of tetrachloroethylene are as a dry cleaning solvent, metal cleaning solvent, or for chemical production. Tetrachloroethylene is used in paints, inks, aerosols, glues, polishes, silicones and rubber products (CARB Fact Sheet on Tetrachloroethylene and OPPT Chemical Fact Sheet on Tetrachloroethylene).

Most emissions of tetrachloroethylene come from degreasing, dry cleaning, or chemical production facilities. There are microorganisms that can produce tetrachloroethylene (ATSDR Toxicological Profile For Tetrachloroethyelene).

As is true for many of the chlorinated hydrocarbons, breathing large concentrations of tetrachloroethylene has central nervous system effects including lightheadedness, coma, convulsions, double vision, intoxication, and death. It also can cause vomiting. In animal studies, it had effects on the liver and kidney. It also is an irritant to eyes, lungs, and skin. However, many of these health effects were observed in occupational settings, where exposure is much higher than in outdoor air. Some animal studies suggest that tetrachloroethylene exposure may lead to leukemia (NIOSH Registry of Toxic Effects of Chemical Substances Information for Tetrachloroethylene). Tetrachloroethylene has been associated with liver and kidney cancer in animals.

The ATSDR has established a Minimal Risk Level (MRL) based on nervous system effects in humans. It is important to note that EPA is currently re-evaluating the toxic potential of tetrachloroethylene, including its carcinogenicity, and therefore no relevant information is available in IRIS. In the interim, EPA recommends the use of CalEPA toxicity values as provisional values. The CalEPA cancer toxicity value is derived by considering data on liver tumors in male and female mice and mononuclear cell leukemia in male and female rats. EPA is currently working to revise the toxicity assessment for tetrachloroethylene.

The California Air Resources Board has monitored tetrachloroethylene at a number of locations within their state, and found a mean value of 0.019 ppb during 1996 (California Air Resources Board Toxic Air Contaminant Identification List Summary for Tetrachloroethylene). The annual mean at Grand Junction - Powell was 0.05 ppb. These levels are greater than the network-wide mean value for California. However, this compound was detected less than half the time.

1,3,5-TRIMETHYBENZENE AND 1,2,4-TRIMETHYLBENZENE

1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene are isomers of the hydrocarbon formula C_9H_{12}. In pure form they are colorless liquids. They are used in chemical manufacturing of medicines, detergents, dyes, paints and inks. Trimethylbenzenes are a large component of distilled petroleum. They are also used as gasoline additives.

The largest sources of trimethylbenzenes in ambient air are likely to be automobiles, gasoline service stations, refineries, and chemical plants. In ambient air, trimethylbenzenes have a half-life of less than a day (EPA OPPT Chemical Summary For 1,2,4-Trimethylbenzene).

Health effects of trimethylbenzenes are similar to those of benzene. It damages the blood-clotting capacity of the body. Like the other volatile organic compounds, breathing large amounts can cause lightheadedness, headache, vomiting, convulsions, coma and death. It also irritates the skin and eyes, exerting a drying effect. Long-term exposure can lead to cough, reduced lung capacity, and bronchitis. However, these health effects are usually seen in workplaces, where levels are thousands of times higher than those in outdoor air. It is not known whether these compounds are carcinogenic. Some animal experiments suggest that they may cause bone formation problems for a developing fetus (EPA OPPT Chemical Summary For 1,2,4-Trimethylbenzene).

The Environmental Protection Agency cites national data indicating that average atmospheric concentrations of 1,2,4-trimethylbenzene are 0.58 ppb in rural areas, and 1.20 ppb in cities (EPA OPPT Chemical Summary For 1,2,4-Trimethylbenzene). The Grand Junction - Powell site had a mean value of 0.09 ppb. As the EPA citation is for 1988, it is likely that concentrations have gone down in recent years.

METALS

Arsenic and manganese are discussed below. Levels of lead observed in Grand Junction were below the Colorado state standard of 1.5 ug/m3 for a monthly average.

ARSENIC

Arsenic is a metal-like element that occurs naturally in the earth’s crust. Its chemical symbol is “As”. It exists in the atmosphere as particulate matter, in compounds formed from combination with other atoms such as oxygen, chlorine, and sulfur (ATSDR Public Health Statement for Arsenic). In the past, arsenic was used as a pesticide for orchard crops. Today, the chief use is in chromated copper arsenate (CCA) used to “pressure-treat” wood, to preserve it from decay in marine or in-ground usage. It is also used in metal alloy, glass-making, and electrical semi-conductors.

Emission sources of arsenic include smelters, coal-fired power plants, wood-burning, metals operations, mining operations, and incinerators. Arsenic occurs naturally in many soils, so wind-blown dusts from exposed land can contain it. Mine tailings piles generally contain enriched levels of arsenic, resulting in emissions of arsenic in the particulate emissions that occur under windy conditions. Soils contaminated by smelter fall-out can also be a source of emissions during high winds. Burning wood treated with CCA also leads to arsenic emissions.

Arsenic’s toxicity has led to its use as a poison. Orally ingesting large amounts can be fatal. The effects of inhalation are similar to the oral effects. Arsenic disturbs the gastro-intestinal system, leading to abdominal pain, vomiting, and diarrhea. It affects the central nervous system, leading to nerve damage in the legs and arms. It can damage the liver and kidney. Arsenic also has effects on the skin, causing dark patches (hyperpigmentation), and skin cancer. Arsenic also irritates the eyes, lungs, and skin. These effects have been observed in situations of occupational exposure that are significantly higher than concentrations seen in outdoor air. Exposure can lead to effects in the blood, such as anemia.

EPA has not established a Reference Concentration for arsenic. The Cal EPA has established a chronic reference level based on the developmental effects in mice; and other target organs included the cardiovascular system and nervous system. Arsenic exposure is known to cause lung cancer. EPA classifies arsenic in Group A, the known human carcinogens, based on an increased lung cancer mortality in multiple human populations exposed primarily through inhalation.

The Agency for Toxic Substances and Disease Registry (ATSDR) states that remote areas have concentrations of 0.001 to 0.003 µg/m3 arsenic in air, while urban locations range from 0.020 to 0.100 µg/m3 (ATSDR Toxicological Profile on Arsenic). The mean level of 0.0003 µg/m3 at Grand Junction – Powell site falls below the cited rural range. It is likely that national levels of arsenic have decreased in recent years.

