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2012 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM)

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2012 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM)

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Office of Air Quality Planning and Standards
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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

List of Appendices

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

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LIST OF TABLES (Continued)

LIST OF ACRONYMS

AADT	Annual Average Daily Traffic
AGL	Above Ground Level
AQS	Air Quality System
ASE	Accelerated Solvent Extractor
ATSDR	Agency for Toxic Substances and Disease Registry
CBSA	Core-Based Statistical Area(s)
CFR	Code of Federal Regulations
CNG	Compressed Natural Gas
CSATAM	Community-Scale Air Toxics Ambient Monitoring
CV	Coefficient of Variation
DNPH	2,4-Dinitrophenylhydrazine
DQI	Data Quality Indicator(s)
DQO	Data Quality Objective(s)
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
F	Fahrenheit
FAC	Federal Advisory Committee
FEM	Federal Equivalent Method
FHWA	Federal Highway Administration
GC/MS-FID	Gas Chromatography/Mass Spectrometry and Flame Ionization Detection
GHG	Greenhouse Gas(es)
GIS	Geographical Information System
GMT	Greenwich Mean Time
GWP	Global Warming Potential
HAP	Hazardous Air Pollutant(s)
HPLC	High-Performance Liquid Chromatography
HQ	Hazard Quotient
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
IC	Ion Chromatography
ICP-MS	Inductively Coupled Plasma/Mass Spectrometry
IPCC	Intergovernmental Panel on Climate Change
kt	Knots
mb	Millibar
MDL	Method Detection Limit
mg/m^3	Milligrams per cubic meter
mL	Milliliter
MQO	Measurement Quality Objective(s)
MRL	Minimal Risk Level
MSA	Metropolitan or Micropolitan Statistical Area(s)
NAAQS	National Ambient Air Quality Standard
NATA	National Air Toxics Assessment

LIST OF ACRONYMS (Continued)

NATTS	National Air Toxics Trends Stations
NCDC	National Climatic Data Center
ND	Non-detect
NEI	National Emissions Inventory
ng/m^3	Nanograms per cubic meter
NMOC	Non-Methane Organic Compound(s)
NMP	National Monitoring Programs
NOAA	National Oceanic and Atmospheric Administration
NOx	Oxides of Nitrogen
NWS	National Weather Service
PAH	Polycyclic Aromatic Hydrocarbon(s)
PAMS	Photochemical Assessment Monitoring Stations
PM	Particulate Matter
PM_{10}	Particulate Matter less than 10 microns
POM	Polycyclic Organic Matter
ppbC	Parts per billion carbon
ppbv	Parts per billion by volume
ppm	Parts per million
PT	Proficiency Test
PUF	Polyurethane Foam
QAPP	Quality Assurance Project Plan
RfC	Reference Concentration(s)
SATMP	School Air Toxics Monitoring Program
SIM	Selected Ion Monitoring
SIP	State Implementation Plan(s)
SNMOC	Speciated Nonmethane Organic Compound(s)
TAD	Technical Assistance Document
TNMOC	Total Nonmethane Organic Compound(s)
tpy	Tons per year
TSP	Total Suspended Particulate
TSV	Total Spatial Variance
UATMP	Urban Air Toxics Monitoring Program
$\mu g/m^3$	Micrograms per cubic meter
µL	Microliter
URE	Unit Risk Estimate(s)
UTC	Universal Time Coordinated
UV	Ultraviolet
UV-VIS	Ultraviolet Visible
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound(s)
WBAN	Weather Bureau/Army/Navy ID

Abstract

This report presents the results and conclusions from the ambient air monitoring conducted as part of the 2012 National Monitoring Programs (NATTS, UATMP, and CSATAM) - three individual programs with different goals, but together result in a better understanding and appreciation of the nature and extent of toxic air pollution. The 2012 NMP includes data from samples collected at 64 monitoring sites that collected 24-hour air samples, typically on a 1-in-6 or 1-in-12 day schedule. Thirty sites sampled for 59 volatile organic compounds (VOCs); 37 sites sampled for 15 carbonyl compounds; eight sites sampled for 80 speciated nonmethane organic compounds (SNMOCs); 25 sites sampled for 22 polycyclic aromatic hydrocarbons (PAHs); 19 sites sampled for 11 metals; and 25 sites sampled for hexavalent chromium. Over 233,000 ambient air concentrations were measured during the 2012 NMP. This report uses various graphical, numerical, and statistical analyses to put the vast amount of ambient air monitoring data collected into perspective. Not surprisingly, the ambient air concentrations measured during the program varied significantly from city-to-city and from season-to-season.

The ambient air monitoring data collected during the 2012 NMP serve a wide range of purposes. Not only do these data characterize the nature and extent of air pollution close to the 64 individual monitoring sites participating in these programs, but they also identify trends and patterns that may be common to urban and rural environments and across the country. Therefore, this report presents results that are specific to particular monitoring locations and presents other results that are common to all environments. The results presented provide additional insight into the complex nature of air pollution. The raw data are included in the appendices of this report.

1.0 Introduction

Air pollution contains many components that originate from a wide range of stationary, mobile, and natural emissions sources. Because some of these components include air toxics that are known or suspected to have the potential for negative human health impacts, the U.S. Environmental Protection Agency (EPA) encourages state, local, and tribal agencies to understand and appreciate the nature and extent of toxic air pollution in their respective locations. To achieve this goal, EPA sponsors the National Monitoring Programs (NMP), which include the Photochemical Assessment Monitoring Stations (PAMS) network, Urban Air Toxics Monitoring Program (UATMP), National Air Toxics Trends Stations (NATTS) network, Community-Scale Air Toxics Ambient Monitoring (CSATAM) Program, and monitoring for other pollutants such as Non-Methane Organic Compounds (NMOCs). These programs have the following program-specific objectives:

- The primary objective of the UATMP is to characterize the composition and magnitude of air toxics pollution through ambient air monitoring.
- The primary objective of the NATTS network is to obtain a statistically significant quantity of high-quality representative air toxics measurements such that long-term trends can be identified.
- The primary objective of the CSATAM Program is to conduct local-scale investigative ambient air toxics monitoring projects.

1.1 Background

EPA began the NMOC program in 1984. Monitoring for selected NMOCs was performed during the morning hours of the summer ozone season. NMOC data were to be used to better understand ozone formation and to develop ozone control strategies. The UATMP was initiated by EPA in 1988 as an extension of the existing NMOC program to meet the increasing need for information on air toxics. Over the years, the program has grown in both participation and targeted pollutants (EPA, 2009a). The program has allowed for the identification of compounds that are prevalent in ambient air and for participating agencies to screen air samples for concentrations of air toxics that could potentially result in adverse human health effects.

The NATTS network was created to generate long-term ambient air toxics concentration data at specific fixed sites across the country. The 10-City Pilot Program (LADCO, 2003) was developed and implemented during 2001 and 2002, leading to the development and initial implementation of the NATTS network during 2003 and 2004. The goal of the program is to estimate the concentrations of air toxics on a national level from fixed sites that remain active over an extended period of time (EPA, 2009a). The generation of large quantities of high-quality data over an extended period may allow concentration trends (i.e., any substantial increase or decrease over a period of time) to be identified. The data generated are also used for validating modeling results and emissions inventories, assessing current regulatory benchmarks, and assessing the potential for developing cancerous and noncancerous health effects (EPA, 2013a; EPA 2009b). The initial site locations were based on existing infrastructure of monitoring site locations (e.g., $PM_{2.5}$ network) and results from preliminary air toxics programs such as the 1996 National Air Toxics Assessment (NATA), which used air toxics emissions data to model ambient monitoring concentrations across the nation. Monitoring sites were placed in both urban and rural locations. Urban areas were chosen to measure population exposure, while rural areas were chosen to determine background levels of air pollution (EPA, 2009b). Currently, 27 NATTS sites are strategically placed across the country (EPA, 2013a).

The CSATAM Program was initiated in 2004 and is intended to support state, local, and tribal agencies in conducting discreet, investigative projects of approximately 2-year durations via periodic grant competitions (EPA, 2009a). The objectives of the CSATAM Program include identifying and profiling air toxics sources; developing and assessing emerging measurement methods; characterizing the degree and extent of local air toxics problems; and tracking progress of air toxics reduction activities (EPA, 2009a).

1.2 The Report

Many environmental and health agencies have participated in these programs to assess the sources, effects, and changes in air pollution within their jurisdictions. This report summarizes and interprets measurements collected at monitoring sites participating in the UATMP, NATTS, and CSATAM programs. Included in this report are data from sites whose operating agencies have opted to have their samples analyzed by EPA’s national contract laboratory, Eastern Research Group, Inc. (ERG). Agencies operating sites under the NMP are not required to have their samples analyzed by ERG or may not have samples for all methods analyzed by ERG, as they may have their own laboratories or use other contract laboratories. In these cases, data are generated by sources other than ERG and are not included in this report. In addition, a state, local, or tribal agency may opt to contract with ERG for a special air toxics monitoring study in which their data are included in the report as well.

In past reports, measurements from UATMP, NATTS, and CSATAM monitoring sites have been presented together and referred to as “UATMP sites.” In more recent reports, a distinction is made among the three programs due to the increasing number of sites covered under each program. Thus, it is appropriate to describe each program; to distinguish among their purposes and scopes; and to integrate the data, which allows each program’s objectives and goals to complement one another.

Included in this report are data collected at 64 monitoring sites around the country. The 64 sites included in this report are located in or near 38 urban or rural locations in 24 states and the District of Columbia, including 35 metropolitan or micropolitan statistical areas (MSAs).

This report provides both a qualitative overview of air toxics pollution at selected urban and rural locations and a quantitative data analysis of the factors that appear to most significantly affect the behavior of air toxics in urban and rural areas. This report also focuses on data characterizations for each of the 64 different air sampling locations, a site-specific approach that allows for a much more detailed evaluation of the factors (e.g., emissions sources, natural sources, meteorological influences) that affect air quality differently from one location to the next. Much of the data analysis and interpretation contained in this report focuses on pollutant-specific risk potential.

This report offers participating agencies relevant information and insight into important air quality issues. For example, participating agencies can use trends and patterns in the monitoring data to determine whether levels of air pollution present public health concerns, to identify which emissions sources contribute most to air pollution, or to forecast whether proposed pollution control initiatives could significantly improve air quality. Monitoring data may also be compared to modeling results, such as from EPA’s NATA.

Policy-relevant questions that the monitoring data may help answer include the following:

- Which anthropogenic sources substantially affect air quality?
- Have pollutant concentrations decreased as a result of regulations (or increased despite regulation)?
- Which pollutants contribute the greatest health risk on a short-term, intermediate-term, and long-term basis?

The data analyses contained in this report are applied to each participating UATMP, NATTS, or CSATAM monitoring site, depending upon pollutants sampled and duration of sampling. Although many types of analyses are presented, state and local environmental agencies are encouraged to perform additional evaluations of the monitoring data so that the many factors that affect their specific ambient air quality can be understood fully.

To facilitate examination of the 2012 UATMP, NATTS, and CSATAM monitoring data, henceforth referred to as NMP data, the complete set of measured concentrations is presented in the appendices of this report. In addition, these data are publicly available in electronic format from EPA's Air Quality System (AQS) (EPA, 2013b).

This report is organized into 32 sections and 17 appendices. While each state section is designed to be a stand-alone section to allow those interested in a particular site or state to understand the associated data analyses without having to read the entire report, it is recommended that Sections 1 through 4 (Introduction, Monitoring Programs Network Overview, Data Treatments and Methods, and Summary of Results) and Sections 29 and 30 (Data Quality and Results, Conclusions, and Recommendations) be read as complements to the individual state sections. Table 1-1 highlights the contents of each section.

Table 1-1. Organization of the 2012 National Monitoring Programs Report

Report Section	Section Title	Overview of Contents
1	Introduction	This section serves as an introduction to the background and scope of the NMP (specifically, the UATMP, NATTS, and CSATAM Programs).
2	The 2012 National Monitoring Programs Network	This section provides information on the 2012 NMP monitoring effort: • Monitoring locations • Pollutants selected for monitoring • Sampling and analytical methods • Sampling schedules • Completeness of the air monitoring programs.
3	Summary of the 2012 National Monitoring Programs Data Treatments and Methods	This section presents and discusses the data treatments applied to the 2012 NMP data to determine significant trends and relationships in the data, characterize data based on how ambient air concentrations varied with monitoring location and with time, interpret the significance of the observed spatial and temporal variations, and evaluate human health risk.

Table 1-1. Organization of the 2012 National Monitoring Programs Report (Continued)

Report Section	Section Title	Overview of Contents
4	Summary of the 2012 National Monitoring Programs Data	This section presents and discusses the results of the data treatments from the 2012 NMP data.
5	Sites in Arizona	Monitoring results for the sites in the Phoenix-Mesa-Scottsdale, AZ MSA (PXSS and SPAZ)
6	Sites in California	Monitoring results for the sites in the Los Angeles-Long Beach-Anaheim, CA MSA (CELA and LBHCA), the Riverside-San Bernardino-Ontario, CA MSA (RUCA), and the San Jose-Sunnyvale-Santa Clara, CA MSA (SJJCA)
7	Sites in Colorado	Monitoring results for the sites in the Grand Junction, CO MSA (GPCO) and the Glenwood Springs, CO MSA (BMCO, BRCO, PACO, RFCO, and RICO)
8	Site in the District of Columbia	Monitoring results for the site in the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA (WADC)
9	Sites in Florida	Monitoring results for the sites in the Orlando-Kissimmee-Sanford, FL MSA (ORFL and PAFL) and the Tampa-St. Petersburg-Clearwater, FL MSA (AZFL, SKFL, and SYFL)
10	Site in Georgia	Monitoring results for the site in the Atlanta-Sandy Springs-Roswell, GA MSA (SDGA)
11	Sites in Illinois	Monitoring results for the sites in the Chicago-Naperville-Elgin, IL-IN-WI MSA (NBIL and SPIL) and the St. Louis, MO-IL MSA (ROIL)
12	Sites in Indiana	Monitoring results for the sites in the Chicago-Naperville-Elgin, IL-IN-WI MSA (INDEM) and the Indianapolis-Carmel-Anderson, IN MSA (WPIN)
13	Sites in Kentucky	Monitoring results for the sites in the Huntington-Ashland, WV-KY-OH MSA (ASKY and ASKY-M), the Lexington-Fayette, KY MSA (LEKY), the Evansville, IN-KY MSA (BAKY), the Paducah, KY-IL MSA (BLKY) and the sites in Marshall County (ATKY, CCKY, LAKY, and TVKY) and Carter County (GLKY)
14	Site in Massachusetts	Monitoring results for the site in the Boston-Cambridge-Newton, MA-NH MSA (BOMA)
15	Sites in Michigan	Monitoring results for the sites in the Detroit-Warren-Dearborn, MI MSA (DEMI, RRMI, and SWMI)
16	Site in Minnesota	Monitoring results for the site in the St. Cloud, MN MSA (STMN)
17	Site in Missouri	Monitoring results for the site in the St. Louis, MO-IL MSA (S4MO)
18	Sites in New Jersey	Monitoring results for the sites in the New York-Newark-Jersey City, NY-NJ-PA MSA (CHNJ, ELNJ, and NBNJ)

Table 1-1. Organization of the 2012 National Monitoring Programs Report (Continued)

Report Section	Section Title	Overview of Contents
19	Sites in New York	Monitoring results for the sites in the New York-Newark-Jersey City, NY-NJ-PA MSA (BXNY and MONY) and the Rochester, NY MSA (ROCH)
20	Sites in Oklahoma	Monitoring results for the sites in the Tulsa, OK MSA (TOOK and TMOK), the Oklahoma City, OK MSA (ADOK and OCOK), and Pryor Creek, OK (PROK)
21	Site in Rhode Island	Monitoring results for the site in the Providence-Warwick, RI-MA MSA (PRRI)
22	Site in South Carolina	Monitoring results for the site in Chesterfield, SC (CHSC)
23	Site in South Dakota	Monitoring results for the site in the Sioux Falls, SD MSA (SSSD)
24	Sites in Texas	Monitoring results for the sites in the Houston-The Woodlands-Sugar Land, TX MSA (CAMS 35) and the Marshall, TX MSA (CAMS 85)
25	Site in Utah	Monitoring results for the site in the Ogden-Clearfield, UT MSA (BTUT)
26	Sites in Vermont	Monitoring results for the sites in the Burlington-South Burlington, VT MSA (BURVT and UNVT) and the Rutland, VT MSA (RUVT)
27	Site in Virginia	Monitoring results for the site in the Richmond, VA MSA (RIVA)
28	Site in Washington	Monitoring results for the site in the Seattle-Tacoma-Bellevue, WA MSA (SEWA)
29	Sites in Wisconsin	Monitoring results for the sites in the Beaver Dam, WI MSA (HOWI) and the Milwaukee-Waukesha-West Allis, WI MSA (MIWI)
30	Data Quality	This section defines and discusses the concepts of precision and accuracy. Based on quantitative and qualitative analyses, this section comments on the precision and accuracy of the 2012 NMP ambient air monitoring data.
31	Results, Conclusions, and Recommendations	This section summarizes the most significant findings of the report and makes several recommendations for future projects that involve ambient air monitoring.
32	References	This section lists the references cited throughout the report.

2.0 The 2012 National Monitoring Programs Network

Agencies operating UATMP, NATTS, or CSATAM sites may choose to have their samples analyzed by EPA's contract laboratory, ERG, in Morrisville, NC. Data from 64 monitoring sites that collected 24-hour integrated ambient air samples for up to 12 months, at 1-in-6 or 1-in-12 day sampling intervals, and sent them to ERG for analysis are included in this report. Samples were analyzed for concentrations of selected hydrocarbons, halogenated hydrocarbons, and polar compounds from canister samples (Speciated Nonmethane Organic Compounds (SNMOCs) and/or Method TO-15), carbonyl compounds from sorbent cartridge samples (Method TO-11A), polycyclic aromatic hydrocarbons (PAHs) from polyurethane foam (PUF) and XAD-2® resin samples (Method TO-13A), trace metals from filters (Method IO-3.5), and hexavalent chromium from sodium bicarbonate-coated filters (ASTM D7614). Section 2.2 provides additional information regarding each of the sampling methodologies used to collect and analyze samples.

Agencies operating sites under the NMP are not required to have their samples analyzed by ERG. They may have samples for only select methods analyzed by ERG, as they may have their own laboratory capabilities for other methods. In these cases, data are generated by sources other than ERG and are therefore not included in this report.

The following sections review the monitoring locations, pollutants selected for monitoring, sampling and analytical methods, collection schedules, and completeness of the 2012 NMP dataset.

2.1 Monitoring Locations

For the NATTS network, monitor siting is based on the need to assess population exposure and background-level concentrations. For the UATMP and CSATAM programs, representatives from the state, local, and tribal agencies that voluntarily participate in the programs select the monitoring locations based on specific siting criteria and study needs. Among these programs, monitors were placed in urban areas near the centers of heavily populated cities (e.g., Chicago, IL and Phoenix, AZ), while others were placed in moderately populated rural areas (e.g., Horicon, WI and Chesterfield, SC).

Figure 2-1 shows the locations of the 64 monitoring sites participating in the 2012 programs, which encompass 38 different urban and rural areas. Outlined in Figure 2-1 are the associated core-based statistical areas (CBSA), as designated by the U.S. Census Bureau, where each site is located (Census Bureau, 2013a). A CBSA refers to either a metropolitan (an urban area with 50,000 or more people) or micropolitan (an urban area with at least 10,000 people but less than 50,000 people) statistical area (Census Bureau, 2013b).

Table 2-1 lists the respective monitoring program and the years of program participation for the 64 monitoring sites. Forty-nine monitoring sites have been included in previous annual reports. Fifteen monitoring sites are new to their respective programs for 2012; these sites are highlighted in green in Table 2-1. One NATTS site (BXNY) was relocated to a different location in 2010 (MONY) while construction was ongoing near the monitoring site. In June 2012, the instrumentation was moved back to the original location at BXNY.

As Figure 2-1 and Table 2-1 show, the 2012 NMP sites are widely distributed across the country. Detailed information about the monitoring sites is provided in Table 2-2 and Appendix A. Monitoring sites that are designated as part of the NATTS network are indicated by bold italic type in Table 2-1 and subsequent tables throughout this report in order to distinguish this program from the other programs. Table 2-2 shows that the location of the monitoring sites vary significantly from site to site. These sites are located in areas of differing elevation, population, land use, climatology, and topography. A more detailed look at each monitoring site's surroundings is provided in the individual state sections.

For record-keeping and reporting purposes, each site was assigned the following:

- A unique four- or five-letter site code used to track samples from the monitoring site to the ERG laboratory.
- A unique nine-digit AQS site code used to index monitoring results in the AQS database.

This report cites the four- or five-letter site code when presenting selected monitoring results. For reference, each site's AQS site code is provided in Table 2-2.

Figure 2-1. Locations of the 2012 National Monitoring Programs Monitoring Sites

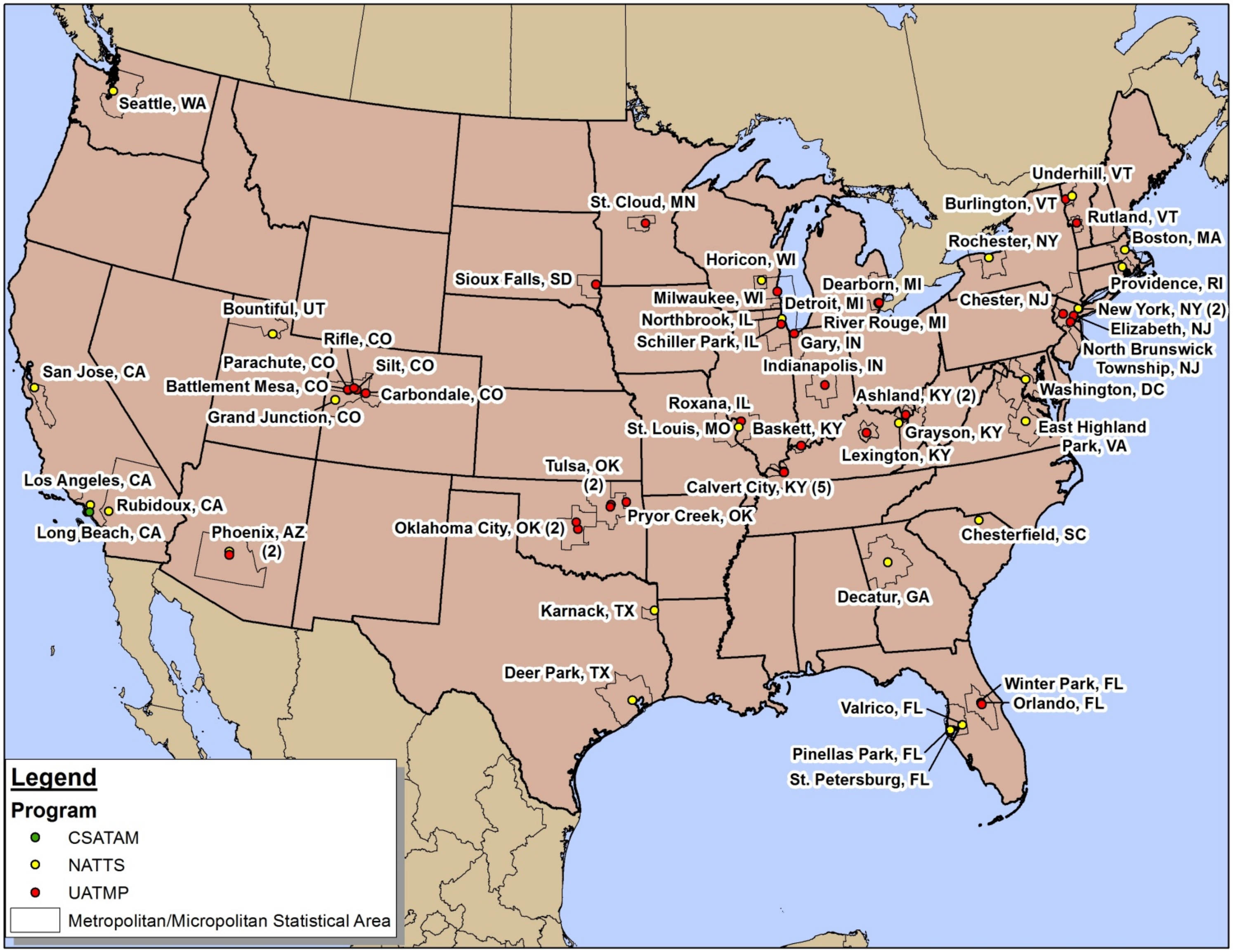

Table 2-1. 2012 National Monitoring Programs Sites and Past Program Participation

Monitoring Location and Site	Program	2002 and Earlier	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Ashland, KY (ASKY)	UATMP											✓
Ashland, KY (ASKY-M)	UATMP											✓
Baskett, KY (BAKY)	UATMP											✓
Battlement Mesa, CO (BMCO)	UATMP									✓	✓	✓
Boston, MA ***(BOMA)***	NATTS		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bountiful, UT ***(BTUT)***	NATTS		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Burlington, VT (BURVT)	UATMP								✓	✓	✓	✓
Calvert City, KY (ATKY)	UATMP											✓
Calvert City, KY (CCKY)	UATMP											✓
Calvert City, KY (LAKY)	UATMP											✓
Calvert City, KY (TVKY)	UATMP											✓
Carbondale, CO (RFCO)	UATMP											✓
Chester, NJ (CHNJ)	UATMP	2001, 2002	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chesterfield, SC ***(CHSC)***	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Dearborn, MI ***(DEMI)***	NATTS	2001, 2002	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Decatur, GA ***(SDGA)***	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Deer Park, TX ***(CAMS 35)***	NATTS						✓	✓	✓	✓	✓	✓

Green shading indicates new site participating in the NMP.
BOLD ITALICS = EPA-designated NATTS site
*Special air toxics monitoring study.

Table 2-1. 2012 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2002 and Earlier	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Detroit, MI (SWMI)	UATMP	2001, 2002									✓	✓
East Highland Park, VA (***RIVA***)	NATTS							✓	✓	✓	✓	✓
Elizabeth, NJ (ELNJ)	UATMP	1999-2002	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Gary, IN (INDEM)	UATMP			✓	✓	✓	✓	✓	✓	✓	✓	✓
Grand Junction, CO ***(GPCO)***	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Grayson, KY ***(GLKY)***	NATTS							✓	✓	✓	✓	✓
Horicon, WI (***HOWI)***	NATTS									✓	✓	✓
Indianapolis, IN (WPIN)	UATMP					✓	✓	✓	✓	✓	✓	✓
Karnack, TX (***CAMS 85***)	NATTS						✓			✓	✓	✓
Lexington, KY (LEKY)	UATMP											✓
Long Beach, CA (LBHCA)	CSATAM											✓
Los Angeles, CA (***CELA***)	NATTS						✓	✓	✓	✓	✓	✓
Milwaukee, WI (MIWI)	UATMP											✓
New York, NY (***BXNY***)	NATTS					✓	✓	✓	✓	✓		✓
New York, NY (***MONY***)	NATTS									✓	✓	✓
Northbrook, IL (***NBIL***)	NATTS		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
North Brunswick, NJ (NBNJ)	UATMP	2001, 2002	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Green shading indicates new site participating in the NMP.
BOLD ITALICS = EPA-designated NATTS site
*Special air toxics monitoring study.

Table 2-1. 2012 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2002 and Earlier	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Oklahoma City, OK (ADOK)	UATMP											✓
Oklahoma City, OK (OCOK)	UATMP								✓	✓	✓	✓
Orlando, FL (PAFL)	UATMP							✓	✓	✓	✓	✓
Parachute, CO (PACO)	UATMP							✓	✓	✓	✓	✓
Phoenix, AZ (***PXSS***)	NATTS	2001, 2002	✓	✓		✓	✓	✓	✓	✓	✓	✓
Phoenix, AZ (SPAZ)	UATMP	2001					✓	✓	✓	✓	✓	✓
Pinellas Park, FL (***SKFL***)	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Providence, RI (***PRRI***)	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Pryor Creek, OK (PROK)	UATMP							✓	✓	✓	✓	✓
Rifle, CO (RICO)	UATMP							✓	✓	✓	✓	✓
River Rouge, MI (RRMI)	UATMP	2001									✓	✓
Rochester, NY (***ROCH***)	NATTS					✓	✓	✓	✓	✓	✓	✓
Roxana, IL (ROIL)	UATMP*											✓
Rubidoux, CA (***RUCA***)	NATTS						✓	✓	✓	✓	✓	✓
Rutland, VT (RUVT)	UATMP	1995-1999, 2002							✓	✓	✓	✓
San Jose, CA (***SJJCA***)	NATTS							✓	✓	✓	✓	✓
Schiller Park, IL (SPIL)	UATMP		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Green shading indicates new site participating in the NMP.
BOLD ITALICS = EPA-designated NATTS site
*Special air toxics monitoring study.

Table 2-1. 2012 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2002 and Earlier	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Seattle, WA (***SEWA***)	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Silt, CO (BRCO)	UATMP							✓	✓	✓	✓	✓
Sioux Falls, SD (SSSD)	UATMP							✓	✓	✓	✓	✓
Smithland, KY (BLKY)	UATMP											✓
St. Cloud, MN (STMN)	UATMP											✓
St. Louis, MO (***S4MO***)	NATTS	2002	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
St. Petersburg, FL (AZFL)	UATMP	1991-1992, 2001-2002	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tulsa, OK (TMOK)	UATMP								✓	✓	✓	✓
Tulsa, OK (TOOK)	UATMP					✓	✓	✓	✓	✓	✓	✓
Underhill, VT (***UNVT***)	NATTS	2002			✓	✓	✓	✓	✓	✓	✓	✓
Valrico, FL (***SYFL***)	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Washington, D.C. (***WADC***)	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Winter Park, FL (ORFL)	UATMP	1990-1991	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Green shading indicates new site participating in the NMP.
BOLD ITALICS = EPA-designated NATTS site
*Special air toxics monitoring study.

Table 2-2. Site Characterizing Information for the 2012 National Monitoring Programs Sites

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population[a]	County-level Vehicle Registration, # of Vehicles[b] (Year)	Estimated Daily Traffic, AADT[b] (Year)	County-level Stationary Source HAP Emissions[c] (tpy)	County-level Mobile Source HAP Emissions[c] (tpy)
ADOK	40-109-0042	Oklahoma City, OK	Commercial	Urban/City Center	741,781	847,824 (2012)	34,100 (2011)	3,898.13	2,760.20
ASKY	21-019-0017	Ashland, KY	Residential	Suburban	49,164	39,227 (2012)	7,229 (2011)	381.85	133.65
ASKY-M	21-019-0002	Ashland, KY	Industrial	Urban/City Center	49,164	39,227 (2012)	12,842 (2012)	381.85	133.65
ATKY	21-157-0016	Calvert City, KY	Industrial	Suburban	31,344	30,297 (2012)	3,262 (2012)	1,200.40	467.15
AZFL	12-103-0018	St. Petersburg, FL	Residential	Suburban	921,319	872,813 (2012)	38,500 (2012)	4,200.72	2,592.37
BAKY	21-101-0014	Baskett, KY	Commercial	Rural	46,513	38,518 (2012)	922 (2012)	515.54	238.32
BLKY	21-139-0004	Smithland, KY	Agricultural	Rural	9,423	8,281 (2012)	2,280 (2010)	59.49	116.57
BMCO	NA	Battlement Mesa, CO	Residential	Rural	56,953	74,508 (2011)	2,527 (2002)	2,896.50	284.27
BOMA	25-025-0042	Boston, MA	Commercial	Urban/City Center	744,426	362,899 (2012)	27,654 (2010)	998.92	965.67
BRCO	08-045-0009	Silt, CO	Agricultural	Rural	56,953	74,508 (2011)	1,102 (2002)	2,896.50	284.27
BTUT	49-011-0004	Bountiful, UT	Residential	Suburban	315,809	259,319 (2012)	129,145 (2011)	1,896.78	844.04
BURVT	50-007-0014	Burlington, VT	Commercial	Urban/City Center	158,504	169,767 (2012)	14,000 (2007)	775.57	505.84
BXNY	36-005-0110	New York, NY	Residential	Urban/City Center	1,408,473	251,398 (2012)	99,201 (2011)	5,267.58	1,158.43

BOLD ITALICS = EPA-designated NATTS site

[a] Reference: Census Bureau, 2013c

[b] Individual references provided in each state section.

[c] Reference: 2011 NEI (EPA, 2013c)

[d] The proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

[e] GPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

NA = Data not loaded into AQS per agency request

Table 2-2. Site Characterizing Information for the 2012 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population[a]	County-level Vehicle Registration, # of Vehicles[b] (Year)	Estimated Daily Traffic, AADT[b] (Year)	County-level Stationary Source HAP Emissions[c] (tpy)	County-level Mobile Source HAP Emissions[c] (tpy)
CAMS 35	48-201-1039	Deer Park, TX	Residential	Urban/City Center	4,253,700	3,252,420 (2012)	31,043 (2004)	23,207.29	6,300.34
CAMS 85	48-203-0002	Karnack, TX	Agricultural	Rural	67,450	71,658 (2012)	1,250 (2011)	926.93	256.41
CCKY	21-157-0018	Calvert City, KY	Residential	Suburban	31,344	30,297 (2012)	4,742 (2010)	1,200.40	467.15
CELA	06-037-1103	Los Angeles, CA	Residential	Urban/City Center	9,962,789	7,422,254 (2012)	229,000 (2012)	28,724.47	13,337.05
CHNJ	34-027-3001	Chester, NJ	Agricultural	Rural	497,999	445,710 (Ratio)[d]	11,215 (2012)	1,117.70	1,229.12
CHSC	45-025-0001	Chesterfield, SC	Forest	Rural	46,103	41,259 (2012)	550 (2012)	277.26	153.23
DEMI	26-163-0033	Dearborn, MI	Industrial	Suburban	1,792,365	1,337,797 (2012)	87,500 (2012)	11,321.82	4,336.32
ELNJ	34-039-0004	Elizabeth, NJ	Industrial	Suburban	543,976	485,449 (Ratio)[d]	250,000 (2006)	2,367.55	958.12
GLKY	21-043-0500	Grayson, KY	Residential	Rural	27,348	25,391 (2012)	303 (2012)	144.52	116.39
GPCO[e]	08-077-0017 08-077-0018	Grand Junction, CO	Commercial	Urban/City Center	147,848	179,213 (2011)	11,000 (2011)	921.64	472.53
HOWI	55-027-0001	Horicon, WI	Agricultural	Rural	88,415	96,912 (2012)	5,100 (2011)	672.72	404.31
INDEM	18-089-0022	Gary, IN	Industrial	Urban/City Center	493,618	419,431 (2011)	34,754 (2011)	2,720.85	1,355.11
LAKY	21-157-0019	Calvert City, KY	Residential	Suburban	31,344	30,297 (2012)	1,189 (2012)	1,200.40	467.15

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[c] Reference: 2011 NEI (EPA, 2013c)

[d] The proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

[e] GPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

NA = Data not loaded into AQS per agency request

Table 2-2. Site Characterizing Information for the 2012 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population[a]	County-level Vehicle Registration, # of Vehicles[b] (Year)	Estimated Daily Traffic, AADT[b] (Year)	County-level Stationary Source HAP Emissions[c] (tpy)	County-level Mobile Source HAP Emissions[c] (tpy)
LBHCA	06-037-4002	Long Beach, CA	Residential	Suburban	9,962,789	7,422,254 (2012)	282,000 (2012)	28,724.47	13,337.05
LEKY	21-067-0012	Lexington, KY	Residential	Suburban	305,489	207,043 (2012)	10,083 (2012)	1,466.57	925.83
MIWI	55-079-0026	Milwaukee, WI	Commercial	Urban/City Center	955,205	632,914 (2012)	12,800 (2013)	5,075.77	1,840.40
MONY	36-005-0080	New York, NY	Residential	Urban/City Center	1,408,473	251,398 (2012)	91,213 (2011)	5,267.58	1,158.43
NBIL	17-031-4201	Northbrook, IL	Residential	Suburban	5,231,351	2,092,085 (2012)	115,100 (2012)	21,497.97	8,212.63
NBNJ	34-023-0006	North Brunswick, NJ	Agricultural	Rural	823,041	733,908 (Ratio)[d]	110,653 (2009)	2,531.15	1,499.95
OCOK	40-109-1037	Oklahoma City, OK	Residential	Suburban	741,781	847,824 (2012)	40,900 (2011)	3,898.13	2,760.20
ORFL	12-095-2002	Winter Park, FL	Commercial	Urban/City Center	1,202,234	1,073,682 (2012)	35,000 (2012)	5,649.93	3,886.50
PACO	08-045-0005	Parachute, CO	Residential	Urban/City Center	56,953	74,508 (2011)	16,000 (2011)	2,896.50	284.27
PAFL	12-095-1004	Orlando, FL	Commercial	Suburban	1,202,234	1,073,682 (2012)	49,500 (2012)	5,649.93	3,886.50
PROK	40-097-0187	Pryor Creek, OK	Industrial	Suburban	41,168	41,391 (2012)	15,100 (2011)	351.44	186.75
PRRI	44-007-0022	Providence, RI	Residential	Urban/City Center	628,323	548,763 (Ratio)[d]	136,800 (2009)	2,745.08	1,103.44
PXSS	04-013-9997	Phoenix, AZ	Residential	Urban/City Center	3,942,169	3,761,859 (2012)	184,000 (2010)	16,951.30	9,549.40

BOLD ITALICS = EPA-designated NATTS site

[a] Reference: Census Bureau, 2013c

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[c] Reference: 2011 NEI (EPA, 2013c)

[d] The proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

[e] GPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

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Table 2-2. Site Characterizing Information for the 2012 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population[a]	County-level Vehicle Registration, # of Vehicles[b] (Year)	Estimated Daily Traffic, AADT[b] (Year)	County-level Stationary Source HAP Emissions[c] (tpy)	County-level Mobile Source HAP Emissions[c] (tpy)
RFCO	08-045-0018	Carbondale, CO	Residential	Rural	56,953	74,508 (2011)	16,000 (2011)	2,896.50	284.27
RICO	08-045-0007	Rifle, CO	Commercial	Urban/City Center	56,953	74,508 (2011)	17,000 (2011)	2,896.50	284.27
RIVA	51-087-0014	East Highland Park, VA	Residential	Suburban	314,932	354,419 (2012)	72,000 (2012)	1,531.17	764.23
ROCH	36-055-1007	Rochester, NY	Residential	Urban/City Center	747,813	556,055 (2012)	88,348 (2011)	3,932.40	1,726.37
ROIL	17-119-9010	Roxana, IL	Industrial	Suburban	267,883	286,043 (2012)	9,400 (2011)	1,807.49	692.36
RRMI	26-163-0005	River Rouge, MI	Industrial	Suburban	1,792,365	1,337,797 (2012)	97,300 (2012)	11,321.82	4,336.32
RUCA	06-065-8001	Rubidoux, CA	Residential	Suburban	2,268,783	1,724,787 (2012)	145,000 (2012)	5,424.56	2,951.80
RUVT	50-021-0002	Rutland, VT	Commercial	Urban/City Center	60,869	70,900 (2012)	6,700 (2012)	307.04	261.25
S4MO	29-510-0085	St. Louis, MO	Residential	Urban/City Center	1,318,610	1,112,866 (2012)	79,558 (2011)	1,714.27	966.57
SDGA	13-089-0002	Decatur, GA	Residential	Suburban	707,089	472,535 (2011)	141,980 (2012)	5,444.91	1,597.34
SEWA	53-033-0080	Seattle, WA	Residential	Urban/City Center	2,007,440	1,403,968 (2012)	224,000 (2012)	9,553.33	6,638.48
SJJCA	06-085-0005	San Jose, CA	Commercial	Urban/City Center	1,837,504	1,529,351 (2012)	106,000 (2012)	5,252.06	3,316.86
SKFL	12-103-0026	Pinellas Park, FL	Residential	Suburban	921,319	872,813 (2012)	49,000 (2012)	4,200.72	2,592.37

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[a] Reference: Census Bureau, 2013c

[b] Individual references provided in each state section.

[c] Reference: 2011 NEI (EPA, 2013c)

[d] The proportion of county-level population to the state-level population was applied to state-level vehicle registration figure and used as a surrogate when county-level vehicle registration counts were not available.

[e] GPCO's hexavalent chromium monitor is at a separate, but adjacent, location; thus, this site has two AQS codes.

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Table 2-2. Site Characterizing Information for the 2012 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	County-level Population[a]	County-level Vehicle Registration, # of Vehicles[b] (Year)	Estimated Daily Traffic, AADT[b] (Year)	County-level Stationary Source HAP Emissions[c] (tpy)	County-level Mobile Source HAP Emissions[c] (tpy)
SPAZ	04-013-4003	Phoenix, AZ	Residential	Urban/City Center	3,942,169	3,761,859 (2012)	128,000 (2010)	16,951.30	9,549.40
SPIL	17-031-3103	Schiller Park, IL	Mobile	Suburban	5,231,351	2,092,085 (2012)	191,700 (2011)	21,497.97	8,212.63
SSSD	46-099-0008	Sioux Falls, SD	Commercial	Urban/City Center	175,037	212,507 (2012)	18,575 (2012)	1,187.98	481.52
STMN	27-145-3053	St. Cloud, MN	Industrial	Suburban	151,606	218,196 (2012)	24,100 (2009)	2,112.70	1,198.42
SWMI	26-163-0015	Detroit, MI	Commercial	Urban/City Center	1,792,365	1,337,797 (2012)	94,400 (2012)	11,321.82	4,336.32
SYFL	12-057-3002	Valrico, FL	Residential	Rural	1,277,746	1,143,207 (2012)	10,400 (2012)	5,928.69	3,869.11
TMOK	40-143-1127	Tulsa, OK	Residential	Urban/City Center	613,816	618,359 (2012)	12,600 (2011)	3,514.68	2,195.17
TOOK	40-143-0235	Tulsa, OK	Industrial	Urban/City Center	613,816	618,359 (2012)	63,000 (2011)	3,514.68	2,195.17
TVKY	21-157-0014	Calvert City, KY	Industrial	Suburban	31,344	30,297 (2012)	2,231 (2011)	1,200.40	467.15
UNVT	50-007-0007	Underhill, VT	Forest	Rural	158,504	169,767 (2012)	1,100 (2011)	775.57	505.84
WADC	11-001-0043	Washington, D.C.	Commercial	Urban/City Center	632,323	316,231 (2011)	7,400 (2010)	2,377.90	863.89
WPIN	18-097-0078	Indianapolis, IN	Residential	Suburban	918,977	820,767 (2011)	143,970 (2011)	4,871.79	3,218.51

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The proximity of the monitoring sites to different emissions sources, especially industrial facilities and heavily traveled roadways, often explains the observed spatial variations in ambient air quality. To provide a first approximation of the potential contributions of stationary and mobile source emissions on ambient air quality at each site, Table 2-2 also lists the following:

- The number of people living within each monitoring site's respective county.
- The county-level number of motor vehicles registered in each site's respective county, based on total vehicle registrations.
- The number of vehicles passing the nearest available representative roadway to the monitoring site, generally expressed as annual average daily traffic (AADT).
- Stationary and mobile source hazardous air pollutant (HAP) emissions for the monitoring site's residing county, according to the 2011 National Emissions Inventory (NEI).

This information is discussed in further detail in Section 4.3 and the individual state sections.

2.2 Analytical Methods and Pollutants Targeted for Monitoring

Air pollution typically contains hundreds of components, including, but not limited to, volatile organic compounds (VOCs), metals, and particulate matter (PM). Because the sampling and analysis required to monitor for every component of air pollution has been prohibitively expensive, the NMP focuses on specific pollutants that are analyzed using specific methods, as listed below. The target pollutants varied from monitoring site to monitoring site.

- *Compendium Method TO-15* was used to measure ambient air concentrations of 59 VOCs.
- *EPA-approved SNMOC Method* was used to measure 80 ozone precursors. This method was often performed concurrently with Method TO-15.
- *Compendium Method TO-11A* was used to measure ambient air concentrations of 15 carbonyl compounds.
- *Compendium Method TO-13A* was used to measure ambient air concentrations of 22 PAHs.
- *Compendium Method IO-3.5* was used to measure ambient air concentrations of 11 metals.
- *ASTM Method D7614* was used to measure ambient air concentrations of hexavalent chromium.

The sample collection equipment at each site was installed either as a stand-alone sampler or in a temperature-controlled enclosure (usually a trailer or a shed) with the sampling probe inlet exposed to the ambient air. With these common setups, most monitoring sites sampled ambient air at heights approximately 5 feet to 20 feet above local ground level.

The detection limits of the analytical methods must be considered carefully when interpreting the corresponding ambient air monitoring data. By definition, method detection limits (MDLs) represent the lowest concentrations at which laboratory equipment have been experimentally determined to reliably quantify concentrations of selected pollutants to a specific confidence level. If a pollutant's concentration in ambient air is below the method sensitivity (as gauged by the MDL), the analytical method might not differentiate the pollutant from other pollutants in the sample or from the random "noise" inherent in the analyses. While quantification below the MDL is possible, the measurement reliability is lower. Therefore, when pollutants are present at concentrations below their respective detection limits, multiple analyses of the same sample may lead to a wide range of measurement results, including highly variable concentrations or "non-detect" observations (i.e., the pollutant was not detected by the instrument). Data analysts should exercise caution when interpreting monitoring data with a high percentage of reported concentrations at levels near or below the corresponding detection limits.

MDLs are determined annually at the ERG laboratory using 40 CFR, Part 136 Appendix B procedures (EPA, 2013d) in accordance with the specifications presented in the NATTS Technical Assistance Document (TAD) (EPA, 2009b). This procedure involves analyzing at least seven replicate standards spiked onto the appropriate sampling media and extracted (per analytical method). Instrument-specific detection limits (replicate analysis of standards in solution) are not determined because sample contamination and preparation variability would not be considered.

MDLs for metals samples were calculated using the procedure described by "Appendix D: DQ FAC Single Laboratory Procedure v2.4" (FAC, 2007), with the exception of the arsenic MDL for Teflon® filters. The FAC MDL procedure involves using historical blank filter data to calculate MDLs for each pollutant. For arsenic, the procedure described in 40 CFR was used to calculate the MDL rather than the FAC procedure because this metal is not present at a high enough level in the background on the filters.

Tables 2-3 through 2-8 identify the specific target pollutants for each analytical method and their corresponding MDLs, as determined for 2012. For the VOC and SNMOC analyses, the experimentally-determined MDLs do not change within a given year unless the sample was diluted. The 2012 VOC and SNMOC MDLs are presented in Tables 2-3 and 2-4, respectively. For the rest of the analyses, the MDLs vary due to the actual volume pulled through the sample or if the sample was diluted. For these analyses, the range and average MDL is presented for each pollutant in Tables 2-5 through 2-8, based on valid samples. If the MDLs presented in Tables 2-5 through 2-8 include an MDL for a diluted sample, the MDL may appear elevated. Dilutions cause the MDL to increase by a factor of the dilution; MDLs affected by dilution are denoted in the tables. ERG's published pollutant-specific MDLs are also presented in Appendix B.

The following discussion presents an overview of the sampling and analytical methods. For detailed descriptions of the methods, refer to EPA's original documentation of the Compendium Methods (EPA, 1998; EPA, 1999a; EPA, 1999b; EPA, 1999c; EPA, 1999d; EPA 2012a; ASTM, 2012; ASTM, 2013).

2.2.1 VOC and SNMOC Concurrent Sampling and Analytical Methods

VOC and SNMOC sampling and analysis can be performed concurrently in accordance with a combination of EPA Compendium Method TO-15 (EPA, 1999a) and the procedure presented in EPA's "Technical Assistance Document for Sampling and Analysis of Ozone Precursors" (EPA, 1998), respectively. When referring to SNMOC, this report may refer to this method as the "concurrent SNMOC method" or "concurrent SNMOC analysis" because both methods were often employed at the same time to analyze the same sample. Ambient air samples for VOC and/or SNMOC analysis were collected in passivated stainless steel canisters. The ERG laboratory distributed the prepared canisters (i.e., cleaned and evacuated) to the monitoring sites before each scheduled sample collection event, and site operators connected the canisters to air sampling equipment prior to each sample day. Prior to field sampling, the passivated canisters had internal pressures much lower than atmospheric pressure. Using this pressure differential, ambient air flowed into the canisters automatically once an associated system solenoid valve was opened. A mass flow controller on the sampling device inlet ensured that ambient air entered the canister at an integrated constant rate across the collection period. At the end of the 24-hour sampling period, the solenoid valve automatically closed and stopped ambient air from flowing into the canister. Site operators recovered and returned the canisters, along with the Chain of Custody forms and all associated documentation, to the ERG laboratory for analysis.

By analyzing each sample with gas chromatography incorporating mass spectrometry (operating in the Selected Ion Monitoring (SIM) mode) and flame ionization detection (GC/MS-FID), laboratory staff determined ambient air concentrations of 59 VOCs and/or 80 SNMOCs, and calculated the total nonmethane organic compounds (TNMOC) concentration. TNMOC is the sum of all hydrocarbon concentrations within the sample. Because isobutene and 1-butene elute from the GC column at the same time, the SNMOC analytical method reports only the sum concentration for these two compounds, and not the separate concentration for each compound. The same approach applies to *m*-xylene and *p*-xylene for both the VOC and concurrent SNMOC methods. Raw data for both methods are presented in Appendices C and D.

Table 2-3 presents the MDLs for the laboratory analysis of VOC samples with Method TO-15 and Table 2-4 presents the MDLs for the analysis of SNMOC samples. Note that beginning in 2012, two VOCs (chloromethylbenzene and methyl ethyl ketone) were removed from the VOC list. The MDL for every VOC is less than 0.075 parts per billion by volume (ppbv). SNMOC detection limits are expressed in parts per billion Carbon (ppbC). All of the SNMOC MDLs are less than 0.40 ppbC.

Table 2-3. 2012 VOC Method Detection Limits

Pollutant	2012 MDL (ppbv)	Pollutant	2012 MDL (ppbv)
Acetonitrile	0.073	Dichloromethane	0.023
Acetylene	0.072	1,2-Dichloropropane	0.019
Acrolein	0.060	*cis*-1,3-Dichloropropene	0.015
Acrylonitrile	0.020	*trans*-1,3-Dichloropropene	0.016
tert-Amyl Methyl Ether	0.016	Dichlorotetrafluoroethane	0.012
Benzene	0.061	Ethyl Acrylate	0.014
Bromochloromethane	0.014	Ethyl *tert*-Butyl Ether	0.011
Bromodichloromethane	0.021	Ethylbenzene	0.023
Bromoform	0.020	Hexachloro-1,3-Butadiene	0.022
Bromomethane	0.013	Methyl Isobutyl Ketone	0.015
1,3-Butadiene	0.011	Methyl Methacrylate	0.025
Carbon Disulfide	0.014	Methyl *tert*-Butyl Ether	0.011
Carbon Tetrachloride	0.025	*n*-Octane	0.020
Chlorobenzene	0.025	Propylene	0.033
Chloroethane	0.017	Styrene	0.024
Chloroform	0.014	1,1,2,2-Tetrachloroethane	0.019
Chloromethane	0.033	Tetrachloroethylene	0.020
Chloroprene	0.012	Toluene	0.045
Dibromochloromethane	0.018	1,2,4-Trichlorobenzene	0.022
1,2-Dibromoethane	0.017	1,1,1-Trichloroethane	0.021
m-Dichlorobenzene	0.024	1,1,2-Trichloroethane	0.021
o-Dichlorobenzene	0.021	Trichloroethylene	0.022
p-Dichlorobenzene	0.019	Trichlorofluoromethane	0.015
Dichlorodifluoromethane	0.023	Trichlorotrifluoroethane	0.017
1,1-Dichloroethane	0.015	1,2,4-Trimethylbenzene	0.025
1,2-Dichloroethane	0.016	1,3,5-Trimethylbenzene	0.022
1,1-Dichloroethene	0.014	Vinyl Chloride	0.011
cis-1,2-Dichloroethylene	0.018	*m,p*-Xylene[1]	0.037
trans-1,2-Dichloroethylene	0.012	*o*-Xylene	0.020

[1] Because *m*-xylene and *p*-xylene elute from the GC column at the same time, the VOC analytical method reports the sum of *m*-xylene and *p*-xylene concentrations and not concentrations of the individual isomers.

Table 2-4. 2012 SNMOC Method Detection Limits

Pollutant	2012 MDL (ppbC)[1]	Pollutant	2012 MDL (ppbC)[1]	Pollutant	2012 MDL (ppbC)[1]
Acetylene	0.151	1-Heptene	0.225	*n*-Pentane	0.161
Benzene	0.192	*n*-Hexane	0.141	1-Pentene	0.183
1,3-Butadiene	0.199	1-Hexene	0.342	*cis*-2-Pentene	0.215
n-Butane	0.198	*cis*-2-Hexene	0.342	*trans*-2-Pentene	0.152
cis-2-Butene	0.199	*trans*-2-Hexene	0.342	*a*-Pinene	0.215
trans-2-Butene	0.145	Isobutane	0.125	*b*-Pinene	0.215
Cyclohexane	0.180	Isobutene/1-Butene[2]	0.165	Propane	0.183
Cyclopentane	0.149	Isopentane	0.260	*n*-Propylbenzene	0.137
Cyclopentene	0.260	Isoprene	0.247	Propylene	0.099
n-Decane	0.155	Isopropylbenzene	0.159	Propyne	0.183
1-Decene	0.215	2-Methyl-1-Butene	0.260	Styrene	0.187
m-Diethylbenzene	0.215	3-Methyl-1-Butene	0.260	Toluene	0.212
p-Diethylbenzene	0.172	2-Methyl-1-Pentene	0.342	*n*-Tridecane	0.383
2,2-Dimethylbutane	0.197	4-Methyl-1-Pentene	0.342	1-Tridecene	0.383
2,3-Dimethylbutane	0.241	2-Methyl-2-Butene	0.260	1,2,3-Trimethylbenzene	0.104
2,3-Dimethylpentane	0.225	Methylcyclohexane	0.142	1,2,4-Trimethylbenzene	0.183
2,4-Dimethylpentane	0.174	Methylcyclopentane	0.114	1,3,5-Trimethylbenzene	0.119
n-Dodecane	0.383	2-Methylheptane	0.126	2,2,3-Trimethylpentane	0.212
1-Dodecene	0.383	3-Methylheptane	0.120	2,2,4-Trimethylpentane	0.125
Ethane	0.102	2-Methylhexane	0.131	2,3,4-Trimethylpentane	0.141
2-Ethyl-1-butene	0.342	3-Methylhexane	0.111	*n*-Undecane	0.237
Ethylbenzene	0.115	2-Methylpentane	0.093	1-Undecene	0.237
Ethylene	0.063	3-Methylpentane	0.155	*m*-Xylene/*p*-Xylene[2]	0.188
m-Ethyltoluene	0.122	*n*-Nonane	0.123	*o*-Xylene	0.094
o-Ethyltoluene	0.135	1-Nonene	0.187	Sum of Knowns	NA
p-Ethyltoluene	0.187	*n*-Octane	0.155	Sum of Unknowns	NA
n-Heptane	0.151	1-Octene	0.212	TNMOC	NA

[1] Concentration in ppbC = concentration in ppbv * number of carbon atoms in the compound.

[2] Because isobutene and 1-butene elute from the GC column at the same time, the SNMOC analytical method reports the sum concentration for these two compounds and not concentrations of the individual compounds. For the same reason, the *m*-xylene and *p*-xylene concentrations are reported as a sum concentration.

NA = Not applicable

2.2.2 Carbonyl Compound Sampling and Analytical Method

Following the specifications of EPA Compendium Method TO-11A (EPA, 1999b), ambient air samples for carbonyl compound analysis were collected by passing ambient air through an ozone scrubber and then through cartridges containing silica gel coated with 2,4-dinitrophenylhydrazine (DNPH), a compound known to react selectively and reversibly with many aldehydes and ketones. Carbonyl compounds in ambient air are retained in the sampling cartridge, while other compounds pass through the cartridge without reacting with the DNPH-coated matrix. The ERG laboratory distributed the DNPH cartridges to the monitoring sites prior to each scheduled sample collection event and site operators connected the cartridges to the air sampling equipment. After each 24-hour sampling period, site operators recovered and returned the cartridges, along with the Chain of Custody forms and all associated documentation, to the ERG laboratory for analysis.

To quantify concentrations of carbonyl compounds in the sampled ambient air, laboratory analysts extracted the exposed DNPH cartridges with acetonitrile. High-performance liquid chromatography (HPLC) analysis and ultraviolet (UV) detection of these solutions determined the relative amounts of individual carbonyl compounds present in the original air sample. Because the three tolualdehyde isomers elute from the HPLC column at the same time, the carbonyl compound analytical method reports only the sum concentration for these isomers, and not the separate concentrations for each isomer. Raw data for Method TO-11A are presented in Appendix E.

Table 2-5 lists the MDLs reported by the ERG laboratory for measuring concentrations of 15 carbonyl compounds. 2-Butanone (methyl ethyl ketone) was added to the TO-11A analysis in 2012. Although the sensitivity varies from pollutant-to-pollutant and from site-to-site due to different volumes pulled through the samples, the average detection limit for valid samples reported by the ERG laboratory for every carbonyl compound is less than 0.011 ppbv.

Table 2-5. 2012 Carbonyl Compound Method Detection Limits

Pollutant	Minimum MDL (ppbv)	Maximum MDL (ppbv)	Average MDL (ppbv)
Acetaldehyde	0.003	0.021[2]	0.007
Acetone	0.005	0.028[2]	0.009
Benzaldehyde	0.002	0.010	0.003
2-Butanone	0.002	0.014	0.004
Butyraldehyde	0.002	0.010	0.003
Crotonaldehyde	0.002	0.010	0.003
2,5-Dimethylbenzaldehyde	0.002	0.010	0.003
Formaldehyde	0.005	0.031[2]	0.010
Hexaldehyde	0.001	0.007	0.002
Isovaleraldehyde	0.001	0.007	0.002
Propionaldehyde	0.002	0.010	0.003
Tolualdehydes[1]	0.002	0.017	0.006
Valeraldehyde	0.002	0.010	0.003

[1] The three tolualdehyde isomers elute from the HPLC column at the same time; thus, the analytical method reports only the sum concentration for these three isomers and not the individual concentrations.

[2] Indicates that sample dilution was required to perform analysis.

2.2.3 PAH Sampling and Analytical Method

PAH sampling and analysis was performed in accordance with EPA Compendium Method TO-13A (EPA, 1999c) and ASTM D6209 (ASTM, 2013). The ERG laboratory prepared sampling media and supplied them to the sites before each scheduled sample collection event. The clean sampling PUF/XAD-2® cartridge and glass fiber filter are installed in a high volume sampler by the site operators and allowed to sample for 24 hours. Sample collection modules and Chain of Custody forms and all associated documentation were returned to the ERG laboratory after sample collection. Within 14 days of sampling, the filter and cartridge are extracted together using a toluene in hexane solution using the Dionex Accelerated Solvent Extractor (ASE) 350 or ASE 300. The sample extract is concentrated to a final volume of 1.0 milliliter (mL). A volume of 1 microliter (μL) is injected into the GC/MS operating in the SIM mode to analyze for 22 PAHs. Raw data for Method TO-13A are presented in Appendix F.

Table 2-6 lists the MDLs for the 22 PAH target pollutants. PAH detection limits are expressed in nanograms per cubic meter (ng/m^3). Although the sensitivity varies from pollutant-to-pollutant and from site-to-site due to the different volumes pulled through the samples, the average detection limit for valid samples reported by the ERG laboratory range from 0.034 ng/m^3 (acenaphthylene) to 0.199 ng/m^3 (naphthalene).

Table 2-6. 2012 PAH Method Detection Limits

Pollutant	Minimum MDL (ng/m^3)	Maximum MDL (ng/m^3)[1]	Average MDL (ng/m^3)
Acenaphthene	0.032	0.555	0.051
Acenaphthylene	0.021	0.368	0.034
Anthracene	0.028	0.492	0.046
Benzo(a)anthracene	0.035	0.605	0.056
Benzo(a)pyrene	0.043	0.754	0.070
Benzo(b)fluoranthene	0.033	0.565	0.052
Benzo(e)pyrene	0.039	0.675	0.063
Benzo(g,h,i)perylene	0.037	0.636	0.059
Benzo(k)fluoranthene	0.042	0.737	0.068
Chrysene	0.032	0.556	0.052
Coronene	0.040	0.704	0.065
Cyclopenta[cd]pyrene	0.054	0.934	0.087
Dibenz(a,h)anthracene	0.036	0.631	0.059
Fluoranthene	0.057	0.983	0.091
Fluorene	0.030	0.522	0.048
9-Fluorenone	0.036	0.631	0.059
Indeno(1,2,3-cd)pyrene	0.042	0.731	0.068
Naphthalene	0.115	2.40	0.197
Perylene	0.043	0.753	0.070
Phenanthrene	0.030	0.516	0.048
Pyrene	0.055	0.964	0.090
Retene	0.101	1.76	0.163

[1] Indicates that sample dilution was required to perform analysis.

2.2.4 Metals Sampling and Analytical Method

Ambient air samples for metals analysis were collected by passing ambient air through either 47mm Teflon® filters or 8" x 10" quartz filters, depending on the separate and distinct sampling apparatus used to collect the sample; the 47mm Teflon® filter is used for low-volume samplers, whereas the 8" x 10" quartz filter is used for high-volume samplers. EPA provides the filters to the monitoring sites. Sites sampled for either particulate matter less than 10 microns (PM_{10}) or total suspended particulate (TSP). Particulates in ambient air were collected on the filters and, after a 24-hour sampling period, site operators recovered and returned the filters, along with the Chain of Custody forms and all associated documentation, to the ERG laboratory for analysis.

Extraction and analysis for the determination of metals in or on particulate matter was performed in accordance with EPA Compendium Method IO-3.5 and EPA FEM Method "Standard Operating Procedure for the Determination of Lead in PM_{10} (or TSP) by Inductively

Coupled Plasma Mass Spectrometry (ICP-MS) with Hot Block Dilute Acid and Hydrogen Peroxide Filter Extraction" (EPA, 1999d; EPA, 2012a). Upon receipt at the laboratory, the whole filters (47mm Teflon®) or filter strips (8" x 10" quartz) were digested using a dilute nitric acid, hydrochloric acid, and/or hydrofluoric acid (Teflon® only) solution. The digestate was then quantified using ICP-MS to determine the concentration of individual metals present in the original air sample. Raw data for speciated metals are presented in Appendix G.

Table 2-7 lists the MDLs for the analysis of the metals samples. Due to the difference in sample volume/filter collection media, there are two sets of MDLs listed in Table 2-7. Although the sensitivity varies from pollutant-to-pollutant and from site-to-site due to the different volumes pulled through the samples, the average MDL for valid samples ranges from 0.004 ng/m^3 (beryllium) to 2.31 ng/m^3 (chromium) for the quartz filters and from 0.010 ng/m^3 (cadmium) to 24.45 ng/m^3 (chromium) for the Teflon® filters.

Table 2-7. 2012 Metals Method Detection Limits

Pollutant	Minimum MDL (ng/m^3)	Maximum MDL (ng/m^3)	Average MDL (ng/m^3)	Pollutant	Minimum MDL (ng/m^3)	Maximum MDL (ng/m^3)	Average MDL (ng/m^3)
8" X 10" Quartz Filters				**47mm Teflon® Filters**			
Antimony	0.008	0.028	0.023	Antimony	0.260	0.340	0.283
Arsenic	0.036	0.552[1]	0.058	Arsenic	0.160	0.200	0.172
Beryllium	0.003	0.005	0.004	Beryllium	0.010	0.020	0.020
Cadmium	0.004	0.008	0.006	Cadmium	0.010	0.010	0.010
Chromium	1.58	2.84	2.31	Chromium	22.5	28.8	24.4
Cobalt	0.017	0.111	0.090	Cobalt	0.030	0.040	0.031
Lead	0.066	18.9[1]	0.135	Lead	0.070	0.090	0.071
Manganese	0.081	0.395	0.320	Manganese	0.300	0.380	0.323
Mercury	0.005	1.25[1]	0.009	Mercury	0.040	0.050	0.050
Nickel	0.253	0.494	0.402	Nickel	0.370	0.480	0.404
Selenium	0.010	0.219[1]	0.023	Selenium	0.320	0.410	0.353

[1] Indicates that sample dilution was required to perform analysis.

2.2.5 Hexavalent Chromium Sampling and Analytical Method

Hexavalent chromium was measured using the method described in ASTM D7614 (ASTM, 2012). Ambient air samples for hexavalent chromium analysis were collected by passing ambient air through sodium bicarbonate impregnated acid-washed cellulose filters. ERG prepared and distributed either filters secured in Teflon® cartridges or in petri dishes to the monitoring sites prior to each scheduled sample collection event. Site operators connected the cartridges or installed the filters to the air sampling equipment. After a 24-hour sampling period, site operators recovered the cartridges and Chain of Custody forms and returned them to the ERG laboratory for analysis. Upon receipt at the laboratory, the filters were extracted using a sodium bicarbonate solution. Ion chromatography (IC) analysis and ultraviolet-visible (UV-Vis) detection of the extracts determined the amount of hexavalent chromium present in each sample.

Although the sensitivity varies from site-to-site due to the different volumes pulled through the samples, Table 2-8 presents the range and average detection limit (0.0036 ng/m^3) for valid samples reported by the ERG laboratory across the program. Raw data for the hexavalent chromium method are presented in Appendix H.

Table 2-8. 2012 Hexavalent Chromium Method Detection Limit

Pollutant	Minimum MDL (ng/m^3)	Maximum MDL[1] (ng/m^3)	Average MDL (ng/m^3)
Hexavalent Chromium	0.0028	0.0335	0.0036

[1] Indicates that sample dilution was required to perform analysis.

2.3 Sample Collection Schedules

Table 2-9 presents the first and last date upon which sample collection occurred for each monitoring site sampling under the NMP in 2012. The first sample date for each site is generally at the beginning of January and sampling continued through the end of December, although there were a few exceptions:

- The Oklahoma City, OK site (ADOK) began sampling TSP metals, carbonyl compounds, and VOCs under the NMP in December 2011. As a result, data from the five December 2011 samples collected at this site have been included with the 2012 data.
- The Milwaukee, WI (MIWI) and St. Cloud, MN (STMN) monitoring sites began sampling hexavalent chromium under the NMP in February. Conversely, the Deer Park, TX (CAMS 35) monitoring site discontinued hexavalent chromium sampling under the NMP in February.
- Several Kentucky monitoring sites began sampling under the NMP between March and July 2012. These sites sampled VOCs, carbonyl compounds, and/or PM_{10} metals.
- The Carbondale, CO (RFCO) monitoring site began sampling SNMOC and carbonyl compounds under the NMP in June.
- Sampling for PAHs at the Decatur, GA (SDGA) monitoring site under the NMP was discontinued at the end of June.

- The instrumentation at the New York, NY monitoring site (MONY) was relocated back to its original NATTS location at PS 52 (BXNY) after the completion of construction in the area. Monitoring at MONY stopped at the end of June after which monitoring at BXNY began in July.
- The Vermont monitoring sites (BURVT, RUVT, and UNVT) began sending carbonyl compound samples to ERG under the NMP in July.
- The Long Beach, CA (LBHCA) monitoring site began sampling PAHs under the NMP in July.
- The Roxana, IL (ROIL) monitoring site began sampling VOCs and carbonyl compounds in July.
- Monitoring at the Pryor Creek, OK (PROK) site was discontinued at the end of October.

According to the NMP schedule, 24-hour integrated samples were collected at each monitoring site on a 1-in-6 day schedule and each sample collection began and ended at midnight, local standard time. However, there were some exceptions, as some sites collected samples on a 1-in-12 day schedule, dependent upon location and monitoring objectives:

- Prior to July 2012, the Garfield County, CO sites (BMCO, BRCO, PACO, RICO) collected samples by initiating the samplers manually. Samples were generally collected from mid-morning of one day to mid-morning of the next. However, beginning in July 2012, timers were added to the samplers, allowing midnight-to-midnight sampling. SNMOC samples were collected on a 1-in-6 day schedule while carbonyl compounds were collected on a 1-in-12 day schedule at BMCO, BRCO, PACO, and RICO. Sampling at RFCO, which began sampling in June, was conducted on a 1-in-12 day schedule for both methods.
- The South Phoenix, AZ site (SPAZ) collected VOC samples on a 1-in-12 day schedule.
- The Orlando, FL site (PAFL) collected metals samples on a 1-in-12 day schedule.
- The Detroit, MI site (SWMI) collected carbonyl compound samples on a 1-in-12 day schedule.
- The Burlington, VT and Rutland, VT sites (BURVT and RUVT) collected VOC samples, and later carbonyl compound samples, on a 1-in-12 day schedule.

Table 2-9. 2012 Sampling Schedules and Completeness Rates

Site	Monitoring Period[1]		Carbonyl Compounds			VOCs			Hexavalent Chromium			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
ADOK[2]	12/5/11	12/29/12	66	66	100	66	66	100	--	--		64	65	98	--	--	--	--		
ASKY	7/14/12	12/29/12	29	29	100	29	29	100	--	--					--	--	--	--	--	
ASKY-M	3/4/12	12/29/12	--	--	--		--	--		--	--	50	51	98	--	--	--	--	--	
ATKY	7/14/12	12/29/12	--	--	--	29	29	100	--	--					--	--	--	--	--	
AZFL	1/4/12	12/29/12	59	61	97	--	--	--		--	--	--	--		--	--	--	--	--	
BAKY	3/4/12	12/29/12	--	--	--		--	--		--	--	50	51	98	--	--	--	--	--	
BLKY	7/14/12	12/29/12	--	--	--	26	29	90	--	--					--	--	--	--	--	
BMCO	1/4/12	12/29/12	26	31	84[3]	--	--	--		--	--	--	--			61	87	--	--	
BOMA	1/4/12	12/29/12	--	--	--	--	--	--	61	61	100	61	61	100 53	--	--	--	59	61	97
BRCO	1/4/12	12/29/12	28	31	90[3]	--	--	--		--						61	95	--		
BTUT	1/4/12	12/29/12	54	61	89	56	61	92	59	61	97	57	60	95 58	56	61	92	59	61	97
BURVT[3]	1/4/12	12/29/12	16	16	100	31	31	100	--	--					--	--	--	--		
BXNY	7/2/12	12/29/12	--	--	--		--	--	31	31	100	--	--		--	--	--	22	31	71
CAMS 35	1/4/12	12/29/12	--	--	--		--	--	61	61	100	--	--		--	--	--	9	10	90
CAMS 85	1/4/12	12/29/12	--	--	--		--	--	59	61	97	--	--		--	--	--	--		

A = Number of valid samples collected.
B = Number of valid samples that should be collected in 2012 based on sample schedule and start/end date of sampling.
C = Completeness (%).

[1] Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.
[2] Includes five samples from December 2011.
[3] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.
BOLD ITALICS = EPA-designated NATTS site.
Shading indicates that completeness is below the MQO of 85%.

Table 2-9. 2012 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period[1]		Carbonyl Compounds			VOCs			Hexavalent Chromium			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
CCKY	3/4/12	12/29/12	--	--	--	26	29	90	--	--		47	51	92	--	--	--	--		
CELA	1/4/12	12/29/12	--	--	--	--		--		-- --					--	--	--	60 --	61 --	98
CHNJ	1/4/12	12/29/12	62	61	>100	61 --	61	100 --	--	-- --	--	--	--		--	--	--	--		
CHSC	1/4/12	12/29/12	--	--	--	--	--	--	50	61 --	82 --	-- --	--		--	--	--	53 --	61 --	87
DEMI	1/4/12	12/29/12	60	61	98	63	61	>100	62	61	>100	-- --	-- --	--	--	--	--	60	61	98
ELNJ	1/4/12	12/29/12	61	61	100	61	61	100	--	--					--	--	--	--		
GLKY	1/4/12	12/29/12	61	61	100	61	61	100	61	61 --	100 --	59 --	61 --	97	--	--	--	61 --	61 --	100
GPCO	1/4/12	12/30/12	61	61	100	62	61	>100	61	61	100	--	--	--	--	--	--	60	61	98
HOWI	1/4/12	12/29/12	--	--	--	--		--	61	61	100	--			--	--	--	--		
INDEM	1/4/12	12/29/12	59	61	97	-- --		--		--		--	--		--	--	--	-- --	--	
LAKY	7/14/12	12/29/12	--	--	--	29 --	29	100 --	--	-- --	--	--	--		--	--	--	-- --	--	
LBHCA	7/14/12	12/29/12	--	--	--	--		--		-- --	--	--	--		--	--	--	26 --	29 --	90
LEKY	3/4/12	12/29/12	27	29	93	29 --	28	>100 --	--	-- --	--	49 --	51 --	96	--	--	--	--		
MIWI	2/27/12	12/29/12	--	--	--	--		--	52	52 --	100	--			--	--	--	-- --	--	
MONY	1/4/12	6/26/12	--	--	--	-- --		--	30	30	100	-- --	--		--	--	--	30 --	30 --	100

A = Number of valid samples collected.
B = Number of valid samples that should be collected in 2012 based on sample schedule and start/end date of sampling. -- --
C = Completeness (%).

[1] Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.
[2] Includes five samples from December 2011.
[3] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

BOLD ITALICS = EPA-designated NATTS site.
Shading indicates that completeness is below the MQO of 85%.

Table 2-9. 2012 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period[1]		Carbonyl Compounds			VOCs			Hexavalent Chromium			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
NBIL	1/4/12	12/29/12	66	61	>100	61	61	100	61	61	100	54	61	89	61	61	100	57	61	93
NBNJ	1/4/12	12/29/12	60	61	98	60	61	98	--	--					--	--	--	--		
OCOK	1/4/12	12/29/12	60	61	98	61	61	100	--	--	--	61	61	100	--	--	--	--	--	
ORFL	1/4/12	12/29/12	61	61	100	--		--		--					--	--	--	--	--	
PACO	1/4/12	12/29/12	27	31	87[3]	--		--		--	--	--	--			60	75	--	--	
PAFL[3]	1/10/12	12/29/12	--	--	--	--		--		--	--	30	30	100 45	--	--	--	--	--	
PROK	1/4/12	10/30/12	51	51	100	51	51	100	--	--		49	51	96	--	--	--	--	--	
PRRI	1/1/12	12/29/12	--	--	--	--		--	61	61	100	--			--	--	--	60	61	98
PXSS	1/4/12	12/31/12	61	61	100	61	61	100	61	61	100	61	61	100	--	--	--	59	61	97
RFCO[3]	6/8/12	12/17/12	15	17	88	--		--		--						17	100	--		
RICO	1/4/12	12/29/12	28	31	90[3]	--		--		--	--	--	--	17		61	98	--	--	
RIVA	1/4/12	12/29/12	--	--	--	--		--	61	61	100	--	--	60	--	--	--	56	61	92
ROCH	1/4/12	12/29/12	--	--	--	--		--	57	61	93	--	--		--	--	--	58	61	95
ROIL	6/8/12	12/29/12	35	35	100	33	35	94	--	--		--	--		--	--	--	--		
RRMI	1/4/12	12/29/12	49	61	80	--		--		--	--	--	--		--	--	--	--	--	

A = Number of valid samples collected.

B = Number of valid samples that should be collected in 2012 based on sample schedule and start/end date of sampling. -- -- -- --

C = Completeness (%).

[1] Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.

[2] Includes five samples from December 2011.

[3] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

BOLD ITALICS = EPA-designated NATTS site.

Shading indicates that completeness is below the MQO of 85%.

Table 2-9. 2012 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period[1]		Carbonyl Compounds			VOCs			Hexavalent Chromium			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
RUCA	1/4/12	12/29/12	--	--	--	--		--		--					--	--	--	61	61	100
RUVT[3]	1/16/12	12/29/12	16	16	100	31	30	>100	--	--	--	--	--		--	--	--	--		
S4MO	1/4/12	12/29/12	61	61	100	58	61	95	60	61	98	61	61	100	--	--	--	60	61	98
SDGA	1/4/12	12/29/12	--	--	--	--		--	54	61	89	--			--	--	--	29	30	97
SEWA	1/4/12	12/29/12	60	61	98	60	61	98	60	61	98	59	61	97	--	--	--	59	61	97
SJJCA	1/4/12	12/29/12	--	--	--	--		--		--		61	61	100	--	--	--	59	61	97
SKFL	1/4/12	12/29/12	59	61	97	--		--	60	61	98	--			--	--	--	61	61	100
SPAZ[3]	1/10/12	12/23/12	--	--	--	30	30	100	--	--		--	--		--	--	--	--		
SPIL	1/4/12	12/29/12	61	61	100	60	61	98	--	--	--	--	--		--	--	--	--	--	
SSSD	1/4/12	12/29/12	58	61	95	61	61	100	--	--	--	--	--			61	100	--	--	
STMN	2/9/12	12/29/12	--	--	--	--		--	54	55	98	--	--	61	--	--	--	--	--	
SWMI[3]	1/10/12	12/23/12	30	30	100	--		--		--		--	--		--	--	--	--	--	
SYFL	1/4/12	12/29/12	60	61	98	--		--	62	61	>100	--	--		--	--	--	59	61	97
TMOK	1/4/12	12/29/12	59	61	97	61	61	100	--	--		61	61	100	--	--	--	--		
TOOK	1/4/12	12/29/12	61	61	100	60	61	98	--	--		61	61	100	--	--	--	--	--	

A = Number of valid samples collected.
B = Number of valid samples that should be collected in 2012 based on sample schedule and start/end date of sampling.
C = Completeness (%).

[1] Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.

[2] Includes five samples from December 2011.

[3] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

BOLD ITALICS = EPA-designated NATTS site.
Shading indicates that completeness is below the MQO of 85%.

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Table 2-9. 2012 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period[1]		Carbonyl Compounds			VOCs			Hexavalent Chromium			Metals			SNMOCs			PAHs		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
TVKY	7/14/12	12/29/12	--	--	--	28	29	97	--	--					--	--	--	--		
UNVT	1/4/12	12/29/12	31	30	>100	61	60	>100	61	61	100	61	61	100	--	--	--	58	61	95
WADC	1/4/12	12/29/12	--	--	--	--		--	61	61	100	--			--	--	--	61	61	100
WPIN	1/4/12	12/29/12	58	61	95	--		--		--					--	--	--	--		

A = Number of valid samples collected.
B = Number of valid samples that should be collected in 2012 based on sample schedule and start/end date of sampling.
C = Completeness (%).
[1] Begins with 1st sample collected and ends with last sample collected; date range presented may not be representative of each method-specific date range.
[2] Includes five samples from December 2011.
[3] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.
BOLD ITALICS = EPA-designated NATTS site.
Shading indicates that completeness is below the MQO of 85%.

Table 2-9 shows the following:

- 30 sites collected VOC samples.
- 37 sites collected carbonyl compound samples.
- 8 sites collected SNMOC samples.
- 25 sites collected PAH samples.
- 19 sites collected metals samples.
- 25 sites collected hexavalent chromium samples.

As part of the sampling schedule, site operators were instructed to collect duplicate (or collocated) samples on roughly 10 percent of the sample days for select methods when duplicate (or collocated) samplers were available. A *duplicate* sample is a sample collected simultaneously with a primary sample using the same sampling system (i.e., two separate samples through the same sampling system at the same time). *Collocated* samples are samples collected simultaneously using two independent collection systems at the same location at the same time. Field blanks were collected once a month for carbonyl compounds, hexavalent chromium, metals, and PAHs. Sampling calendars were distributed to help site operators schedule the collection of samples, duplicates, and field blanks. In cases where a valid sample was not collected for a given scheduled sample day, site operators were instructed to reschedule or "make up" samples on other days. This practice explains why some monitoring locations periodically strayed from the 1-in-6 or 1-in-12 day sampling schedule.

The 1-in-6 or 1-in-12 day sampling schedule provides cost-effective approaches to data collection for trends characterization of toxic pollutants in ambient air and ensures that sample days are evenly distributed among the seven days of the week to allow weekday/weekend comparison of air quality. Because the 1-in-6 day schedule yields twice the number of measurements than the 1-in-12 day schedule, data characterization based on this schedule tends to be more representative.

2.4 Completeness

Completeness refers to the number of valid samples collected and analyzed compared to the number of total samples expected based on a 1-in-6 or 1-in-12 day sample schedule. Monitoring programs that consistently generate valid samples have higher completeness than programs that consistently have invalid samples. The completeness of an air monitoring program, therefore, can be a qualitative measure of the reliability of air sampling and laboratory analytical equipment as well as a measure of the efficiency with which the program is managed. The completeness for each monitoring site and method sampled is presented in Table 2-9.

The measurement quality objective (MQO) for completeness based on the EPA-approved Quality Assurance Project Plan (QAPP) specifies that at least 85 percent of samples from a given monitoring site must be collected and analyzed successfully to be considered sufficient for data trends analysis (ERG, 2012). The data in Table 2-9 show that five datasets from a total of 144 datasets from the 2012 NMP monitoring effort did not meet this MQO (shaded cells in Table 2-9):

- Sampler issues at PACO resulted in an SNMOC completeness less than 85 percent. Similarly, sampler issues at BMCO resulted in a carbonyl compound completeness less than 85 percent.
- The PAH sampler at the BXNY monitoring site sustained damage during Hurricane Sandy in late October 2012. The PAH sampler was back on-line by early December 2012.
- Intermittent sampler issues throughout much of 2012 resulted in a hexavalent chromium completeness less than 85 percent for CHSC.
- A collection error at RRMI resulted in the invalidation of carbonyl compound samples between May 15, 2012 and July 8, 2012.

Although the completeness for S4MO's VOCs is 95 percent, it should be noted that the Missouri Department of Natural Resources discovered a sampler contamination issue and invalidated all of its acrylonitrile results for this site through the end of October 2012. Similarly, the Kentucky Department of Environmental Protection invalidated all of its acrylonitrile and carbon disulfide data for GLKY through the end of September 2012. These issues are discussed in more detail in the individual state sections.

Appendix I identifies samples that were invalidated and lists the reason for invalidation, based on the applied AQS null code.

Table 2-10 presents method-specific completeness. Method-specific completeness was greater than 90 percent for all six methods performed under the 2012 NMP and ranged from 92.8 percent for SNMOCs to 99.0 percent for VOCs.

Table 2-10. Method Completeness Rates for 2012

Method	# of Valid Samples	# of Samples Scheduled	Method Completeness (%)	Minimum Site-Specific Completeness (%)	Maximum Site-Specific Completeness (%)
VOC	1,466	1,481	99.0	90 (BLKY)	>100 (5 sites)
SNMOC	411	443	92.8	75 (PACO)	100 (3 sites)
Carbonyl Compounds	1,796	1,846	97.3	80 (RRMI)	>100 (3 sites)
PAH	1,296	1,350	96.0	71 (***BXNY***)	100 (5 sites)
Metals Analysis	1,056	1,081	97.7	89 (***NBIL***)	>100 (2 sites)
Hexavalent Chromium	1,421	1,449	98.1	82 (***CHSC***)	>100 (2 sites)

BOLD ITALICS = EPA-designated NATTS site.

3.0 Summary of the 2012 National Monitoring Programs Data Treatment and Methods

This section summarizes the data treatment and approaches used to evaluate the measurements generated from samples collected during the 2012 NMP sampling year. These data were analyzed on a program-wide basis as well as a site-specific basis.

Results from the program-wide data analyses are presented in Section 4 while results from the site-specific data analyses are presented in the individual state sections, Sections 5 through 29.

A total of 233,600 valid air toxics concentrations (including non-detects, duplicate analyses, replicate analyses, and analyses for collocated samples) were produced from 9,686 valid samples collected at 64 monitoring sites during the 2012 reporting year. A tabular presentation of the raw data and statistical summaries are found in Appendices C through O, as presented in Table 3-1. Appendix P serves as the glossary for the NMP report and many of the terms discussed and defined throughout the report are provided there.

Table 3-1. Overview and Layout of Data Presented

Pollutant Group	Number of Sites	Appendix	
		Raw Data	Statistical Summary
VOCs	30	C	J
SNMOCs	8	D	K
Carbonyl Compounds	37	E	L
PAHs	25	F	M
Metals	19	G	N
Hexavalent Chromium	25	H	O

3.1 Approach to Data Treatment

This section examines the various statistical tools employed to characterize the data collected during the 2012 sampling year. Certain data analyses were performed at the program-level, other data analyses were performed at both the program-level and on a site-specific basis, and still other approaches were reserved for site-specific data analyses only. Regardless of the data analysis employed, it is important to understand how the concentration data were treated. The following paragraphs describe techniques used to prepare this large quantity of concentration data for data analysis.

Most monitoring sites collected duplicate or collocated samples on 10 percent of sample days, as discussed in Section 2.3. At the laboratory, these duplicate or collocated samples were then analyzed in replicate. *Replicate measurements* are repeated analyses performed on a duplicate or collocated pair of samples. In the event duplicate or collocated collection events were not possible at a given monitoring site, additional replicate samples were run on individual samples to provide an indication of analytical precision. For each monitoring site with primary, duplicate (or collocated), and replicate measurements, the results were averaged together for each pollutant in order to calculate a single concentration per sample date and method. This is referred to as the *preprocessed daily measurement*.

Concentrations of *m,p*-xylene and *o*-xylene were summed together and are henceforth referred to as "total xylenes," "xylenes (total)," or simply "xylenes" throughout the remainder of this report, with a few exceptions. One exception is Section 4.1, which examines the results of basic statistical calculations performed on the dataset. Table 4-1 and Table 4-2, which are the method-specific statistics for VOCs and SNMOCs, respectively, present the xylenes results retained as *m,p*-xylene and *o*-xylene species. This is also true of the Data Quality section (Section 30).

For the 2012 NMP, where statistical parameters are calculated based on the preprocessed daily measurements, zeros have been substituted for non-detect results. In past reports, the substitution of zeros was applied only to risk-related analyses; however, beginning with the 2010 NMP report, the substitution of zeros was applied to all analyses. This approach is consistent with how data are loaded into AQS per the NATTS TAD **(**EPA, 2009b) as well as other EPA air toxics monitoring programs, such as the School Air Toxics Monitoring Program (SATMP) (EPA, 2011a) and associated reports, such as the NATTS Network Assessment (EPA, 2012b). The substitution of zeros for non-detects results in lower average concentrations of pollutants that are rarely measured at or above the associated MDL and/or have a relatively high MDL.

In order to compare concentrations across multiple sampling methods, all concentrations have been converted to a common unit of measure: microgram per cubic meter ($\mu g/m^3$). However, whenever a particular sampling method is isolated from others, such as in Tables 4-1 through 4-6, the statistical parameters are presented in the units of measure associated with the particular sampling method. Thus, it is important to pay close attention to the unit of measure associated with each data analysis discussed in this and subsequent sections of the report.

In addition, this report presents various time-based averages to summarize the measurements for a specific site; where applicable, quarterly and annual averages were calculated for each site. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly averages include the substitution of zeros for all non-detects. Quarterly averages for the first quarter in the calendar year include concentrations from January, February, and March; the second quarter includes April, May, and June; the third quarter includes July, August, and September; and the fourth quarter includes October, November, and December. A minimum of 75 percent of the total number of samples possible within a given quarter must be valid to have a quarterly average presented. For sites sampling on a 1-in-6 day sampling schedule, 12 samples represents 75 percent; for sites sampling on a 1-in-12 day schedule, six samples represents 75 percent. Sites that do not meet these minimum requirements do not have a quarterly average concentration presented. Sites may not meet this minimum requirement due to invalidated or missed samples or because of a shortened sampling duration.

An *annual average* includes all measured detections and substituted zeros for non-detects for a given calendar year (2012). Annual average concentrations were calculated for monitoring sites where three quarterly averages could be calculated and where method completeness, as presented in Section 2.4, was greater than or equal to 85 percent. Sites that do not meet these requirements do not have an annual average concentration presented.

The concentration averages presented in this report are often provided with their associated 95 percent confidence intervals. Confidence intervals represent the interval within which the true average concentration falls 95 percent of the time. The confidence interval includes an equal amount of quantities above and below the concentration average. For example, an average concentration may be written as 1.25 ± 0.25 $\mu g/m^3$; thus, the interval over which the true average would be expected to fall would be between 1.00 to 1.50 $\mu g/m^3$ (EPA, 2011a).

3.2 Human Health Risk and the Pollutants of Interest

A practical approach to making an assessment on a large number of measurements is to focus on a subset of pollutants based on the end-use of the dataset. Thus, a subset of pollutants is selected for further data analyses for each annual NMP report. In past NMP annual reports, health risk-based calculations have been used to identify “pollutants of interest.” For the 2012 NMP report, the pollutants of interest are also based on risk potential. The following paragraphs provide an overview of health risk terms and concepts and outline how the pollutants of interest are determined and then used throughout the remainder of the report.

EPA defines risk as “the probability that damage to life, health, or the environment will occur as a result of a given hazard (such as exposure to a toxic chemical)” (EPA, 2011b). Human health risk can be defined in terms of time. Chronic effects develop from repeated exposure over long periods of time; acute effects develop from a single exposure or from exposures over short periods of time (EPA, 2010). Health risk is also route-specific; that is, risk varies depending upon route of exposure (i.e., oral vs. inhalation). Because this report covers air toxics in ambient air, only the inhalation route is considered. Hazardous air pollutants (HAPs) are those pollutants “known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects” (EPA, 2013e).

Health risks are typically divided into cancer and noncancer effects when referring to human health risk. Cancer risk is defined as the likelihood of developing cancer as a result of exposure to a given concentration over a 70-year period, and is presented as the number of people at risk for cancer per million people. Noncancer health effects include conditions such as asthma; noncancer health risks are presented as a hazard quotient, the value below which no adverse health effects are expected (EPA, 2011b). Cancer risk is presented as a probability while the hazard quotient is a ratio and thus, a unitless value.

In order to assess health risk, EPA and other agencies develop toxicity factors, such as cancer unit risk estimates (UREs) and noncancer reference concentrations (RfCs), to estimate cancer and noncancer risks and to identify (or screen) where air toxics concentrations may present a human health risk. EPA has published a guidance document outlining a risk-based screening approach for performing an initial screen of ambient air toxics monitoring datasets (EPA, 2010). The *preliminary risk-based screening process* provided in this report is an adaption of that approach and is a risk-based methodology for analysts and interested parties to identify which pollutants may pose a risk in their area. Cancer UREs and noncancer RfCs are used as screening values. Not all pollutants analyzed under the NMP have screening values; of the pollutants sampled under the NMP, 71 pollutants have screening values in the guidance document. The screening values used in this analysis are presented in Appendix Q[1].

The preprocessed daily measurements of the target pollutants were compared to these chronic risk screening values in order to identify pollutants of interest across the program. The following risk-based screening process was used to identify pollutants of interest:

1. The TO-15 and SNMOC methods have 12 pollutants in common. If a pollutant was measured by both the TO-15 and SNMOC methods at the same site, the TO-15 results were used. The purpose of this data treatment is to have one concentration per pollutant for each sample day.

2. Each preprocessed daily measurement was compared to the risk screening value. Concentrations that are greater than the risk screening value are described as "failing the screen."

3. The number of failed screens was summed for each applicable pollutant.

4. The percent contribution of the number of failed screens to the total number of failed screens program-wide was calculated for each applicable pollutant.

5. The pollutants contributing to the top 95 percent of the total failed screens were identified as pollutants of interest.

In regards to Step 5 above, the actual cumulative contribution may exceed 95 percent in order to include all pollutants contributing to the minimum 95 percent criteria (refer to acenaphthene in Table 4-7 for an example). In addition, if the 95 percent cumulative criterion is reached, but the next pollutant contributed equally to the number of failed screens, that pollutant was also designated as a pollutant of interest. Results of the program-wide risk-based screening process are provided in Section 4.2.

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[1] The risk-based screening process used in this report comes from guidance from EPA Region 4's report "A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Datasets" but the screening values referenced in that report have since been updated (EPA, 2013f).

Laboratory analysts have indicated that acetonitrile values may be artificially high (or non-existent) due to site conditions and potential cross-contamination with concurrent sampling of carbonyl compounds using Method TO-11A. The inclusion of acetonitrile in data analyses must be determined on a site-specific basis by the agency responsible for the site. Thus, acetonitrile results are excluded from certain program-wide and site-specific data analyses, particularly those related to risk.

Laboratory analysts have indicated that acrylonitrile and carbon disulfide values may also be artificially high due to potential contamination of the samplers using Method TO-15. The inclusion of acrylonitrile and carbon disulfide in data analyses must be determined on a site-specific basis by the agency responsible for the site. Thus, results for these pollutants are also excluded from program-wide and site-specific data analyses related to risk.

The NATTS TAD (EPA, 2009b) identifies 19 pollutants (“MQO Core Analytes”) that participating sites are required to sample and analyze for under the NATTS program. Table 3-2 presents these 19 NATTS MQO Core Analytes. Monitoring for these pollutants is required because they are major health risk drivers according to EPA (EPA, 2009b). Many of the pollutants listed in Table 3-2 are identified as pollutants of interest via the risk-based screening process. In past reports, these pollutants were considered pollutants of interest by default, although this has changed for the 2012 report.

Acrolein was excluded from the preliminary risk-based screening process due to questions about the consistency and reliability of the measurements (EPA, 2013g). Thus, the results from sampling and analysis of this pollutant have been excluded from any risk-related analyses presented in this report, similar to acetonitrile, acrylonitrile, and carbon disulfide.

Table 3-2. NATTS MQO Core Analytes

Pollutant	Class/Method
Acrolein	VOCs/TO-15
Benzene	
1,3-Butadiene	
Carbon Tetrachloride	
Chloroform	
Tetrachloroethylene	
Trichloroethylene	
Vinyl Chloride	
Acetaldehyde	Carbonyl Compounds/ TO-11A
Formaldehyde	
Naphthalene	PAHs/TO-13A
Benzo(a)pyrene	
Arsenic	Metals/IO-3.5
Beryllium	
Cadmium	
Manganese	
Lead	
Nickel	
Hexavalent chromium	Metals/ASTM D7614

The "pollutants of interest" designation is reserved for pollutants targeted for sampling through the NMP that meet the identified criteria. As discussed in Section 2.0, agencies operating monitoring sites that participate under the NMP are not required to have their samples analyzed by ERG or may measure analytes other than those targeted under the NMP. In these cases, data are generated by sources other than ERG and are not included in the preliminary risk-based screening process or any other data analysis contained in this report.

3.3 Noncancer Risk-Based Screening Evaluation Using Minimum Risk Levels

In addition to the preliminary risk-based screening process described above, a second risk-based screening was conducted using the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRL) health risk benchmarks (ATSDR, 2013a). This screening is simply informational and was not used to identify any additional pollutants of interest. An MRL is a concentration of a hazardous substance that is "likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure," similar to EPA's RfCs (ATSDR, 2013b). MRLs are intended to be used as screening tools, similar to the preliminary risk-based screening process discussed above, although "exposure to a level above the MRL does not mean that adverse health effects will occur" (ATSDR, 2013b). ATSDR defines MRLs for three durations of exposure: acute, intermediate, and chronic exposure. Acute risk results from exposures of 1 to 14 days; intermediate risk results from exposures of 15 to 364 days; and chronic risk results from exposures of 1 year or greater (ATSDR, 2013a). MRLs, as published by ATSDR, are presented in parts per million (ppm) for gases and milligrams per cubic meter (mg/m^3) for particulates. The MRLs used in this report have been converted to µg/m^3, have one significant figure, and are presented in Appendix Q.

For this risk-based screening evaluation, the preprocessed daily measurements were compared to acute MRLs; quarterly averages were compared to intermediate MRLs; and annual averages were compared to chronic MRLs. Section 4.2.2 presents the number of preprocessed daily measurements, quarterly averages, and/or annual averages that are greater than their respective MRL for each pollutant, summed to the program level. The number of site-specific concentrations and/or time period averages that are greater than their respective MRLs is also expanded upon in the individual state sections.

3.4 Additional Program-Level Analyses of the 2012 National Monitoring Programs Dataset

This section summarizes additional analyses performed on the 2012 NMP dataset at the program level. Additional program-level analyses include an examination of the potential effect of motor vehicles and a review of how concentrations vary among the sites themselves and from quarter-to-quarter. The results of these analyses are presented in Sections 4.3 and 4.4.

3.4.1 The Effect of Mobile Source Emissions on Spatial Variations

Mobile source emissions contribute significantly to air pollution. "Mobile sources" are emitters of air pollutants that are capable of moving from place to place; mobile sources include both on-road (i.e., passenger vehicles) and non-road emissions (i.e., lawnmowers). Pollutants found in motor vehicle exhaust generally result from incomplete combustion of vehicle fuels. Although modern vehicles and, more recently, vehicle fuels have been engineered to minimize air emissions, all motor vehicles with internal combustion engines emit a wide range of pollutants. The magnitude of these emissions primarily depends on the volume of traffic, while the chemical profile of these emissions depends more on vehicle design and fuel formulation.

This report uses a variety of parameters to quantify and relate motor vehicle emissions to ambient air quality, which are discussed further in Section 4.3:

- Emissions data from the NEI
- Total hydrocarbon concentrations
- Motor vehicle ownership data
- Estimated daily traffic volume
- Vehicle miles traveled (VMT).

This report uses Pearson correlation coefficients to measure the degree of correlation between two variables, such as the ones listed above. By definition, Pearson correlation coefficients always lie between -1 and +1. Three qualification statements apply:

- A correlation coefficient of -1 indicates a perfectly "negative" relationship, indicating that increases in the magnitude of one variable are associated with proportionate decreases in the magnitude of the other variable, and vice versa.
- A correlation coefficient of +1 indicates a perfectly "positive" relationship, indicating that the magnitudes of two variables both increase and both decrease proportionately.
- Data that are completely uncorrelated have Pearson correlation coefficients of 0.

Therefore, the sign (positive or negative) and magnitude of the Pearson correlation coefficient indicate the direction and strength, respectively, of data correlations. In this report, correlation coefficients greater than or equal to 0.50 and less than or equal to -0.50 are classified as strong, while correlation coefficients less than 0.50 and greater than -0.50 are classified as weak.

The number of observations used in a calculation is an important factor to consider when analyzing the correlations. A correlation using relatively few observations may skew the correlation, making the degree of correlation appear higher (or lower) than it may actually be. Thus, in this report, a minimum of five data points must be available to present a correlation.

3.4.2 Variability Analyses

Variability refers to the degree of difference among values in a dataset. Three types of variability are analyzed for this report. The first type examines the coefficient of variation (CV) for each of the program-level pollutants of interest across the program sites. The CV provides a relative measure of variability by expressing the standard deviation to the magnitude of the arithmetic mean for each of the program-level pollutants of interest, as identified in Section 4.2.

It is particularly useful when comparing different sets of data because it is unitless (Pagano, P. and Gauvreau, K., 2000). In this report, variability across data distributions for different sites and different pollutants are compared. The CVs are shown in the form of scatter plots, where data points represent the CV and a trend line is plotted to show linearity. In addition, the "R^2" value is also shown on each scatter plot. R^2 is the coefficient of determination and is an indicator of how dependant one variable is on the other. If R^2 is equal to 1.0, the data exhibit perfect linearity; the lower R^2, the less dependent the variables are each other (Pagano, P. and Gauvreau, K., 2000). Pollutants of interest whose data points are clustered together indicate uniformity in how the concentrations are dispersed among the sites. This suggests that concentrations are affected by typical and consistent sources (e.g., mobile sources). Data points that are not clustered suggest the likelihood of a stationary source not typically found in most urban areas (e.g., coke manufacturing facility). An example of a CV scatter plot is shown in Figure 4-1a.

The second type of variability assessed in this report is inter-site variability and is paired with the CV analysis in Section 4.4. The annual average concentration for each site is plotted in the form of a bar graph for each program-wide pollutant of interest. The criteria for calculating an annual average are discussed in Section 3.1 and sites that do not meet these requirements do not have an annual average concentration presented. This assessment allows the reader to visualize how concentrations varied across the sites for a particular pollutant of interest. In order to further this analysis, the program-level average concentrations, as presented in Tables 4-1 through 4-6 in Section 4.1, are plotted against the site-specific annual averages. This allows the reader to see how the site-specific annual averages compared to the program-level average for each pollutant. An example of an inter-site variability bar graph is shown in Figure 4-1b. Note that the average concentrations shown for VOCs, SNMOCs, and carbonyl compounds in Tables 4-1 through 4-3 are presented in method-specific units, but have been converted to a common unit of measurement ($\mu g/m^3$) for the purposes of this analysis.

Quarterly variability is the third type of variability assessed in this report. The concentration data for each site were divided into the four quarters of the year, as described in Section 3.1. The completeness criteria, also described in Section 3.1, are maintained here as well. The site-specific quarterly averages are illustrated by bar graphs for each program-level pollutant of interest. An example of a quarterly variability bar graph is shown in Figure 4-16. This analysis allows for a determination of a quarterly (or seasonal) correlation with the magnitude of concentrations for a specific pollutant.

3.4.3 Greenhouse Gas Assessment

Currently, there is considerable discussion about climate change among atmospheric and environmental scientists. Climate change refers to an extended period of change in meteorological variables used to determine climate, such as temperature and precipitation. Researchers are typically concerned with greenhouse gases (GHGs), which are those that cause heat to be retained in the atmosphere (EPA, 2013h).

Agencies researching the effects of greenhouse gases tend to concentrate primarily on tropospheric levels of these gases. The troposphere is the lowest level of the atmosphere, whose height varies depending on season and latitude. This is also the layer in which weather phenomenon occur (NOAA, 2013). A few VOCs measured with Method TO-15 are greenhouse gases, although these measurements reflect the concentration at the surface, or in the breathing zone, and do not represent the entire troposphere. Section 4.5 presents the 10 GHGs currently measured with Method TO-15, their 100-year Global Warming Potential (GWP), and the average concentration across the NMP program. GWP is a way to determine a pollutant's ability to retain heat relative to carbon dioxide, which is one of the predominant anthropogenic GHGs in the atmosphere; higher GWPs indicate a higher potential contribution to global warming (EPA, 2013i). In the future, additional GHGs may be added to the NMP Method TO-15 target pollutant list in order to assess their surface-level ambient concentrations.

3.5 Additional Site-Specific Analyses

In addition to many of the analyses described in the preceding sections, the state-specific sections contain additional analyses that are applicable only at the local level. This section provides an overview of these analyses but does not discuss their results. Results of these site-specific analyses are presented in the individual state-specific sections (Sections 5 through 29).

3.5.1 Site Characterization

For each site participating in the 2012 NMP, a site characterization was performed. This characterization includes a review of the nearby area surrounding the monitoring site; plotting of emissions sources surrounding the monitoring site; and obtaining population, vehicle registration, traffic data, and other characterizing information. For the 2012 NMP report, the locations of point sources located near the monitoring sites were obtained from Version 1 of the 2011 NEI (EPA, 2013c). Sources for other site-characterizing data are provided in the individual state sections.

3.5.2 Meteorological Analysis

Several site-specific meteorological analyses were performed in order to help readers determine which meteorological factors may play a role in a given site's air quality. First, an overview of the general climatology is provided, based on the area where each site in located, to give readers a general idea of what types of meteorological conditions likely affect the site. Next, the average (or mean) for several meteorological parameters (such as temperature and relative humidity) are provided. Two averages are presented for each parameter, one average for all days in 2012 and one average for sample days only. These two averages allow for the determination of how meteorological conditions on sample days varied from typical conditions experienced throughout the year. These averages are based on hourly meteorological observations collected from the National Weather Service (NWS) weather station nearest each site and obtained from the National Climatic Data Center (NCDC) (NCDC, 2011 and 2012). Although some monitoring sites have meteorological instruments on-site and report these data to AQS, NWS data were chosen for this analysis for several reasons:

- Some sites do not have meteorological instruments on-site.
- Some sites collect meteorological data but do not report them to AQS; thus, they are not readily available.
- There are differences among the sites in the meteorological parameters reported to AQS.

Although there are limitations to using NWS data, the data used are standardized and quality-assured per NWS protocol.

In addition to the climate summary and the statistical calculations performed on meteorological observations collected near each monitoring site, the following sections describe additional meteorological analyses that were performed for each monitoring site. These analyses were performed to further characterize the meteorology at or near each monitoring site and to determine if the meteorological conditions on days samples were collected were representative of conditions typically experienced near each site.

3.5.2.1 Back Trajectory Analysis

For all sites sampling under the NMP for 2012, a back trajectory analysis was conducted. A back trajectory traces the origin of an air parcel in relation to the location where it is currently being measured. The method of constructing a back trajectory uses the Lagrangian frame of reference. In simplest terms, an air parcel can be traced back one hour to a new point of reference based on the current measured wind speed and direction. At this new point of reference (that is one hour prior to the current observation), the wind speed and direction are used again to determine where the air was one hour before. Back trajectory calculations are also governed by other meteorological parameters, such as pressure and temperature. Each time segment is referred to as a “time step.”

Gridded meteorological data and the model used for back trajectory analyses were prepared and developed by the National Oceanic and Atmospheric Administration (NOAA) using data from the NWS and other cooperative agencies. The model used is the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model (Draxler, R.R. and Rolph, G.D., 1997 and 1998; Draxler, R.R., 1999). Back trajectories were computed using the HYPLIT model to represent four times for each sample day, one at 00Z, 06Z, 12Z, and 18Z. “Z” time is “Zulu Time” and the same time as UTC (Universal Time Coordinated) or GMT (Greenwich Mean Time), or the local time at the prime meridian (NOAA, 2013). Although back trajectories can be modeled for extended periods of time, trajectories were constructed for durations of 24 hours to match the 24-hour sampling duration. Trajectories are modeled with an initial height of 50 meters above ground level (AGL), and each sample day’s back trajectories are plotted to create a composite back trajectory map. A composite back trajectory map was constructed for each monitoring site using Geographical Information System (GIS) software. The composite back trajectory map can be used in the estimation of a 24-hour air shed domain for each site. An air shed domain is the geographical area surrounding a site from which an air parcel may typically travel within the 24-hour time frame. Information about the maximum and average trajectory length may also be provided in reference to the composite back trajectory maps. Note that the distances provided are straight-line distances, or the length from the site to end point, not necessarily the length of the actual trajectory. Agencies can use the air shed domain to evaluate regions where long-range transport may affect their monitoring site.

In addition to the composite back trajectory map, the HYSPLIT model was used to perform trajectory cluster analysis. This analysis is a grouping technique that allows the model to create a subset of trajectories or "clusters" that represent back trajectories originating from similar locations. For each monitoring site, data from each sample day's back trajectories were used as input for the cluster analysis program. The model compares the end points between each trajectory and calculates a spatial variance. Trajectories that are similar to each other have lower spatial variances while trajectories that are dissimilar have larger spatial variances. The model then provides the user with information about total spatial variance (TSV) among the trajectories, which allows the user to determine how many clusters best represent a given group of trajectories (Draxler, R.R., et. al., 2009). Similar to the composite map, once the cluster trajectories for each site were computed, a cluster map was constructed for each monitoring site using GIS software. Both the direction and the distance from the monitoring site are considered in the clustering process. A minimum of 30 trajectories must be available for the model to run the cluster analysis. Since four back trajectories were computed for each sample day, a minimum of 30 sample days was the criteria used to perform the cluster analysis for this report. The cluster analysis is useful for scientifically and quantitatively determining where air most often originates for a given location.

3.5.2.2 Wind Rose Analysis

Wind roses were constructed for each site to help identify the predominant direction from which the wind blows. A wind rose shows the frequency of wind directions as petals positioned around a 16-point compass, and uses color or shading to represent wind speeds. Wind roses are constructed by uploading hourly NWS surface wind data from the nearest weather station (with sufficient data) into a wind rose software program, WRPLOT (Lakes, 2011). For each site, three wind roses were constructed: first, historical data were used to construct a wind rose for up to 10 years prior to the current sampling year; second, 2012 data were used to construct a wind rose presenting wind data for the entire calendar year; and lastly, a wind rose was constructed to present wind data for sample days only. In addition to the wind roses, a map showing the distance between the NWS station used and the monitoring site is presented. This allows for topographical influences on the wind patterns to potentially be identified.

A wind rose is often used in determining where to install an ambient monitoring site when trying to capture emissions from an upwind source. A wind rose may also be useful in determining whether high concentrations correlate with a specific wind direction. While the composite back trajectory map shows where air parcels originated on a number of days, the wind rose shows the frequency at which a given wind speed and direction are measured near the monitoring site. Thus, the back trajectory analysis focuses on long range transport, while the wind rose captures day-to-day fluctuations at the surface. Both are used to identify potential meteorological influences on a monitoring site.

3.5.3 Preliminary Risk-Based Screening and Pollutants of Interest

The preliminary risk-based screening process described in Section 3.2 and applied at the program-level was also completed for each individual monitoring site to determine site-specific pollutants of interest. Once these were determined, the time-period averages (quarterly and annual) described in Section 3.1 were calculated for each site and were used for various data analyses at the site-specific level, as described below:

- Comparison to the program-level concentrations
- Trends Analysis
- Comparison to ATSDR MRLs, as described in Section 3.3, including the emission tracer analysis described below
- The calculation of cancer risk and noncancer hazard approximations in relation to cancer and noncancer health effects
- Risk-based emissions assessment.

3.5.3.1 Site-Specific Comparison to Program-level Average Concentrations

To better understand how an individual site's concentrations compare to the program-level results, as presented in Tables 4-1 through 4-6 of Section 4.1, the site-specific and program-level concentrations are presented together graphically for the site-specific pollutants of interest indentified via the risk-based screening process. This analysis is an extension of the analysis discussed in Section 3.4.2 and utilizes box and whisker plots, or simply box plots, to visually show this comparison. These box plots were created in Microsoft Excel, using the Peltier Box and Whisker Plot Utility (Peltier, 2012). Note that for sites sampling VOCs (or SNMOCs), pollutants are shown only in comparison to other sites sampling VOCs (or SNMOCs) to match the program-level averages presented in Tables 4-1 and 4-2 in Section 4.1.

The box plots used in this analysis overlay the site-specific minimum, annual average, and maximum concentrations over several program-level statistical metrics. For the program-level, the first, second (median), third, and fourth (maximum) quartiles are shown as colored segments on a "bar" where the color changes indicate the exact numerical value of the quartile. The thin vertical line represents the program-level average concentration. The site-specific annual average is shown as a white circle plotted on top of the bar and the horizontal lines extending outward from the white circle represent the minimum and maximum concentration measured at the site. An example of this figure is shown in Figure 5-10. Note that the program-level average concentrations shown for VOCs, SNMOCs, and carbonyl compounds in Tables 4-1 through 4-3 are presented in method-specific units, but have been converted to a common unit of measurement ($\mu g/m^3$) for the purposes of this analysis. These graphs are presented in Sections 5 through 29, and are grouped by pollutant within each state section. This allows for both a "site vs. program" comparison, and an inter-site comparison for sites within a given state.

3.5.3.2 Site Trends Analysis

Table 2-1 presents current monitoring sites that have participated in the NMP in previous years. A site-specific trends analysis was conducted for sites with at least 5 consecutive years of method-specific data analyzed under the NMP. The trends analysis was conducted for each of the site-specific pollutants of interest identified via the risk-based screening process. Thirty-eight of the 64 sites have sampled at least one pollutant group long enough for the trends analysis to be conducted. The approach to this trends analysis is described below and the results are presented in the individual state sections (Sections 5 through 29).

The trends figures and analyses are presented as 1-year statistical metrics. The following criteria were used to calculate valid statistical metrics:

- Analysis must have been performed under the NMP.
- There must be a minimum of at least 5 years of consecutive data.

Five individual statistical metrics were used in this analysis and are presented as box and whisker plots, an example of which can be seen in Figure 5-22. The statistical metrics shown include the minimum and maximum concentration measured during each year (as shown by the upper and lower value of the lines extending from the box); the 5th percentile, 50th percentile (or median), and 95th percentile (as shown by the y-values corresponding with the bottom, blue line, or top of the box, respectively); and the average (or mean) concentration (as denoted by the orange diamond). Each of the five metrics represents all measurements from that 1-year period.

For each 1-year period, there must be a minimum of 85 percent completeness, which corresponds to roughly 51 valid samples or approximately 10 months of sampling (for a site sampling on a 1-in-6 day sampling schedule) for an average to be presented. For cases where sampling began mid-year, a minimum of six months of sampling is required. In these cases, the 1-year average is not provided but the range and quartiles are still presented.

Data used in this analysis were downloaded from EPA's AQS database (EPA, 2013b), where non-detects are uploaded into AQS as zeros (EPA, 2009b). Similar to other analyses presented in this report, zeros representing these non-detects were incorporated into the statistical calculations. The results from sample days with precision data (duplicates, collocates, and/or replicates) were averaged together to allow for the determination of a single concentration per pollutant for each site, reflecting the data treatment described in Section 3.1.

3.5.3.3 Emission Tracer Analysis

The preprocessed daily measurements and time-period average concentrations for each site-specific pollutant of interest were compared to the ATSDR MRL noncancer health risk benchmarks in the same fashion described in Section 3.3. To further this analysis, pollution roses were created for each of the site-specific pollutants of interest that have preprocessed daily measurements greater than their respective ATSDR acute MRL health benchmark (where applicable). This analysis is performed to help identify the geographical area where the emissions sources of these pollutants may have originated. A pollution rose is a plot of the ambient concentration versus the wind speed and direction; high concentrations may be shown in relation to the direction of potential emissions sources.

3.5.3.4 Cancer Risk and Noncancer Hazard Approximations

Risk was further examined by calculating cancer risk and noncancer hazard approximations for each of the site-specific pollutants of interest. The cancer risk approximations presented in this report estimate the cancer risk due to exposure at the annual average concentration over a 70-year period (not the risk resulting from exposure over the time period covered in this report). A cancer risk approximation less than 1 in-a-million is considered negligible; a cancer risk greater than 1 in-a-million but less than 100 in-a-million is generally considered acceptable; and a cancer risk greater than 100 in-a-million is considered significant (EPA, 2009c). The noncancer hazard approximation is presented as the Noncancer Hazard

Quotient (HQ), which is a unitless value. According to EPA, "If the HQ is calculated to be equal to or less than 1.0, then no adverse health effects are expected as a result of exposure. If the HQ is greater than 1.0, then adverse health effects are possible" (EPA, 2011b).

The toxicity factors applied to calculate the cancer risk and noncancer hazard approximations are typically UREs (for cancer) or RfCs (for noncancer), which are developed by EPA. However, UREs and RfCs are not available for all pollutants. In the absence of EPA values, toxicity factors developed by agencies with credible methods and that are similar in scope and definition were used (EPA, 2013f). Cancer URE and noncancer RfC toxicity factors can be applied to the annual averages to approximate risk based on ambient monitoring data. While the cancer risk and noncancer hazard approximations do not incorporate human activity patterns and therefore do not reflect true human inhalation exposure, they may allow analysts to further refine their focus by identifying concentrations of specific pollutants that may present health risks. Cancer UREs and/or noncancer RfCs, site-specific annual averages, and corresponding annual average-based cancer risk and noncancer hazard approximations are presented in each state section (Sections 5 through 29).

3.5.3.5 Risk-Based Emissions Assessment

A pollutant emitted in high quantities does not necessarily present a higher risk to human health than a pollutant emitted in very low quantities. The more toxic the pollutant, the more risk associated with its emissions in ambient air. The development of various health-based toxicity factors has allowed analysts to apply weight to the emissions of pollutants based on toxicity rather than mass emissions. This approach considers both a pollutant's toxicity potential and the quantity emitted.

This assessment compares county-level emissions to toxicity-weighted emissions based on the EPA-approved approach described below (EPA, 2007). The 10 pollutants with the highest total mass emissions and the 10 pollutants with the highest associated toxicity-weighted emissions for pollutants with cancer and noncancer toxicity factors are presented in each state section. While the *absolute magnitude* of the pollutant-specific toxicity-weighted emissions is not meaningful, the *relative magnitude* of toxicity-weighted emissions is useful in identifying the order of potential priority for air quality managers. Higher values suggest greater priority; however, even the highest values may not reflect potential cancer effects greater than the level of concern (100 in-a-million) or potential noncancer effects above the level of concern (e.g., HQ = 1.0). The pollutants exhibiting the 10 highest annual average-based risk approximations for cancer and noncancer effects are also presented in each state section. The results of this data analysis may help state, local, and tribal agencies better understand which pollutants emitted, from a toxicity basis, are of the greatest concern.

The toxicity-weighted emissions approach consists of the following steps:

1. Obtain HAP emissions data for all anthropogenic sectors from the NEI. For point sources, sum the process-level emissions to the county-level.
2. Apply the mass extraction speciation profiles to extract metal and cyanide mass. The only exception is for two chromium species: chromium and chromium compounds.
3. Apply weight to the emissions derived from the steps above based on their toxicity. The results of the toxicity-weighting process are unitless.
    a. To apply weight based on cancer toxicity, multiply the emissions of each pollutant by its cancer URE.
    b. To apply weight based on noncancer toxicity, divide the emissions of each pollutant by its noncancer RfC.

The PAHs measured using Method TO-13A are a sub-group of Polycyclic Organic Matter (POM). Because these compounds are often not speciated into individual compounds in the NEI, the PAHs are grouped into POM Groups in order to assess risk attributable to these pollutants (EPA, 2011c). Thus, emissions data and toxicity-weighted emissions for PAHs are presented by POM Groups for this analysis. Table 3-3 presents the 22 PAHs measured by Method TO-13A and their associated POM Groups. The POM groups are sub-grouped in Table 3-3 because toxicity research has led to the refining of UREs for certain PAHs (EPA, 2013f). Note that naphthalene emissions are reported to the NEI individually; therefore, naphthalene is not included in one of the POM Groups. Also note that four pollutants analyzed by Method TO-13A and listed in Table 3-3 do not have assigned POM Groups.

Table 3-3. POM Groups for PAHs

Pollutant	POM Group	POM Subgroup
Acenaphthene	Group 2	Group 2b
Acenaphthylene	Group 2	Group 2b
Anthracene	Group 2	Group 2d
Benzo(a)anthracene	Group 6	
Benzo(a)pyrene	Group 5	Group5a
Benzo(b)fluoranthene	Group 6	
Benzo(e)pyrene	Group 2	Group 2b
Benzo(g,h,i)perylene	Group 2	Group 2b
Benzo(k)fluoranthene	Group 6	
Chrysene	Group 7	
Coronene	NA	
Cyclopenta[cd]pyrene	NA	
Dibenz(a,h)anthracene	Group 5	Group5b
Fluoranthene	Group 2	Group 2b
Fluorene	Group 2	Group 2b
9-Fluorenone	NA	
Indeno(1,2,3-cd)pyrene	Group 6	
Naphthalene*	NA	
Perylene	Group 2	Group 2b
Phenanthrene	Group 2	Group 2d
Pyrene	Group 2	Group 2d
Retene	NA	

* Naphthalene emissions are reported to the NEI individually; therefore, naphthalene is not included in one of the POM Groups.
NA = no POM Group assigned.

4.0 Summary of the 2012 National Monitoring Programs Data

This section summarizes the results of the data analyses performed on the NMP dataset, as described in Section 3.

4.1 Statistical Results

This section examines the following statistical parameters for the target pollutants of each analytical method: 1) detection rates, 2) concentration ranges and data distribution, and 3) central tendency statistics. Tables 4-1 through 4-6 present statistical summaries for the target pollutants and Sections 4.1.1 through 4.1.3 review the basic findings of these statistical calculations.

4.1.1 Target Pollutant Detection Rates

There is an experimentally determined MDL for every target pollutant, as described in Section 2.2. Quantification below the MDL is possible, although the measurement's reliability is lower. If a concentration does not exceed the MDL, it does not mean that the pollutant is not present in the air. If the instrument does not generate a numerical concentration, the measurement is marked as "ND," or "non-detect." As explained in Section 2.2, data analysts should exercise caution when interpreting monitoring data with a high percentage of reported concentrations at levels near or below the corresponding MDLs. A thorough review of the number of measured detections, the number of non-detects, and the total number of samples is beneficial to understanding the representativeness of the interpretations made.

Tables 4-1 through 4-6 summarize the number of times the target pollutants were detected out of the number of valid samples collected and analyzed. Approximately 53 percent of the reported measurements (based on the preprocessed daily measurements) were above the MDLs across the program. The following list provides the percentage of measurements that were above the MDLs for each analytical method:

- 41.2 percent for VOCs
- 48.8 percent for SNMOCs
- 82.3 percent for carbonyl compounds
- 60.1 percent for PAHs
- 77.8 percent for metals
- 71.5 percent for hexavalent chromium samples.

Some pollutants were detected in every sample collected while others were infrequently detected or not detected at all. Similar to previous years' reports, acetaldehyde, formaldehyde, and acetone had the greatest number of measured detections (1,796), using the preprocessed daily measurements. These pollutants were reported in every valid carbonyl compound sample collected (1,796). Eleven VOCs, including acetylene, benzene, carbon tetrachloride, and toluene, were detected in every valid VOC sample collected (1,466). Ten pollutants, including acetylene, ethylene, ethane, and propylene, were detected in every valid SNMOC sample collected (411). Naphthalene, phenanthrene, fluoranthene, and pyrene were detected in every valid PAH sample collected (1,296). Lead, manganese, and nickel were detected in every valid metal sample collected (1,056). Hexavalent chromium was detected in 1,019 samples (out of 1,421 samples).

Although NBIL and BTUT have the greatest number of measured detections (6,980 for NBIL and 6,708 for BTUT), they were also the only two sites that collected samples for all six analytical methods/pollutant groups. However, the detection rates for these sites (63 percent and 65 percent, respectively) were not as high as other sites. Detection rates for sites that sampled suites of pollutants that are frequently detected tended to be higher (refer to the list of method-specific percentages of measurements above the MDL listed above). For example, metals were rarely reported as non-detects. As a result, sites that sampled only metals (such as PAFL) would be expected to have higher detection rates. PAFL's detection rate is 100 percent. Conversely, VOCs had the lowest percentage of concentrations greater than the MDLs (41.2 percent). A site measuring only VOCs would be expected to have lower detection rates, such as SPAZ (52.5 percent).

Table 4-1. Statistical Summaries of the VOC Concentrations

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	Mode (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)
Acetonitrile	1,466	0	0.033	437	10.7	0.361	0.112	0.178	1.89	39.8
Acetylene	1,466	0	0.091	17.2	0.892	0.579	1.02	0.366	0.956	1.27
Acrolein	1,442	24	0.054	10.8	0.521	0.366	0	0.222	0.601	0.699
Acrylonitrile[3,4]	206	1,167	0.018	2.47	0.051	0	0	0	0	0.179
tert-Amyl Methyl Ether	31	1,435	0.003	0.016	<0.001	0	0	0	0	0.001
Benzene	1,466	0	0.034	1.79	0.281	0.216	0.182	0.158	0.323	0.213
Bromochloromethane	6	1,460	0.008	0.012	<0.001	0	0	0	0	0.001
Bromodichloromethane	116	1,350	0.006	4.10	0.010	0	0	0	0	0.152
Bromoform	167	1,299	0.004	0.088	0.001	0	0	0	0	0.004
Bromomethane	1,183	283	0.007	0.141	0.011	0.011	0	0.008	0.013	0.010
1,3-Butadiene	1,322	144	0.006	1.85	0.049	0.031	0	0.018	0.064	0.075
Carbon Disulfide[4]	1,408	13	0.004	16.2	0.669	0.021	0.012	0.012	0.197	1.66
Carbon Tetrachloride	1,466	0	0.018	0.781	0.110	0.109	0.110	0.099	0.118	0.030
Chlorobenzene	111	1,355	0.004	0.291	0.002	0	0	0	0	0.017
Chloroethane	140	1,326	0.010	0.341	0.005	0	0	0	0	0.023
Chloroform	948	518	0.010	9.37	0.049	0.019	0	0	0.032	0.350
Chloromethane	1,466	0	0.288	1.66	0.570	0.555	0.544	0.506	0.610	0.107
Chloroprene	5	1,461	0.007	0.021	<0.001	0	0	0	0	0.001
Dibromochloromethane	604	862	0.001	1.42	0.006	0	0	0	0.006	0.057
1,2-Dibromoethane	71	1,395	0.004	0.017	<0.001	0	0	0	0	0.002
m-Dichlorobenzene	176	1,290	0.003	0.641	0.002	0	0	0	0	0.019
o-Dichlorobenzene	206	1,260	0.002	0.107	0.001	0	0	0	0	0.006
p-Dichlorobenzene	961	505	0.002	0.228	0.011	0.007	0	0	0.014	0.016

[1] Out of 1,466 valid samples

[2] Excludes zeros for non-detects

[3] Because S4MO invalidated all acrylonitrile data through October 2012, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected.

[4] Because GLKY invalidated all acrylonitrile and carbon disulfide data through September 24, 2012, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected.

NA = Not applicable for these parameters

Table 4-1. Statistical Summaries of the VOC Concentrations (Continued)

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	Mode (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)
Dichlorodifluoromethane	1,466	0	0.266	1.17	0.502	0.498	0.460	0.469	0.529	0.053
1,1-Dichloroethane	19	1,447	0.004	0.092	<0.001	0	0	0	0	0.004
1,2-Dichloroethane	1,282	184	0.009	4.21	0.037	0.019	0	0.015	0.023	0.180
1,1-Dichloroethene	51	1,415	0.005	0.109	<0.001	0	0	0	0	0.003
cis-1,2-Dichloroethylene	4	1,462	0.036	0.063	<0.001	0	0	0	0	0.003
trans-1,2-Dichloroethylene	38	1,428	0.007	0.214	0.001	0	0	0	0	0.006
Dichloromethane	1,464	2	0.034	214	0.727	0.116	0.074	0.083	0.182	7.22
1,2-Dichloropropane	1	1,465	0.012	0.012	<0.001	0	0	0	0	<0.001
cis-1,3-Dichloropropene	3	1,463	0.015	0.020	<0.001	0	0	0	0	0.001
trans-1,3-Dichloropropene	1	1,465	0.016	0.016	<0.001	0	0	0	0	<0.001
Dichlorotetrafluoroethane	1,466	0	0.008	0.055	0.018	0.016	0.016	0.015	0.018	0.005
Ethyl Acrylate	13	1,453	0.004	0.071	<0.001	0	0	0	0	0.003
Ethyl *tert*-Butyl Ether	220	1,246	0.004	0.273	0.011	0	0	0	0	0.033
Ethylbenzene	1,459	7	0.004	0.834	0.081	0.056	0.020	0.034	0.096	0.082
Hexachloro-1,3-butadiene	186	1,280	0.002	0.019	0.001	0	0	0	0	0.002
Methyl Isobutyl Ketone	1,377	89	0.006	1.17	0.038	0.031	0	0.021	0.046	0.041
Methyl Methacrylate	139	1,327	0.002	0.213	0.003	0	0	0	0	0.012
Methyl *tert*-Butyl Ether	203	1,263	0.005	0.089	0.005	0	0	0	0	0.013
n-Octane	1,366	100	0.008	0.663	0.057	0.041	0	0.026	0.070	0.059
Propylene	1,466	0	0.091	43.7	0.694	0.348	0.288	0.257	0.566	2.07
Styrene	1,222	244	0.006	9.14	0.069	0.029	0	0.015	0.045	0.347
1,1,2,2-Tetrachloroethane	112	1,354	0.004	0.026	0.001	0	0	0	0	0.002
Tetrachloroethylene	1,252	214	0.004	0.792	0.022	0.013	0	0.007	0.024	0.039

[1] Out of 1,466 valid samples

[2] Excludes zeros for non-detects

[3] Because S4MO invalidated all acrylonitrile data through October 2012, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected.

[4] Because GLKY invalidated all acrylonitrile and carbon disulfide data through September 24, 2012, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected.

NA = Not applicable for these parameters

Table 4-1. Statistical Summaries of the VOC Concentrations (Continued)

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	Mode (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)
Toluene	1,466	0	0.017	5.70	0.596	0.362	0.092	0.176	0.737	0.683
1,2,4-Trichlorobenzene	120	1,346	0.003	0.062	0.001	0	0	0	0	0.005
1,1,1-Trichloroethane	1,268	198	0.004	0.066	0.008	0.008	0.008	0.007	0.010	0.005
1,1,2-Trichloroethane	38	1,428	0.006	0.074	<0.001	0	0	0	0	0.004
Trichloroethylene	365	1,101	0.005	3.25	0.009	0	0	0	0	0.093
Trichlorofluoromethane	1,466	0	0.140	1.04	0.270	0.263	0.256	0.245	0.282	0.055
Trichlorotrifluoroethane	1,466	0	0.060	0.177	0.085	0.083	0.079	0.078	0.090	0.010
1,2,4-Trimethylbenzene	1,426	40	0.006	1.05	0.076	0.054	0	0.031	0.093	0.080
1,3,5-Trimethylbenzene	1,305	161	0.004	0.663	0.029	0.023	0	0.013	0.034	0.032
Vinyl chloride	154	1,312	0.004	3.83	0.013	0	0	0	0	0.135
m,p-Xylene	1,462	4	0.007	3.42	0.218	0.137	0.055	0.071	0.258	0.270
o-Xylene	1,454	12	0.004	0.981	0.088	0.059	0.037	0.032	0.107	0.096

[1] Out of 1,466 valid samples

[2] Excludes zeros for non-detects

[3] Because S4MO invalidated all acrylonitrile data through October 2012, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected.

[4] Because GLKY invalidated all acrylonitrile and carbon disulfide data through September 24, 2012, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected.

NA = Not applicable for these parameters

Table 4-2. Statistical Summaries of the SNMOC Concentrations

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbC)	Maximum (ppbC)	Arithmetic Mean (ppbC)	Median (ppbC)	Mode (ppbC)	First Quartile (ppbC)	Third Quartile (ppbC)	Standard Deviation (ppbC)
Acetylene	411	0	0.166	13.0	1.37	1.02	1.31	0.659	1.61	1.25
Benzene[3]	368	43	0.229	5.74	1.38	1.27	0	0.711	1.93	0.963
1,3-Butadiene[3]	277	134	0.048	1.03	0.193	0.140	0	0	0.298	0.201
n-Butane	409	2	0.648	113	12.6	9.40	14.8	4.02	16.2	12.5
cis-2-Butene	277	134	0.061	2.53	0.191	0.137	0	0	0.238	0.281
trans-2-Butene[3]	267	144	0.065	2.72	0.226	0.160	0	0	0.286	0.338
Cyclohexane	402	9	0.074	13.0	1.89	1.20	0	0.274	3.01	1.97
Cyclopentane[3]	349	62	0.084	4.76	0.505	0.434	0	0.238	0.699	0.444
Cyclopentene[3]	36	375	0.094	1.59	0.029	0	0	0	0	0.130
n-Decane[3]	356	55	0.083	6.50	0.428	0.344	0	0.181	0.541	0.475
1-Decene	6	405	0.109	0.418	0.003	0	0	0	0	0.029
m-Diethylbenzene[3]	158	253	0.039	6.87	0.239	0	0	0	0.242	0.711
p-Diethylbenzene[3]	77	334	0.061	2.41	0.057	0	0	0	0	0.187
2,2-Dimethylbutane	363	48	0.079	2.74	0.436	0.386	0	0.200	0.592	0.350
2,3-Dimethylbutane	330	81	0.078	3.33	0.608	0.466	0	0.148	0.955	0.577
2,3-Dimethylpentane	405	6	0.095	4.32	0.566	0.485	0	0.262	0.708	0.430
2,4-Dimethylpentane	365	46	0.074	2.98	0.359	0.335	0	0.154	0.496	0.290
n-Dodecane	310	101	0.056	2.78	0.188	0.147	0	0.066	0.236	0.230
1-Dodecene[3]	89	322	0.061	3.04	0.083	0	0	0	0	0.253
Ethane	411	0	2.14	276	40.1	21.2	13.8	7.99	59.4	44.1
2-Ethyl-1-butene	1	410	4.62	4.62	0.011	0	0	0	0	0.228
Ethylbenzene	376	35	0.073	2.36	0.354	0.268	0	0.145	0.487	0.306
Ethylene	411	0	0.709	13.4	2.79	2.34	2.00	1.72	3.22	1.72
m-Ethyltoluene[3]	330	81	0.067	2.26	0.374	0.284	0	0.133	0.516	0.368
o-Ethyltoluene	206	205	0.060	3.28	0.134	0.060	0	0	0.211	0.239

[1] Out of 411 valid samples

[2] Excludes zeros for non-detects

[3] The number of non-detects includes those samples where no value could be reported due to co-elution.

NA = Not applicable for these parameters

Table 4-2. Statistical Summaries of the SNMOC Concentrations (Continued)

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbC)	Maximum (ppbC)	Arithmetic Mean (ppbC)	Median (ppbC)	Mode (ppbC)	First Quartile (ppbC)	Third Quartile (ppbC)	Standard Deviation (ppbC)
p-Ethyltoluene	301	110	0.063	2.65	0.226	0.175	0	0	0.307	0.252
n-Heptane	408	3	0.077	8.56	1.58	1.22	2.59	0.301	2.49	1.43
1-Heptene[3]	189	222	0.047	2.36	0.267	0	0	0	0.496	0.410
n-Hexane	411	0	0.147	19.7	3.38	2.60	11.7	0.805	5.01	3.09
1-Hexene	131	280	0.077	0.439	0.066	0	0	0	0.131	0.109
cis-2-Hexene	8	403	0.062	0.153	0.002	0	0	0	0	0.014
trans-2-Hexene	24	387	0.062	0.234	0.006	0	0	0	0	0.028
Isobutane[3]	410	1	0.332	61.2	9.69	6.53	13.8	1.83	13.8	10.4
Isobutene/1-Butene[3]	20	391	0.211	5.50	0.157	0	0	0	0	0.814
Isopentane[3]	285	126	0.726	68.5	8.29	3.99	0	0	12.7	10.6
Isoprene	291	120	0.070	7.92	0.545	0.186	0	0	0.645	0.914
Isopropylbenzene	95	316	0.060	0.449	0.034	0	0	0	0	0.068
2-Methyl-1-butene[3]	244	167	0.070	1.96	0.186	0.150	0	0	0.309	0.220
3-Methyl-1-butene[3]	25	386	0.088	1.14	0.021	0	0	0	0	0.101
2-Methyl-1-pentene	8	403	0.060	0.356	0.003	0	0	0	0	0.024
4-Methyl-1-pentene	27	384	0.081	0.169	0.008	0	0	0	0	0.030
2-Methyl-2-butene[3]	253	158	0.074	2.02	0.235	0.210	0	0	0.370	0.273
Methylcyclohexane[3]	375	36	0.082	23.1	3.34	1.90	0	0.286	5.66	3.64
Methylcyclopentane	408	3	0.116	9.65	1.79	1.40	1.74	0.475	2.65	1.54
2-Methylheptane[3]	289	122	0.068	2.62	0.396	0.322	0	0	0.655	0.395
3-Methylheptane	318	93	0.060	2.02	0.319	0.271	0	0.095	0.489	0.294
2-Methylhexane[3]	408	3	0.154	4.88	1.30	1.12	1.19	0.593	1.83	0.866
3-Methylhexane[3]	334	77	0.096	4.95	1.02	0.935	0	0.300	1.55	0.871
2-Methylpentane[3]	411	0	0.304	17.5	3.49	3.01	1.36	1.15	5.02	2.78
3-Methylpentane	411	0	0.130	9.45	1.86	1.65	3.10	0.643	2.65	1.50

[1] Out of 411 valid samples

[2] Excludes zeros for non-detects

[3] The number of non-detects includes those samples where no value could be reported due to co-elution.

NA = Not applicable for these parameters

Table 4-2. Statistical Summaries of the SNMOC Concentrations (Continued)

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbC)	Maximum (ppbC)	Arithmetic Mean (ppbC)	Median (ppbC)	Mode (ppbC)	First Quartile (ppbC)	Third Quartile (ppbC)	Standard Deviation (ppbC)
n-Nonane	377	34	0.079	3.45	0.462	0.358	0	0.170	0.617	0.424
1-Nonene[3]	153	258	0.061	3.75	0.151	0	0	0	0.141	0.384
n-Octane[3]	404	7	0.071	6.70	1.00	0.764	0	0.280	1.50	0.902
1-Octene	227	184	0.061	0.922	0.125	0.094	0	0	0.210	0.149
n-Pentane	411	0	0.285	51.8	6.99	5.72	11.2	2.22	9.98	6.28
1-Pentene[3]	361	50	0.089	16.2	0.389	0.230	0	0.145	0.424	1.05
cis-2-Pentene	187	224	0.068	102	0.326	0	0	0	0.141	5.02
trans-2-Pentene	299	112	0.060	2.04	0.190	0.148	0	0	0.268	0.214
α-Pinene	116	295	0.077	1.91	0.115	0	0	0	0.150	0.261
β-Pinene[3]	151	260	0.086	4.45	0.277	0	0	0	0.448	0.513
Propane	411	0	1.59	248	28.0	19.4	28.9	6.82	37.4	29.9
n-Propylbenzene	218	193	0.064	1.34	0.125	0.102	0	0	0.197	0.165
Propylene	411	0	0.305	7.08	1.14	0.913	1.15	0.640	1.34	0.819
Propyne	1	410	0.434	0.434	0.001	0	0	0	0	0.021
Styrene[3]	91	320	0.138	24.7	1.15	0	0	0	0	3.48
Toluene	411	0	0.302	36.4	4.18	3.10	1.44	1.42	4.87	4.56
n-Tridecane	71	340	0.059	1.40	0.028	0	0	0	0	0.103
1-Tridecene	5	406	0.083	0.177	0.001	0	0	0	0	0.014
1,2,3-Trimethylbenzene	202	209	0.067	1.92	0.133	0	0	0	0.182	0.210
1,2,4-Trimethylbenzene	397	14	0.108	4.02	0.573	0.437	0	0.278	0.710	0.489
1,3,5-Trimethylbenzene	228	183	0.069	0.936	0.156	0.129	0	0	0.268	0.175
2,2,3-Trimethylpentane	126	285	0.074	1.14	0.074	0	0	0	0.142	0.132
2,2,4-Trimethylpentane[3]	257	154	0.060	8.53	0.438	0.215	0	0	0.510	0.757
2,3,4-Trimethylpentane	313	98	0.060	2.04	0.209	0.150	0	0.083	0.265	0.232
n-Undecane	324	87	0.077	4.70	0.246	0.196	0	0.107	0.317	0.322
1-Undecene	29	382	0.059	0.727	0.021	0	0	0	0	0.089

[1] Out of 411 valid samples

[2] Excludes zeros for non-detects

[3] The number of non-detects includes those samples where no value could be reported due to co-elution.

NA = Not applicable for these parameters

Table 4-2. Statistical Summaries of the SNMOC Concentrations (Continued)

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbC)	Maximum (ppbC)	Arithmetic Mean (ppbC)	Median (ppbC)	Mode (ppbC)	First Quartile (ppbC)	Third Quartile (ppbC)	Standard Deviation (ppbC)
m-Xylene/*p*-Xylene	409	2	0.125	7.39	1.41	1.19	1.99	0.570	2.04	1.02
o-Xylene	398	13	0.091	1.87	0.438	0.367	0	0.217	0.601	0.295
SNMOC (Sum of Knowns)	411	NA	20.8	793	153	116	184	52.0	211	129
Sum of Unknowns	411	NA	15.3	1,880	110	66.3	116	42.9	112	172
TNMOC	411	NA	11.2	1,970	263	206	160	127	332	210

[1] Out of 411 valid samples

[2] Excludes zeros for non-detects

[3] The number of non-detects includes those samples where no value could be reported due to co-elution.

NA = Not applicable for these parameters

Table 4-3. Statistical Summaries of the Carbonyl Compound Concentrations

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	Mode (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)
Acetaldehyde	1,796	0	0.019	11.3	0.980	0.795	1.03	0.539	1.23	0.712
Acetone	1,796	0	0.067	11.6	1.25	1.05	1.16	0.665	1.55	0.913
Benzaldehyde[3]	1,740	56	0.003	0.285	0.029	0.023	0.014	0.014	0.034	0.025
2-Butanone[3]	1,734	57	0.009	4.30	0.169	0.131	0	0.079	0.211	0.170
Butyraldehyde[3]	1,780	16	0.005	2.12	0.089	0.072	0.041	0.046	0.106	0.085
Crotonaldehyde[3]	1,755	41	0.003	1.46	0.106	0.044	0	0.022	0.129	0.148
2,5-Dimethylbenzaldehyde	3	1,793	0.010	0.072	<0.001	0	0	0	0	0.002
Formaldehyde	1,796	0	0.020	10.4	2.19	1.84	1.10	1.19	2.77	1.49
Hexaldehyde[3]	1,761	35	0.002	0.546	0.031	0.023	0.011	0.013	0.037	0.036
Isovaleraldehyde	9	1,787	0.005	0.154	<0.001	0	0	0	0	0.004
Propionaldehyde	1,790	6	0.002	0.848	0.128	0.106	0.065	0.070	0.160	0.090
Tolualdehydes[3]	1,538	258	0.004	0.325	0.025	0.022	0	0.013	0.034	0.022
Valeraldehyde[3]	1,719	77	0.002	0.305	0.028	0.022	0	0.013	0.034	0.025

[1] Out of 1,796 valid samples for all compounds except 2-butanone. The total for 2-butanone is 1,791 due to the five carbonyl compound samples from 2011 included with ADOK's data, when 2-butanone was not part of the analytes included with this method.

[2] Excludes zeros for non-detects

[3] The number of non-detects includes those samples where no value could be reported due to co-elution.

Table 4-4. Statistical Summaries of the PAH Concentrations

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ng/m^3)	Maximum (ng/m^3)	Arithmetic Mean (ng/m^3)	Median (ng/m^3)	Mode (ng/m^3)	First Quartile (ng/m^3)	Third Quartile (ng/m^3)	Standard Deviation (ng/m^3)
Acenaphthene	1,277	19	0.081	182	5.00	2.28	0	1.12	4.67	9.87
Acenaphthylene	655	641	0.024	14.0	0.567	0.034	0	0	0.538	1.28
Anthracene	1,020	276	0.028	18.9	0.396	0.207	0	0.070	0.459	0.949
Benzo(a)anthracene	950	346	0.011	2.67	0.094	0.045	0	0	0.100	0.178
Benzo(a)pyrene	824	472	0.017	3.60	0.086	0.038	0	0	0.093	0.177
Benzo(b)fluoranthene	1,179	117	0.019	5.93	0.214	0.108	0	0.050	0.249	0.327
Benzo(e)pyrene	1,067	229	0.016	2.81	0.109	0.059	0	0.030	0.131	0.165
Benzo(g,h,i)perylene	1,079	217	0.019	1.94	0.113	0.060	0	0.031	0.133	0.159
Benzo(k)fluoranthene	673	623	0.010	2.06	0.053	0.022	0	0	0.063	0.109
Chrysene	1,253	43	0.019	2.94	0.218	0.132	0	0.072	0.259	0.262
Coronene	664	632	0.017	0.590	0.038	0.020	0	0	0.051	0.062
Cyclopenta[cd]pyrene	194	1,102	0.014	0.718	0.017	0	0	0	0	0.061
Dibenz(a,h)anthracene	242	1,054	0.017	0.396	0.009	0	0	0	0	0.026
Fluoranthene	1,296	0	0.078	42.9	2.34	1.32	1.04	0.745	2.51	3.38
Fluorene	1,280	16	0.338	93.4	5.16	3.08	0	1.80	5.35	7.10
9-Fluorenone	1,295	1	0.102	14.2	1.54	1.07	1.25	0.623	1.89	1.52
Indeno(1,2,3-cd)pyrene	966	330	0.016	2.36	0.097	0.053	0	0	0.115	0.146
Naphthalene	1,296	0	2.61	822	86.4	63.3	101	35.3	114	78.4
Perylene	361	935	0.017	0.853	0.017	0	0	0	0.023	0.043
Phenanthrene	1,296	0	0.432	251	10.1	5.68	10.3	3.11	10.4	15.5
Pyrene	1,296	0	0.046	17.4	1.30	0.797	1.03	0.454	1.51	1.57
Retene	1,230	66	0.025	29.6	0.366	0.157	0	0.090	0.332	1.05

[1] Out of 1,296 valid samples

[2] Excludes zeros for non-detects

Table 4-5. Statistical Summaries of the Metals Concentrations

Pollutant	# of Measured Detections[1,2]	# of Non-Detects[1,2]	Minimum[3] (ng/m^3)	Maximum (ng/m^3)	Arithmetic Mean (ng/m^3)	Median (ng/m^3)	Mode (ng/m^3)	First Quartile (ng/m^3)	Third Quartile (ng/m^3)	Standard Deviation (ng/m^3)
Antimony (PM_{10})	754	6	0.009	24.8	1.44	0.903	0.870	0.510	1.52	1.86
Arsenic (PM_{10})	749	11	0.003	7.23	0.751	0.542	0	0.340	0.879	0.739
Beryllium (PM_{10})	697	63	0.00003	0.550	0.014	0.007	0.010	0.003	0.020	0.028
Cadmium (PM_{10})	755	5	0.0005	2.91	0.170	0.090	0.060	0.057	0.150	0.306
Chromium (PM_{10})	652	108	0.0002	20.9	2.52	2.44	0	0.440	3.70	2.10
Cobalt (PM_{10})	755	5	0.0001	7.26	0.202	0.100	0.060	0.055	0.190	0.441
Lead (PM_{10})	760	0	0.070	111	4.52	2.62	1.27	1.53	4.42	7.73
Manganese (PM_{10})	760	0	0.190	275	10.6	5.80	10.1	2.96	11.2	18.0
Mercury (PM_{10})	719	41	0.0001	0.328	0.017	0.010	0.020	0.007	0.020	0.022
Nickel (PM_{10})	760	0	0.070	17.3	1.26	0.841	0.420	0.460	1.42	1.57
Selenium (PM_{10})	730	30	0.0001	4.92	0.610	0.410	0	0.204	0.840	0.594
Antimony (TSP)	296	0	0.061	7.22	0.712	0.520	0.324	0.323	0.885	0.788
Arsenic (TSP)	296	0	0.162	2.28	0.679	0.600	0.634	0.413	0.827	0.371
Beryllium (TSP)	296	0	0.002	0.525	0.032	0.020	0.017	0.012	0.032	0.055
Cadmium (TSP)	296	0	0.029	2.30	0.195	0.144	0.061	0.090	0.235	0.196
Chromium (TSP)	296	0	0.796	11.0	2.65	2.59	1.17	1.65	3.15	1.30
Cobalt (TSP)	296	0	0.060	15.4	0.939	0.459	0.330	0.254	0.926	1.49
Lead (TSP)	296	0	0.562	304	6.54	3.75	2.17	2.23	6.06	19.0
Manganese (TSP)	296	0	1.36	273	23.6	17.1	20.4	11.4	27.9	27.5
Mercury (TSP)	295	1	0.003	0.088	0.016	0.013	0.011	0.010	0.019	0.011
Nickel (TSP)	296	0	0.288	12.8	1.42	1.08	1.10	0.773	1.66	1.23
Selenium (TSP)	296	0	0.113	2.88	0.766	0.721	0.702	0.434	0.975	0.426

[1] For PM_{10}, out of 760 valid samples

[2] For TSP, out of 296 valid samples

[3] Excludes zeros for non-detects

Table 4-6. Statistical Summary of the Hexavalent Chromium Concentrations

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ng/m^3)	Maximum (ng/m^3)	Arithmetic Mean (ng/m^3)	Median (ng/m^3)	Mode (ng/m^3)	First Quartile (ng/m^3)	Third Quartile (ng/m^3)	Standard Deviation (ng/m^3)
Hexavalent Chromium	1,019	402	0.0025	8.51	0.037	0.016	0	0	0.029	0.260

[1] Out of 1,421 valid samples

[2] Excludes zeros for non-detects

4.1.2 Concentration Range and Data Distribution

The concentrations measured during the 2012 NMP exhibit a wide range of variability. The minimum and maximum concentration measured (excluding zeros substituted for non-detects) for each target pollutant are presented in Tables 4-1 through 4-6 (in respective pollutant group units). Some pollutants, such as acetonitrile, had a wide range of concentrations measured, while other pollutants, such as dichlorotetrafluoroethane, did not, even though they were both detected frequently. The pollutant for each method-specific pollutant group with the largest range in measured concentrations is as follows:

- For VOCs, acetonitrile (0.033 ppbv to 437 ppbv)
- For SNMOCs, ethane (2.14 ppbC to 276 ppbC)
- For carbonyl compounds, acetone (0.067 ppbv to 11.6 ppbv)
- For PAHs, naphthalene (2.61 ng/m^3 to 822 ng/m^3)
- For metals in PM_{10}, manganese (0.190 ng/m^3 to 275 ng/m^3)
- For metals in TSP, lead (0.562 ng/m^3 to 304 ng/m^3)
- For hexavalent chromium, 0.0025 ng/m^3 to 8.51 ng/m^3.

4.1.3 Central Tendency

In addition to the number of measured detections and the concentration ranges, Tables 4-1 through 4-6 also present a number of central tendency and data distribution statistics (arithmetic mean, median, mode, first and third quartiles, and standard deviation) for each of the pollutants sampled during the 2012 NMP in respective pollutant group units. A multitude of observations can be made from these tables. The pollutants with the three highest average concentrations, by mass, for each pollutant group are provided below, with respective confidence intervals (although the 95 percent confidence interval is not provided in the table).

The top three VOCs by average mass concentration, as presented in Table 4-1, are:

- Acetonitrile (10.7 ± 2.04 ppbv)
- Acetylene (0.892 ± 0.065 ppbv)
- Dichloromethane (0.727 ± 0.370 ppbv).

The top three SNMOCs by average mass concentration, as presented in Table 4-2, are:

- Ethane (40.1 ± 4.27 ppbC)
- Propane (28.0 ± 2.90 ppbC)
- *n*-Butane (12.6 ± 1.21 ppbC).

The top three carbonyl compounds by average mass concentration, as presented in Table 4-3, are:

- Formaldehyde (2.19 ± 0.069 ppbv)
- Acetone (1.25 ± 0.042 ppbv).
- Acetaldehyde (0.980 ± 0.033 ppbv)

The top three PAHs by average mass concentration, as presented in Tables 4-4, are:

- Naphthalene (86.4 ± 4.27 ng/m^3)
- Phenanthrene (10.1 ± 0.845 ng/m^3)
- Fluorene (5.16 ± 0.387 ng/m^3).

The top three metals by average mass concentration for both PM_{10} and TSP fractions, as presented in Table 4-5, are;

- Manganese (PM_{10} = 10.6 ± 1.28 ng/m^3, TSP = 23.6 ± 3.15 ng/m^3)
- Lead (PM_{10} = 4.52 ± 0.551 ng/m^3, TSP = 6.54 ± 2.18 ng/m^3)
- Total chromium (PM_{10} = 2.52 ± 0.150 ng/m^3, TSP = 2.65 ± 0.148 ng/m^3).

The average mass concentration of hexavalent chromium, as presented in Table 4-6, is 0.037 ± 0.014 ng/m^3.

Appendices J through O present statistical calculations on a site-specific basis, similar to those presented in Tables 4-1 through 4-6.

4.2 Preliminary Risk-Based Screening and Pollutants of Interest

Based on the preliminary risk-based screening process described in Section 3.2, Table 4-7 identifies the pollutants that failed at least one screen; summarizes each pollutant's total number of measured detections, percentage of screens failed, and cumulative percentage of failed screens; and highlights those pollutants contributing to the top 95 percent of failed screens (shaded in gray) and thereby designated as program-wide pollutants of interest.

Table 4-7. Results of the Program-Level Preliminary Risk-Based Screening Process

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Failed Screens	% of Total Failures	Cumulative % Contribution
Formaldehyde	0.077	1,792	1,796	99.78	12.92	12.92
Acetaldehyde	0.45	1,711	1,796	95.27	12.34	25.26
Benzene	0.13	1,693	1,695	99.88	12.21	37.47
Carbon Tetrachloride	0.17	1,464	1,466	99.86	10.56	48.03
1,3-Butadiene	0.03	1,375	1,473	93.35	9.92	57.94
1,2-Dichloroethane	0.038	1,280	1,282	99.84	9.23	67.17
Naphthalene	0.029	1,013	1,296	78.16	7.31	74.48
Arsenic	0.00023	944	1,045	90.33	6.81	81.29
Manganese	0.005	706	1,056	66.86	5.09	86.38
Ethylbenzene	0.4	399	1,675	23.82	2.88	89.26
p-Dichlorobenzene	0.091	321	961	33.40	2.31	91.57
Nickel	0.0021	146	1,056	13.83	1.05	92.62
Fluorene	0.011	135	1,280	10.55	0.97	93.60
Hexachloro-1,3-butadiene	0.045	130	186	69.89	0.94	94.53
Acenaphthene	0.011	127	1,277	9.95	0.92	95.45
1,1,2,2-Tetrachloroethane	0.017	112	112	100.00	0.81	96.26
1,2-Dibromoethane	0.0017	71	71	100.00	0.51	96.77
Hexavalent Chromium	0.000083	64	1,019	6.28	0.46	97.23
Propionaldehyde	0.8	59	1,790	3.30	0.43	97.66
Cadmium	0.00056	52	1,051	4.95	0.37	98.03
Lead	0.015	50	1,056	4.73	0.36	98.39
Vinyl chloride	0.11	49	154	31.82	0.35	98.75
Trichloroethylene	0.2	46	365	12.60	0.33	99.08
Fluoranthene	0.011	36	1,296	2.78	0.26	99.34
Benzo(a)pyrene	0.00057	28	824	3.40	0.20	99.54
Dichloromethane	7.7	24	1,464	1.64	0.17	99.71
1,1,2-Trichloroethane	0.0625	14	38	36.84	0.10	99.81
Xylenes	10	7	1,696	0.41	0.05	99.86
Chloroprene	0.0021	5	5	100.00	0.04	99.90
Beryllium	0.00042	4	993	0.40	0.03	99.93
Chloroform	9.8	3	948	0.32	0.02	99.95
Acenaphthylene	0.011	1	655	0.15	0.01	99.96
Antimony	0.02	1	1,050	0.10	0.01	99.96
Benzo(b)fluoranthene	0.0057	1	1,179	0.08	0.01	99.97
Bromoform	0.91	1	167	0.60	0.01	99.98
Bromomethane	0.5	1	1,183	0.08	0.01	99.99
Cobalt	0.01	1	1,051	0.10	0.01	99.99
Tetrachloroethylene	3.8	1	1,252	0.08	0.01	100.00
Total		13,867	38,759	35.78		

The results in Table 4-7 are listed in descending order by number of screens failed. Table 4-7 shows that formaldehyde failed the greatest number of screens (1,792), although acetaldehyde and benzene were not far behind (1,711 and 1,693, respectively). These three pollutants were also among those with the greatest number of measured detections. Conversely, seven pollutants listed in Table 4-7 failed only one screen each. The number of measured detections for these seven pollutants varied significantly. Tetrachloroethylene was detected in 1,252 samples while bromoform was detected less frequently (167), both out of 1,466 valid samples. Although three pollutants exhibited a failure rate of 100 percent 1,1,2,2-tetrachloroethane, 1,2-dibromoethane, and chloroprene), all of these were infrequently detected (less than 10 percent). Thus, the number of failed screens, the number of measured detections, and the failure rate must all be considered when reviewing the results of the preliminary risk-based screening process.

The program-level pollutants of interest, as indicated by the shading in Table 4-7, were identified as follows:

- Acenaphthene
- Acetaldehyde
- Arsenic
- Benzene
- 1,3-Butadiene
- Carbon Tetrachloride
- *p*-Dichlorobenzene
- 1,2-Dichloroethane
- Ethylbenzene
- Fluorene
- Formaldehyde
- Hexachloro-1,3-butadiene
- Manganese
- Naphthalene
- Nickel.

The pollutants of interest identified via the preliminary risk-based screening approach for 2012 is similar to the list of pollutants identified in previous years.

Of the 71 pollutants sampled for under the NMP that have corresponding screening values, concentrations of 38 pollutants failed at least one screen (or roughly 54 percent of pollutants). Of these, a total of 13,867 out of 38,759 concentrations (or nearly 36 percent) failed screens. If all of the pollutants with screening values are considered (including those that did not fail any screens), the percentage of concentrations failing screens is less (13,867 of 55,796, or

25 percent). Note that this percentage excludes acrolein, acetonitrile, acrylonitrile, and carbon disulfide measurements per the explanations provided in Section 3.2.

Table 4-8 presents the total number of failed screens per site, in descending order, as a means of comparing the results of the preliminary risk-based screening process across the sites. As shown, S4MO has the largest number of failed screens (692), followed by PXSS (671) and TOOK (605). In addition to the number of failed screens, Table 4-8 also provides the total number of screens conducted (one screen per valid preprocessed daily measurement for each site for all pollutants with screening values). The failure rate, as a percentage, was determined from the number of failed screens and the total number of screens conducted (based on applicable measured detections) and is also provided in Table 4-8. Note that the results in this table also exclude acrolein, acetonitrile, acrylonitrile, and carbon disulfide.

The total number of screens and the number of pollutant groups measured by each site must be considered when interpreting the results in Table 4-8. For example, sites sampling four, five, or six pollutant groups tended to have a higher number of failed screens. Although WPIN, RRMI, ORFL, AZFL, and INDEM have the highest failure rates (66 percent to 67 percent each), these sites sampled only one pollutant group (carbonyl compounds). Three pollutants measured with Method TO-11A (carbonyl compounds) have screening values (acetaldehyde, formaldehyde, and propionaldehyde) and two of these pollutants typically fail all or most of the screens conducted, as shown in Table 4-7. Thus, sites sampling only carbonyl compounds have relatively high failure rates. Conversely, sites that sampled several pollutant groups tended to have lower failure rates due to the larger number of HAPs screened, as is the case with S4MO, PXSS, NBIL, GLKY, BTUT, and SEWA. These sites each sampled five or six pollutant groups and have a failure rate between 19 percent and 26 percent. For this reason, the number of pollutant groups for which sampling was conducted is also presented in Table 4-8. Note that measurements for two sites, HOWI and CAMS 85, did not fail any screens. Both of these sites sampled only hexavalent chromium.

The following sections from this point forward focus primarily on those pollutants designated as program-level pollutants of interest.

Table 4-8. Site-Specific Risk-Based Screening Comparison

Site	# of Failed Screens	Total # of Measured Detections[1]	% of Failed Screens	# of Pollutant Groups Analyzed
S4MO	692	2,745	25.21	5
PXSS	671	2,565	26.16	5
TOOK	605	1,767	34.24	3
GPCO	600	2,070	28.99	4
NBIL	562	2,591	21.69	6
TMOK	559	1,793	31.18	3
DEMI	520	2,101	24.75	4
ADOK	514	1,858	27.66	4
SEWA	512	2,433	21.04	5
BTUT	508	2,265	22.43	6
OCOK	507	1,767	28.69	3
ELNJ	432	1,319	32.75	2
GLKY	424	2,261	18.75	5
PROK	409	1,458	28.05	3
SPIL	409	1,236	33.09	2
NBNJ	399	1,360	29.34	2
CHNJ	382	1,267	30.15	2
SSSD	359	1,215	29.55	3
UNVT	288	1,992	14.46	5
LEKY	253	1,003	25.22	3
ROIL	228	678	33.63	2
ASKY	181	556	32.55	2
BURVT	177	596	29.70	2
SKFL	176	941	18.70	3
RUVT	174	558	31.18	2
CCKY	173	875	19.77	2
RICO	173	481	35.97	2
SPAZ	166	526	31.56	1
ASKY-M	155	498	31.12	1
SYFL	153	780	19.62	3
BOMA	140	1,438	9.74	3
LAKY	137	522	26.25	1
TVKY	130	504	25.79	1
SJJCA	128	1,159	11.04	2
BRCO	127	415	30.60	2
ATKY	121	509	23.77	1
BMCO	121	396	30.56	2
ORFL	121	183	66.12	1
PACO	121	357	33.89	2
AZFL	117	177	66.10	1

[1] Total number of measured detections for all pollutants with screening values, not just those failing screens. Also excludes acrolein, acetonitrile, acrylonitrile, and carbon disulfide results.

BOLD ITALICS = EPA-designated NATTS Site

Table 4-8. Site-Specific Risk-Based Screening Comparison (Continued)

Site	# of Failed Screens	Total # of Measured Detections[1]	% of Failed Screens	# of Pollutant Groups Analyzed
INDEM	117	177	66.10	1
WPIN	117	174	67.24	1
BLKY	102	385	26.49	1
RRMI	98	147	66.67	1
ROCH	91	757	12.02	2
BAKY	83	496	16.73	1
CELA	74	669	11.06	1
WADC	63	673	9.36	2
RIVA	59	612	9.64	2
PRRI	58	811	7.15	2
RUCA	58	647	8.96	1
SWMI	58	90	64.44	1
RFCO	49	150	32.67	2
MONY	46	464	9.91	2
BXNY	38	312	12.18	2
PAFL	37	300	12.33	1
SDGA	31	342	9.06	2
LBHCA	26	250	10.40	1
CAMS 35	13	168	7.74	2
MIWI	12	41	29.27	1
CHSC	7	409	1.71	2
STMN	6	39	15.38	1
CAMS 85	0	47	0	1
HOWI	0	35	0	1

[1] Total number of measured detections for all pollutants with screening values, not just those failing screens. Also excludes acrolein, acetonitrile, acrylonitrile, and carbon disulfide results.

BOLD ITALICS = EPA-designated NATTS Site

4.2.1 Concentrations of the Pollutants of Interest

Concentrations of the program-level pollutants of interest vary significantly, among the pollutants and among the sites. Tables 4-9 through 4-12 present the top 10 annual average concentrations and 95 percent confidence intervals by site for each of the program-level pollutants of interest (for VOCs, carbonyl compounds, PAHs, and metals, respectively). As described in Section 3.1, an annual average is the average concentration of all measured detections and zeros substituted for non-detects for a given year. Further, an annual average is only presented where there are at least three quarterly averages and where the site-specific method completeness is at least 85 percent. The annual average concentrations for PAHs in Table 4-11 and metals in Table 4-12 are reported in ng/m^3 for ease of viewing, while annual average concentrations in Tables 4-9 and 4-10, for VOCs and carbonyl compounds, respectively, are reported in $\mu g/m^3$. Note that not all sites sampled each pollutant; thus, the list of possible sites presented in Tables 4-9 through 4-12 is limited to those sites sampling each pollutant. For example, only five sites sampled TSP metals; thus, all five sites appear in Table 4-12 for each metal (TSP) pollutant of interest shown.

Table 4-9. Annual Average Concentration Comparison of the VOC Pollutants of Interest

Rank	Benzene (µg/m^3)	1,3-Butadiene (µg/m^3)	Carbon Tetrachloride (µg/m^3)	*p*-Dichlorobenzene (µg/m^3)	1,2-Dichloroethane (µg/m^3)	Ethylbenzene (µg/m^3)	Hexachloro-1,3-Butadiene (µg/m^3)
1	TOOK 2.21 ± 0.31	SPAZ 0.26 ± 0.07	***DEMI*** 0.71 ± 0.02	SPAZ 0.26 ± 0.06	***S4MO*** 0.08 ± 0.01	TOOK 0.91 ± 0.17	NBNJ 0.02 ± 0.01
2	SPAZ 1.43 ± 0.31	***PXSS*** 0.22 ± 0.05	***NBIL*** 0.71 ± 0.05	***PXSS*** 0.20 ± 0.03	***GPCO*** 0.08 ± 0.01	SPAZ 0.84 ± 0.18	***S4MO*** 0.02 ± 0.01
3	***PXSS*** 1.28 ± 0.21	RICO 0.18 ± 0.03	***SEWA*** 0.70 ± 0.02	***S4MO*** 0.18 ± 0.06	NBNJ 0.08 ± 0.01	***PXSS*** 0.73 ± 0.12	CHNJ 0.02 ± 0.01
4	***GPCO*** 1.28 ± 0.12	***GPCO*** 0.18 ± 0.03	PROK 0.70 ± 0.03	ADOK 0.13 ± 0.04	***BTUT*** 0.08 ± 0.01	***GPCO*** 0.70 ± 0.11	***GPCO*** 0.02 ± 0.01
5	TMOK 1.25 ± 0.16	ELNJ 0.14 ± 0.02	***GLKY*** 0.69 ± 0.03	TOOK 0.09 ± 0.01	SPIL 0.08 ± 0.01	TMOK 0.56 ± 0.08	BURVT 0.01 ± 0.01
6	BMCO 1.09 ± 0.12	SPIL 0.14 ± 0.03	***PXSS*** 0.68 ± 0.02	PROK 0.09 ± 0.02	BURVT 0.08 ± 0.01	***DEMI*** 0.53 ± 0.14	TOOK 0.01 ± 0.01
7	RUVT 1.05 ± 0.20	RUVT 0.13 ± 0.04	SPIL 0.68 ± 0.03	TMOK 0.08 ± 0.01	SPAZ 0.08 ± 0.01	ELNJ 0.41 ± 0.05	***UNVT*** 0.01 ± 0.01
8	ELNJ 1.04 ± 0.14	TMOK 0.13 ± 0.02	TMOK 0.68 ± 0.02	ELNJ 0.07 ± 0.02	ELNJ 0.08 ± 0.01	***BTUT*** 0.36 ± 0.06	***NBIL*** 0.01 ± 0.01
9	***BTUT*** 1.02 ± 0.13	***BTUT*** 0.12 ± 0.03	RUVT 0.68 ± 0.04	***GPCO*** 0.07 ± 0.01	RUVT 0.07 ± 0.01	RUVT 0.36 ± 0.05	ELNJ 0.01 ± 0.01
10	RICO 1.00 ± 0.12	***DEMI*** 0.12 ± 0.03	***S4MO*** 0.68 ± 0.02	OCOK 0.07 ± 0.01	TOOK 0.07 ± 0.01	***S4MO*** 0.36 ± 0.05	TMOK 0.01 ± 0.01

BOLD ITALICS = EPA-designated NATTS Site

Table 4-10. Annual Average Concentration Comparison of the Carbonyl Compound Pollutants of Interest

Rank	Acetaldehyde (µg/m³)	Formaldehyde (µg/m³)
1	***PXSS*** 2.90 ± 0.30	***BTUT*** 4.44 ± 0.75
2	***GPCO*** 2.89 ± 0.27	WPIN 4.31 ± 0.61
3	TOOK 2.78 ± 0.43	***PXSS*** 3.96 ± 0.27
4	SPIL 2.72 ± 0.77	ELNJ 3.89 ± 0.47
5	ELNJ 2.66 ± 0.34	TMOK 3.63 ± 0.47
6	***BTUT*** 2.54 ± 0.35	PROK 3.58 ± 0.65
7	OCOK 2.34 ± 0.32	OCOK 3.49 ± 0.54
8	TMOK 2.33 ± 0.32	***DEMI*** 3.45 ± 0.44
9	WPIN 2.28 ± 0.27	TOOK 3.42 ± 0.54
10	***S4MO*** 1.86 ± 0.22	***S4MO*** 3.26 ± 0.52

BOLD ITALICS = EPA-designated NATTS Site

Table 4-11. Annual Average Concentration Comparison of the PAH Pollutants of Interest

Rank	Acenaphthene (ng/m³)	Fluorene (ng/m³)	Naphthalene (ng/m³)
1	***GPCO*** 20.53 ± 7.27	***GPCO*** 12.56 ± 2.86	***GPCO*** 203.78 ± 35.24
2	***DEMI*** 12.60 ± 4.41	***NBIL*** 12.31 ± 4.18	***CELA*** 179.67 ± 20.99
3	***ROCH*** 12.27 ± 3.43	***DEMI*** 11.35 ± 3.53	***DEMI*** 141.70 ± 23.82
4	***NBIL*** 11.51 ± 3.62	***ROCH*** 9.95 ± 2.68	***S4MO*** 110.45 ± 19.71
5	***S4MO*** 7.37 ± 1.59	***S4MO*** 8.32 ± 1.67	***WADC*** 104.38 ± 19.17
6	***CELA*** 5.44 ± 0.70	***CELA*** 7.67 ± 1.07	***PXSS*** 97.83 ± 19.46
7	***RIVA*** 3.76 ± 0.75	***RUCA*** 4.27 ± 0.48	***RUCA*** 96.96 ± 15.56
8	***SEWA*** 3.60 ± 0.88	***RIVA*** 4.16 ± 0.65	***SKFL*** 96.91 ± 21.04
9	***BOMA*** 3.04 ± 1.23	***WADC*** 4.03 ± 0.53	***RIVA*** 93.95 ± 12.47
10	***WADC*** 3.03 ± 0.49	***BOMA*** 3.76 ± 1.41	***NBIL*** 77.94 ± 17.78

BOLD ITALICS = EPA-designated NATTS Site

Table 4-12. Annual Average Concentration Comparison of the Metals Pollutants of Interest

Rank	Arsenic (PM_{10}) (ng/m^3)	Arsenic (TSP) (ng/m^3)	Manganese (PM_{10}) (ng/m^3)	Manganese (TSP) (ng/m^3)	Nickel (PM_{10}) (ng/m^3)	Nickel (TSP) (ng/m^3)
1	ASKY-M 1.79 ± 0.37	TOOK 0.92 ± 0.10	ASKY-M 34.09 ± 10.54	TOOK 38.33 ± 8.81	ASKY-M 2.94 ± 0.90	TOOK 2.42 ± 0.49
2	***S4MO*** 1.09 ± 0.25	TMOK 0.77 ± 0.11	***PXSS*** 22.75 ± 4.01	TMOK 26.22 ± 8.46	***SEWA*** 2.74 ± 0.71	TMOK 1.67 ± 0.26
3	PAFL 1.03 ± 0.33	PROK 0.63 ± 0.10	***S4MO*** 22.66 ± 9.60	OCOK 21.10 ± 4.26	***PXSS*** 2.04 ± 0.34	OCOK 1.10 ± 0.16
4	BAKY 0.93 ± 0.20	OCOK 0.57 ± 0.07	***SEWA*** 9.80 ± 2.88	PROK 18.66 ± 8.09	***S4MO*** 1.42 ± 0.36	PROK 0.99 ± 0.21
5	LEKY 0.92 ± 0.18	ADOK 0.49 ± 0.05	***NBIL*** 9.11 ± 1.86	ADOK 13.09 ± 2.635	***BOMA*** 1.41 ± 0.29	ADOK 0.86 ± 0.10
6	CCKY 0.86 ± 0.28		***BTUT*** 7.97 ± 1.24		***BTUT*** 1.41 ± 0.19	
7	***NBIL*** 0.73 ± 0.12		BAKY 6.74 ± 0.84		***SJJCA*** 1.17 ± 0.19	
8	***SEWA*** 0.68 ± 0.11		LEKY 6.69 ± 0.96		***NBIL*** 1.04 ± 0.16	
9	***PXSS*** 0.68 ± 0.11		CCKY 6.50 ± 0.96		PAFL 0.81 ± 0.11	
10	***GLKY*** 0.59 ± 0.10		***SJJCA*** 6.22 ± 1.18		LEKY 0.62 ± 0.21	

BOLD ITALICS = EPA-designated NATTS Site

Observations from Tables 4-9 through 4-12 include the following:

- The highest annual average concentration among the program-wide pollutants of interest was calculated for formaldehyde for BTUT (4.44 ± 0.75 $\mu g/m^3$). As shown in Table 4-10, WPIN also has an annual average concentration greater than 4 $\mu g/m^3$ (4.31 ± 0.61 $\mu g/m^3$) and all of the sites shown in Table 4-10 have annual average concentrations greater than 3 $\mu g/m^3$. Formaldehyde and acetaldehyde together account for 19 of the 20 annual average concentrations greater than 2.0 $\mu g/m^3$ in Tables 4-9 through 4-12 (the one exception being for TOOK's annual average concentration of benzene).

- The annual average concentrations of benzene are the only annual averages among the VOCs shown greater than 1 $\mu g/m^3$. TOOK's annual average benzene concentration (2.21 ± 0.31 $\mu g/m^3$) is significantly higher than the next highest annual average benzene concentration (1.43 ± 0.31 $\mu g/m^3$ for SPAZ), but is considerably less than its annual average for the 2011 NMP report (3.59 ± 0.98 $\mu g/m^3$). Across the program, six of the 11 individual benzene measurements greater than 4 $\mu g/m^3$ were measured at TOOK. The other Tulsa site (TMOK) ranks fifth for benzene. The two Phoenix sites (SPAZ and PXSS) rank second and third, respectively, for benzene. Three of the six Colorado sites also appear among the sites with the 10 highest annual average benzene concentrations.

- Concentrations of some of the VOCs vary significantly while others do not. The difference between the highest and 10th highest annual average concentration of carbon tetrachloride is only 0.035 $\mu g/m^3$. The difference between the highest and 10th highest annual average concentrations of both 1,2-dichloroethane and hexachloro-1,3-butadiene is even less, approximately 0.011 µg/m^3 for both pollutants. Conversely, the difference between the highest and 10th highest annual average concentration of benzene is 1.21 µg/m^3.

- The sites with the five highest annual averages concentrations of benzene are the same sites with the five highest annual averages concentrations for ethylbenzene. Altogether, eight of the 10 sites are the same in the benzene and ethylbenzene columns.

- Although BTUT has the highest annual average concentration of formaldehyde (4.44 ± 0.75 µg/m^3) shown in Table 4-10, the maximum concentration measured across the program is shared between TOOK and SPIL (a concentration of 12.8 µg/m^3 was measured at each site). Of the five formaldehyde concentrations greater than 12 µg/m^3 measured across the program, one was measured at BTUT, one at TOOK, one at PROK, and two were measured at SPIL. However, SPIL does not appear in Table 4-10 because its annual average concentration ranks 12th.

- While the three highest acetaldehyde concentrations across the program (ranging from 8.74 µg/m^3 to 20.4 µg/m^3) were all measured at SPIL, its annual average concentration ranked fourth among other sites sampling carbonyl compounds. The variability in this site's acetaldehyde concentrations is indicated by its confidence interval, which is nearly twice the confidence intervals shown for the other sites in Table 4-10.

- Seven of the 10 sites shown in Table 4-10 for formaldehyde also appear among the sites with the highest annual average concentrations of acetaldehyde.

- Table 4-11 shows that GPCO has the highest annual average concentration for each of the program-wide PAH pollutants of interest. The annual average concentrations of acenaphthene and naphthalene for GPCO are considerably higher than the next highest annual averages and have relatively large confidence intervals associated with them. GPCO has the four highest measurements of naphthalene program-wide (ranging from 475 ng/m^3 to 822 ng/m^3). GPCO also has the only two concentrations of acenaphthene greater than 100 ng/m^3 measured across the program, as well as five of the nine measurements greater than 50 ng/m^3. GPCO's annual average concentration of fluorene is relatively similar to the second highest annual average concentration of this pollutant (calculated for NBIL).

- ASKY-M has the highest annual average concentration of each of the three program-wide PM_{10} metals pollutants of interest. All five Kentucky sites sampling PM_{10} metals appear in Table 4-11 for arsenic; four of the five Kentucky sites appear in Table 4-11 for manganese; and only two appear in Table 4-11 for nickel. S4MO, which has had the highest concentration of arsenic and manganese in past reports, ranks second for arsenic, third for manganese (behind PXSS), and fifth for nickel for 2012. S4MO and ASKY-M each have one manganese concentration greater than 200 ng/m^3 and another greater than 100 ng/m^3 (as does PXSS).

- TOOK has the highest annual average concentration of each of the three program-wide TSP metals pollutants of interest. Further, for the TSP metals, the Tulsa sites are the two Oklahoma sites with the highest annual average concentrations.

- S4MO is on the top 10 list for 13 of the 19 program-level pollutants of interest; PXSS is on the top 10 list for 11 of the 19 program-level pollutants of interest; and GPCO is on the top 10 list for 10 of the 19 program-level pollutants of interest. NBIL, BTUT, and ELNJ each appear in Tables 4-9 through 4-12 a total of 8 times. Conversely, 26 sites do not appear in Table 4-9 through 4-12 at all. Note, however, that some sites did not meet the criteria for annual averages to be calculated.

4.2.2 Risk-Based Screening Assessment Using MRLs

Table 4-13 presents the pollutants analyzed under the NMP that have associated ATSDR MRLs. Note that some pollutants do not have MRLs for one or more of the designated time frames (acute, intermediate, or chronic). None of the preprocessed daily measurements are greater than the associated acute MRL; none of the quarterly average concentrations, where they could be calculated, are greater than the associated intermediate MRL; and none of the annual average concentrations, where they could be calculated, are greater than the associated chronic MRL. Thus, Table 4-13 also presents the maximum preprocessed daily measurement, quarterly average concentration, and annual average concentration associated with each pollutant. This allows the reader to see how close (or how far) from the MRL(s) some concentrations were. For example, the acute MRL for benzene is 30 $\mu g/m^3$ and the maximum benzene concentration measured in 2012 was 5.73 $\mu g/m^3$; the acute MRL for acetone is 60,000 $\mu g/m^3$ while the maximum concentration measured was 27.6 $\mu g/m^3$.

Table 4-13. Comparison of Maximum Concentrations vs. ATSDR MRLs

Pollutant	**ATSDR Acute MRL[1] ($\mu g/m^3$)**	**Maximum Preprocessed Daily Measurement ($\mu g/m^3$)**	**ATSDR Intermediate MRL[1] ($\mu g/m^3$)**	**Maximum Quarterly Average Concentration ($\mu g/m^3$)**	**ATSDR Chronic MRL[1] ($\mu g/m^3$)**	**Maximum Annual Average Concentration ($\mu g/m^3$)**
Acetone	60,000	27.60	30,000	10.96	30,000	7.88
Benzene	30	5.73	20	2.51	10	2.21
Bromomethane	200	0.55	200	0.19	20	0.11
Cadmium	0.03	0.003	--	--	0.01	0.001
Carbon Disulfide	--	--	--	--	900	11.56
Carbon Tetrachloride	--	--	200	1.28	200	0.71
Chloroethane	40,000	0.90	--	--	--	--
Chloroform	500	45.80	200	5.29	100	2.48
Chloromethane	1,000	3.43	400	1.49	100	1.32
Cobalt	--	--	--	--	0.1	0.002
p-Dichlorobenzene	10,000	1.37	1,000	0.50	60	0.26
1,2-Dichloroethane	--	--	--	--	2,000	0.08
1,1-Dichloroethene	--	--	80	0.04	--	--
trans-1,2-Dichloroethylene	800	0.85	800	0.05	--	--
cis/trans-1,3-dichloropropene[2]	--	--	40	0.10	30	0.02
Dichloromethane	2,000	745.00	1,000	104.13	1,000	40.23
1,2-Dichloropropane	200	0.06	30	0.004	--	--
Ethylbenzene	20,000	3.63	9,000	1.41	300	0.91
Formaldehyde	50	12.80	40	8.30	10	4.44
n-Hexane	--	--	--	--	2,000	3.34
Hexavalent Chromium	--	--	0.3	0.001	--	--
Manganese	--	--	--	--	0.3	0.04
Mercury	--	--	--	--	0.2	0.00004
Methyl *tert*-Butyl Ether	7,000	0.32	3,000	0.22	3,000	0.12
Naphthalene	--	--	--	--	4	0.20
Nickel	--	--	0.2	0.01	0.09	0.003
Styrene	20,000	39.00	--	--	900	2.97

[1] Reflects the use of one significant digit for MRLs

[2] The MRL for 1,3-dichloropropene was applied to both isomers (*cis*-1,3-dichloropropene and *trans*-1,3-dichloropropene), with the maximum concentration for the pair provided in Table 4-13.

Table 4-13. Comparison of Maximum Concentrations vs. ATSDR MRLs (Continued)

Pollutant	**ATSDR Acute MRL[1] (µg/m^3)**	**Maximum Preprocessed Daily Measurement (µg/m^3)**	**ATSDR Intermediate MRL[1] (µg/m^3)**	**Maximum Quarterly Average Concentration (µg/m^3)**	**ATSDR Chronic MRL[1] (µg/m^3)**	**Maximum Annual Average Concentration (µg/m^3)**
Tetrachloroethylene	1,000	5.38	--	--	300	0.46
Toluene	4,000	21.50	--	--	300	6.56
1,1,1-Trichloroethane	10,000	0.36	4,000	0.08	--	--
Trichloroethylene	--	--	--	--	2	0.71
Vinyl Chloride	1,000	9.81	80	1.05	--	--
Xylenes	9,000	18.03	3,000	5.63	200	4.09

[1] Reflects the use of one significant digit for MRLs

[2] The MRL for 1,3-dichloropropene was applied to both isomers (*cis*-1,3-dichloropropene and *trans*-1,3-dichloropropene), with the maximum concentration for the pair provided in Table 4-13.

The pollutant with the preprocessed daily measurement closest to the acute MRL is dichloromethane (the acute MRL is 2000 $\mu g/m^3$ and the maximum dichloromethane measurement is 745 $\mu g/m^3$). The pollutant with the quarterly average concentration closest to the intermediate MRL is formaldehyde (the intermediate MRL is 40 $\mu g/m^3$ and the maximum quarterly average is 8.30 $\mu g/m^3$). The pollutant with the annual average concentration closest to the chronic MRL is also formaldehyde (the chronic MRL is 10 $\mu g/m^3$ and the maximum annual average is 4.44 $\mu g/m^3$).

Because none of the preprocessed daily measurements are greater than associated acute MRLs, the emission tracer analysis described in Section 3.5.3.3 was not performed.

4.3 The Effect of Mobile Sources

Ambient air is significantly affected by mobile sources, as discussed in Section 3.4.1. Table 4-14 contains several parameters that are used to assess if mobile sources are affecting air quality near the monitoring sites, including emissions data from the NEI, concentration data, and site-characterizing data, such as vehicle ownership.

4.3.1 Mobile Source Emissions

Emissions from mobile sources contribute significantly to air pollution in the United States. Mobile source emissions can be broken into two categories: on-road and non-road. On-road emissions come from mobile sources such as automobiles, buses, and trucks that use roadways; non-road emissions come from the remaining mobile sources such as locomotives, lawn mowers, airplanes, and boats (EPA, 2011b). Table 4-14 contains county-level on-road and non-road HAP emissions from the 2011 NEI.

Mobile source emissions tend to be highest in large urban areas and lowest in rural areas. Estimated on-road county emissions were highest in Los Angeles County, CA (where CELA and LBHCA are located), followed Maricopa County, AZ (where PXSS and SPAZ are located), and Cook County, IL (where NBIL and SPIL are located). Estimated on-road emissions were lowest in Livingston County, KY (BLKY), Chesterfield County, SC (CHSC), and Carter County, KY (GLKY). Estimated non-road county emissions were also highest in Los Angeles County, CA; Cook County, IL; and Maricopa County, AZ. Estimated non-road county emissions were lowest in Carter County, KY; Boyd County, KY (where ASKY and ASKY-M are located); and Chesterfield County, SC.

Table 4-14. Summary of Mobile Source Information by Monitoring Site

Site	County-level Motor Vehicle Registration[1] (# of Vehicles)	Annual Average Daily Traffic[1] (# of Vehicles)	County-level Daily VMT[1]	County-Level On-road Emissions[2] (tpy)	County-Level Non-road Emissions[2] (tpy)	Hydrocarbon Average[3] (ppbv)
ADOK	847,824	34,100	27,411,171	2,075.41	684.79	1.46
ASKY	39,227	7,229	1,281,000	110.93	22.72	2.86
ASKY-M	39,227	12,842	1,281,000	110.93	22.72	NA
ATKY	30,297	3,262	1,292,000	116.37	350.78	4.62
AZFL	872,813	38,500	21,387,550	1,716.20	876.17	NA
BAKY	38,518	922	1,417,000	137.79	100.53	NA
BLKY	8,281	2,280	398,000	36.29	80.28	2.72
BMCO	74,508	2,527	1,902,077	209.80	74.47	NA
BOMA	362,899	27,654	10,890,178	621.13	344.54	NA
BRCO	74,508	1,102	1,902,077	209.80	74.47	NA
BTUT	259,319	129,145	6,866,779	586.54	257.49	3.33
BURVT	169,767	14,000	4,032,329	315.99	189.85	2.18
BXNY	251,398	99,201	8,178,210	917.00	241.43	NA
CAMS 35	3,252,420	31,043	57,020,660	4,639.61	1,660.72	NA
CAMS 85	71,658	1,250	2,405,125	158.35	98.06	NA
CCKY	30,297	4,742	1,292,000	116.37	350.78	2.92
CELA	7,422,254	229,000	214,458,140	9,326.27	4,010.78	NA
CHNJ	445,710	11,215	14,844,444	697.15	531.97	2.74
CHSC	41,259	550	1,228,145	96.86	56.37	NA
DEMI	1,337,797	87,500	40,951,779	3,354.28	982.04	3.09
ELNJ	485,449	250,000	12,264,174	636.49	321.63	6.19
GLKY	25,391	303	1,080,000	104.91	11.48	1.12
GPCO	179,213	11,000	2,009,730	325.68	146.85	5.14
HOWI	96,912	5,100	2,626,054	227.28	177.03	NA
INDEM	419,431	34,754	16,226,000	831.30	523.81	NA
LAKY	30,297	1,189	1,292,000	116.37	350.78	3.86
LBHCA	7,422,254	282,000	214,458,140	9,326.27	4,010.78	NA
LEKY	207,043	10,083	7,545,000	591.61	334.21	1.90
MIWI	632,914	12,800	17,532,434	1,365.75	474.65	NA
MONY	251,398	91,213	8,178,210	917.00	241.43	NA
NBIL	2,092,085	115,100	86,217,829	4,729.93	3,482.70	2.13
NBNJ	733,908	110,653	20,644,392	976.00	523.95	2.99
OCOK	847,824	40,900	27,411,171	2,075.41	684.79	2.01
ORFL	1,073,682	35,000	34,099,958	2,663.78	1,222.71	NA
PACO	74,508	16,000	1,902,077	209.80	74.47	NA
PAFL	1,073,682	49,500	34,099,958	2,663.78	1,222.71	NA
PROK	41,391	15,100	1,662,076	126.46	60.29	1.89
PRRI	548,763	136,800	NA	798.94	304.50	NA
PXSS	3,761,859	184,000	90,393,000	6,467.29	3,082.11	4.70
RFCO	74,508	16,000	1,902,077	209.80	74.47	NA
RICO	74,508	17,000	1,902,077	209.80	74.47	NA

[1] Individual references provided in each state section.

[2] Reference: EPA, 2013c

[3] This parameter is only available for monitoring sites sampling VOCs and is not limited by the annual average criteria.

BOLD ITALICS = EPA-designated NATTS Site

NA = VOC samples were not collected at this monitoring site.

Table 4-14. Summary of Mobile Source Information by Monitoring Site (Continued)

Site	County-level Motor Vehicle Registration[1] (# of Vehicles)	Annual Average Daily Traffic[1] (# of Vehicles)	County-level Daily VMT[1]	County-Level On-road Emissions[2] (tpy)	County-Level Non-road Emissions[2] (tpy)	Hydrocarbon Average[3] (ppbv)
RIVA	354,419	72,000	8,232,198	618.44	145.79	NA
ROCH	556,055	88,348	15,980,952	1,152.75	573.62	NA
ROIL	286,043	9,400	7,867,318	475.89	216.47	3.56
RRMI	1,337,797	97,300	40,951,779	3,354.28	982.04	NA
RUCA	1,724,787	145,000	55,717,760	2,070.71	881.09	NA
RUVT	70,900	6,700	1,745,205	134.11	127.14	3.14
S4MO	1,112,866	79,558	23,994,911	809.51	157.06	2.76
SDGA	472,535	141,980	20,113,000	1,328.12	269.22	NA
SEWA	1,403,968	224,000	23,044,858	4,461.96	2,176.51	2.01
SJJCA	1,529,351	106,000	41,250,490	2,715.06	601.80	NA
SKFL	872,813	49,000	21,387,550	1,716.20	876.17	NA
SPAZ	3,761,859	128,000	90,393,000	6,467.29	3,082.11	5.38
SPIL	2,092,085	191,700	86,217,829	4,729.93	3,482.70	2.76
SSSD	212,507	18,575	3,778,321	365.04	116.48	1.62
STMN	218,196	24,100	4,983,115	542.65	655.77	NA
SWMI	1,337,797	94,400	40,951,779	3,354.28	982.04	NA
SYFL	1,143,207	10,400	34,061,637	2,824.86	1,044.25	NA
TMOK	618,359	12,600	20,402,564	1,480.37	714.80	3.69
TOOK	618,359	63,000	20,402,564	1,480.37	714.80	6.55
TVKY	30,297	2,231	1,292,000	116.37	350.78	6.12
UNVT	169,767	1,100	4,032,329	315.99	189.85	0.92
WADC	316,231	7,400	9,775,000	615.46	248.44	NA
WPIN	820,767	143,970	32,005,000	2,593.89	624.63	NA

[1] Individual references provided in each state section.
[2] Reference: EPA, 2013c
[3] This parameter is only available for monitoring sites sampling VOCs and is not limited by the annual average criteria.
BOLD ITALICS = EPA-designated NATTS Site
NA = VOC samples were not collected at this monitoring site.