MANGANESE

Manganese is a metal that occurs naturally in the earth's crust. Its chemical symbol is "Mn". It exists in the atmosphere as particulate matter, in compounds formed from combination with other atoms. Manganese is used as an additive in metal processing and steel production. It is also used in ceramics, matches, glass, dyes, batteries, and as a pigment in paints (California Air Resources Board Fact Sheet on Manganese). It is also employed in wood preservatives. Organic forms of manganese are used as pesticides and for disease prevention in crops such as fruits, vegetables, and cotton.

Emission sources of manganese include petroleum refineries, steel producers, cement producers, coal-fired power plants, wood-burning, metals operations, mining operations, and incinerators. Manganese occurs naturally in some soils, so wind-blown dusts from exposed land can contain it. Soils contaminated by smelter fall-out can also be a source of emissions during high winds.

Manganese is considered an essential micronutrient in the human body. The body tends to regulate manganese concentrations, so oral exposure to small amounts naturally present in food is rarely a problem. Exposure of manganese by inhalation can lead to health effects. Manganese health effects on the respiratory system include lung irritation, chemical pneumonia, cough, and bronchitis. Manganese may damage the central nervous system. The disease known as "manganism", which results from manganese poisoning, includes psychological and nervous system damage. Individuals with manganism have a mask-like face, depression, uncontrollable laughter, and lethargy. The central nervous system effects include trouble with tremors, balance and walking that is similar to that of Parkinson's disease. Central nervous system damage can occur at exposure levels below those that lead to manganism. Examples are decreases in visual reaction time, hand steadiness, and eye-hand coordination. Manganese also affects the gastro-intestinal tract and the kidneys. However, it should be noted that these health effects have been observed in workers with long-term exposure to manganese fumes and dusts in industrial settings. These exposures were at levels hundreds or thousands of times higher than manganese levels in outdoor air.

EPA classifies manganese as Group D, unclassifiable as to carcinogenic potential. This is because there is little evidence to link it to cancer health effects. EPA has established a Reference Concentration for manganese based on an impairment of neurobehavioral function in humans in occupational exposure studies.

The California Air Resources Board monitored manganese in 1996. They report a network-wide average of 0.0212 µg/m3 total manganese (CARB Fact Sheet on Manganese). The 0.0130 annual mean measured at Grand Junction is below the California average.

REFERENCES

REFERENCES FOR CARBONYLS SECTION

Agency for Toxic Substances and Disease Registry. (ATSDR) "Toxicological Profiles" for Various Compounds. Web Address: **http://www.atsdr.cdc.gov/toxprofiles/**

Toxicological Profile for Formaldehyde, dated July 1999.

California Air Resources Board. (CARB)
Web Address: **http://www.arb.ca.gov/toxics/cattable.htm**

Acetaldehyde, dated September 1997.

United States Environmental Protection Agency. (EPA). Technology Transfer Network Air Toxics Website. "Dose-Response Assessment for Assessing Health Risks Associated With Exposure To Hazardous Air Pollutants", Table 1, December 2, 2002.
Web Address: **http://www.epa.gov/ttn/atw/toxsource/summary.html**

Kirk-Othmer Encyclopedia of Chemical Technology. Third Edition. (Kirk-Othmer)
John Wiley and Sons, New York, New York. USA. 1978.

Acetaldehyde, Volume 1, Pages 97 – 112.
Formaldehyde, Volume 11, Pages 231 – 250.

REFERENCES FOR VOLATILE ORGANIC COMPOUNDS SECTION

Agency For Toxic Substances and Disease Registry. (ATSDR) "Toxicological Profiles" for Various Compounds. Web Address: **http://www.atsdr.cdc.gov/toxprofiles/**

Toxicological Profile for Benzene, dated September 1997.
Toxicological Profile for 1,3-Butadiene, dated April 1993.
Toxicological Profile for Carbon Tetrachloride, dated May 1994.
Toxicological Profile for Tetrachloroethylene, dated September 1997.

California Air Resources Board. (CARB)
Web Address: http://www.arb.ca.gov/toxics/cattable.htm

Benzene, dated September 1997.
1,3-Butadiene, dated September 1997.
Carbon Tetrachloride, dated September 1997.
Tetrachloroethylene, dated September 1997.

Eastern Research Group. (ERG) "2002 Urban Air Toxics Monitoring Program (UATMP): Final Report". Prepared under EPA Contract Number 68-D-99-007. October 2003.

United States Environmental Protection Agency. *Technology Transfer Network, Clearinghouse of Inventories and Emission Factors (CHIEF).* Compilation of Air Pollution Emission Factors, AP-42, Fifth Edition, Volume 1. (EPA CHIEF).
Web Address: http://www.epa.gov/ttn/chief/ap42/index.html**.**

Chapter 1: External Combustion Sources. Section 1.10: Residential Wood Stoves.

United States Environmental Protection Agency. (EPA) Technology Transfer Network Air Toxics Website. Health Effects Worksheets For Various Substances.
Web Address: http://www.epa.gov/ttn/atw/hlthef

Carbon Tetrachloride, dated December 1999.
Tetrachloroethylene, dated December 1999.

United States Environmental Protection Agency. (EPA) Office of Pollution Prevention and Toxics. Chemicals in the Environment: OPPT Chemical Fact Sheets.
Web Address: http://www.epa.gov/opptintr/chemfact/index.html

Perchloroethylene Fact Sheet, dated August 1994.
Perchloroethylene Chemical Summary, dated August 1994.
1,2,4-Trimethylbenzene Fact Sheet, dated August 1994.
1,2,4-Trimethylbenzene Chemical Summary, dated August 1994.

United States Environmental Protection Agency. (EPA) Integrated Risk Information System. Full IRIS Summary Of Various Substances.
Web Address: http://www.epa.gov/iris/subst/

Benzene, dated April 17, 2003.

United States Environmental Protection Agency. (EPA) 2002 Urban Air Toxics Monitoring Program (UATMP), Final Report. October 2003. EPA Contract No. 68-D-99-007, by Eastern Research Group.

National Institute For Occupational Safety and Health. (NIOSH) Current Intelligence Bulletins.

Current Intelligence Bulletin 41: 1,3-Butadiene. Dated February 9, 1984.
Web Address: http://www.cdc.gov/niosh/84105_41.html

National Institute For Occupational Safety and Health. (NIOSH) International Chemical Safety Cards.

1,3-Butadiene. Dated 2000. Web Address: http://www.cdc.gov/niosh/ipcsneng/neng0017.html
Carbon Tetrachloride. Dated 2000. Web Address: http://www.cdc.gov/niosh/ipcsneng/neng0024.html
Tetrachloroethylene, dated 2001. Web Address: http://www.cdc.gov/niosh/ipcsneng/neng0076.html
1,3,5-Trimethylbenzene. Dated 2002. Web Address: http://www.cdc.gov/niosh/ipcsneng/neng1155.html
1,2,4-Trimethylbenzene. Dated 2002. Web Address: http://www.cdc.gov/niosh/ipcsneng/neng1433.html
Trimethylbenzene (Mixed Isomers). Dated 2002. Web Address:
http://www.cdc.gov/niosh/ipcsneng/neng1389.html

National Institute For Occupational Safety and Health. (NIOSH) Pocket Guide to Chemical Hazards.

Carbon Tetrachloride. Web Address: http://www.cdc.gov/niosh/npg/npgd0107.html
Tetrachloroethylene. Web Address: http://www.cdc.gov/niosh/npg/npgd0599.html
1,3,5-Trimethylbenzene. Web Address: http://www.cdc.gov/niosh/npg/npgd0639.html
1,2,4-Trimethylbenzene. Web Address: http://www.cdc.gov/niosh/npg/npgd0638.html

National Institute For Occupational Safety and Health. (NIOSH) Registry of Toxic Effects of Chemical Substances. (RTECS)

Carbon Tetrachloride, dated October 2002.
Web Address: http://www.cdc.gov/niosh/rtecs/fg4ac4a0.html

New Jersey Department of Health and Senior Services. "Hazardous Substance Fact Sheets" for Various Substances.
Web Address: http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm

Benzene, dated January 2001.
1,3-Butadiene, dated July 1998.
Carbon Tetrachloride, dated August 1998.
Tetrachloroethylene, dated March 2002.
Trimethylbenzene (Mixed Isomers), dated May 2003.

Occupational Safety and Health Administration. (OSHA) "OSHA Comments from the January 19, 1989 Final Rule on Air Contaminants Project". (Rule remanded by court and not currently in force).

Perchloroethylene (Tetrachloroethylene). Web Address: **http://www.cdc.gov/niosh/pel88/127-18.html**

REFERENCES FOR METALS

Agency For Toxic Substances and Disease Registry. (ATSDR) "Toxicological Profiles" for Various Compounds. Web Address: **http://www.atsdr.cdc.gov/toxprofiles/**

Arsenic, dated September 2000.
Manganese, dated September 2000.

California Air Resources Board. (CARB)
Web Address: **http://www.arb.ca.gov/toxics/cattable.htm**

Arsenic and Compounds, dated September 1997.
Manganese Compounds, dated September 1997.

United States Environmental Protection Agency. (EPA) Integrated Risk Information System. Full IRIS Summary Of Various Substances.
Web Address: **http://www.epa.gov/iris/subst/**

Arsenic, inorganic. Dated April 10, 1998. Web address: **http://www.epa.gov/iris/subst/0278.html**
Manganese. Dated December 1, 1996. Web address: **http://www.epa.gov/iris/subst/0373.htm**

United States Environmental Protection Agency. (EPA). Technology Transfer Network Air Toxics Website. Health Effects Worksheets for Various Substances.
Web Address: **http://www.epa.gov/ttn/atw/hlthef**

Arsenic Compounds, dated December 1999.
Manganese Compounds, dated December 1999.

National Institute for Occupational Safety and Health. (NIOSH) Criteria For a Recommended Standard…. Occupational Exposure to Inorganic Arsenic, 1975.
Web Address: **http://www.cdc.gov/niosh/pdfs/75-149a.pdf**

National Institute for Occupational Safety and Health. (NIOSH) Documentation for Immediately Dangerous to Life or Health Concentrations (IDLHs).

Arsenic, dated August 16, 1996. Web address: **http://www.cdc.gov/niosh/idlh/7440382.html**
Manganese compounds (as Mn), dated August 15, 1996.
Web address: **http://www.cdc.gov/niosh/idlh/7439965.html**

National Institute for Occupational Safety and Health. (NIOSH) International Chemical Safety Cards.

Arsenic. Dated 1999. Web Address: **http://www.cdc.gov/niosh/ipcsneng/neng0013.html**
Manganese. Dated 2002. Web Address: **http://www.cdc.gov/niosh/ipcsneng/neng0232.html**

National Institute for Occupational Safety and Health. (NIOSH) Pocket Guide to Chemical Hazards.

Arsenic. Web Address: **http://www.cdc.gov/niosh/npg/npgd0038.html**
Manganese Compounds and fume (as Mn). Web Address: **http://www.cdc.gov/niosh/npg/npgd0379.html**

National Institute for Occupational Safety and Health. (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS).

Arsenic, dated October 2002. Web Address: **http://www.cdc.gov/niosh/rtecs/cg802c8.html**
Manganese, dated October 2002. Web Address: **http://www.cdc.gov/niosh/rtecs/008d8678.html**

New Jersey Department of Health and Senior Services. "Hazardous Substance Fact Sheets" for Various Substances. Web Address: **http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm**

Arsenic, dated June 1998.
Manganese, dated September 1999.

Occupational Safety and Health Administration. (OSHA) "OSHA Comments from the January 19, 1989 Final Rule on Air Contaminants Project". (Rule remanded by court and not currently in force).