4.3.2 Hydrocarbon Concentrations

Hydrocarbons are organic compounds that contain only carbon and hydrogen. Hydrocarbons are derived primarily from crude petroleum sources and are classified according to their arrangement of atoms as alicyclic, aliphatic, and aromatic. Hydrocarbons are of prime economic importance because they encompass the constituents of the major fossil fuels, petroleum and natural gas, as well as plastics, waxes, and oils. Hydrocarbons in the atmosphere originate from natural sources and from various anthropogenic sources, such as the combustion of fuel and biomass, petroleum refining, petrochemical manufacturing, solvent use, and gas and oil production and use. In urban air pollution, these components, along with oxides of nitrogen (NO_x) and sunlight, contribute to the formation of tropospheric ozone. Thus, the concentration of hydrocarbons in ambient air may act as an indicator of mobile source activity levels. Several hydrocarbons are sampled with Method TO-15, including benzene, ethylbenzene, and toluene.

Table 4-14 presents the average of the sum of hydrocarbon concentrations for each site sampling VOCs. Note that only sites sampling VOCs have data in this column. Table 4-14 shows that TOOK, ELNJ, TVKY, and SPAZ have the highest hydrocarbon averages among the sites monitoring VOCs. TOOK and ELNJ are located in highly populated urban areas and in relatively close proximity to heavily traveled roadways. TOOK is located near Exit 3A of I-244 in Tulsa, Oklahoma while ELNJ is location on Exit 13A of the New Jersey Turnpike. SPAZ is located in a highly urbanized area (Phoenix), but not near a major roadway. TVKY is located in a highly industrialized area in a moderately populated area. The sites with the lowest hydrocarbon averages are UNVT, GLKY, and ADOK. UNVT and GLKY are located in rural areas. ADOK is located on the edge of an urbanized area just south of a major roadway. The average sum of hydrocarbon concentrations can be compared to other indicators of mobile source activity, such as the ones discussed below, to determine if correlations exist.

4.3.3 Motor Vehicle Ownership

Another indicator of motor vehicle activity near the monitoring sites is the total number of vehicles owned by residents in the county where each monitoring site is located, which includes passenger vehicles, trucks, and commercial vehicles, as well as vehicles that can be regional in use such as boats or snowmobiles. Actual county-level vehicle registration data were obtained from each applicable state or local agency, where possible. If data were not available, vehicle registration data are available at the state-level (FHWA, 2013a). The county proportion of the state population was then applied to the state registration count.

The county-level motor vehicle ownership data and the average summed hydrocarbon concentrations are presented in Table 4-14. As previously discussed, TOOK, ELNJ, TVKY, and SPAZ have the highest average summed hydrocarbon concentrations, respectively, while UNVT, GLKY, and ADOK have the lowest. Table 4-14 also shows that SPAZ, PXSS, NBIL, and SPIL have the highest county-level vehicle ownership of the sites sampling VOCs, while the Kentucky sites located in Livingston, Carter, and Marshall Counties have the lowest. The Pearson correlation coefficient calculated between these two datasets is 0.19, which is considered a weak correlation. CELA and LBHCA, which have the highest county-level vehicle ownership of all

NMP sites, did not sample VOCs under the NMP; this is also true for many of the sites with larger vehicle ownership counts.

The vehicle ownership at the county-level may not be completely indicative of the ownership in a particular area. As an illustration, for a county with a large city in the middle of its boundaries and less populated areas surrounding it, the total county-level ownership may be more representative of areas inside the city limits than in the rural outskirts.

Other factors may affect the reliability of motor vehicle ownership data as an indicator of ambient air monitoring data results:

- Estimates of higher vehicle ownership surrounding a monitoring site do not necessarily imply increased motor vehicle use in the immediate vicinity of a monitoring site. Conversely, sparsely populated regions often contain heavily traveled roadways.

- Emissions sources in the area other than motor vehicles may significantly affect levels of hydrocarbons in ambient air.

4.3.4 Estimated Traffic Volume

Traffic data for each of the participating monitoring sites were obtained from state and local agencies, primarily departments of transportation. Most of the traffic counts in this report reflect AADT, which is "the annual traffic count divided by the number of days in the year," and incorporates both directions of traffic (FHWA, 2013b). AADT counts obtained were based on data from 2002 to 2013, primarily 2011 forward. The updated traffic values are presented in Table 4-14. The traffic data presented in Table 4-14 represent the most recently available data applicable to the monitoring sites.

There are several limitations to obtaining the AADT near each monitoring site. AADT statistics are developed for roadways, such as interstates, state highways, or local roadways, which are managed by different municipalities or government agencies. AADT is not always available for rural areas or for secondary roadways. For monitoring sites located near interstates, the AADT for the interstate segment closest to the site was obtained. For other monitoring sites, the highway or secondary road closest to the monitoring site was used. Only one AADT value was obtained for each monitoring site. The intersection or roadway chosen for each monitoring site is discussed in each individual state section (Sections 5 through 29).

Table 4-14 shows that ELNJ, SEWA, and SPIL have the highest daily traffic volumes of the sites sampling VOCs, while GLKY, UNVT, and LAKY have the lowest. For all monitoring sites (not just those sampling VOCs), the highest daily traffic volume occurs near LBHCA, ELNJ, CELA, and SEWA. LBHCA is near I-405 east of the intersection with I-710; ELNJ is located near Exit 13A on I-95; CELA is located in downtown Los Angeles; and SEWA is located in Seattle near I-5 south of its intersection with I-9. ELNJ has the second highest traffic volume and the second highest hydrocarbon average, but SEWA, which has the fourth highest traffic volume, has the 23rd highest hydrocarbon average. Again, LBHCA and CELA did not measure VOCs under the NMP. A Pearson correlation coefficient calculated between the average summed hydrocarbon calculations and the traffic counts is 0.25, which is also considered a weak correlation.

4.3.5 Vehicle Miles Traveled

Another approach to determine how mobile sources affect urban air quality is to review VMT. VMT is "the mileage traveled by all vehicles on a road system over a period of time such as a year" (FHWA, 2013b). Thus, VMT values tend to be large (in the millions). County-level VMT was obtained for each of the participating monitoring sites from state organizations, primarily departments of transportation. However, these data are not readily available for all states. In addition, not all states provide this information on the same level. For example, many states provide VMT for all public roads, while the state of Colorado provided this information for state highways only. County-level VMT are presented in Table 4-14, where available.

Of the sites sampling VOCs, county-level VMT, where available, was highest for PXSS and SPAZ, SPIL and NBIL, and DEMI (Wayne County, MI). The sites with the lowest county-level VMT, where available, are BLKY, GLKY, and ASKY. A Pearson correlation coefficient calculated between the average summed hydrocarbon concentrations and VMT, where available, is 0.12, indicating little correlation between hydrocarbon concentrations and county-level VMT. It is important to note that many of the sites with larger VMT did not measure VOCs under the NMP (such as CELA, LBHCA, CAMS 35, RUCA, and SJJCA). In addition, county-level VMT was not readily available for Rhode Island.

4.4 Variability Analysis

This section presents the results of the three variability analyses described in Section 3.4.2.

4.4.1 Coefficient of Variation and Inter-site Variability

The site-specific CVs and the inter-site comparison analyses are discussed together in this section. Figures 4-1a through 4-15a are graphical displays of site-specific CVs (standard deviation vs. annual average concentration) for the program-level pollutants of interest. Figures 4-1b through 4-15b are bar graphs depicting the site-specific annual averages overlain on the program-level averages (indicated by the yellow shading), as presented in Section 4.1. For each program-level pollutant of interest, the CV graph is shown first, followed by the inter-site variability graph. The figures are aligned this way because they complement each other; the data point with the highest annual average concentration and/or standard deviation in the CV graph is easily identifiable in the inter-site variability graph. Further, the inter-site variability graphs allow the reader to see how the individual site-specific annual averages feed into the program-level averages (i.e., if a specific site(s) is driving the program average). In addition to the standard deviations on the CV graphs, the confidence intervals provided on the inter-site variability graphs are a further indication of the amount of variability contained within the site-specific annual averages.

Several items to note about these figures: Some sites do not have annual averages presented on the inter-site variability graphs because they did not meet the criteria specified in Section 3.1. These same sites without annual averages on the inter-site variability graphs are not represented by a data point on the corresponding CV graphs. For the sites sampling metals, the program-level average for sites collecting PM_{10} samples is presented in green while the program-level average for sites collecting TSP samples is presented in pink. The annual averages for the sites sampling only SNMOCs are not included in the graphs for benzene, 1,3-butadiene, or ethylbenzene.

The CV figures show that few of the pollutants appear to exhibit the "clustering" discussed in Section 3.4.2. Figure 4-6a for carbon tetrachloride exhibits clustering, or uniformity in concentrations. Carbon tetrachloride is a pollutant that was used worldwide as a refrigerant. However, it was identified as an ozone-depleting substance in the stratosphere and its use was banned at the Kyoto Protocol. This pollutant has a long lifetime in the atmosphere, but slowly degrades over time. Today, its concentration in ambient air is fairly ubiquitous regardless of where it is measured. The CVs shown in Figure 4-6a not only support the expected uniformity (i.e., lack of variability) in "background" concentrations of carbon tetrachloride, but are also a testament to the representativeness of the data generated under the NMP. Figure 4-6b supports what is shown in Figure 4-6a. The inter-site variability is relatively low, with the annual average concentrations of carbon tetrachloride ranging from 0.64 $\mu g/m^3$ for SSSD to 0.71 $\mu g/m^3$ for DEMI. Further, the confidence intervals for all sites shown are less than ± 0.05 $\mu g/m^3$.

Figure 4-8a shows that 1,2-dichloroethane also exhibits clustering, and is supported in Figure 4-8b by the relatively small differences in the annual averages and confidence intervals shown for every site. The annual average concentrations of 1,2-dichloroethane ranged from 0.061 $\mu g/m^3$ for UNVT to 0.083 $\mu g/m^3$ for S4MO. Further, the confidence intervals for all sites shown are less than ± 0.014 $\mu g/m^3$. However, the program-level average concentration (approximately 0.15 $\mu g/m^3$), as indicated by the yellow shading, is roughly twice the site-specific annual averages shown. This is because data for all sites are included in the program-level averages, not just those with valid annual averages; thus, one or more sites without an annual average shown in Figure 4-8b are driving the program-level average. A review of the data shows that concentrations of 1,2-dichloroethane from the Calvert City, Kentucky sites are driving this program-level average. These five sites account for the highest 56 measurements of this pollutant, which range from 0.18 $\mu g/m^3$ to 17.1 $\mu g/m^3$. Annual averages for these sites could not be calculated because they did not begin sampling until July 2012 under the NMP. However, the average concentrations for 1,2-dichloroethane for these sites over the period of sampling is provided in Appendix J.

Hexchloro-1,3-butadiene is another pollutant that exhibits clustering. Figure 4-12a shows that the annual average concentrations have a very small range, ranging from 0 $\mu g/m^3$ (SEWA) to 0.02 $\mu g/m^3$ (NBNJ). Figure 4-12a also shows that the standard deviations tended to be higher than the averages themselves, the exception being for the site that did not detect this pollutant (SEWA). Hexchloro-1,3-butadiene was detected in fewer than 15 percent of samples collected, resulting in a large number of zero substitutions. Thus, the standard deviations are relatively large, as are the associated confidence intervals shown in Figure 4-12b. Even the site with the highest annual average concentration of hexachloro-1,3-butadiene (NBNJ) detected this pollutant in fewer than one quarter of the samples collected.

The CVs for several of the program-level pollutants of interest follow a linear trend line. Examples of pollutants whose annual average concentrations exhibit this trend include acetaldehyde, benzene, fluorene, formaldehyde, and naphthalene. This means that as the annual averages increase, so do the standard deviations, indicating increasing variability. This increased variability is often a result of an increased range of individual measurements that are used to calculate the annual average**.** This is supported by the corresponding inter-site variability graphs for each pollutant. The site-specific annual averages that extend well above the program-level average concentration for each pollutant tend to have a larger confidence interval associated with them, indicating a wider range of measurements and the possible influence of outliers. The annual averages considerably less than the program-level average concentration tend to have much smaller confidence intervals. Figures 4-10a and 4-10b for fluorene and Figures 4-14a and 4-14b for naphthalene are good examples of this trend. The higher annual averages for sites such as CELA, DEMI, and GPCO have large confidence intervals associated with them while sites such as CHSC, GLKY, and UNVT have significantly lower annual averages as well as very small confidence intervals. To illustrate this point, the range of measured detections of fluorene for GPCO is 1.93 ng/m^3 to 68.2 ng/m^3 while the range of measurements for GLKY was 0 ng/m^3 to 2.36 ng/m^3.

Some of the pollutants' annual averages follow a linear pattern, but one of the annual average concentrations is significantly higher than the annual average concentrations for the other sites, one of the standard deviations is significantly higher than other sites, or both. Examples of this include acetaldehyde, arsenic, benzene. Figures 4-4a and 4-4b show that the annual average benzene concentration for TOOK is more than 85 percent higher than the next highest annual average concentration of this pollutant. A review of TOOK's benzene data shows that all but eight of TOOK's preprocessed daily measurements (out of 60) were greater than the program-level average concentration of 0.90 µg/m^3. Thus, concentrations of benzene at TOOK tend to run higher than at other sites. Although the annual average concentration of acetaldehyde for SPIL does not stand out in Figure 4-2b, its standard deviation is more than twice the standard deviations for the other monitoring sites. A review of this site's data shows that the three highest concentrations of acetaldehyde across the program were measured at SPIL, ranging from

8.74 µg/m^3 to 20.4 µg/m^3, yet more than 75 percent of the measurements from this site are less than 3 µg/m^3. The confidence interval for SPIL's acetaldehyde annual average is reflecting the influence of the higher concentrations. Figure 4-3a shows that one of the annual average concentrations of arsenic is considerably higher than the annual averages calculated for other sites and has a relatively high standard deviation associated with it. Figure 4-3b shows that this CV is based on arsenic data for ASKY-M. Although the maximum arsenic concentration measured across the program was not measured at ASKY-M, this site has the greatest number of arsenic concentrations greater than 2 ng/m^3 (23, vs. the next highest site, LEKY at 6). These account for nearly half of the samples collected at this site. However, arsenic concentrations measured at this site range from 0.1 ng/m^3 to 5.90 ng/m^3, explaining the variability reflected in the CV.

Figure 4-7a for *p*-dichlorobenzene is an example where a relatively high annual average and/or a relatively high confidence interval are affecting the graph. If the CVs for S4MO, ADOK, PXSS, and SPAZ were removed from Figure 4-7a, this graph would exhibit easily identifiable clustering. Figure 4-7b shows that the confidence intervals for S4MO, ADOK, and SPAZ are relatively large, indicating that these annual averages may be influenced by outlier(s). Collectively, these three sites account for all 13 measurements of *p*-dichlorobenzene greater than 0.5 µg/m^3 measured across the program. Conversely, the confidence interval for PXSS is smaller than the others, indicating that concentrations of this pollutant may run higher on a more regular basis. Another consideration for SPAZ is the sampling frequency. VOC sampling at SPAZ occurs on a 1-in-12 day schedule, resulting in fewer overall samples and generally a higher confidence interval. The calculation of the median concentration for all four datasets completes the story. The median concentrations for ADOK and S4MO are 0.060 µg/m^3 and 0.096 µg/m^3, respectively, which are roughly half their annual averages (0.125 µg/m^3 and 0.180 µg/m^3), indicating that concentrations at the higher end of the range are driving the average concentrations. Conversely, the median concentrations for PXSS and SPAZ are 0.160 µg/m^3 and 0.217 µg/m^3, respectively, which are more similar to their respective annual average concentrations of 0.195 µg/m^3 and 0.258 µg/m^3, indicating that the *p*-dichlorobenzene concentrations measured at the two Phoenix sites tend to run higher on a regular basis.

Figure 4-1a. Coefficient of Variation Analysis of Acenaphthene Across 20 Sites

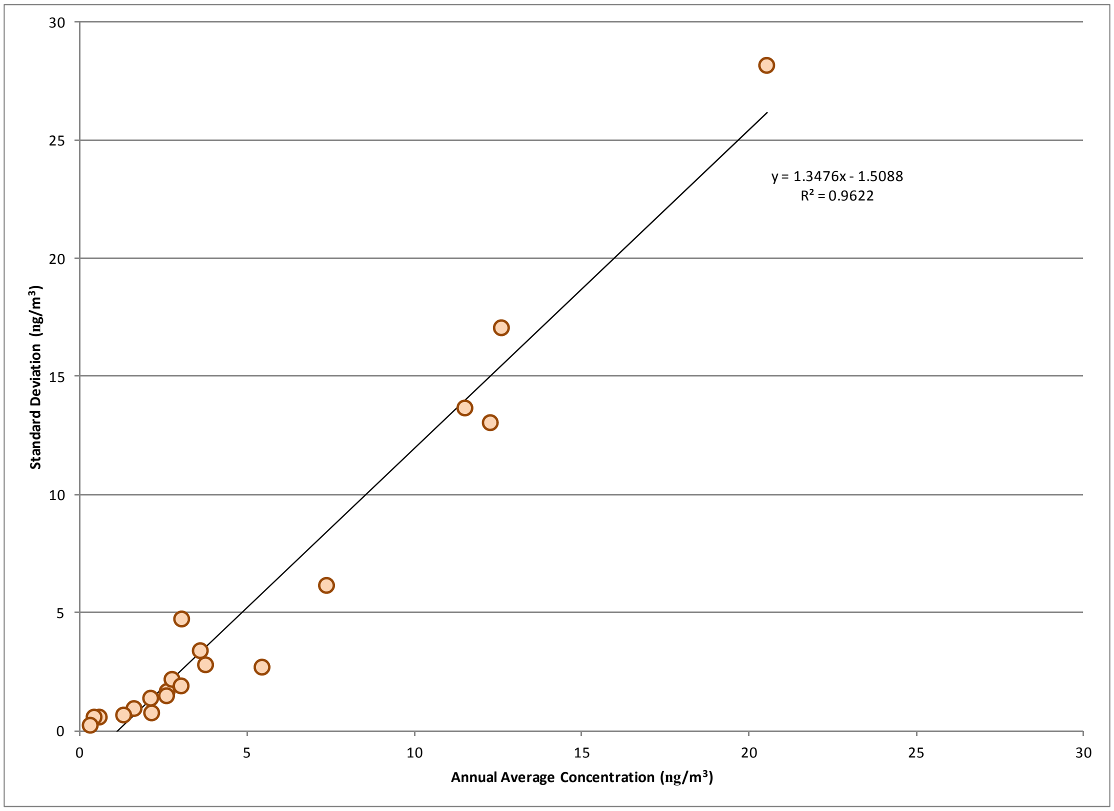


Figure 4-1b. Inter-Site Variability for Acenaphthene

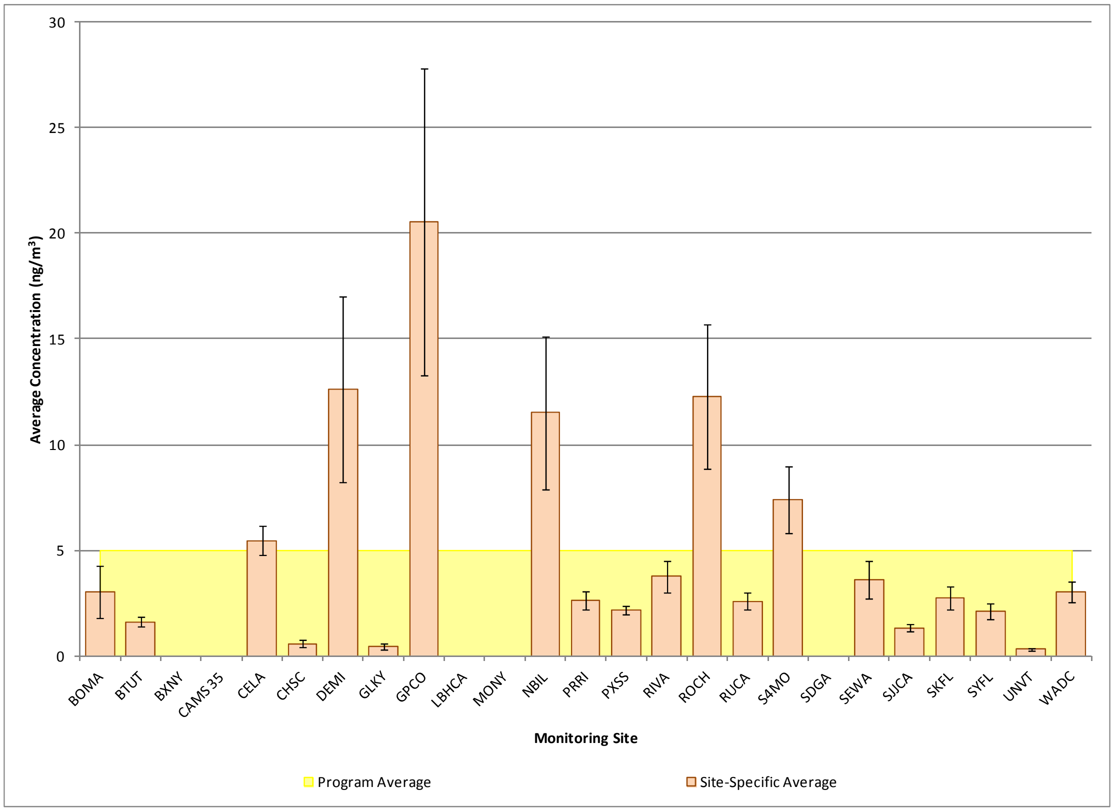


Figure 4-2a. Coefficient of Variation Analysis of Acetaldehyde Across 28 Sites

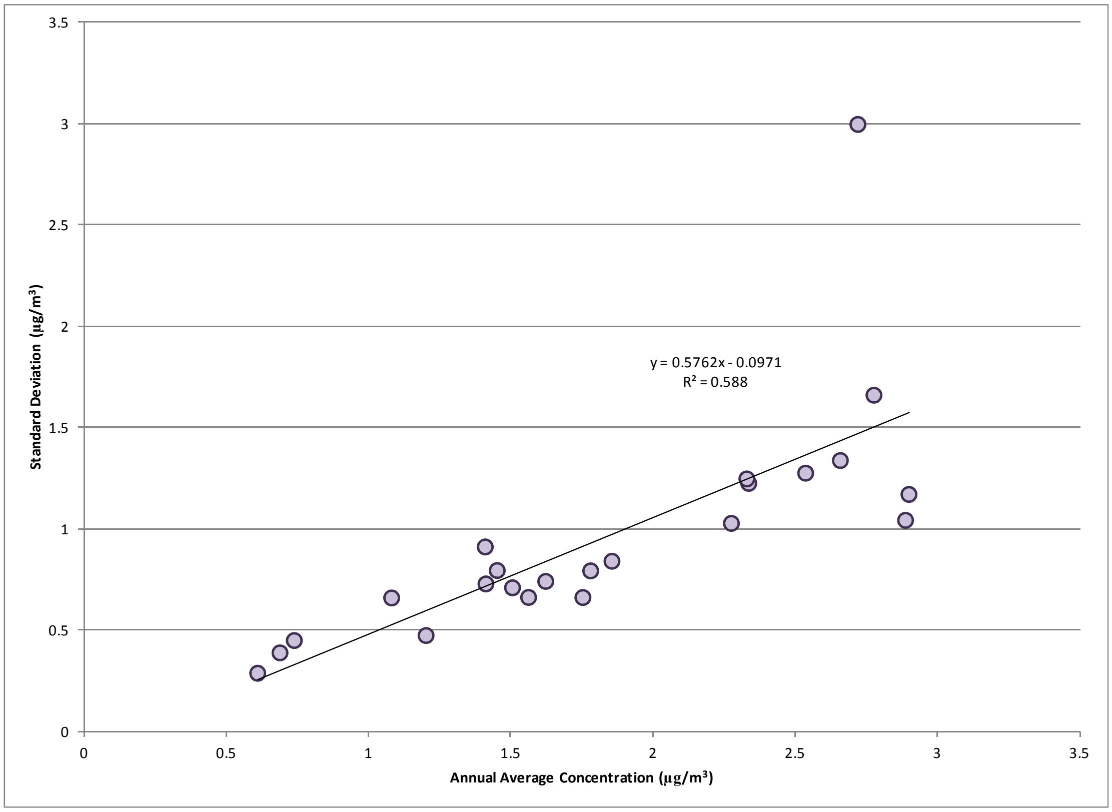


Figure 4-2b. Inter-Site Variability for Acetaldehyde

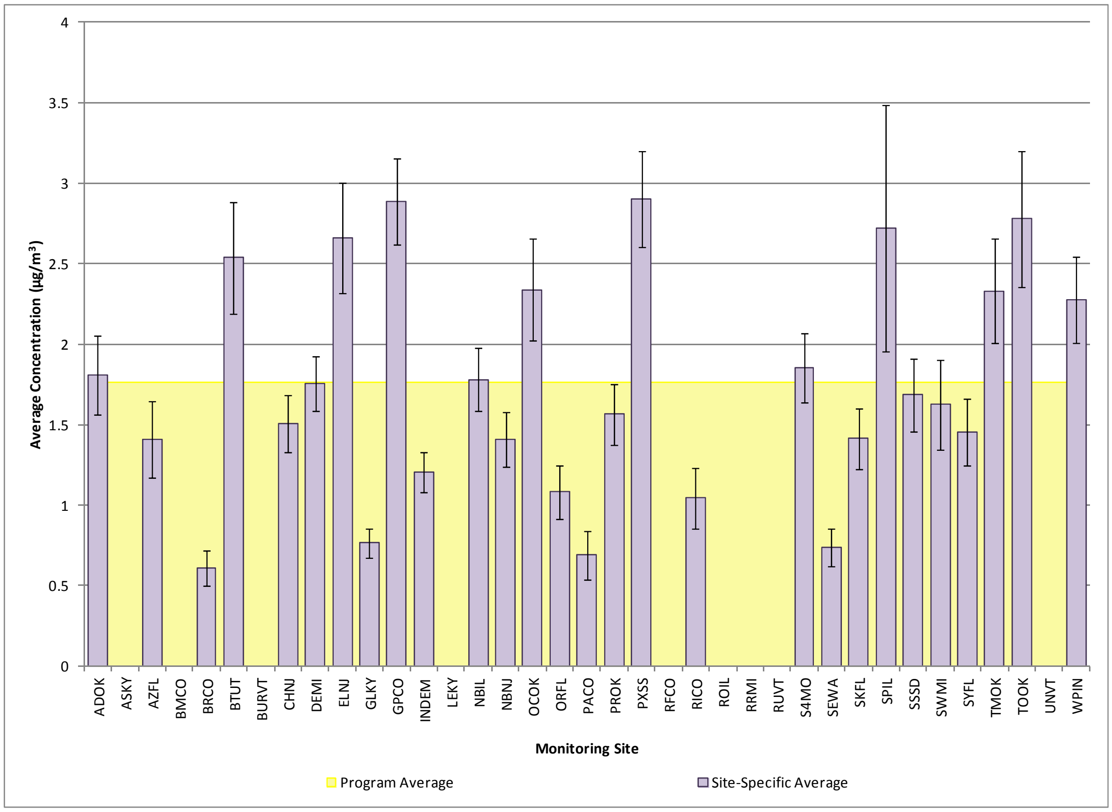


Figure 4-3a. Coefficient of Variation Analysis of Arsenic Across 19 Sites

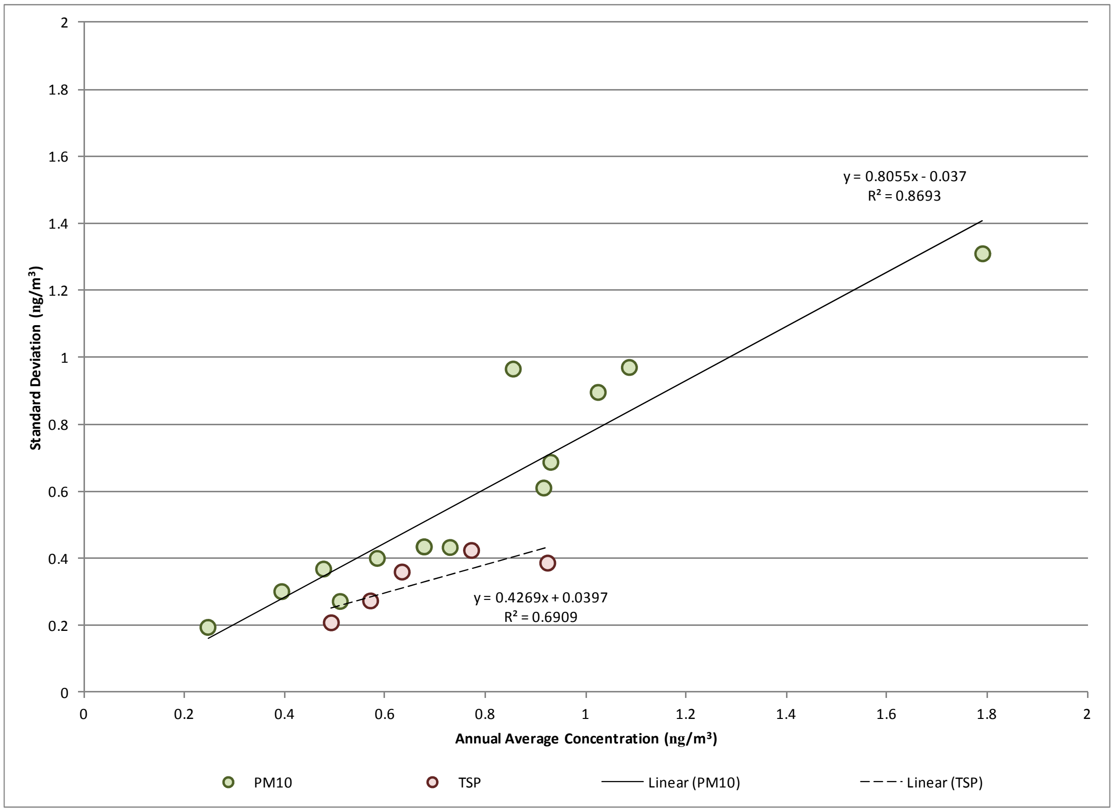


Figure 4-3. Inter-Site Variability for Arsenic

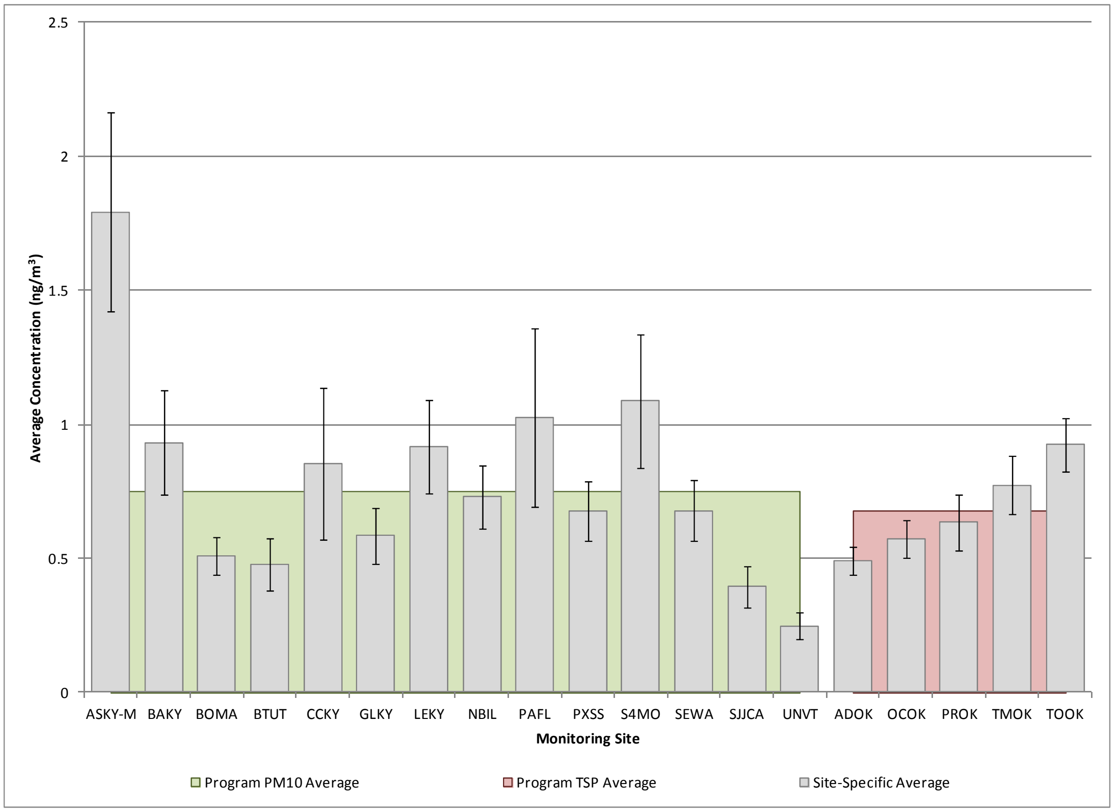


Figure 4-4a. Coefficient of Variation Analysis of Benzene Across 22 Sites

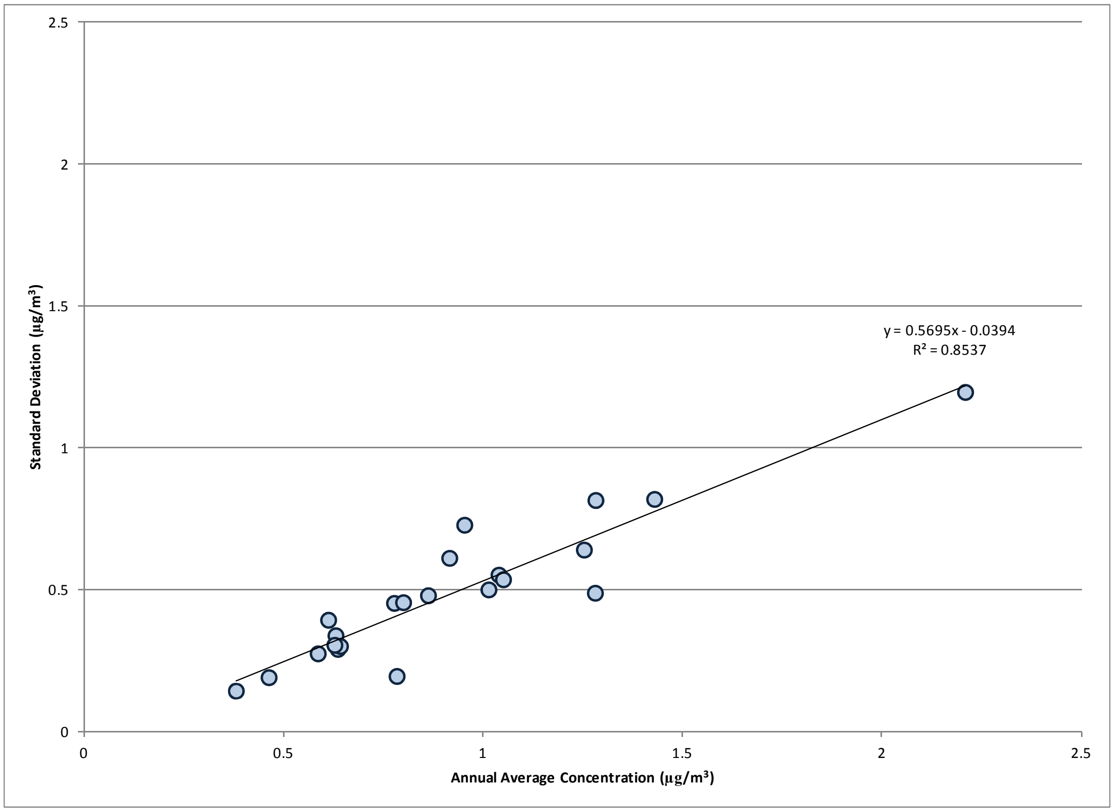


Figure 4-4b. Inter-Site Variability for Benzene

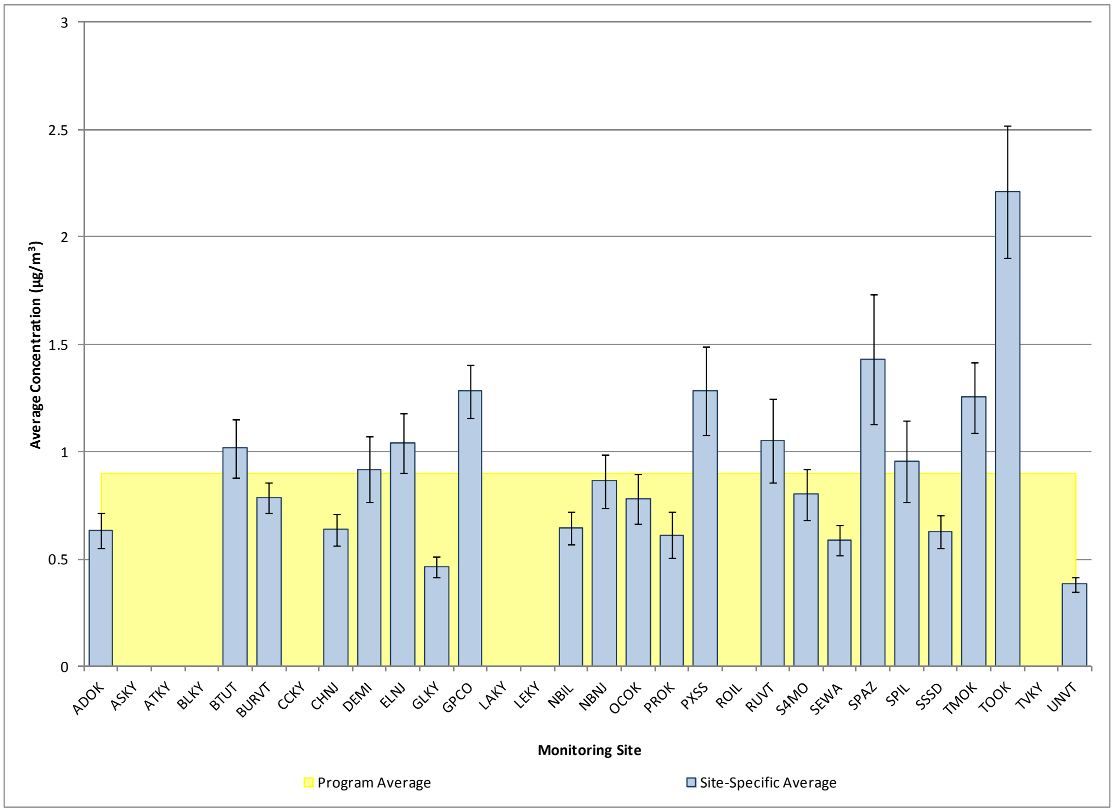


Figure 4-5a. Coefficient of Variation Analysis of 1,3-Butadiene Across 22 Sites

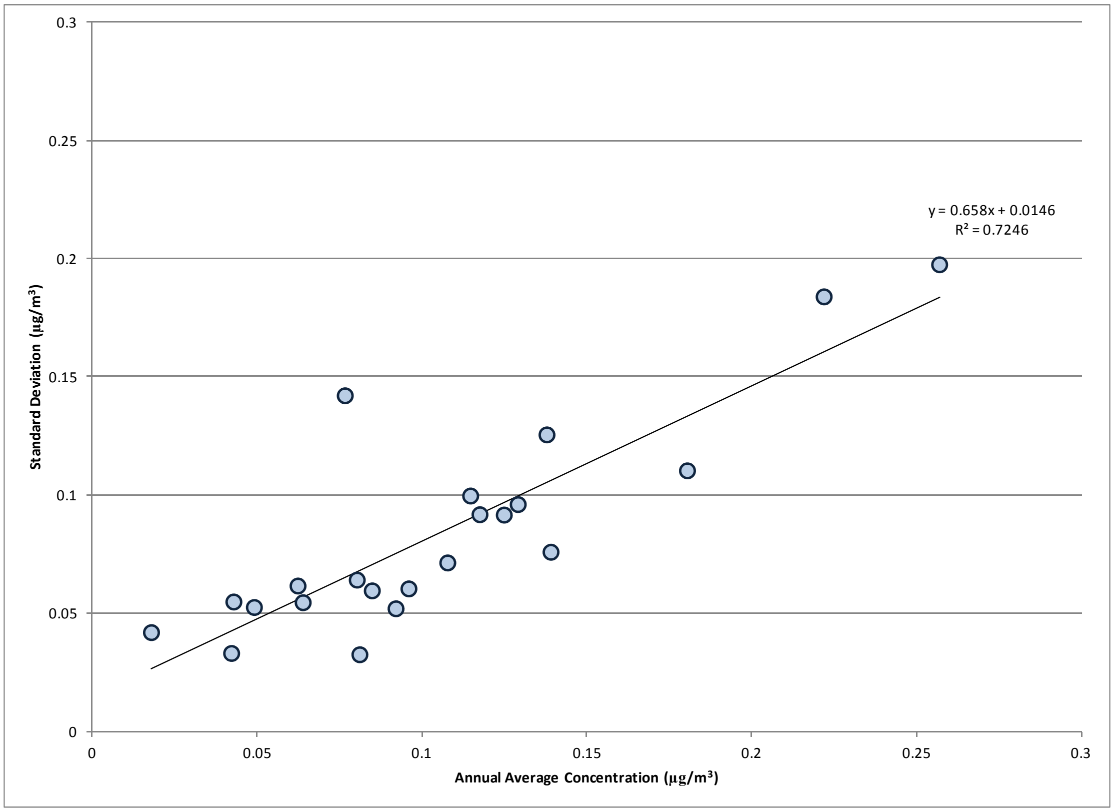


Figure 4-5b. Inter-Site Variability for 1,3-Butadiene

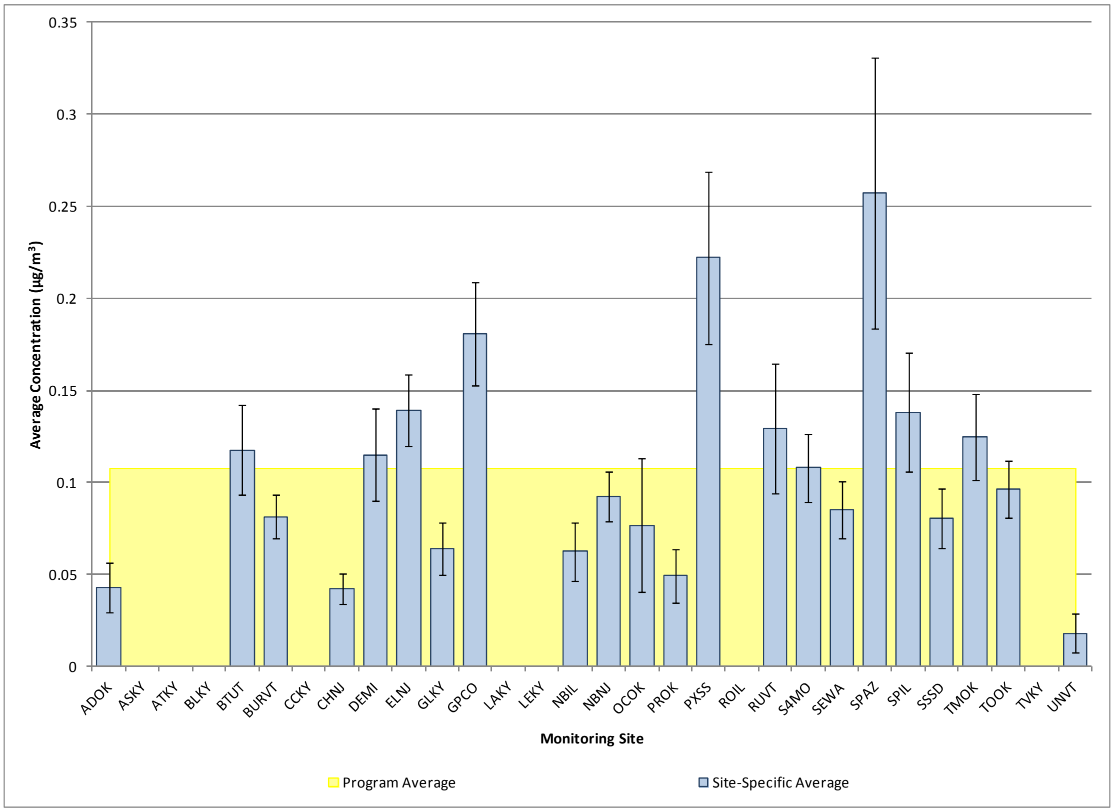


Figure 4-6a. Coefficient of Variation Analysis of Carbon Tetrachloride Across 22 Sites

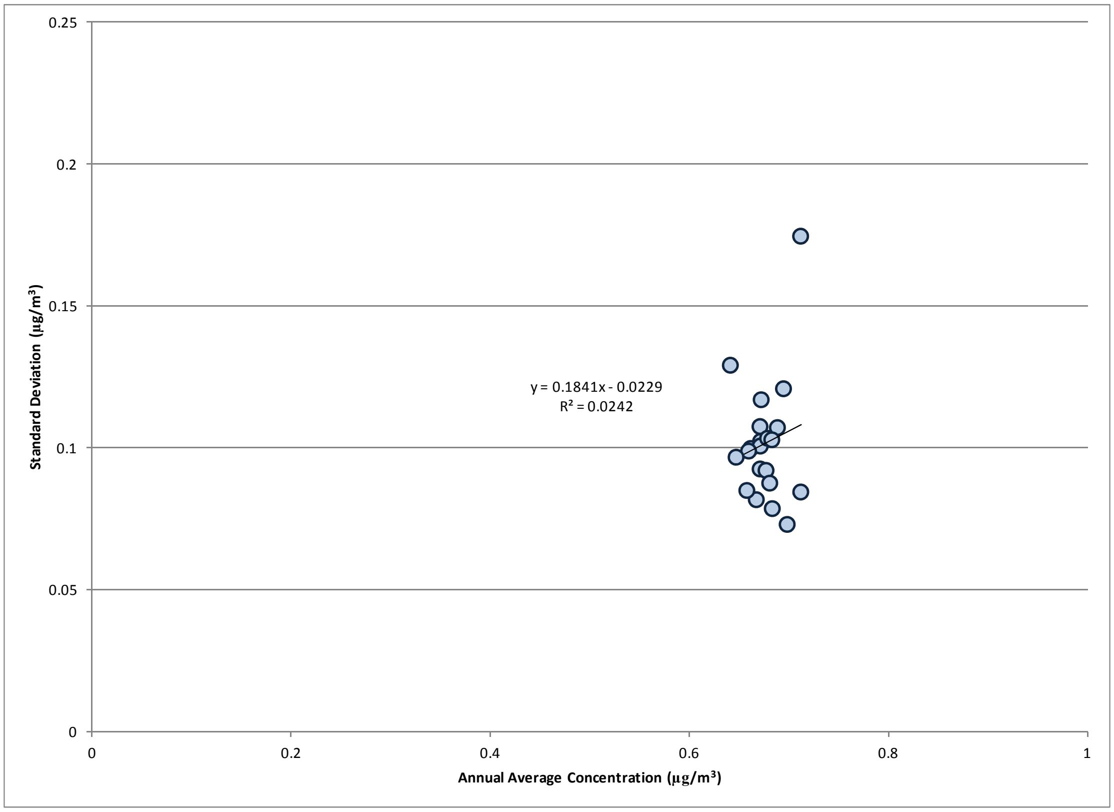


Figure 4-6b. Inter-Site Variability for Carbon Tetrachloride

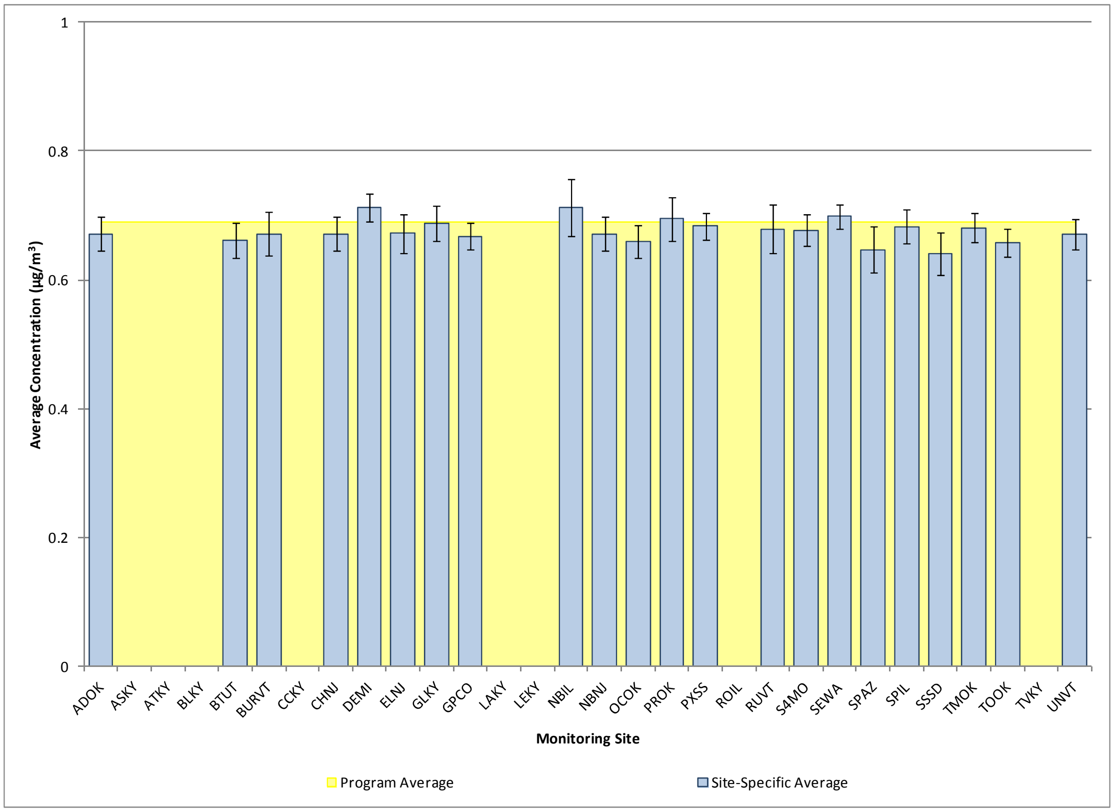


Figure 4-7a. Coefficient of Variation Analysis of *p*-Dichlorobenzene Across 22 Sites

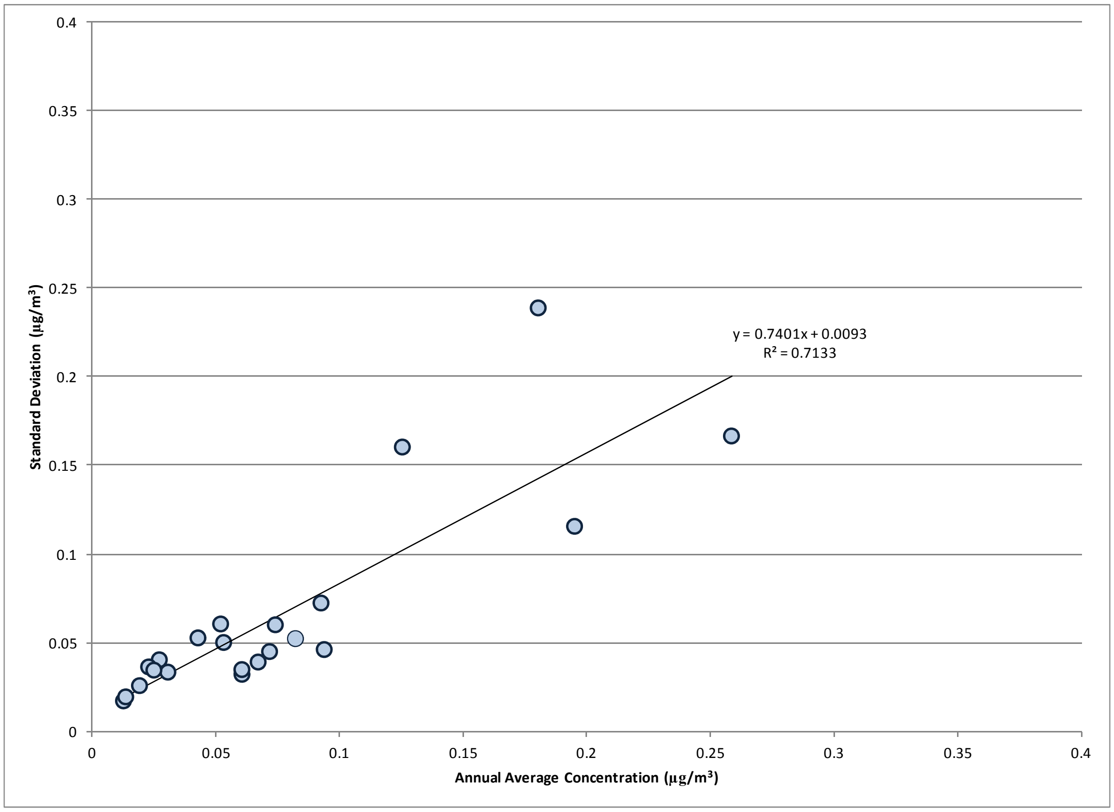


Figure 4-7b. Inter-Site Variability for *p*-Dichlorobenzene

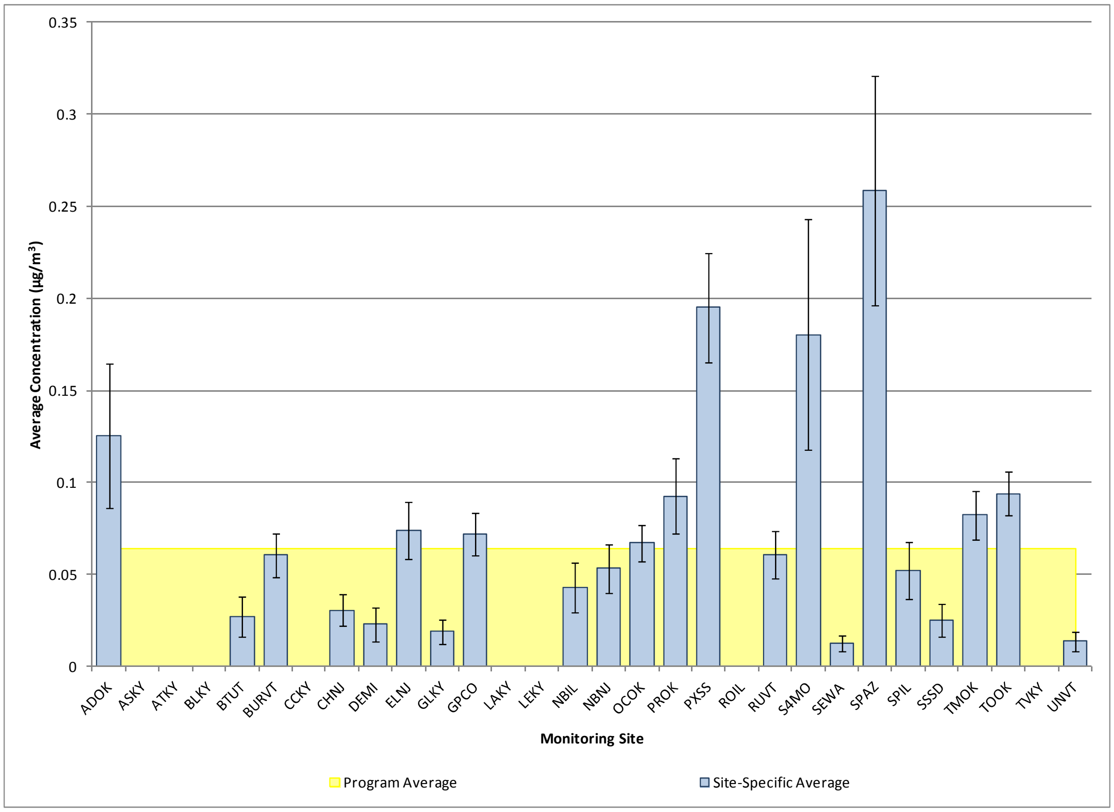


Figure 4-8a. Coefficient of Variation Analysis of 1,2-Dichloroethane Across 22 Sites

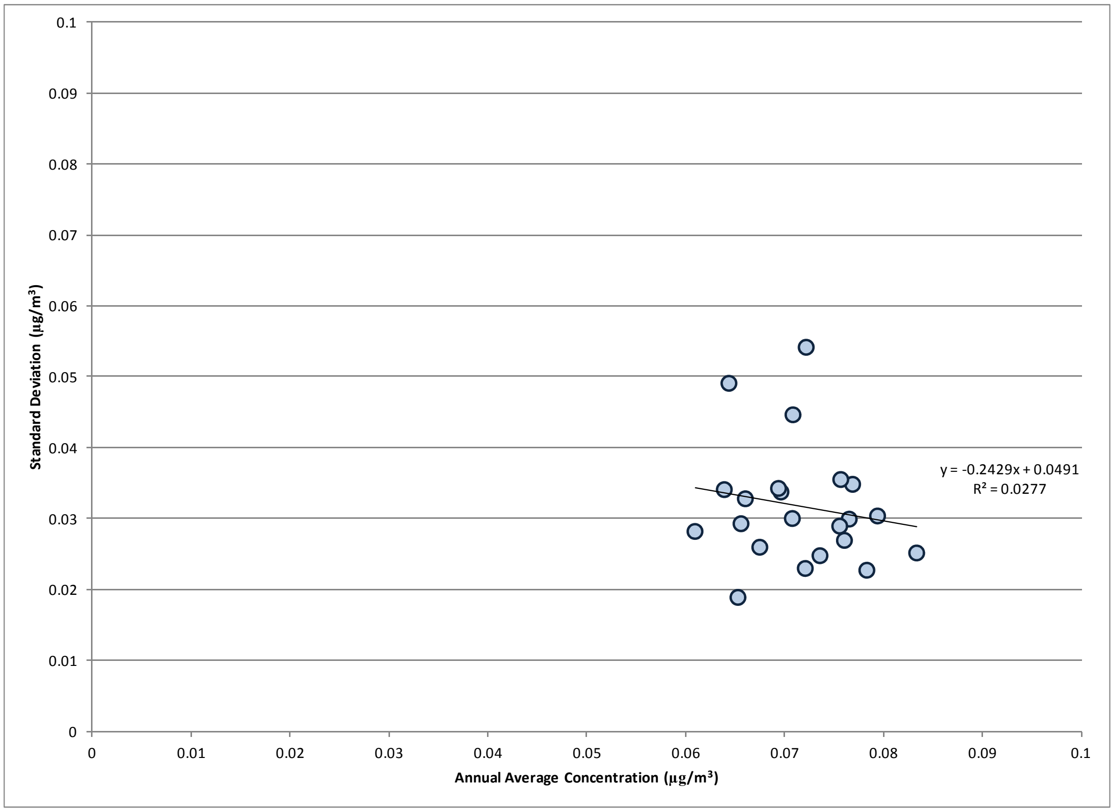


Figure 4-8b. Inter-Site Variability for 1,2-Dichloroethane

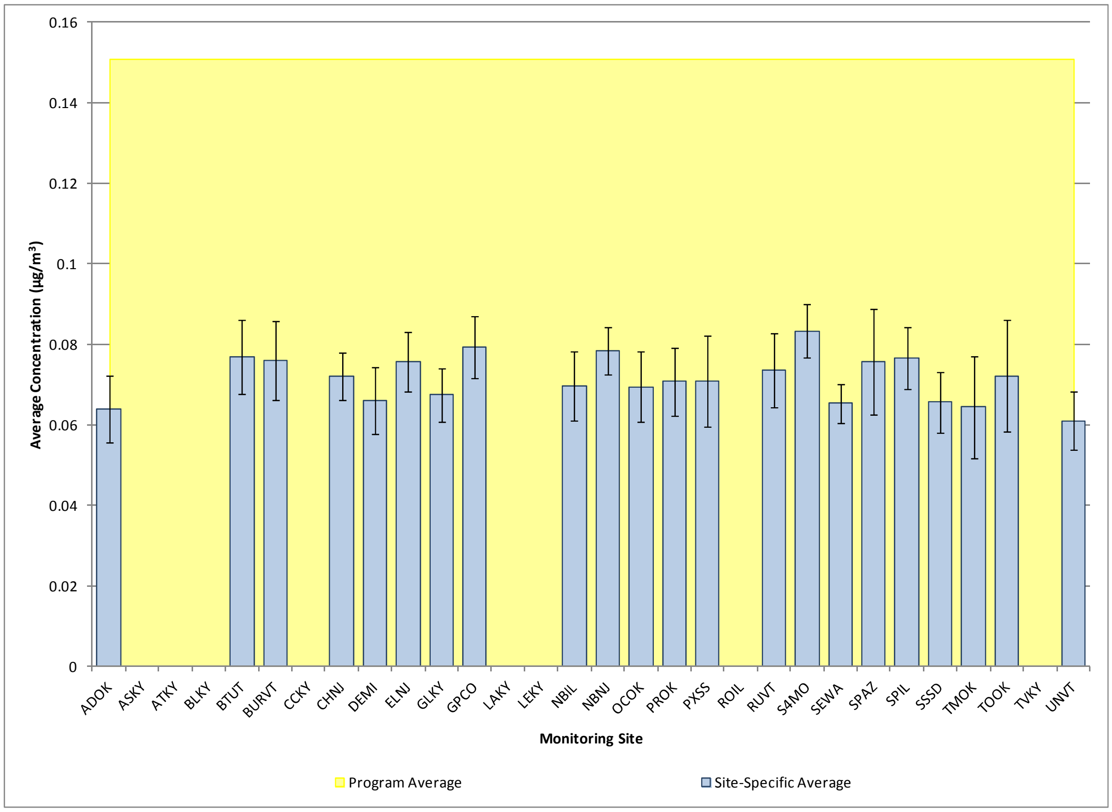


Figure 4-9a. Coefficient of Variation Analysis of Ethylbenzene Across 22 Sites

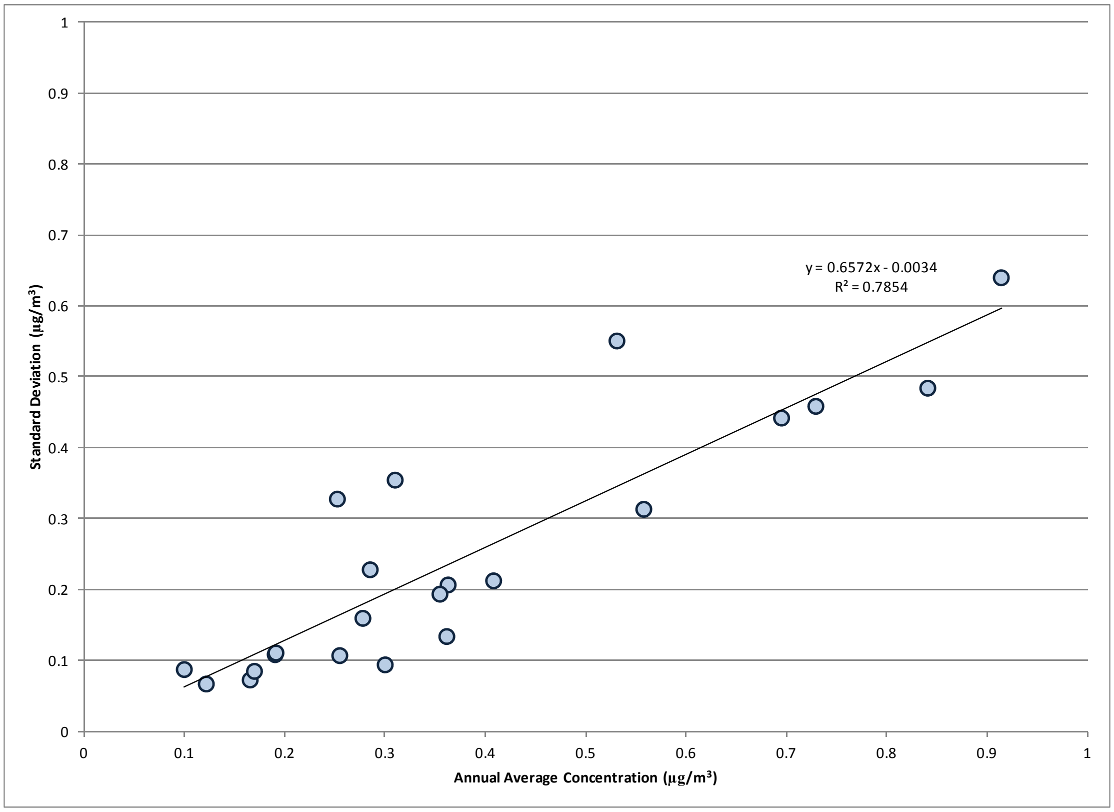


Figure 4-9b. Inter-Site Variability for Ethylbenzene

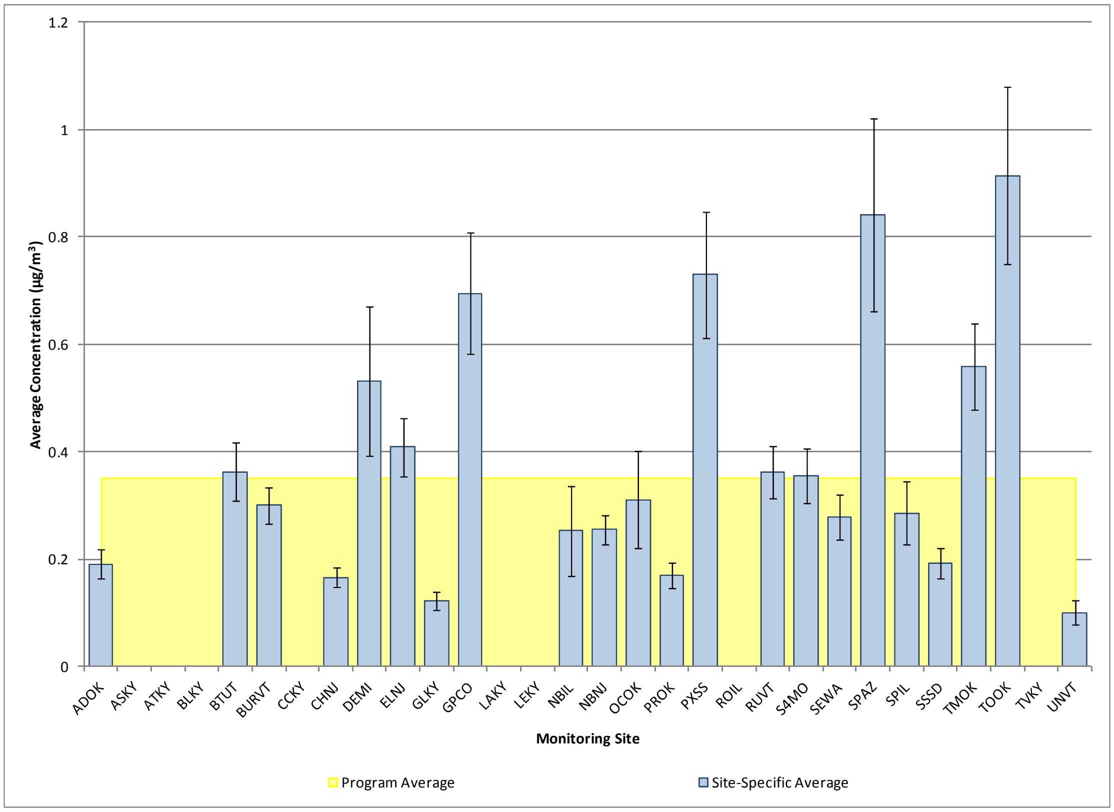


Figure 4-10a. Coefficient of Variation Analysis of Fluorene Across 20 Sites

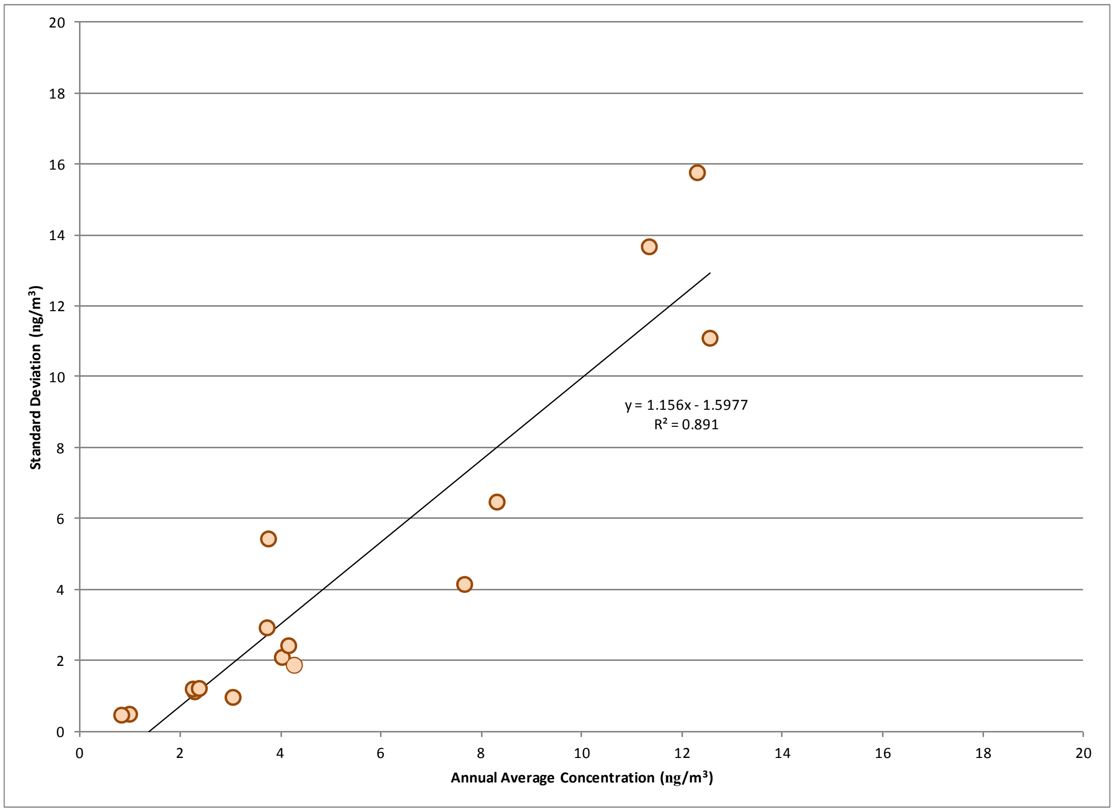


Figure 4-10b. Inter-Site Variability for Fluorene

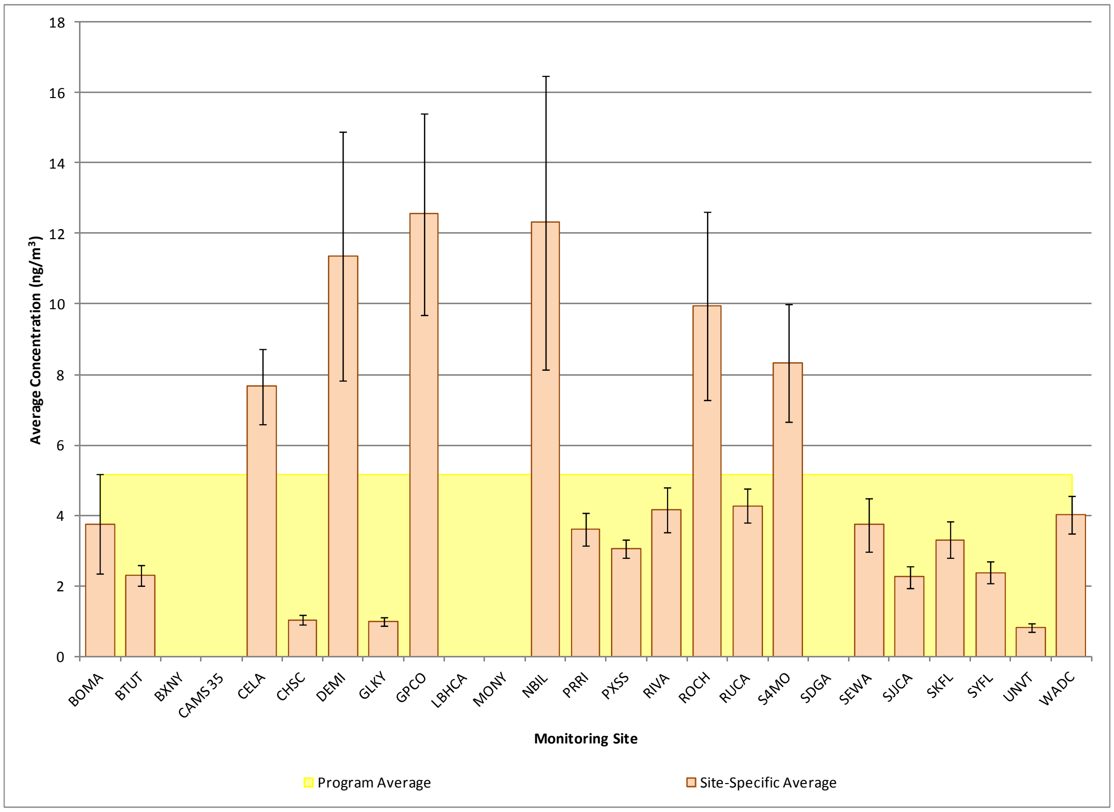


Figure 4-11a. Coefficient of Variation Analysis of Formaldehyde Across 28 Sites

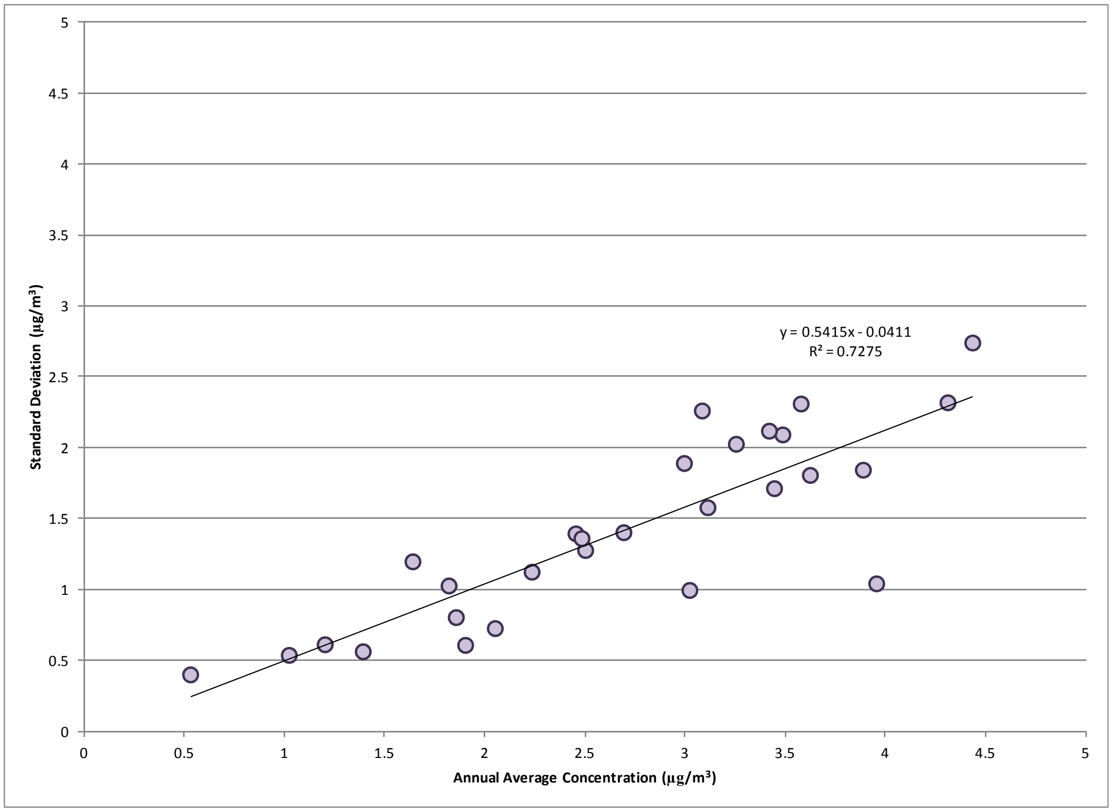


Figure 4-11b. Inter-Site Variability for Formaldehyde

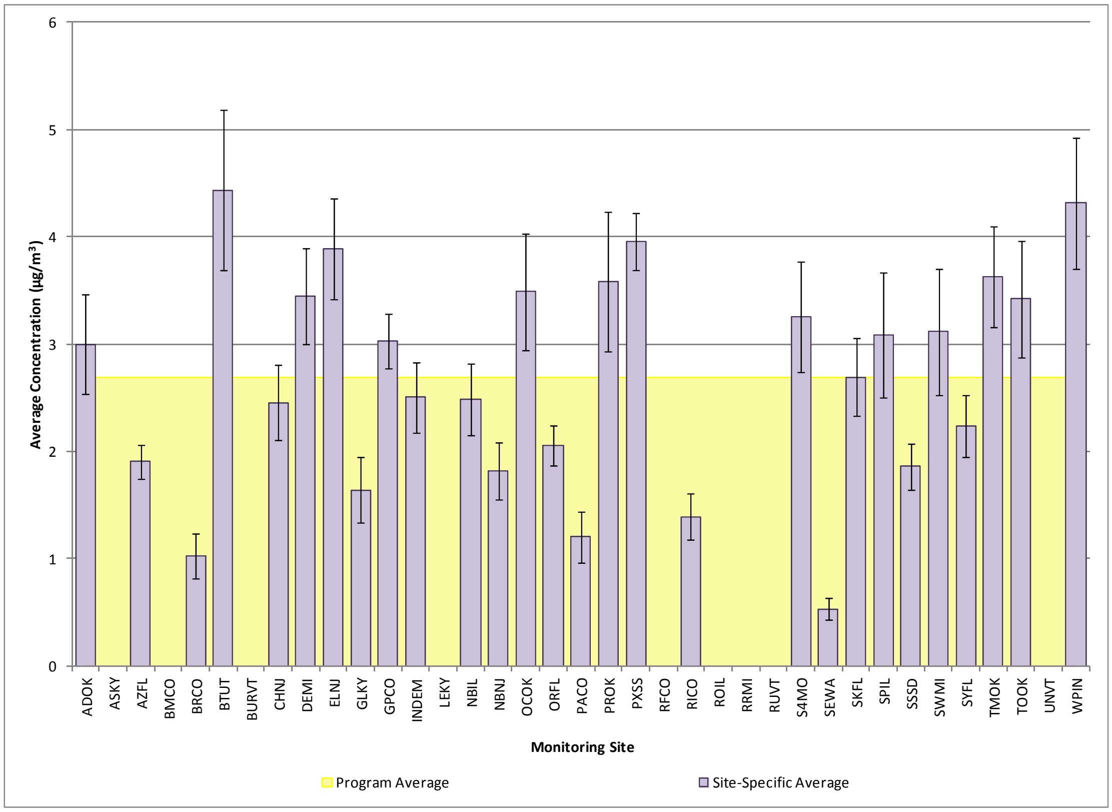


Figure 4-12a. Coefficient of Variation Analysis of Hexachloro-1,3-Butadiene Across 22 Sites

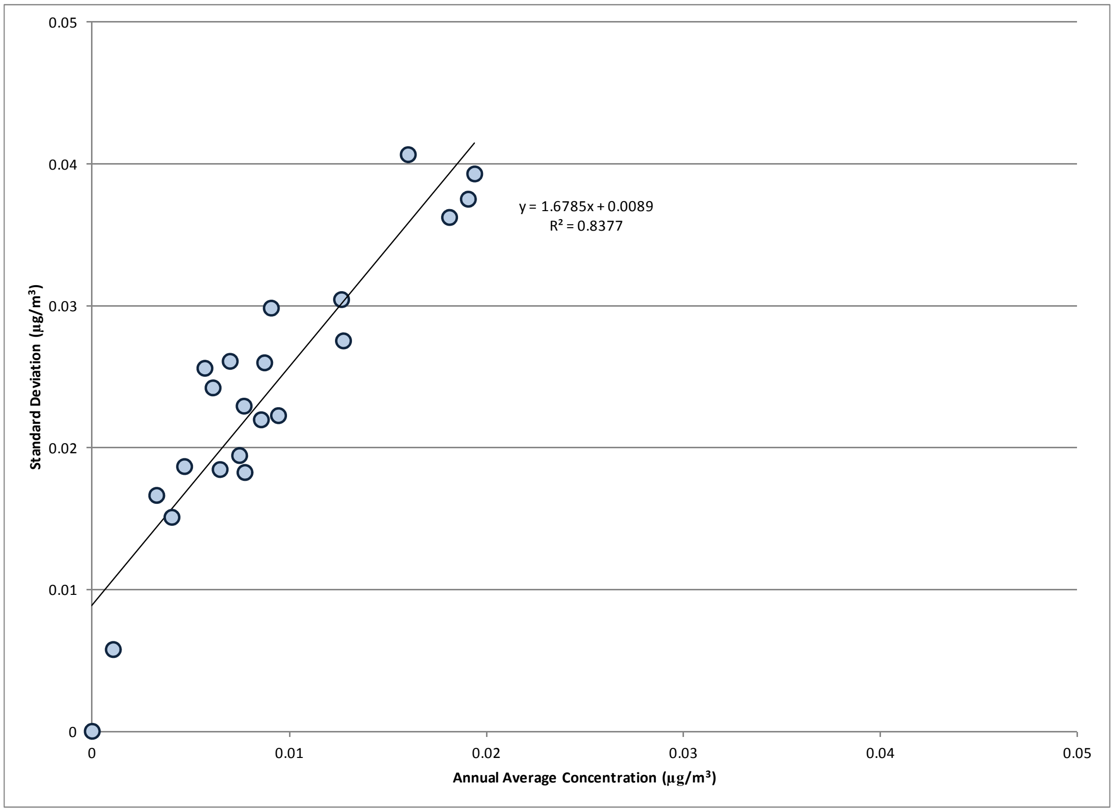


Figure 4-12b. Inter-Site Variability for Hexachloro-1,3-butadiene

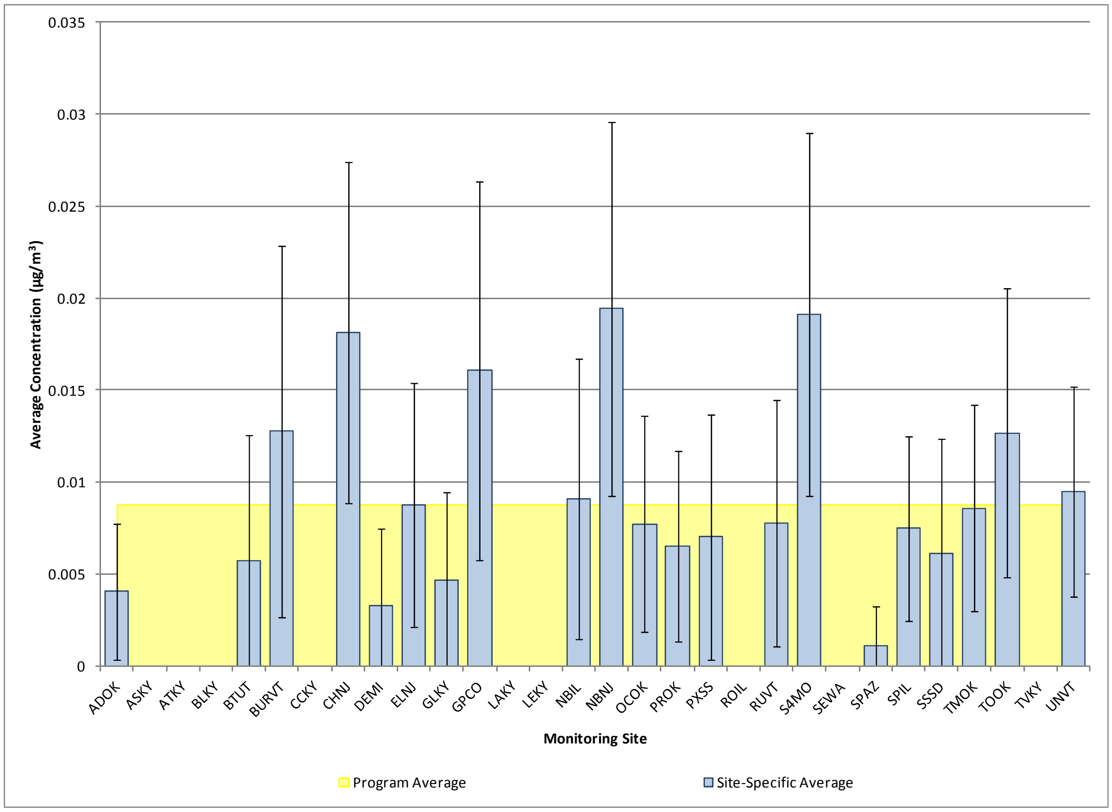


Figure 4-13a. Coefficient of Variation Analysis of Manganese Across 19 Sites

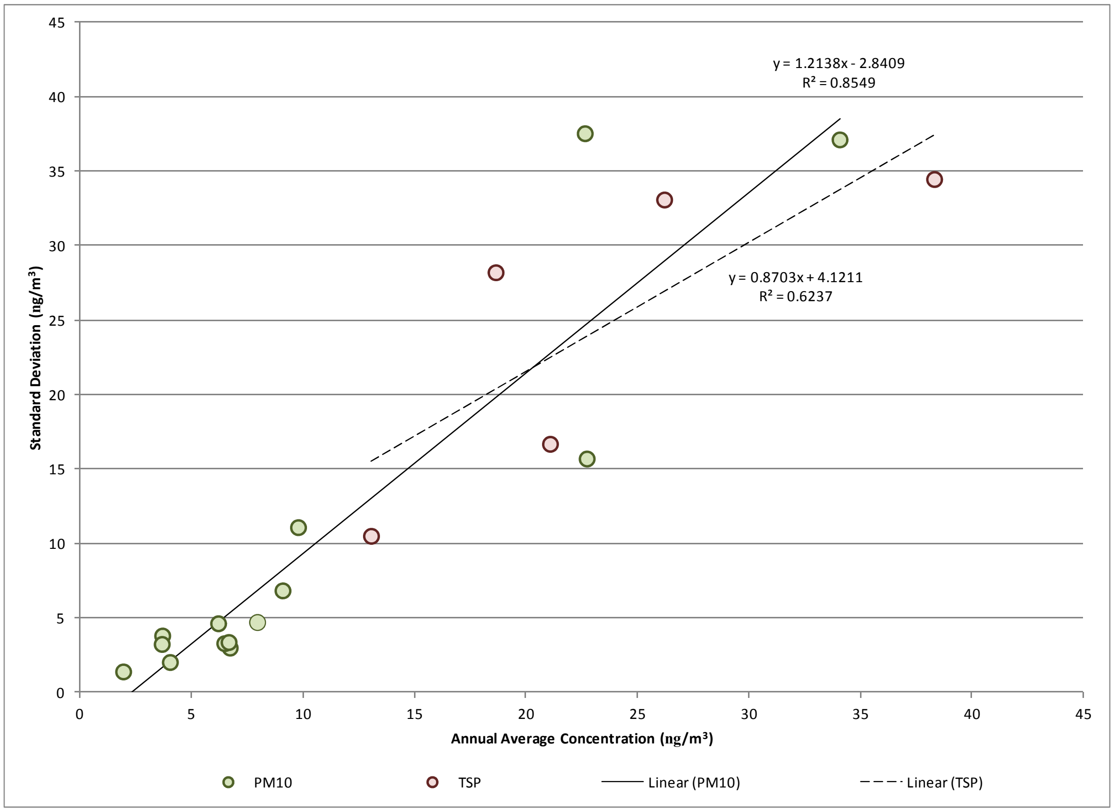


Figure 4-13b. Inter-Site Variability for Manganese

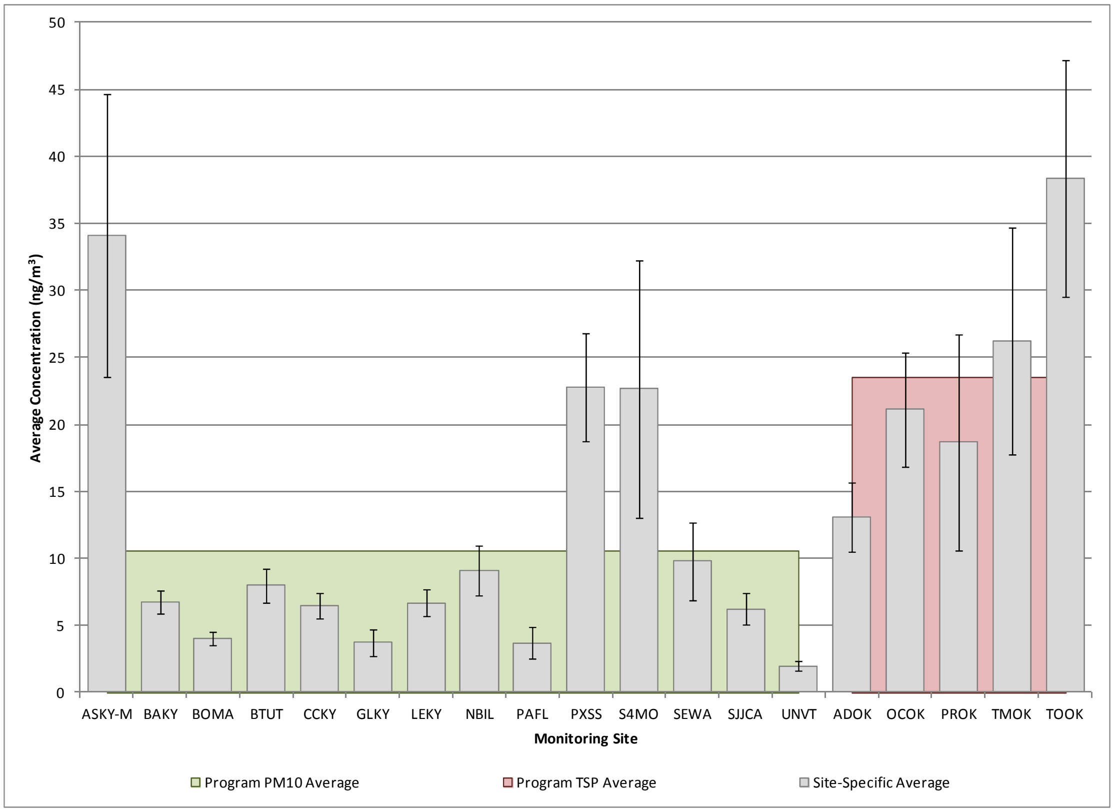


Figure 4-14a. Coefficient of Variation Analysis of Naphthalene Across 20 Sites

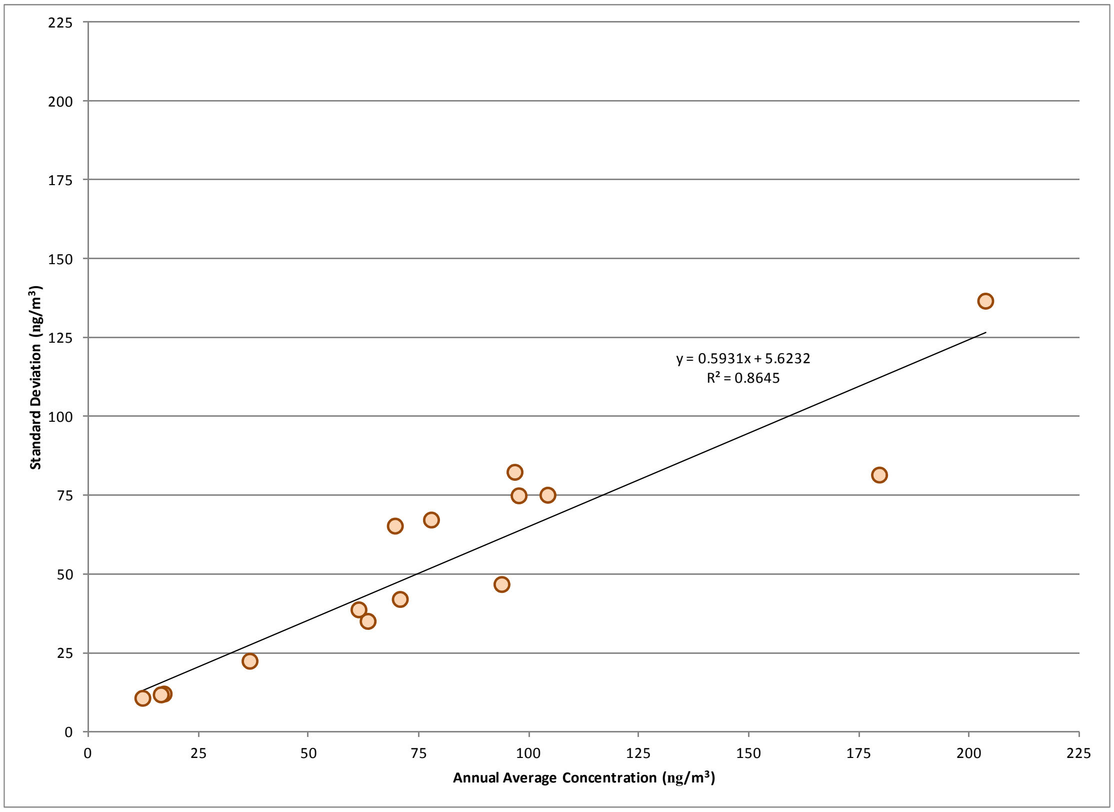


Figure 4-14b. Inter-Site Variability for Naphthalene

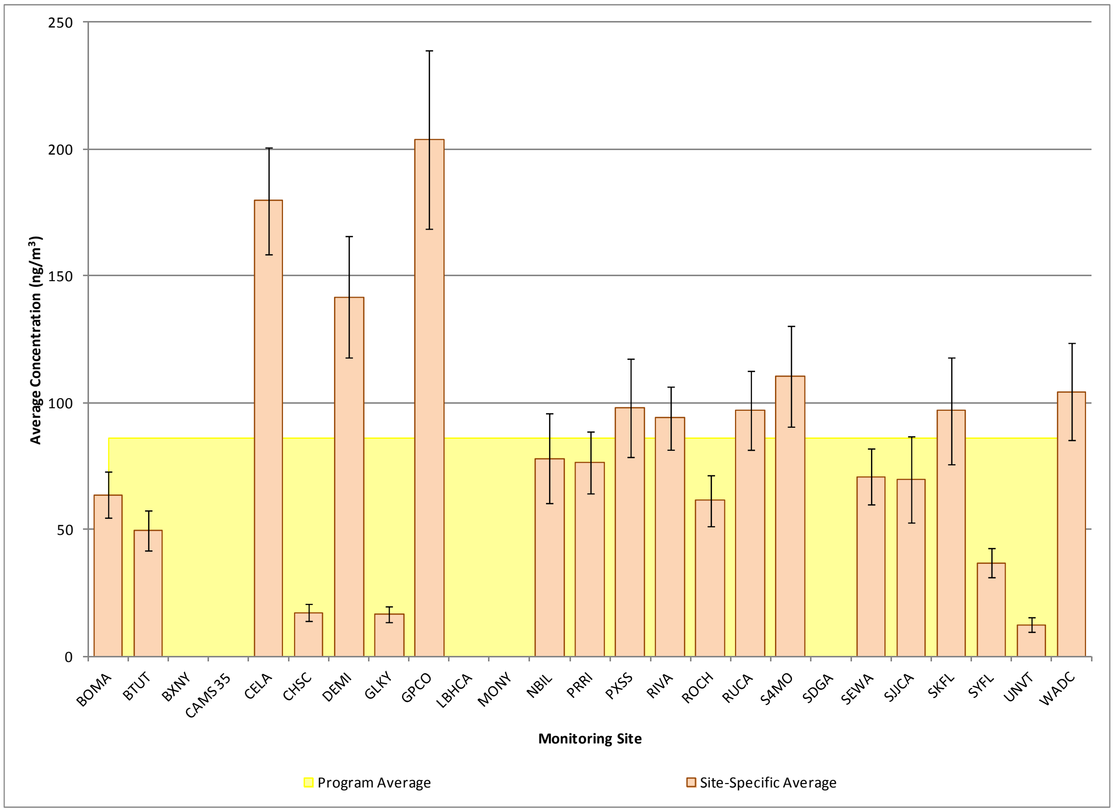


Figure 4-15a. Coefficient of Variation Analysis of Nickel Across 19 Sites

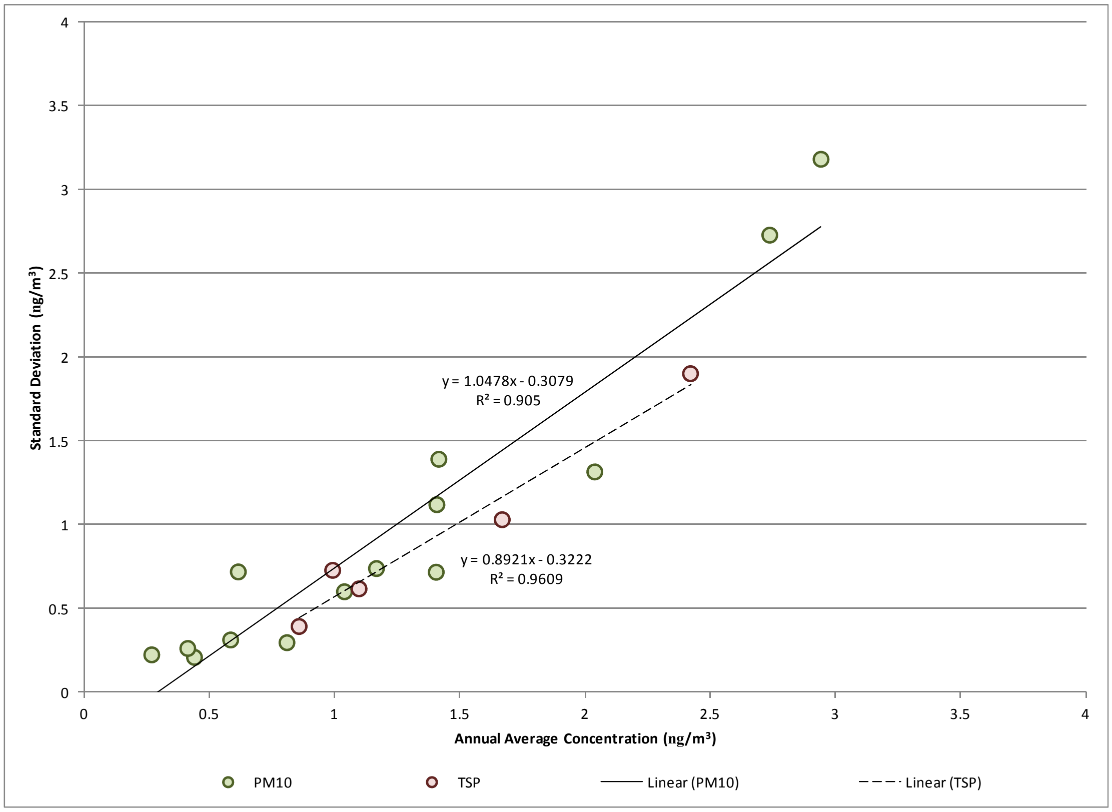
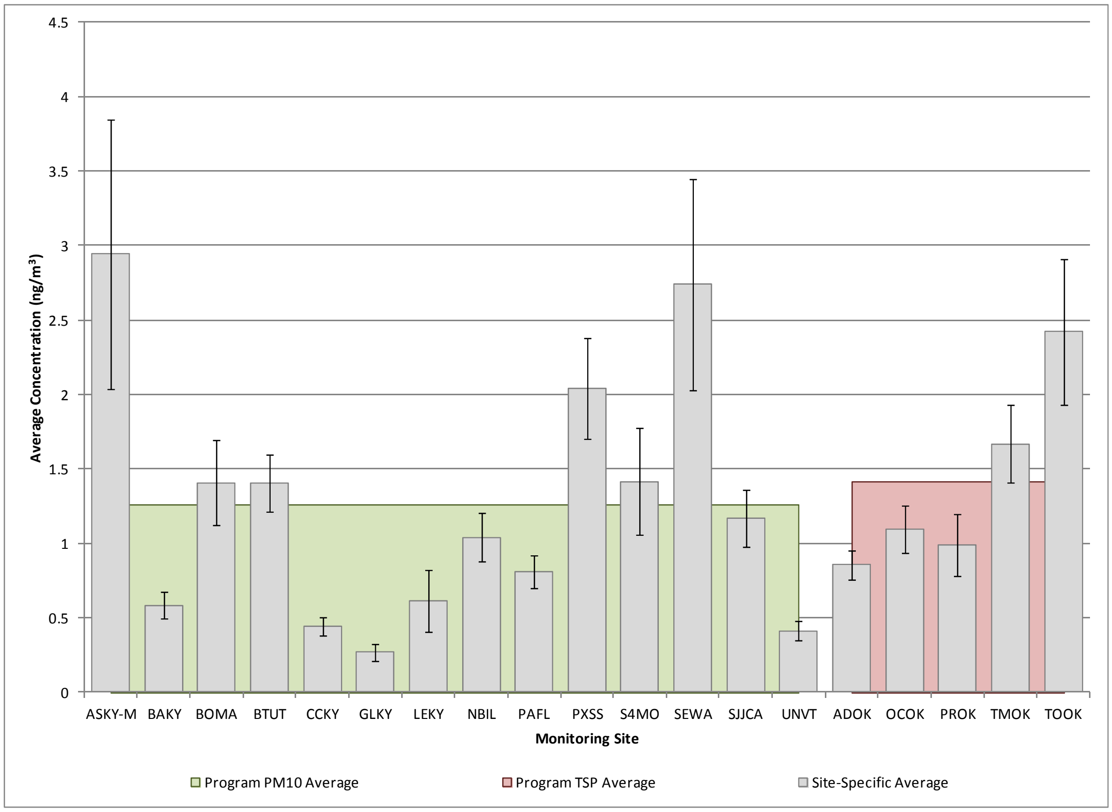


Figure 4-15b. Inter-Site Variability for Nickel



4.4.2 Quarterly Variability Analysis

Figures 4-16 through 4-30 provide a graphical display of the site-specific quarterly average concentrations for each of the program-level pollutants of interest. Quarterly averages are calculated based on the criteria specified in Section 3.1. If the pollutant of interest has a corresponding ATSDR Intermediate MRL, as defined in Section 3.3, then this value is indicated on the graph and is plotted where applicable. Note that the scales on the PM_{10} and TSP graphs are the same for a given speciated metal.