Manganese Fume. Web Address: **http://www.cdc.gov/niosh/pel88/7439-96.html**

Appendix B: Documentation for Grand Junction Urban Air Toxics Trends Monitoring Locations

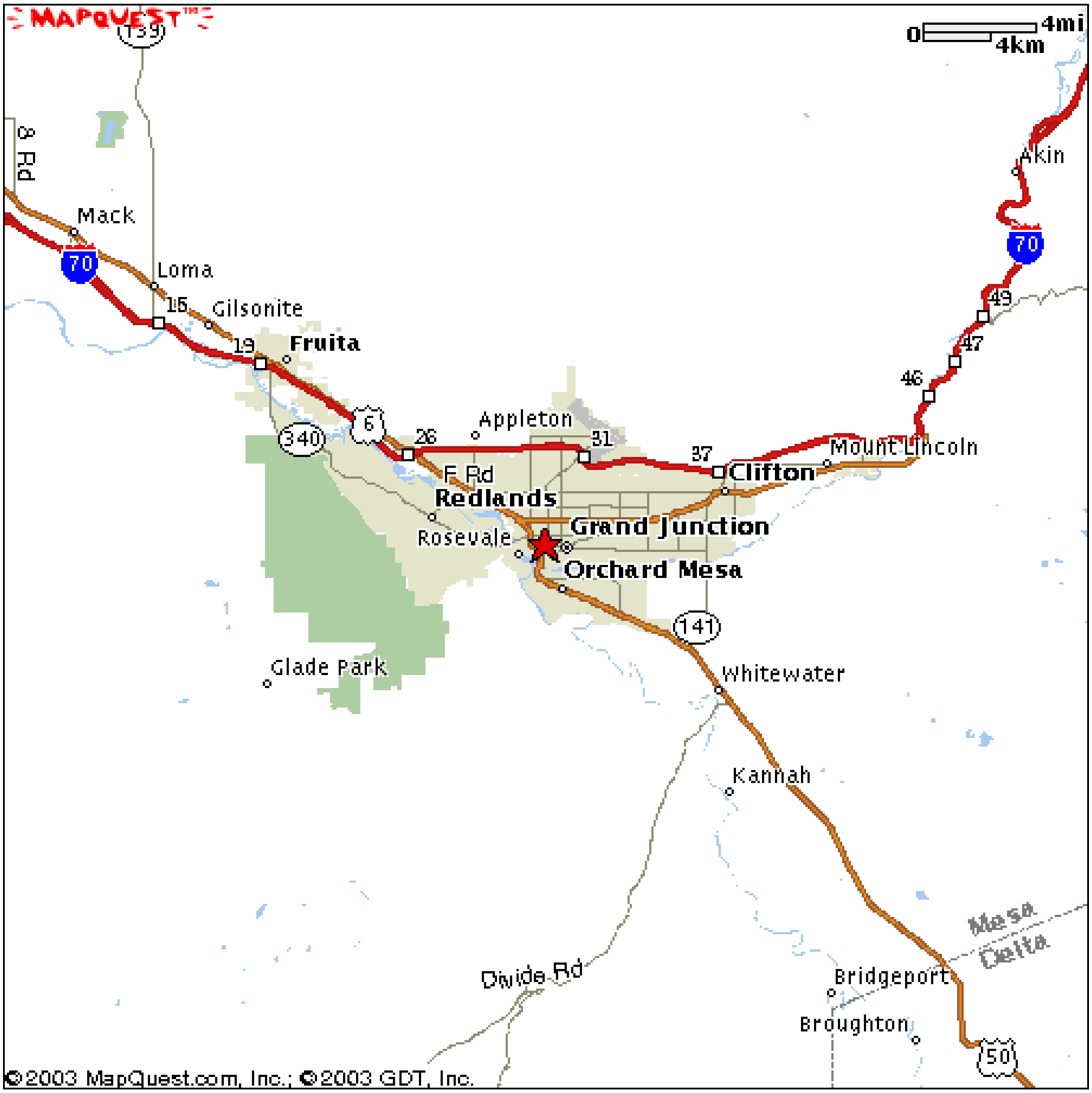
REGIONAL MAP (5 - 30 miles)

AQS ID: **08-077-0017** Site Name: **Grand Junction – Powell Building**

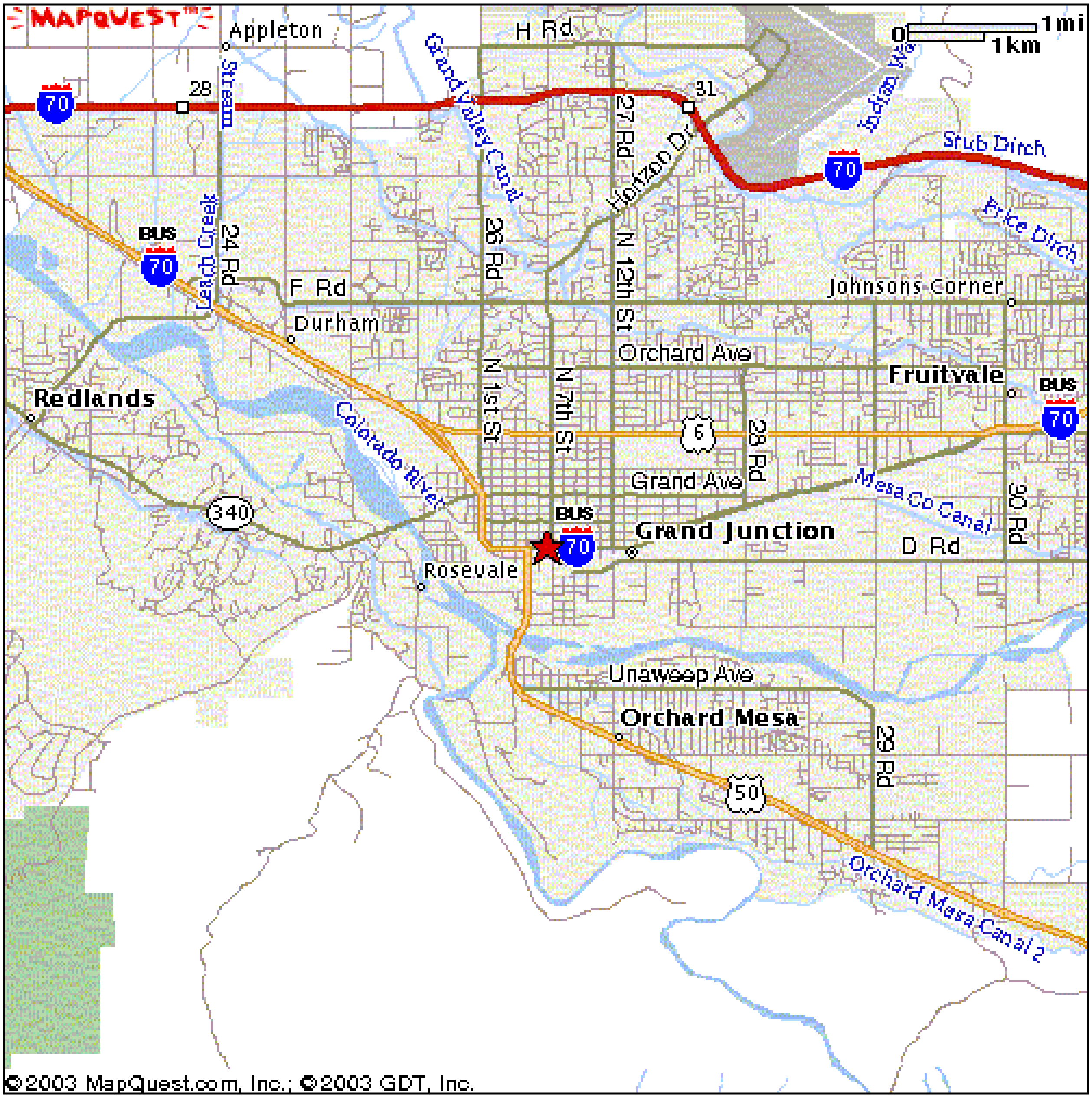
650 South Avenue, Grand Junction, CO 81501
GPS: Zone 12, 710962 E, 4326741 N, elev. 1396m
39° 03' 51" N, 108° 33' 42" W

AQS ID: **08-077-0018** Site Name: **Grand Junction – Pitkin Shelter**

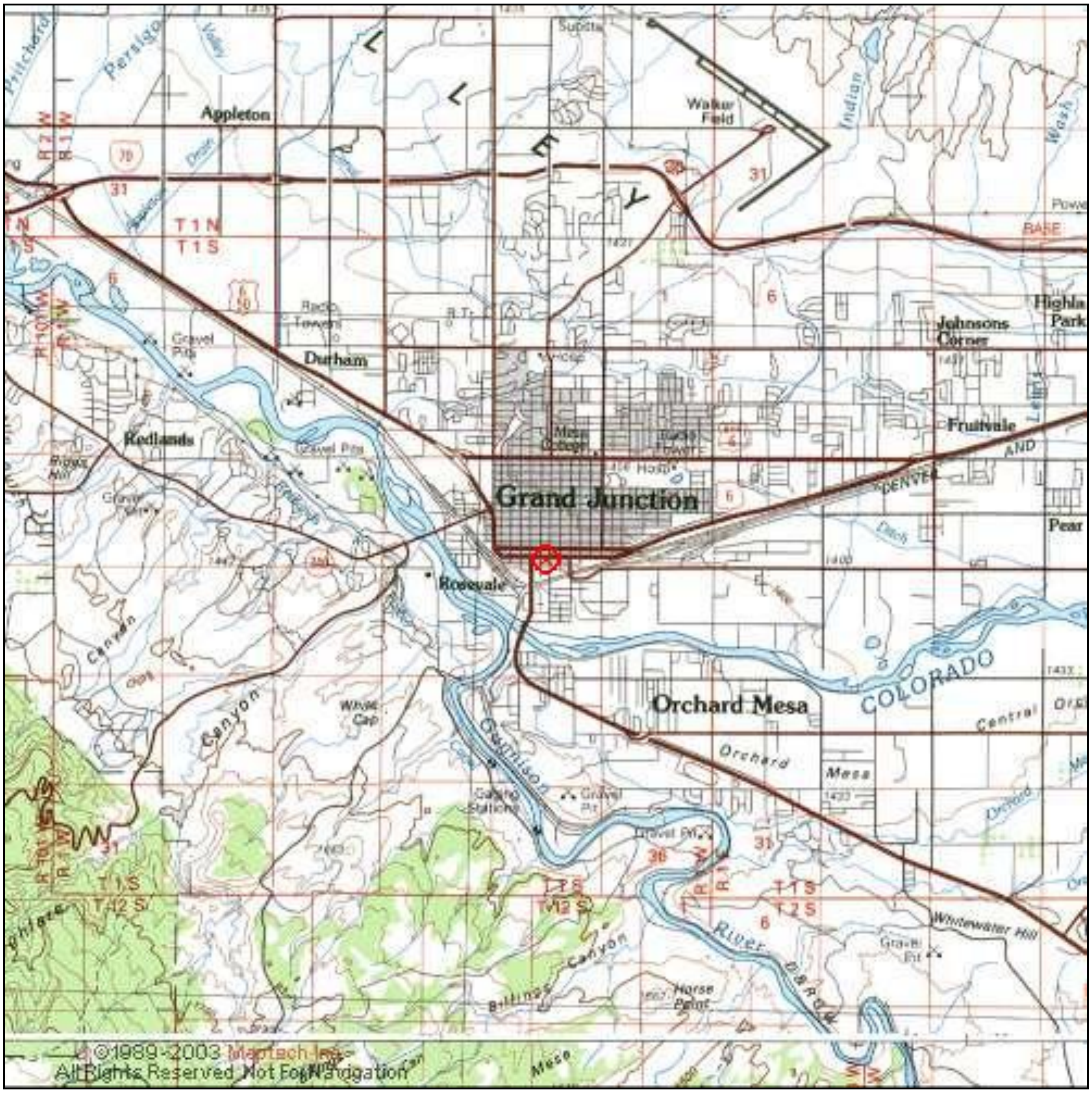
645 ¼ Pitkin Avenue, Grand Junction, CO 81501
GPS: Zone 12, 710962 E, 4326741 N, elev. 1396m
39° 03' 51" N, 108° 33' 42" W