Data gaps, or missing quarterly averages, in the figures for the pollutants of interest can be attributed to several reasons. First, some of the program-wide pollutants of interest were infrequently detected in some quarters and thus have a quarterly average concentration of zero as a result of the substitution of zeros for non-detects. One example of this is Figure 4-27 for hexachloro-1,3-butadiene. This pollutant was infrequently detected (186 measured detections out of 1,466 valid samples); of the 102 possible quarterly averages of this pollutant, 30 of them are zero. Thus, relatively few quarterly averages appear in Figure 4-27. Further, most of the remaining quarterly averages have relatively few measured detections and include many zero substitutions for non-detects, resulting in relatively low quarterly averages. (Although this pollutant was detected in less than 13 percent of VOC samples collected, its risk screening value is relatively low; thus, 70 percent of the measured detections of this pollutant failed screens.)

Another reason for data gaps in the figures is due to the sampling duration of each site. Some sites started late or ended early, which may result in a lack of quarterly averages. For example, benzene is almost always detected in VOC samples, thus the gaps in Figure 4-19 are primarily due to sampling duration. Many of the Kentucky sites started sampling VOCs in July 2012; thus, the first and second quarterly averages could not be calculated and therefore appear as gaps in the figure.

In addition, the criteria in Section 3.1 require a site to have 75 percent of the possible samples within a given calendar quarter (12 for a site sampling on a 1-in-6 day schedule). GPCO experienced sampling issues for VOCs during the month of August which led to the invalidation of several samples. As a result, there were fewer than 12 valid samples during the third quarter of 2012 and thus no third quarter benzene average could be calculated for GPCO in Figure 4-19.

Some pollutants of interest, such as acetaldehyde, benzene, carbon tetrachloride, ethylbenzene, formaldehyde, and naphthalene, were detected year-round. Comparing the quarterly averages for sites with four valid quarterly averages in a year may reveal a temporal trend for these pollutants. For example, formaldehyde averages tended to be highest during the third quarter, as shown in Figure 4-26, with 27 of the 37 sites sampling formaldehyde exhibiting the highest quarterly average for the period from July through September (although quarterly averages could not be calculated for every quarter for every site). Thus, it appears that formaldehyde concentrations tend to be highest during the summer months. Conversely, 1,3-butadiene averages tended to be higher during the fourth quarter of 2012, as shown in Figure 4-20. Twenty-six of 35 sites have their highest quarterly 1,3-butadiene concentration for the fourth quarter. However, several of the sites shown in Figure 4-20 did not begin sampling until half way through the year. Of the 20 sites with four quarterly 1,3-butadiene averages presented in Figure 4-20, 16 have the fourth quarter average as the maximum quarterly average concentration.

Other notable trends include benzene with higher concentrations in the first and fourth quarters and acenaphthene, acetaldehyde, and fluorene with higher concentrations in the third quarter. Arsenic tended to be highest during the second quarter for all five sites sampling TSP metals, although a similar trend is not shown for the sites sampling PM_{10} metals.

The quarterly average comparison also allows for the identification of sites with unusually high concentrations of the pollutants of interest compared to other sites and when those high concentrations were measured. This is evident in Figures 4-21, 4-22, 4-23, and 4-30a for carbon tetrachloride, *p*-dichlorobenzene, 1,2-dichloroethane, and nickel, respectively, to name a few. For example, Figure 4-23 shows that the quarterly averages of 1,2-dichloroethane for the Calvert City, Kentucky sites (ATKY, BLKY, CCKY, LAKY, and TVKY) are significantly higher than for other sites sampling VOCs, as most of the other bars are less than the first gridline on the graph. Figure 4-22 shows that the fourth quarter average concentration of *p*-dichlorobenzene for SPAZ is significantly higher than this site’s other quarterly averages as well as most other sites’ quarterly averages. Similarly, SEWA’s third quarter average concentration of nickel is more than twice this site’s other quarterly averages and is the highest quarterly average calculated for this pollutant.

Figure 4-21 shows that the quarterly average concentrations of carbon tetrachloride that are available for TVKY (this site did not begin sampling VOCs until July) are significantly higher than all of the other sites sampling VOCs. These graphs may also reveal when there is very little variability in the quarterly averages across other sites. Figure 4-21 for carbon tetrachloride also shows that the quarterly averages of this pollutant did not vary significantly across the sites, with the exception of TVKY.

Other notable trends are revealed in these graphs. For example, SPAZ and PXSS have relatively high fourth quarter average concentrations for four of the VOC pollutants of interest (benzene, ethylbenzene, 1,3-butadiene, and *p*-dichlorobenzene), compared to their other quarterly averages and most other NMP sites. While benzene tended to be highest during the first and fourth quarters of 2012 for most sites, the second and third quarter averages were highest for TOOK, the site with the highest annual average concentration of this pollutant, as shown in Figure 4-19. For ASKY-M, the second quarter average concentrations of the PM_{10} metal pollutants of interest were considerably higher than the other quarterly averages for this site (although sampling began in March so no first quarter average is available). In the case of arsenic, both the second and third quarter average concentrations for ASKY-M are much higher than the other sites' quarterly averages in Figure 4-18a.

These graphs also show that only six of the 16 program-level pollutants of interest have ATSDR Intermediate MRLs. For the six that do, the quarterly average concentrations are significantly less than their respective ATSDR Intermediate MRLs, generally by an order of magnitude or more, which is also discussed in Section 4.2.2. In all six cases, the ATSDR Intermediate MRL is considerably greater than the scale on the graph and is provided in a text box rather than plotted in the figure.

Figure 4-16. Comparison of Average Quarterly Acenaphthene Concentrations

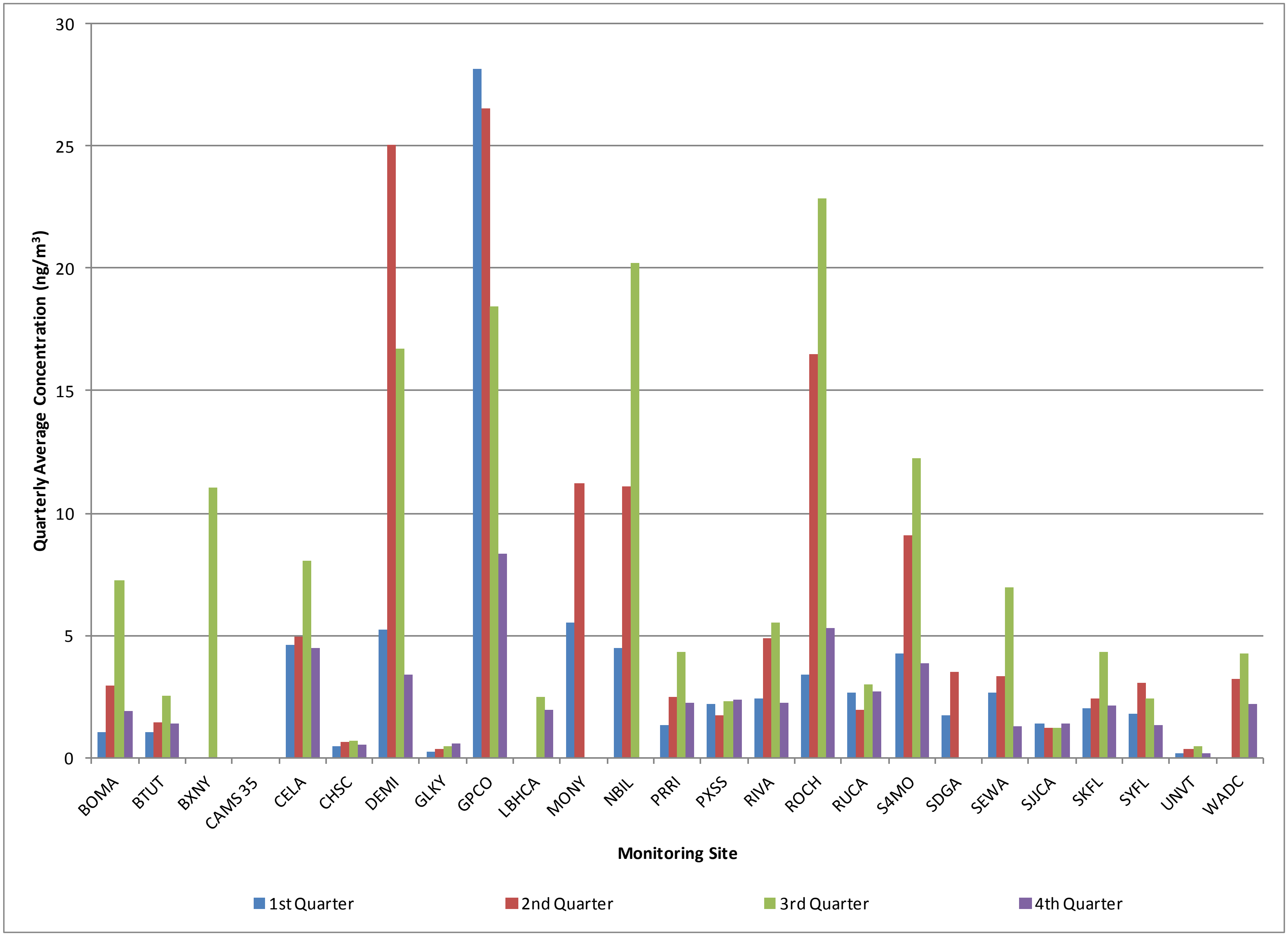


Figure 4-17. Comparison of Average Quarterly Acetaldehyde Concentrations

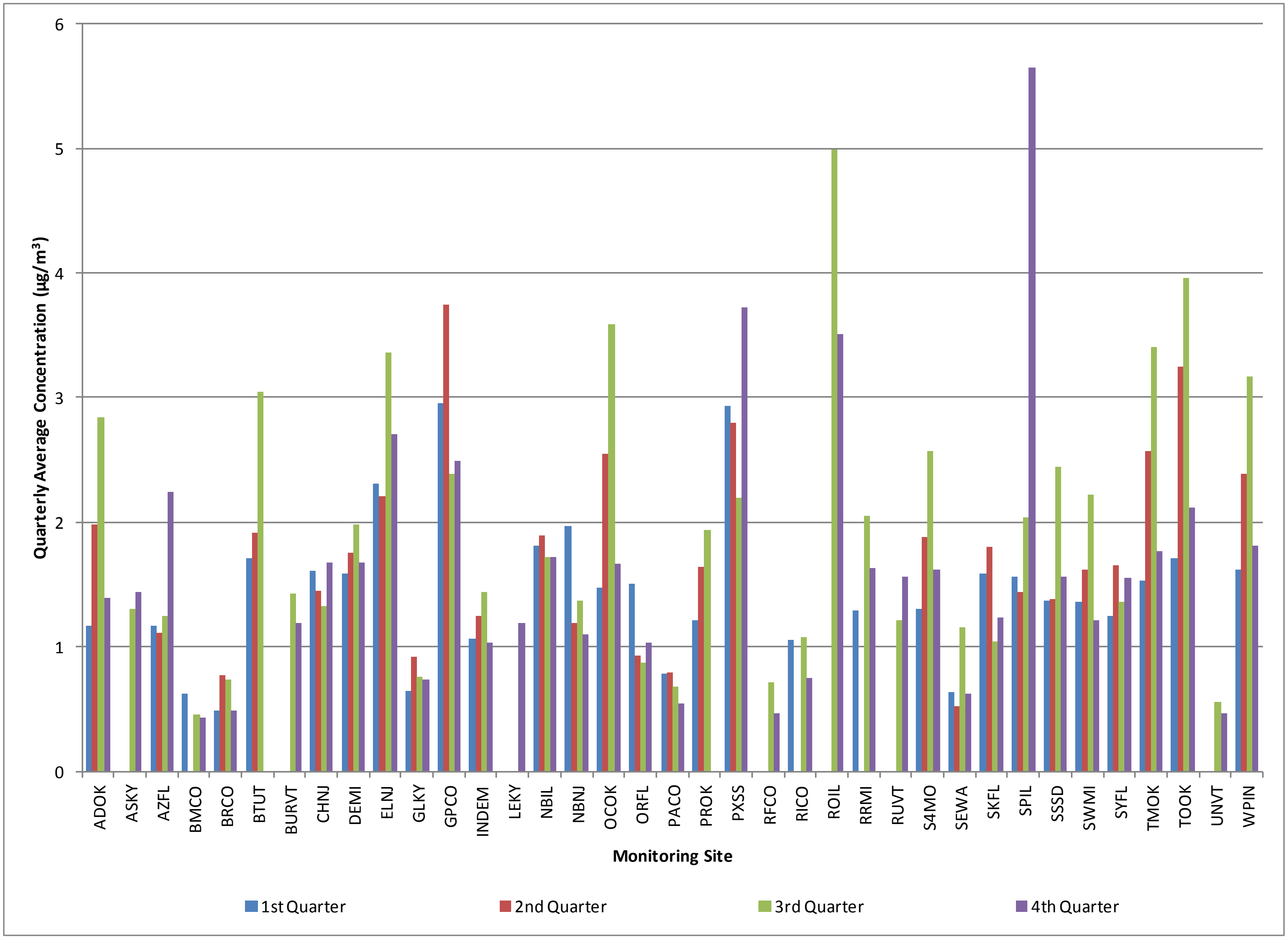


Figure 4-18a. Comparison of Average Quarterly Arsenic (PM_{10}) Concentrations

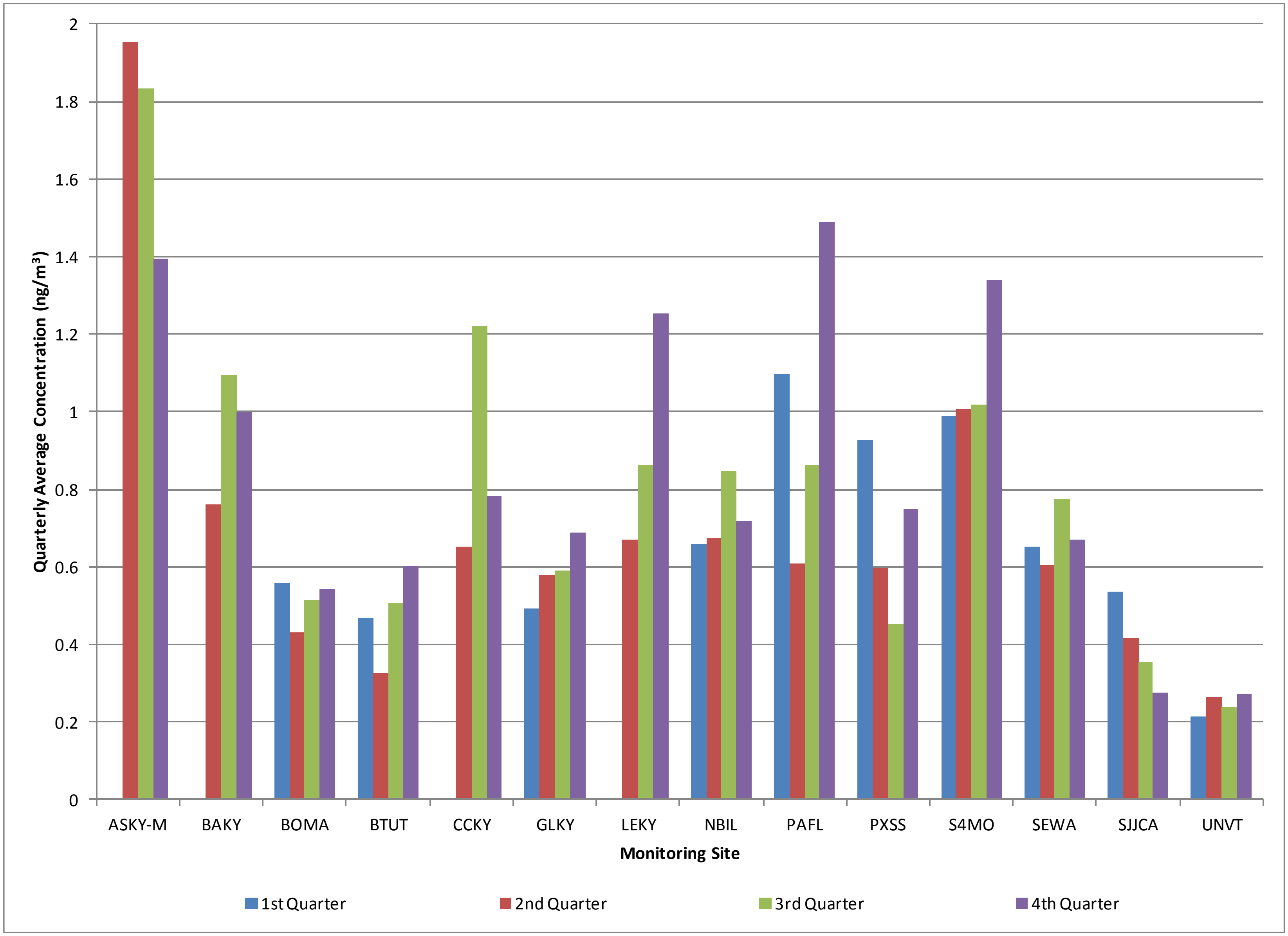


Figure 4-18b. Comparison of Average Quarterly Arsenic (TSP) Concentrations

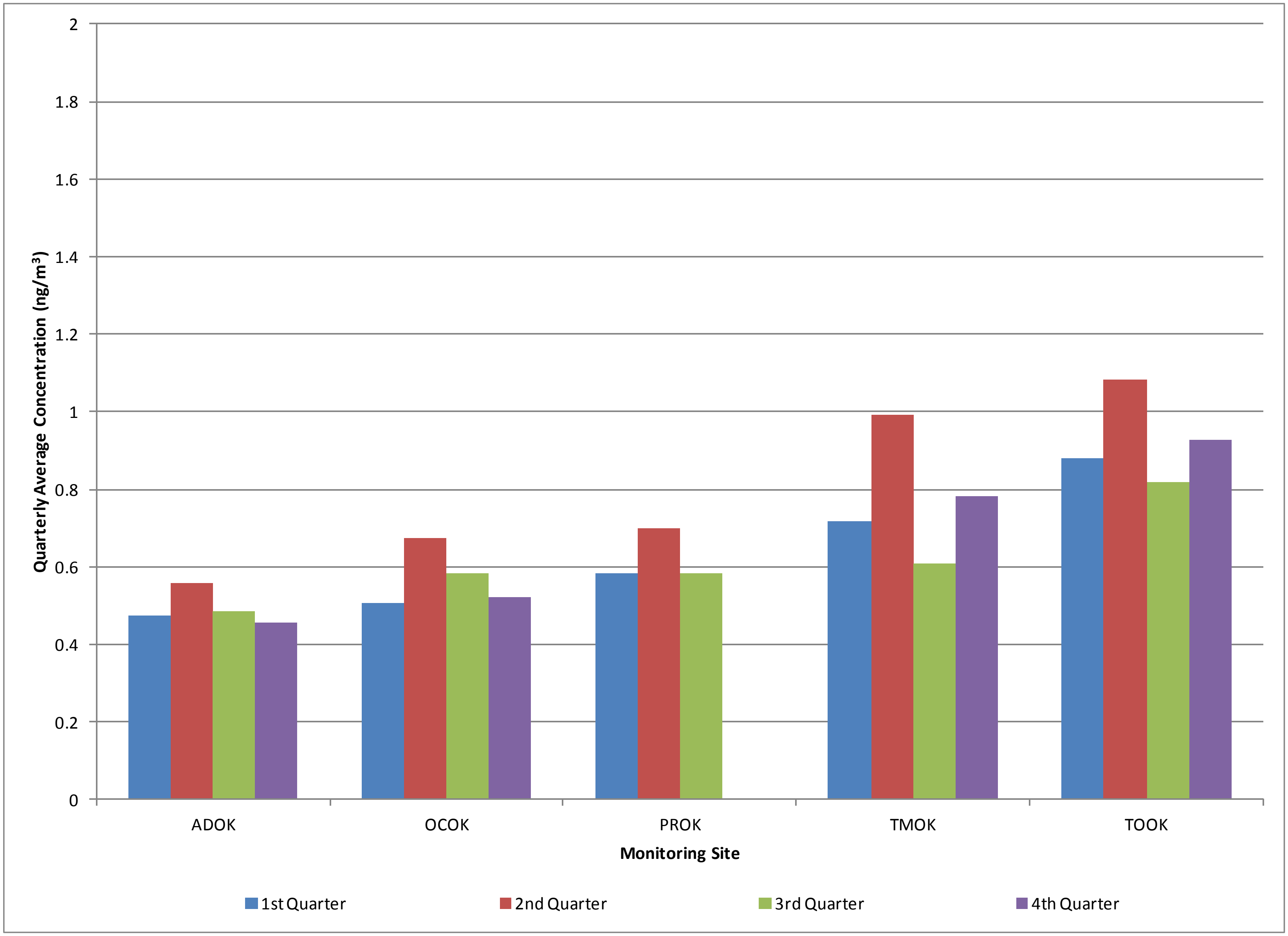


Figure 4-19. Comparison of Average Quarterly Benzene Concentrations

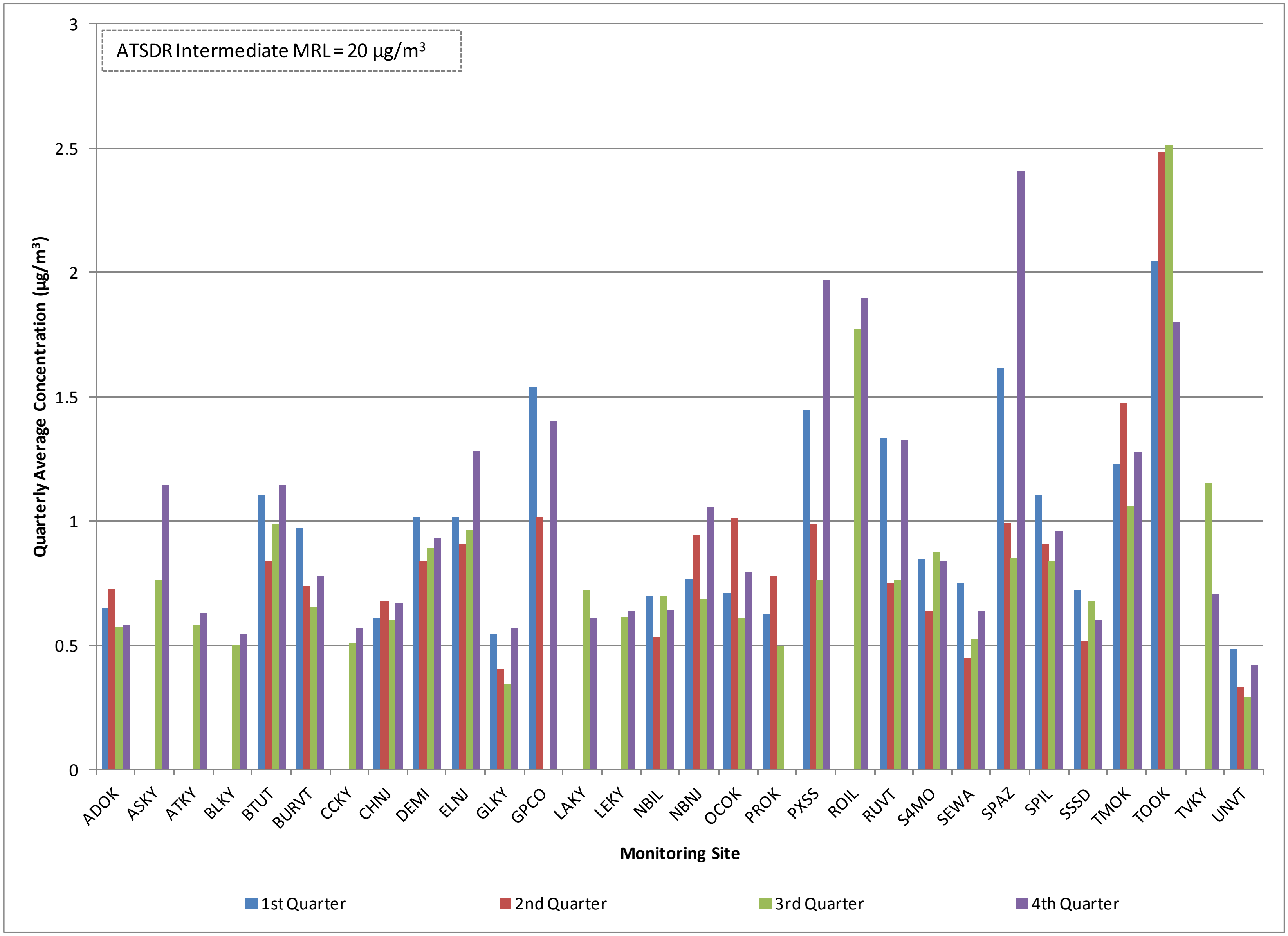


Figure 4-20. Comparison of Average Quarterly 1,3-Butadiene Concentrations

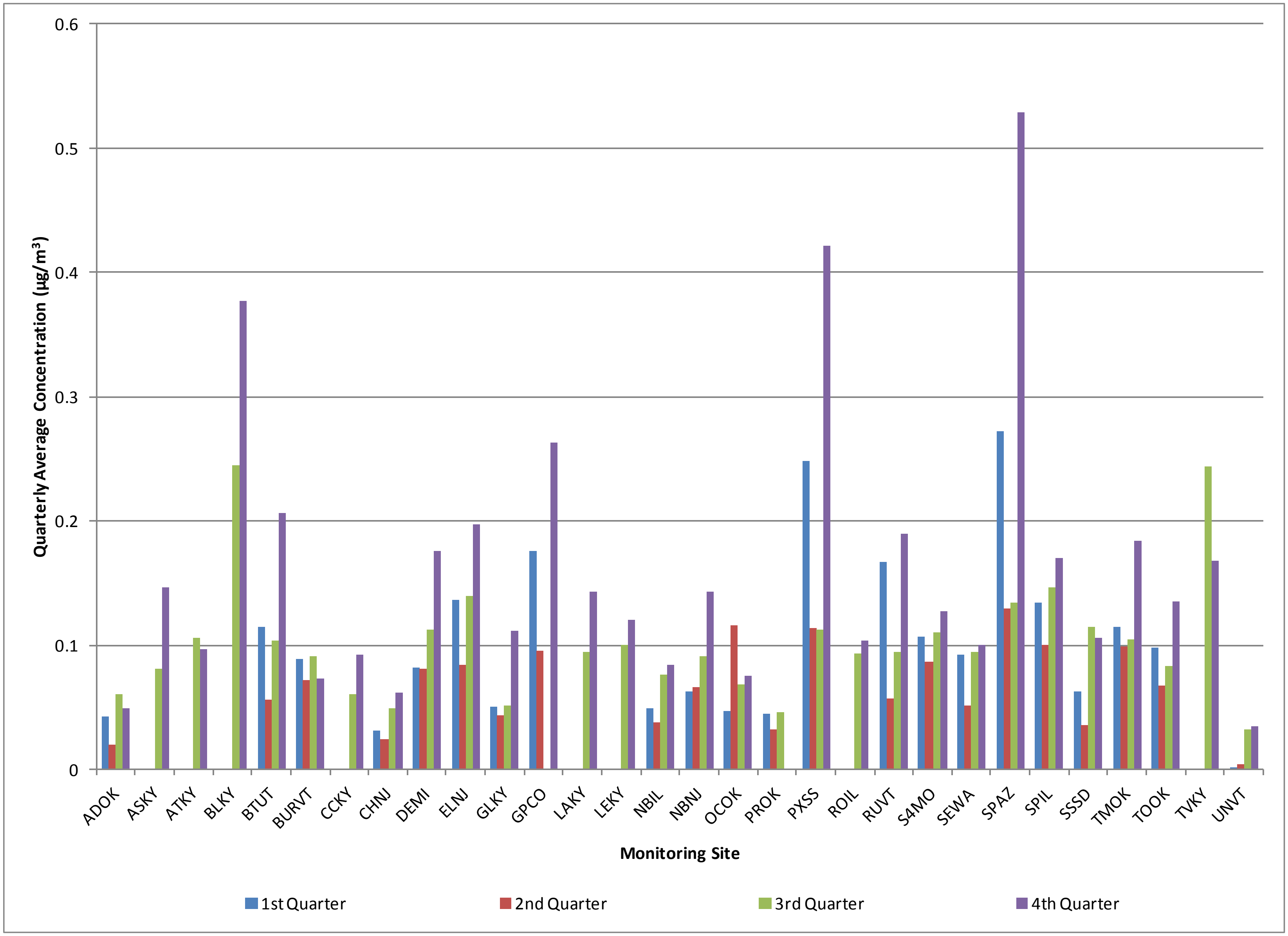


Figure 4-21. Comparison of Average Quarterly Carbon Tetrachloride Concentrations

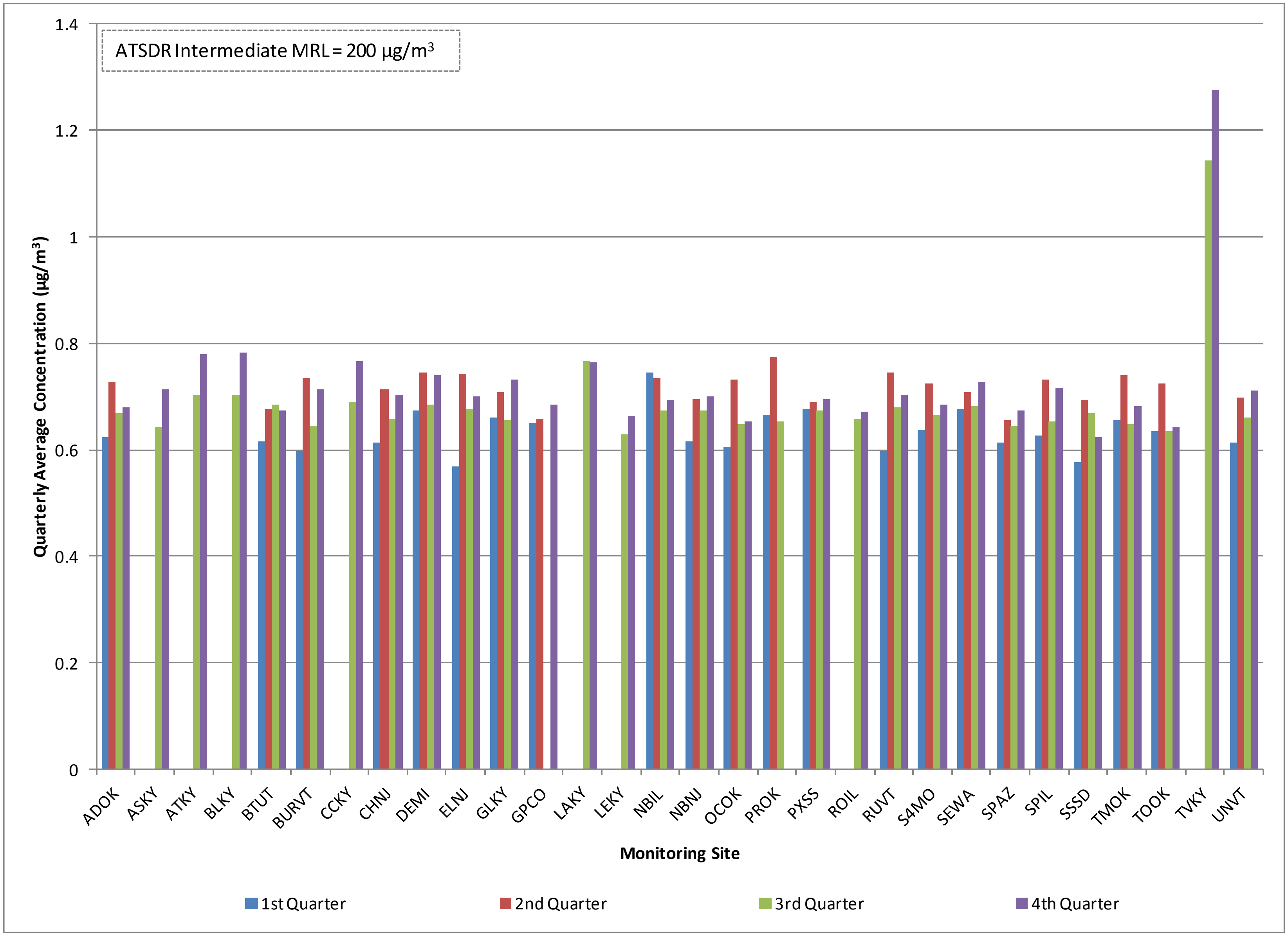


Figure 4-22. Comparison of Average Quarterly *p*-Dichlorobenzene Concentrations

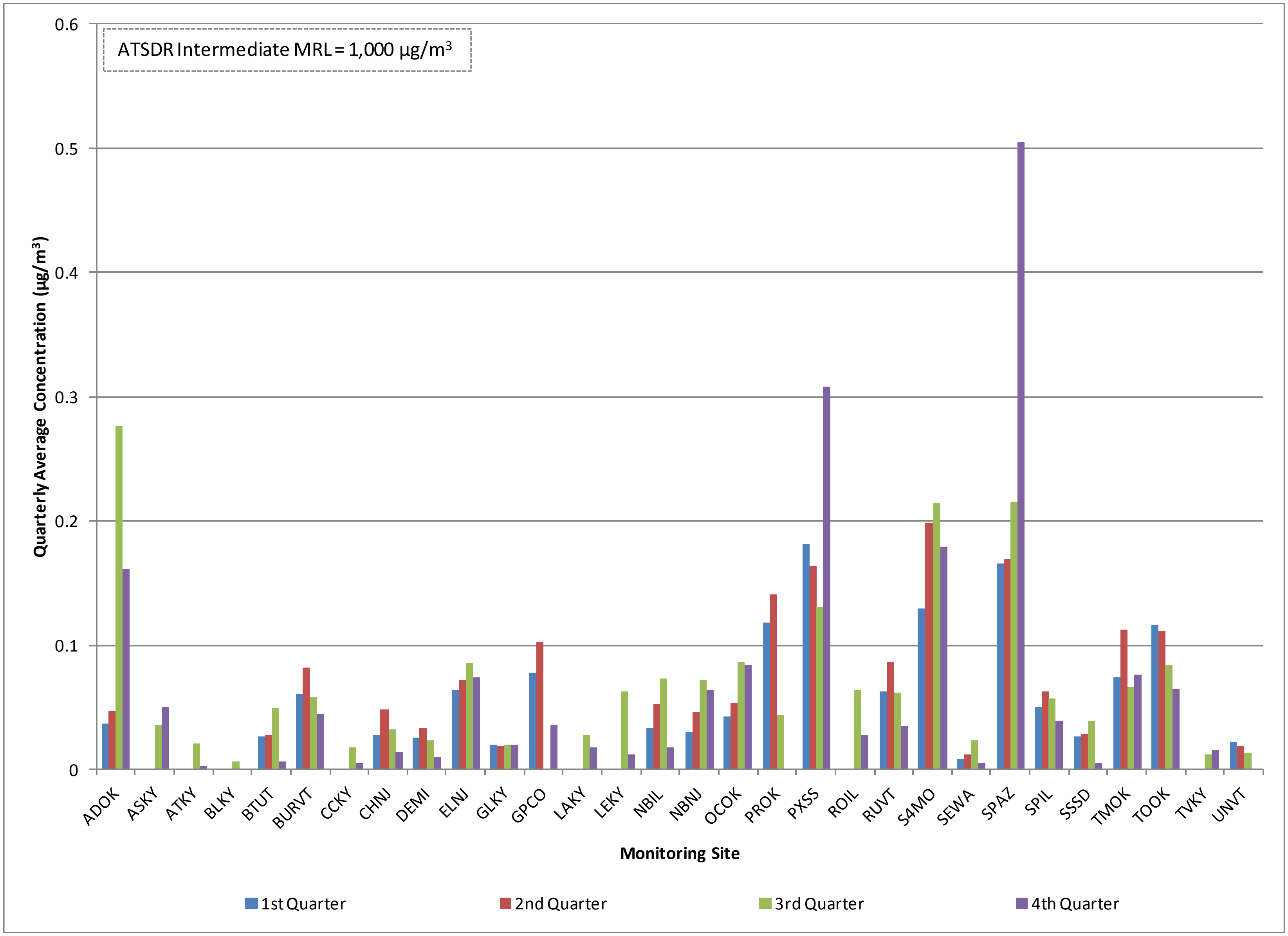


Figure 4-23. Comparison of Average Quarterly 1,2-Dichloroethane Concentrations

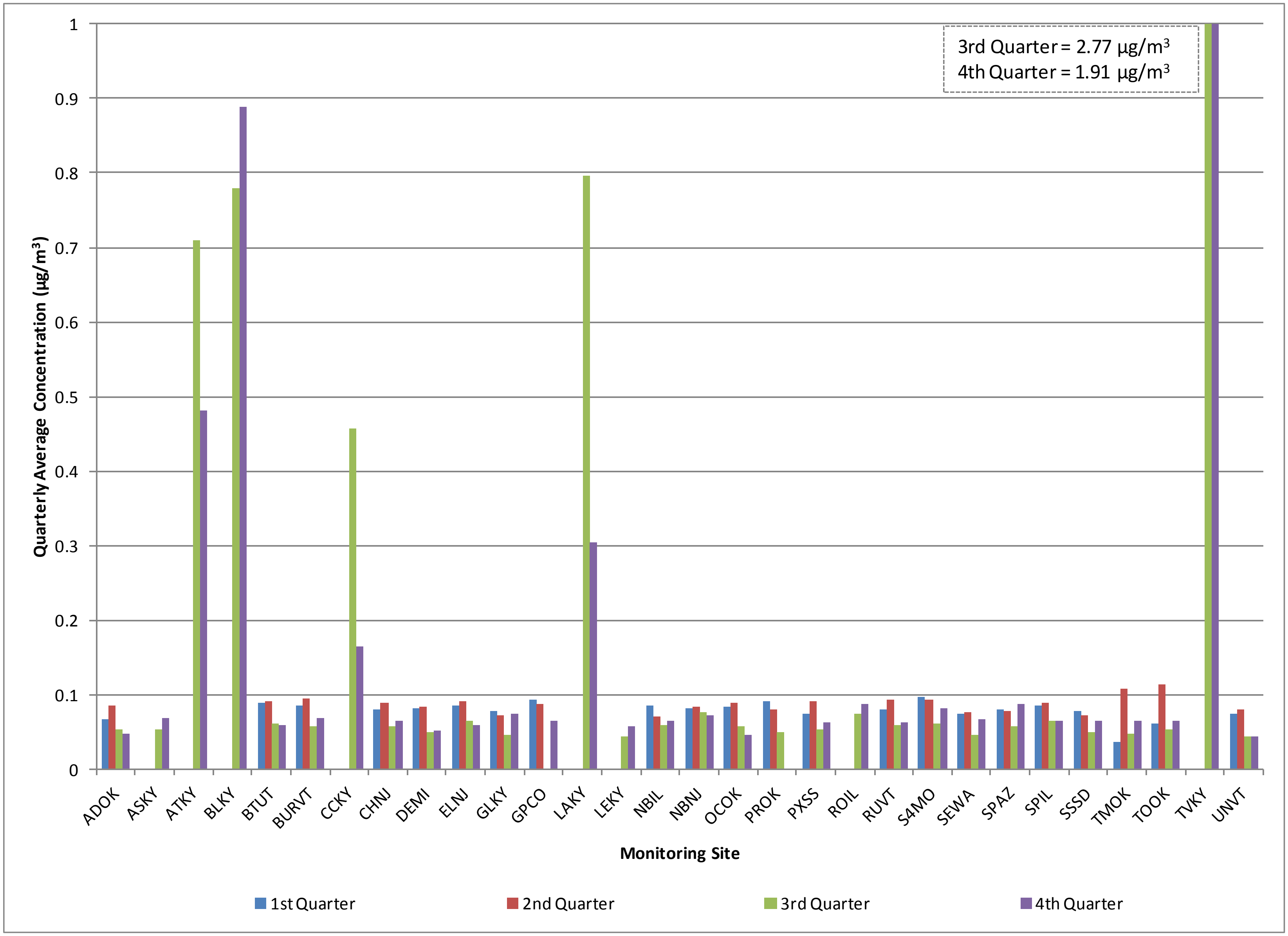


Figure 4-24. Comparison of Average Quarterly Ethylbenzene Concentrations

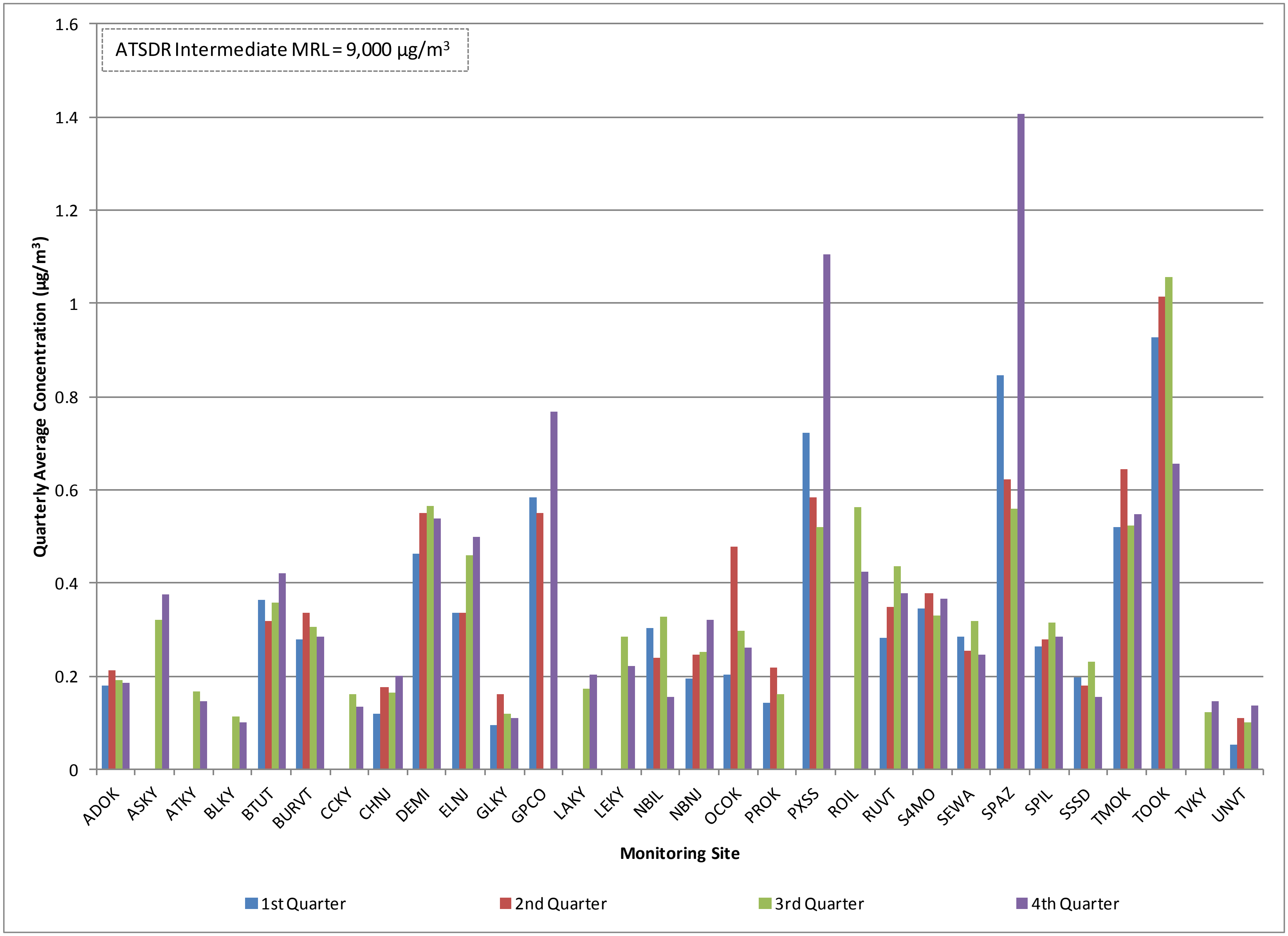


Figure 4-25. Comparison of Average Quarterly Fluorene Concentrations

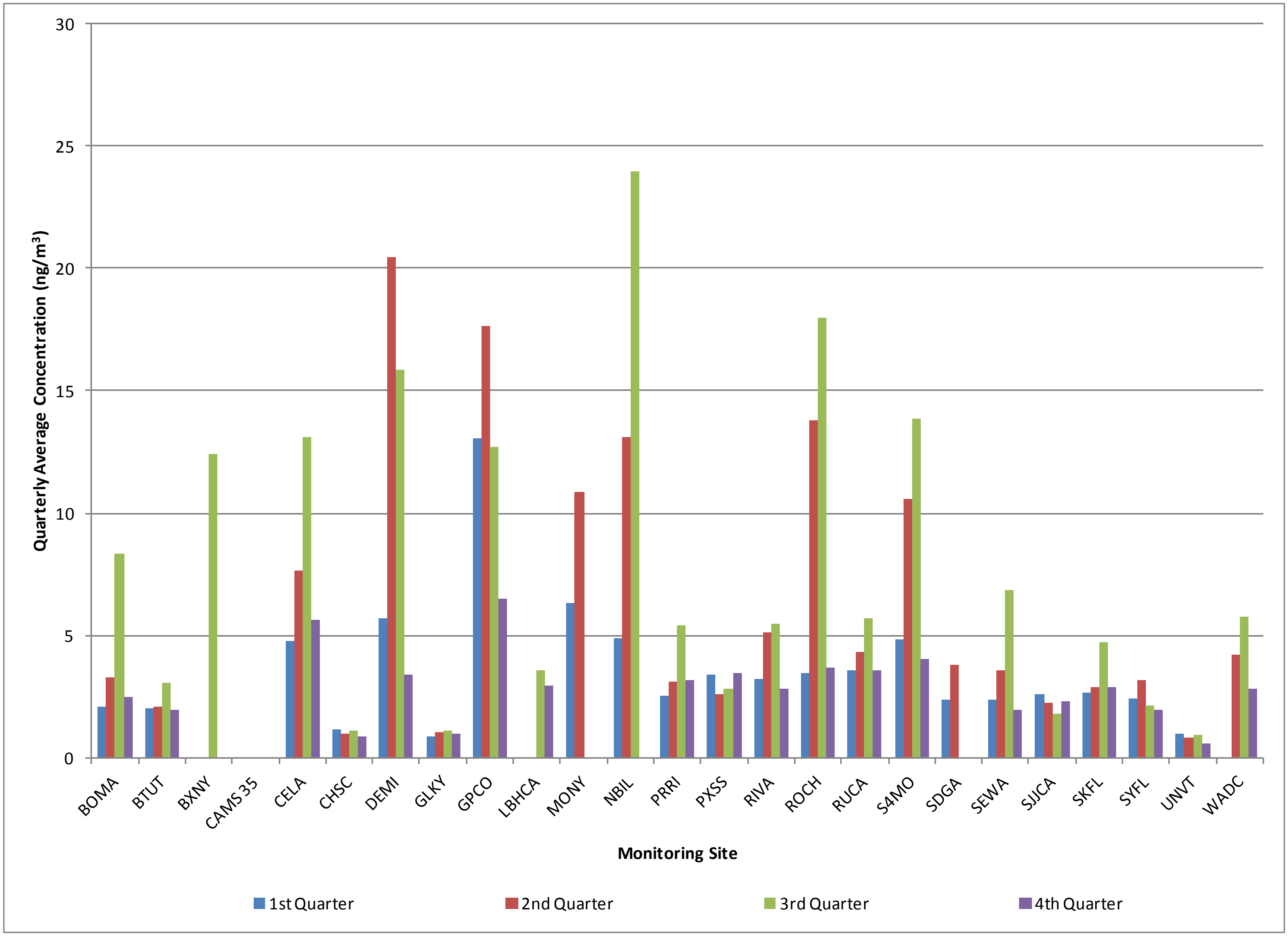


Figure 4-26. Comparison of Average Quarterly Formaldehyde Concentrations

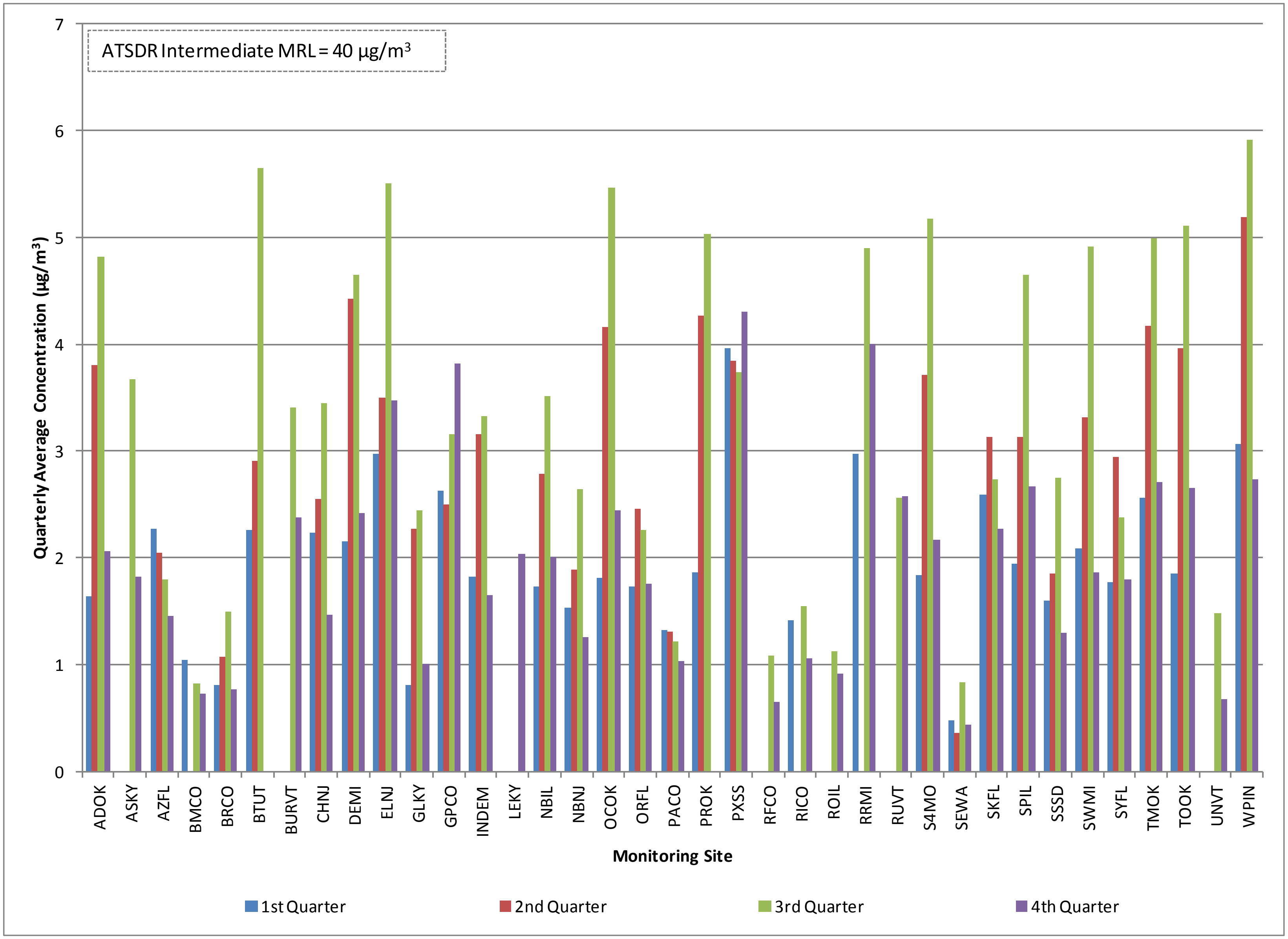


Figure 4-27. Comparison of Average Quarterly Hexachloro-1,3-butadiene Concentrations

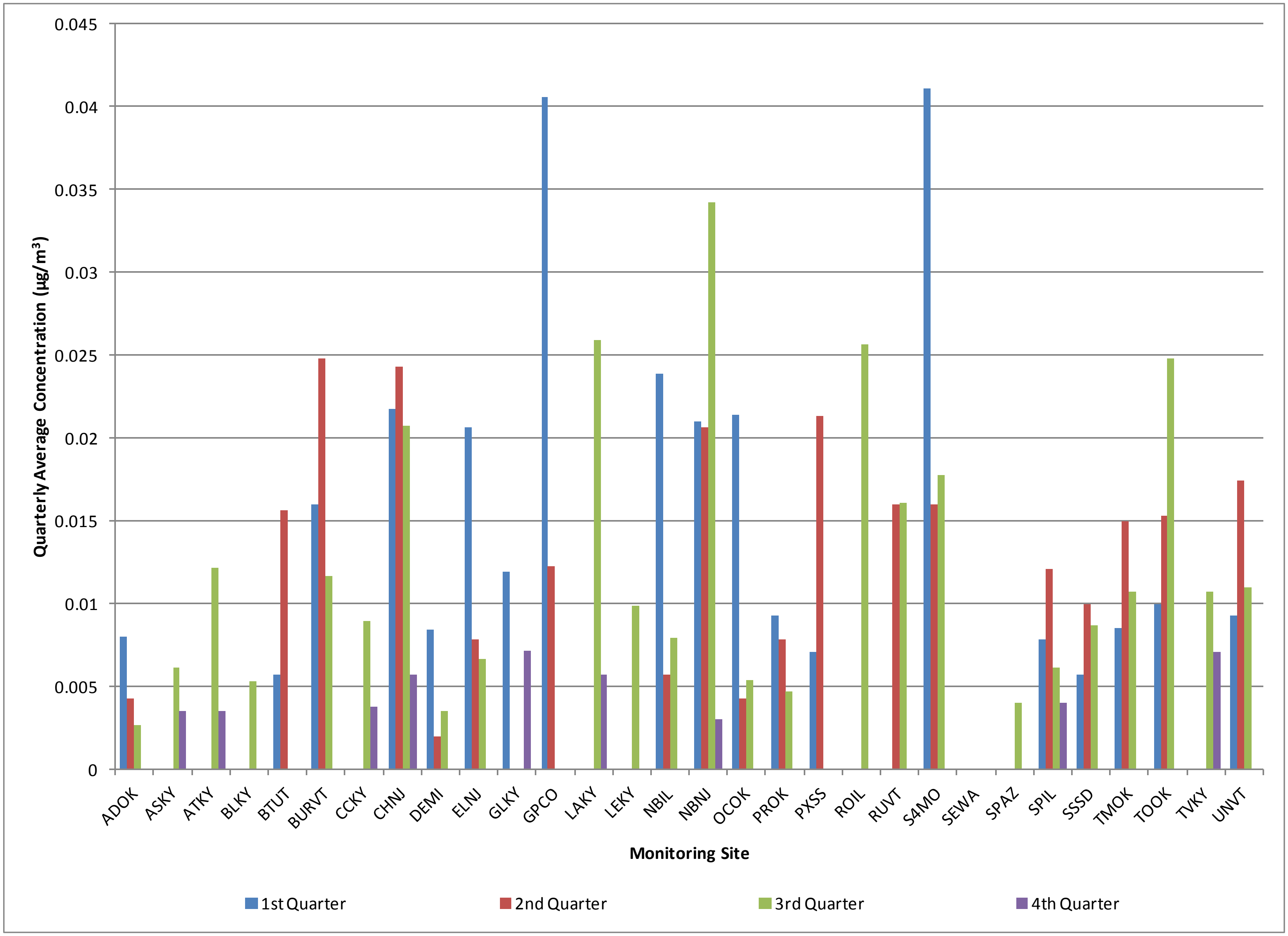


Figure 4-28a. Comparison of Average Quarterly Manganese (PM_{10}) Concentrations

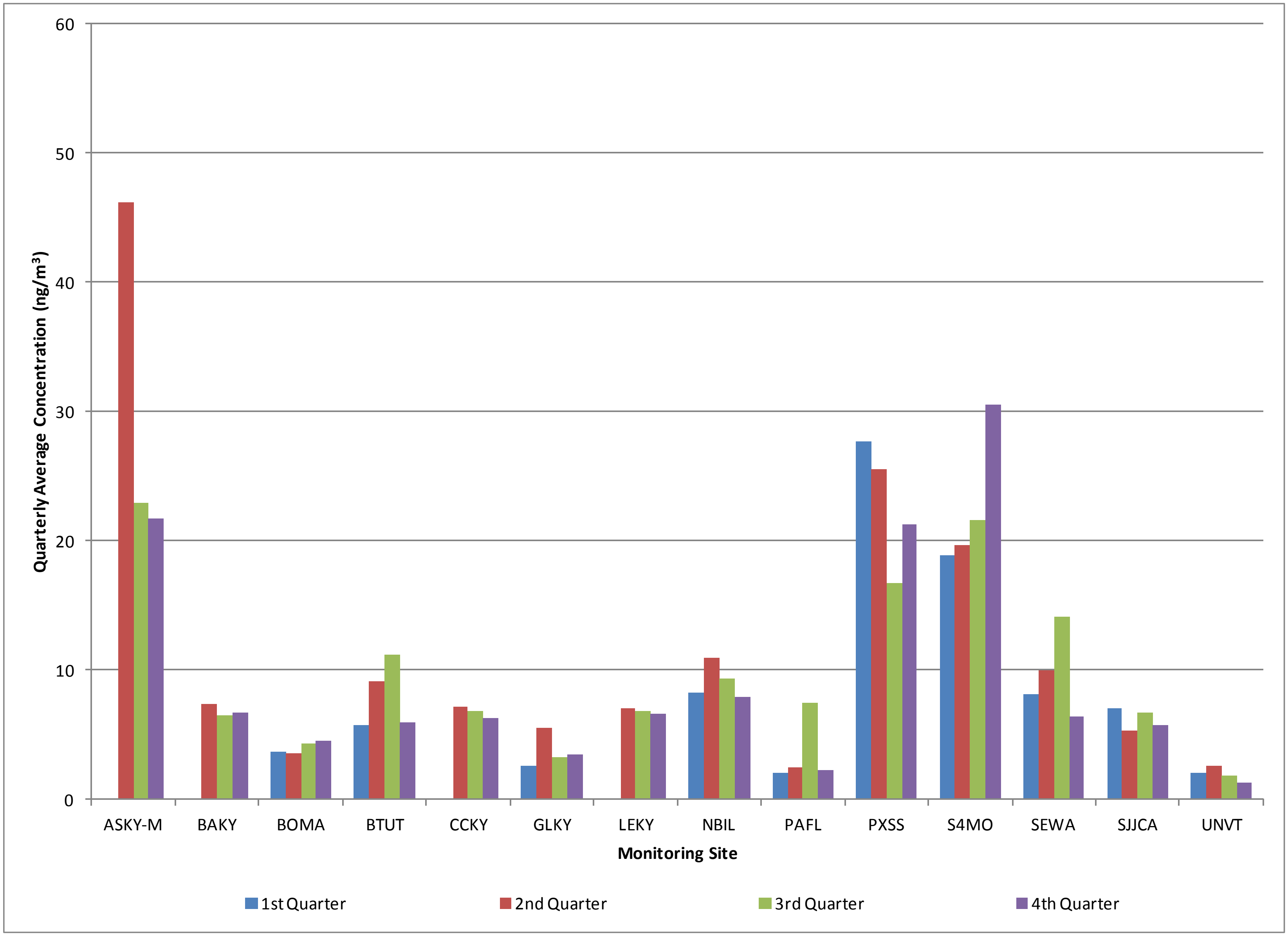


Figure 4-28b. Comparison of Average Quarterly Manganese (TSP) Concentrations

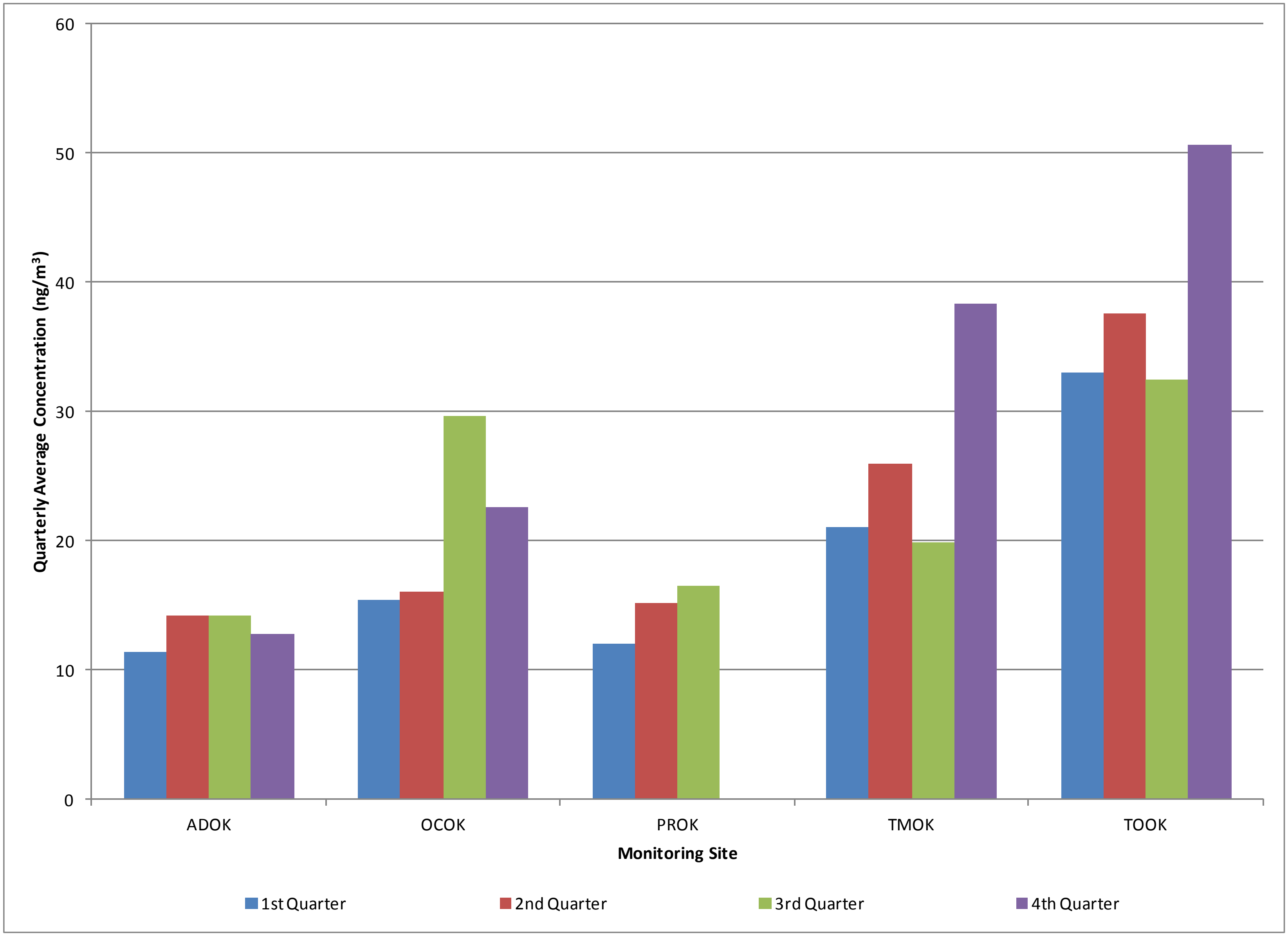


Figure 4-29. Comparison of Average Quarterly Naphthalene Concentrations

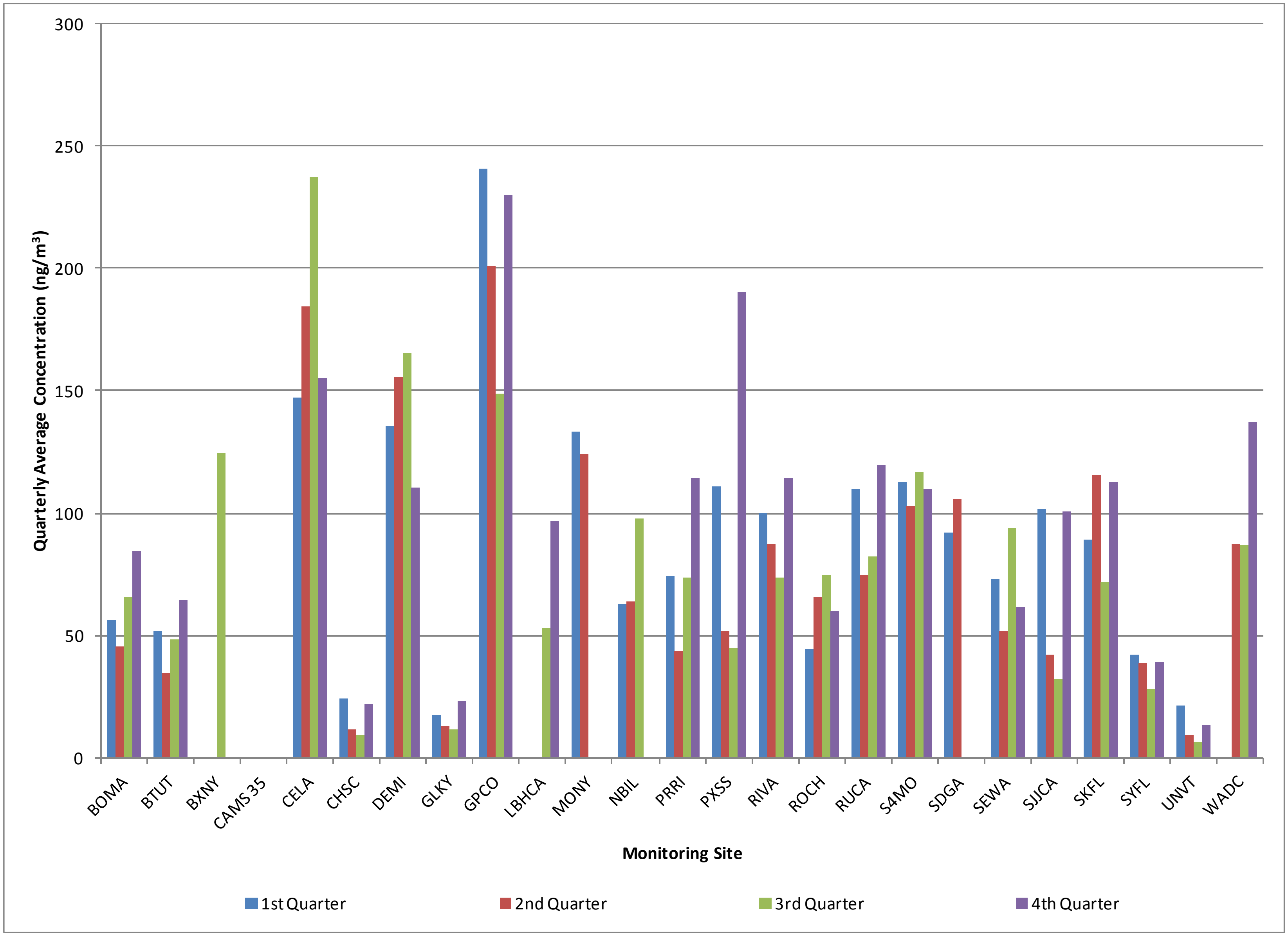


Figure 4-30a. Comparison of Average Quarterly Nickel (PM_{10}) Concentrations

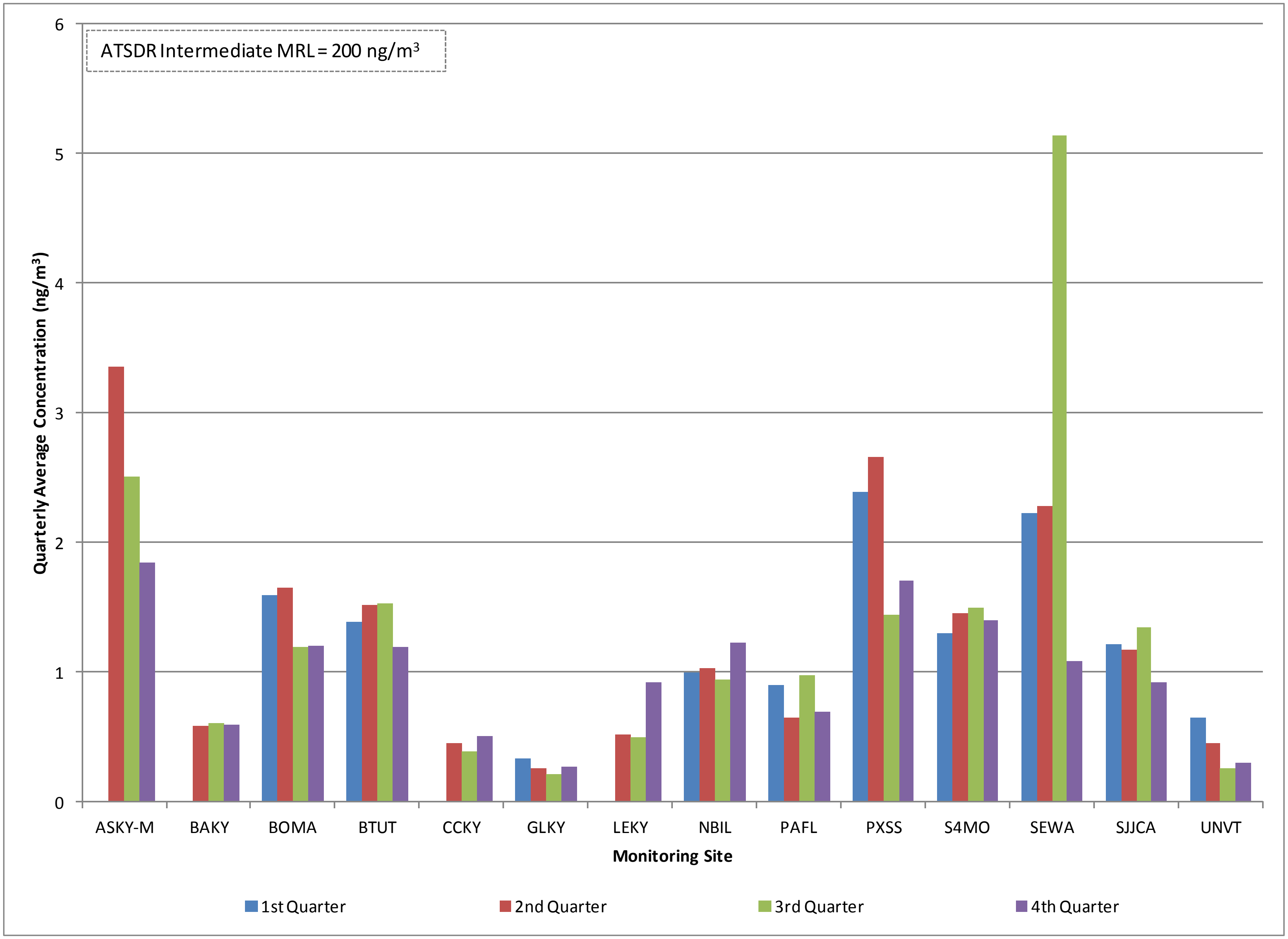
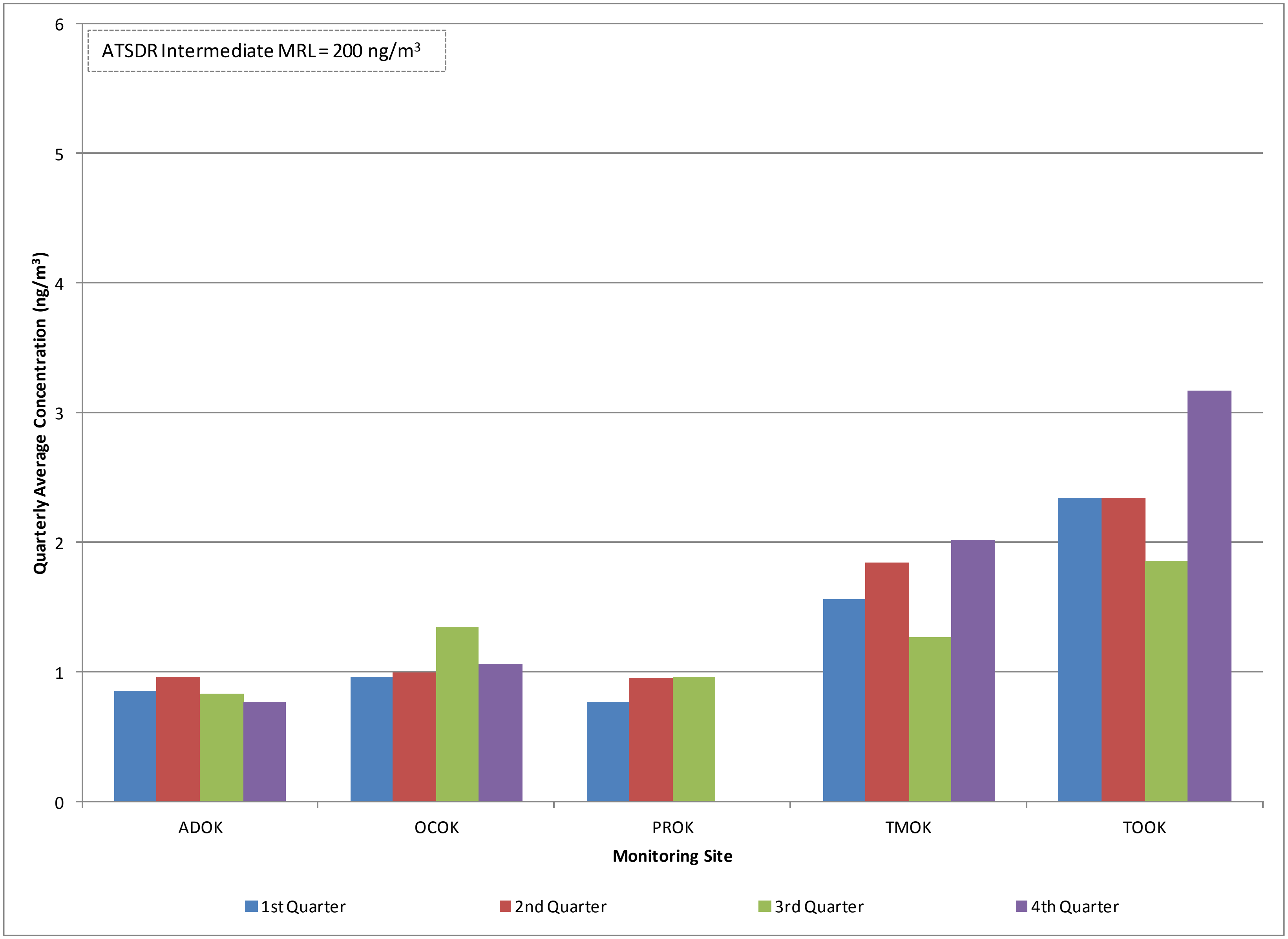


Figure 4-30b. Comparison of Average Quarterly Nickel (TSP) Concentrations



4.5 Greenhouse Gases

Table 4-15 presents the program-level average concentrations for the 10 GHGs measured using Method TO-15, in descending order by GWP. As shown, most of the GHGs were detected in nearly every sample collected (a total 1,466 valid VOC samples). Chloroform, bromomethane, and 1,1,1-trichloroethane were the only pollutants detected in less than 95 percent of VOC samples collected, although even these were detected in greater than 50 percent of samples. Dichlorodifluoromethane and dichlorotetrafluoroethane have the highest GWPs of the GHGs measured by Method TO-15 (10,900 and 10,000 respectively), while bromomethane and dichloromethane have the lowest GWPs (5 and 9, respectively).

Dichloromethane has the highest program-level average concentration among the GHGs measured (2.53 ± 1.29 $\mu g/m^3$), although the program-level average concentration for dichlorodifluoromethane is similar in magnitude (2.49 ± 0.01 $\mu g/m^3$). The confidence interval for dichloromethane indicates that this concentration is likely influenced by outliers, while the confidence interval for dichlorodifluoromethane indicates little variability. A review of the data shows that high concentrations for a few sites contributed to this dichloromethane average concentration. The highest concentrations of this pollutant were measured at GPCO and ranged from 124 $\mu g/m^3$ to 745 $\mu g/m^3$. An additional concentration of 153 $\mu g/m^3$ was also measured at BTUT. However, the median concentration of this pollutant is less than 0.5 $\mu g/m^3$, indicating that these high concentrations are the exception and not the rule. The median concentration for dichlorodifluoromethane (2.47 $\mu g/m^3$) is very similar to its program average; the similarities in these two calculations indicate little variability in the central tendency of this pollutant. Besides dichloromethane and dichlorodifluoromethane, only two additional GHGs shown in Table 4-15 have program-level average concentrations greater than 1 $\mu g/m^3$: trichlorofluoromethane and chloromethane.

Table 4-15. Greenhouse Gases Measured by Method TO-15

Pollutant	Global Warming Potential[1] (100 yrs)	Total # of Measured Detections[2]	2012 Program Average (µg/m³)
Dichlorodifluoromethane	10,900	1,466	2.49 ± 0.01
Dichlorotetrafluoroethane	10,000	1,466	0.12 ± <0.01
Trichlorotrifluoroethane	6,130	1,466	0.65 ± <0.01
Trichlorofluoromethane	4,750	1,466	1.52 ± 0.02
Carbon Tetrachloride	1,400	1,466	0.69 ± 0.01
1,1,1-Trichloroethane	146	1,268	0.04 ± <0.01
Chloroform	31	948	0.24 ± 0.09
Chloromethane	13	1,466	1.18 ± 0.01
Dichloromethane	9	1,464	2.53 ± 1.29
Bromomethane	5	1,183	0.04 ± <0.01

[1] GWPs presented here are from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) (IPCC, 2012).

[2] Out of 1,466 valid samples

5.0 Sites in Arizona

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Arizona, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

5.1 Site Characterization

This section characterizes the Arizona monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The Arizona monitoring sites are located in Phoenix, Arizona. Figures 5-1 and 5-2 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites and their immediate surroundings. Figure 5-3 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 5-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radii are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 5-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 5-1. Phoenix, Arizona (PXSS) Monitoring Site

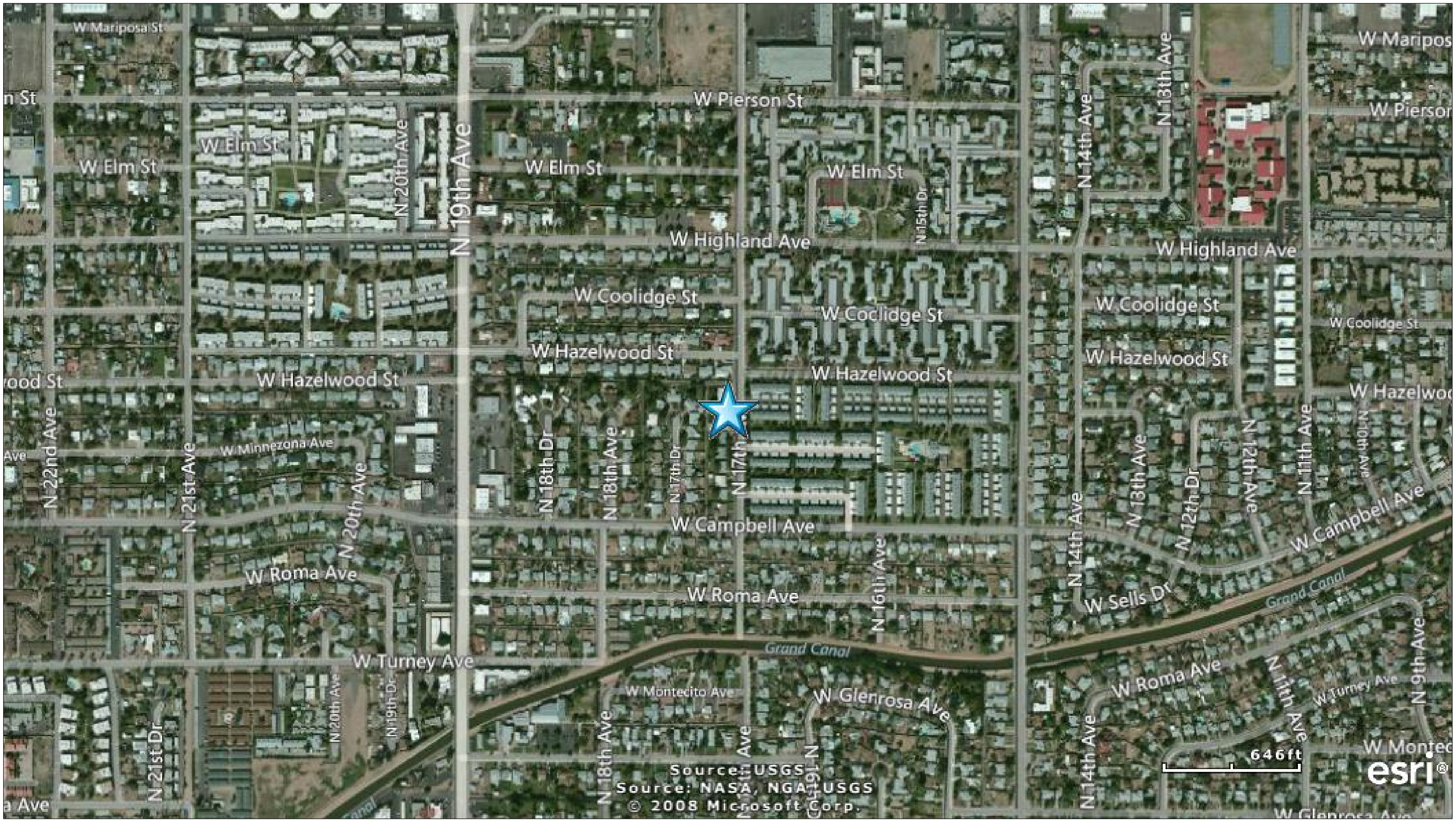


Figure 5-2. South Phoenix, Arizona (SPAZ) Monitoring Site

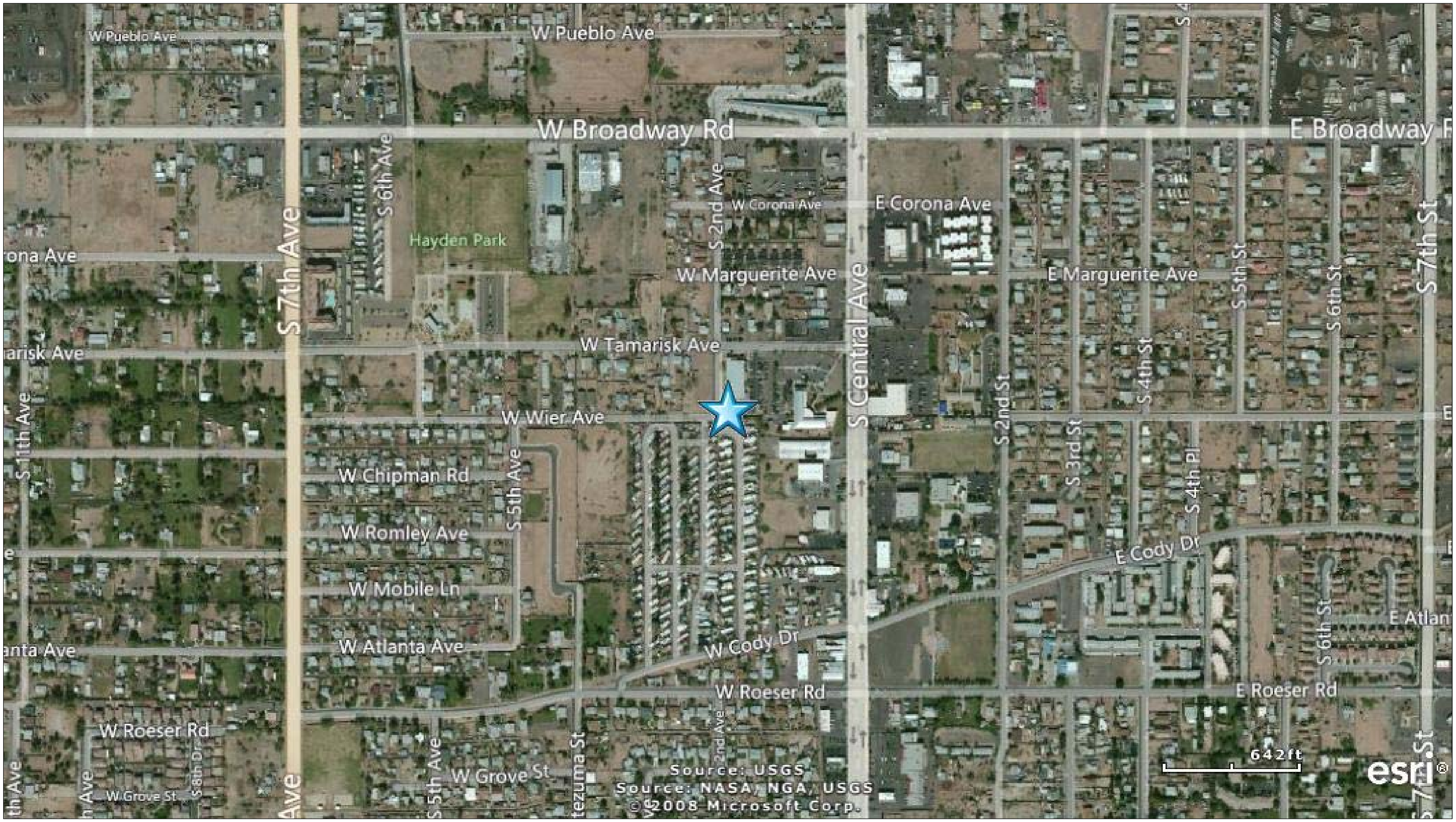


Figure 5-3. NEI Point Sources Located Within 10 Miles of PXSS and SPAZ

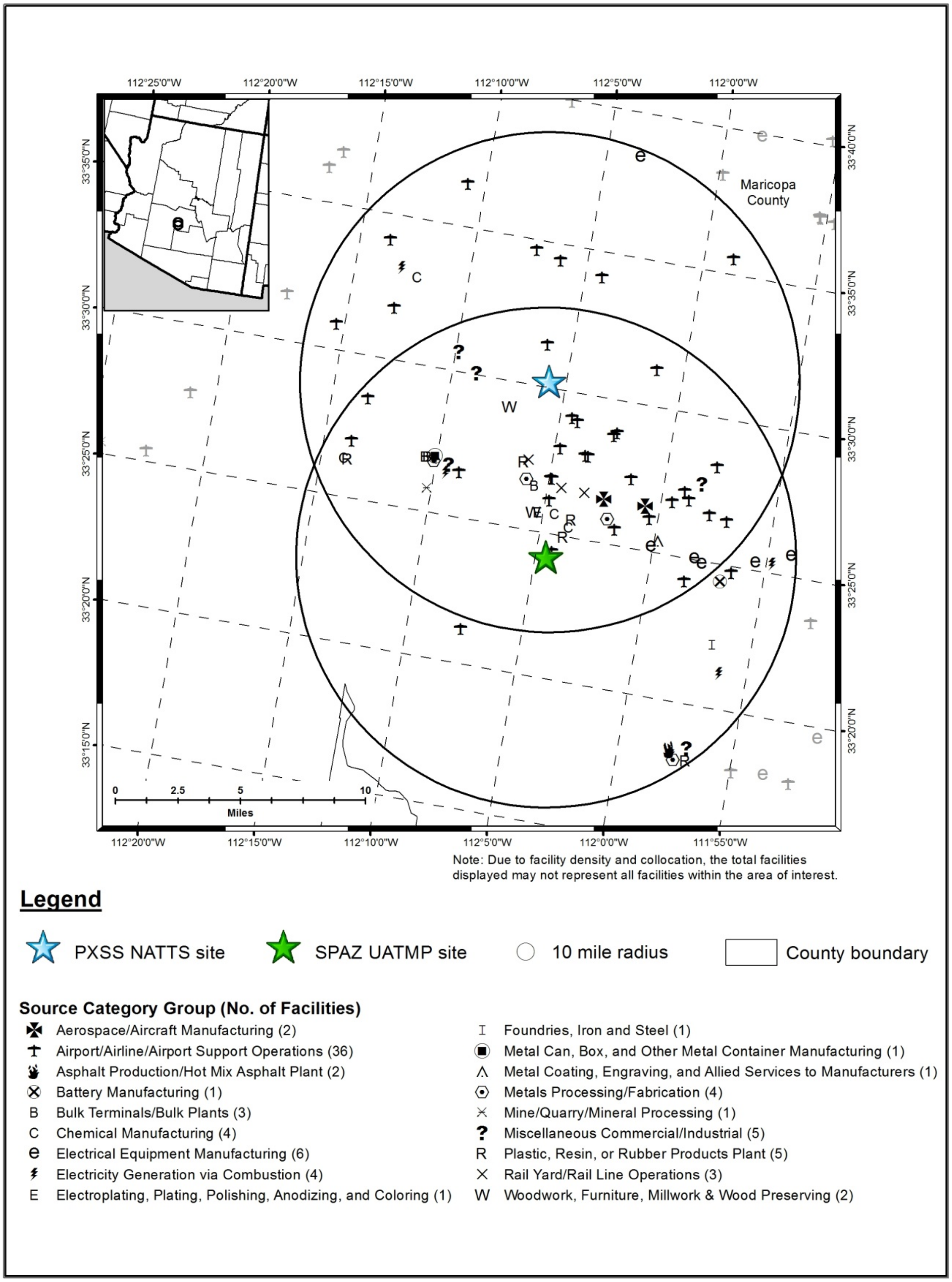


Table 5-1. Geographical Information for the Arizona Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
PXSS	04-013-9997	Phoenix	Maricopa	Phoenix-Mesa-Scottsdale, AZ MSA	33.503833, -112.095767	Residential	Urban/City Center	Haze, CO, SO$_2$, NO, NO$_2$, NO$_x$, NO$_y$, PAMS, O$_3$, Meteorological parameters, PM$_{10}$, PM Coarse, PM$_{2.5}$, PM$_{2.5}$ Speciation, IMPROVE Speciation.
SPAZ	04-013-4003	Phoenix	Maricopa	Phoenix-Mesa-Scottsdale, AZ MSA	33.40316, -112.07533	Residential	Urban/City Center	CO, O$_3$, Meteorological parameters, PM$_{10,}$ PM Coarse, PM$_{2.5}$.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

PXSS is located in central Phoenix. Figure 5-1 shows that PXSS is located in a highly residential area on North 17th Avenue. The Grand Canal is shown along the bottom of Figure 5-1. The monitoring site is approximately 3/4 of a mile east of I-17 and 2 miles north of I-10. Figure 5-2 shows that SPAZ is located in South Phoenix near the intersection of West Tamarisk Avenue and South Central Avenue. SPAZ is surrounded by residential properties to the west and south and commercial properties to the east. SPAZ is located approximately 1 mile south of I-17/I-10.