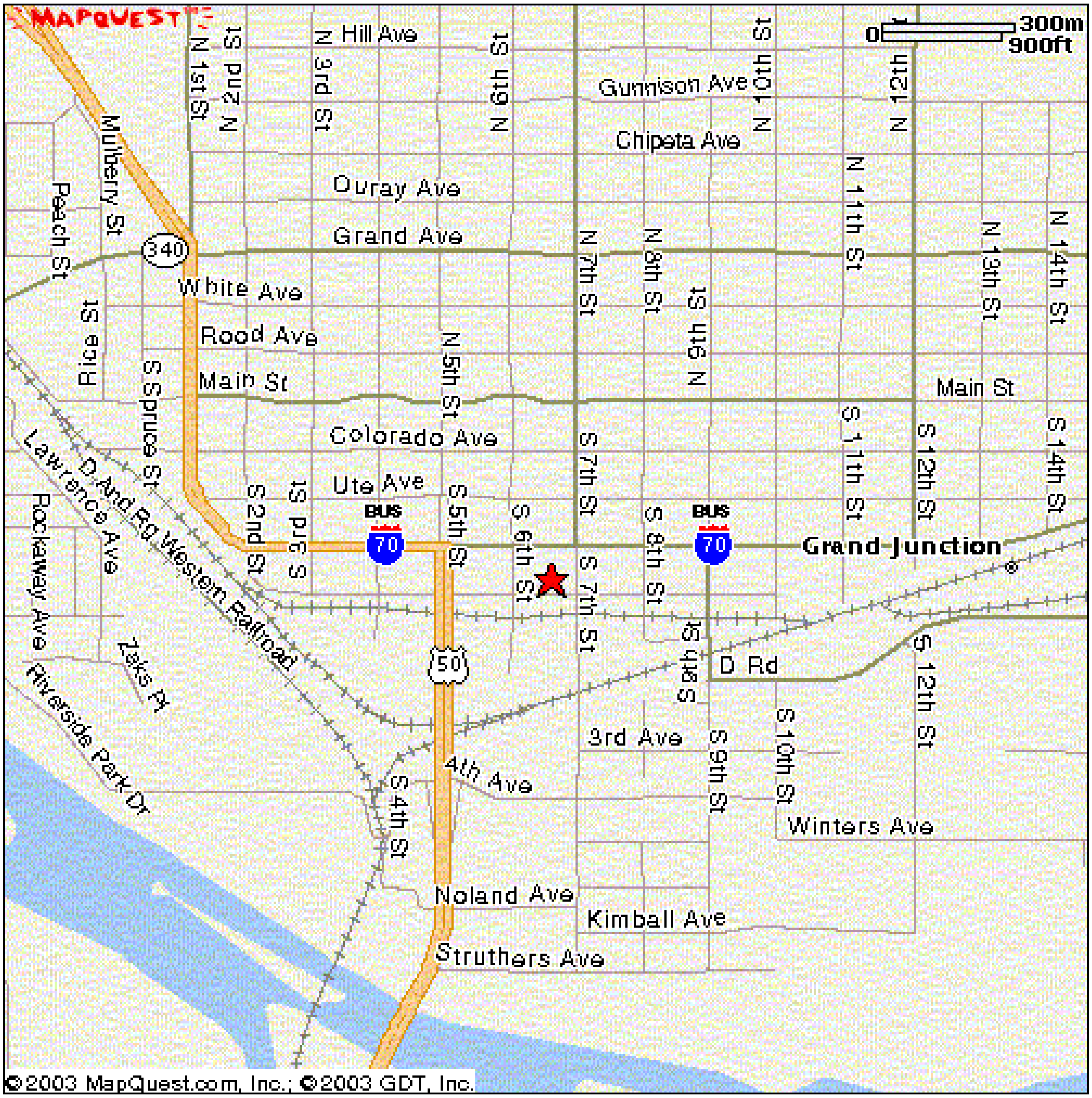
REGIONAL MAP (5 - 30 miles)



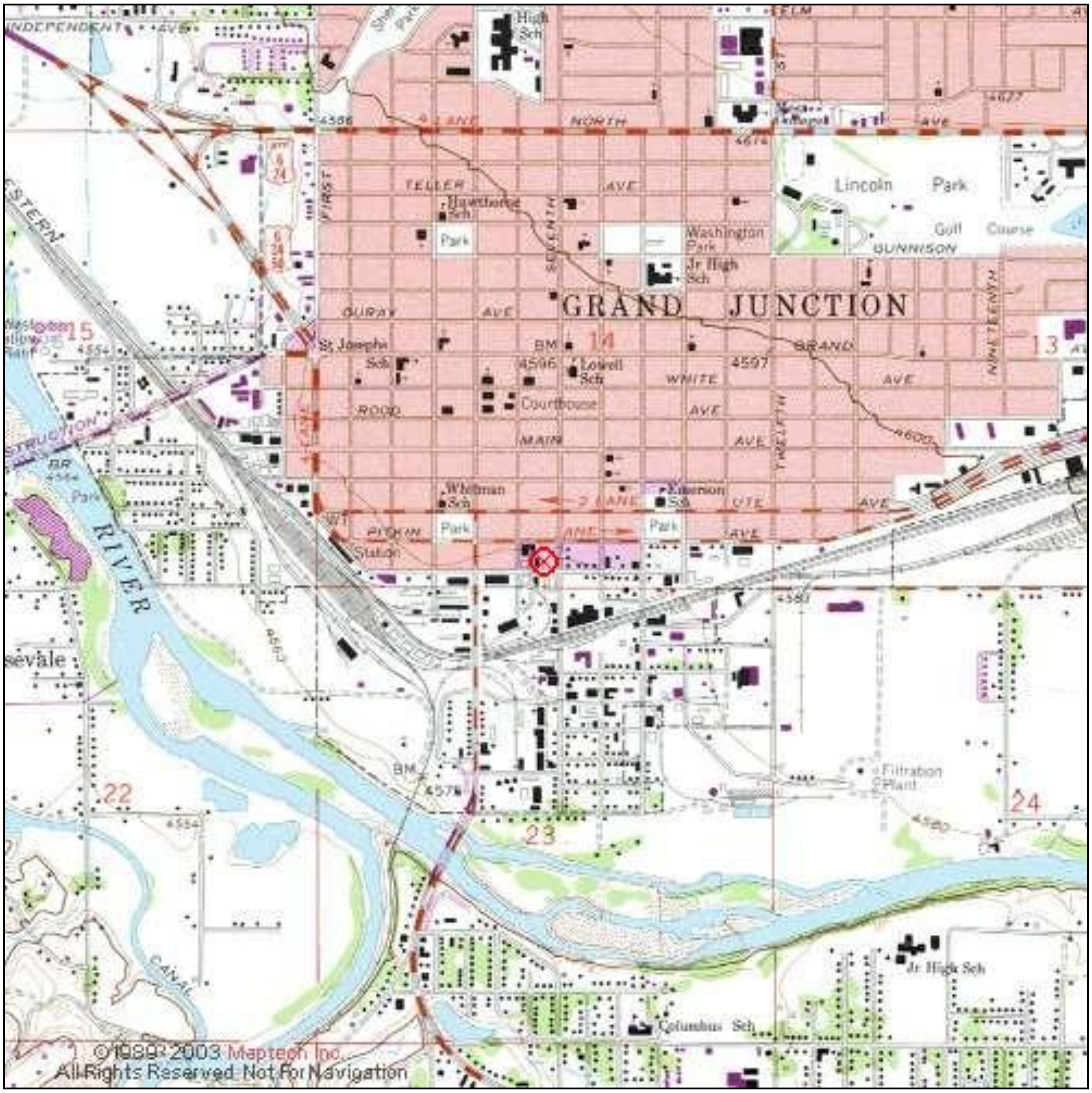
REGIONAL MAP (5 - 30 miles)