PXSS is located approximately 7 miles north of SPAZ. The majority of emissions sources are located between the sites, to the south of PXSS and north of SPAZ, as shown in Figure 5-3. The source category with the greatest number of emissions sources near these monitoring sites is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. The emissions source nearest PXSS is a hospital heliport while the source nearest SPAZ is a heliport at a police station.

Table 5-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Arizona monitoring sites. Table 5-2 includes both county-level population and vehicle registration information. Table 5-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 5-2 presents the county-level daily VMT for Maricopa County.

Table 5-2. Population, Motor Vehicle, and Traffic Information for the Arizona Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
PXSS	3,942,169	3,761,859	184,000	I-17 b/w Exits 202 and 203	90,393,000
SPAZ			128,000	I-17 b/w Exits 195B and 196	

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (AZ DOT, 2011)
[3] AADT reflects 2010 data (AZ DOT, 2010)
[4] County-level VMT reflects 2012 data (AZ DOT, 2013)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 5-2 include the following:

- Maricopa County has the fourth highest county-level population and second highest county-level vehicle registration compared to other counties with NMP sites.

- PXSS experiences a higher traffic volume compared to SPAZ, based on locations along I-17. The traffic volume near PXSS is the sixth highest compared to traffic volumes near other NMP sites, with the traffic volume near SPAZ ranking 12th.

- The daily VMT for Maricopa County is the second highest compared to other counties with NMP sites (where VMT data were available).

5.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Arizona on sample days, as well as over the course of the year.

5.2.1 Climate Summary

Phoenix is located in the Salt River Valley, which is part of the Sonora Desert. The area experiences mild winters and extremely hot and dry summers. Differences between the daytime maximum temperature and overnight minimum temperature can be as high as 50°F. A summer “monsoon” period brings precipitation to the area for part of the summer, while storm systems originating over the Pacific Ocean bring rain in the winter and early spring. However, normal monthly rainfall totals are generally less than one inch. Winds are generally light and out of the east for much of the year (Wood, 2004; WRCC, 2013).

5.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Arizona monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather station to both PXSS and SPAZ is located at Phoenix Sky Harbor International Airport (WBAN 23183). Additional information about the Phoenix Sky Harbor weather station, such as the distance between the sites and the weather station, is provided in Table 5-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 5-3. Average Meteorological Conditions near the Arizona Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Phoenix, Arizona - PXSS									
Phoenix Sky Harbor Intl. Airport 23183 (33.44, -111.99)	7.3 miles 146° (SE)	Sample Days (69)	88.6 ± 3.8	77.4 ± 3.8	37.6 ± 3.2	56.5 ± 2.5	28.7 ± 3.3	1011.7 ± 1.2	5.0 ± 0.5
		2012	87.7 ± 1.6	76.7 ± 1.6	36.8 ± 1.5	56.0 ± 1.0	28.3 ± 1.4	1011.4 ± 0.5	5.2 ± 0.2
South Phoenix, Arizona - SPAZ									
Phoenix Sky Harbor Intl. Airport 23183 (33.44, -111.99)	4.3 miles 77° (ENE)	Sample Days (31)	86.4 ± 6.0	75.4 ± 5.9	37.9 ± 5.0	55.7 ± 3.9	30.0 ± 4.2	1011.8 ± 1.8	5.2 ± 0.8
		2012	87.7 ± 1.6	76.7 ± 1.6	36.8 ± 1.5	56.0 ± 1.0	28.3 ± 1.4	1011.4 ± 0.5	5.2 ± 0.2

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 5-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 5-3 is the 95 percent confidence interval for each parameter. As shown in Table 5-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year. Even though the observations are from the same weather station, roughly two degrees separates the sample day averages for the maximum and average temperatures for PXSS and SPAZ. This is primarily due to the sampling schedule. Samples were collected on a 1-in-6 day schedule at PXSS while samples were collected on a 1-in-12 day schedule at SPAZ, yielding roughly half the number of collection events; thus, the number of observations included in each sample day calculation for SPAZ is less. The number of sample days for each site is provided in Table 5-3. Some of the hottest sampling days of 2012 for PXSS were days sampling did not occur at SPAZ. The difference in the number of observations included in the calculations is also reflected in the larger confidence intervals for SPAZ, as is the increased variability in the observations themselves. These sites experienced the lowest relative humidity level and sea level pressures among all NMP sites. Temperatures were also warmest near these sites.

5.2.3 Back Trajectory Analysis

Figure 5-4 is the composite back trajectory map for days on which samples were collected at the PXSS monitoring site. Included in Figure 5-4 are four back trajectories per sample day. Figure 5-5 is the corresponding cluster analysis. Similarly, Figures 5-6 and 5-7 are the composite back trajectory map and corresponding cluster analysis for days on which samples were collected at SPAZ. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 5-4 through 5-7 represents 100 miles.

Figure 5-4. Composite Back Trajectory Map for PXSS

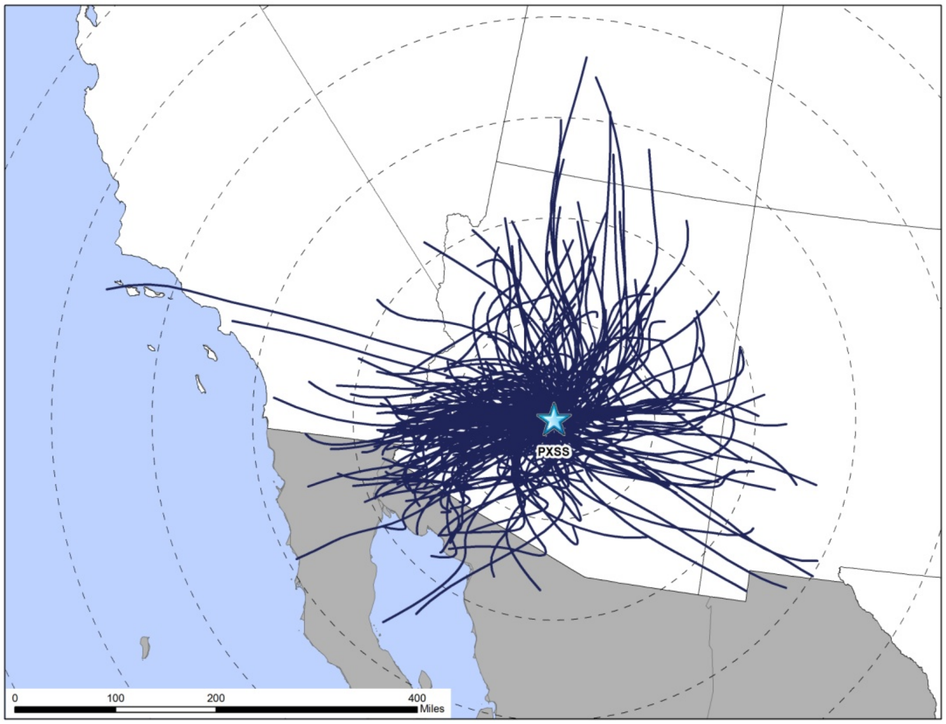


Figure 5-5. Back Trajectory Cluster Map for PXSS

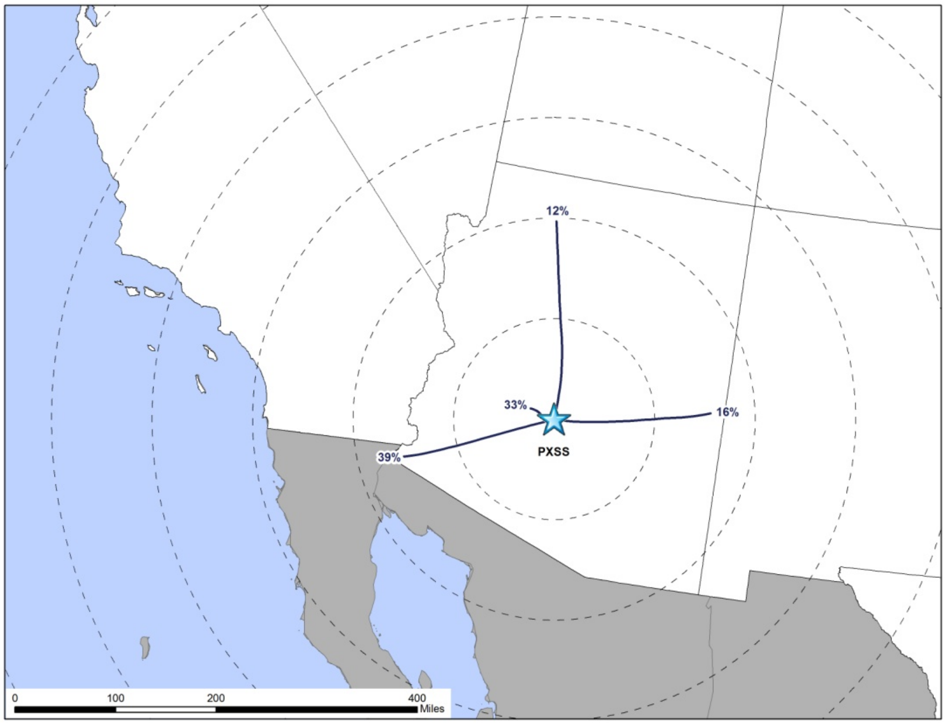


Figure 5-6. Composite Back Trajectory Map for SPAZ

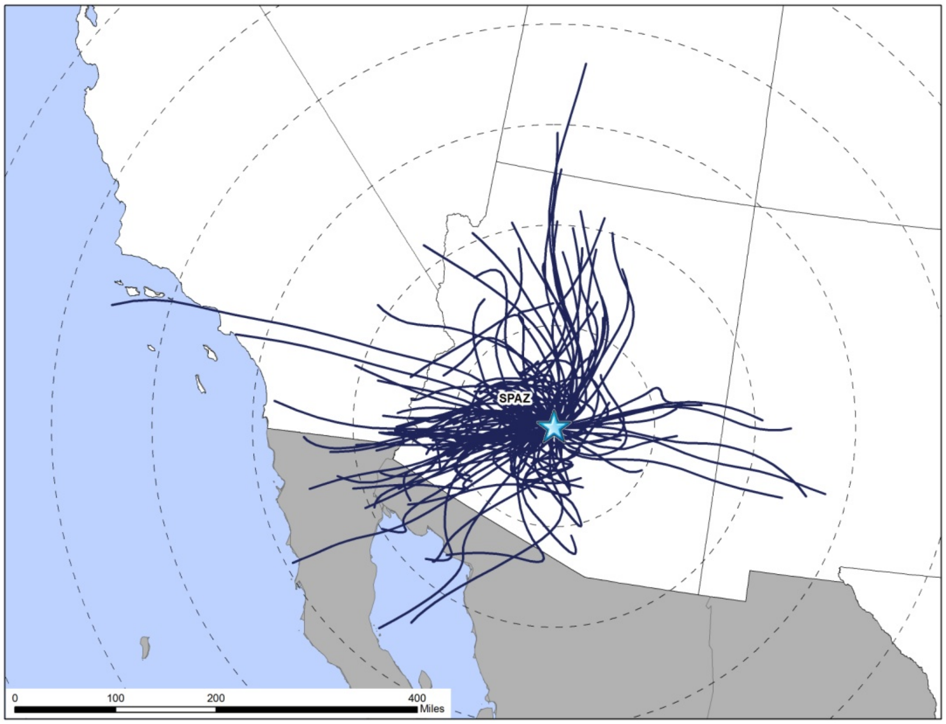
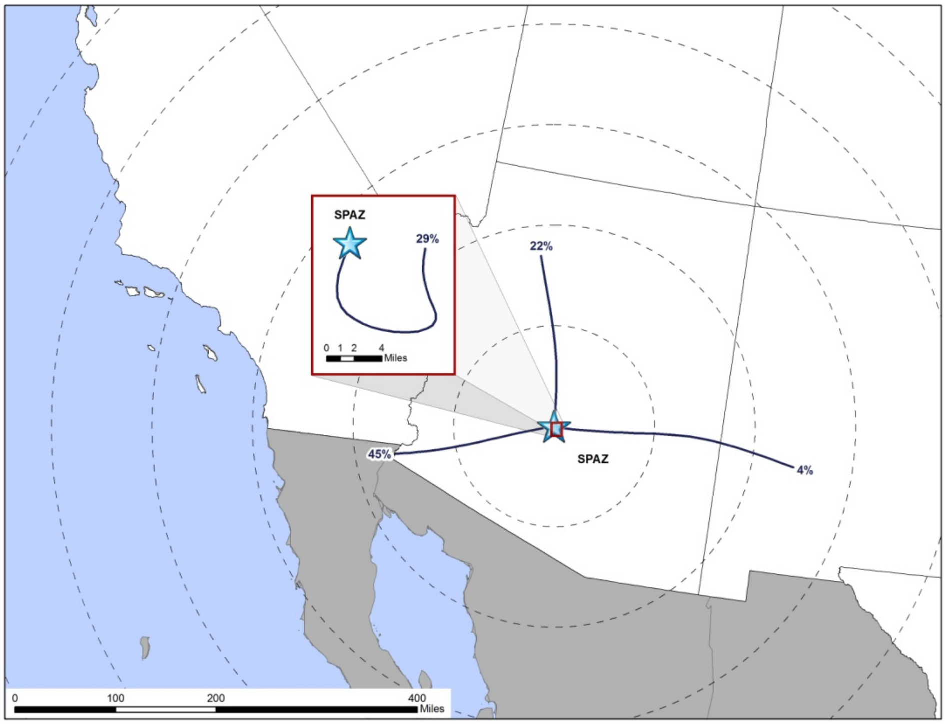


Figure 5-7. Back Trajectory Cluster Map for SPAZ



Observations from Figures 5-4 and 5-5 for PXSS include the following:

- The 24-hour air shed domain for PXSS is among the smallest in size, based on average back trajectory length, compared to other NMP sites. Only the Colorado monitoring sites have smaller air shed domains than PXSS. The farthest away a back trajectory originated from PXSS was off the coast of California and over the Channel Islands, or just greater than 450 miles away. However, most back trajectories (93 percent) originated less than 250 miles from PXSS and the average trajectory length was approximately 141 miles.

- Back trajectories originated from a variety of directions at PXSS, although many back trajectories originated from the southwest and west. Back trajectories also originated from the north, northeast, and east of the site. Few back trajectories originated from the northwest or south.

- The cluster analysis map supports the observations above regarding the direction of trajectory origin as well as the observations about trajectory distances. Nearly 40 percent of back trajectories originated to the southwest and west of PXSS, over southwest Arizona, southern California, and Baja California, Mexico. The short cluster trajectory (33 percent) represents back trajectories originating from nearly all directions, but generally over southwest and central Arizona. Another 12 percent of back trajectories originated over the northern half of the state while 16 percent originated to the northeast, east, and southeast of the site.

Observations from Figures 5-6 and 5-7 for SPAZ include the following:

- Samples were collected every 12 days at SPAZ, which is half the frequency of sample collection at PXSS, as discussed in Section 5.2.2. As a result, fewer back trajectories are shown in Figure 5-6 than Figure 5-4.

- The 24-hour air shed domain for SPAZ is similar in size to the air shed domain for PXSS, based on average back trajectory length. The farthest away a back trajectory originated from SPAZ was off the coast of California and over the Channel Islands, or just greater than 450 miles away. However, most trajectories (91 percent) originated less than 250 miles from SPAZ and the average trajectory length was approximately 147 miles.

- The composite trajectory map for SPAZ has a trajectory distribution pattern similar to PXSS. The cluster analysis maps are similar to each other directionally, although their percentages differ. One cluster trajectory for SPAZ is short enough that it is covered up by the star symbol; thus, the trajectory is presented in the inset map in Figure 5-7. This shorter trajectory includes back trajectories of varying directions but generally short distances.

5.2.4 Wind Rose Comparison

Hourly surface wind data from the weather station at Phoenix Sky Harbor International Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 5-8 presents a map showing the distance between the weather station and PXSS, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 5-8 also presents three different wind roses for the PXSS monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind observations for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 5-9 presents the distance map and three wind roses for SPAZ.

Observations from Figures 5-8 and 5-9 for the Arizona monitoring sites include the following:

- The weather station at Phoenix Sky Harbor International Airport is the closest weather station to both PXSS and SPAZ. The Phoenix Sky Harbor weather station is located 7.3 miles southeast of PXSS and 4.3 miles east-northeast of SPAZ.

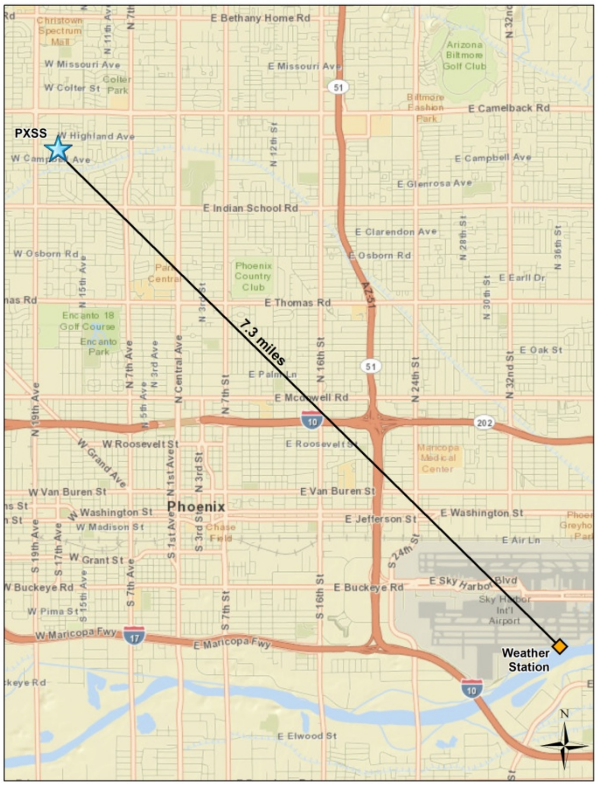
- Because the Phoenix Sky Harbor weather station is the closest weather station to both sites, the historical and 2012 wind roses for PXSS are the same as those for SPAZ.

- The historical wind rose shows that easterly winds were the most commonly observed winds near PXSS and SPAZ (accounting for approximately 20 percent of wind observations), followed by westerly (12 percent) and east-southeasterly (9 percent) winds. Winds from the northwest to north to northeast were infrequently observed, as were winds from the south-southeast to south-southwest. Calm winds (≤ 2 knots) account for 16 percent of the hourly wind measurements from 2002 to 2011.

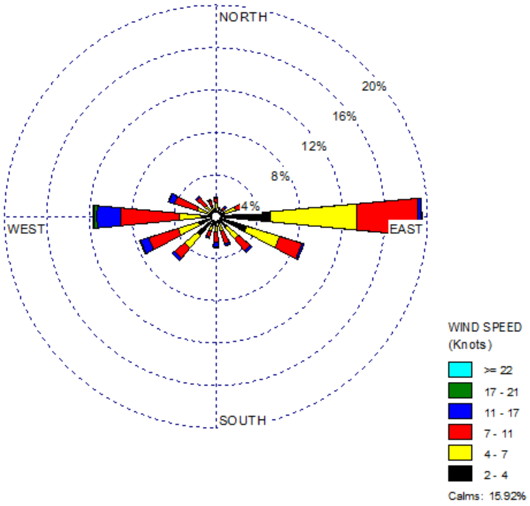
- The 2012 wind patterns are similar to the historical wind patterns. Further, the sample day wind patterns for each site resemble both the historical and 2012 wind patterns, indicating that wind conditions on sample days were representative of those experienced over the entire year and historically.

Figure 5-8. Wind Roses for the Phoenix Sky Harbor International Airport Weather Station near PXSS

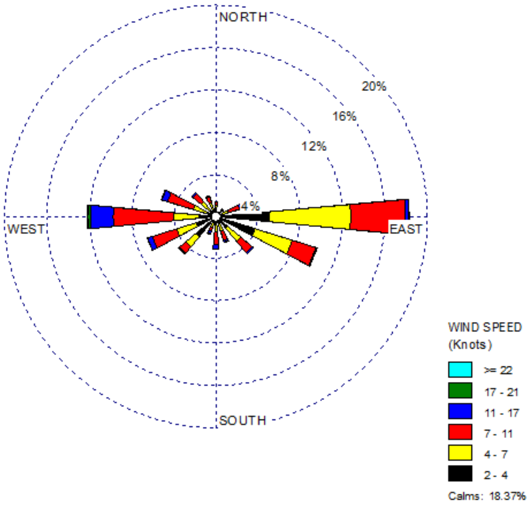
Location of PXSS and Weather Station



2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

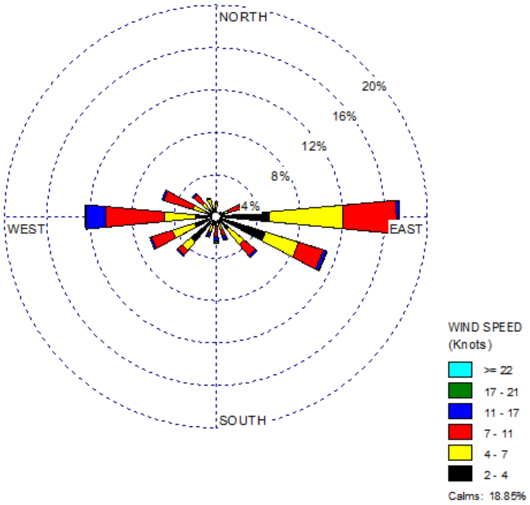
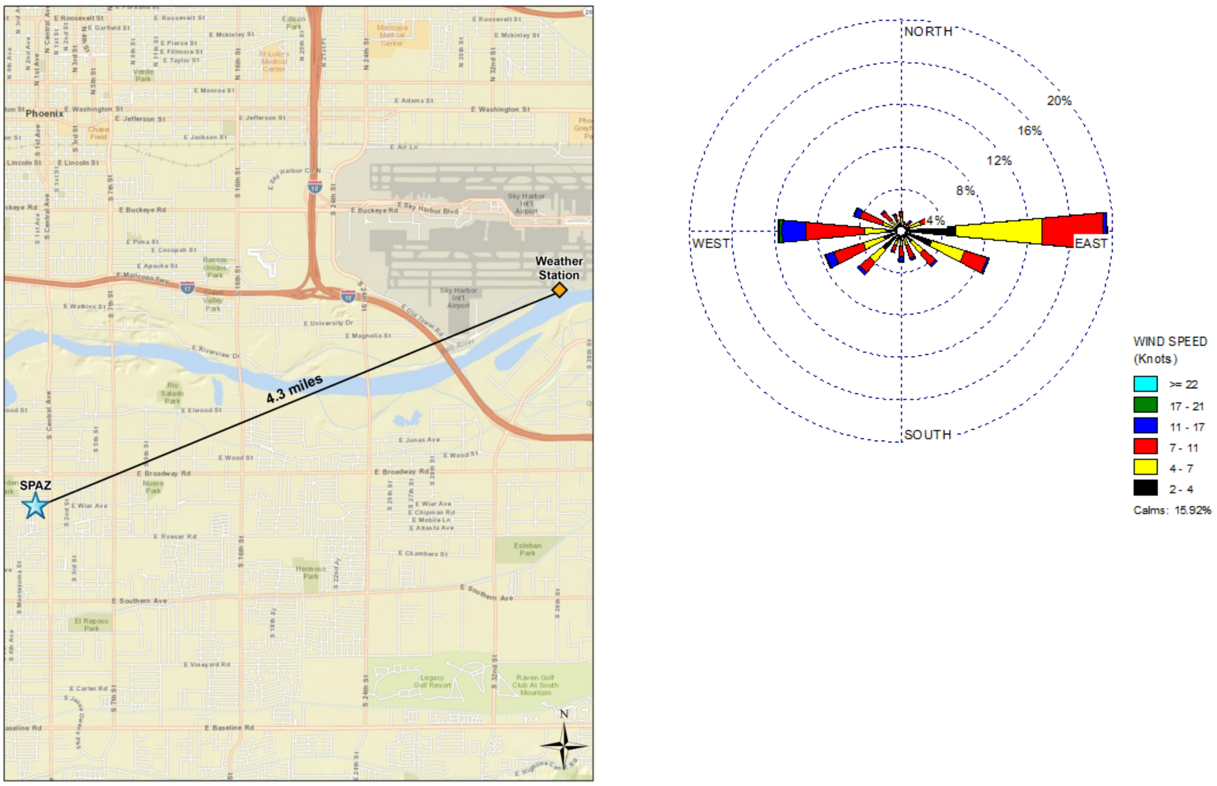
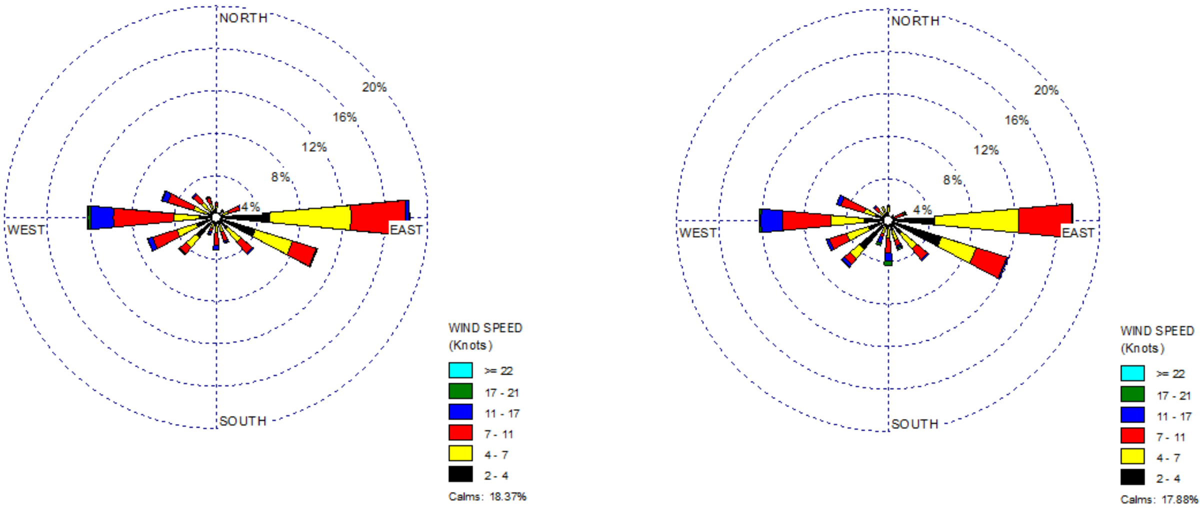


Figure 5-9. Wind Roses for the Phoenix Sky Harbor International Airport Weather Station near SPAZ


Location of SPAZ and Weather Station

2002-2011 Historical Wind Rose


2012 Wind Rose

Sample Day Wind Rose

5.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Arizona monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 5-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 5-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. PXSS sampled for VOCs, carbonyl compounds, PAHs, metals (PM_{10}), and hexavalent chromium; SPAZ sampled for VOCs only.

Table 5-4. Risk-Based Screening Results for the Arizona Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Phoenix, Arizona - PXSS						
Acetaldehyde	0.45	61	61	100.00	9.09	9.09
Benzene	0.13	61	61	100.00	9.09	18.18
1,3-Butadiene	0.03	61	61	100.00	9.09	27.27
Carbon Tetrachloride	0.17	61	61	100.00	9.09	36.36
Formaldehyde	0.077	61	61	100.00	9.09	45.45
Manganese	0.005	61	61	100.00	9.09	54.55
Arsenic	0.00023	58	61	95.08	8.64	63.19
Naphthalene	0.029	53	59	89.83	7.90	71.09
p-Dichlorobenzene	0.091	50	60	83.33	7.45	78.54
1,2-Dichloroethane	0.038	47	47	100.00	7.00	85.54
Ethylbenzene	0.4	42	61	68.85	6.26	91.80
Nickel	0.0021	24	61	39.34	3.58	95.38
Hexavalent Chromium	0.000083	9	61	14.75	1.34	96.72
Propionaldehyde	0.8	6	61	9.84	0.89	97.62
Benzo(a)pyrene	0.00057	4	36	11.11	0.60	98.21
Hexachloro-1,3-butadiene	0.045	4	5	80.00	0.60	98.81
1,1,2,2-Tetrachloroethane	0.017	3	3	100.00	0.45	99.25
1,2-Dibromoethane	0.0017	2	2	100.00	0.30	99.55
Benzo(b)fluoranthene	0.0057	1	53	1.89	0.15	99.70
Cadmium	0.00056	1	61	1.64	0.15	99.85
Dichloromethane	7.7	1	61	1.64	0.15	100.00
Total		671	1,058	63.42		

Table 5-4. Risk-Based Screening Results for the Arizona Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
South Phoenix, Arizona - SPAZ						
Benzene	0.13	30	30	100.00	18.07	18.07
1,3-Butadiene	0.03	30	30	100.00	18.07	36.14
Carbon Tetrachloride	0.17	30	30	100.00	18.07	54.22
1,2-Dichloroethane	0.038	26	26	100.00	15.66	69.88
Ethylbenzene	0.4	25	30	83.33	15.06	84.94
p-Dichlorobenzene	0.091	24	30	80.00	14.46	99.40
Chloroprene	0.0021	1	1	100.00	0.60	100.00
Total		166	177	93.79		

Observations from Table 5-4 include the following:

- The number of pollutants failing screens varied significantly between the two monitoring sites; this is expected given the difference in pollutants measured at each site.

- Twenty-one pollutants failed at least one screen for PXSS; 63 percent of concentrations for these 21 pollutants were greater than their associated risk screening value (or failed screens).

- Twelve pollutants contributed to 95 percent of failed screens for PXSS and therefore were identified as pollutants of interest for PXSS. These 12 include two carbonyl compounds, six VOCs, three PM_{10} metals, and one PAH.

- PXSS failed the second highest number of screens (671) among all NMP sites, behind only S4MO with 692 failed screens (refer to Table 4-8 of Section 4.2). However, the failure rate for PXSS, when incorporating all pollutants with screening values, is relatively low, at 26 percent. This is due primarily to the relatively high number of pollutants sampled for at this site, as discussed in Section 4.2.

- Seven pollutants failed screens for SPAZ; approximately 94 percent of concentrations for these seven pollutants were greater than their associated risk screening value (or failed screens). This percentage is greater than the percentage for PXSS. However, nearly all of the measured detections for the pollutants listed for SPAZ failed screens; for PXSS, the percentage of screens failed for each individual pollutant is more varied.

- Six pollutants contributed to 95 percent of failed screens for SPAZ and therefore were identified as pollutants of interest for this site.

- Of the VOCs measured at these sites, benzene, 1,3-butadiene, carbon tetrachloride, and 1,2-dichloroethane failed 100 percent of screens for each site. While other VOCs, such chloroprene (for SPAZ) and 1,2-dibromoethane (for PXSS), also failed 100 percent of screens, they were detected infrequently.

- Acetaldehyde, formaldehyde, and manganese also failed 100 percent of screens for PXSS and were detected in all of the valid samples collected at this site.

5.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Arizona monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual average concentrations are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for PXSS and SPAZ are provided in Appendices J, L, M, N, and O.

5.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Arizona monitoring site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Arizona monitoring sites are presented in Table 5-5, where applicable. Note that concentrations of the PAHs, metals, and hexavalent chromium for PXSS are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 5-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Arizona Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Phoenix, Arizona - PXSS						
Acetaldehyde	61/61	2.93 ± 0.63	2.80 ± 0.52	2.20 ± 0.45	3.72 ± 0.65	2.90 ± 0.30
Benzene	61/61	1.45 ± 0.41	0.99 ± 0.30	0.76 ± 0.21	1.97 ± 0.49	1.28 ± 0.21
1,3-Butadiene	61/61	0.25 ± 0.09	0.11 ± 0.03	0.11 ± 0.03	0.42 ± 0.11	0.22 ± 0.05
Carbon Tetrachloride	61/61	0.68 ± 0.03	0.69 ± 0.07	0.67 ± 0.03	0.69 ± 0.04	0.68 ± 0.02
p-Dichlorobenzene	60/61	0.18 ± 0.06	0.16 ± 0.03	0.13 ± 0.04	0.31 ± 0.07	0.20 ± 0.03
1,2-Dichloroethane	47/61	0.08 ± 0.02	0.09 ± 0.03	0.05 ± 0.02	0.06 ± 0.03	0.07 ± 0.01
Ethylbenzene	61/61	0.72 ± 0.25	0.58 ± 0.15	0.52 ± 0.16	1.11 ± 0.28	0.73 ± 0.12
Formaldehyde	61/61	3.96 ± 0.53	3.84 ± 0.51	3.74 ± 0.55	4.30 ± 0.62	3.96 ± 0.27
Arsenic (PM$_{10}$)[a]	61/61	0.93 ± 0.38	0.60 ± 0.12	0.45 ± 0.09	0.75 ± 0.16	0.68 ± 0.11
Manganese (PM$_{10}$)[a]	61/61	27.76 ± 13.45	25.58 ± 7.50	16.75 ± 4.71	21.31 ± 4.16	22.75 ± 4.01
Naphthalene[a]	59/59	110.69 ± 27.32	51.62 ± 12.04	45.13 ± 12.58	190.04 ± 43.90	97.83 ± 19.46
Nickel (PM$_{10}$)[a]	61/61	2.39 ± 0.69	2.66 ± 1.05	1.45 ± 0.34	1.70 ± 0.31	2.04 ± 0.34
South Phoenix, Arizona - SPAZ						
Benzene	30/30	1.62 ± 0.74	0.99 ± 0.27	0.85 ± 0.31	2.40 ± 0.50	1.43 ± 0.30
1,3-Butadiene	30/30	0.27 ± 0.14	0.13 ± 0.05	0.13 ± 0.05	0.53 ± 0.14	0.26 ± 0.07
Carbon Tetrachloride	30/30	0.61 ± 0.14	0.65 ± 0.07	0.65 ± 0.05	0.67 ± 0.02	0.65 ± 0.04
p-Dichlorobenzene	30/30	0.17 ± 0.08	0.17 ± 0.05	0.22 ± 0.10	0.50 ± 0.09	0.26 ± 0.06
1,2-Dichloroethane	26/30	0.08 ± 0.03	0.08 ± 0.03	0.06 ± 0.02	0.09 ± 0.03	0.08 ± 0.01
Ethylbenzene	30/30	0.85 ± 0.44	0.62 ± 0.22	0.56 ± 0.24	1.41 ± 0.31	0.84 ± 0.18

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for PXSS from Table 5-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde (3.96 ± 0.27 $\mu g/m^3$) and acetaldehyde (2.90 ± 0.30 $\mu g/m^3$). Benzene is the only other pollutant of interest with an annual average concentration greater than 1 $\mu g/m^3$ (1.28 ± 0.21 $\mu g/m^3$) for this site.

- The first and fourth quarter average concentrations for 1,3-butadiene are greater than the second and third quarter average concentrations, supporting the seasonal tendency discussed in Section 4.4.2, with higher quarterly averages for the quarters that include colder months of the year. The quarterly averages for benzene exhibit a similar tendency.

- The fourth quarter average concentrations of many of PXSS's pollutants of interest (including acetaldehyde, formaldehyde, *p*-dichlorobenzene, ethylbenzene, and naphthalene) are higher than the other quarterly averages. A review of the data shows that many of the highest concentrations of the VOCs were measured during the period from October 30, 2012 through December 23, 2012. Higher measurements were also collected on the first two sample days of 2012 (January 4th and January 10th). This is particularly true for naphthalene. All but one of the nine concentrations of naphthalene greater than 200 ng/m^3 were measured at PXSS during the fourth quarter of 2012.

- Manganese is the pollutant with the highest annual average concentration (22.75 ± 4.01 ng/m^3) of the three PM_{10} metals. The first and second quarter averages are higher than the other quarterly averages and the first quarter average has a relatively large confidence interval associated with it. The maximum concentration of this pollutant (106 ng/m^3) was measured at PXSS on January 22, 2012, is nearly twice the next highest concentration of this pollutant measured at PXSS (62.2 ng/m^3), and is the fifth highest manganese concentration measured among NMP sites sampling PM_{10} metals. Three of the 10 highest manganese concentrations among NMP sites sampling PM_{10} metals were measured at PXSS. Figure 4-28a in Section 4.4.2 shows that PXSS is one of the three NMP sites with the highest quarterly averages of manganese (besides ASKY-M and S4MO).

- The first and second quarter averages of nickel are also higher than the other quarterly averages while the second quarter average has a relatively large confidence interval associated with it. The maximum nickel concentration (7.73 ng/m^3) was measured at PXSS on June 20, 2012 and ties for eighth highest among nickel concentrations measured among NMP sites sampling PM_{10} metals. The second highest nickel concentration measured at PXSS (6.55 ng/m^3) was also measured during the second quarter and ranks 12th highest across the program. However, the third through seventh highest concentrations of nickel were all measured in January and February.

- The quarterly averages of arsenic have a similar pattern as the VOCs and carbonyl compounds in that they are higher during the first and fourth quarters of 2012. All but one of the nine arsenic concentrations greater than 1 ng/m^3 measured at PXSS were measured in samples collected in January, February, November, or December.

Observations for SPAZ from Table 5-5 include the following:

- The pollutant of interest with the highest annual average concentration for SPAZ is benzene (1.43 ± 0.30 $\mu g/m^3$), which is the only pollutant of interest with an annual average concentration greater than 1 $\mu g/m^3$.

- The fourth quarter average concentration of 1,3-butadiene for SPAZ is the highest valid quarterly average of this pollutant among all NMP sites sampling this pollutant, as shown in Figure 4-20 in Section 4.4.2. The maximum 1,3-butadiene concentration measured at SPAZ (0.738 $\mu g/m^3$) was measured on November 29, 2012; further, the top five 1,3-butadiene concentrations were all measured at this site in November and December. In addition, the top 10 concentrations of 1,3-butadiene measured at SPAZ (those greater than 0.25 $\mu g/m^3$) were all measured in January and February or November and December, further supporting the seasonality observations in these concentrations.

- A similar trend is shown for benzene. The top three concentrations of benzene were all measured at SPAZ in November; further, six of the eight highest concentrations (those greater than 2 $\mu g/m^3$) were measured at SPAZ during the fourth quarter of 2012 (with the other two measured during the first quarter). The three highest concentrations of ethylbenzene and *p*-dichlorobenzene were also measured at SPAZ on the same days in November as benzene. Figures 4-22 and 4-24 for *p*-dichlorobenzene and ethylbenzene in Section 4.4.2 show that the maximum quarterly average concentration for each pollutant across the program was calculated for SPAZ for the fourth quarter. SPAZ's fourth quarter benzene concentration ranks third highest among other NMP sites sampling this pollutant.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for PXSS and SPAZ from those tables include the following:

- PXSS and SPAZ appear in Tables 4-9 through 4-12 a total of 16 times.

- SPAZ has the highest annual average concentration of 1,3-butadiene and *p*-dichlorobenzene, similar to 2011, among all NMP sites sampling VOCs. SPAZ also has the second highest annual average concentration of benzene and ethylbenzene. PXSS has the second highest annual average concentrations of 1,3-butadiene and *p*-dichlorobenzene and the third highest annual average concentrations of benzene and ethylbenzene (behind SPAZ).

- PXSS has the highest annual average concentration of acetaldehyde and the third highest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds.

- The annual average concentration of naphthalene for PXSS ranks sixth among NMP sites sampling PAHs.

- PXSS appears in Table 4-12 for all three speciated metal pollutants of interest, with its annual averages ranking second highest for manganese, third highest for nickel, and ninth highest for arsenic, among NMP sites sampling PM_{10} metals.

5.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 5-4 for PXSS and SPAZ. Figures 5-10 through 5-21 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 5-10. Program vs. Site-Specific Average Acetaldehyde Concentration

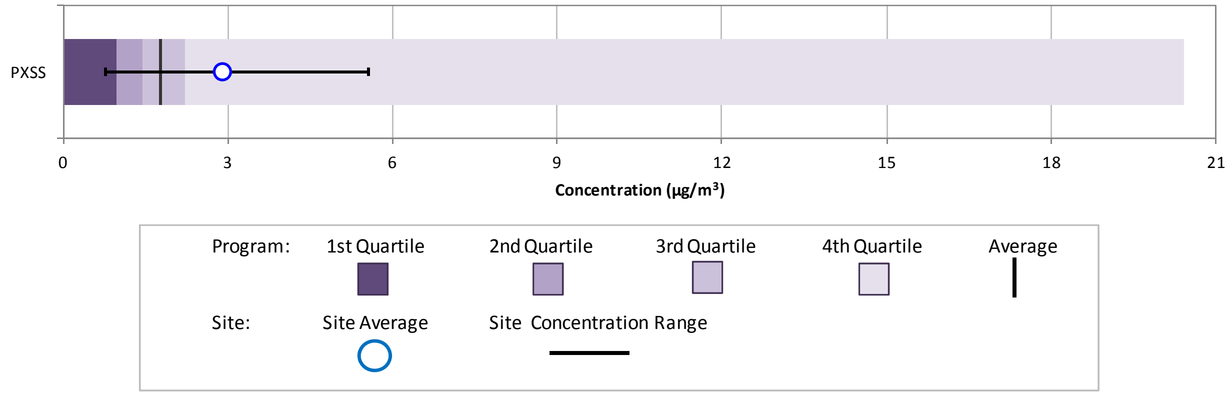


Figure 5-11. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

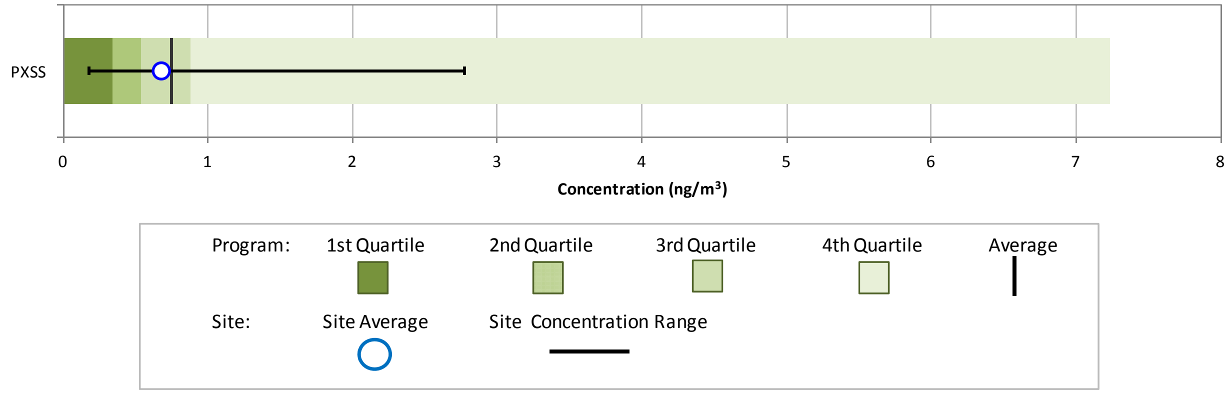


Figure 5-12. Program vs. Site-Specific Average Benzene Concentrations

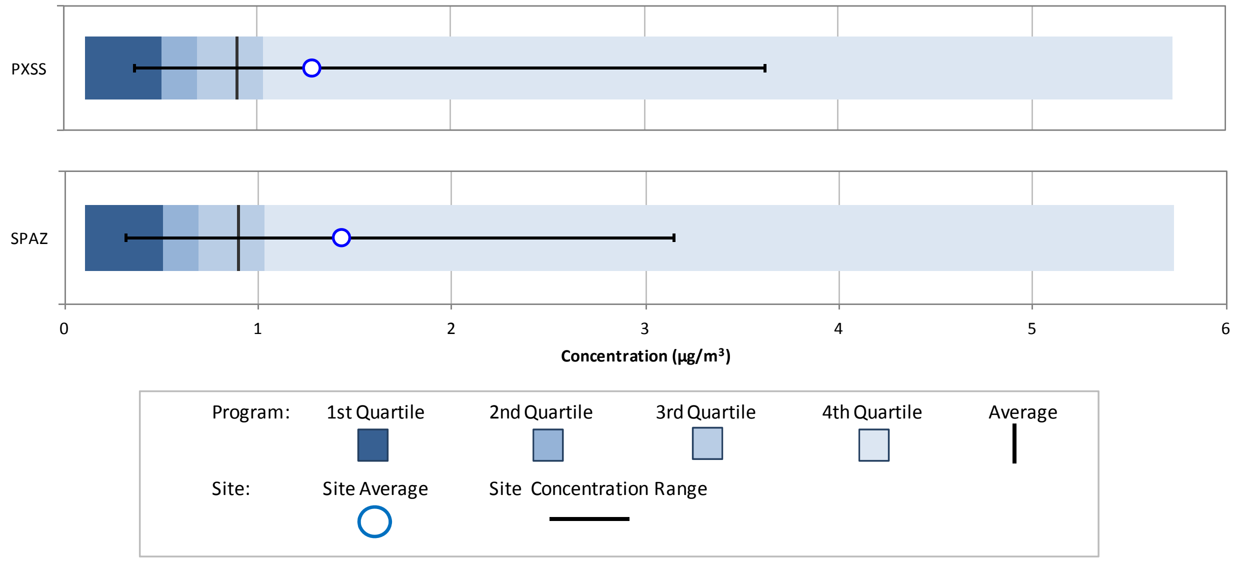


Figure 5-13. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

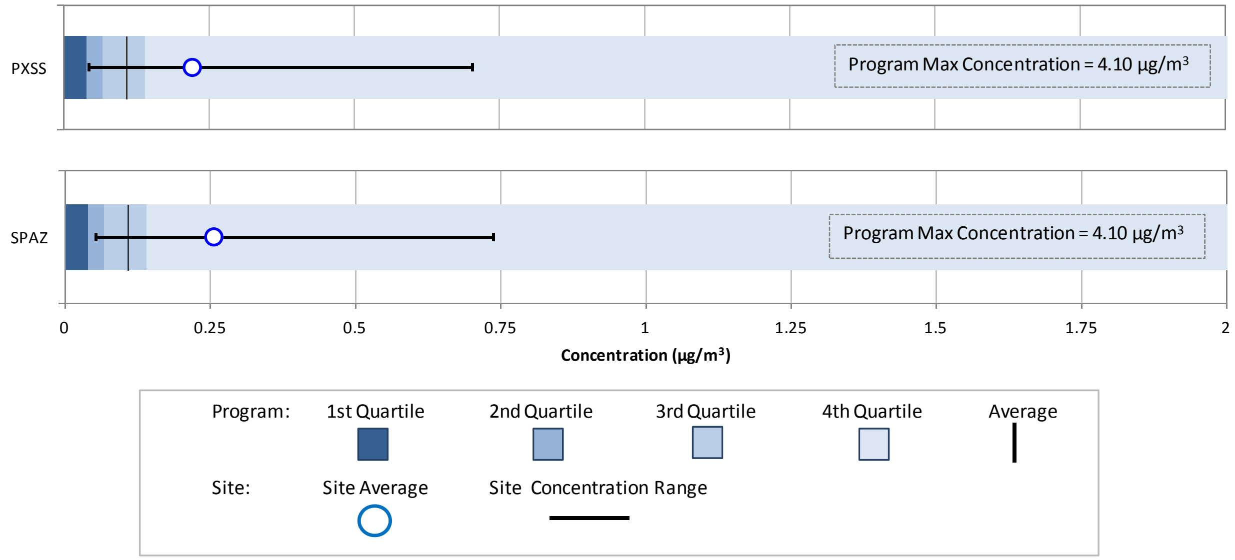


Figure 5-14. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

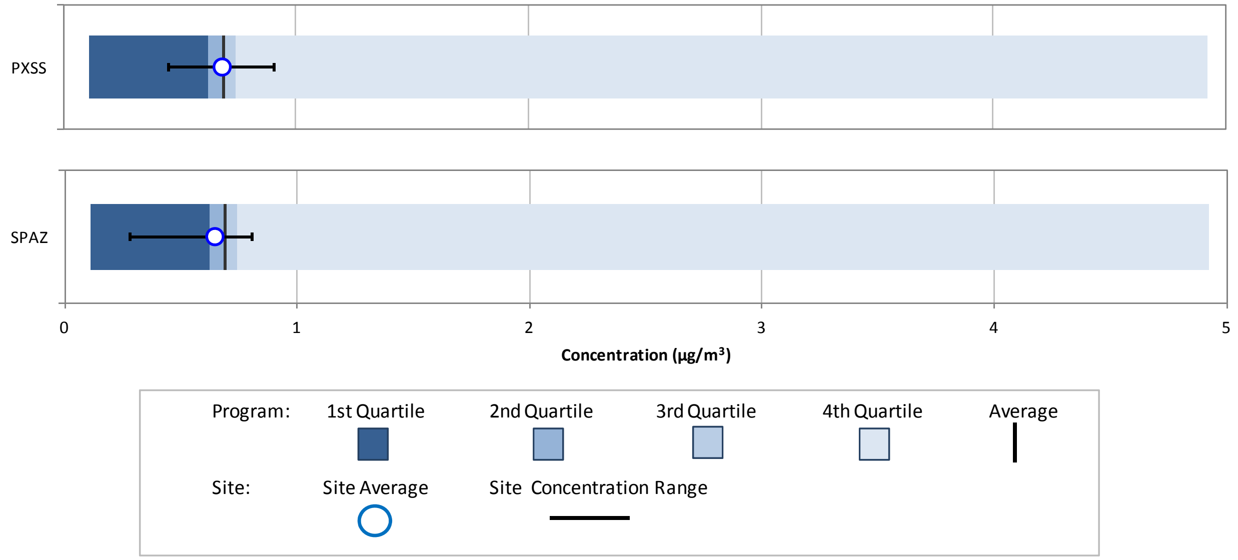


Figure 5-15. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentrations

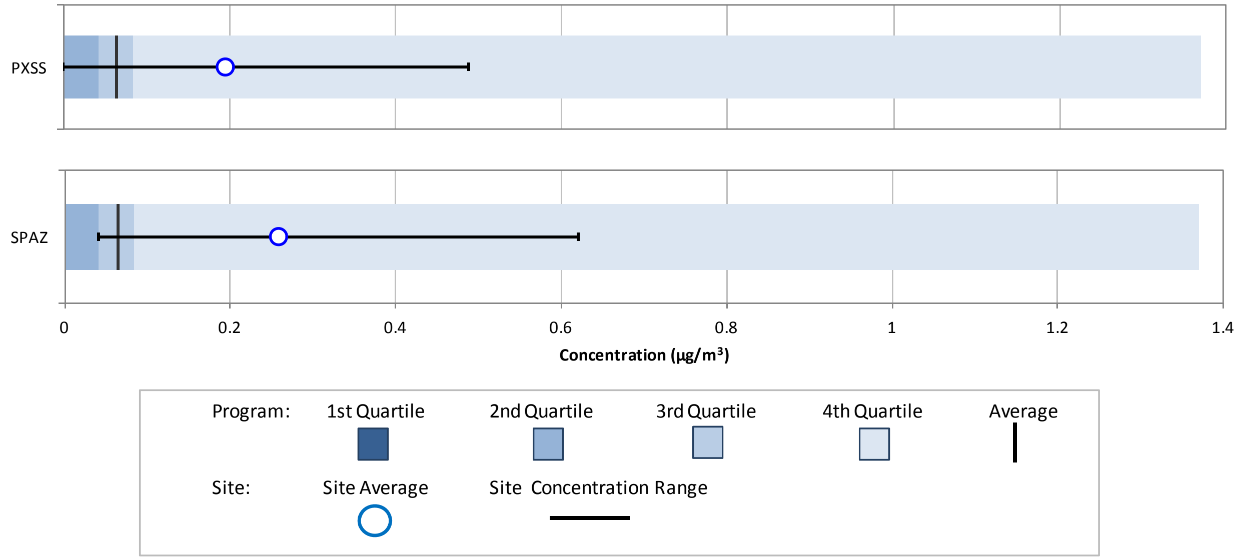


Figure 5-16. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

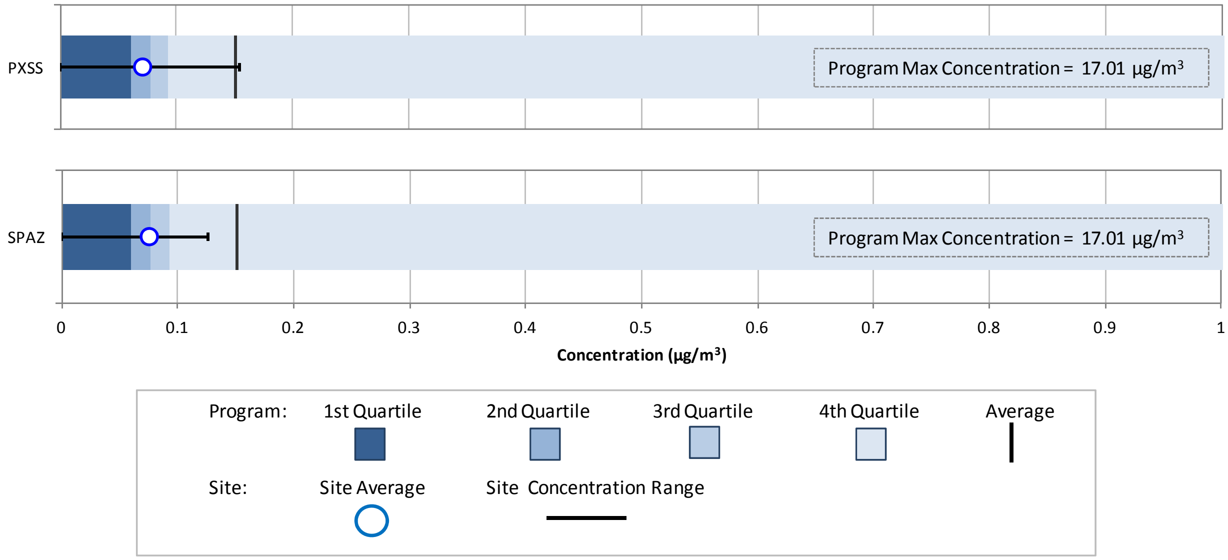


Figure 5-17. Program vs. Site-Specific Average Ethylbenzene Concentrations

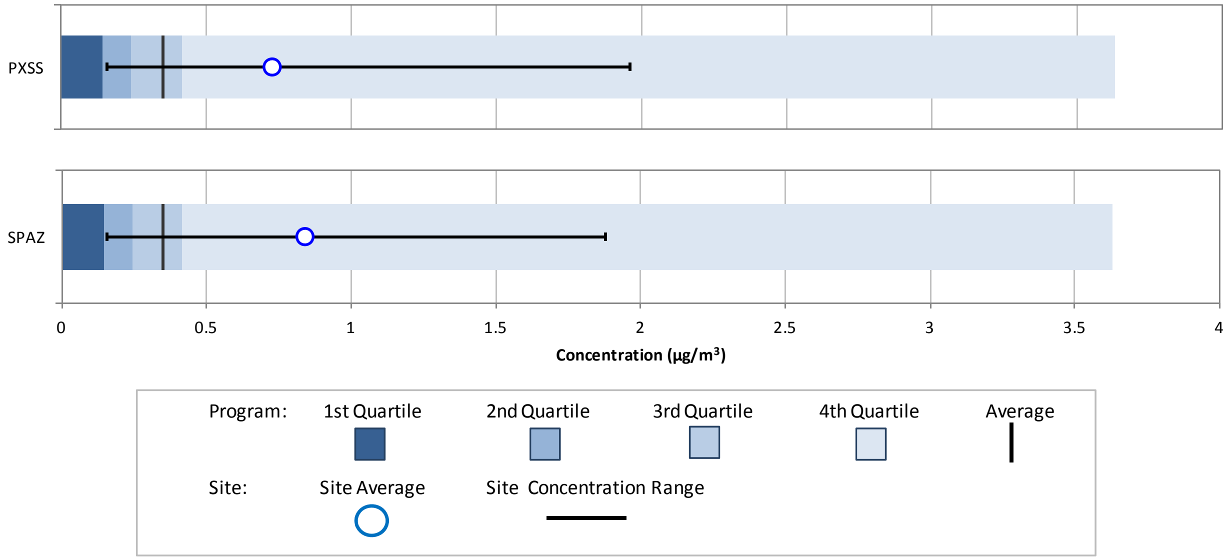


Figure 5-18. Program vs. Site-Specific Average Formaldehyde Concentration

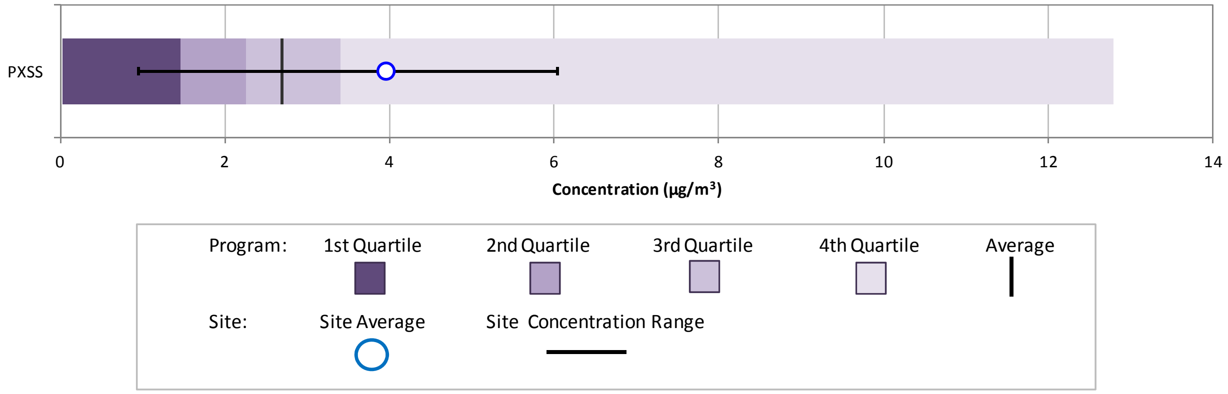


Figure 5-19. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

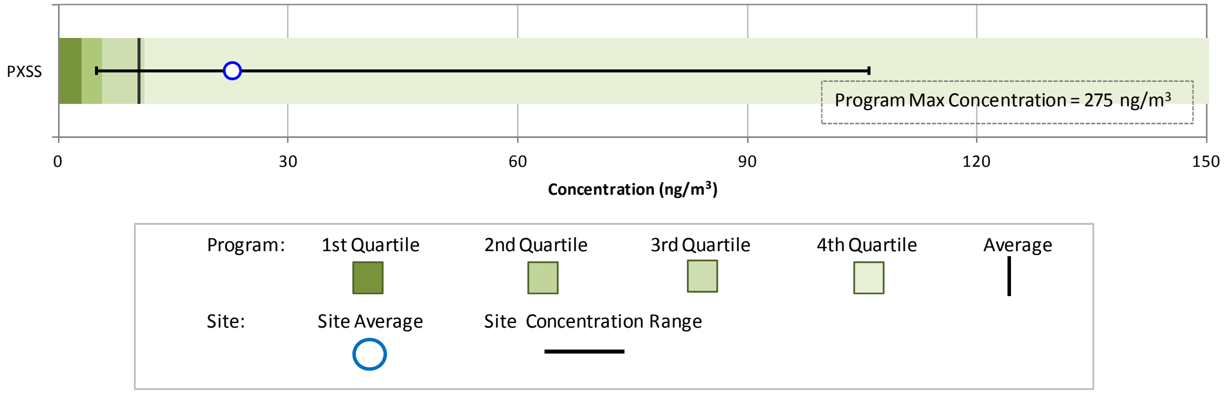


Figure 5-20. Program vs. Site-Specific Average Naphthalene Concentration

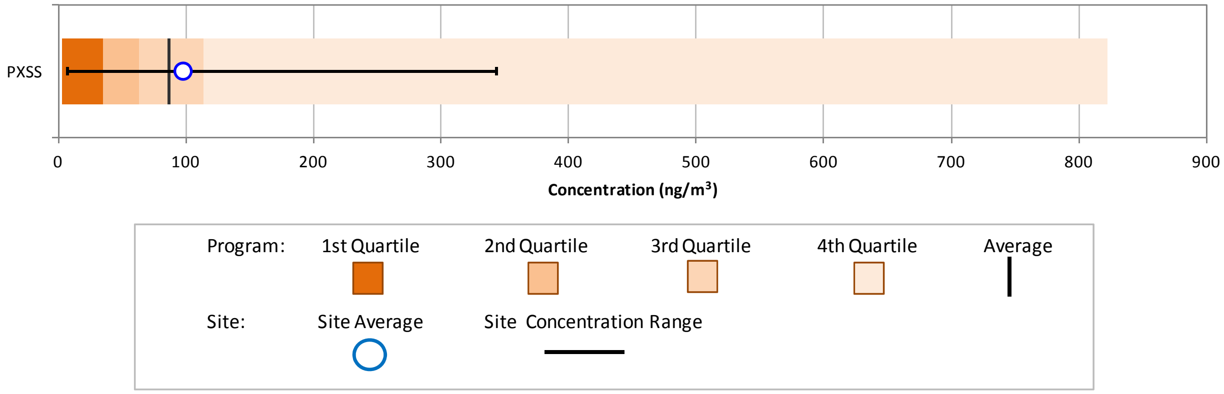
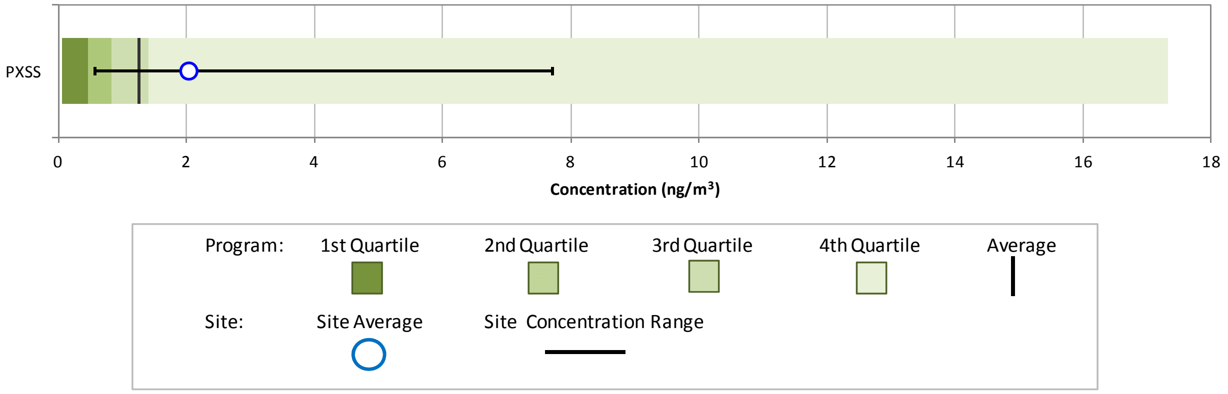


Figure 5-21. Program vs. Site-Specific Average Nickel (PM_{10}) Concentration



Observations from Figures 5-10 through 5-21 include the following:

- Figure 5-10 for acetaldehyde shows that PXSS's annual average concentration of nearly 3 µg/m^3 is greater than the program-level average concentration as well as the program-level third quartile. Recall from the previous section that PXSS has the highest annual average concentration among NMP sites sampling this pollutant. The minimum concentration measured at PXSS is just less than the program-level first quartile.

- Figure 5-11 shows that the annual average arsenic (PM_{10}) concentration for PXSS is just less than the program-level average for arsenic (PM_{10}) and ranked ninth highest among the 14 NMP sites sampling PM_{10} metals. Although the maximum concentration of arsenic measured across the program was not measured at PXSS, the maximum concentration measured at PXSS (2.76 ng/m^3) is among the higher arsenic measurements. There were no non-detects of arsenic measured at PXSS.

- Figure 5-12 for benzene shows both Arizona sites, as both SPAZ and PXSS sampled VOCs. While neither Arizona site measured the maximum benzene concentration measured across the program, both annual averages are greater than the program-level average concentration. The annual average benzene concentration for SPAZ is slightly higher than the annual average concentration for PXSS, although the range of concentrations measured is greater for PXSS. SPAZ and PXSS have the second and third highest annual average concentrations of benzene, respectively, among NMP sites sampling this pollutant.

- Figure 5-13 for 1,3-butadiene also shows both sites. Note that the program-level maximum concentration (4.10 µg/m^3) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to 2 µg/m^3. The annual average concentrations for both sites are more than twice the program-level average concentration. Further, these two sites have the highest annual average concentrations of this pollutant across the program, as mentioned above, with the annual average concentration for SPAZ slightly higher than the annual average concentration for PXSS. The minimum concentrations measured at these two sites are greater than the program-level first quartile.

- Figure 5-14 presents the box plots for carbon tetrachloride for both sites. Figure 5-14 shows that the annual average concentration of carbon tetrachloride for PXSS is nearly identical to the program-level average while the annual average for SPAZ is just less than the program-level average concentration. The range of concentrations measured at PXSS is slightly less than the range for SPAZ, although the minimum concentration measured at SPAZ is less than that of PXSS.

- Figure 5-15 presents the box plots for *p*-dichlorobenzene for both sites. Note that the program-level first quartile is zero and therefore not visible on the box plots. Similar to 1,3-butadiene, SPAZ and PXSS have the highest annual average concentrations of *p*-dichlorobenzene among NMP sites sampling VOCs. The annual average for PXSS is three times the program-level average concentration and the annual average for SPAZ is four times the program-level average. Although the maximum concentrations measured at these sites are considerably less than the program maximum concentration, several of the concentrations measured at SPAZ are among the highest measured across the program. A single non-detect of *p*-dichlorobenzene was measured at PXSS while the minimum concentration measured at SPAZ is equivalent to the program-level median concentration.

- Figure 5-16 presents the box plots for 1,2-dichloroethane for both sites. Note that the program-level maximum concentration (17.01 µg/m^3) is not shown directly on the box plots as the scale has been reduced to 1 µg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is greater than the program-level third quartile for this pollutant and is greater than or similar to the maximum concentration measured at most sites sampling 1,2-dichloroethane. This is because the program-level average is being driven by the higher measurements collected at a handful of monitoring sites. Figure 5-16 shows that the maximum 1,2-dichloroethane concentrations measured at the Arizona sites are two orders of magnitude less than the maximum concentration measured across the program. The annual averages for SPAZ and PXSS are similar to the median concentration at the program level. The maximum concentration measured at PXSS is similar to the program-level average concentration while the maximum concentration measured at SPAZ is less than the program-level average concentration. Non-detects of 1,2-dichloroethane were measured at both Arizona sites, although the number is greater for PXSS (14) than SPAZ (4).

- Figure 5-17 presents that box plots for ethylbenzene for the Arizona monitoring sites. While neither Arizona site measured the maximum ethylbenzene concentration measured across the program, both annual averages are more than twice the program-level average concentration, and both are greater than the program-level the third quartile. The annual average ethylbenzene concentration for SPAZ is slightly higher than the annual average concentration for PXSS, although the maximum concentration measured at PXSS is slightly higher than the maximum concentration measured at SPAZ. SPAZ and PXSS have the second and third highest annual average concentrations of ethylbenzene, respectively, among NMP sites sampling this pollutant. The minimum ethylbenzene concentrations measured at PXSS and SPAZ are greater than the program-level first quartile.

- Figure 5-18 is the box plot for formaldehyde. This figure shows that the annual average concentration for PXSS is greater than both the program-level average concentration and third quartile. Recall from the previous section that this site has the third highest annual average concentration among NMP sites sampling carbonyl compounds.

- Figure 5-19 is the box plot for manganese (PM_{10}) for PXSS. Note that the program-level maximum concentration (275 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 150 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. Note also that the program-level average is just less than the program-level third quartile, indicating that the measurements at the higher end of the concentration range are driving the average. Figure 5-19 shows the annual average concentration of manganese for PXSS (22.75 ng/m^3) is more than twice the program-level average concentration (10.58 ng/m^3) and twice the program-level third quartile (11.18 ng/m^3). PXSS has the second highest annual average concentration of manganese among NMP sites sampling PM_{10} metals, as discussed above. While the maximum concentration measured at PXSS (106 ng/m^3) is considerably less than the program-level maximum concentration, this is the fifth highest measurement of manganese measured among the NMP sites sampling PM_{10} metals. The minimum concentration measured at PXSS (5.07 ng/m^3) is just less than the program-level median concentration (5.80 ng/m^3). There were no non-detects of manganese measured among sites sampling PM_{10} metals.

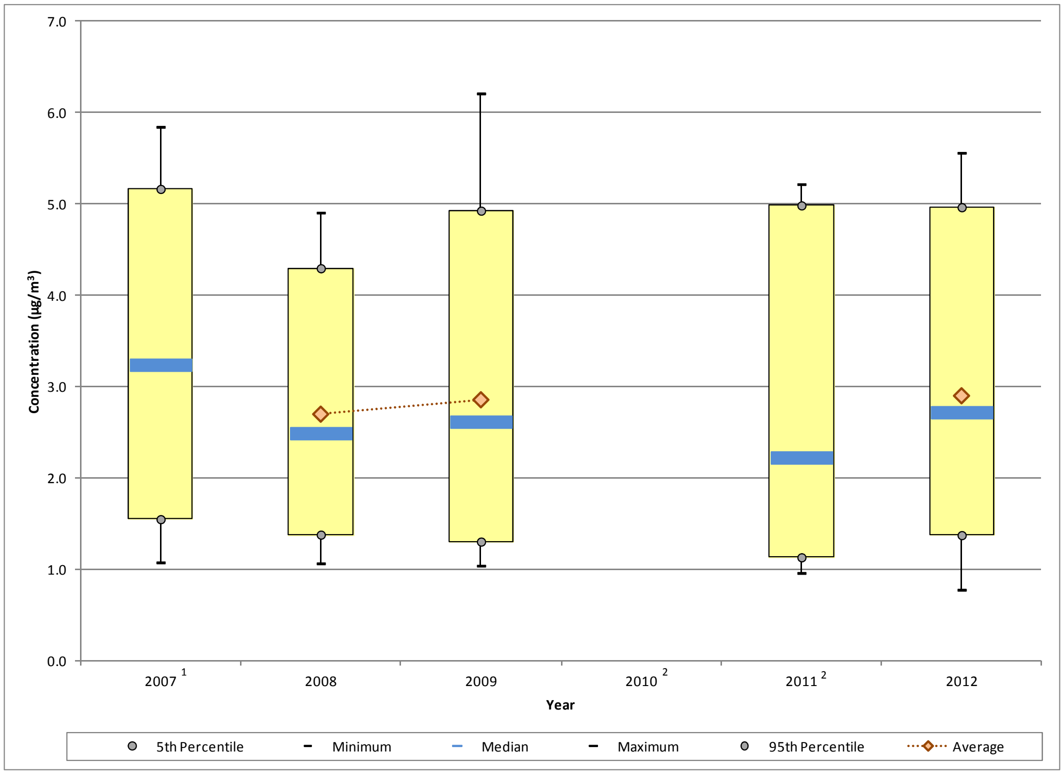
- Figure 5-20 is the box plot for naphthalene for PXSS. Figure 5-20 shows that the annual average naphthalene concentration of just less than 100 ng/m^3 is greater than the program-level average concentration (86.37 ng/m^3). The maximum naphthalene concentration measured at PXSS (343 ng/m^3) is considerably less than the maximum concentration measured at the program level. There were no non-detects of naphthalene measured at PXSS or among sites sampling PAHs.

- Figure 5-21 is the box plot for nickel (PM_{10}) for PXSS. The program-level average is just less than the program-level third quartile, indicating that the measurements at the higher end of the concentration range are driving the program average. Figure 5-21 shows the annual average concentration of nickel for PXSS is greater than the program-level average concentration and the program-level third quartile. The minimum concentration measured at PXSS is greater than the program-level first quartile and is the highest minimum nickel concentration among NMP sites sampling PM_{10} metals. Recall from the previous section that PXSS has the third highest annual average concentration of nickel.

5.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. PXSS has sampled PM_{10} metals under the NMP since 2006; in addition, SPAZ began sampling VOCs and PXSS began sampling VOCs, carbonyl compounds, and PAHs under the NMP in 2007. Thus, Figures 5-22 through 5-39 present the 1-year statistical metrics for each of the pollutants of interest first for PXSS, then for SPAZ. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 5-22. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at PXSS



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.
[2] Some statistical metrics are not presented because data from Feb 2010 to March 2011 was invalidated.

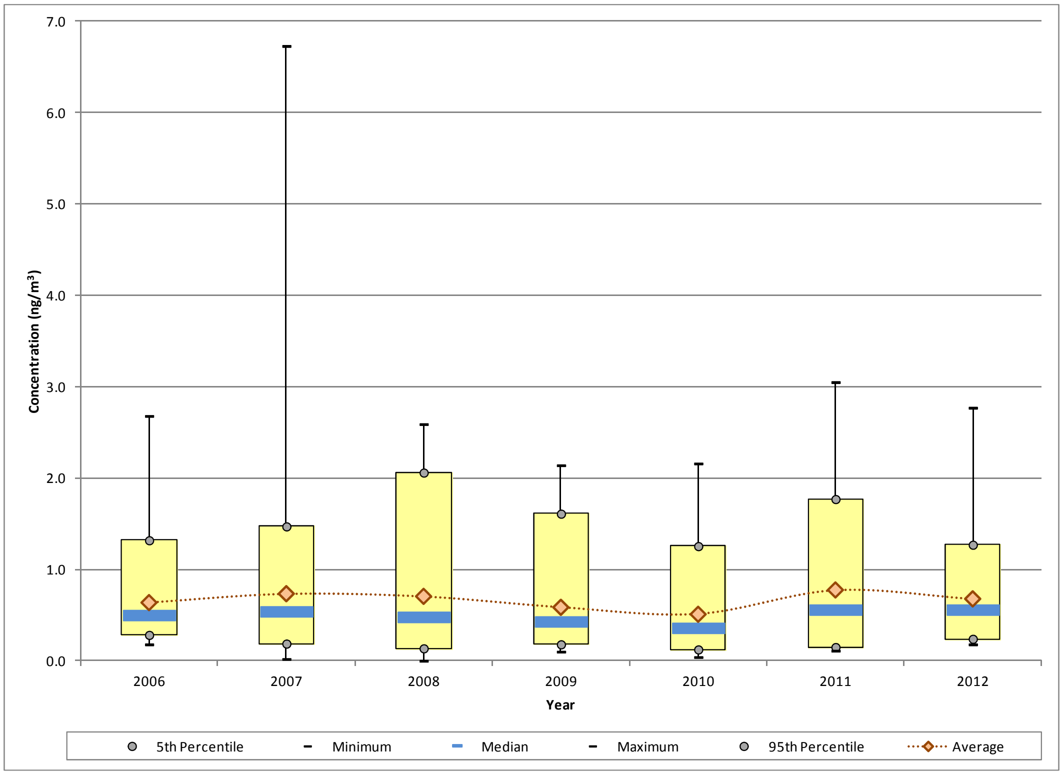
Observations from Figure 5-22 for acetaldehyde measurements collected at PXSS include the following:

- PXSS began sampling acetaldehyde under the NMP in July 2007. Because a full year's worth of data is not available, a 1-year average for 2007 is not presented, although the range of measurements is provided. In addition, much of the data between February 2010 and March 2011 was invalidated due to sampler maintenance issues on the primary sampler. No statistical metrics are provided for 2010 due to the low number of valid measurements. The range of measurements is provided for 2011, although a 1-year average is not provided.

- The maximum acetaldehyde concentration (6.21 µg/m^3) was measured on January 1, 2009, although this measurement is not significantly higher than the maximum concentrations measured in other years.

- A distinct trend is hard to identify because few 1-year averages are shown. However, the range of measurements has remained fairly static over the years. The median concentrations have varied from 2.23 µg/m^3 (2011) to 3.24 µg/m^3 (2007).

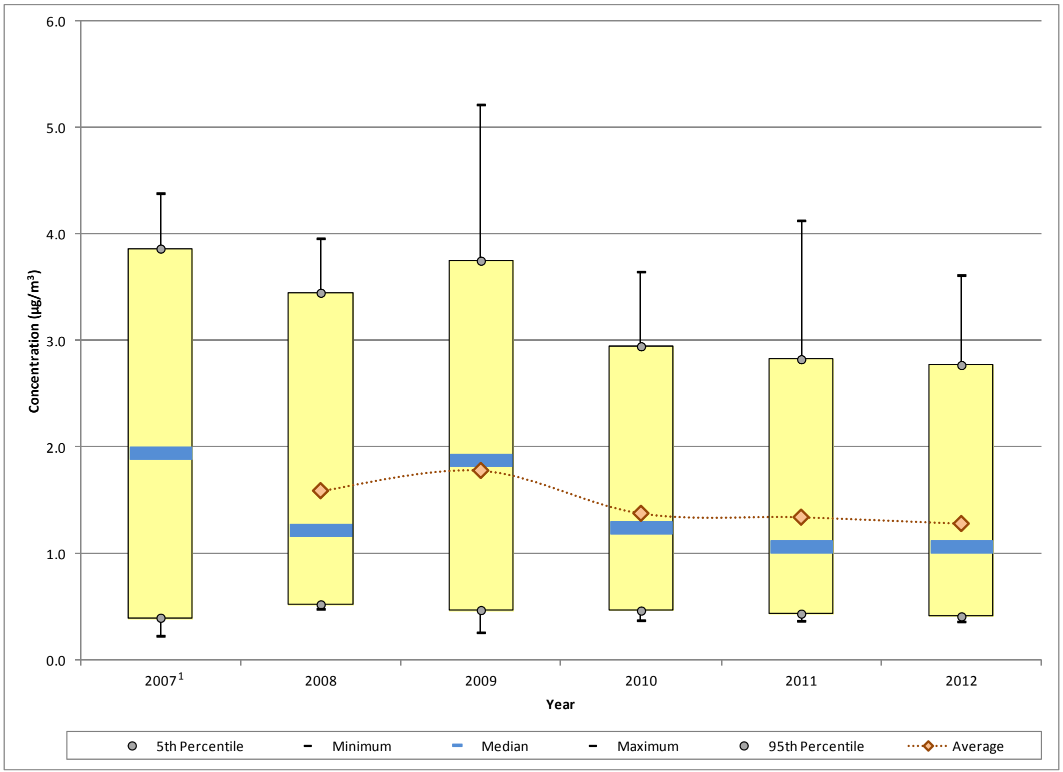
Figure 5-23. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at PXSS



Observations from Figure 5-23 for arsenic measurements collected at PXSS include the following:

- PXSS began sampling arsenic under the NMP in January 2006.
- The maximum arsenic concentration (6.73 ng/m^3) was measured on December 26, 2007 and is more than twice the next highest concentration (3.05 ng/m^3), measured on August 19, 2011. The third highest concentration was measured on January 10, 2012 (2.77 ng/m^3).
- The 1-year average concentration increased from 2010 to 2011 after several years of a slight decreasing trend, although the changes across the years of sampling are not statistically significant. The 1-year averages range from 0.51 ng/m^3 (2010) to 0.77 ng/m^3 (2011).
- The median concentrations did not change between 2011 and 2012 (0.56 ng/m^3). However, the 95th percentile decreased by 0.5 ng/m^3. For both years, the 95th percentile represents the fourth highest concentration measured at PXSS. While the number of measurements between 1 ng/m^3 and the 95th percentile decreased from 12 to five from 2011 to 2012, the number of measurements between the median and 1 ng/m^3 increased from 14 to 21, resulting in an unchanged median (or 50th percentile) concentration.

Figure 5-24. Yearly Statistical Metrics for Benzene Concentrations Measured at PXSS



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-24 for benzene measurements collected at PXSS include the following:

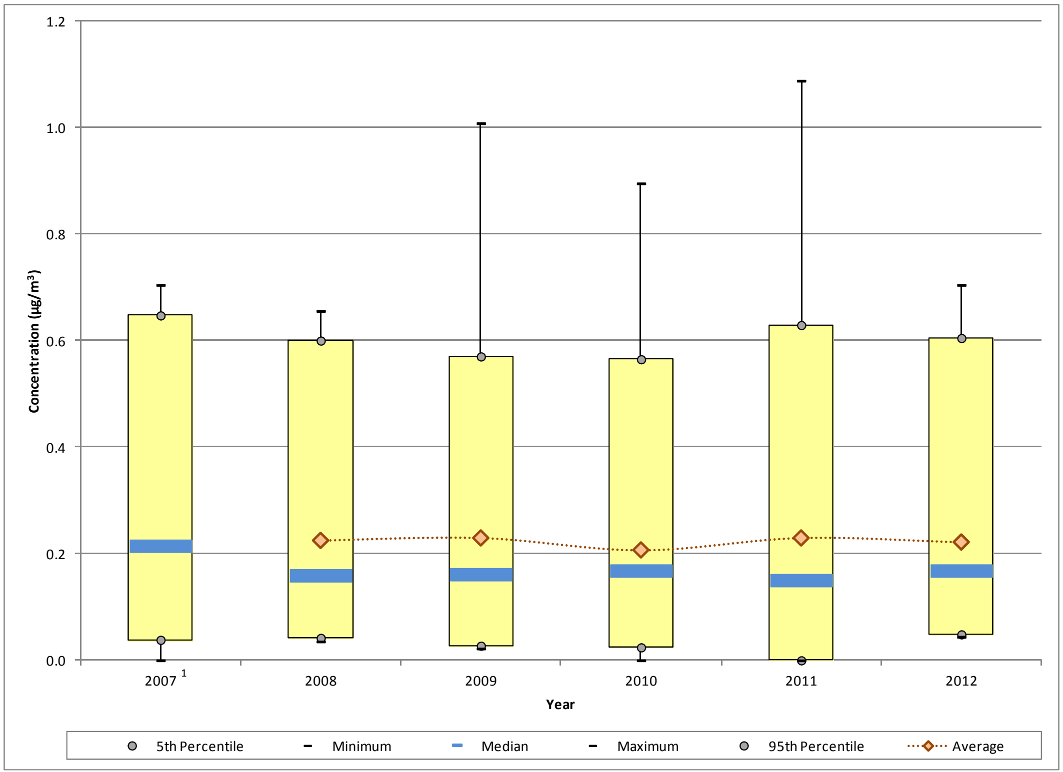
- PXSS began sampling VOCs under the NMP in July 2007. Because a full year's worth of data is not available, a 1-year average for 2007 is not presented, although the range of measurements is provided.

- The maximum benzene concentration shown was measured on January 1, 2009 (5.21 µg/m^3). Only three additional measurements greater than 4 µg/m^3 have been measured at this site (one each in 2007, 2009, and 2011).

- After an increase from 2008 to 2009, the 1-year average benzene concentration has a decreasing trend, although the largest change is from 2009 to 2010. The median concentration exhibits a similar trend.

- The median concentration increased significantly from 2008 to 2009 and is actually greater than the 1-year average concentration for 2009. A review of the data shows that the number of concentrations greater than 2 µg/m^3 increased from 15 to 24 from 2008 to 2009, representing more than 42 percent of the concentrations measured in 2009, as compared to 29 percent in 2008.

Figure 5-25. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at PXSS



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

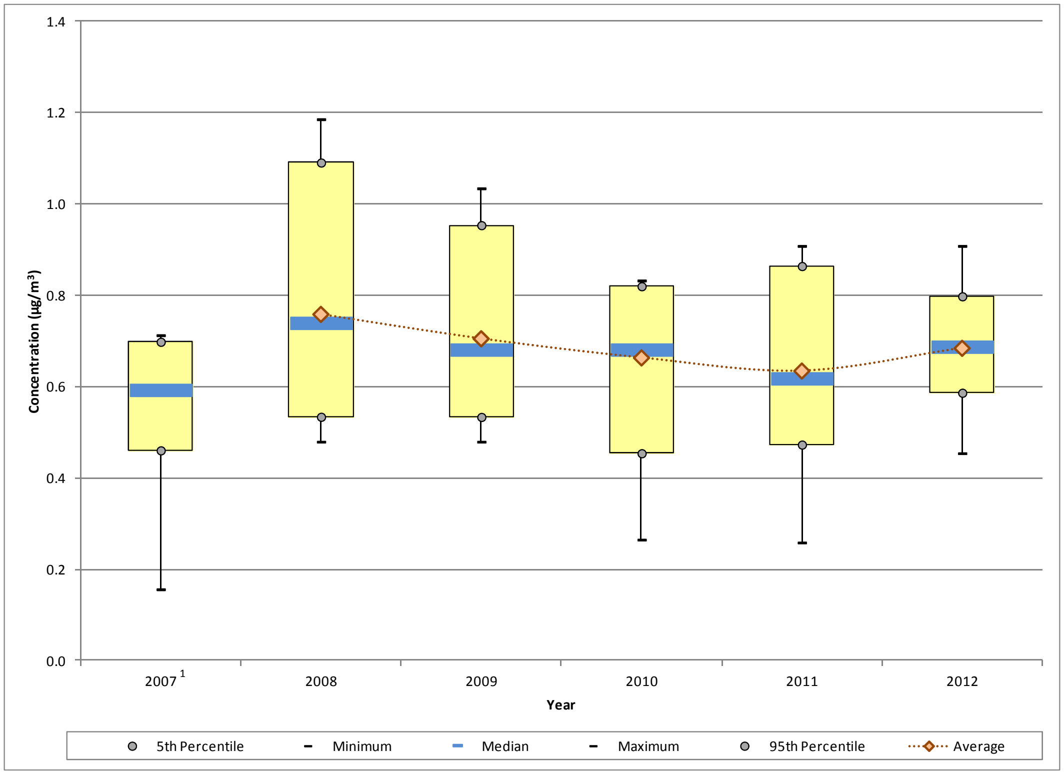
Observations from Figure 5-25 for 1,3-butadiene measurements collected at PXSS include the following:

- The maximum 1,3-butadiene concentration (1.08 µg/m^3) was measured on December 11, 2011. The only other concentration greater than 1.0 µg/m^3 was measured at PXSS on January 1, 2009. All but one of the 76 concentrations greater than 0.35 µg/m^3 were measured during the first or fourth quarters, supporting the observations regarding the trend in the quarterly averages discussed in the previous sections and Section 4.4.2.

- The 1-year average 1,3-butadiene concentrations exhibit little change over the periods shown, ranging from 0.207 µg/m^3 (2010) to 0.230 µg/m^3 (both 2009 and 2011). The median concentration exhibits a similar consistency in magnitude for the periods where 1-year averages could be calculated.

- There have been eight non-detects of 1,3-butadiene measured at PXSS since the onset of VOC sampling at PXSS under the NMP. Five of these were measured in 2011, two were measured in 2010, and one was measured in 2007. For 2011, the minimum and 5th percentile were both equal to zero. None of the non-detects of 1,3-butadiene were measured in the first or fourth quarters of the year.

Figure 5-26. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at PXSS



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-26 for carbon tetrachloride measurements collected at PXSS include the following:

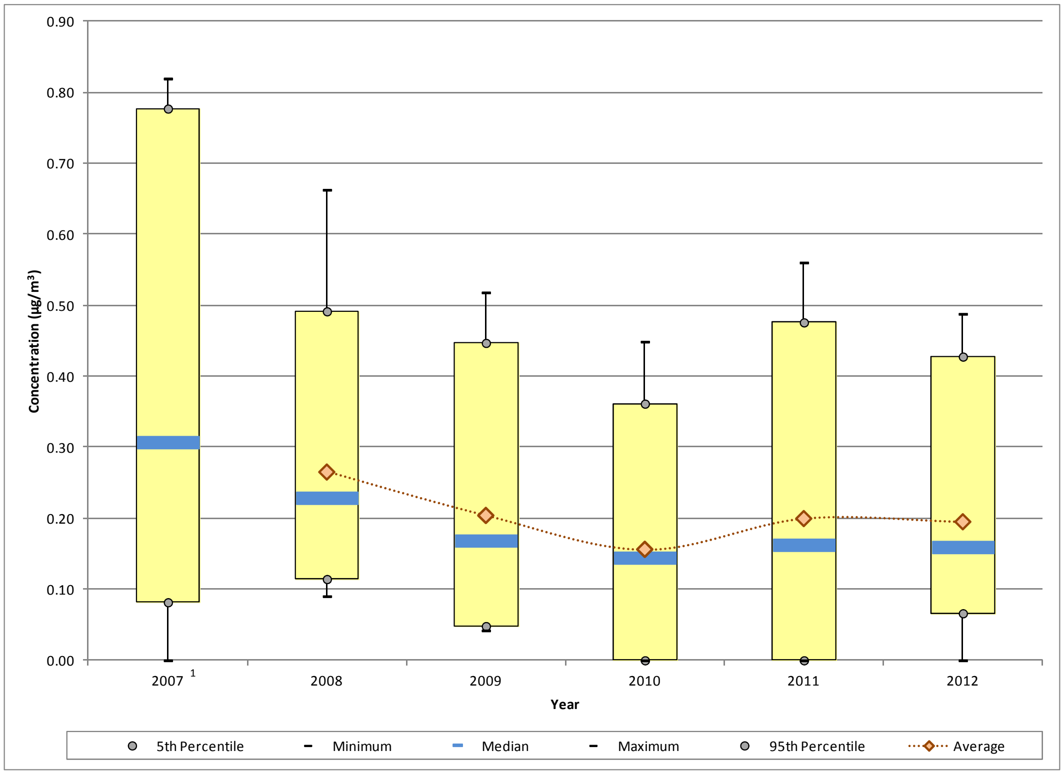
- Six concentrations of carbon tetrachloride greater than 1.0 µg/m^3 have been measured at PXSS since the onset of sampling in 2007. All of these were measured in 2008 and 2009.

- For 2007, 2010, and 2011, the box and whisker plots for this pollutant appear "inverted," with the minimum concentration extending farther away from the majority of the measurements rather than the maximum, which is more common (see benzene or 1,3-butadiene as examples).

- The 1-year average exhibits a decreasing trend through 2011, after which an increase is shown for 2012.

- The difference between the 1-year average and median concentrations is less than 0.025 µg/m^3 for each year (where both were calculated), with 2012 having the smallest difference. This indicates decreasing variability in the central tendency of this pollutant.

Figure 5-27. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at PXSS

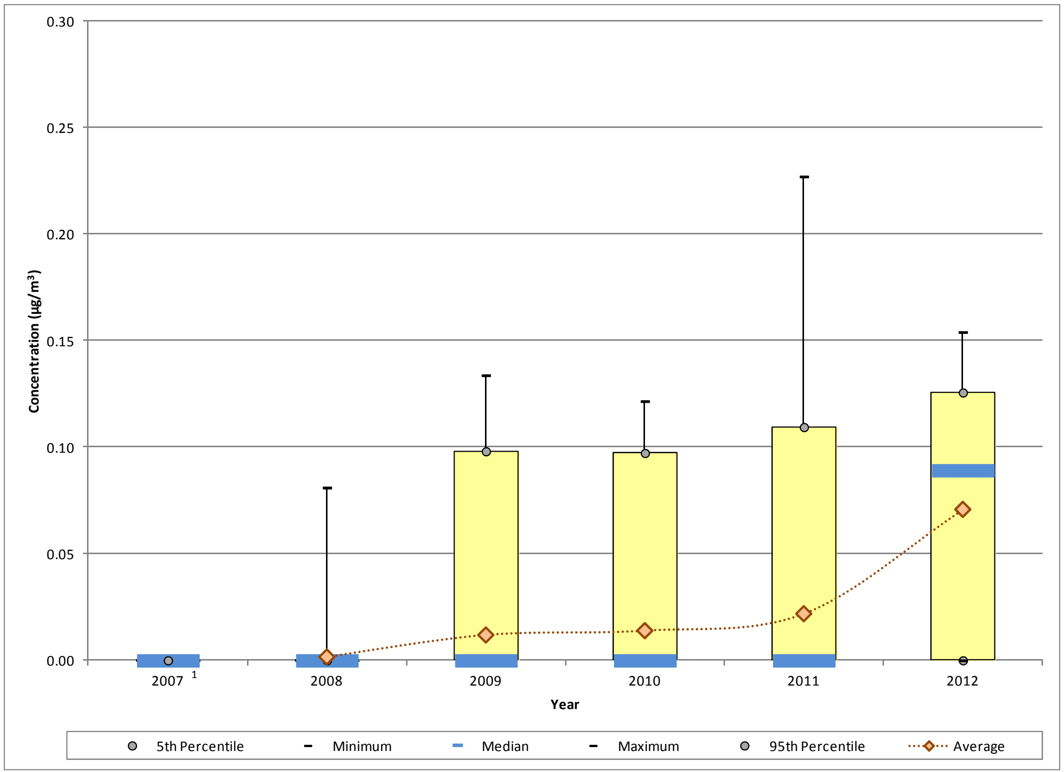


[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-27 for *p*-dichlorobenzene measurements collected at PXSS include the following:

- The three highest concentrations of *p*-dichlorobenzene were all measured in November 2007.
- The maximum, 95th percentile, 1-year average, and median concentrations all exhibit a significant decreasing trend through 2010. Even the minimum concentration and 5th percentile decreased from 2008 through 2010. Prior to 2010, a single non-detect was measured; for 2010, nine non-detects were measured. Each of the statistical parameters increased for 2011, with the exception of the minimum and 5th percentile, as six additional non-detects were measured in 2011. Only one non-detect was measured in 2012.
- Although the range of measurements within which the majority of the concentrations fall tightened up for 2012, little change is shown for the 1-year average or median concentrations from 2011 to 2012.

Figure 5-28. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at PXSS

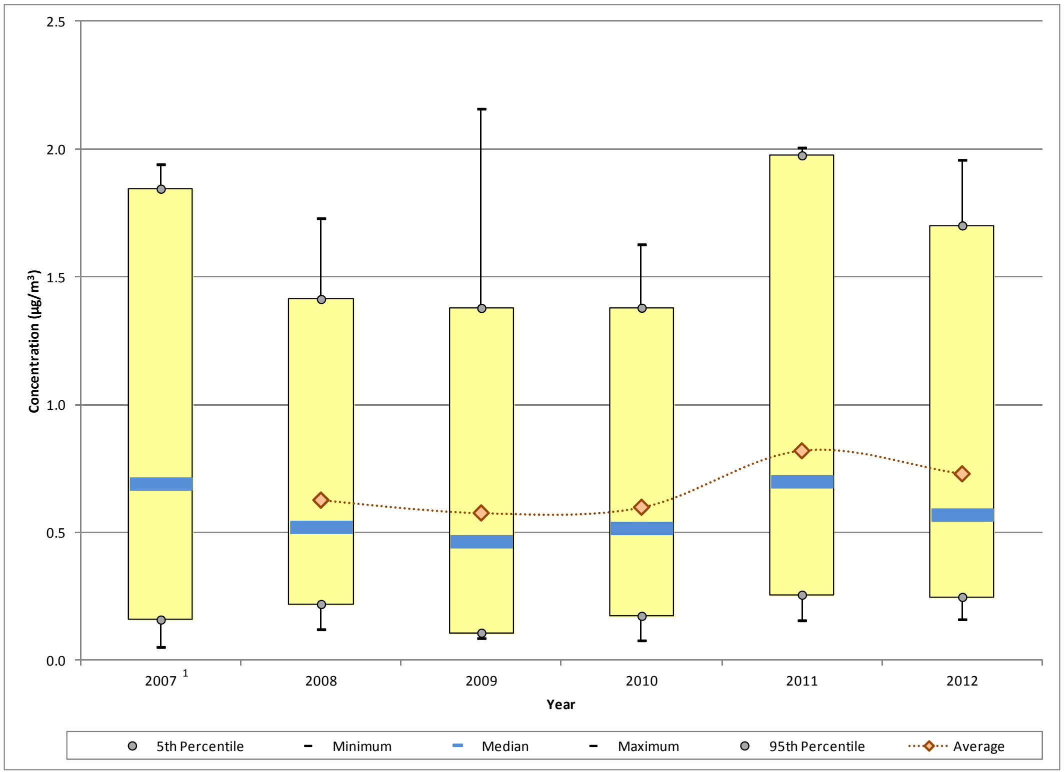


[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-28 for 1,2-dichloroethane measurements collected at PXSS include the following:

- There were no measured detections of 1,2-dichloroethane in 2007, one measured detection in 2008, seven in 2009, nine in 2010, 12 in 2011, and 47 in 2012.
- With the exception of 2012, the median concentration is zero for all years, indicating that at least 50 percent of the measurements were non-detects.
- As the number of measured detections increase, so do each of the corresponding statistical metrics shown in Figure 5-28.
- As the number of measured detections increased dramatically for 2012, the median and 1-year average concentrations increased correspondingly. The median concentration is actually greater than the 1-year average for 2012. This is because there were still 14 non-detects (or zeros) factoring into the 1-year average concentration for the year.

Figure 5-29. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at PXSS



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

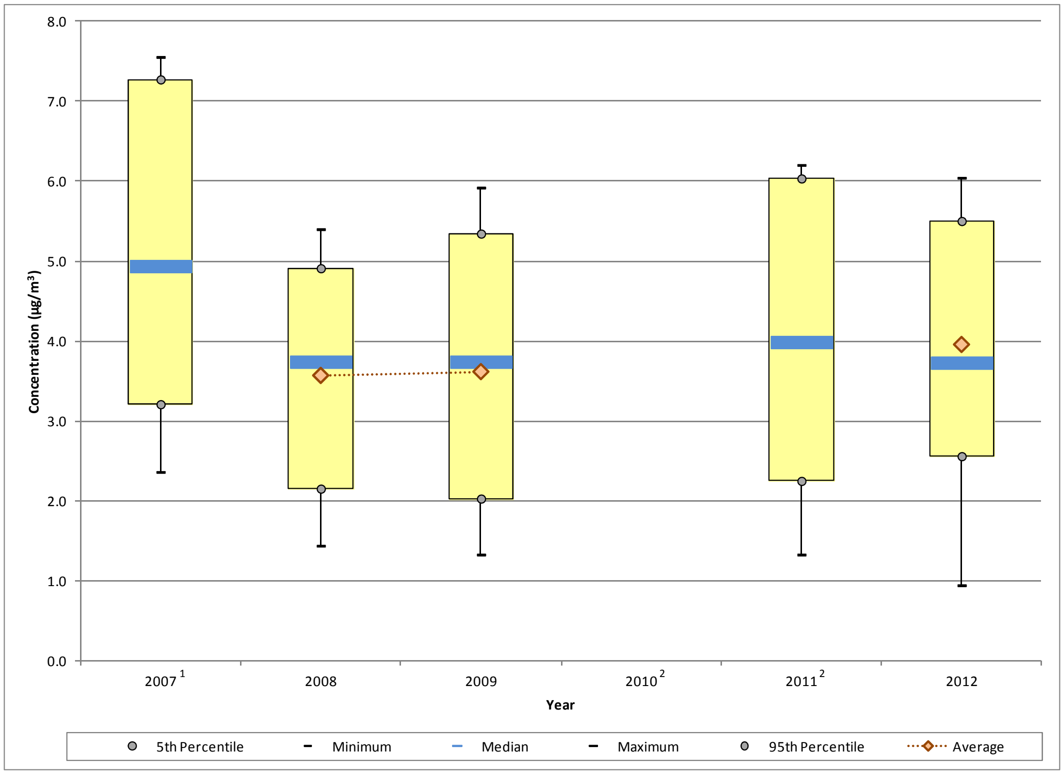
Observations from Figure 5-29 for ethylbenzene measurements collected at PXSS include the following:

- The maximum concentration of ethylbenzene measured at PXSS (2.16 µg/m^3) was measured on January 1, 2009. The next four highest concentrations were all measured in November 2011, including the only other concentration greater than 2 µg/m^3 that has been measured at PXSS (2.01 µg/m^3).

- Similar to 1,3-butadiene, the highest ethylbenzene concentrations were measured during the first and fourth quarters of the years. All but one of the 30 highest concentrations (those greater than 1.40 µg/m^3) were measured between October and December or January and March of any given year.

- The median concentration has a decreasing trend through 2009, after which an increasing trend is shown, reaching a maximum in 2011. The 1-year average concentration follows a similar pattern. All of the statistical parameters shown increased from 2010 to 2011. Nearly twice the number of measurements greater than 1 µg/m^3 (20) were measured in 2011 than the previous years (11 or less), accounting for one-third of the total measurements for that year. The number of measurements greater than 1 µg/m^3 for 2012 is down slightly (14) but still higher than years prior to 2011.

Figure 5-30. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at PXSS



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.
[2] Some statistical metrics are not presented because data from Feb 2010 to March 2011 was invalidated.

Observations from Figure 5-30 for formaldehyde measurements collected at PXSS include the following:

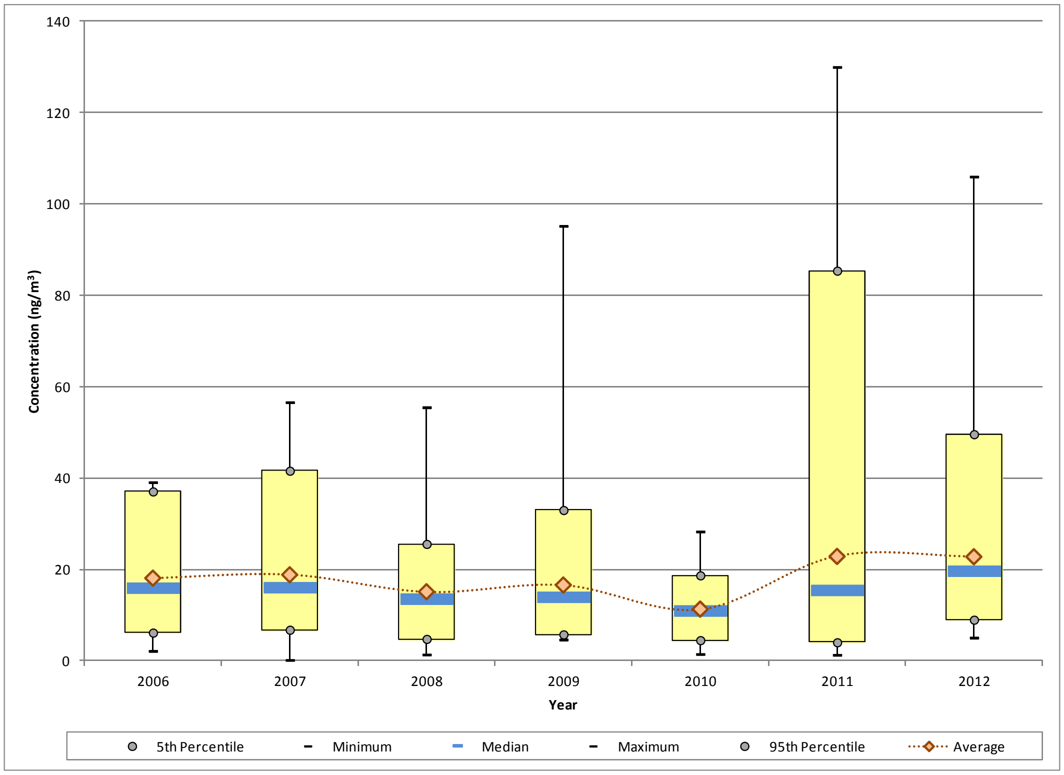
- PXSS began sampling formaldehyde under the NMP in July 2007. Because a full year's worth of data is not available, a 1-year average for 2007 is not presented, although the range of measurements is provided. In addition, much of the data between February 2010 and March 2011 was invalidated due to sampler maintenance issues on the primary sampler. No statistical metrics are provided for 2010 due to the low number of valid measurements. The range of measurements is provided for 2011, although a 1-year average is not provided.

- The five highest formaldehyde concentrations (ranging from 6.28 µg/m^3 to 7.55 µg/m^3) were all measured in 2007. The next five highest concentrations were all measured in either 2007 or 2011.

- The median concentration for 2007 is nearly 5 µg/m^3. The median concentration for the years that follow are all less than 4 µg/m^3.

- Only one formaldehyde concentration less than 1 µg/m^3 has been measured at PXSS (2012) and only eight less than 2 µg/m^3 have been measured since 2007.

Figure 5-31. Yearly Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at PXSS



Observations from Figure 5-31 for manganese measurements collected at PXSS include the following:

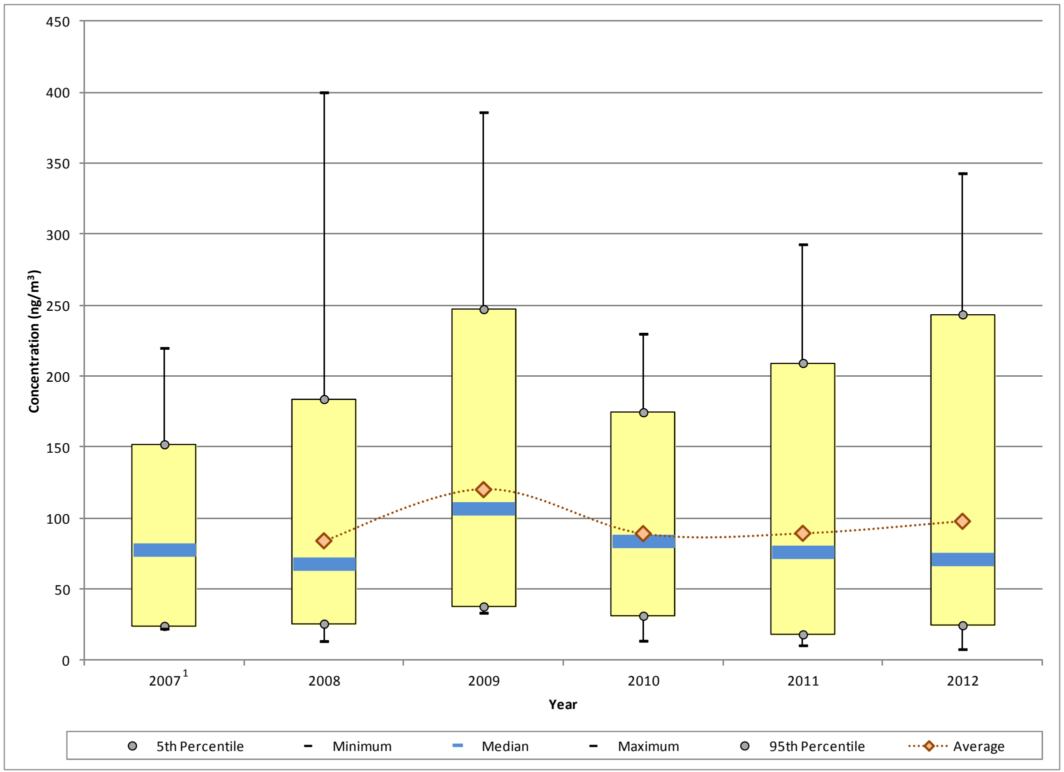
- Four manganese concentrations greater than 100 ng/m^3 have been measured at PXSS since metals sampling began; three were measured in 2011 and the fourth was measured in 2012. Of the 12 concentrations greater than 50 ng/m^3, five were measured during 2011, three in 2012, two in 2009, and one each in 2007 and 2008.

- The 1-year average concentration of manganese decreased significantly from 2009 to 2010 then increased significantly for 2011. The 1-year average concentration for 2011 is twice the 1-year average for 2010. Over the course of sampling, the measurements from 2011 exhibit the most variability while the measurements from 2010 exhibit the least.

- PXSS has the second highest annual average concentration of manganese for 2012. Previous reports indicate that PXSS consistently has one of the highest annual average concentrations of manganese among NMP sites sampling for PM_{10} metals.

- Even though the maximum and 95th percentiles decreased from 2011 to 2012, the median concentration increased for 2012. Although 2011 had a higher number of measurements at the upper end of the scale, there were also more measurements at the lower end of the scale for 2011 compared to 2012. For example, there were five measurements less than 10 ng/m^3 for 2012 compared to 14 for 2011.

Figure 5-32. Yearly Statistical Metrics for Naphthalene Concentrations Measured at PXSS



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-32 for naphthalene measurements collected at PXSS include the following:

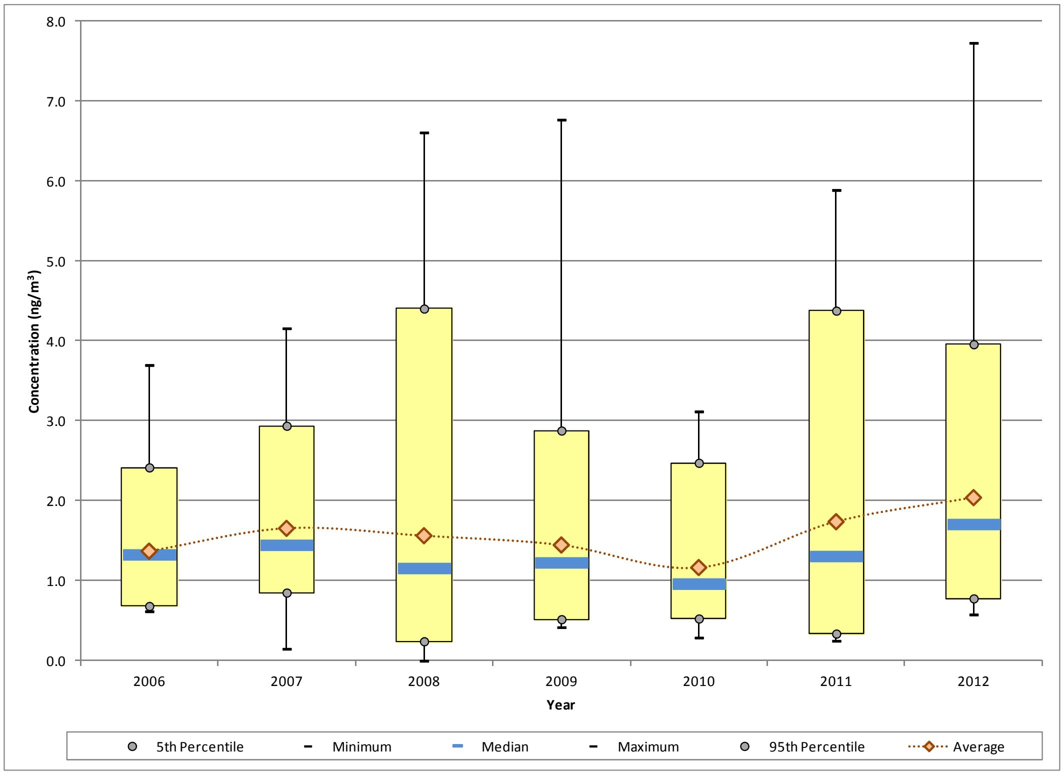
- PXSS began sampling PAHs under the NMP in July 2007.

- The maximum naphthalene concentration was measured in December 2008. Although this is the only measurement greater than 400 ng/m^3 measured at PXSS, a similar concentration was also measured twelve days later on January 1, 2009 (386 ng/m^3). The only other measurement greater than 300 ng/m^3 was measured on December 23, 2012.

- Many of the statistical parameters were highest for 2009. The median, or midpoint, for 2009 is 107 ng/m^3. By comparison, the median concentrations for the other years were less, ranging from 68.1 ng/m^3 (2008) to 84.1 ng/m^3 (2010).

- The difference between the 5th and 95th percentiles (the range of concentrations where 90 percent of the measurements lie) has been increasing since 2010 and is greatest for 2012. Thus, the range of concentrations within which the majority of concentrations lie has an increasing trend.

Figure 5-33. Yearly Statistical Metrics for Nickel (PM_{10}) Concentrations Measured at PXSS



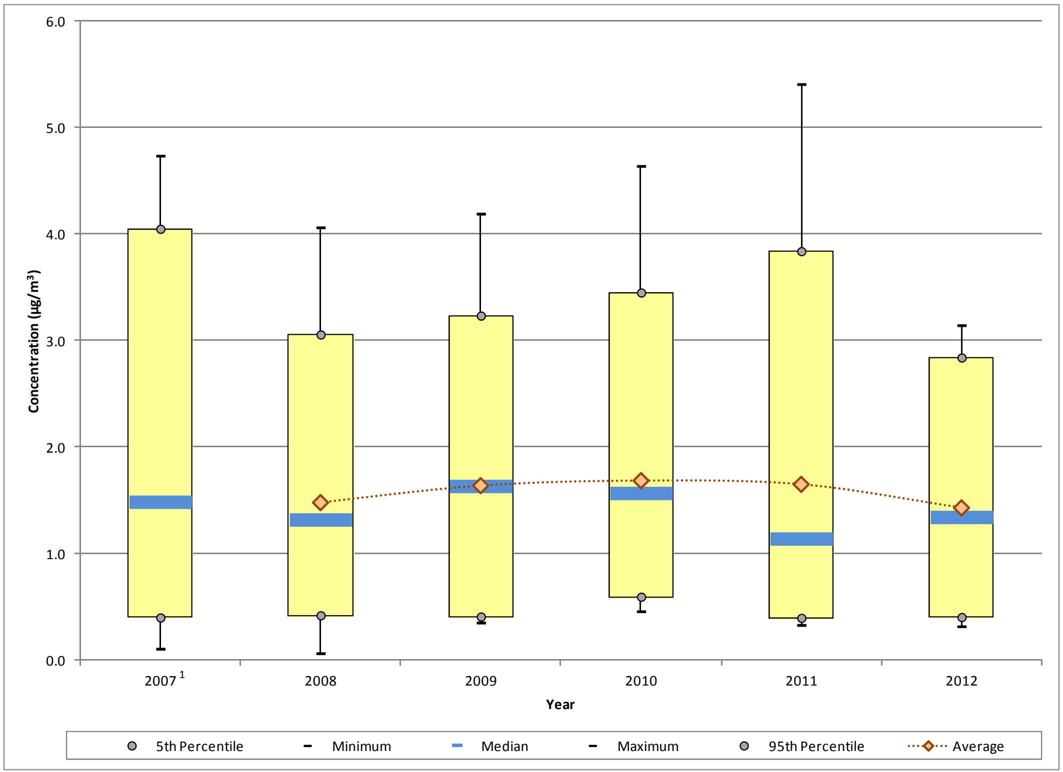
Observations from Figure 5-33 for nickel measurements collected at PXSS include the following:

- The maximum nickel concentration was measured at PXSS on June 20, 2012 (7.73 ng/m^3). Four additional concentrations greater than 6 ng/m^3 have been measured at PXSS since metals sampling under the NMP began; two were measured in 2008, one in 2009, and one in 2012.

- The 1-year average concentration of nickel exhibits a decreasing trend from 2007 through 2010, after which an increasing trend is shown. The increase from 2010 to 2011 is significant, representing a nearly 50 percent increase. The median concentration exhibits a similar tendency between 2010 and 2012. The increase in the median indicates that concentrations are running higher in these later years as the median is less sensitive to outliers, or a few concentrations at the higher end of the range, than the average concentration. PXSS has the third highest annual average concentration of nickel for 2012 among NMP sites sampling PM_{10} metals.

- The only two non-detects of nickel measured at PXSS were both measured in 2008.

Figure 5-34. Yearly Statistical Metrics for Benzene Concentrations Measured at SPAZ



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-34 for benzene measurements collected at SPAZ include the following:

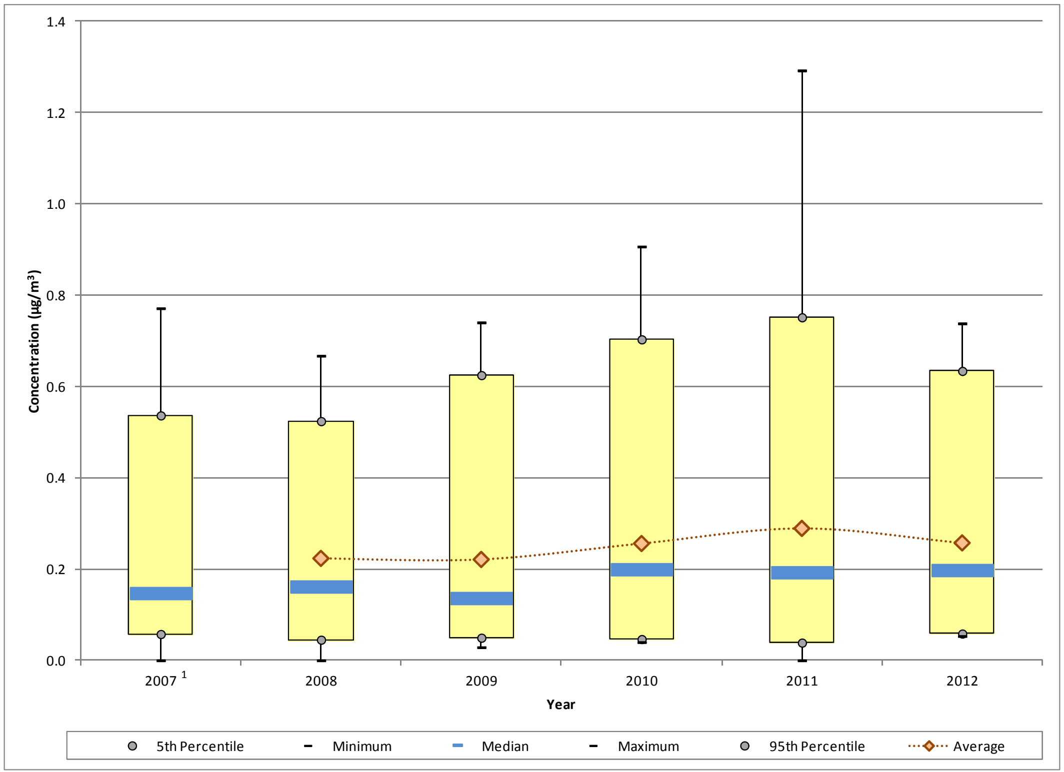
- SPAZ also began sampling VOCs under the NMP in July 2007. Because a full year's worth of data is not available, a 1-year average for 2007 is not presented, although the range of concentrations measured is provided.

- The maximum benzene concentration shown was measured on January 27, 2011 (5.41 µg/m^3) and is the only concentration greater than 5 µg/m^3 measured at SPAZ. Only five additional measurements greater than 4 µg/m^3 have been measured at this site (one for each year of sampling except 2012).

- After several years of increasing, both the maximum and 95th percentile are at a minimum for 2012. Although the 1-year average concentration is also down for 2012, the median concentration actually increased. For 2011, the concentrations at the higher end of the concentration range are driving the 1-year average concentration, whereas there is less variability in the 2012 measurements.

- Forty-five of the 49 benzene concentrations greater than 2 µg/m^3 were measured during the first or fourth quarters of the year.

Figure 5-35. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at SPAZ



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

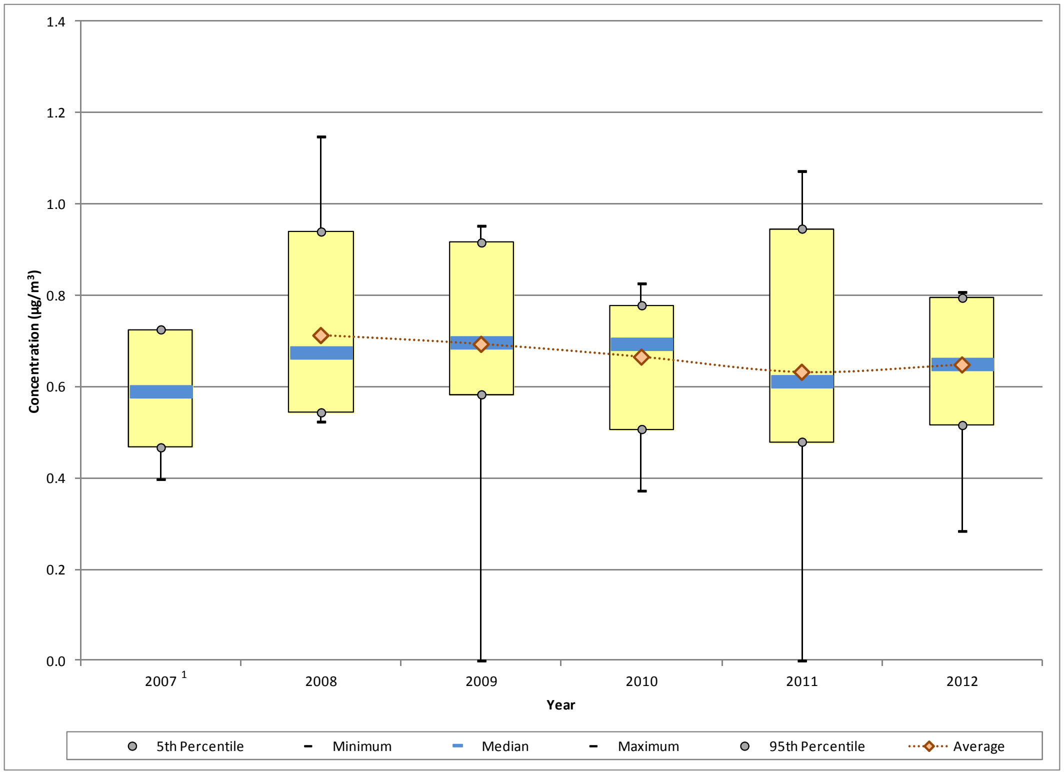
Observations from Figure 5-35 for 1,3-butadiene measurements collected at SPAZ include the following:

- The maximum 1,3-butadiene concentration (1.08 µg/m^3) was measured on January 27, 2011. Thirty-seven of the 39 concentrations greater than 0.35 µg/m^3 were measured during the first or fourth quarters of a given year, similar to the trend seen in PXSS 1,3-butadiene measurements.

- The maximum concentration and 95th percentile increased each year after 2008 through 2011, while the 5th percentile remained fairly static. This indicates that more of the measurements collected were at the higher end of the concentration range. For 2012, the range of concentrations measured is smaller, as the maximum concentration for 2012 is less than the 95th percentile for 2011. This is a pattern similar to that exhibited by benzene in Figure 5-34.

- The 1-year average concentration decreased slightly from 2008 to 2009, then exhibits a slight increasing trend through 2011, followed by a return to 2010 levels for 2012. Confidence intervals calculated for the 1-year averages indicate that these changes are not statistically significant. The median concentration exhibits a steeper decrease from 2008 to 2009 and a steeper increase from 2009 to 2010. Little change is exhibited by the median concentration between 2010 and 2012.

Figure 5-36. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at SPAZ



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-36 for carbon tetrachloride measurements collected at SPAZ include the following:

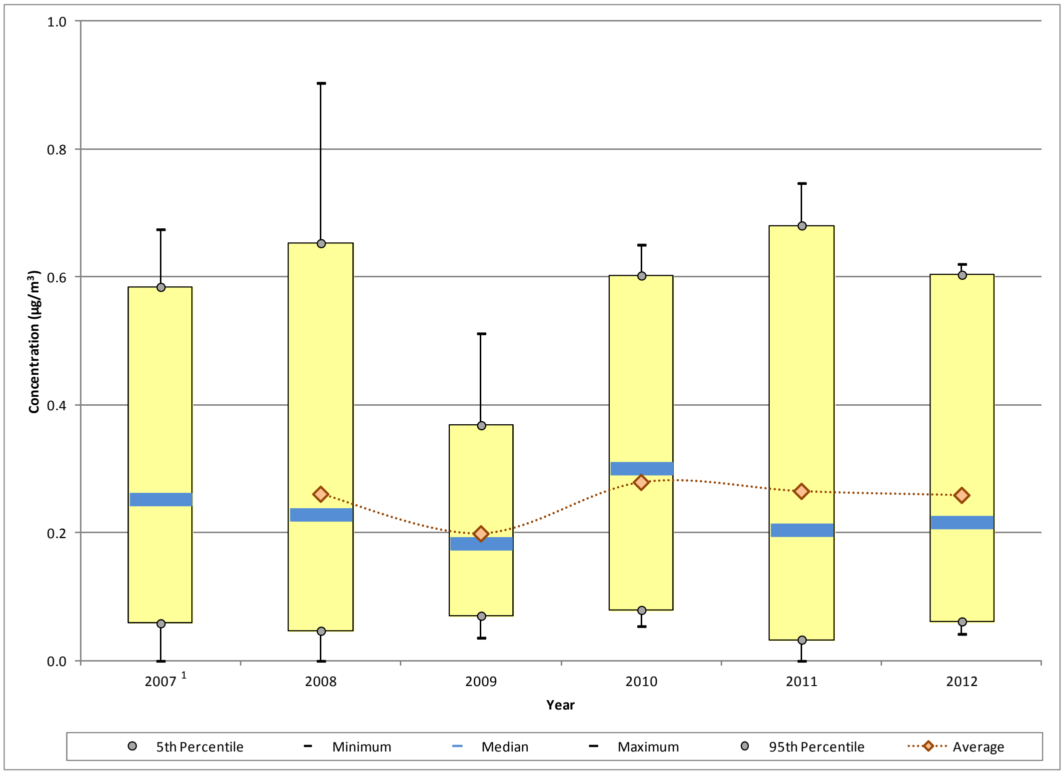
- Two concentrations of carbon tetrachloride greater than 1.0 µg/m^3 have been measured at SPAZ since the onset of sampling in 2007. One was measured in 2008 and one was measured in 2011 (although another concentration just less than 1 µg/m^3 was measured in 2011). Conversely, two non-detects of carbon tetrachloride were measured in 2009 and 2011.

- For the years 2009 and later, the box and whisker plots for this pollutant appear "inverted," with the minimum concentration extending farther away from the majority of the measurements for several years rather than the maximum (see benzene or 1,3-butadiene as examples), which is more common.

- The 1-year average exhibits a decreasing trend through 2011, after which a slight increase is shown for 2012. However, these changes represent an overall change of only 0.08 µg/m^3 and, based on the confidence intervals, are not statistically significant. The median concentration exhibits little change between 2008 and 2010 then decreases substantially for 2011.

- The difference between the 1-year average and median concentrations is at a minimum for 2012, indicating less variability in the central tendency than for other years.

Figure 5-37. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at SPAZ



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

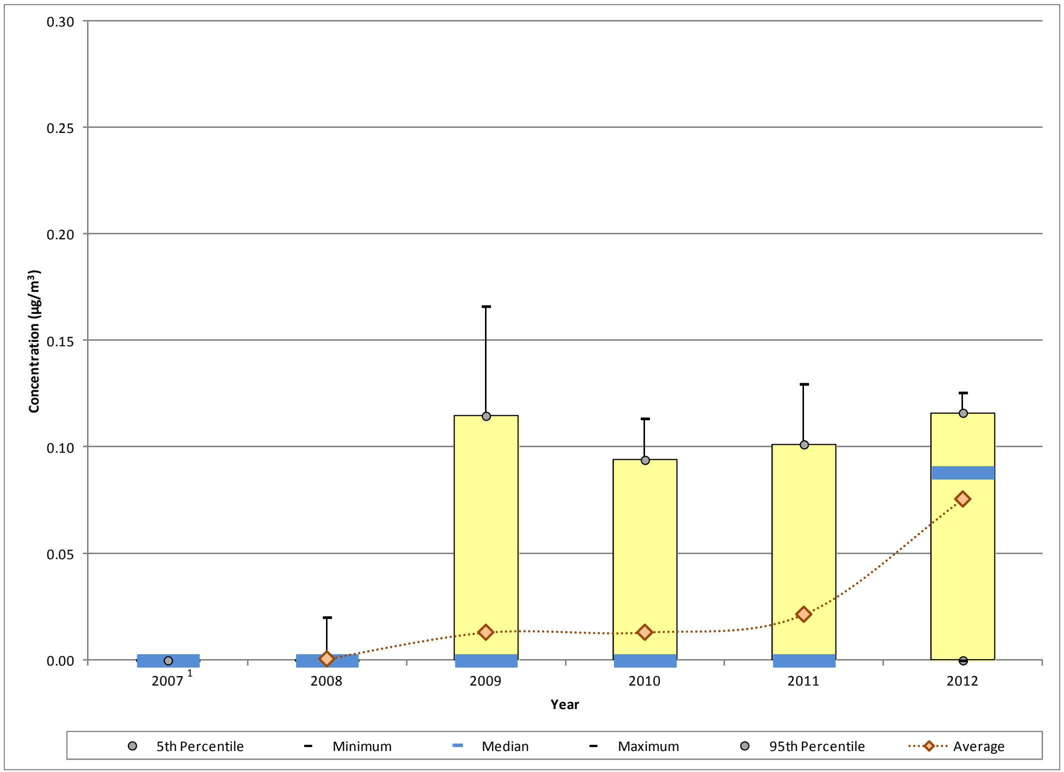
Observations from Figure 5-37 for *p*-dichlorobenzene measurements collected at SPAZ include the following:

- The widest range of *p*-dichlorobenzene concentrations is shown for 2008 (non-detect to 0.90 µg/m^3), while the smallest range is shown for the following year (0.036 µg/m^3 to 0.51 µg/m^3).

- The 1-year average concentration decreased from 2008 to 2009, increased for 2010, then decreased slightly for 2011 and 2012. However, confidence intervals calculated for these averages indicate that the changes are not statistically significant.

- The median concentrations appear to exhibit larger fluctuations than the 1-year average concentrations. Yet, the largest year-to-year difference is the change from 2009 to 2010 and represents a change of less than 0.12 µg/m^3.

Figure 5-38. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at SPAZ

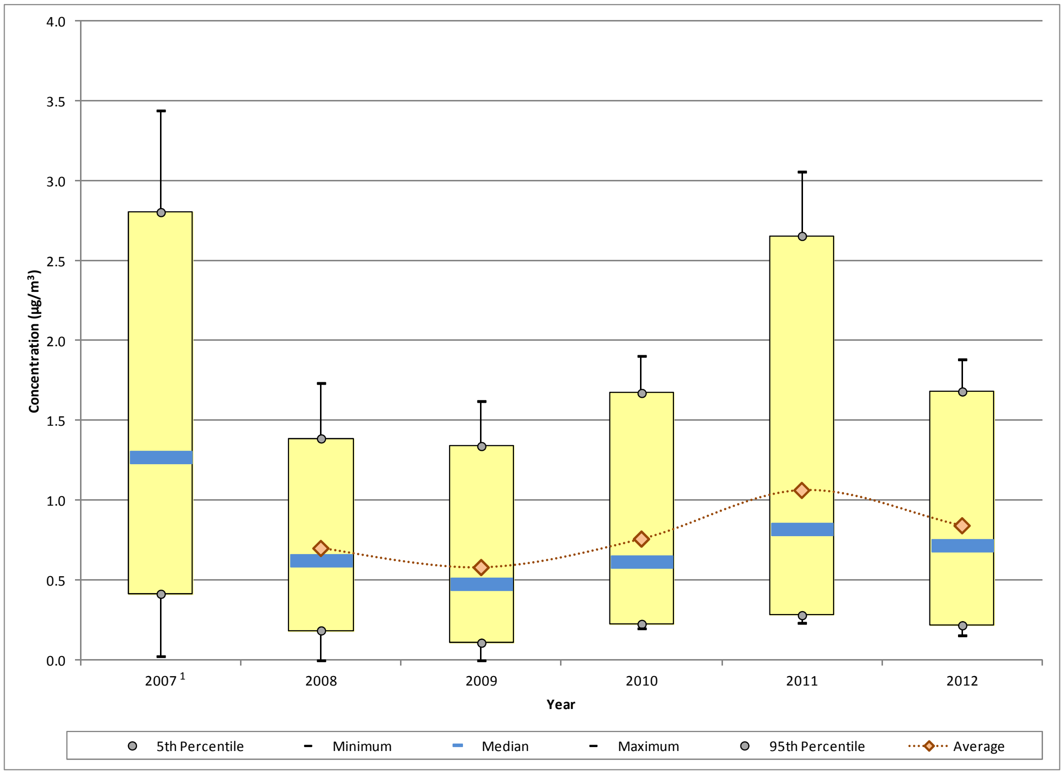


[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-38 for 1,2-dichloroethane measurements collected at SPAZ include the following:

- There were no measured detections of 1,2-dichloroethane in 2007, one measured detection in 2008, three in 2009, four in 2010, seven in 2011, and 26 in 2012.
- The median concentration is zero for all years except 2012, indicating that at least 50 percent of the measurements were non-detects.
- As the number of measured detections increase, so do the corresponding central tendency statistics shown in Figure 5-38.
- As the number of measured detections increased dramatically for 2012, the median and 1-year average concentrations increased correspondingly. The median concentration is greater than the 1-year average for 2012. This is because the four non-detects (or zeros) factored into the 1-year average concentration are pulling the average down (just like a maximum or outlier concentration can pull the average up).

Figure 5-39. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at SPAZ



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2007.

Observations from Figure 5-39 for ethylbenzene measurements collected at SPAZ include the following:

- The maximum concentration of ethylbenzene measured at SPAZ (3.44 µg/m^3) was measured in 2007. The only other concentration greater than 3.0 µg/m^3 was measured at SPAZ on January 27, 2011 (3.06 µg/m^3). All eight concentrations between 2.0 µg/m^3 and 3.0 µg/m^3 were measured in either 2007 or 2011.

- The median concentration is at a maximum for 2007, after which the median decreases by half. Recall that 2007 includes only a half a year's worth of samples. The downward trend continues through 2009, followed by an increase that continues through 2011. The median decreases somewhat for 2012. The 1-year average concentration has a similar pattern, although no 1-year average is presented for 2007.

- The minimum concentration measured each year before 2010 is at or near zero (non-detect); the minimum concentration in later years is an order of magnitude higher. The 5th percentile for each of the later years is similar to the minimum concentrations measured (less than 0.065 µg/m^3).

The following observations summarize some of the highlights from Figures 5-22 through 5-39 for PXSS and SPAZ:

- Several of the pollutants of interest for PXSS were highest on January 1, 2009 (or measured their second highest concentration on this date). Some of the VOC pollutants of interest for SPAZ were highest on January 27, 2011 (or measured their second highest concentration on this date).

- The highest measurements of several of the VOCs, 1,3-butadiene and ethylbenzene in particular, were most often measured during the colder months of the year. This trend is more prevalent at PXSS than SPAZ.

5.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each Arizona monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

5.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Arizona monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

5.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Arizona monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 5-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations for PXSS from Table 5-6 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde, acetaldehyde, and benzene, and are the only pollutants of interest with annual average concentrations greater than 1 µg/m^3.
- Based on the annual averages and cancer UREs, formaldehyde has the highest cancer risk approximation (51.44 in-a-million), followed by benzene (10.01 in-a-million), 1,3-butadiene (6.66 in-a-million), and acetaldehyde (6.38 in-a-million).
- Formaldehyde’s cancer risk approximation for PXSS is the third highest cancer risk approximation among all of the site-specific pollutants of interest across the program.
- None of the pollutants of interest for PXSS have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for PXSS is manganese (0.45). This noncancer hazard approximation is the fourth highest noncancer hazard approximation among all site-specific pollutants of interest.

Table 5-6. Risk Approximations for the Arizona Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Phoenix, Arizona - PXSS						
Acetaldehyde	0.0000022	0.009	61/61	2.90 ± 0.30	6.38	0.32
Arsenic (PM_{10})[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	2.92	0.05
Benzene	0.0000078	0.03	61/61	1.28 ± 0.21	10.01	0.04
1,3-Butadiene	0.00003	0.002	61/61	0.22 ± 0.05	6.66	0.11
Carbon Tetrachloride	0.000006	0.1	61/61	0.68 ± 0.02	4.10	0.01
p-Dichlorobenzene	0.000011	0.8	60/61	0.20 ± 0.03	2.15	<0.01
1,2-Dichloroethane	0.000026	2.4	47/61	0.07 ± 0.01	1.84	<0.01
Ethylbenzene	0.0000025	1	61/61	0.73 ± 0.12	1.82	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.96 ± 0.27	51.44	0.40
Manganese (PM_{10})[a]	--	0.00005	61/61	0.02 ± <0.01	--	0.45
Naphthalene[a]	0.000034	0.003	59/59	0.10 ± 0.02	3.33	0.03
Nickel (PM_{10})[a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.98	0.02
South Phoenix, Arizona - SPAZ						
Benzene	0.0000078	0.03	30/30	1.43 ± 0.30	11.16	0.05
1,3-Butadiene	0.00003	0.002	30/30	0.26 ± 0.07	7.71	0.13
Carbon Tetrachloride	0.000006	0.1	30/30	0.65 ± 0.04	3.88	0.01
p-Dichlorobenzene	0.000011	0.8	30/30	0.26 ± 0.06	2.84	<0.01
1,2-Dichloroethane	0.000026	2.4	26/30	0.08 ± 0.01	1.97	<0.01
Ethylbenzene	0.0000025	1	30/30	0.84 ± 0.18	2.10	<0.01

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 5-5.

Observations for SPAZ from Table 5-6 include the following:

- The pollutants with the highest annual average concentrations are benzene, ethylbenzene, and carbon tetrachloride. Only benzene has an annual average concentration greater than 1 $\mu g/m^3$.

- Based on the annual averages and cancer UREs, benzene has the highest cancer risk approximation for SPAZ (11.16 in-a-million), followed by 1,3-butadiene (7.71 in-a-million), and carbon tetrachloride (3.88 in-a-million).

- None of the pollutants of interest for SPAZ have noncancer hazard approximations greater than 1.0, indicating no adverse health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for SPAZ is 1,3-butadiene (0.13).

5.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 5-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 5-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 5-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 5-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 5-7. Table 5-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 5.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 5-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Arizona Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Phoenix, Arizona (Maricopa County) – PXSS					
Benzene	937.42	Formaldehyde	9.92E-03	Formaldehyde	51.44
Formaldehyde	763.28	Benzene	7.31E-03	Benzene	10.01
Ethylbenzene	668.61	1,3-Butadiene	3.93E-03	1,3-Butadiene	6.66
Acetaldehyde	407.11	Naphthalene	2.55E-03	Acetaldehyde	6.38
Tetrachloroethylene	216.22	Ethylbenzene	1.67E-03	Carbon Tetrachloride	4.10
1,3-Butadiene	130.89	POM, Group 2b	9.94E-04	Naphthalene	3.33
Naphthalene	75.03	POM, Group 2d	8.96E-04	Arsenic	2.92
Dichloromethane	12.33	Acetaldehyde	8.96E-04	*p*-Dichlorobenzene	2.15
POM, Group 2b	11.29	Arsenic, PM	6.95E-04	1,2-Dichloroethane	1.84
POM, Group 2d	10.18	Hexavalent Chromium, PM	5.02E-04	Ethylbenzene	1.82
South Phoenix, Arizona (Maricopa County) – SPAZ					
Benzene	937.42	Formaldehyde	9.92E-03	Benzene	11.16
Formaldehyde	763.28	Benzene	7.31E-03	1,3-Butadiene	7.71
Ethylbenzene	668.61	1,3-Butadiene	3.93E-03	Carbon Tetrachloride	3.88
Acetaldehyde	407.11	Naphthalene	2.55E-03	*p*-Dichlorobenzene	2.84
Tetrachloroethylene	216.22	Ethylbenzene	1.67E-03	Ethylbenzene	2.10
1,3-Butadiene	130.89	POM, Group 2b	9.94E-04	1,2-Dichloroethane	1.97
Naphthalene	75.03	POM, Group 2d	8.96E-04		
Dichloromethane	12.33	Acetaldehyde	8.96E-04		
POM, Group 2b	11.29	Arsenic, PM	6.95E-04		
POM, Group 2d	10.18	Hexavalent Chromium, PM	5.02E-04		

Table 5-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Arizona Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Phoenix, Arizona (Maricopa County) – PXSS					
Toluene	9,063.05	Acrolein	2,007,476.52	Manganese	0.45
Ethylene glycol	5,143.63	Formaldehyde	77,886.07	Formaldehyde	0.40
Hexane	2,587.16	1,3-Butadiene	65,443.47	Acetaldehyde	0.32
Xylenes	2,542.34	Acetaldehyde	45,234.52	1,3-Butadiene	0.11
Methanol	2,398.84	Lead, PM	34,311.59	Arsenic	0.05
Benzene	937.42	Benzene	31,247.27	Benzene	0.04
Formaldehyde	763.28	Xylenes	25,423.43	Naphthalene	0.03
Ethylbenzene	668.61	Naphthalene	25,010.69	Nickel	0.02
Acetaldehyde	407.11	Ethylene glycol	12,859.08	Carbon Tetrachloride	0.01
Methyl isobutyl ketone	326.37	Arsenic, PM	10,773.68	Ethylbenzene	<0.01
South Phoenix, Arizona (Maricopa County) – SPAZ					
Toluene	9,063.05	Acrolein	2,007,476.52	1,3-Butadiene	0.13
Ethylene glycol	5,143.63	Formaldehyde	77,886.07	Benzene	0.05
Hexane	2,587.16	1,3-Butadiene	65,443.47	Carbon Tetrachloride	0.01
Xylenes	2,542.34	Acetaldehyde	45,234.52	Ethylbenzene	<0.01
Methanol	2,398.84	Lead, PM	34,311.59	*p*-Dichlorobenzene	<0.01
Benzene	937.42	Benzene	31,247.27	1,2-Dichloroethane	<0.01
Formaldehyde	763.28	Xylenes	25,423.43		
Ethylbenzene	668.61	Naphthalene	25,010.69		
Acetaldehyde	407.11	Ethylene glycol	12,859.08		
Methyl isobutyl ketone	326.37	Arsenic, PM	10,773.68		

Observations from Table 5-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Maricopa County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, and 1,3-butadiene.

- Eight of the highest emitted pollutants in Maricopa County also have the highest toxicity-weighted emissions.

- Formaldehyde has the highest cancer risk approximation for PXSS; carbonyl compounds were not sampled for at SPAZ, thus, a cancer risk approximation is not available for this pollutant for SPAZ. Formaldehyde has the second highest emissions and highest toxicity-weighted emissions for Maricopa County.

- Among the VOCs, benzene, 1,3-butadiene, and carbon tetrachloride have highest cancer risk approximations for PXSS and SPAZ. The cancer risk approximations for these pollutants are similar between the two sites. While benzene and 1,3-butadiene both appear among the pollutants with the highest emissions and highest toxicity-weighted emissions for Maricopa County, carbon tetrachloride does not appear on either list.

- Naphthalene is among the highest emitted pollutants (seventh), has one of the highest toxicity-weighted emissions (fourth), and has one of the highest cancer risk approximations for PXSS (sixth). POM, Group 2b is the ninth highest emitted "pollutant" in Maricopa County and ranks sixth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at PXSS including acenaphthene, benzo(e)pyrene, fluoranthene, and perylene. Similarly, POM, Group 2d is the 10th highest emitted "pollutant" and ranks seventh for toxicity-weighted emissions. POM, Group 2d includes several PAHs sampled for at PXSS including anthracene, phenanthrene, and pyrene. None of the PAHs included in POM, Groups 2b or 2d were identified as pollutants of interest for PXSS (or failed any screens).

- Arsenic has the seventh highest cancer risk approximation among the pollutants of interest for PXSS. This pollutant ranks ninth for its toxicity-weighted emissions but does not appear among the highest emitted pollutants in Maricopa County.

Observations from Table 5-8 include the following:

- Toluene, ethylene glycol, and hexane are the highest emitted pollutants with noncancer RfCs in Maricopa County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene.

- Five of the highest emitted pollutants also have the highest toxicity-weighted emissions for Maricopa County.

- Acrolein has the highest toxicity-weighted emissions (by two orders of magnitude) for Maricopa County. Although acrolein was sampled for at both sites, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. The emissions for acrolein rank 16th.

- Manganese has the highest noncancer hazard approximation for PXSS (although considerably less than an HQ of 1.0), followed by formaldehyde and acetaldehyde. While all three of these pollutants appear among those with the highest toxicity-weighted emissions, only formaldehyde and acetaldehyde appear among the highest emitted.

- 1,3-Butadiene has the highest noncancer hazard approximation for SPAZ (0.13). Although the noncancer hazard approximation for PXSS (0.11) is similar in magnitude to that of SPAZ, it ranks fourth behind three pollutants for which SPAZ does not sample. 1,3-Butadiene has the third highest toxicity-weighted emissions but is not one of the highest emitted pollutants in Maricopa County (with a noncancer RfC), as it ranks 12th.

5.6 Summary of the 2012 Monitoring Data for PXSS and SPAZ

Results from several of the data treatments described in this section include the following:

- ❖ *Twenty-one pollutants failed screens for PXSS; seven pollutants failed screens for SPAZ.*

- ❖ *Of the site-specific pollutants of interest for PXSS, formaldehyde had the highest annual average concentration. For SPAZ, benzene had the highest annual average concentration among this site's pollutants of interest.*

- ❖ *Concentrations of several VOCs, including benzene and 1,3-butadiene, tended to be higher during the colder months of the year. This was also reflected in the concentration data from previous years of sampling.*

- ❖ *SPAZ and PXSS have the highest and second highest annual average concentrations of 1,3-butadiene and p-dichlorobenzene among NMP sites sampling VOCs. These sites also rank second and third highest for benzene and ethylbenzene. PXSS has the highest annual average concentration of acetaldehyde among all NMP sites sampling carbonyl compounds. Among NMP sites sampling PM_{10} metals, PXSS ranks second for its annual average concentration of manganese.*

- ❖ *Concentrations of nickel have been increasing at PXSS over the last few years of sampling. The detection rate of 1,2-dichloroethane has been increasing steadily at both sites over the last few years of sampling.*

6.0 Sites in California

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at three NATTS sites and one CSATAM site in California, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

6.1 Site Characterization

This section characterizes the California monitoring sites by providing geographical and physical information about the locations of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The California monitoring sites are located in Los Angeles, Long Beach, Rubidoux, and San Jose. Figure 6-1 and 6-2 are the composite satellite images retrieved from ArcGIS Explorer showing the Los Angeles and Long Beach monitoring sites and their immediate surroundings. Figure 6-3 identifies nearby point source emissions locations by source category for each site, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 6-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside each 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 6-4 through 6-7 are the composite satellite images and emissions maps for the Rubidoux and San Jose monitoring sites. Table 6-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 6-1. Los Angeles, California (CELA) Monitoring Site

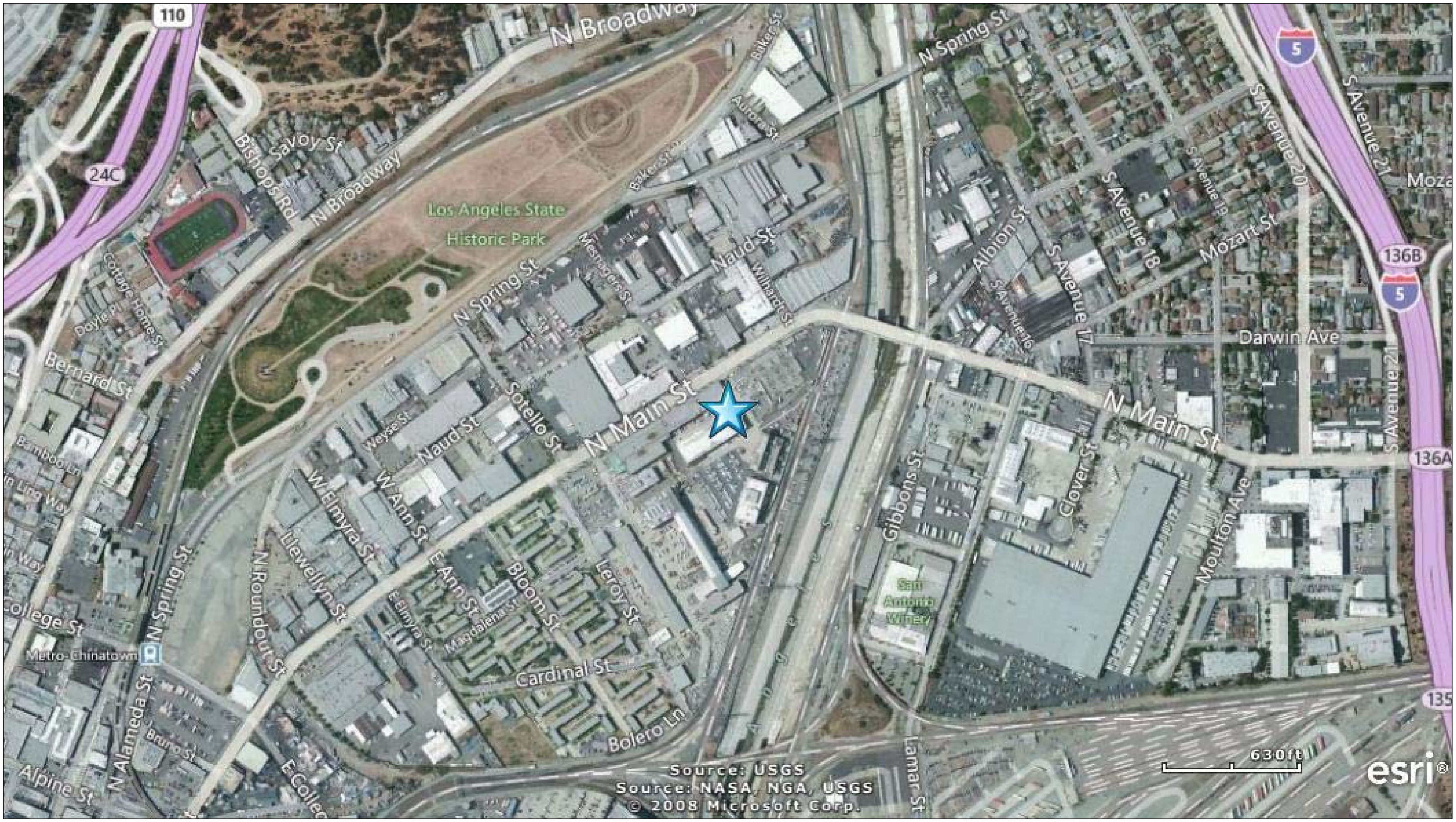
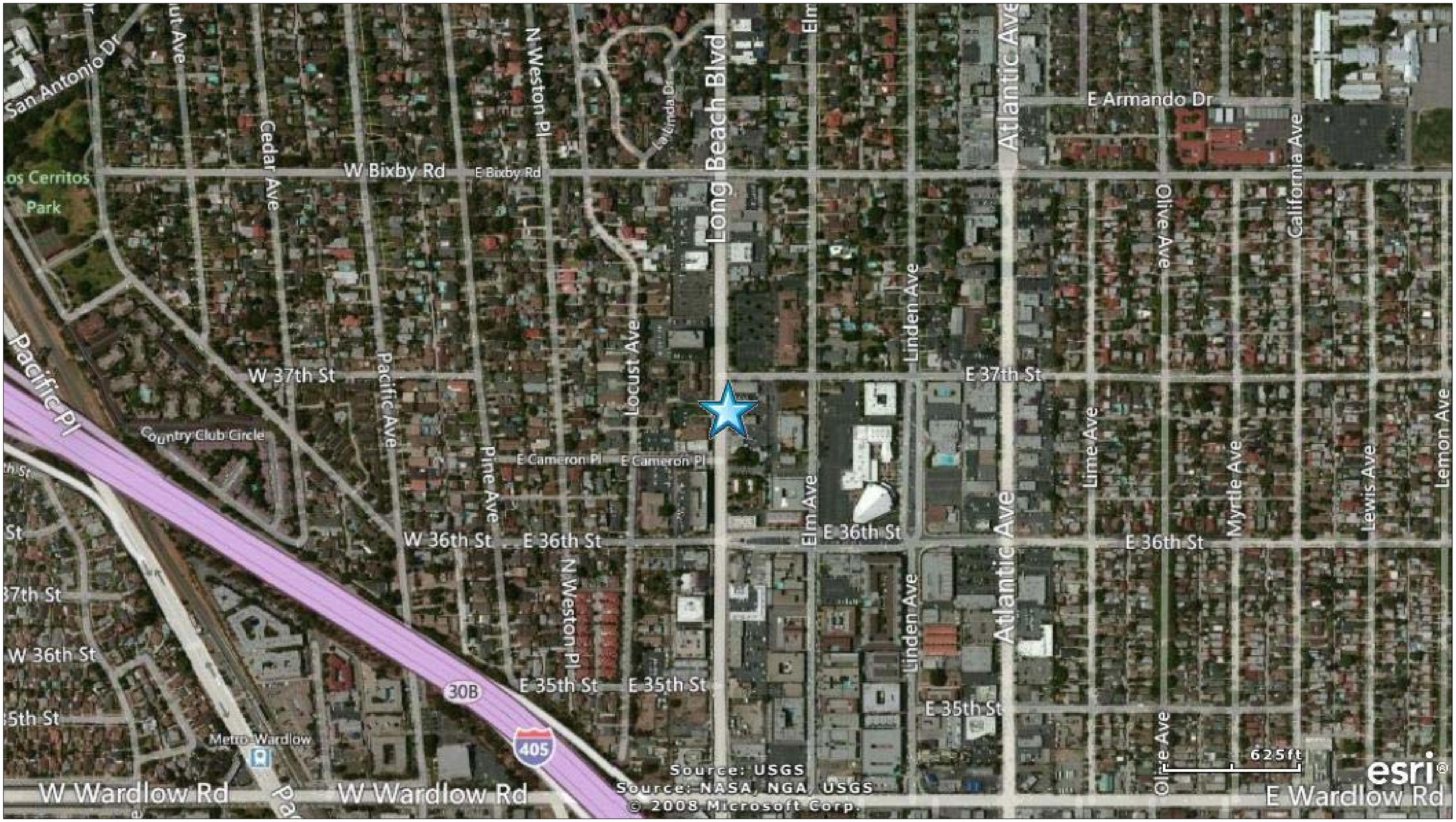
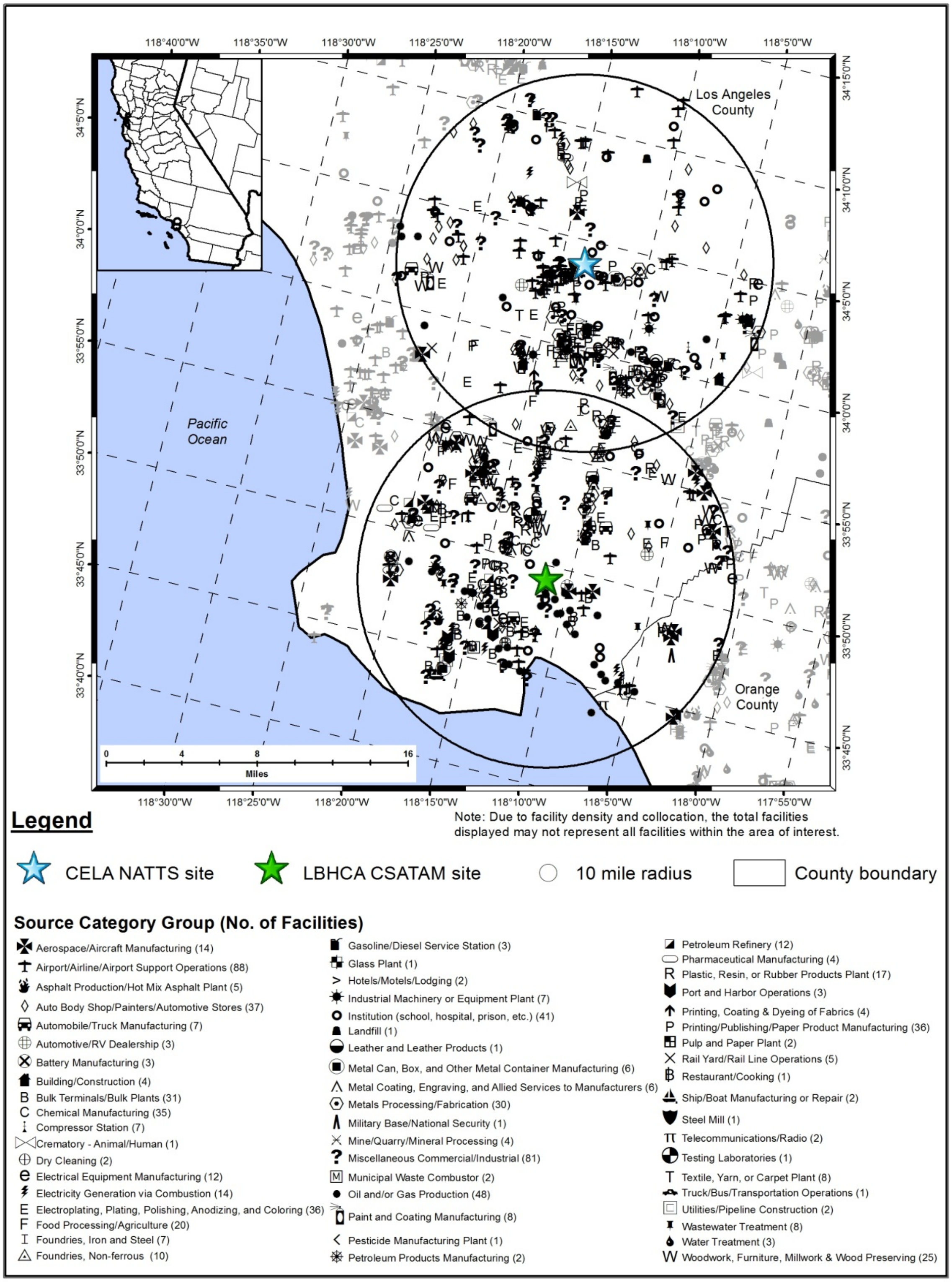


Figure 6-2. Long Beach, California (LBHCA) Monitoring Site



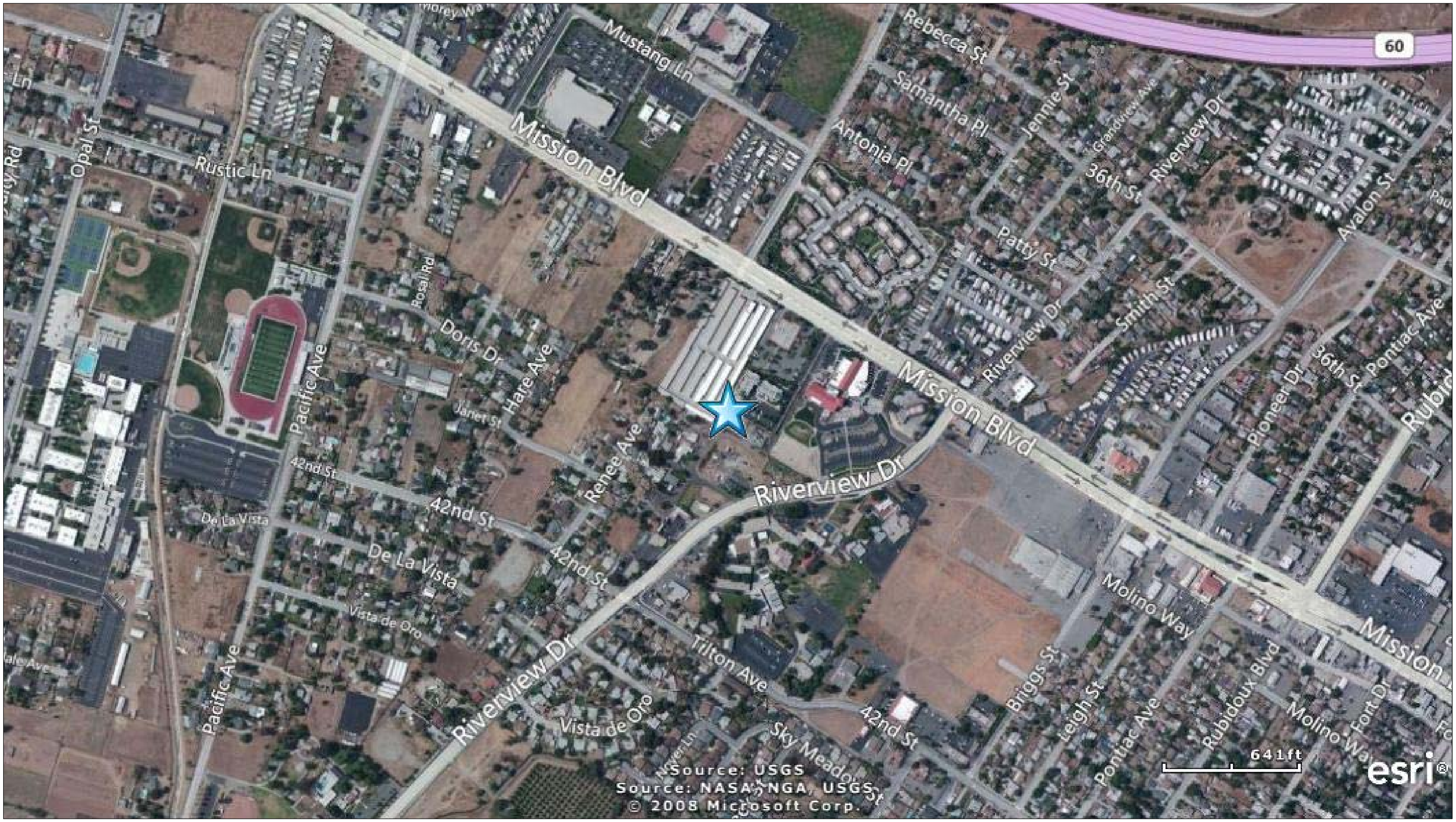
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 6-3. NEI Point Sources Located Within 10 Miles of CELA and LBHCA



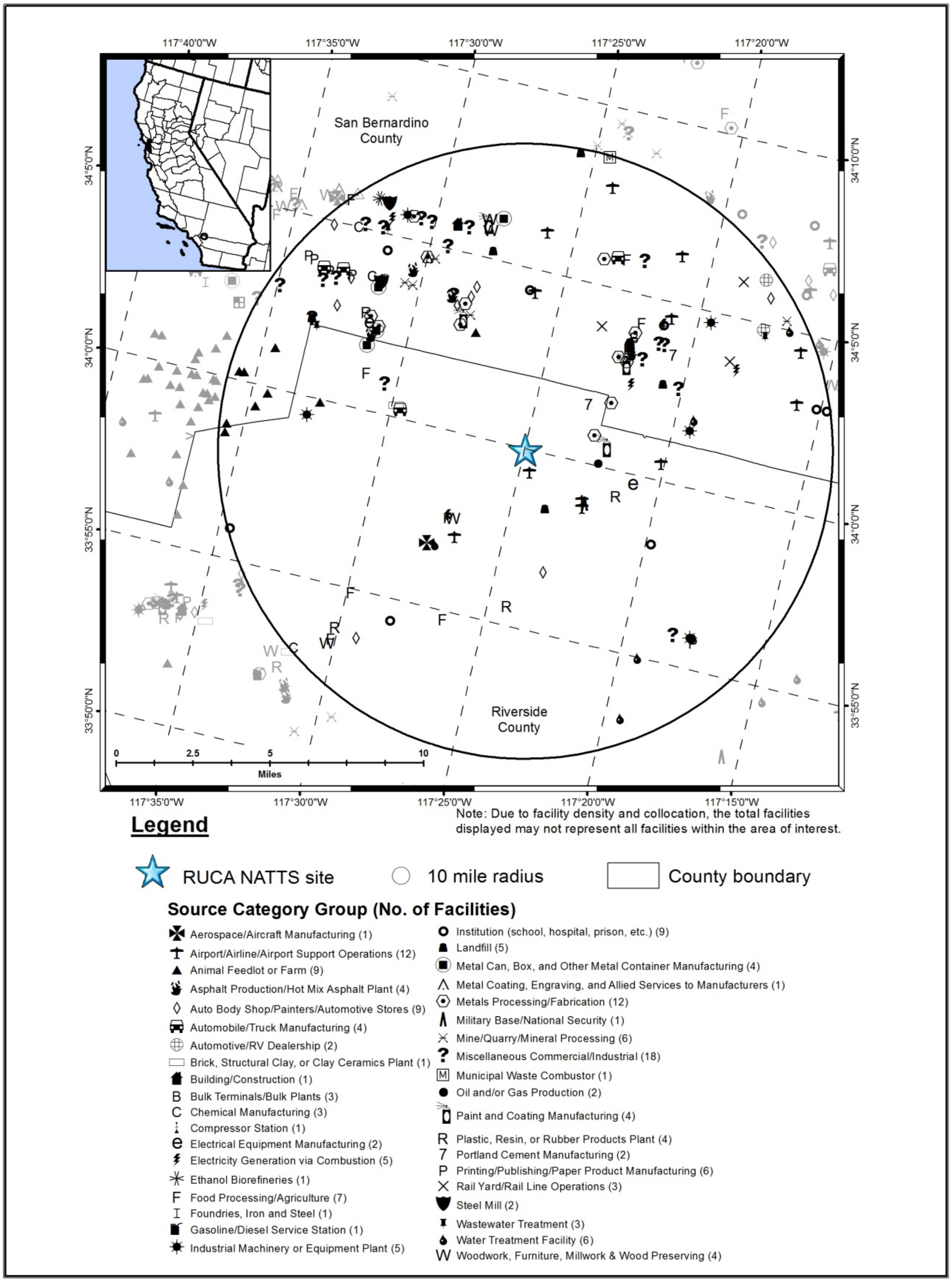
Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 6-4. Rubidoux, California (RUCA) Monitoring Site



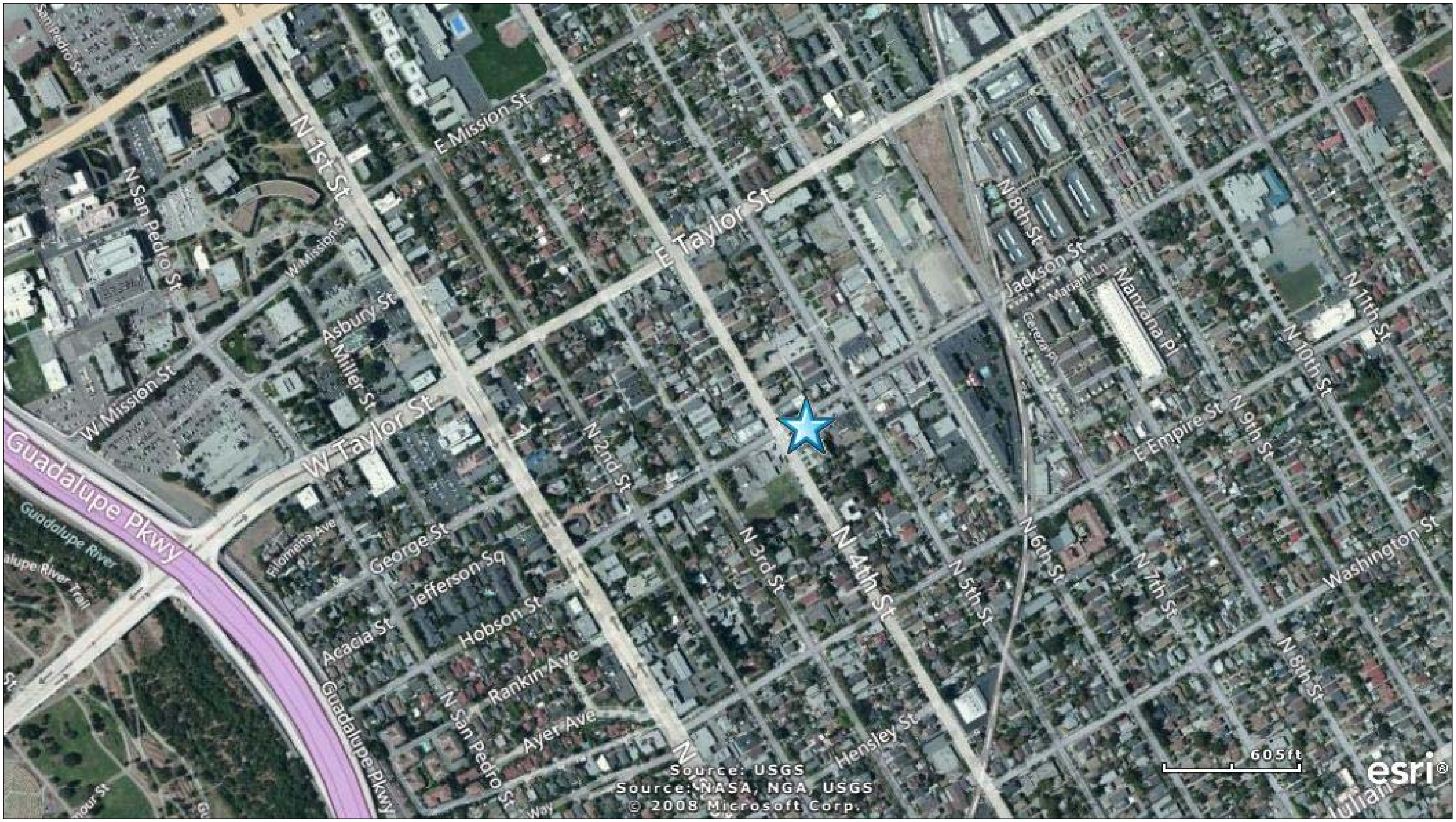
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 6-5. NEI Point Sources Located Within 10 Miles of RUCA



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 6-6. San Jose, California (SJJCA) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 6-7. NEI Point Sources Located Within 10 Miles of SJJCA

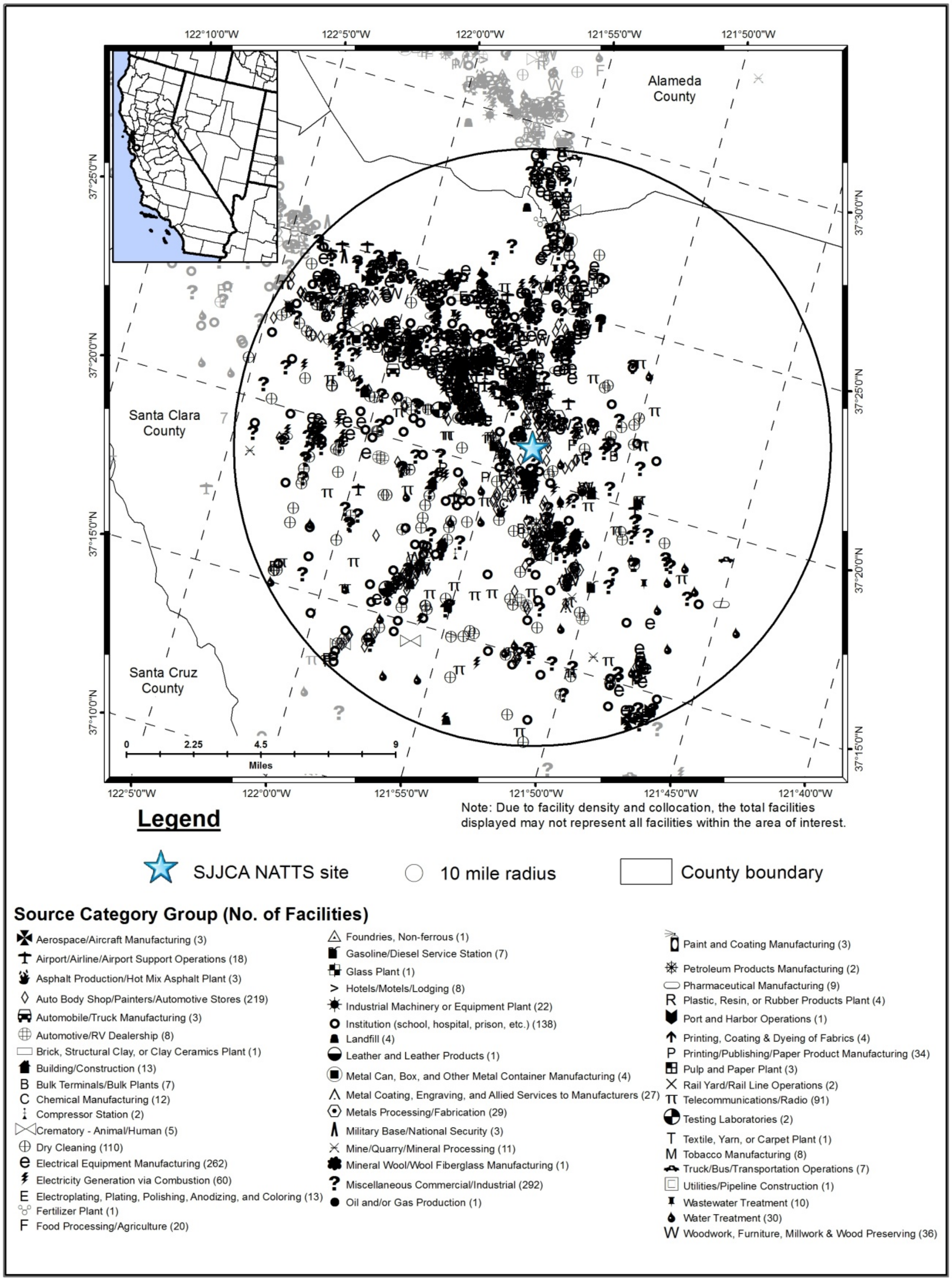


Table 6-1. Geographical Information for the California Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
CELA	06-037-1103	Los Angeles	Los Angeles	Los Angeles-Long Beach-Anaheim, CA MSA	34.06659, -118.22688	Residential	Urban/City Center	TSP, TSP Speciation, Hexavalent chromium, CO, SO_2, NO, NO_2, NO_x, NO_y, PAMS, Carbonyl compounds, VOCs, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, PM Coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
LBHCA	06-037-4002	Long Beach	Los Angeles	Los Angeles-Long Beach-Anaheim, CA MSA	33.82376, -118.18921	Residential	Suburban	TSP, TSP Speciation, Hexavalent chromium, CO, SO_2, NO, NO_2, NO_x, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$,
RUCA	06-065-8001	Rubidoux	Riverside	Riverside-San Bernardino-Ontario, CA MSA	33.99958, -117.41601	Residential	Suburban	Haze, TSP, TSP Speciation, Hexavalent chromium, CO, SO_2, NO, NO_2, NO_x, NO_y, PAMS, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, PM Coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
SJJCA	06-085-0005	San Jose	Santa Clara	San Jose-Sunnyvale-Santa Clara, CA MSA	37.348497, -121.894898	Commercial	Urban/City Center	TSP Speciation, Hexavalent chromium, CO, SO_2, NO, NO_2, NO_x, NO_y, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, PM Coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMRPOVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

CELA is located on the rooftop of a two-story building northeast of downtown Los Angeles, just southeast of Dodgers' Stadium. Figure 6-1 shows that CELA is surrounded by major freeways, including I-5 and Route 110. Highway 101 is located farther south. Although the area is classified as residential, a freight yard is located to the south of the site. The Los Angeles River runs north-south just east of the site. This monitoring site was originally set up as an emergency response monitor.

The LBHCA monitoring site is located on the property of a church in Long Beach. The surrounding area is considered residential and suburban, although commercial areas are also located nearby and along Long Beach Blvd, as shown in Figure 6-2. Interstate-405 is located approximately one-third of a mile from LBHCA and intersects with I-710 just one mile west of the site. This monitoring site is located approximately four miles north of the shores of Long Beach as well as the Port of Long Beach, the second-busiest port in the U.S. (POLB, 2013).

Figure 6-3 shows that LBHCA is nearly 17 miles south of CELA. These sites are situated among a high density of point sources. The source category with the greatest number of emissions sources near these monitoring sites is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. Other source categories with a large number of emissions sources within 10 miles of CELA and LBHCA are oil and gas production; institutions such as school, hospitals, and/or prisons; auto body shops, painters, and automotive stores; printing, publishing, and paper product manufacturing; electroplating, plating, polishing, anodizing, and coloring; and chemical manufacturing. There is a cluster of emissions sources located just to the west and southwest of CELA. There is also a second large cluster of sources to the south of the site. The sources closest to CELA are a mineral processing facility, a carpet plant, a facility involved in oil/gas production, and a heliport at a detention center. Several emissions sources are located directly south of LBHCA, including several involved in oil and gas production.

RUCA is located just outside of Riverside, in a residential area of the suburban town of Rubidoux. Figure 6-4 shows that RUCA is adjacent to a power substation west of a storage facility near the intersection of Mission Boulevard and Riverview Drive. Residential areas surround RUCA, including three schools: a middle school north of Mission Boulevard, an elementary school south of Riverview Drive, and a high school to the west of Pacific Avenue, the football and baseball fields of which are prominent features in Figure 6-4. Highway 60 runs east-west to the north of the site. Flabob Airport is located approximately three-quarters of a mile to the southeast of the site. RUCA is located approximately 45 miles west of CELA and 46 miles northwest of LBHCA. Figure 6-5 shows that fewer emissions sources surround RUCA than CELA and LBHCA. Most of the emissions sources are located to the northeast and northwest of the site. The point source located closest to RUCA is Flabob Airport. Although the emissions source categories are varied, the emissions source categories with the greatest number of sources near RUCA include airport operations; metals processing; auto body shops, painters, and automotive stores; animal feedlots or farms; and institutions such as school, hospitals, and/or prisons.

SJJCA is located in central San Jose. Figure 6-6 shows that SJJCA is located in a commercial area surrounded by residential areas. A railroad is shown just east of the monitoring site, running north-south in Figure 6-6. Guadalupe Parkway (Route 87) intersects with I-880 approximately 1 mile northwest of the monitoring site. San Jose International Airport is just on the other side of this intersection. The Guadalupe River runs along the eastern boundary of the airport and runs parallel to the Guadalupe Parkway, as does the Guadalupe River Park and Gardens, a park and trail system which can be seen on the bottom left of Figure 6-6. Figure 6-7 shows that the density of point sources is significantly higher near SJJCA than the other California monitoring sites. The emissions source categories with the greatest number of sources are electrical equipment manufacturing; auto body, paint, and automotive shops; institutions such as school, hospitals, and/or prisons; dry cleaning; and telecommunications. Sources closest to SJJCA include a food processing facility and several auto body shops.

Table 6-2 presents additional site-characterizing information, including indicators of mobile source activity, for the California monitoring sites. Table 6-2 includes both county-level population and vehicle registration information. Table 6-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 6-2 presents the county-level daily VMT for Los Angeles, Riverside, and Santa Clara Counties.

Table 6-2. Population, Motor Vehicle, and Traffic Information for the California Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
CELA	9,962,789	7,422,254	229,000	I-5 between Exits 136 and 137	214,458,140
LBHCA			282,000	I-405 between Exits 30 and 32	
RUCA	2,268,783	1,724,787	145,000	Mission Blvd between Rubidoux Blvd & Valley Way	55,717,760
SJJCA	1,837,504	1,529,351	106,000	Guadalupe Pkwy (87) between Julian St & W Taylor St	41,250,490

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (CA DMV, 2012)
[3] AADT reflects 2012 data (CA DOT, 2012a)
[4] County-level VMT reflects 2011 data (CA DOT, 2012b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 6-2 include the following:

- Los Angeles County (CELA and LBHCA) has the highest county-level population and vehicle registration compared to all counties with NMP sites.

- Riverside and Santa Clara Counties are also in the top 10 for county-level population and vehicle registration among counties with NMP sites.

- LBHCA experiences the highest annual average daily traffic among NMP sites, with CELA's traffic ranking third. These two sites are located relatively close to major freeways in the Los Angeles metro area. The traffic volume for RUCA also ranks among the top 10. The traffic volume for SJJCA ranks 15th.

- Los Angeles County's daily VMT is the highest among all counties with NMP sites, where VMT was available. This VMT is an order of magnitude higher than the next highest county-level VMT (Maricopa County, AZ). The VMT for Riverside and Santa Clara Counties are also in the top 10 for VMT among counties with NMP sites, where VMT data were available, ranking fifth and sixth, respectively.

6.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in California on sample days, as well as over the course of the year.

6.2.1 Climate Summary

The climate of Los Angeles and the surrounding areas is generally mild. While the proximity to the Pacific Ocean acts as a moderating influence on the Los Angeles area, the elevation changes between the mountains and valleys allow the distance from the ocean to create substantial differences in temperature, rainfall, and wind over a relatively short distance.

Precipitation falls primarily in winter months, while summers tend to be dry. Westerly winds are prevalent for much of the year. Stagnant wind conditions in the summer can result in air pollution episodes, while breezy Santa Ana winds can create hot, dusty conditions. Fog and cloudy conditions are more prevalent near the coast than farther inland (Wood, 2004; WRCC, 2013).

San Jose is located to the southeast of San Francisco, near the base of the San Francisco Bay. The city is situated in the Santa Clara Valley, between the Santa Cruz Mountains to the south and west and the Diablo Range to the east. San Jose experiences a Mediterranean climate, with distinct wet-dry seasons. The period from November through March represents the wet season, with cool but mild conditions prevailing. Little rainfall occurs the rest of the year and conditions tend to be warm and sunny. San Jose is not outside the marine influences of the cold ocean currents typically affecting the San Francisco area (Wood, 2004; NOAA, 1999).

6.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the stations closest to the California monitoring sites (NCDC, 2012), as described in Section 3.5.2. The weather station nearest CELA is located at Downtown Los Angeles/USC Campus; the weather station nearest LBHCA is located at Long Beach/Daugherty Field Airport; the nearest weather station to RUCA is located at Riverside Municipal Airport; and the nearest station to SJJCA is located at San Jose International Airport (WBANs 93134, 23129, 03171, and 23293, respectively). Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 6-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 6-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 6-3 is the 95 percent confidence interval for each parameter. As shown in Table 6-3, average meteorological conditions on sample days near CELA, RUCA, and SJJCA were representative of average weather conditions experienced throughout the year. The most significant difference in the table for these sites is for average dew point temperature for SJJCA, but is still only 1°F different.

Table 6-3. Average Meteorological Conditions near the California Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Los Angeles, California - CELA									
Downtown L.A./USC Campus Airport 93134 (34.03, -118.30)	4.6 miles 244° (WSW)	Sample Days (65)	73.9 ± 2.3	63.9 ± 1.8	49.7 ± 2.5	56.4 ± 1.6	64.4 ± 3.5	1015.4 ± 0.9	1.2 ± 0.2
		2012	73.8 ± 0.9	63.8 ± 0.8	49.8 ± 1.0	56.4 ± 0.7	64.6 ± 1.5	1014.8 ± 0.4	1.2 ± 0.1
Long Beach, California - LBHCA									
Long Beach/Daugherty Field Airport 23129 (33.82, -118.15)	2.5 miles 124° (ESE)	Sample Days (32)	75.6 ± 3.8	66.7 ± 2.9	54.7 ± 2.9	59.9 ± 2.3	68.9 ± 4.5	1015.3 ± 1.3	3.8 ± 0.5
		2012	74.0 ± 1.0	64.2 ± 0.8	51.1 ± 0.9	57.1 ± 0.7	66.4 ± 1.3	1015.0 ± 0.4	3.9 ± 0.2
Rubidoux, California - RUCA									
Riverside Municipal Airport 03171 (33.95, -117.44)	3.5 miles 214° (SW)	Sample Days (63)	80.3 ± 3.3	66.5 ± 2.5	44.6 ± 3.2	55.1 ± 1.9	52.6 ± 4.6	1014.3 ± 1.0	3.6 ± 0.3
		2012	80.2 ± 1.3	66.3 ± 1.1	44.8 ± 1.3	55.1 ± 0.8	53.1 ± 1.8	1013.8 ± 0.4	3.6 ± 0.1
San Jose, California - SJJCA									
San Jose Intl. Airport 23293 (37.36, -121.93)	1.7 miles 312° (NW)	Sample Days (66)	70.2 ± 2.3	59.4 ± 1.7	47.6 ± 1.8	53.2 ± 1.5	68.0 ± 2.4	1016.9 ± 1.0	5.9 ± 0.6
		2012	70.0 ± 1.0	58.9 ± 0.7	46.6 ± 0.8	52.5 ± 0.6	67.4 ± 1.2	1016.7 ± 0.4	5.7 ± 0.2

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

The differences between the average meteorological conditions for 2012 and those experienced on sample days near LBHCA are greater than the other sites. However, sampling at LBHCA did not begin until July; therefore, the sample day averages for this site include only data for the second half of 2012. However, the differences between the full-year averages and the sample day averages are still relatively small, with the largest difference for dew point temperature.

Table 6-3 shows that wind speeds near the southern California sites tend to be rather light, particularly for CELA, which has the lowest average scalar wind speed among all NMP sites. As expected, conditions tended to be cooler near SJJCA than near the other sites. For the southern California sites, average temperatures tended to be slightly higher for RUCA, which is farther inland than the other two sites.

6.2.3 Back Trajectory Analysis

Figure 6-8 is the composite back trajectory map for days on which samples were collected at the CELA monitoring site in 2012. Included in Figure 6-8 are four back trajectories per sample day. Figure 6-9 is the corresponding cluster analysis. Similarly, Figures 6-10 through 6-15 are the composite back trajectory maps for days on which samples were collected at LBHCA, RUCA, and SJJCA, respectively, and the corresponding cluster analyses. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 6-8 through 6-15 represents 100 miles.