SITE MAP (1/4 - 1 mile)

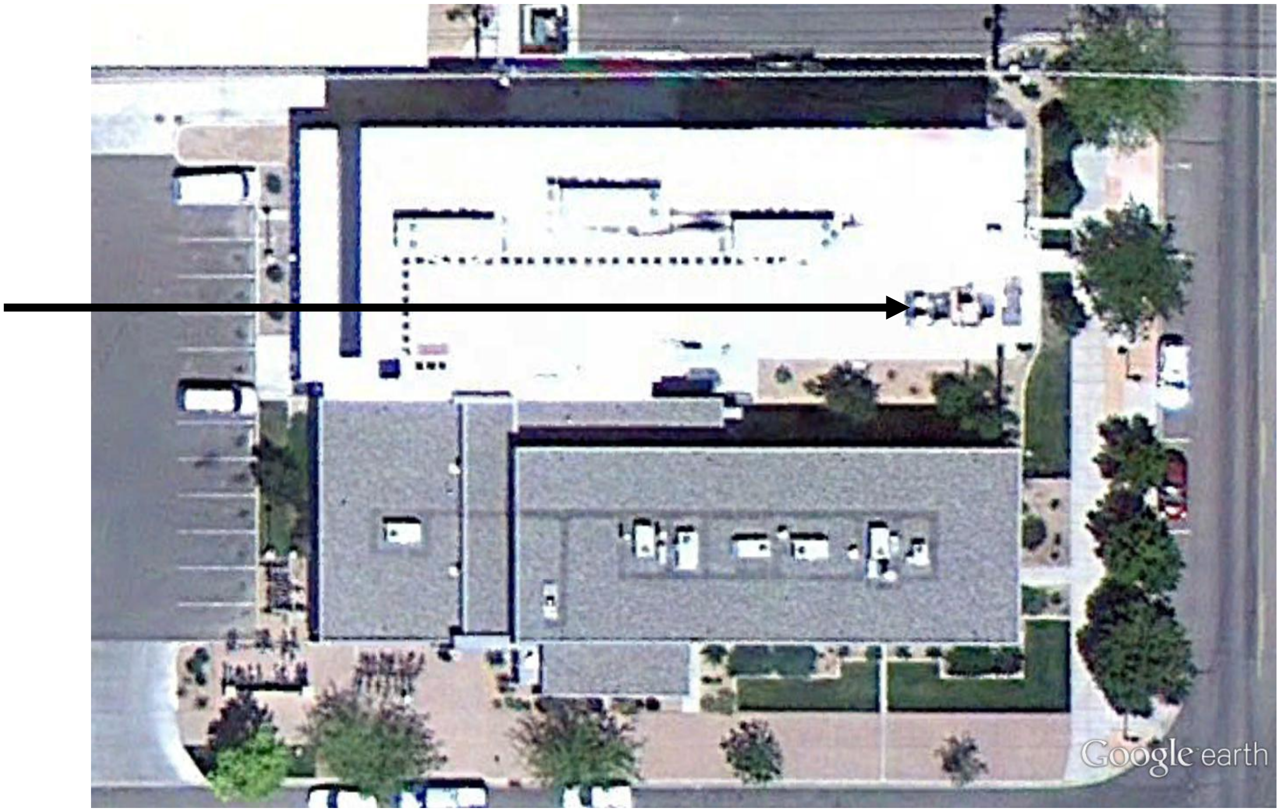


SITE MAP (1/4 - 1 mile)



SITE MAP (1/4 - 1 mile)

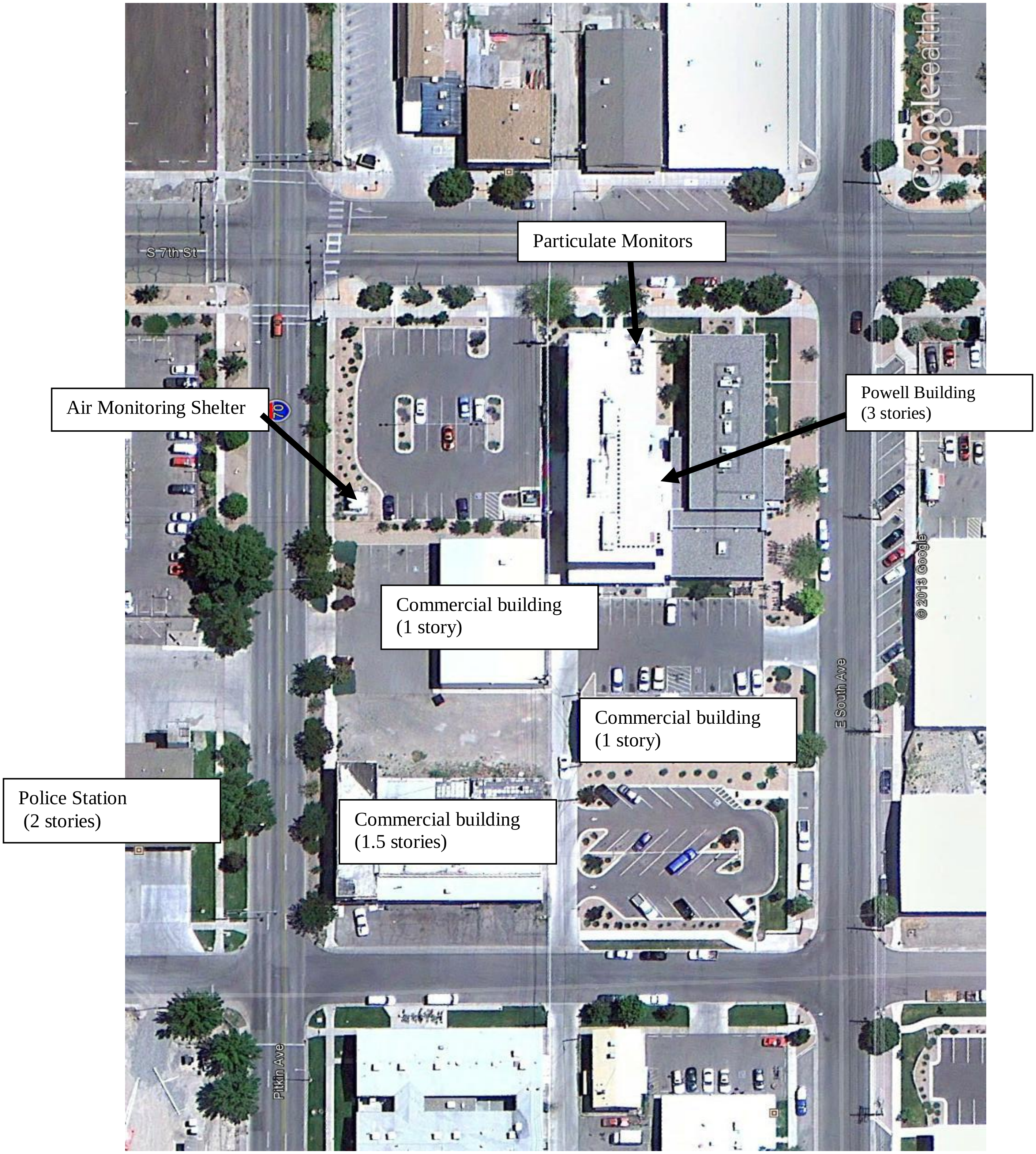
AIRS ID: **08-077-0017** Site Name: **Grand Junction – Powell Building**