Figure 6-8. Composite Back Trajectory Map for CELA

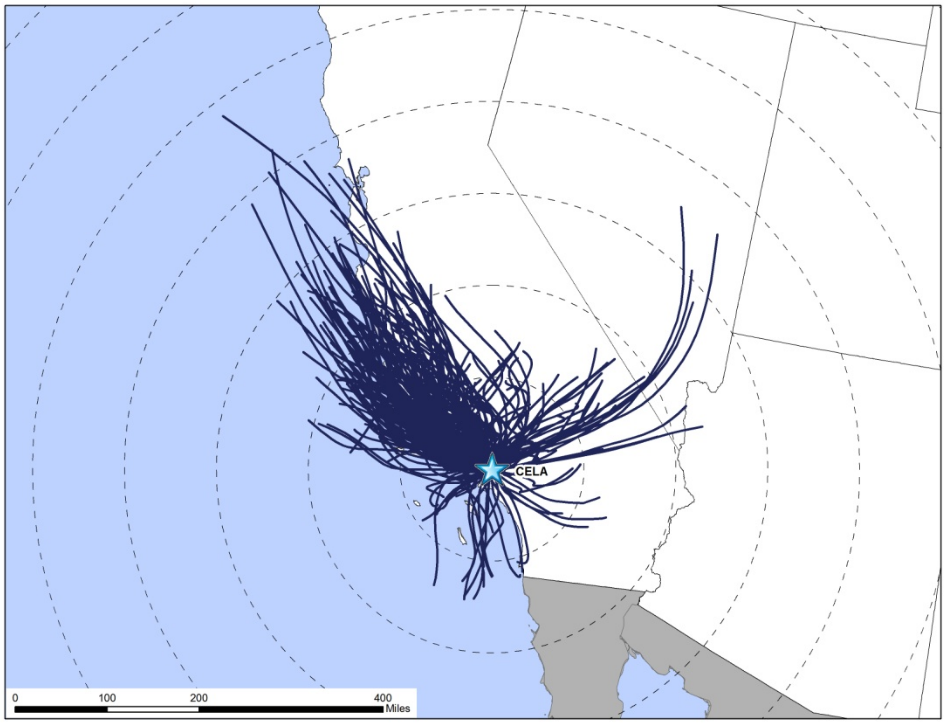


Figure 6-9. Back Trajectory Cluster Map for CELA

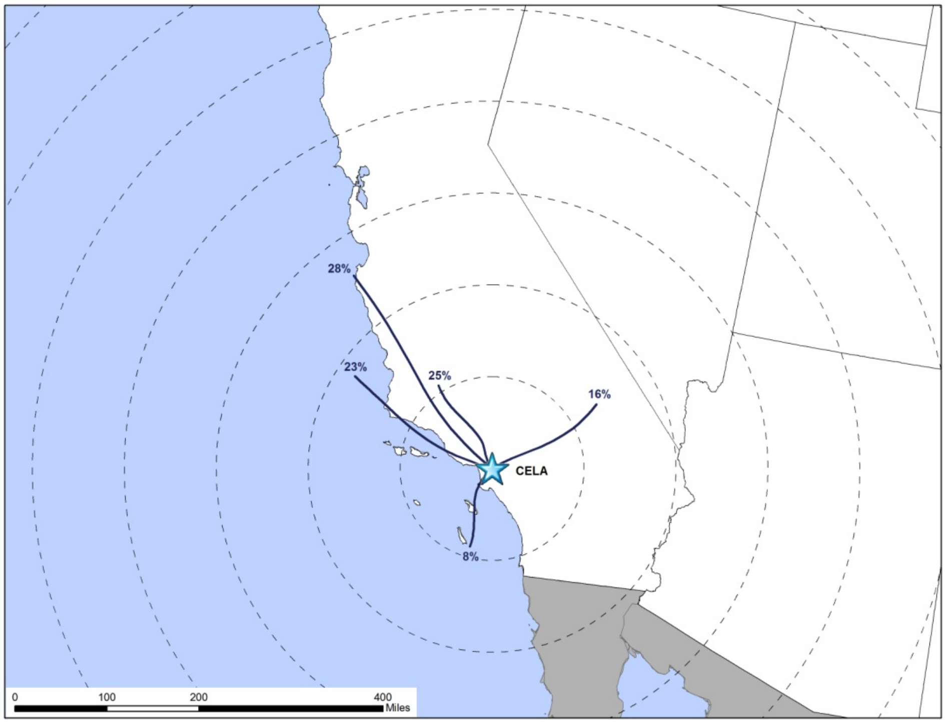


Figure 6-10. Composite Back Trajectory Map for LBHCA

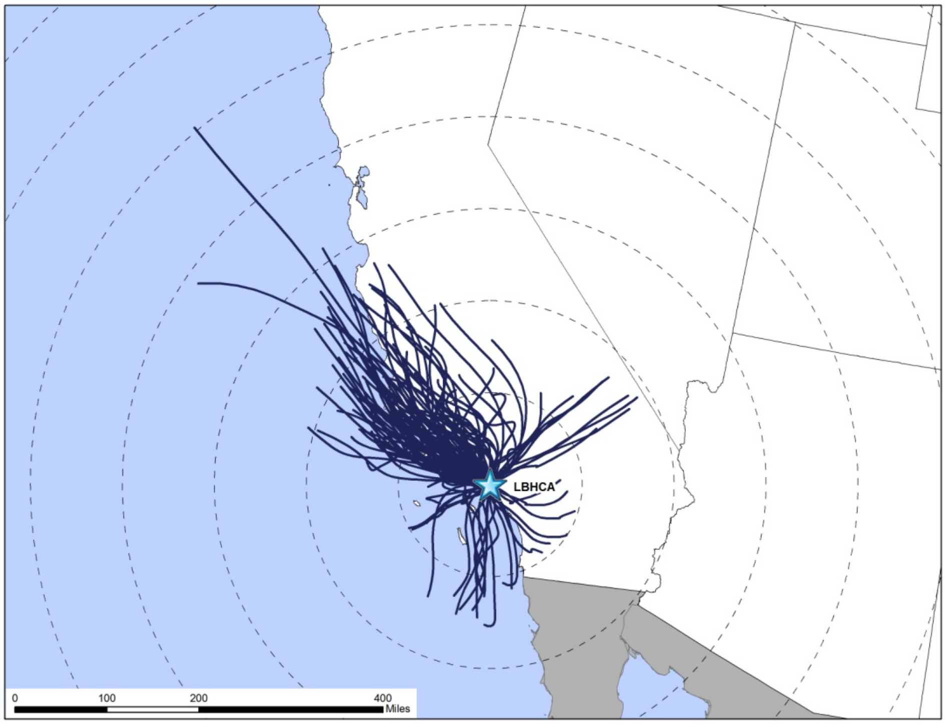


Figure 6-11. Back Trajectory Cluster Map for LBHCA

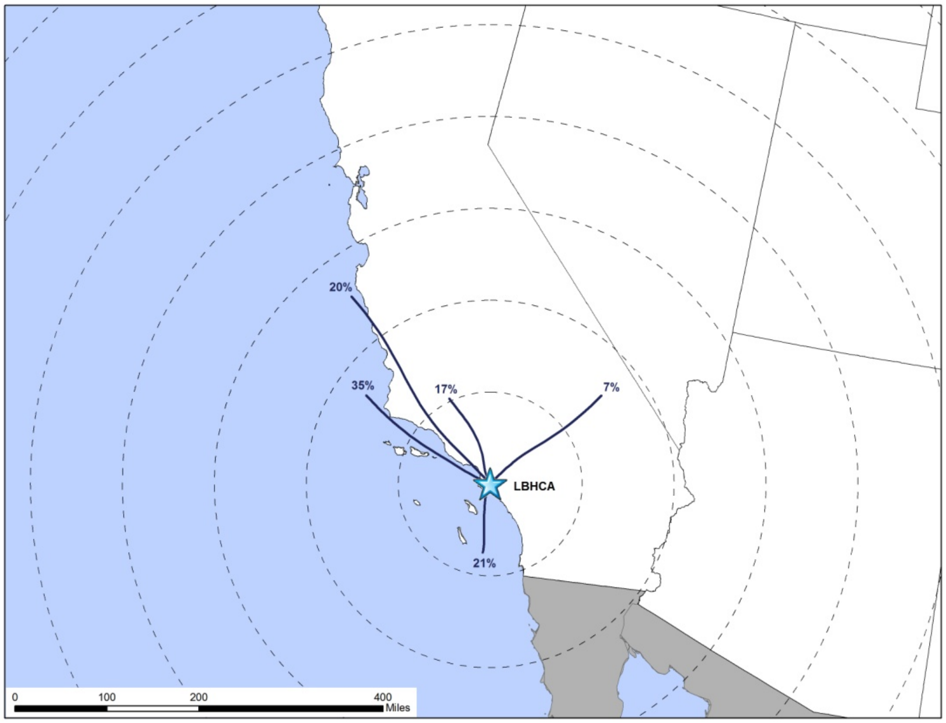


Figure 6-12. Composite Back Trajectory Map for RUCA

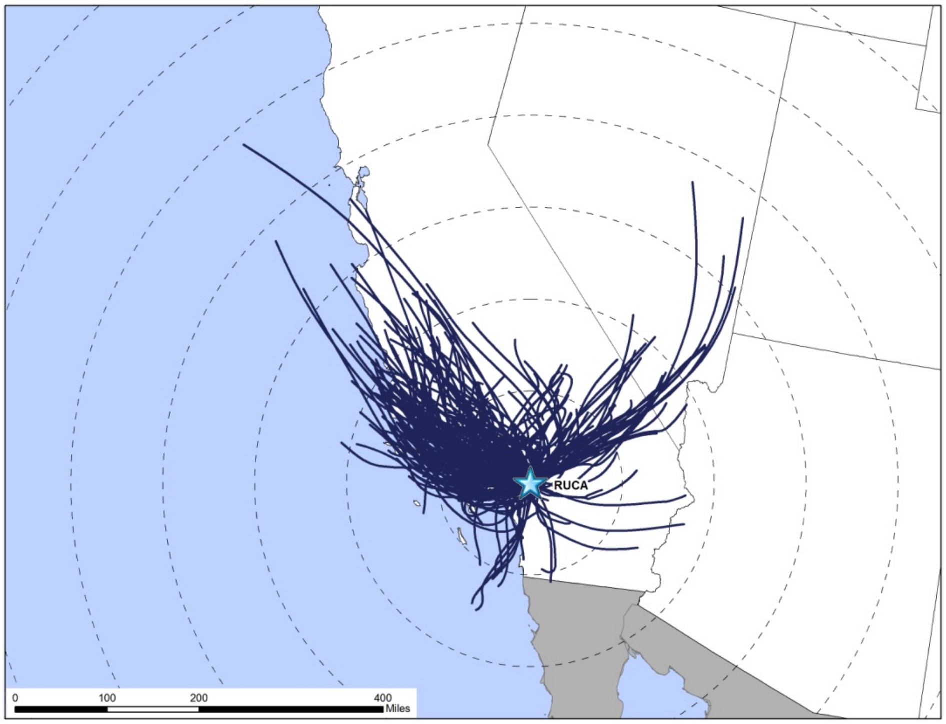


Figure 6-13. Back Trajectory Cluster Map for RUCA

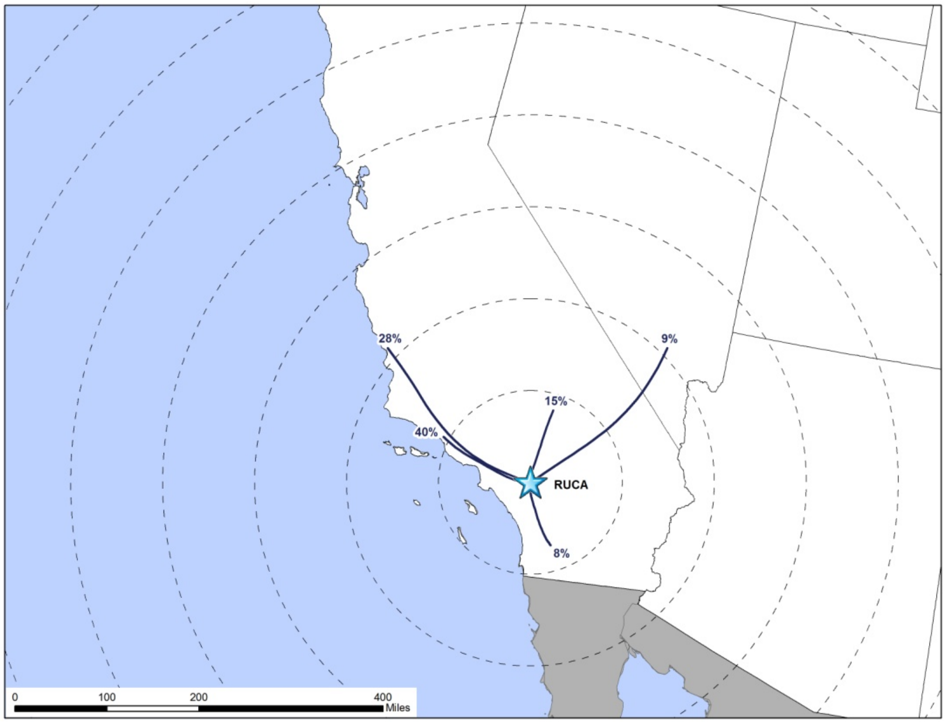


Figure 6-14. Composite Back Trajectory Map for SJJCA

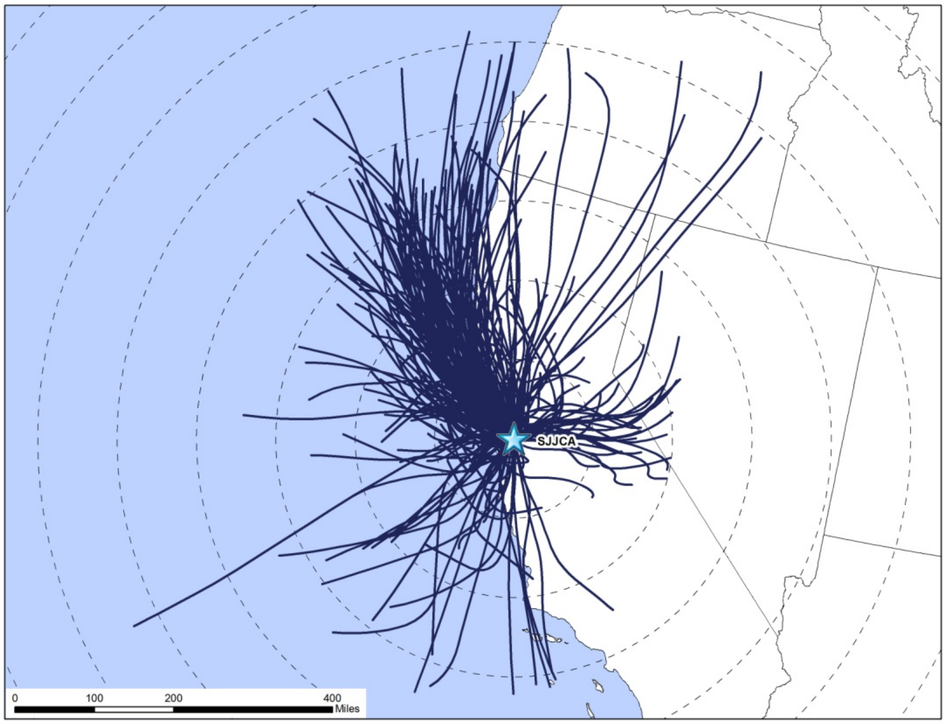
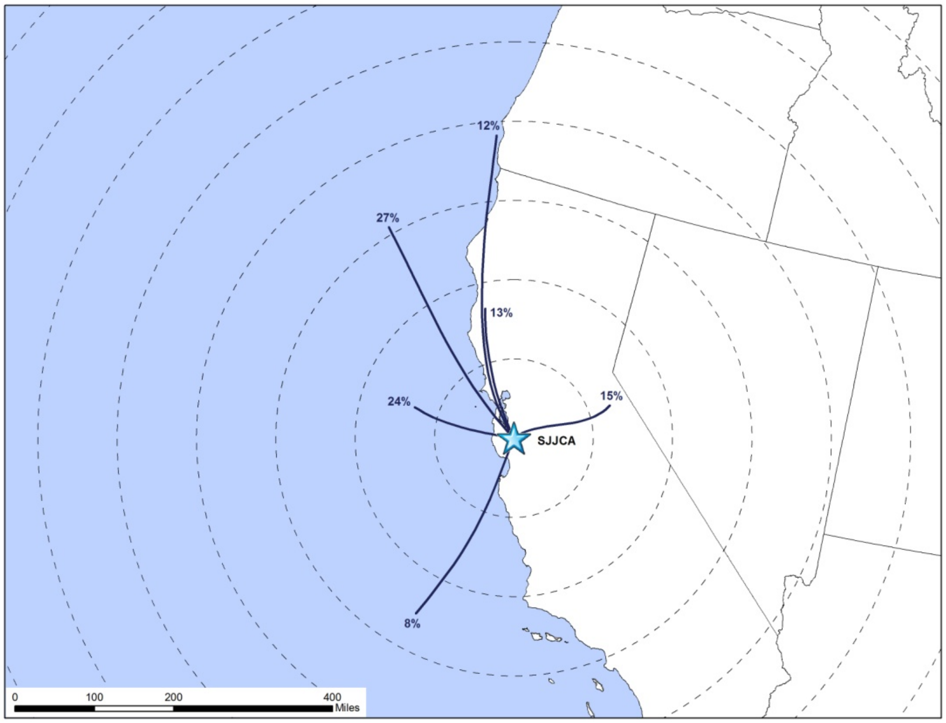


Figure 6-15. Back Trajectory Cluster Map for SJJCA



Observations from Figures 6-8 and 6-9 for CELA include the following:

- The 24-hour air shed domain for CELA is among the smaller ones compared to other NMP monitoring sites, based on the average length of back trajectories (174 miles). Although the farthest away a back trajectory originated was off the northern California coast, or nearly 500 miles away, most back trajectories (84 percent) originated within 250 miles of CELA. Only three back trajectories originated greater than 400 miles away.

- Back trajectories originated from a variety of directions at CELA. However, a large number of back trajectories originated from the northwest over the Pacific Ocean and along the California coastline. Another cluster originated from the east-northeast. Fewer back trajectories originated from the east, southeast, south, or southwest.

- The cluster analysis shows that roughly three-quarters of back trajectories originated from the northwest and/or offshore, although of varying distances. The shorter cluster trajectory (25 percent) includes back trajectories originating to the northwest of Los Angeles, south of Bakersfield and Santa Maria, as well as shorter back trajectories originating just offshore. Another 23 percent of back trajectories originated offshore west of San Luis Obispo and 28 percent originated towards Monterrey and San Francisco and the adjacent offshore waters. The cluster trajectory originating over the interior of California (16 percent) represents back trajectories originating over the desert areas of southern California as well as southern portions of Nevada. The short cluster trajectory (8 percent) originating due south of the Los Angeles area includes back trajectories originating over the San Diego area as well as the offshore waters between the two metro areas.

Observations from Figures 6-10 and 6-11 for LBHCA include the following:

- The composite back trajectory map for LBHCA is similar to the CELA map in back trajectory distribution, although there are roughly half the back trajectories shown in Figure 6-10, as this site did not begin sampling until July. The 24-hour air shed domain for LBHCA is slightly smaller than CELA's, based on the average length of back trajectories (160 miles). The farthest away a back trajectory originated was over the Pacific Ocean, off the northern California coast, or just greater than 500 miles away. However, most trajectories (89 percent) originated within 250 miles of LBHCA and only three originated greater than 300 miles away.

- The cluster analysis for LHBCA is very similar to the cluster analysis for CELA in trajectory distribution, although the percentages differ. While back trajectories originating from a northwesterly direction account for more than 72 percent of the back trajectories, back trajectories originating to the south account for a higher percentage than those originating to the northeast compared to CELA.

Observations from Figures 6-12 and 6-13 for RUCA include the following:

- The composite back trajectory map for RUCA is very similar to the one for CELA, which is not surprising given their relatively close proximity to each other. The 24-hour air shed domain for RUCA is smaller in size to CELA, based on the average back trajectory length (147 miles). The farthest away a back trajectory originated was off the northern California coast, nearly 500 miles away. However, nearly 95 percent of back trajectories originated within 250 miles of RUCA and only one back trajectory originated farther than 400 miles away.

- The cluster analysis for RUCA is similar to the cluster analysis for CELA in that nearly 70 percent of back trajectories originated from the northwest of the site. However, the cluster analysis splits these into two cluster trajectories rather than three. The shorter cluster trajectory (40 percent) includes back trajectories originating primarily to the west and northwest of the site, along the coastline and offshore waters of the Santa Barbara Channel while the other cluster trajectory (28 percent) represents those back trajectories originating farther up the coast as far north as the San Francisco area. The cluster analysis splits the north and northeastward originating back trajectories into two cluster trajectories. One cluster (15 percent) includes relatively short back trajectories originating primarily to the north and northeast of the site while the other cluster (9 percent) includes the longer back trajectories originating near and beyond the California/Nevada border. The final cluster originating to the south of RUCA includes relatively short back trajectories originating toward and offshore of the San Diego area as well as those originating to the east and southeast over the Mojave and Sonora Deserts.

Observations from Figures 6-14 and 6-15 for SJJCA include the following:

- Based on the average length of the back trajectories, the 24-hour air shed domain for SJJCA is larger than the air shed domains for the other California sites. The average length of back trajectories for SJJCA is 236 miles. The farthest away a back trajectory originated was over northeast Oregon or greater than 500 miles away, although a second back trajectory of similar distance also originated well over the Pacific Ocean, southwest of the monitoring site. Only 56 percent of back trajectories originated within 250 miles of SJJCA, while greater than 80 percent originated within 250 miles of CELA, LBHCA, and RUCA. Eighteen back trajectories originated farther than 400 miles away from the site.

- Back trajectories originated from a variety of directions at SJJCA, seemingly more so than for the other California sites. However, the composite map still shows a large number of back trajectories originated from the north, northwest, and along the coast. Fewer back trajectories originated from other directions.

- The cluster analysis shows that 25 percent of back trajectories originated to the north of the site, along the northern California coastline, although these are split into two cluster trajectories based on the length of the back trajectory. Another 27 percent of back trajectory originated farther offshore. Nearly 25 percent of back trajectories originated offshore and to the west of the site, although these tended to be shorter in length than those originating from a more northwesterly or northerly direction.

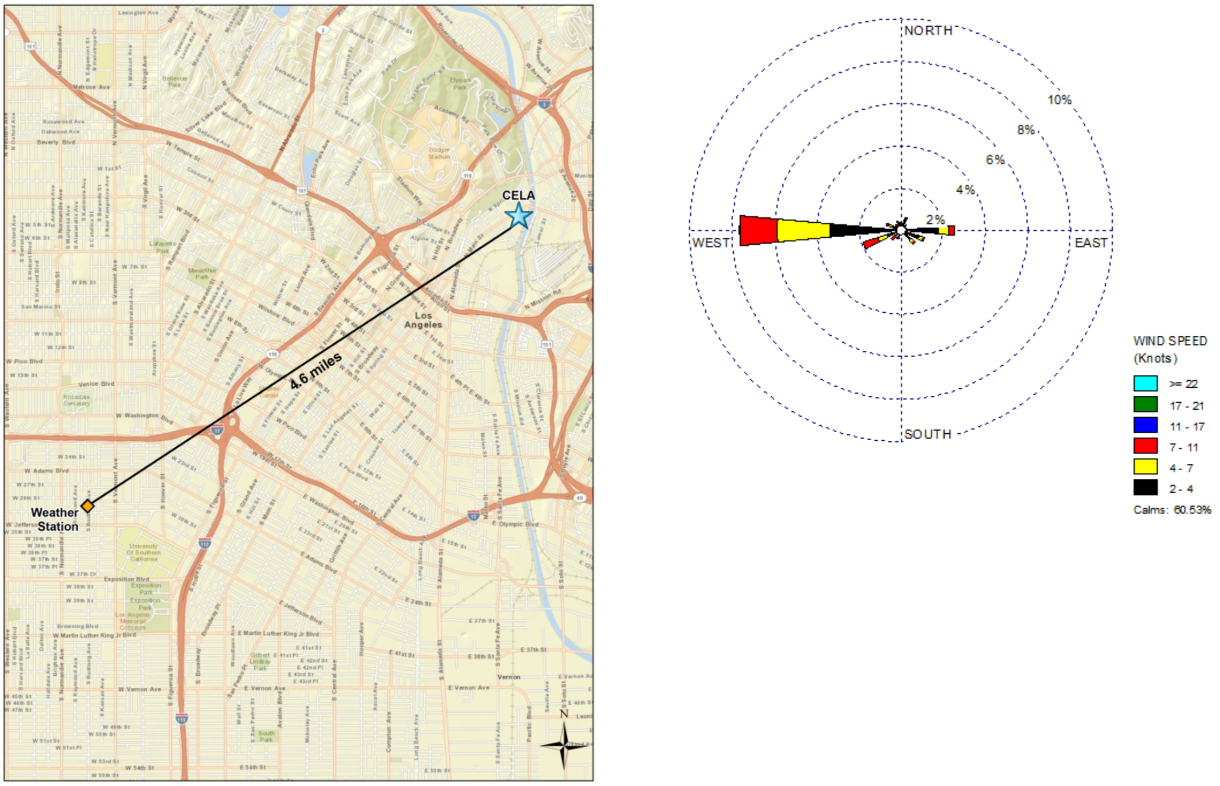
> Fifteen percent of back trajectories originated over central California and west-central Nevada. These too tended to be shorter in length (less than 200 miles long). Finally, the last eight percent of back trajectories are represented by the cluster trajectory originating to the south of SJJCA, and include back trajectories originating over the Los Angeles area and both the adjacent Pacific waters as well as those farther offshore.

6.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations at the Downtown Los Angeles/USC Campus (for CELA), Long Beach/Daugherty Field Airport (for LBHCA), Riverside Municipal Airport (for RUCA), and San Jose International Airport (for SJJCA) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

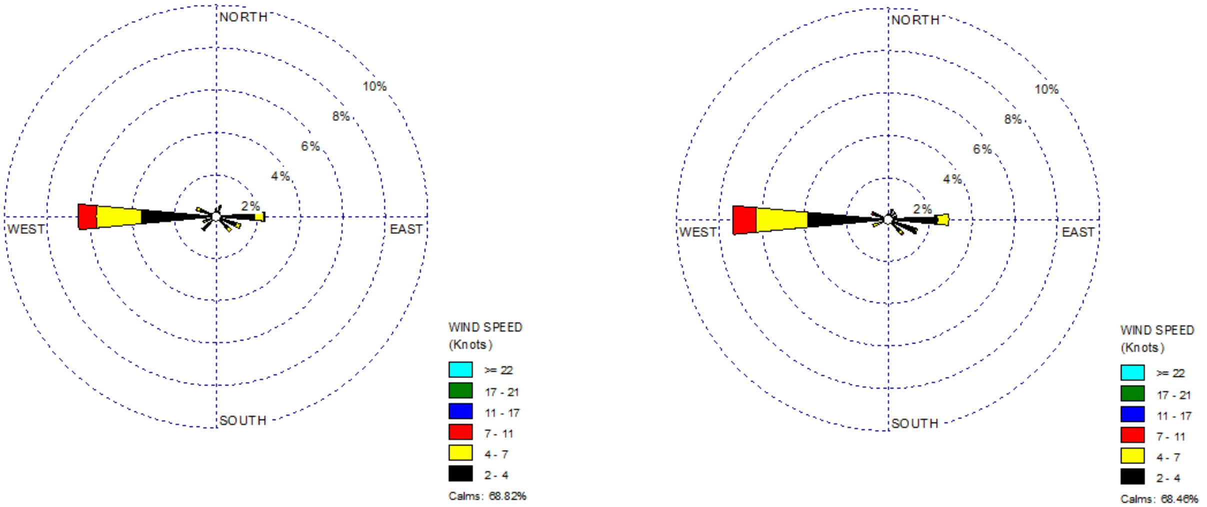
Figure 6-16 presents a map showing the distance between the weather station and CELA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 6-16 also presents three different wind roses for the CELA monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 6-17 through 6-19 present the distance maps and wind roses for LBHCA, RUCA, and SJJCA, respectively.

Figure 6-16. Wind Roses for the Downtown Los Angeles/USC Campus Weather Station near CELA



Location of CELA and Weather Station

2002-2011 Historical Wind Rose



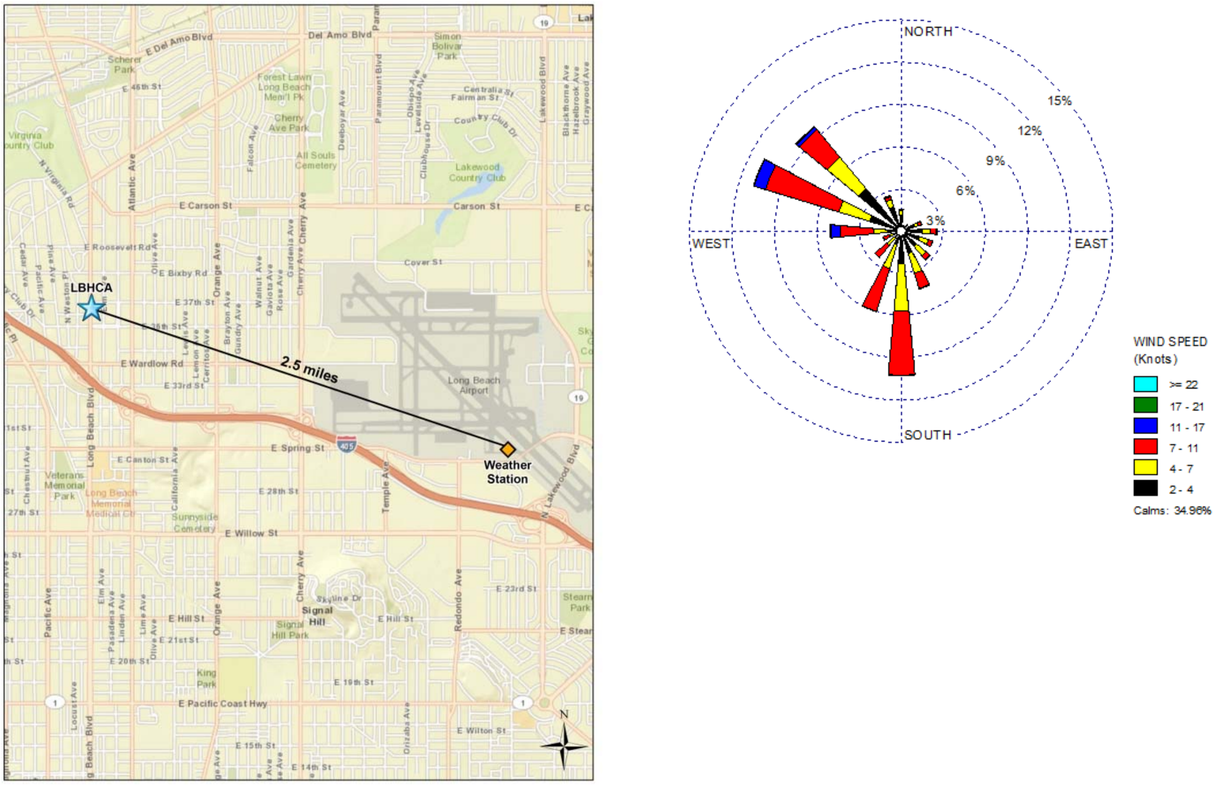
2012 Wind Rose

Sample Day Wind Rose

Figure 6-17. Wind Roses for the Long Beach/Daugherty Field Airport Weather Station near LBHCA

Location of LBHCA and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

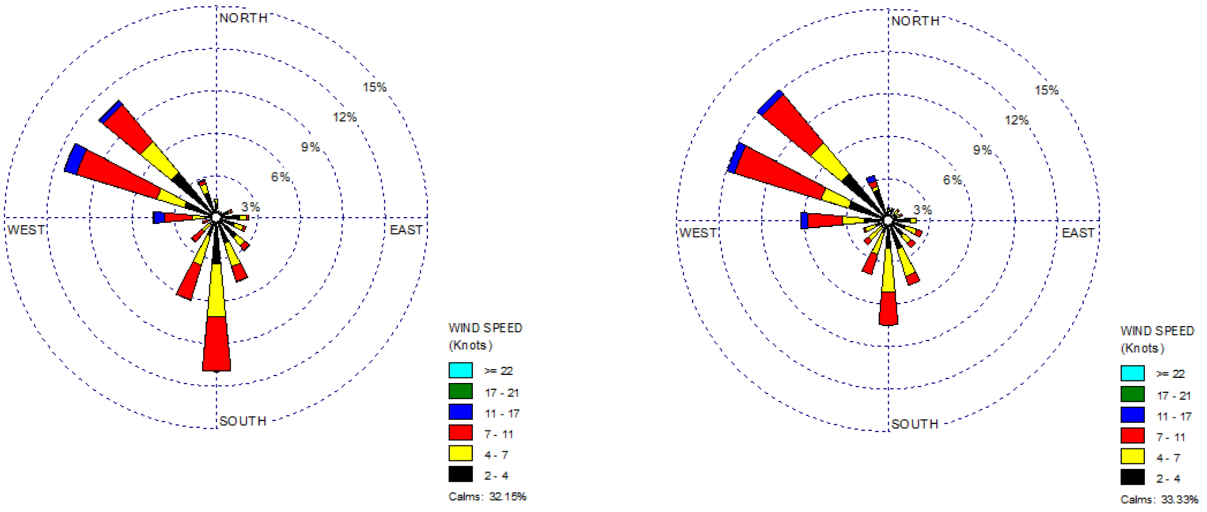
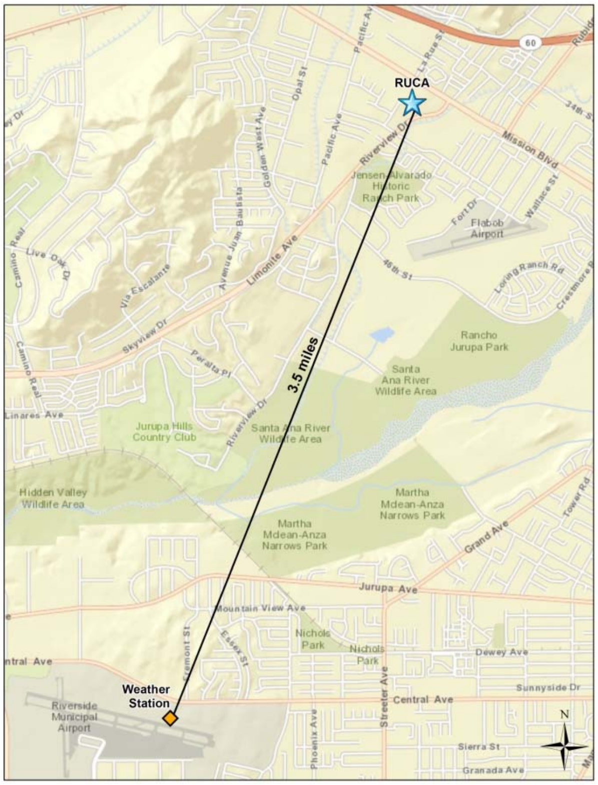
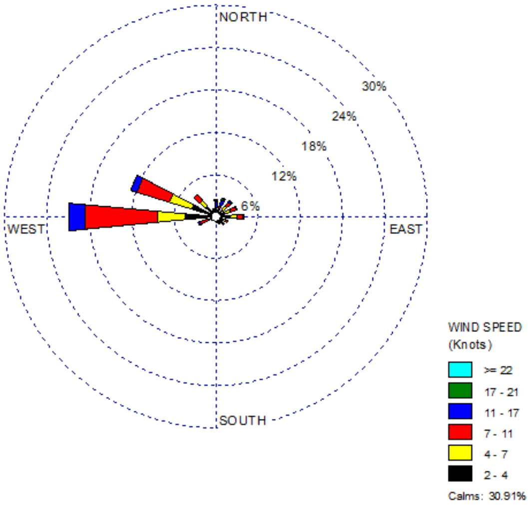


Figure 6-18. Wind Roses for the Riverside Municipal Airport Weather Station near RUCA

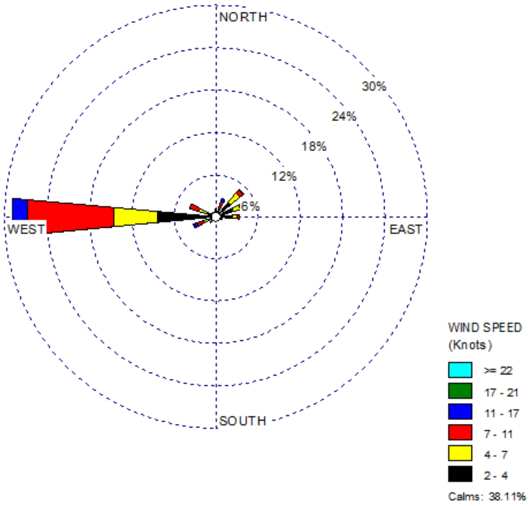
Locations of RUCA and Weather Station



2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

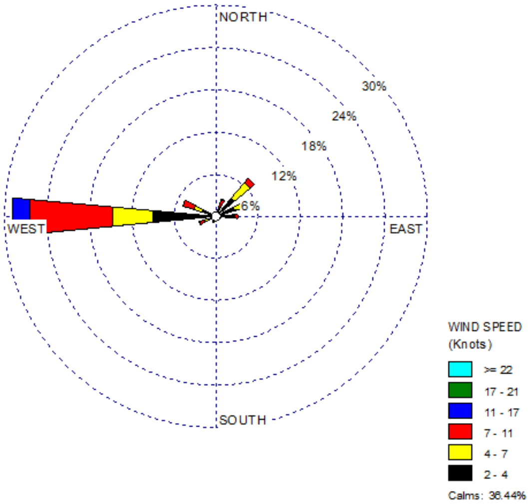
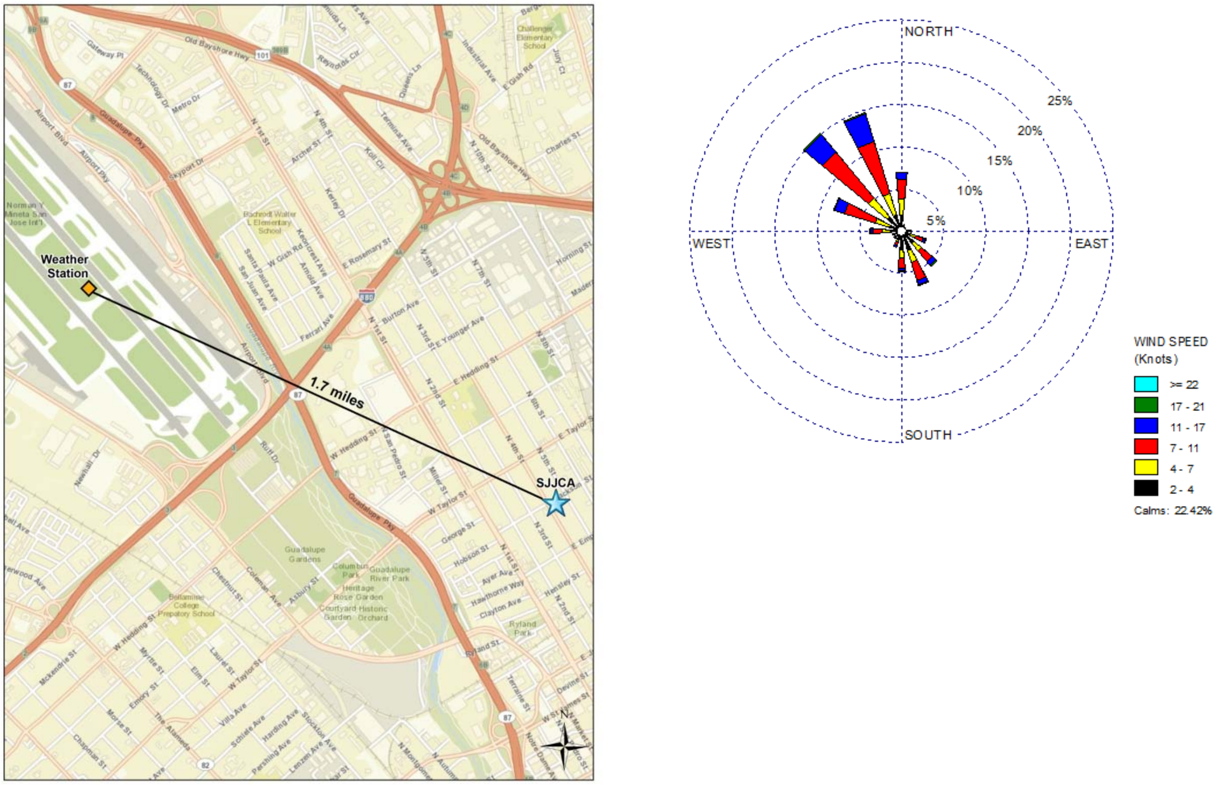
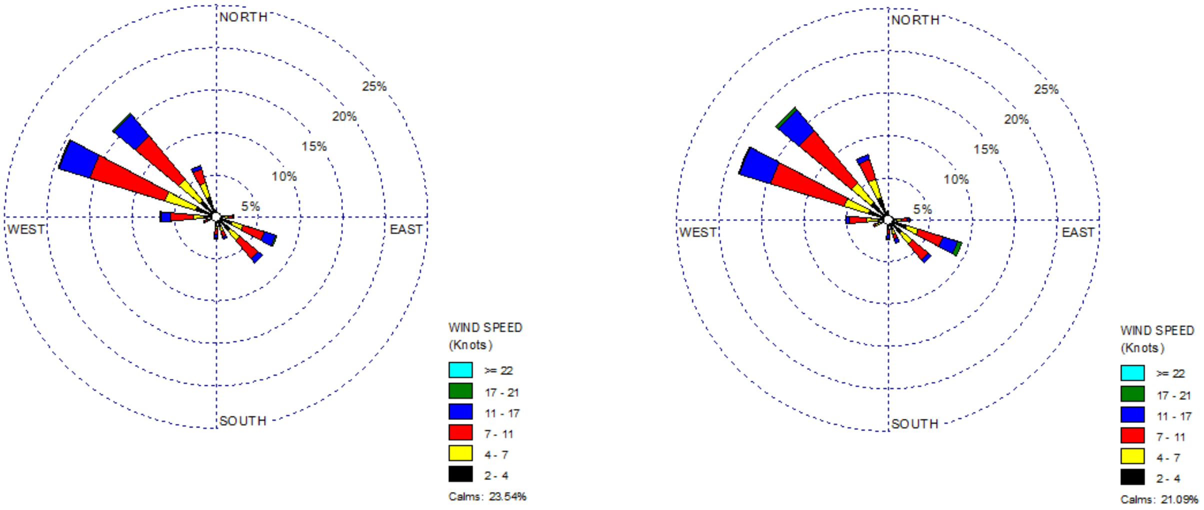


Figure 6-19. Wind Roses for the San Jose International Airport Weather Station near SJJCA



Location of SJJCA and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Observations from Figure 6-16 for CELA include the following:

- The weather station at the Downtown Los Angeles/USC Campus is located approximately 4.6 miles west-southwest of CELA.

- Historically, winds were generally light near this site, with calm winds (≤ 2 knots) observed for 60 percent of the wind observations. For wind speeds greater than 2 knots, westerly winds were most common, followed by easterly and west-southwesterly winds. Wind speeds greater than 11 knots were not measured at this weather station.

- The 2012 full-year and sample day wind roses are similar to the historical wind rose in that calm winds make up the majority of the observations and that westerly winds were prominent. However, a higher percentage of calm winds were measured in 2012 while west-southwesterly winds were rarely observed. Yet, the wind patterns shown on the full-year and sample day wind roses generally resemble the historical wind patterns, indicating that conditions in 2012 and on sample days were representative of those experienced historically.

Observations from Figure 6-17 for LBHCA include the following:

- The weather station at the Long Beach/Daugherty Field Airport is located approximately 2.5 miles east-southeast of LBHCA.

- The historical wind rose shows that calm winds were observed for more than one-third of the observations near LBHCA. Winds from the west-northwest and northwest together account for approximately 20 percent of the wind observations while winds from the south account for another 10 percent of observations. Winds from the northeast quadrant were generally not observed near this site.

- The wind patterns on the 2012 full-year wind rose are very similar to the historical wind patterns, indicating that conditions in 2012 were representative of those experienced historically. The sample day wind rose has a higher percentage of west-northwesterly and northwesterly winds and fewer winds from the south and south-southwest. Recall however, that sampling at LBHCA began in July, and thus does not include wind observations from the first half of the year. The wind patterns on the sample day wind rose may be indicative of a seasonal wind pattern.

Observations from Figure 6-18 for RUCA include the following:

- The weather station at the Riverside Municipal Airport is located south of the Santa Ana River and Wildlife Area, approximately 3.5 miles southwest of RUCA.

- Although calm winds were observed for approximately 31 percent of the wind observations near RUCA, westerly and west-northwesterly winds were also frequently observed, accounting for approximately 21 percent and 12 percent of wind observations, respectively, based on the historical wind rose.

- The 2012 wind rose exhibits a higher percentage of calm winds (38 percent) compared to the historical wind rose. In addition, westerly winds make up almost the same percentage of wind observations in 2012 as both westerly and west-northwesterly winds on the historical wind rose, as west-northwesterly winds were observed infrequently in 2012. As similar observation was noted in the 2011 NMP report.

- The wind patterns shown on the sample day wind rose resemble the wind patterns shown on the full-year wind rose, indicating that conditions on sample days in 2012 were representative of those experienced over the entire year.

Observations from Figure 6-19 for SJJCA include the following:

- The weather station at the San Jose International Airport is located 1.7 miles northwest of SJJCA, across I-880, the Guadalupe Parkway, and the Guadalupe River.

- Between 2002 and 2011, approximately 45 percent of winds were from the west-northwest to north. Another 18 percent of winds were from the southeast to south. Winds from the northeastern and southwestern quadrants were rarely observed. Approximately one-fifth of the winds were calm.

- The wind patterns on the full-year and sample day wind roses exhibit a shift in primary wind direction, from west-northwest to north on the historical wind rose to west to north-northwest on the 2012 wind roses. This shift is also shown in the secondary wind directions, from southeast to south on the historical to east-southeast to southeast on the 2012 wind rose. This shift was also shown on the 2009, 2010, and 2011 wind roses in the 2008-2009, 2010, and 2011 NMP reports.

- The wind patterns shown on the sample day wind rose generally resemble the wind patterns shown on the full-year wind rose, indicating that conditions on sample days were representative of those experienced over the entire year.

6.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each California monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 6-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 6-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. All four California sites sampled PAHs; in addition, SJJCA also sampled metals (PM_{10}).

Table 6-4. Risk-Based Screening Results for the California Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Los Angeles, California - CELA						
Naphthalene	0.029	60	60	100.00	81.08	81.08
Fluorene	0.011	12	60	20.00	16.22	97.30
Acenaphthene	0.011	2	60	3.33	2.70	100.00
Total		74	180	41.11		
Long Beach, California - LBHCA						
Naphthalene	0.029	25	26	96.15	96.15	96.15
Benzo(a)pyrene	0.00057	1	13	7.69	3.85	100.00
Total		26	39	66.67		
Rubidoux, California - RUCA						
Naphthalene	0.029	58	61	95.08	100.00	100.00
Total		58	61	95.08		
San Jose, California - SJJCA						
Arsenic (PM_{10})	0.00023	45	58	77.59	35.16	35.16
Naphthalene	0.029	43	59	72.88	33.59	68.75
Manganese (PM_{10})	0.005	32	61	52.46	25.00	93.75
Nickel (PM_{10})	0.0021	7	61	11.48	5.47	99.22
Benzo(a)pyrene	0.00057	1	15	6.67	0.78	100.00
Total		128	254	50.39		

Observations from Table 6-4 include the following:

- Naphthalene failed the majority of screens for all three California monitoring sites where only PAHs were sampled. Naphthalene's site-specific contribution to the total failed screens for these sites ranges from 81 percent (CELA) to 100 percent (RUCA).

- Fluorene and acenaphthene also failed screens for CELA; however, only naphthalene and fluorene were identified as pollutants of interest for CELA.

- Benzo(a)pyrene failed a single screen for LBHCA. Since naphthalene accounts for 96 percent of failed screens for LBHCA, only naphthalene is a pollutant of interest for this site.

- Naphthalene is the only pollutant to fail screens for RUCA and is therefore RUCA's only pollutant of interest.

- SJJCA is the only site for which naphthalene does not account for the majority of failed screens; arsenic failed two more screens than naphthalene. Together, these two pollutants account for nearly 70 percent of SJJCA's total failed screens. Manganese, nickel, and benzo(a)pyrene also failed screens for this site. Arsenic, naphthalene, manganese, and nickel contributed to 95 percent of failed screens for SJJCA and were therefore identified as pollutants of interest for this site.

6.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the California monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.

- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for the California monitoring sites are provided in Appendices M and N.

6.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each California site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the California monitoring sites are presented in Table 6-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 6-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the California Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Los Angeles, California - CELA						
Fluorene	60/60	4.78 ± 1.02	7.63 ± 1.24	13.12 ± 2.12	5.64 ± 1.35	7.67 ± 1.07
Naphthalene	60/60	147.31 ± 40.04	184.68 ± 44.58	237.14 ± 40.44	155.03 ± 36.73	179.67 ± 20.99
Long Beach, California - LBHCA						
Naphthalene	26/26	NA	NA	52.95 ± 8.70	96.81 ± 31.44	NA
Rubidoux, California - RUCA						
Naphthalene	61/61	109.91 ± 46.06	74.53 ± 18.15	82.21 ± 21.13	119.68 ± 32.49	96.96 ± 15.56
San Jose, California - SJJCA						
Arsenic (PM_{10})	58/61	0.54 ± 0.25	0.42 ± 0.12	0.35 ± 0.08	0.27 ± 0.13	0.39 ± 0.08
Manganese (PM_{10})	61/61	7.05 ± 3.15	5.27 ± 1.78	6.78 ± 1.32	5.74 ± 3.21	6.22 ± 1.18
Naphthalene	59/59	101.47 ± 43.40	41.90 ± 11.09	32.26 ± 11.86	100.84 ± 41.23	69.73 ± 16.96
Nickel (PM_{10})	61/61	1.22 ± 0.52	1.17 ± 0.33	1.35 ± 0.26	0.92 ± 0.43	1.17 ± 0.19

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for the California monitoring sites from Table 6-5 include the following:

- Naphthalene was identified as a pollutant of interest for all four sites. Concentrations of naphthalene were highest at CELA and lowest at SJJCA, based on the annual averages. LBHCA does not have an annual average presented in Table 6-5 because sampling did not begin at this site until July. However, summary statistics for LBHCA covering the sampling period are provided in Appendix M.

- Concentrations of naphthalene for CELA were highest in the second and third quarters of 2012, particularly the third quarter. However, the confidence intervals calculated for these quarterly averages indicate a high level of variability is associated with these measurements. For example, naphthalene concentrations measured at CELA ranged from 41.2 ng/m^3 to 369 ng/m^3 with a median concentration of 168 ng/m^3. CELA has the second highest number of naphthalene concentrations greater than 300 ng/m^3 (seven) among NMP sites sampling PAHs. Of these seven, all but one was measured between June and August.

- Fluorene concentrations at CELA were also highest during the second and third quarters of 2012, particularly the third quarter. Fluorene concentrations ranged from 2.06 ng/m^3 to 19.3 ng/m^3 with a median concentration of 6.74 ng/m^3. Of the 15 concentrations greater than 10 ng/m^3 measured at CELA, all but two were measured in either the second or third quarter of 2012. Conversely, of the 13 concentrations less than 4 ng/m^3, all but one was measured during the first or fourth quarters of 2012. This supports the observations in Section 4.4.2 regarding fluorene measurements being higher in the warmer months of the year.

- Concentrations of naphthalene measured at LBHCA ranged from 27.7 ng/m^3 to 245 ng/m^3. Because this site began sampling in July, only third and fourth quarter averages are presented in Table 6-5. The fourth quarter average concentration is significantly higher than the third quarter average. All five concentrations greater than 100 ng/m^3 measured at LBHCA were measured in October, November, or December. Further, the measurements collected in the fourth quarter have more variability associated with them, as indicated by the confidence intervals. Measurements collected between July and September ranged from 27.7 ng/m^3 to 76.7 ng/m^3, with a median concentration of 56.1 ng/m^3; measurements collected between October and December ranged from 39.3 ng/m^3 to 245 ng/m^3, with a median concentration of 81.6 ng/m^3.

- Concentrations of naphthalene at RUCA also tended to be higher during the colder months of the year. Not only are the first and fourth quarter averages higher than the other quarterly averages, they also have more variability associated with them. Concentrations measured during the first and fourth quarters range from 9.09 ng/m^3 to 374 ng/m^3 with a median concentration of 103 ng/m^3. Concentrations measured during the second and third quarters range from 32.8 ng/m^3 to 166 ng/m^3 with a median concentration of 69.1 ng/m^3.

- Naphthalene concentrations measured at SJJCA follow a similar pattern as those measured at RUCA. The first and fourth quarter naphthalene averages are significantly higher than the other quarterly averages, and they too have more variability associated with them. Concentrations measured during the first and fourth quarters range from 23.5 ng/m^3 to 294 ng/m^3 with a median concentration of 66.8 ng/m^3. Concentrations measured during the second and third quarters range from 13.2 ng/m^3 to 101 ng/m^3 with a median concentration of 30.2 ng/m^3.

- Manganese has the highest annual average concentration of the PM_{10} metal pollutants of interest for SJJCA, followed by nickel and arsenic. Although the quarterly averages of manganese are not significantly different from each other, the first and fourth quarter average concentrations have a relatively high level of variability associated with them, as indicated by the confidence intervals. Concentrations measured in the first and fourth quarters span approximately 22 ng/m^3 between the minimum and maximum measurement in each quarter while the range is less than 10 ng/m^3 for the second and third quarters.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the California sites from those tables include the following:

- CELA and RUCA appear in Table 4-11 for PAHs a total of five times. CELA has the second highest annual average concentration naphthalene among NMP sites sampling PAHs (behind only GPCO); RUCA ranks seventh for naphthalene. CELA and RUCA rank sixth and seventh for fluorene, respectively. CELA also ranks sixth for acenaphthalene, although RUCA does not appear in Table 4-11 for this pollutant (it ranks 13th). SJJCA does not appear in Table 4-11.

- SJJCA appears twice in Table 4-12 for PM_{10} metals. SJJCA has the seventh highest annual average concentration of nickel and 10th highest annual average concentration of manganese among NMP sites sampling PM_{10} metals.

6.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 6-4 for CELA, RUCA, and SJJCA. Figures 6-20 through 6-24 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1. Because annual averages could not be calculated for LBHCA, box plots were not created for this site.

Figure 6-20. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

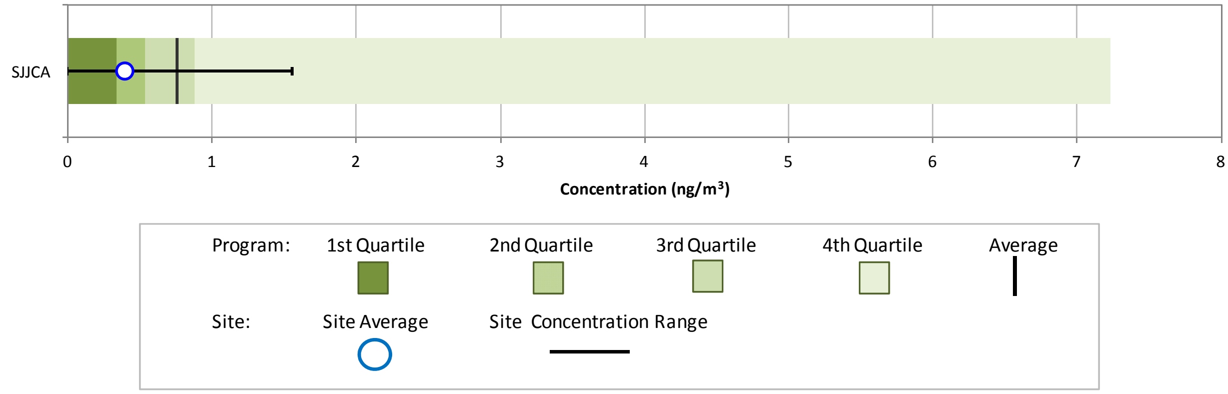


Figure 6-21. Program vs. Site-Specific Average Fluorene Concentration

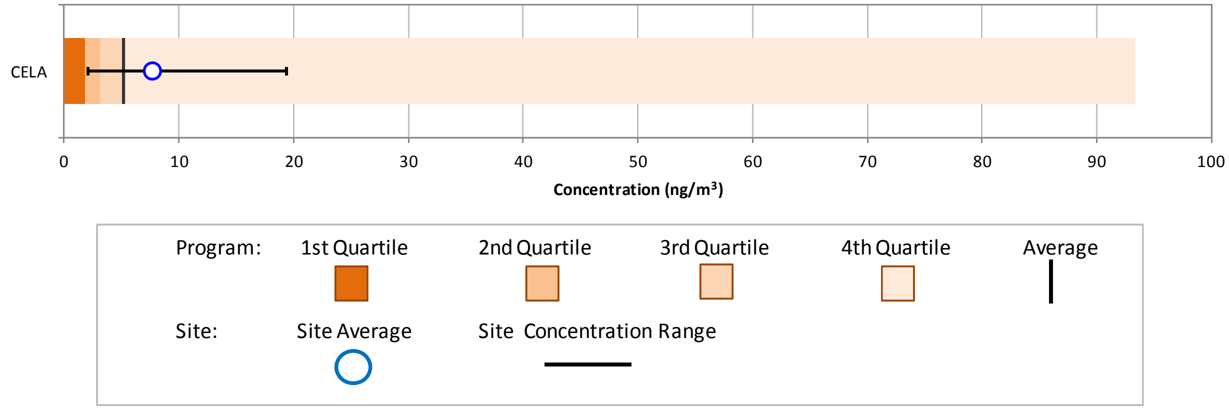


Figure 6-22. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

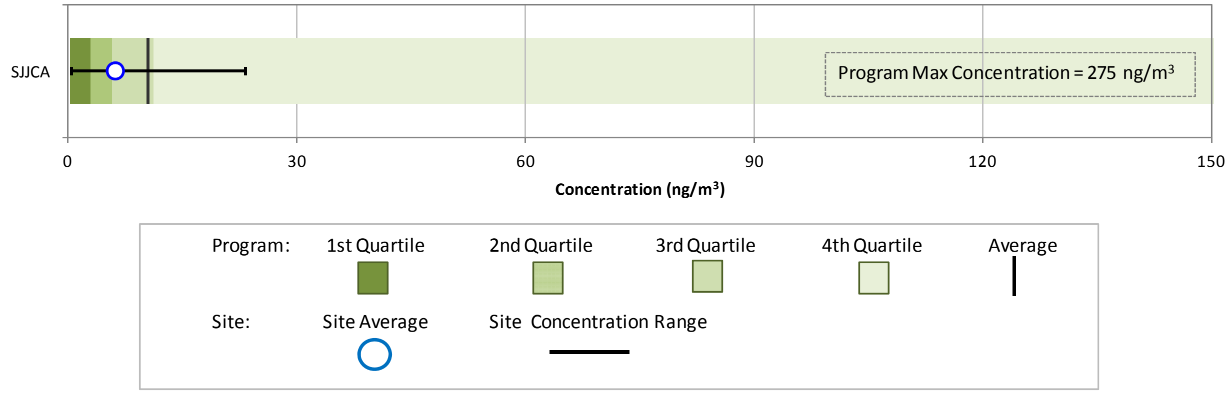


Figure 6-23. Program vs. Site-Specific Average Naphthalene Concentrations

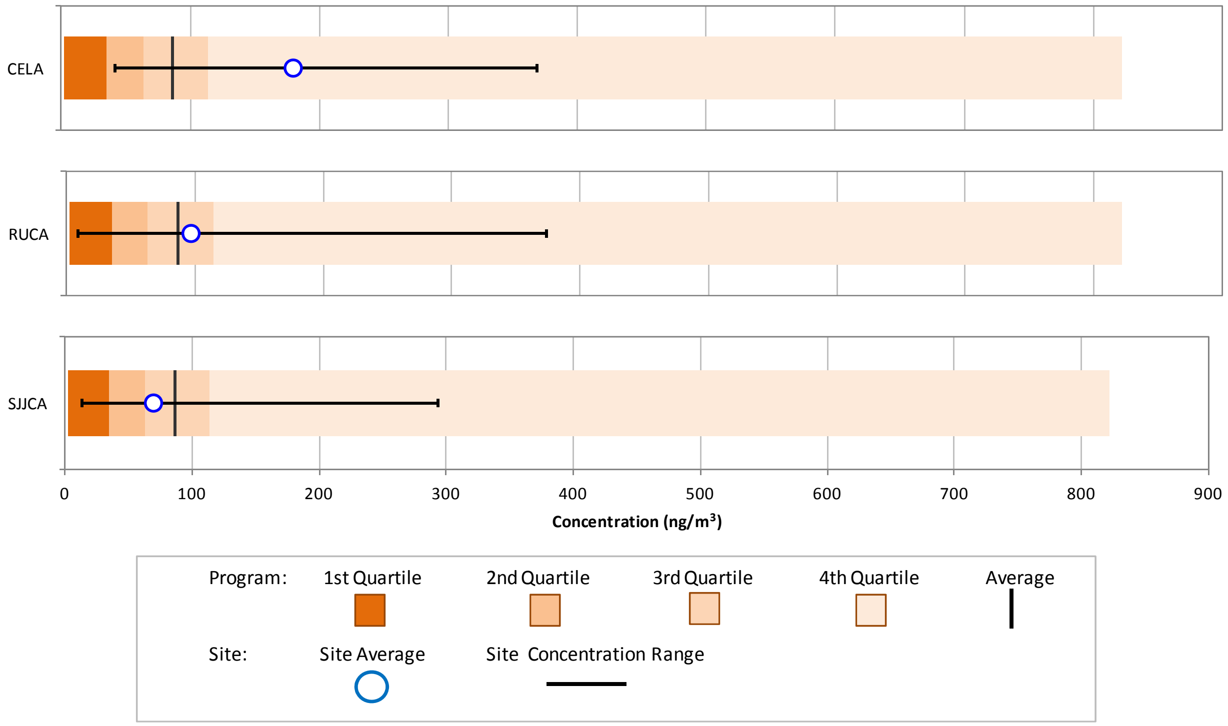
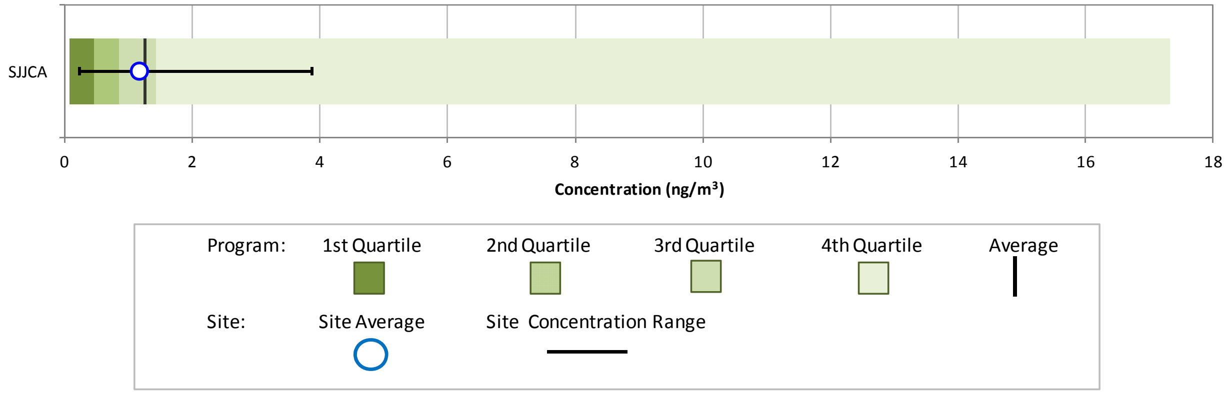


Figure 6-24. Program vs. Site-Specific Average Nickel (PM_{10}) Concentration



Observations from Figures 6-20 through 6-24 include the following:

- Figure 6-20 shows that the annual average arsenic (PM_{10}) concentration for SJJCA is less than both the program-level average and median concentrations of arsenic (PM_{10}). The annual average concentration of arsenic for SJJCA (0.39 ng/m^3) is just greater than the program-level first quartile (0.34 ng/m^3). Three non-detects of arsenic were measured at SJJCA. SJJCA is one of only three sites to measure non-detects of this pollutant (UNVT and BTUT are the others).

- Figure 6-21 for fluorene includes only CELA because this is the only site for which fluorene is a pollutant of interest. Figure 6-21 shows that the annual average concentration of fluorene for CELA is greater than both the program-level average and third quartile. Although the maximum concentration measured at CELA is significantly less than the maximum concentration measured across the program, the minimum concentration measured at CELA is greater than the program-level first quartile. There were no non-detects of fluorene measured at CELA, although a few were measured at other NMP sites sampling PAHs.

- Figure 6-22 is the box plot for manganese (PM_{10}) for SJJCA. Note that the program-level maximum concentration (275 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 150 ng/m^3. Figure 6-22 shows that the annual average concentration of manganese (PM_{10}) for SJJCA is less than the program-level average concentration and just greater than the program-level median concentration. The maximum manganese concentration measured at SJJCA is an order of magnitude less than the maximum concentration measured across the program. The minimum concentration measured at SJJCA is one of the lowest concentrations measured among NMP sites sampling PM_{10} metals (only five measurements are lower).

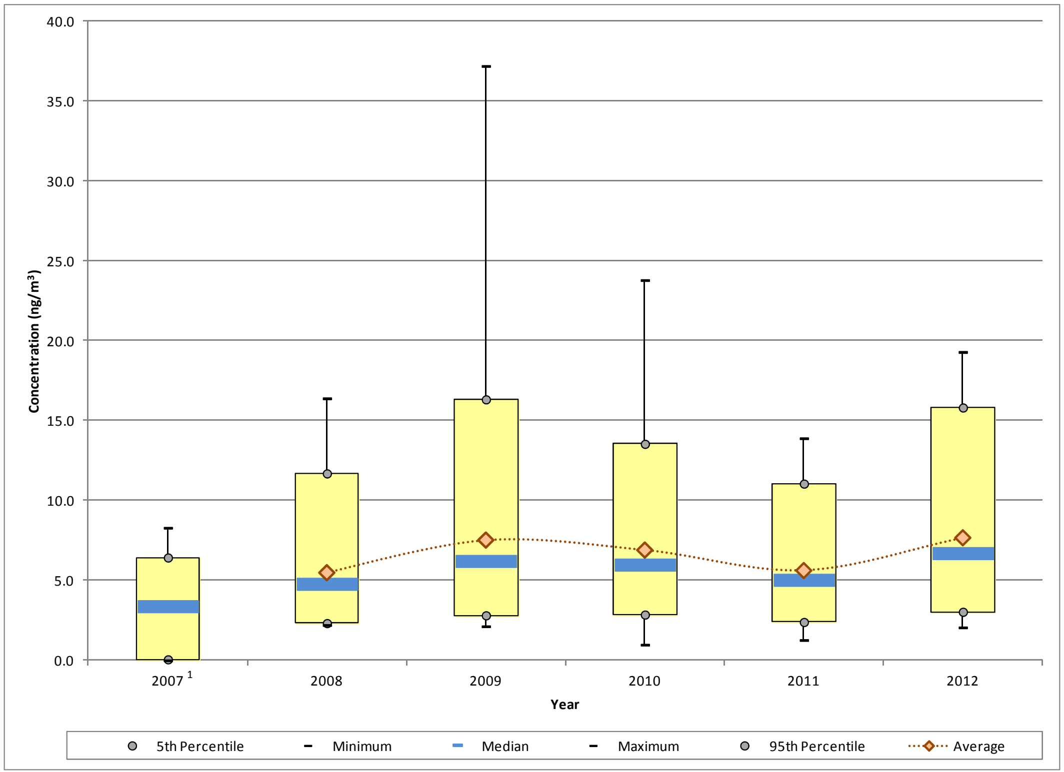
- Figure 6-23 for naphthalene shows all three sites with available annual averages. The box plots make an inter-site comparison relatively easy; the annual average concentration is highest for CELA, followed by RUCA, and lowest SJJCA. The annual average naphthalene concentration for CELA is greater than the program-level average concentration and third quartile; the annual average concentration for RUCA is just greater than the program-level average concentration; and the annual average concentration for SJJCA is less than the program-level average concentration but just greater than the program-level median concentration. Figure 6-23 also shows the range of concentrations measured at each site. Although the maximum concentrations measured at CELA and RUCA are similar, the minimum concentration measured at RUCA is less than the minimum concentration measured at CELA; further, the minimum concentration measured at CELA is greater than the program-level first quartile. There were no non-detects of naphthalene measured at CELA, RUCA, SJJCA, or across the program.

- Figure 6-24 is the box plot for nickel (PM_{10}) for SJJCA. Figure 6-24 shows that the annual average concentration of nickel for SJJCA is just less than the program-level average concentration. The maximum nickel concentration measured at SJJCA is considerably less than the maximum concentration measured across the program. There were no non-detects of nickel measured at SJJCA or across the program.

6.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. Both CELA and RUCA began sampling PAHs under the NMP in 2007. SJJCA began sampling PAHs and metals under the NMP in 2008. Thus, Figures 6-25 through 6-31 present the 1-year statistical metrics for each of the pollutants of interest first for CELA, then for RUCA, and finally for SJJCA. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented. A trends analysis was not conducted for LBHCA because this site has not sampled under the NMP for at least 5 consecutive years.

Figure 6-25. Yearly Statistical Metrics for Fluorene Concentrations Measured at CELA



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2007.

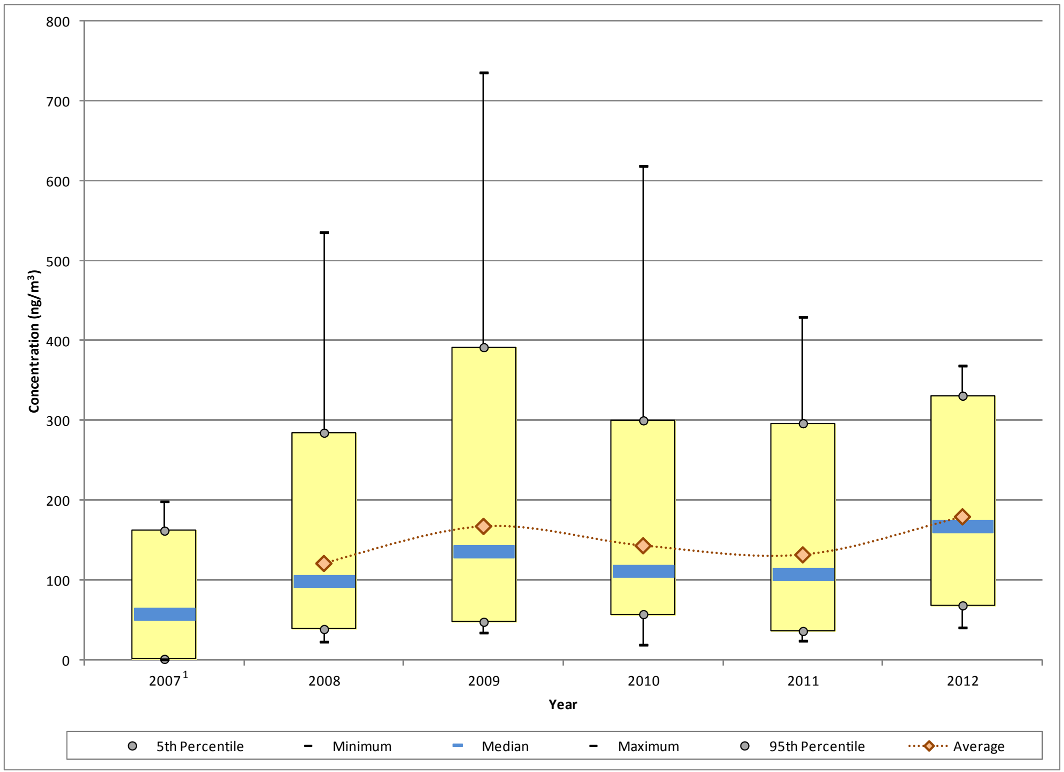
Observations from Figure 6-25 for fluorene measurements collected at CELA include the following:

- CELA began sampling PAHs under the NMP at the end of April 2007. Because a full year's worth of data is not available, a 1-year average is not presented, although the range of measurements is provided.

- The smallest range of measurements was collected in 2007, although the statistical metrics do not represent a full year of sampling. This was also the only year a non-detect was measured. The range of measurements, and thus the statistical parameters shown, increase through 2009, when the maximum fluorene concentration was measured. The maximum concentration for 2009 is the only measurement greater than 25 ng/m^3 measured at this site. The maximum, 95th percentile, 1-year average, and median concentrations decrease from 2009 to 2010 and again for 2011. Concentrations measured in 2011 exhibit the least amount of variability besides the initial year of sampling.

- All of the statistical parameters shown in Figure 6-25 exhibit an increase from 2011 to 2012.

Figure 6-26. Yearly Statistical Metrics for Naphthalene Concentrations Measured at CELA

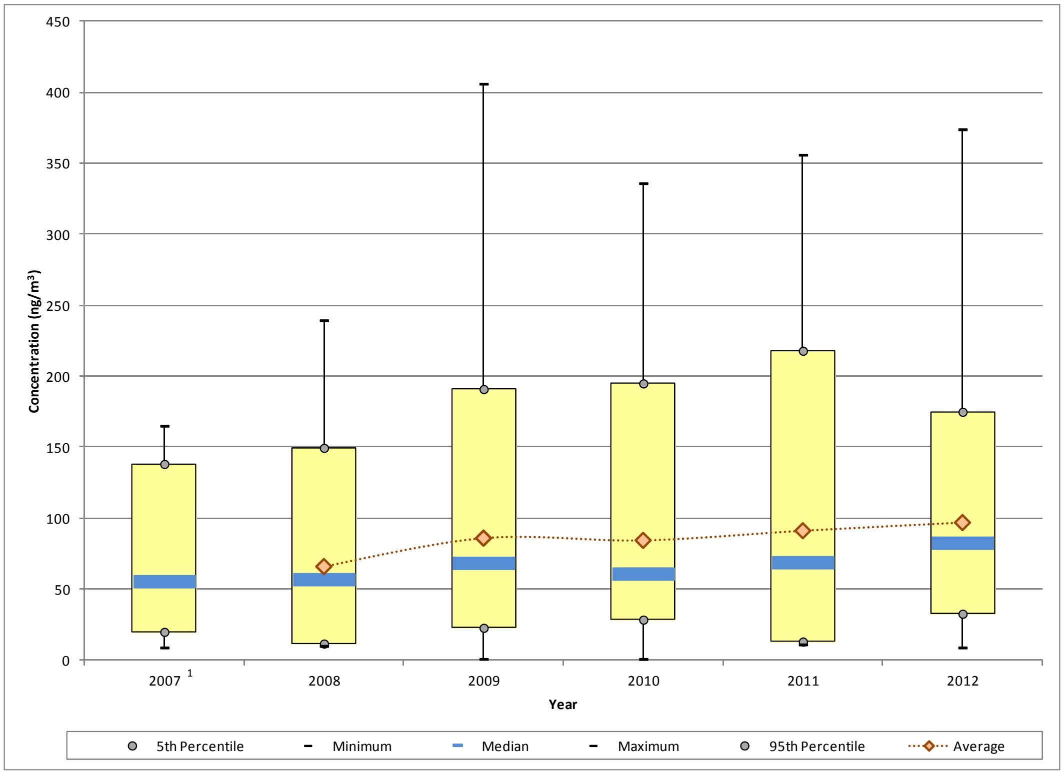


[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2007.

Observations from Figure 6-26 for naphthalene measurements collected at CELA include the following:

- The statistical parameters shown for naphthalene in Figure 6-26 exhibit a similar pattern as the statistical parameters for fluorene shown in Figure 6-25.
- The smallest range of measurements was again collected in 2007, although the statistical metrics do not represent a full year of sampling. The minimum concentration measured at CELA was measured in 2007 (1.30 ng/m^3); further, 2007 is the only year in which a concentration less than 19 ng/m^3 was measured. The range of naphthalene measurements, and thus the statistical parameters shown, increase through 2009, when the maximum concentration was measured (736 ng/m^3). Concentrations greater than 500 ng/m^3 were also measured in 2008 and 2010. The maximum, 95th percentile, 1-year average, and median concentrations decrease from 2009 to 2010 and again for 2011.
- All of the statistical parameters shown in Figure 6-26 exhibit an increase from 2011 to 2012 except the maximum concentration. The increase in the 1-year average concentration from 2011 to 2012 is significant, even though the range of concentrations measured in 2012 is the smallest since the initial year of sampling.

Figure 6-27. Yearly Statistical Metrics for Naphthalene Concentrations Measured at RUCA



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2007.

Observations from Figure 6-27 for naphthalene measurements collected at RUCA include the following:

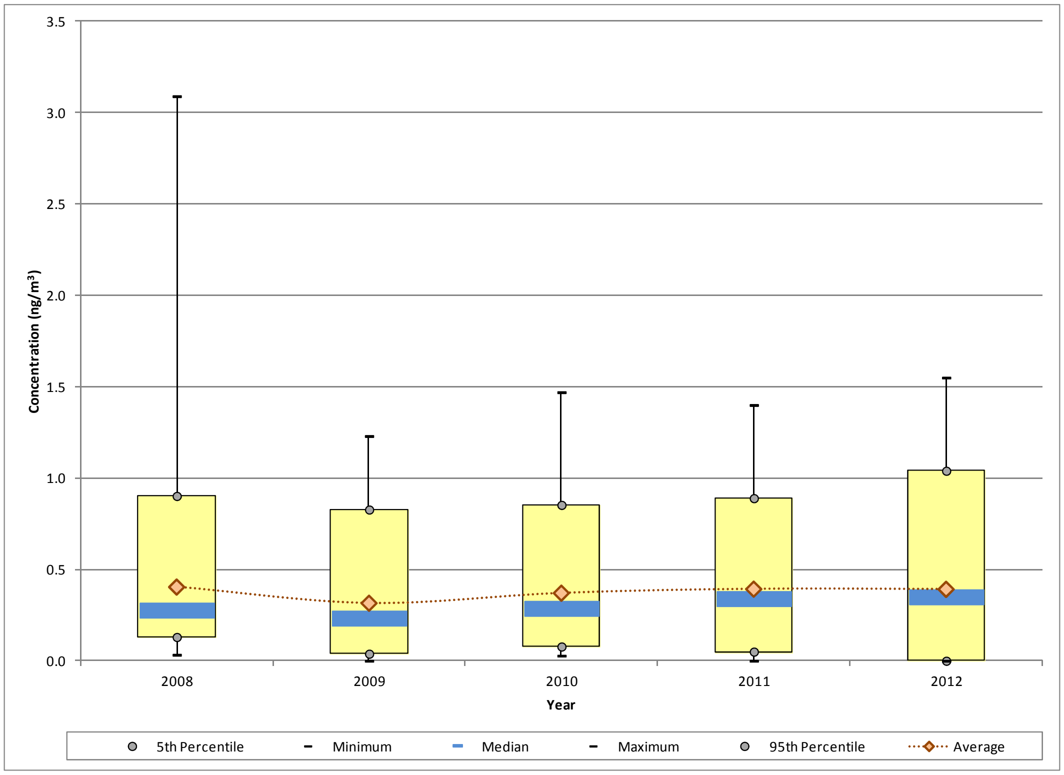
- RUCA began sampling PAHs under the NMP in May 2007. Because a full year's worth of data is not available, a 1-year average is not presented, although the range of measurements is provided.

- The smallest range of measurements was collected in 2007, although the statistical metrics do not represent a full year of sampling.

- The maximum naphthalene concentration was measured at RUCA in 2009. This concentration (406 ng/m^3) is the only one greater than 400 ng/m^3 measured at RUCA. The second highest naphthalene concentration (374 ng/m^3) was measured in 2012.

- The 1-year average concentration has an increasing trend over most of the years of sampling, although 2010 was down slightly. The range of concentrations measured at RUCA reflects the relatively high level of variability of the measurements collected. For some years, the maximum concentration is driving the average upward. In the case of 2009, the maximum concentration is twice the 95th percentile. Even though the majority of concentrations measured in 2012 fall within a tighter range of measurements, the 1-year average concentration is still higher for 2012 than 2011, due in part to the maximum concentration measured. However, the 20 percent increase in the median concentration indicates that concentrations were higher overall for 2012.

Figure 6-28. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at SJJCA



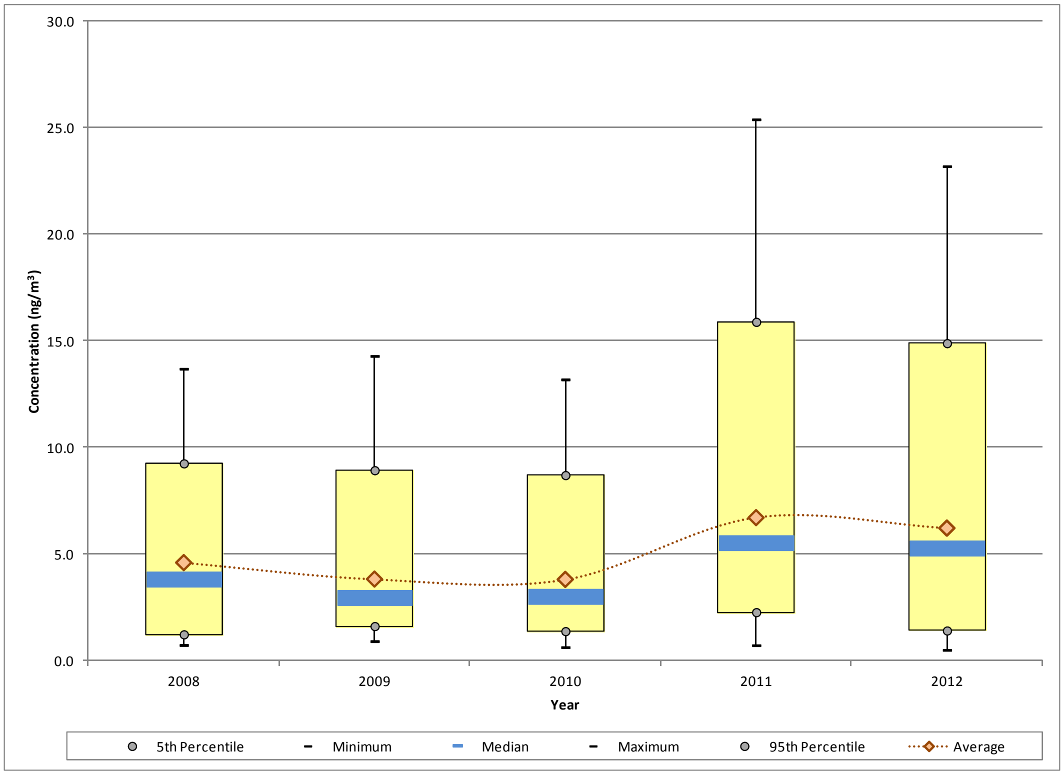
Observations from Figure 6-28 for arsenic measurements collected at SJJCA include the following:

- The maximum concentration of arsenic was measured on the first day of sampling at this site (January 1, 2008). The second highest concentration was measured at the end of 2008 and was roughly half as high.

- The 1-year average arsenic concentration decreased from 2008 to 2009. Although this mostly due to the high concentration measured in 2008, the 95th percentile, median (50th percentile), and 5th percentile all decreased from 2008 to 2009, indicating that the decrease is not only due to the difference in the maximum concentrations.

- After a slight increase from 2009 to 2010, the 1-year average arsenic concentration has not changed significantly. Between 2010 and 2012, the 1-year average concentration ranged from 0.37 ng/m^3 to 0.39 ng/m^3. Even though the maximum and 95th percentile exhibit increases for 2012, the 5th percentile decreased to zero, indicating that additional non-detects were measured in 2012. Thus, the number of concentrations on both the low- and high-end of the concentration range increased for 2012.

Figure 6-29. Yearly Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at SJJCA

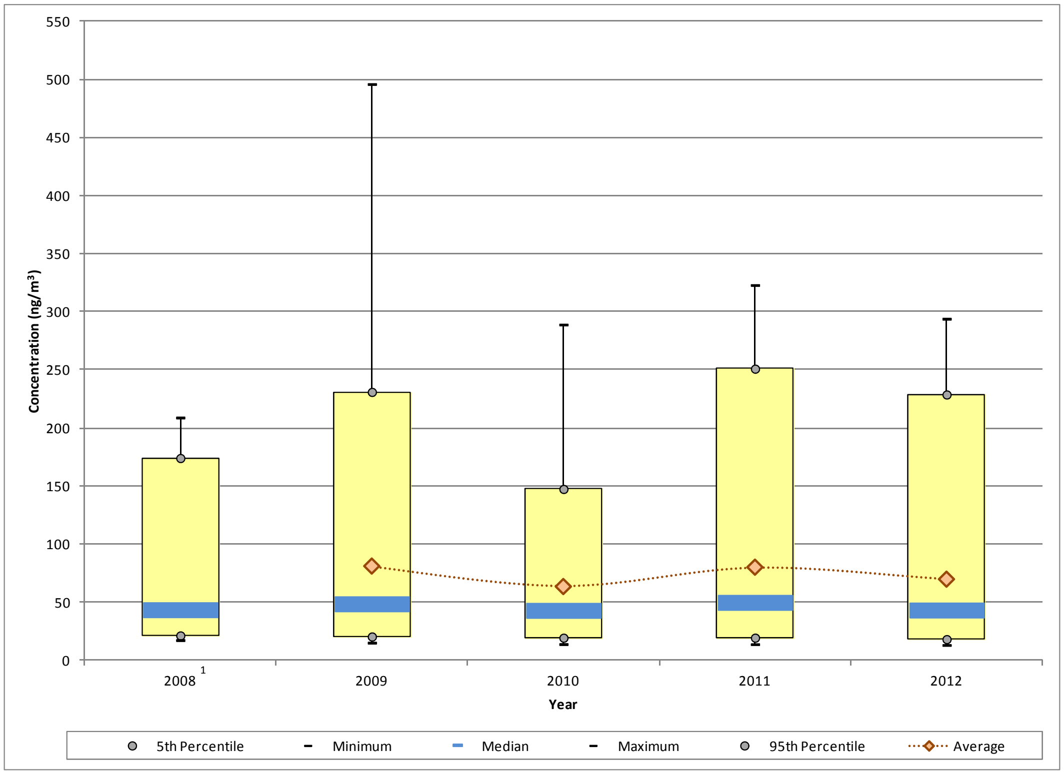


Observations from Figure 6-29 for manganese measurements collected at SJJCA include the following:

- The maximum concentration of manganese was measured in 2011. The eight highest concentrations of manganese were all measured at SJJCA in either 2011 or 2012.

- After a slight decreasing trend, the 1-year average manganese concentration increased significantly from 2010 to 2011. The median concentration nearly doubled for this timeframe. The 95th percentile for both 2011 and 2012 is greater than the maximum concentration measured in previous years. The difference between the 5th and 95th percentiles nearly doubled from 2010 to 2011, indicating that the magnitude of the majority of the measurements is higher for these years compared to previous years.

Figure 6-30. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SJJCA



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2008.

Observations from Figure 6-30 for naphthalene measurements collected at SJJCA include the following:

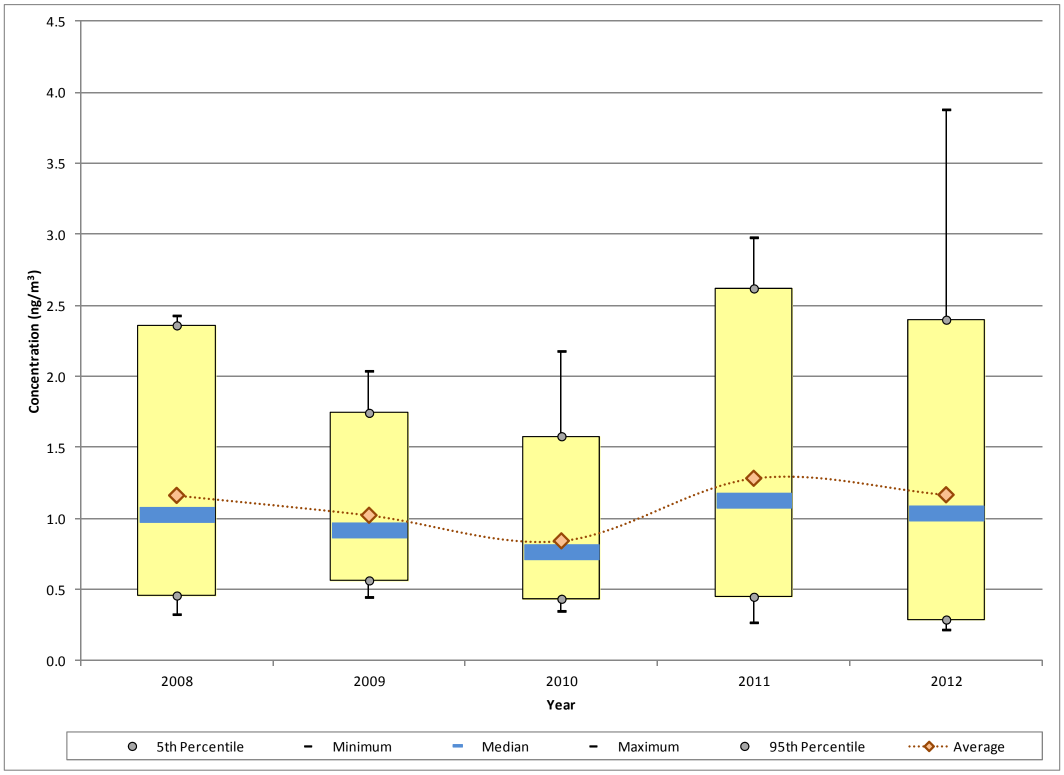
- SJJCA began sampling PAHs under the NMP in May 2008. Because a full year's worth of data is not available, a 1-year average is not presented, although the range of measurements is provided.

- The maximum concentration of naphthalene was measured at SJJCA in 2009 (496 ng/m^3). A measurement of similar magnitude has not been measured a second time at SJJCA.

- The median concentration has changed little over the years of sampling, ranging from 43.0 ng/m^3 (2010) to 49.9 ng/m^3 (2011). The 1-year average concentration exhibits more variability, ranging from 63.4 ng/m^3 (2010) to 81.0 ng/m^3 (2009), although the changes are not statistically significant.

- There is very little change among the minimum concentrations and 5th percentiles across the years of sampling while there are significant fluctuations in the statistical parameters at the higher end of the concentration range. For example, the 95th percentile increased by 70 percent from 2010 to 2011.

Figure 6-31. Yearly Statistical Metrics for Nickel (PM_{10}) Concentrations Measured at SJJCA



Observations from Figure 6-31 for nickel measurements collected at SJJCA include the following:

- The statistical parameters shown for nickel in Figure 6-31 exhibit a similar pattern as the statistical parameters for manganese shown in Figure 6-29.

- The two maximum concentrations of nickel were both measured in 2012 and are the only concentrations measured at SJJCA greater than 3 ng/m^3. The nine highest concentrations of nickel were all measured in either 2011 or 2012.

- After a significant decreasing trend between 2008 and 2010, the 1-year average nickel concentration increased significantly from 2010 to 2011. This trend is reflected in the median concentrations as well. The 95th percentile for 2011 is greater than the maximum concentration measured in previous years.

- Even though the nine highest concentrations of nickel were measured in 2011 and 2012, the six lowest concentrations were also measured in these years. The minimum concentration decreased by half between 2009 and 2012.

6.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each California monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

6.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the California monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

6.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the California monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 6-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 6-6. Risk Approximations for the California Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Los Angeles, California - CELA						
Fluorene	0.000088	--	60/60	7.67 ± 1.07	0.67	--
Naphthalene	0.000034	0.003	60/60	179.67 ± 20.99	6.11	0.06
Long Beach, California - LBHCA						
Naphthalene	0.000034	0.003	26/26	NA	NA	NA
Rubidoux, California - RUCA						
Naphthalene	0.000034	0.003	61/61	96.96 ± 15.56	3.30	0.03
San Jose, California - SJJCA						
Arsenic (PM_{10})	0.0043	0.000015	58/61	0.39 ± 0.08	1.69	0.03
Manganese (PM_{10})	--	0.00005	61/61	6.22 ± 1.18	--	0.12
Naphthalene	0.000034	0.003	59/59	69.73 ± 16.96	2.37	0.02
Nickel (PM_{10})	0.00048	0.00009	61/61	1.17 ± 0.19	0.56	0.01

-- = A Cancer URE or Noncancer RfC is not available.
NA = Not available due to the criteria for calculating an annual average.

Observations for the California sites from Table 6-6 include the following:

- Naphthalene has the highest annual average concentration for each of the California monitoring sites among the site-specific pollutants of interest, as discussed in the previous section. The annual average for CELA is more than double the annual average for SJJCA and is significantly higher than the annual average for RUCA.

- Naphthalene also has the highest cancer risk approximation among the site-specific pollutants of interest for the California monitoring sites. The cancer risk approximations range from 2.37 in-a-million for SJJCA to 6.11 in-a-million for CELA.

- Of the metals listed for SJJCA, manganese has the highest annual average concentration; however, this pollutant has no cancer toxicity factor. Arsenic has the highest cancer risk approximation among the metals in Table 6-6 (1.69 in-a-million). Even though the annual average concentration of arsenic is two orders of magnitude less than the annual average of naphthalene, the cancer risk approximations are not much different. This is an indication of the relative toxicity of arsenic compared to naphthalene.

- All of the noncancer hazard approximations for the pollutants of interest for the California monitoring sites are less than 1.0, indicating that no adverse health effects are expected from these individual pollutants.

- Cancer risk and noncancer hazard approximations could not calculated for LBHCA due to the July start date of sampling, as discussed in the previous sections.