SITE MAP (1/4 - 1 mile)

AIRS ID: **08-077-0018** Site Name: **Grand Junction – Pitkin (shelter)**

SITE MAP (1/4 - 1 mile)



AQS ID: **08-077-0017** Site Name: **Grand Junction – Powell Building**

Photo Date: 10/16/2013

Looking **NORTH**

Looking **NORTHEAST**

AQS ID: **08-077-0017** Site Name: **Grand Junction – Powell Building**

Photo Date: 10/16/2013

Looking **EAST**

Looking **SOUTHEAST**

AQS ID: **08-077-0017** Site Name: **Grand Junction – Powell Building**

Photo Date: 10/16/2013

Looking **SOUTH**

Looking **SOUTHWEST**

AQS ID: **08-077-0017** Site Name: **Grand Junction – Powell Building**

Photo Date: 10/16/2013

Looking **WEST**

Looking **NORTHWEST**

AQS ID: **08-077-0017** Site Name: **Grand Junction – Powell Building**

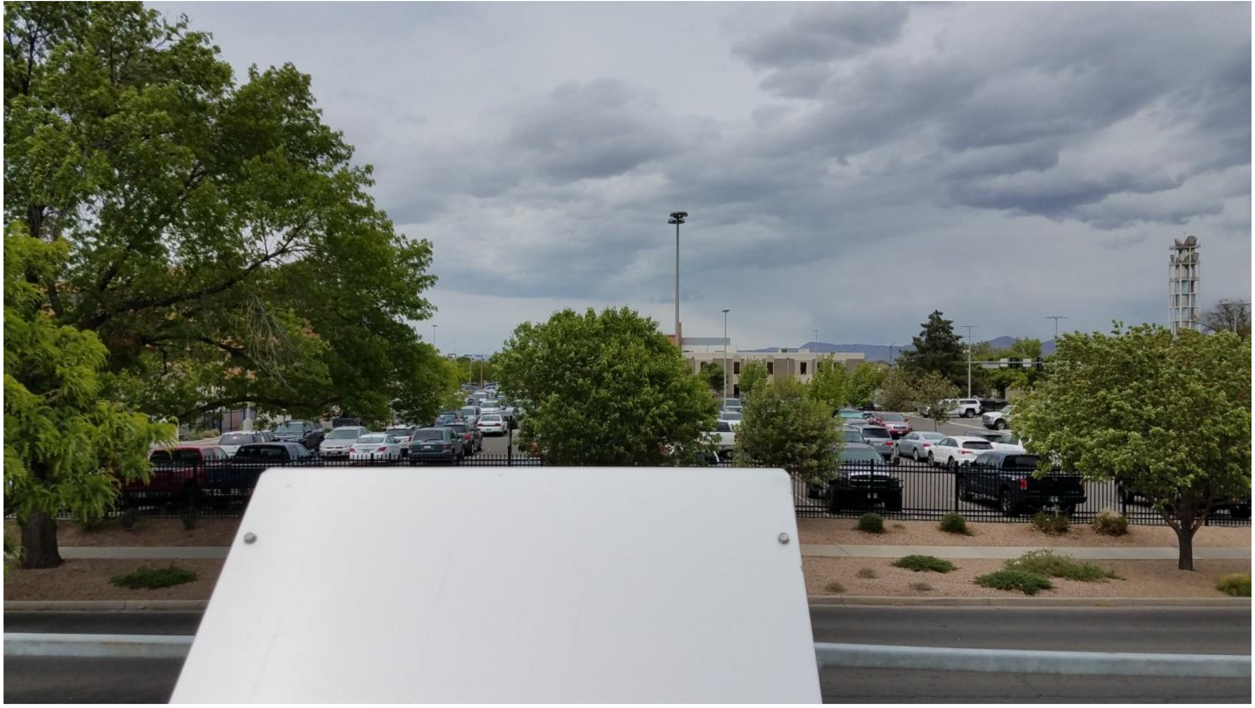
Photo Date: 10/16/2013

Site Photo: Particulate samplers (looking **SOUTH)**

AQS ID: **08-077-0018** Site Name: **Grand Junction – Pitkin Shelter**

Photo Date: 04/24/2017

Looking **NORTH**



Looking **NORTHEAST**

AQS ID: **08-077-0018** Site Name: **Grand Junction – Pitkin Shelter**

Photo Date: 04/24/2017

Looking **EAST**

Looking **SOUTHEAST**

AQS ID: **08-077-0018** Site Name: **Grand Junction – Pitkin Shelter**

Photo Date: 04/24/2017

Looking **SOUTH**

Looking **SOUTHWEST**

AQS ID: **08-077-0018** Site Name: **Grand Junction – Pitkin Shelter**

Photo Date: 04/24/2017

Looking **WEST**

Looking **NORTHWEST**

AQS ID: **08-077-0018** Site Name: **Grand Junction – Pitkin Shelter**

Photo Date: 04/24/2017

Site Photo: Shelter and inlets (looking **NORTHWEST**)