6.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 6-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 6-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 6-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 6-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 6-7. Table 6-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to those pollutants for which each respective site sampled. As discussed in Section 6.3, each of the California monitoring sites sampled PAHs; SJJCA also sampled metals (PM_{10}). In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. Thus, LBHCA does not have cancer risk and noncancer hazard approximations in Tables 6-7 and 6-8. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 6.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 6-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the California Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Los Angeles, California (Los Angeles County) - CELA					
Formaldehyde	2,039.76	Formaldehyde	2.65E-02	Naphthalene	6.11
Dichloromethane	1,707.53	POM, Group 1a	2.22E-02	Fluorene	0.67
Tetrachloroethylene	1,424.90	Benzene	1.08E-02		
Benzene	1,381.37	1,3-Butadiene	8.76E-03		
Ethylbenzene	849.87	Naphthalene	4.48E-03		
Acetaldehyde	795.99	Arsenic, PM	4.29E-03		
p-Dichlorobenzene	339.36	*p*-Dichlorobenzene	3.73E-03		
1,3-Butadiene	292.06	Hexavalent Chromium, PM	2.62E-03		
POM, Group 1a	252.09	Ethylbenzene	2.12E-03		
Naphthalene	131.79	POM, Group 2b	1.89E-03		
Long Beach, California (Los Angeles County) - LBHCA					
Formaldehyde	2,039.76	Formaldehyde	2.65E-02		
Dichloromethane	1,707.53	POM, Group 1a	2.22E-02		
Tetrachloroethylene	1,424.90	Benzene	1.08E-02		
Benzene	1,381.37	1,3-Butadiene	8.76E-03		
Ethylbenzene	849.87	Naphthalene	4.48E-03		
Acetaldehyde	795.99	Arsenic, PM	4.29E-03		
p-Dichlorobenzene	339.36	*p*-Dichlorobenzene	3.73E-03		
1,3-Butadiene	292.06	Hexavalent Chromium, PM	2.62E-03		
POM, Group 1a	252.09	Ethylbenzene	2.12E-03		
Naphthalene	131.79	POM, Group 2b	1.89E-03		

Table 6-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the California Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		**Top 10 Cancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Rubidoux, California (Riverside County) - RUCA					
Formaldehyde	532.83	Formaldehyde	6.93E-03	Naphthalene	3.30
Benzene	284.75	POM, Group 1a	5.12E-03		
Tetrachloroethylene	272.91	Benzene	2.22E-03		
Acetaldehyde	246.53	1,3-Butadiene	2.01E-03		
Dichloromethane	212.10	Hexavalent Chromium, PM	1.90E-03		
Ethylbenzene	178.59	Arsenic, PM	1.03E-03		
p-Dichlorobenzene	70.48	Naphthalene	1.02E-03		
1,3-Butadiene	66.97	*p*-Dichlorobenzene	7.75E-04		
POM, Group 1a	58.14	Acetaldehyde	5.42E-04		
Naphthalene	30.14	Ethylbenzene	4.46E-04		
San Jose, California (Santa Clara County) - SJJCA					
Formaldehyde	363.98	POM, Group 1a	5.52E-03	Naphthalene	2.37
Benzene	302.63	Formaldehyde	4.73E-03	Arsenic	1.69
Ethylbenzene	218.82	Benzene	2.36E-03	Nickel	0.56
Dichloromethane	191.74	1,3-Butadiene	1.88E-03		
Tetrachloroethylene	153.82	Hexavalent Chromium, PM	1.59E-03		
Acetaldehyde	151.80	Naphthalene	1.08E-03		
1,3-Butadiene	62.80	Arsenic, PM	1.04E-03		
POM, Group 1a	62.72	*p*-Dichlorobenzene	6.64E-04		
p-Dichlorobenzene	60.37	POM, Group 2b	5.58E-04		
Naphthalene	31.71	Ethylbenzene	5.47E-04		

Table 6-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the California Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Los Angeles, California (Los Angeles County) - CELA					
Toluene	8,302.59	Acrolein	5,981,887.03	Naphthalene	0.06
1,1,1-Trichloroethane	6,903.35	Chlorine	290,023.06		
Ethylene glycol	4,337.04	Formaldehyde	208,138.95		
Xylenes	4,120.59	1,3-Butadiene	146,028.22		
Hexane	3,927.94	Acetaldehyde	88,443.41		
Formaldehyde	2,039.76	Arsenic, PM	66,543.97		
Dichloromethane	1,707.53	Cyanide Compounds, PM	63,440.92		
Tetrachloroethylene	1,424.90	Cadmium, PM	62,581.30		
Benzene	1,381.37	Trichloroethylene	60,450.02		
Methanol	1,338.87	Benzene	46,045.79		
Long Beach, California (Los Angeles County) - LBHCA					
Toluene	8,302.59	Acrolein	5,981,887.03		
1,1,1-Trichloroethane	6,903.35	Chlorine	290,023.06		
Ethylene glycol	4,337.04	Formaldehyde	208,138.95		
Xylenes	4,120.59	1,3-Butadiene	146,028.22		
Hexane	3,927.94	Acetaldehyde	88,443.41		
Formaldehyde	2,039.76	Arsenic, PM	66,543.97		
Dichloromethane	1,707.53	Cyanide Compounds, PM	63,440.92		
Tetrachloroethylene	1,424.90	Cadmium, PM	62,581.30		
Benzene	1,381.37	Trichloroethylene	60,450.02		
Methanol	1,338.87	Benzene	46,045.79		

Table 6-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the California Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Rubidoux, California (Riverside County) - RUCA					
Toluene	1,799.61	Acrolein	1,281,660.39	Naphthalene	0.03
Xylenes	1,020.69	Chlorine	98,782.17		
Hexane	958.45	Formaldehyde	54,370.16		
Ethylene glycol	835.09	1,3-Butadiene	33,482.53		
1,1,1-Trichloroethane	617.83	Acetaldehyde	27,392.75		
Formaldehyde	532.83	Arsenic, PM	15,991.32		
Benzene	284.75	Propionaldehyde	14,957.55		
Tetrachloroethylene	272.91	Bromomethane	13,246.82		
Acetaldehyde	246.53	Trichloroethylene	12,385.28		
Methanol	218.81	Lead, PM	11,114.81		
San Jose, California (Santa Clara County) - SJJCA					
Toluene	1,704.32	Acrolein	2,001,785.79	Manganese	0.12
1,1,1-Trichloroethane	1,289.63	Chlorine	139,092.17	Arsenic	0.03
Xylenes	979.05	Formaldehyde	37,140.79	Naphthalene	0.02
Hexane	892.98	1,3-Butadiene	31,399.05	Nickel	0.01
Ethylene glycol	826.56	Acetaldehyde	16,866.55		
Formaldehyde	363.98	Arsenic, PM	16,104.51		
Benzene	302.63	Trichloroethylene	14,797.50		
Ethylbenzene	218.82	Naphthalene	10,571.46		
Methanol	216.15	Benzene	10,087.68		
Dichloromethane	191.74	Xylenes	9,790.52		

Observations from Table 6-7 include the following:

- Formaldehyde is the highest emitted pollutant with cancer UREs in all three California counties. The quantity emitted is greater for Los Angeles County than Riverside and Santa Clara Counties. Dichloromethane is the second highest emitted pollutant in Los Angeles County but ranks fourth and fifth for Santa Clara and Riverside Counties, respectively. Benzene is the second highest emitted pollutant in Santa Clara and Riverside Counties but ranks fourth for Los Angeles County.

- Formaldehyde and POM, Group 1 are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Los Angeles and Riverside Counties, while the order is reversed for Santa Clara County. Benzene ranks third for all three counties.

- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Los Angeles and Santa Clara Counties, while there are eight in common for Riverside County. While dichloromethane and tetrachloroethylene are among the highest emitted pollutants for each county, neither pollutant appears among those with the highest toxicity-weighted emissions. Conversely, hexavalent chromium and arsenic are among those with the highest toxicity-weighted emissions for all three counties, but are not among the highest emitted pollutants.

- Naphthalene has the highest cancer risk approximation for all three sites for which annual averages could be calculated. Naphthalene appears on both emissions-based lists for all three counties.

- Arsenic, which has the second highest cancer risk approximation for SJJCA, has the seventh highest toxicity-weighted emissions for Santa Clara County, but is not among the highest emitted pollutants for this county (and ranks 20th). Nickel, the only other pollutant of interest for SJJCA, does not appear on either emissions-based list.

Observations from Table 6-8 include the following:

- Toluene is the highest emitted pollutant with a noncancer RfC in all three California counties. The quantity emitted is significantly higher for Los Angeles County than Riverside and Santa Clara Counties. 1,1,1-Trichloroethane is the second highest emitted pollutant in Los Angeles and Santa Clara Counties but ranks fifth for Riverside County. Xylenes are the second highest emitted pollutant in Riverside County but ranks third and fourth for Santa Clara and Los Angeles Counties, respectively.

- Acrolein, chlorine, and formaldehyde are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for all three counties. While acrolein and chlorine rank highest for toxicity-weighted emissions for each county, neither pollutant appears among the highest emitted. Conversely, formaldehyde has the sixth highest emissions for each county.

- Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Santa Clara County, while only two of the highest emitted pollutants also have the highest toxicity-weighted emissions for Los Angeles and Riverside Counties.

- Naphthalene, the only pollutant for which a noncancer hazard approximation could be calculated for CELA and RUCA, does not appear on either emissions based list in Table 6-8. Naphthalene ranks eighth for toxicity-weighted emissions for Santa Clara County but is not one of the highest emitted (of pollutants with noncancer RfCs).

- Manganese, which has the highest noncancer hazard approximation for SJJCA, does not appear on either emissions-based list in Table 6-8. This is also true for nickel. Arsenic ranks sixth for its toxicity-weighted emissions but is also not one of the highest emitted pollutants in Santa Clara County.

6.6 Summary of the 2012 Monitoring Data for the California Monitoring Sites

Results from several of the data treatments described in this section include the following:

- *Naphthalene failed screens for all four California sites. Two additional PAHs failed screens for CELA, one additional PAH failed screens for LBHCA, and only naphthalene failed screens for RUCA. Two PAHs and three PM_{10} metals failed screens for SJJCA.*

- *Naphthalene had the highest annual average concentration among the site-specific pollutants of interest for each of the California monitoring sites. CELA has the second highest annual average concentration of naphthalene among NMP sites sampling PAHs. Among the metals sampled at SJJCA, manganese had the highest annual average concentration, which ranks tenth among other NMP sites sampling PM_{10} metals.*

- *Concentrations of naphthalene were higher during the first and fourth quarters (or the colder months) of 2012 for RUCA and SJJCA; conversely, naphthalene concentrations were higher during the second and third quarters (or warmer months) for CELA.*

- *Concentrations of naphthalene and fluorene increased at CELA from 2011 to 2012. Significant increases in manganese and nickel concentrations at SJJCA occurred between 2010 and 2011, with little change for 2012.*

7.0 Sites in Colorado

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Colorado, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

7.1 Site Characterization

This section characterizes the Colorado monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The NATTS site in Colorado is located in Grand Junction (GPCO) while the other five sites are located in Garfield County, between 35 miles and 76 miles northeast of Grand Junction, in the towns of Battlement Mesa (BMCO), Silt (BRCO), Parachute (PACO), Carbondale (RFCO), and Rifle (RICO). Figure 7-1 for GPCO is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 7-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 7-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 7-3 through 7-9 are the composite satellite maps and emissions sources maps for the Garfield County sites. Table 7-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 7-1. Grand Junction, Colorado (GPCO) Monitoring Site

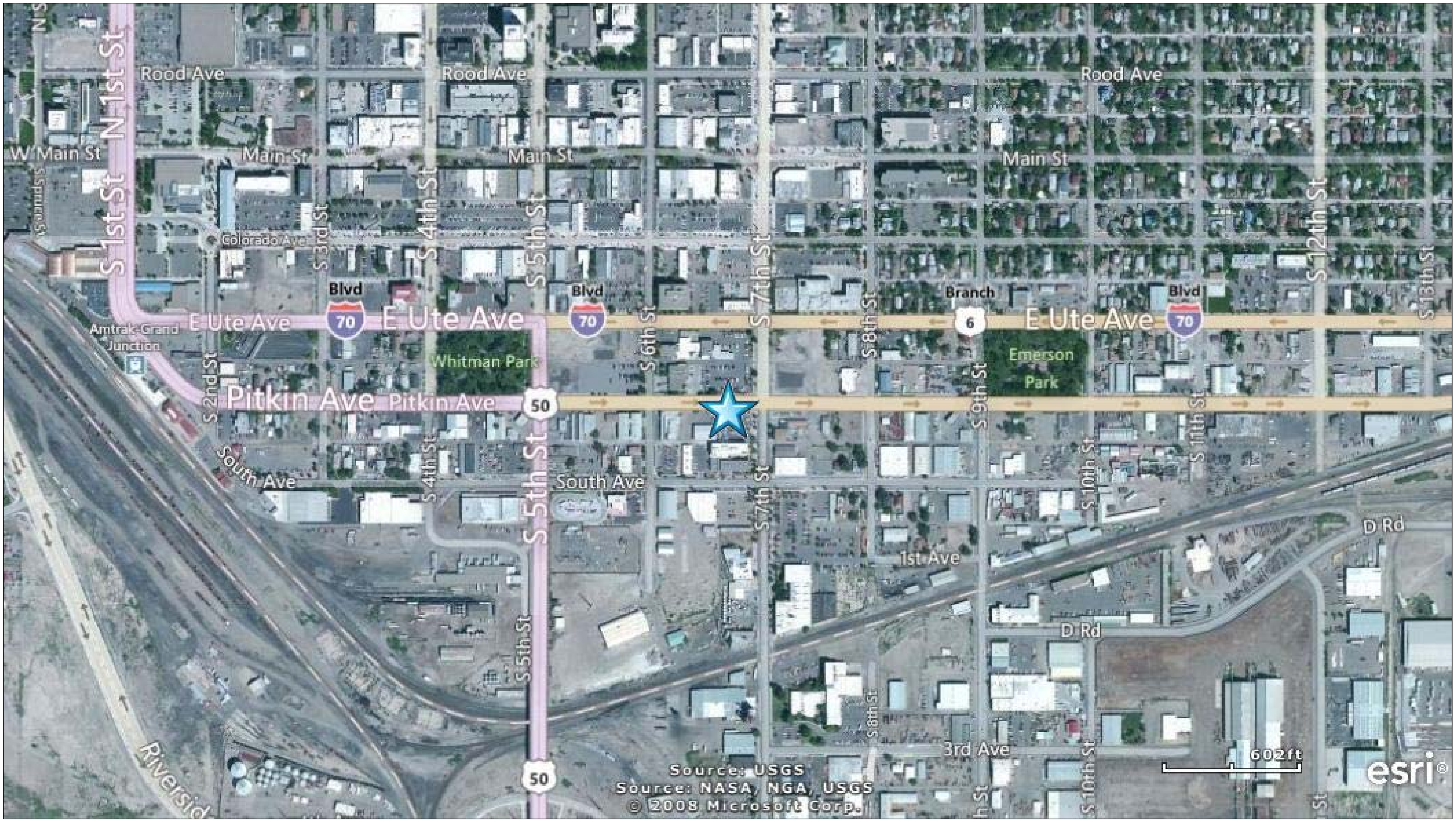
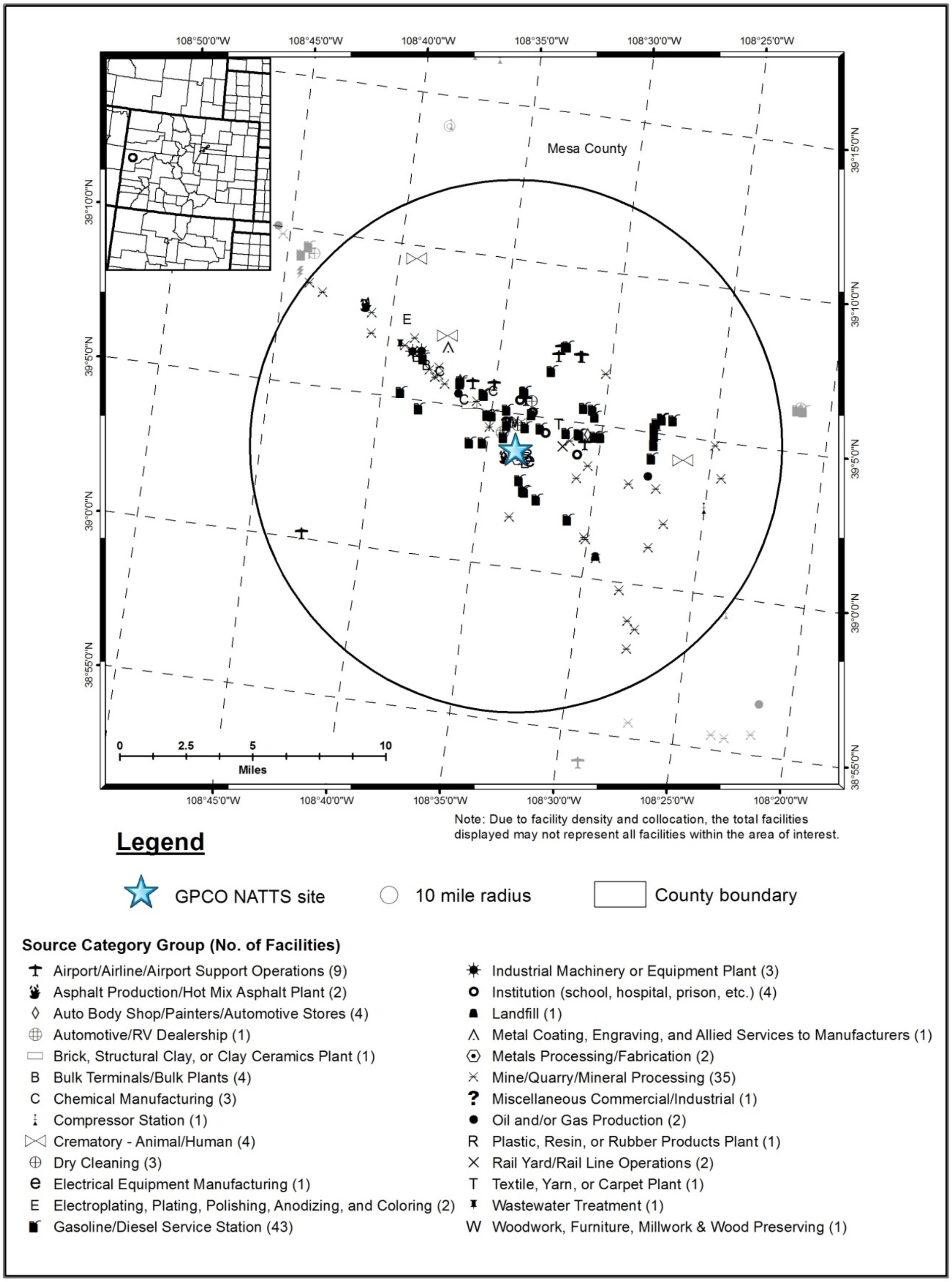


Figure 7-2. NEI Point Sources Located Within 10 Miles of GPCO



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 7-3. Battlement Mesa, Colorado (BMCO) Monitoring Site

Source: USGS
Source: NASA, NGA, USGS
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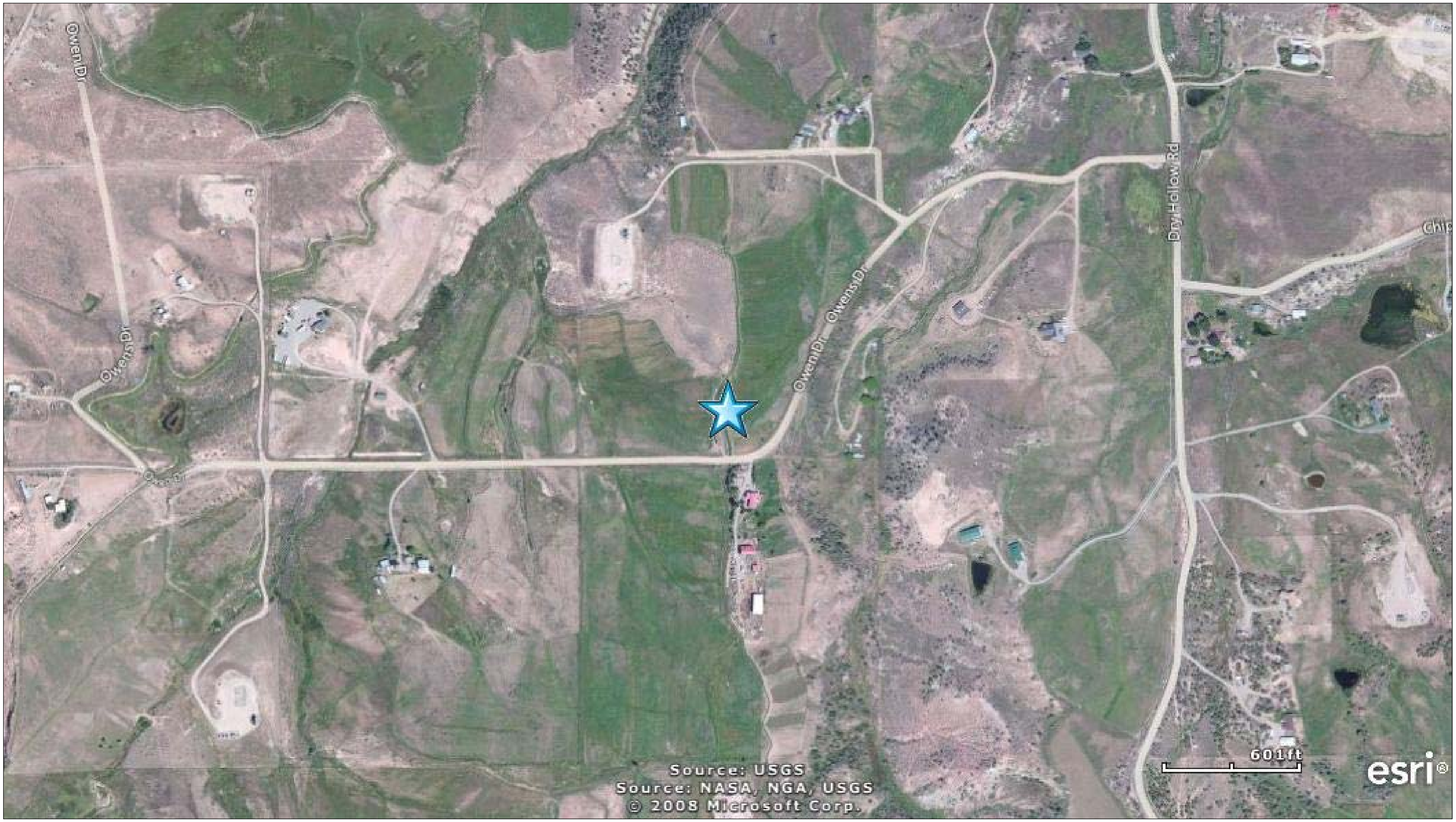
Figure 7-4. Silt, Colorado (BRCO) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 7-5. Parachute, Colorado (PACO) Monitoring Site

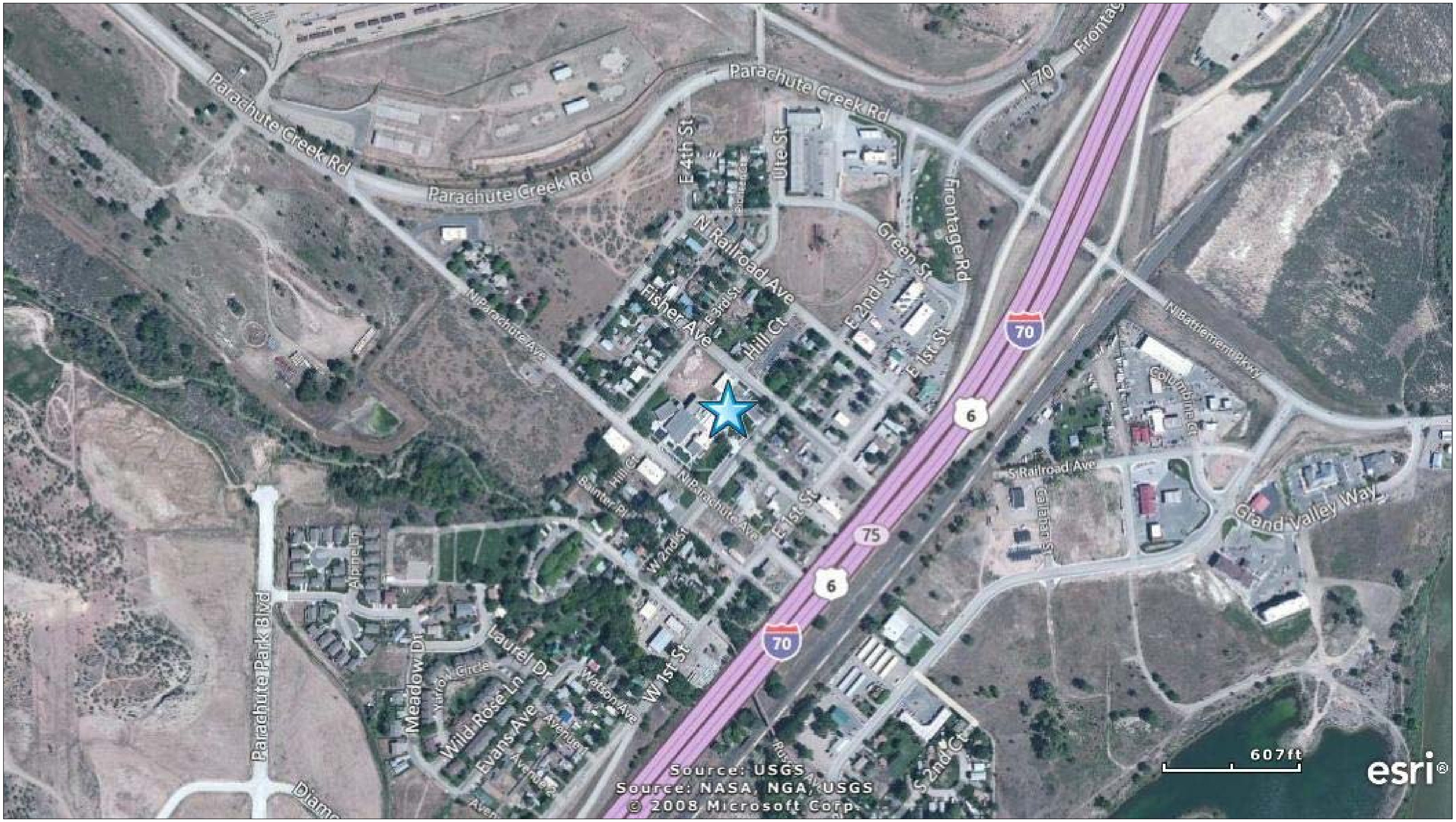
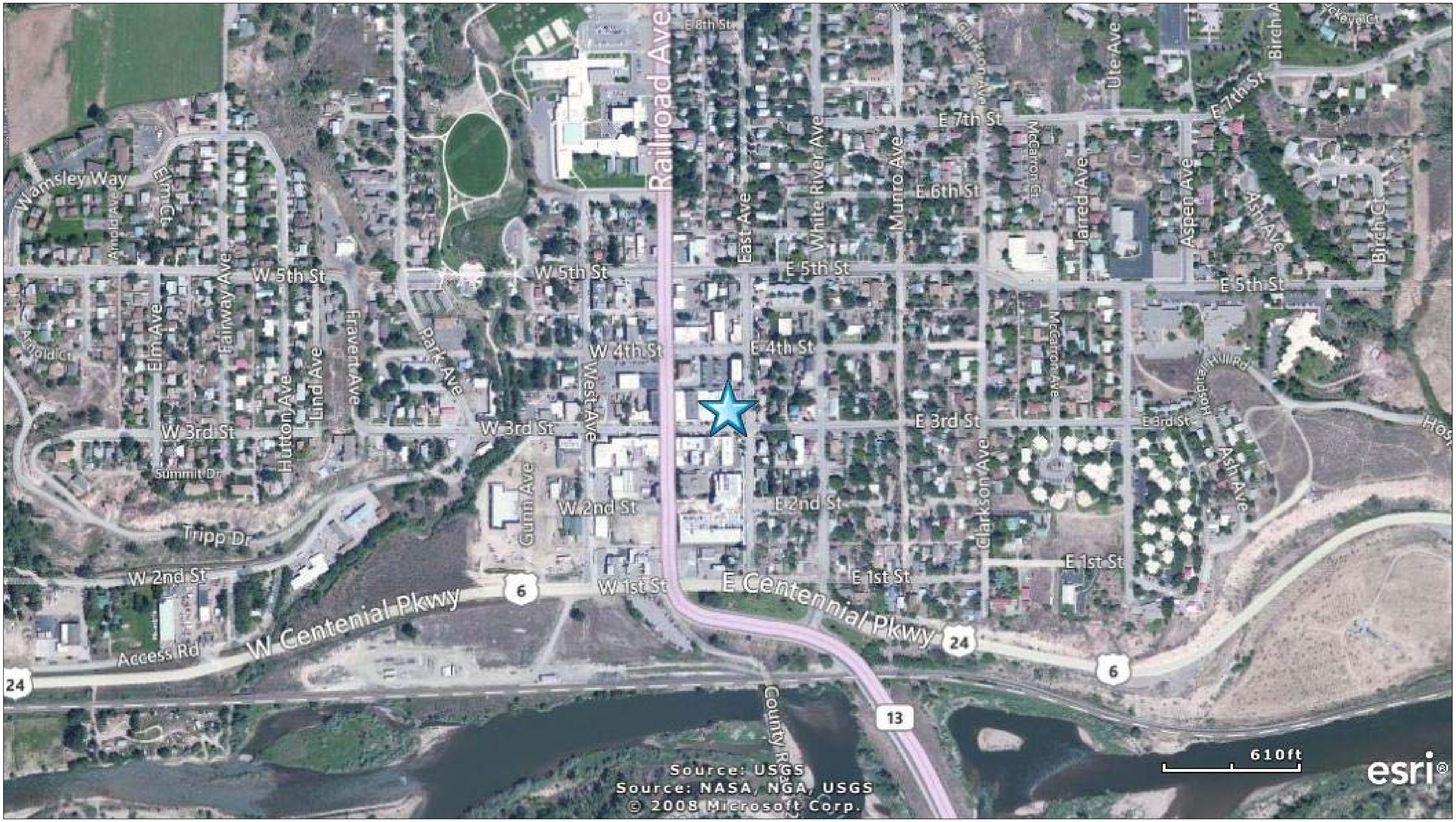
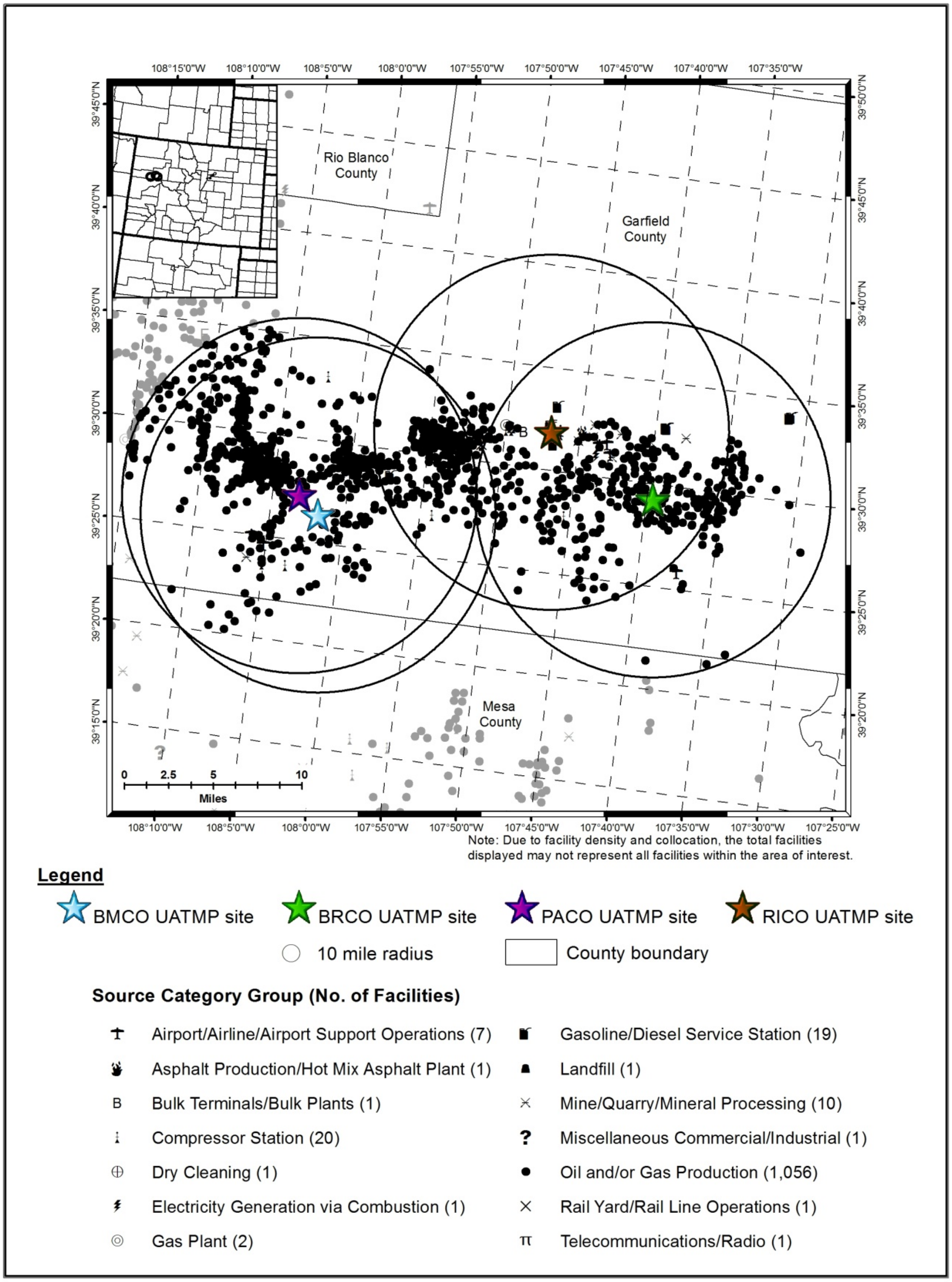


Figure 7-6. Rifle, Colorado (RICO) Monitoring Site



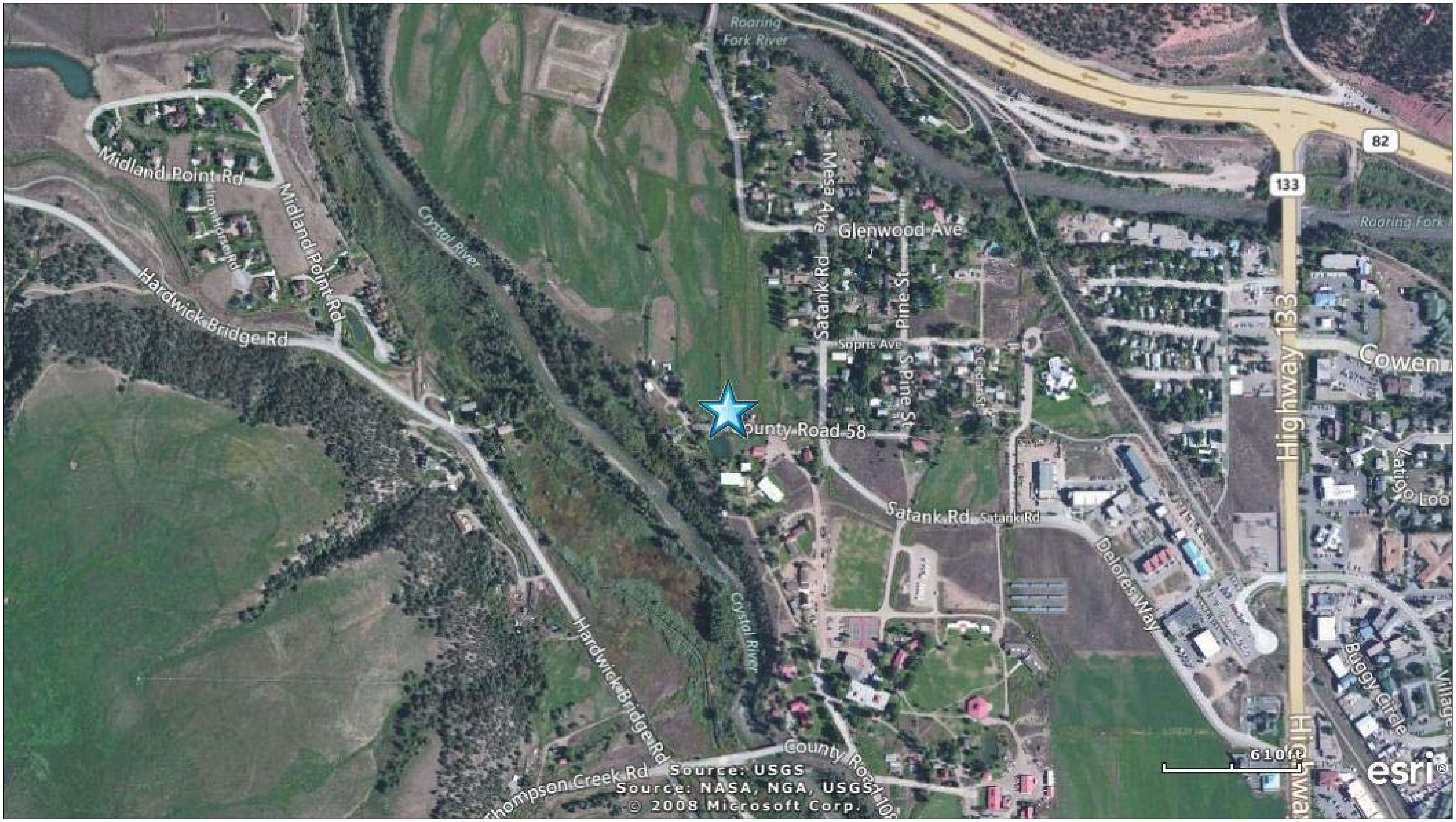
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 7-7. NEI Point Sources Located Within 10 Miles of BMCO, BRCO, PACO, and RICO



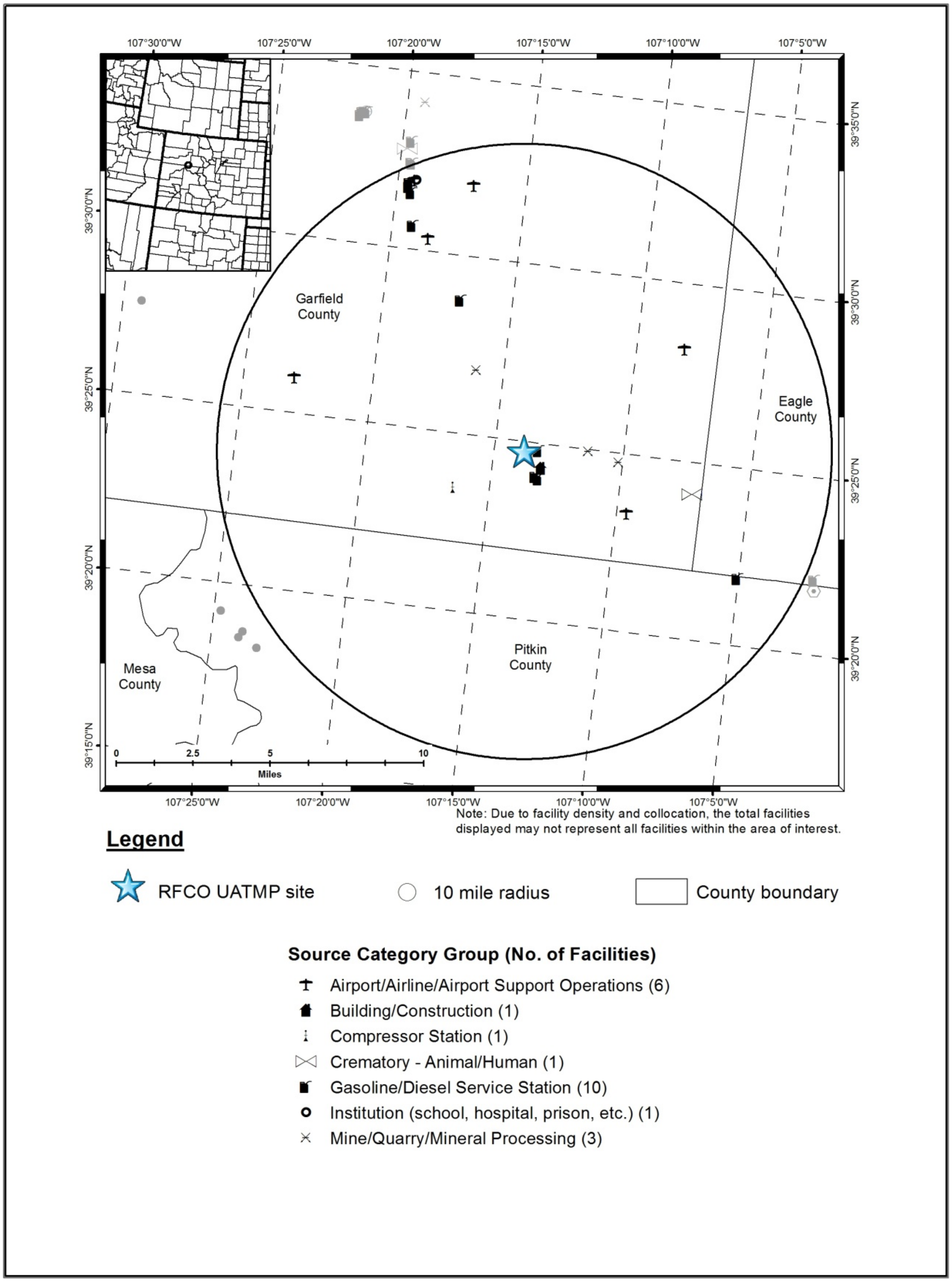
Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 7-8. Carbondale, Colorado (RFCO) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 7-9. NEI Point Sources Located Within 10 Miles of RFCO



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 7-1. Geographical Information for the Colorado Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
GPCO	08-077-0017 08-077-0018	Grand Junction	Mesa	Grand Junction, CO MSA	39.064289, -108.56155	Commercial	Urban/City Center	Meteorological parameters, CO, PM_{10}, PM_{10} Speciation, PM Coarse, $PM_{2.5}$, and $PM_{2.5}$ Speciation, IMPROVE Speciation.
BMCO	None	Battlement Mesa	Garfield	Glenwood Springs, CO MSA	39.439989, -108.029769	Residential	Rural	No AQS entry.
BRCO	08-045-0009	Silt	Garfield	Glenwood Springs, CO MSA	39.487755, -107.659685	Agricultural	Rural	None.
PACO	08-045-0005	Parachute	Garfield	Glenwood Springs, CO MSA	39.453654, -108.053259	Residential	Urban/City Center	PM_{10}.
RICO	08-045-0007	Rifle	Garfield	Glenwood Springs, CO MSA	39.531813, -107.782298	Commercial	Urban/City Center	PM_{10}.
RFCO	08-045-0018	Carbondale	Garfield	Glenwood Springs, CO MSA	39.412278, -107.230397	Residential	Rural	PM_{10}.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The GPCO monitoring site is comprised of two locations. The first location is a small 1-story shelter that houses the VOC and carbonyl compound samplers, with the PAH sampler located just outside the shelter. The second location, which is on the roof of an adjacent 2-story building, is comprised of the hexavalent chromium samplers. As a result, two AQS codes are provided in Table 7-1. Figure 7-1 shows that the area surrounding GPCO is of mixed usage, with commercial businesses to the west, northwest, and north; residential areas to the northeast and east; and industrial areas to the southeast, south, and southwest. This site's location is next to one of the major east-west roads in Grand Junction (I-70 Business). A railroad runs east-west to the south of the GPCO monitoring site, and merges with another railroad to the southwest of the site.

As Figure 7-2 shows, GPCO is located within 10 miles of numerous emissions sources. Many of the sources are located along a diagonal line running roughly northwest to southeast along Highways 6 and 50 and Business-70 and oriented along the mountain valley. Many of the point sources near GPCO fall into the gasoline/diesel service station and mine/quarry/mineral processing source categories. The sources closest to GPCO are an industrial machinery/equipment plant, a bulk terminal/bulk plant, a gasoline/diesel service station, and an auto body shop.

The BMCO monitoring site is located in Battlement Mesa, a rural community located to the southeast of Parachute. The monitoring site is located on the roof of the Grand Valley Fire Protection District facility, near the intersection of Stone Quarry Road and West Battlement Parkway, as shown in Figure 7-3. The site is surrounded primarily by residential subdivisions. A cemetery is located to the south of the site and a church is located to the east.

The BRCO monitoring site is located on Bell/Melton Ranch, off Owens Drive, approximately 4 miles south of the town of Silt. The site is both rural and agricultural in nature. As shown in Figure 7-4, the closest major roadway is County Road 331, Dry Hollow Road.

PACO is located on the roof of the old Parachute High School building, which is presently operating as a day care facility. This location is in the center of the town of Parachute, as shown in Figure 7-5. The surrounding area is considered residential. Interstate-70 is less than a quarter of a mile from the monitoring site.

RICO is located on the roof of the Henry Annex Building in downtown Rifle. This location is near the crossroads of several major roadways through town, as shown in Figure 7-6. Highway 13 and US-6 intersect just south of the site and I-70 is just over a half-mile south of the monitoring site, across the Colorado River. The surrounding area is considered commercial.

These four Garfield County sites are located along a line running roughly east-west and spanning approximately 20 miles; hence, they are shown together in Figure 7-7. There are more than 1,000 petroleum or natural gas wells (collectively shown as the oil and/or gas production source category) within 10 miles of these sites. One reason Garfield County is conducting air monitoring is to characterize the effects these wells may have on the surrounding areas (GCPH, 2013).

The RFCO monitoring site is the only site in Garfield County not located along the I-70 corridor. This site is located in the southeast corner of Garfield County in Carbondale. The town of Carbondale resides in a valley between the Roaring Fork and Crystal Rivers, north of Mt. Sopris (Carbondale, 2014). The RFCO monitoring site is located near the boathouse of the Rocky Mountain School on the bank of the Crystal River in the northern part of town. The surrounding area is considered residential and rural. Highway 82, which runs southward from Glenwood Springs and separates Carbondale from the base of Red Hill, is just over one-third of a mile north of RFCO and is visible in the top right-hand corner of Figure 7-8.

Because RFCO is 24 miles from the next closest Garfield County monitoring site, the emissions sources surrounding RFCO are provided in a separate map in Figure 7-9. This figure shows that the few emissions sources within 10 miles of RFCO are primarily gasoline and/or diesel service stations. There is also a building/construction company, a compressor station, two mine/quarry/mineral processing facilities, and an airport within a few miles of this site.

Table 7-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Colorado monitoring sites. Table 7-2 includes both county-level population and vehicle registration information. Table 7-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 7-2 presents the county-level daily VMT for Mesa and Garfield Counties. Note that the VMT presented is for state highways only, which differs from the VMT presented in this table in most other state sections.

Table 7-2. Population, Motor Vehicle, and Traffic Information for the Colorado Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
GPCO	147,848	179,213	11,000	Pitkin Ave, east of 7th St	2,009,730
BMCO	56,953	74,508	2,527	S. Battlement Pkwy (CO Road 300)	1,902,077
BRCO			1,102	Dry Hollow Rd (CO Road 331)	
PACO			16,000	I-70 near exit 75	
RFCO			16,000	Route 133, south of 82	
RICO			17,000	Route 13, Route 6 at I-70	

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c).

[2] County-level vehicle registration reflects 2011 data (CO DOR, 2012).

[3] AADT reflects 2002 data for BMCO and BRCO from Garfield County (GCRBD, 2002) and 2011 data for GPCO, PACO, RFCO and RICO from the Colorado DOT (CO DOT, 2011).

[4] County-level VMT reflects 2012 data for state highways only (CO DOT, 2012).

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 7-2 include the following:

- Mesa County's population and vehicle ownership are considerably higher than those for Garfield County. However, both counties rank in the bottom-third compared to other counties with NMP sites.

- The traffic volumes near RICO, RFCO, PACO, and GPCO are considerably higher than the traffic volumes near BMCO and BRCO. Yet, the traffic volumes for all six Colorado sites rank in the bottom half compared to the traffic volumes for other NMP sites. The traffic volume for BRCO is one of the lowest among all NMP sites. However, this monitoring site is located in the most rural of settings compared to the other Colorado sites.

- While the Mesa and Garfield County VMTs are fairly similar to each other, they are also among the lowest for counties with NMP sites, where VMT data were available. However, the county-level VMT available from the Colorado DOT is for state highways only and is therefore biased low compared to other sites.

7.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Colorado on sample days, as well as over the course of the year.

7.2.1 Climate Summary

Grand Junction is located in a mountain valley on the west side of the Rockies. The mountains surrounding the valley help protect the city from dramatic weather changes. The area tends to be fairly dry, with annual precipitation amounts less than 10 inches. On average, one to two snowfalls occur during each of the winter months, but tend to be short-lived in duration. Winds tend to flow out of the east-southeast on average, due to the valley breeze effect (Wood, 2004). Valley breezes occur as the sun heats up the side of a mountain; the warm air rises, creating a current that will move up the valley walls (Boubel, et al., 1994).

The towns of Battlement Mesa, Parachute, Rifle, and Silt are located to the northeast of Grand Junction, across the county line and along the I-70 corridor. These towns are located along a river valley running north of the Grand Mesa. The town of Carbondale is farther east, in a river valley in the southeast corner of Garfield County. Similar to Grand Junction, these towns are shielded from drastic changes in weather by the surrounding terrain and tend to experience fairly dry conditions for most of the year. Wind patterns in these towns are affected by the high canyons, the Colorado River and its tributaries, and valley breezes (GCPH, 2013; WRCC, 2013).

7.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the Colorado monitoring sites (NCDC, 2012), as described in Section 3.5.2. The weather station nearest GPCO is located at Walker Field Airport (WBAN 23066). The closest weather station to four of the five Garfield County sites is located at Garfield County Regional Airport (WBAN 03016) while the weather station closest to RFCO is located at Aspen-Pitkin County Airport (WBAN 93073). Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 7-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 7-3. Average Meteorological Conditions near the Colorado Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Grand Junction, Colorado - GPCO									
Walker Field Airport 23066 (39.13, -108.54)	4.9 miles 21° (NNE)	Sample Day (75)	65.9 ± 5.1	52.9 ± 4.7	25.5 ± 2.9	40.1 ± 3.2	43.7 ± 5.0	1016.1 ± 1.8	5.8 ± 0.5
		2012	68.3 ± 2.2	55.4 ± 2.0	26.1 ± 1.3	41.6 ± 1.3	40.7 ± 2.1	1014.5 ± 0.8	6.3 ± 0.3
Battlement Mesa, Colorado - BMCO									
Garfield County Regional Airport 03016 (39.53, -107.73)	16.7 miles 76° (ENE)	Sample Day (59)	65.5 ± 5.5	50.2 ± 4.8	27.2 ± 3.2	39.2 ± 3.4	50.0 ± 4.9	1017.5 ± 1.9	4.1 ± 0.6
		2012	65.9 ± 2.2	50.5 ± 1.9	26.2 ± 1.3	39.1 ± 1.4	47.7 ± 1.9	1016.4 ± 0.8	4.5 ± 0.3
Silt, Colorado - BRCO									
Garfield County Regional Airport 03016 (39.53, -107.73)	4.1 miles 320° (NW)	Sample Day (61)	66.0 ± 5.4	50.7 ± 4.8	27.8 ± 3.2	39.7 ± 3.4	50.0 ± 4.7	1017.3 ± 1.8	4.2 ± 0.6
		2012	65.9 ± 2.2	50.5 ± 1.9	26.2 ± 1.3	39.1 ± 1.4	47.7 ± 1.9	1016.4 ± 0.8	4.5 ± 0.3
Parachute, Colorado - PACO									
Garfield County Regional Airport 03016 (39.53, -107.73)	17.5 miles 81° (E)	Sample Day (57)	66.3 ± 5.7	50.7 ± 5.1	26.8 ± 3.3	39.3 ± 3.6	48.6 ± 4.9	1017.1 ± 1.9	4.3 ± 0.6
		2012	65.9 ± 2.2	50.5 ± 1.9	26.2 ± 1.3	39.1 ± 1.4	47.7 ± 1.9	1016.4 ± 0.8	4.5 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 7-3. Average Meteorological Conditions near the Colorado Monitoring Sites (Continued)

Closest NWS Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Rifle, Colorado - RICO									
Garfield County Regional Airport 03016 (39.53, -107.73)	3.2 miles 102° (ESE)	Sample Day (61)	65.8 ± 5.5	50.6 ± 4.8	27.4 ± 3.1	39.5 ± 3.3	49.7 ± 4.9	1017.1 ± 1.9	4.3 ± 0.6
		2012	65.9 ± 2.2	50.5 ± 1.9	26.2 ± 1.3	39.1 ± 1.4	47.7 ± 1.9	1016.4 ± 0.8	4.5 ± 0.3
Carbondale, Colorado - RFCO									
Aspen-Pitkin County Airport 93073 (39.23, -106.87)	22.1 miles 132° (SE)	Sample Day (18)	64.7 ± 9.4	50.5 ± 8.0	27.9 ± 6.6	39.7 ± 6.0	49.7 ± 8.8	1015.5 ± 2.8	4.6 ± 0.5
		2012	58.3 ± 1.9	43.7 ± 1.7	22.7 ± 1.3	34.3 ± 1.3	50.8 ± 1.7	1014.9 ± 0.8	5.1 ± 0.2

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 7-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 7-3 is the 95 percent confidence interval for each parameter. As shown in Table 7-3, average meteorological conditions on sample days near BMCO, BRCO, PACO, and RICO were representative of average weather conditions experienced throughout the year. The parameter with the highest difference between the full-year average and the sample day average for these sites is relative humidity.

The differences between the sample day and full-year averages for the temperature, relative humidity, and pressure parameters for GPCO are higher than most of the Garfield County sites. A review of the data shows that there were 14 make-up days for GPCO, the majority of which were collected in the cooler months of the year (10 of these were collected between January and February or October through December). This explains why conditions on sample days appear cooler than conditions experienced over the entire year.

For RFCO, the temperature parameters on sample days are considerably higher than those shown for the entire year. RFCO did not begin sampling until June 2012, thereby missing the coldest months of the year. RFCO also sampled on a 1-in-12 day schedule, yielding roughly half the number of collection events as the other sites; thus, the number of observations included in each calculation for RFCO is less than the other sites. As a result, the confidence intervals indicate a higher level of variability in the meteorological parameters for this site.

The lowest average dew point and wet bulb temperatures among NMP sites were calculated for the Colorado monitoring sites. These sites also experienced some of the lowest relative humidity levels among NMP sites.

7.2.3 Back Trajectory Analysis

Figure 7-10 is the composite back trajectory map for days on which samples were collected at the GPCO monitoring site. Included in Figure 7-10 are four back trajectories per sample day. Figure 7-11 is the corresponding cluster analysis. Similarly, Figures 7-12 through 7-20 are the composite back trajectory maps and corresponding cluster analyses for the Garfield

County monitoring sites. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 7-10 through 7-20 represents 100 miles.

Observations for GPCO from Figures 7-10 and 7-11 include the following:

- The 24-hour air shed domain for GPCO is the second smallest in size, based on average back trajectory length (132 miles), compared to other NMP monitoring sites. Only RFCO has a smaller average back trajectory length (131 miles). The farthest away a back trajectory originated was near the western border of Idaho, or just less than 500 miles away. However, most trajectories (90 percent) originated within 250 miles of GPCO.

- Back trajectories originated from a variety of directions at GPCO, although a majority of the back trajectories had a westerly component. A large cluster of back trajectories originated to the southwest of GPCO and a second cluster originated to the northwest of the site.

- The cluster analysis shows that about one-third of back trajectories originated from the southwest and west of GPCO. These are split into two cluster trajectories, one representing shorter back trajectories originating over southeast Utah and the other representing those originating over northern Arizona. Another 31 percent of back trajectories originated within approximately 100 miles of GPCO and are represented by the short cluster trajectory shown in the inset in the bottom-right side of the figure. Seventeen percent of back trajectories originated from the northwest of GPCO. These too are split into two cluster trajectories, one representing shorter back trajectories originating over northern Utah and the other representing longer back trajectories originating over Idaho and northeast Nevada. Back trajectories originating over the southeast corner of Colorado account for 17 percent of back trajectories while back trajectories originating over the northwest corner of Colorado or south-central Wyoming account for 3 percent of back trajectories.

Figure 7-10. Composite Back Trajectory Map for GPCO

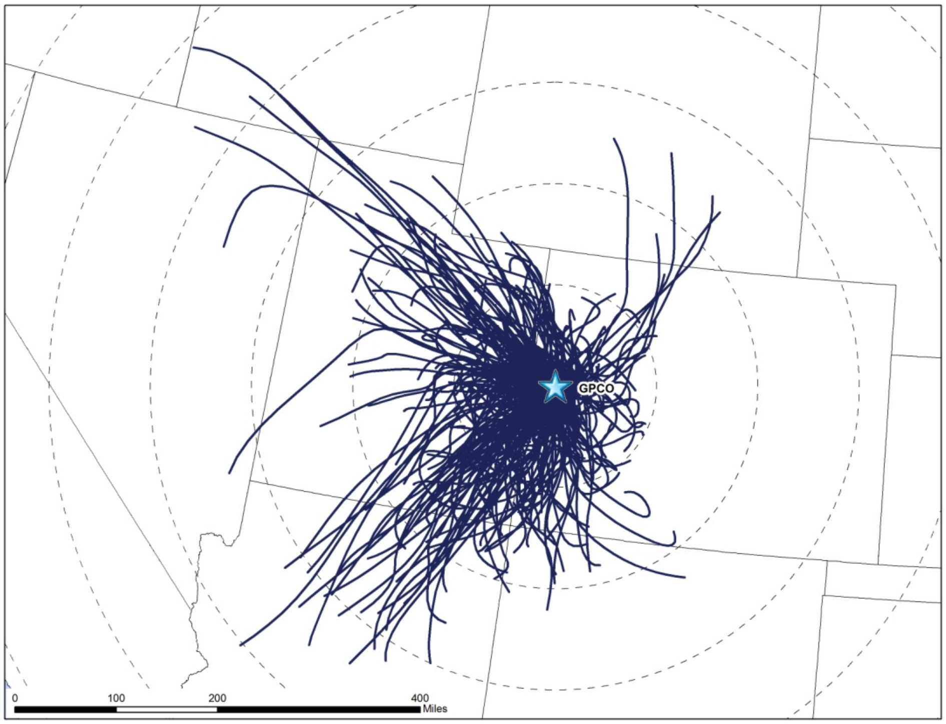


Figure 7-11. Back Trajectory Cluster Map for GPCO

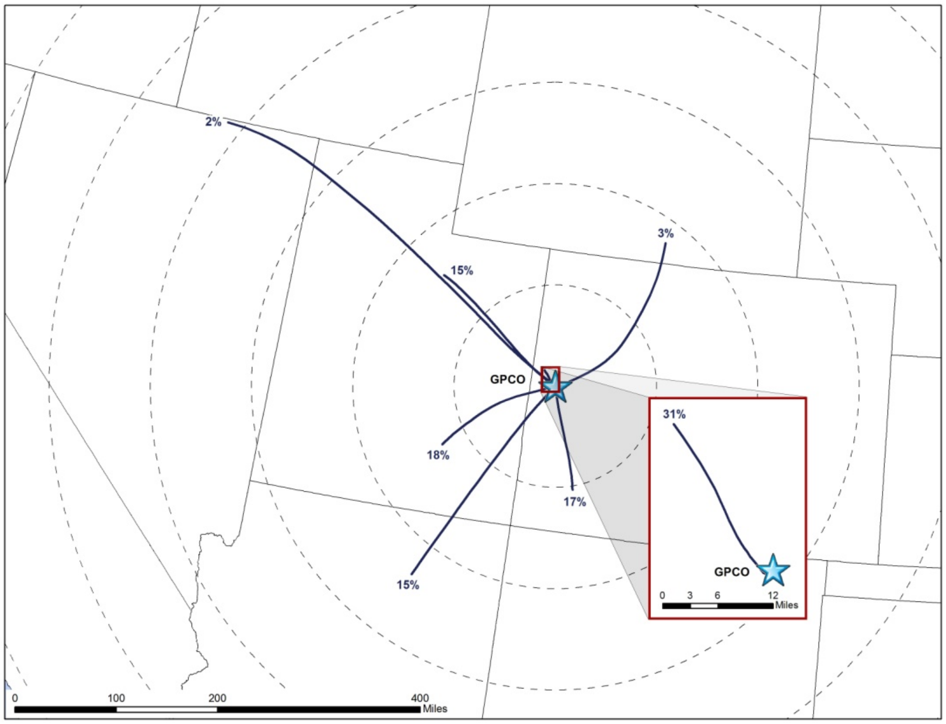


Figure 7-12. Composite Back Trajectory Map for BMCO

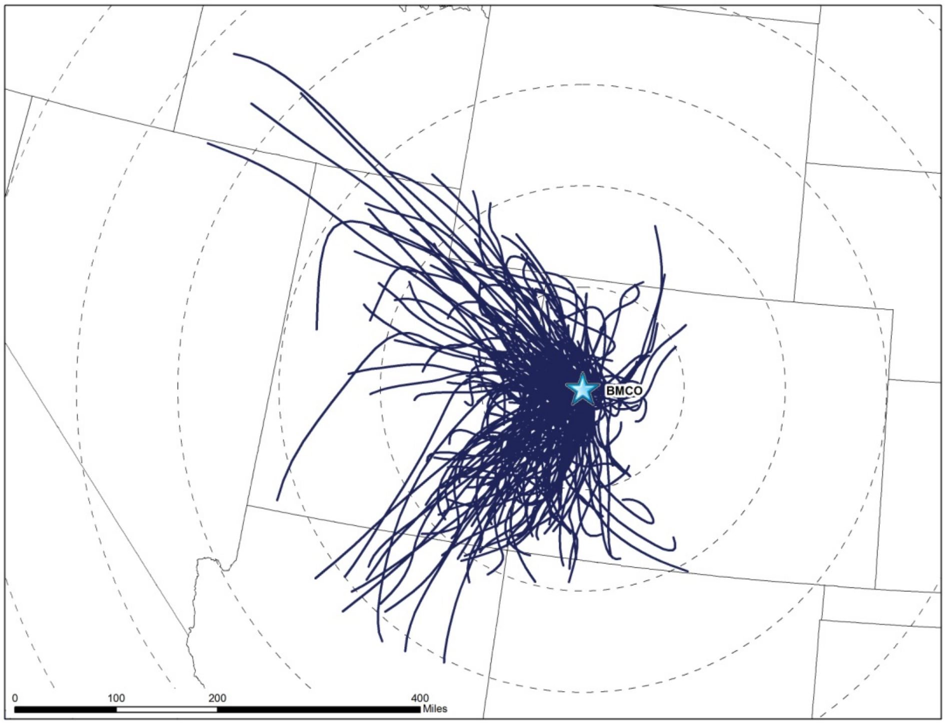


Figure 7-13. Back Trajectory Cluster Map for BMCO

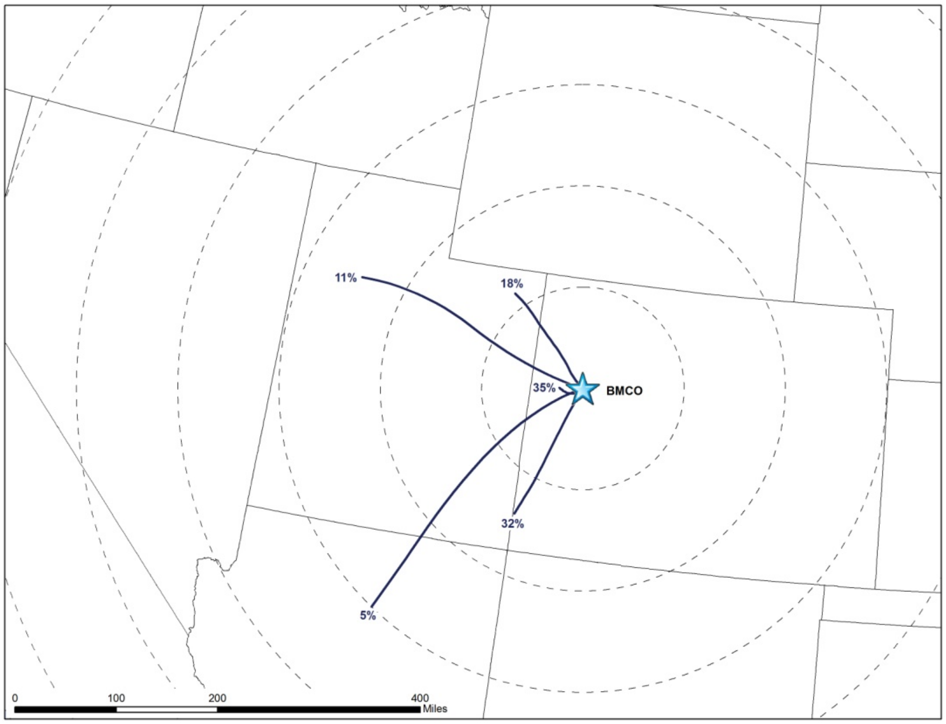


Figure 7-14. Composite Back Trajectory Map for BRCO

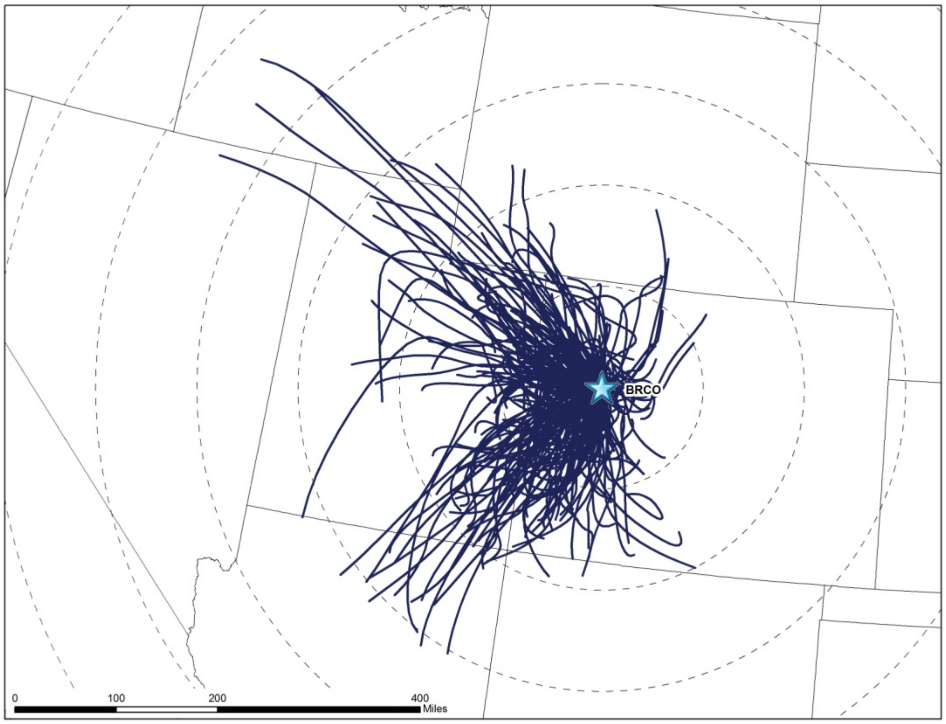


Figure 7-15. Back Trajectory Cluster Map for BRCO

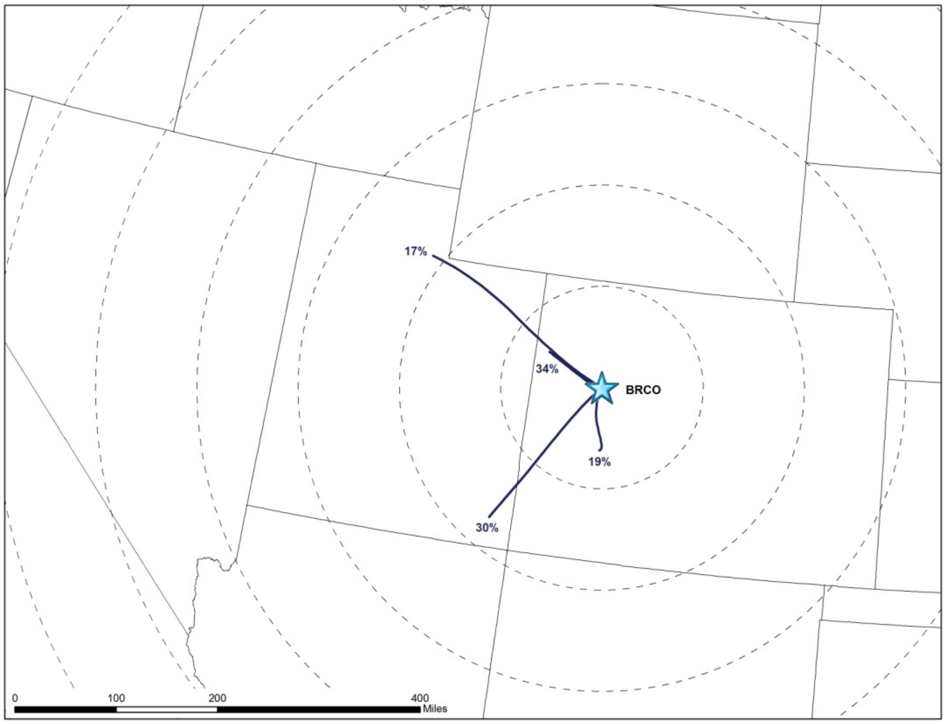


Figure 7-16. Composite Back Trajectory Map for PACO

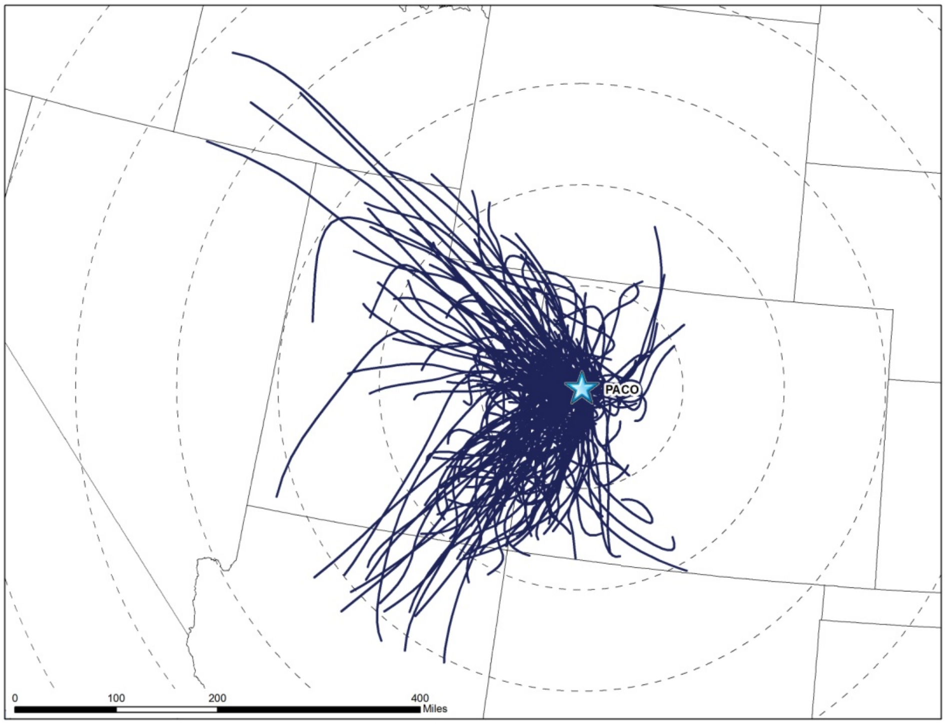


Figure 7-17. Back Trajectory Cluster Map for PACO

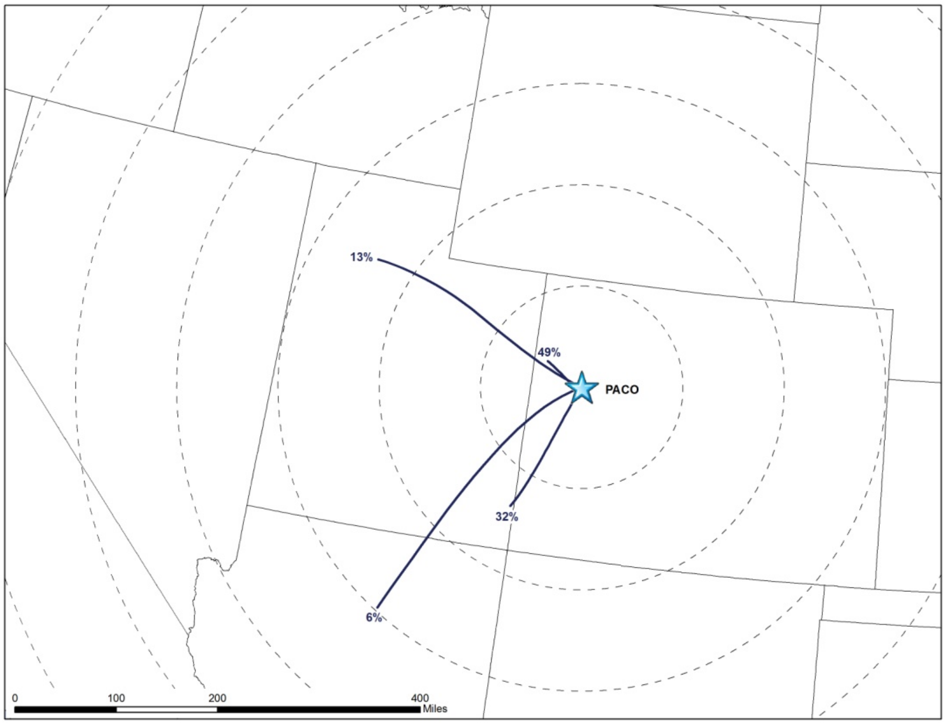


Figure 7-18. Composite Back Trajectory Map for RICO

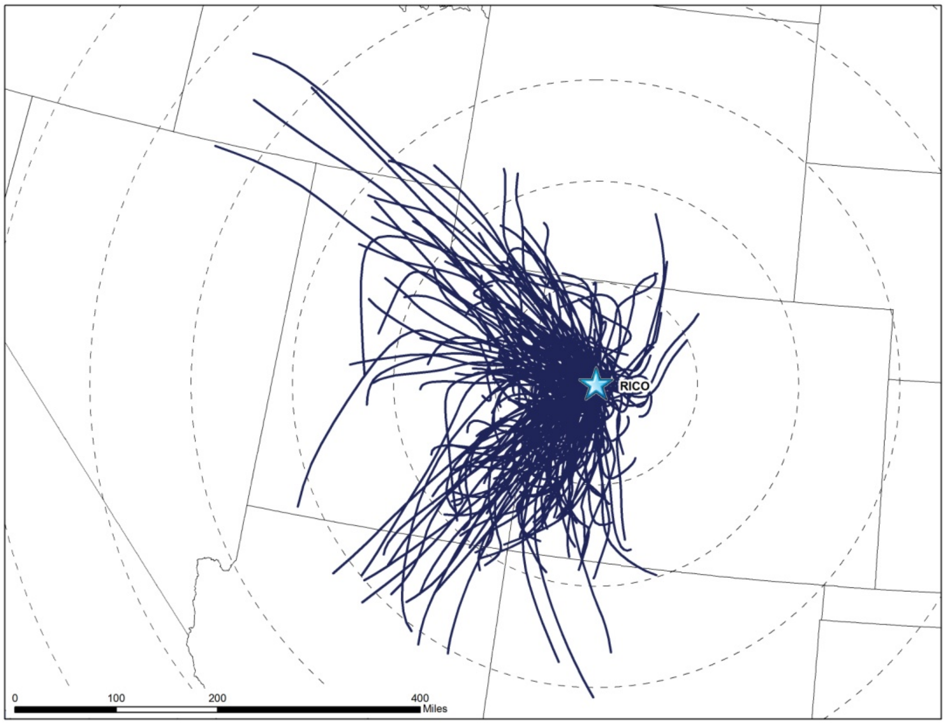


Figure 7-19. Back Trajectory Cluster Map for RICO

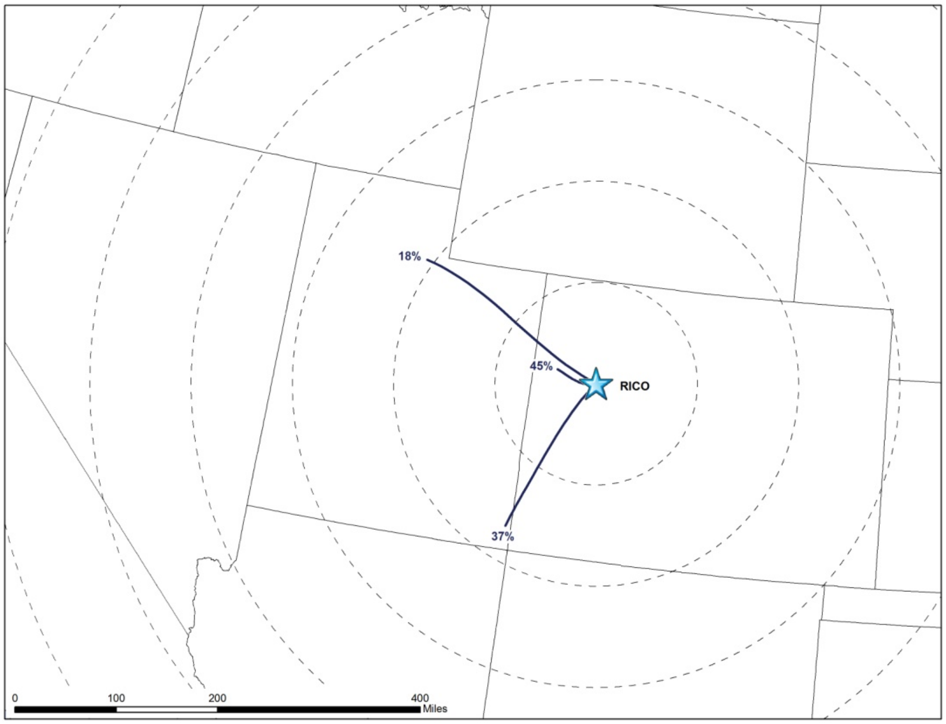
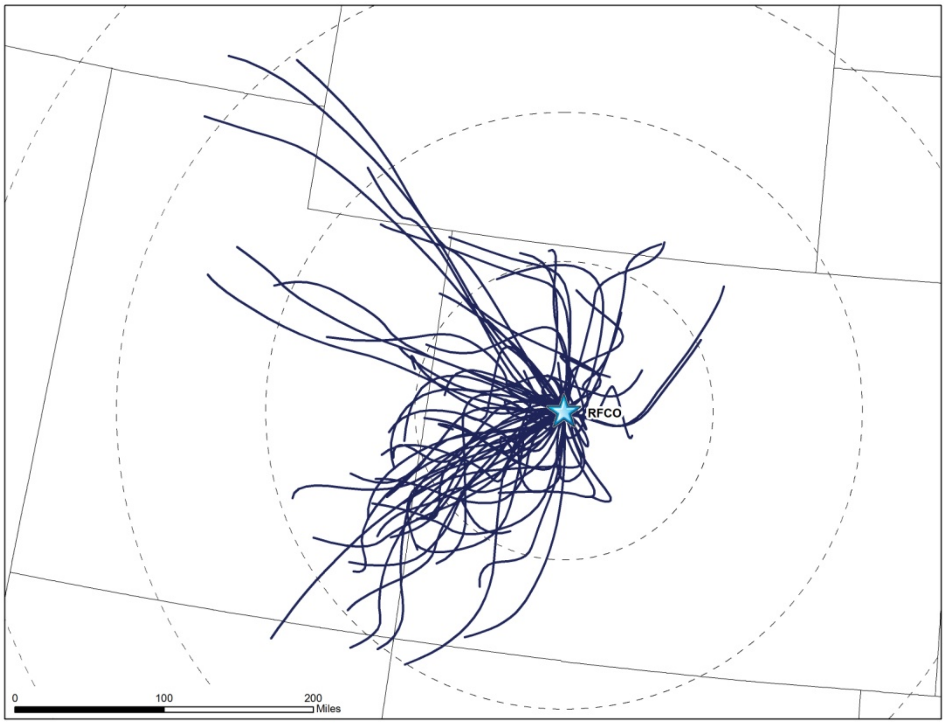


Figure 7-20. Composite Back Trajectory Map for RFCO



Observations from Figures 7-12 through 7-20 for the Garfield County sites include the following:

- The composite back trajectory maps for the Garfield County sites resemble the one for GPCO. This is expected, given the sites' relatively close proximity to GPCO (and to each other). Even the composite map for RFCO has a similar back trajectory distribution as the other sites, even though the number of back trajectories in Figure 7-20 for RFCO is less than half the back trajectories compared to the other Garfield County sites. This is due to a combination of late start to sampling (June) and a 1-in-12 day sampling schedule.

- The 24-hour air shed domains for the Garfield County sites were similar in size to GPCO, with the average trajectory length ranging from 130 miles (RFCO) to 139 miles (RICO). The longest back trajectories for these sites originated over Idaho. The longest back trajectory for each site except RFCO represents the back trajectory constructed for midday January 22, 2012.

- The cluster maps for the Garfield County sites resemble the cluster map for GPCO, in that most of the back trajectories have a southwesterly or northwesterly component, although the exact clusters constructed and the associated percentages vary. The HYSPLIT model grouped the back trajectories for BMCO into five clusters but grouped the back trajectories for RICO into just three clusters. However, common elements of the cluster analyses include: 1) between 30 percent and 40 percent of back trajectories originated with approximately 100 miles of the sites and are represented by the short cluster trajectory originating towards the Colorado/Utah border, 2) approximately one-third of back trajectories originated to the southwest of the sites, and 3) between 10 percent and 20 percent of back trajectories originated to the northwest of the sites.

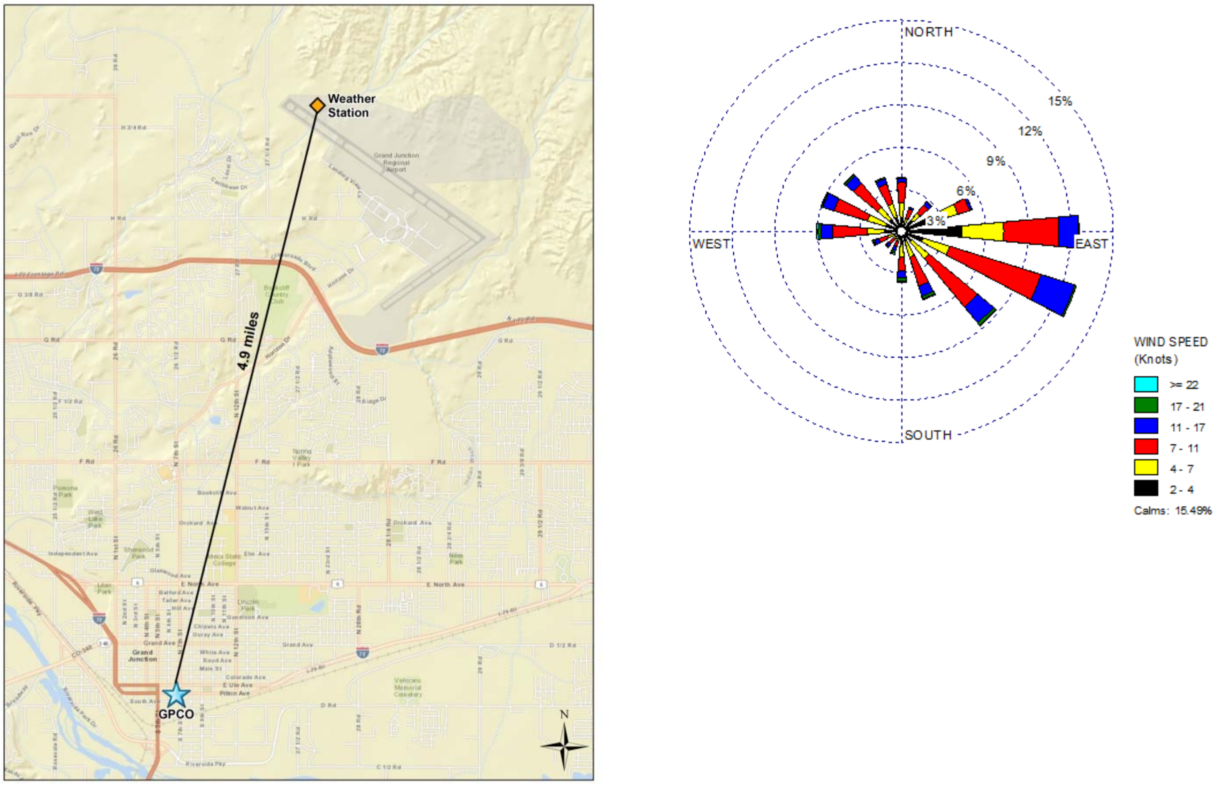
- Because RFCO has fewer than 30 sample days, a cluster analysis was not performed for this site, as specified in Section 3.5.2.1.

7.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations at the Walker Field Airport (for GPCO), Garfield County Regional Airport (for BMCO, BRCO, PACO, and RICO), and Pitkin-Aspen County Airport (for RFCO) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

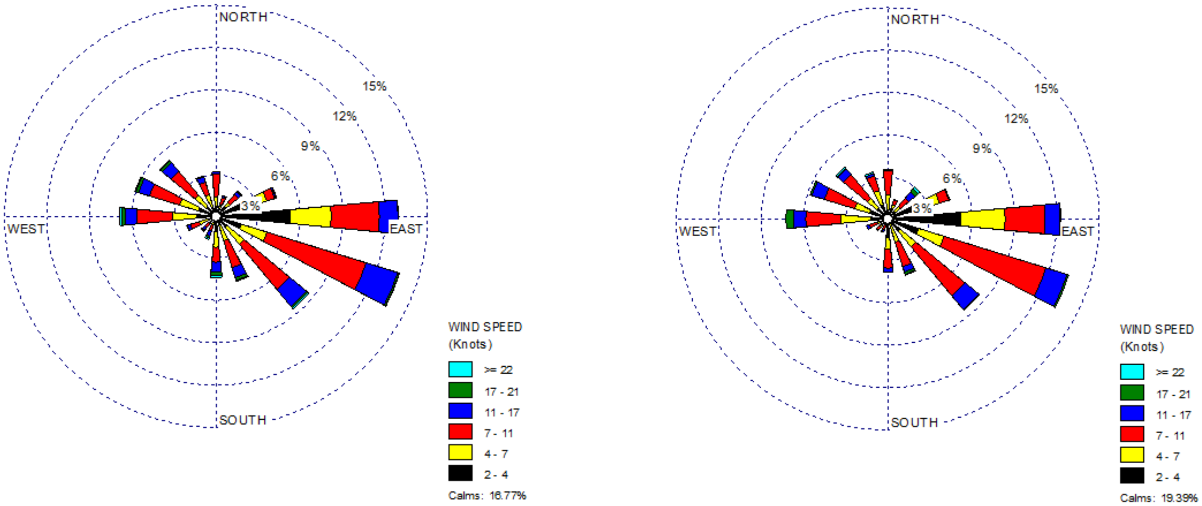
Figure 7-21 presents a map showing the distance between the weather station and GPCO, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 7-21 also presents three different wind roses for the GPCO monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind observations for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 7-22 through 7-26 present the distance maps and wind roses for the five Garfield County sites.

Figure 7-21. Wind Roses for the Walker Field Airport Weather Station near GPCO



Location of GPCO and Weather Station

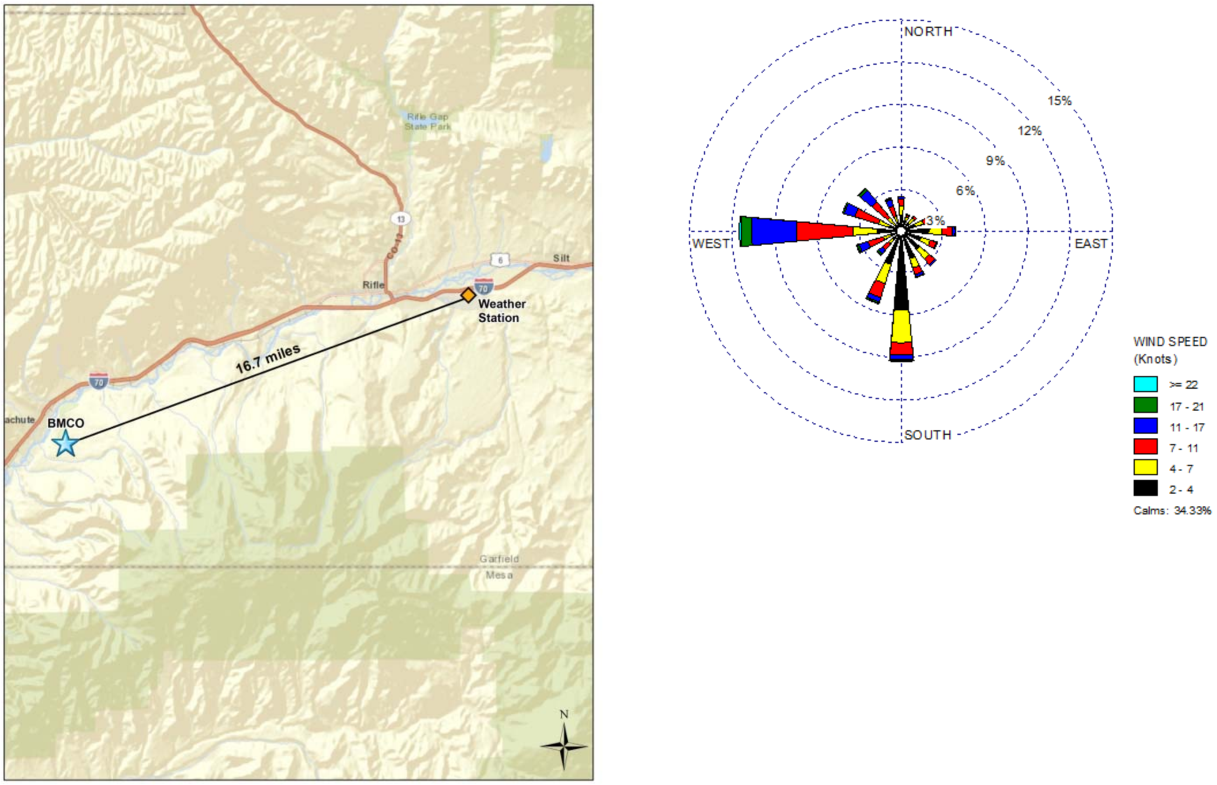
2002-2011 Historical Wind Rose



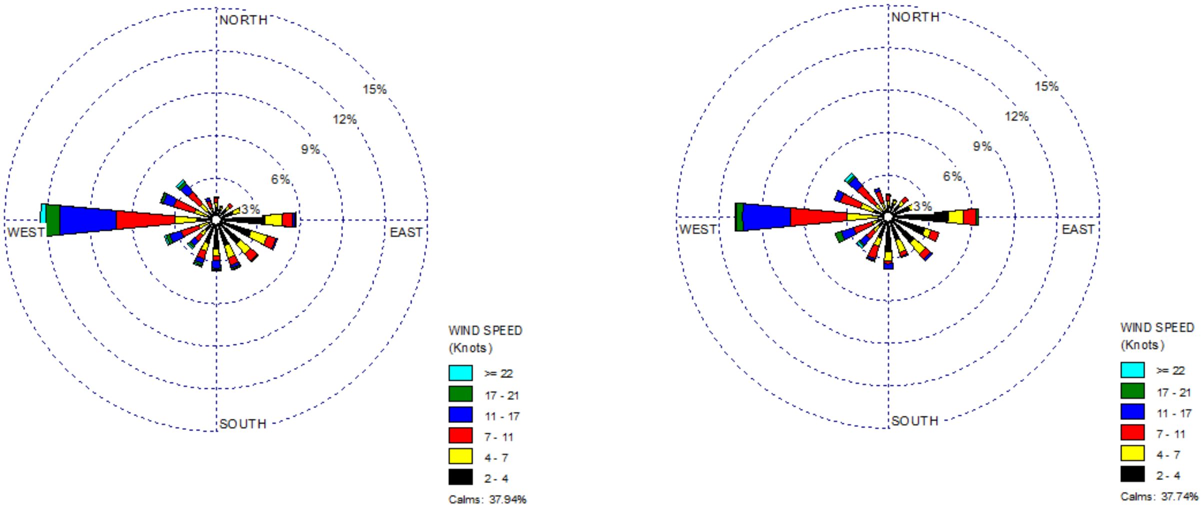
2012 Wind Rose

Sample Day Wind Rose

Figure 7-22. Wind Roses for the Garfield County Regional Airport Weather Station near BMCO

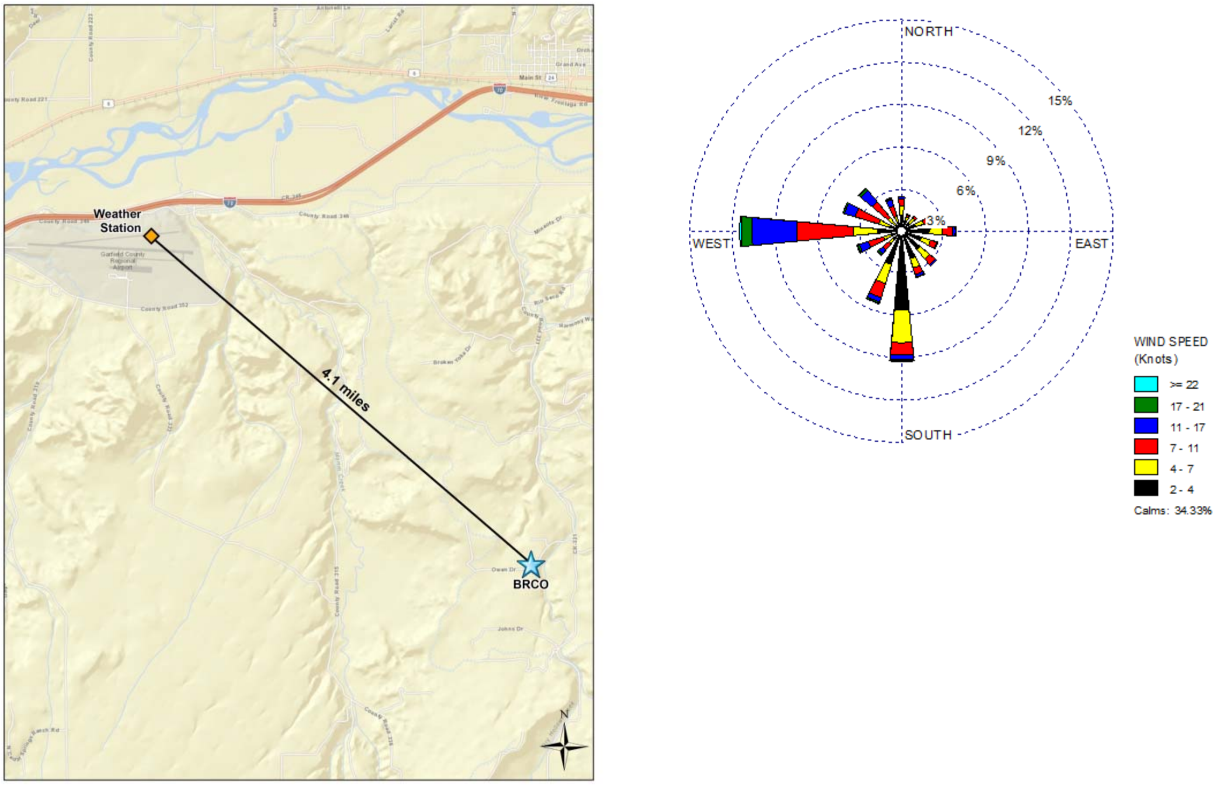

Location of BMCO and Weather Station

2002-2011 Historical Wind Rose


2012 Wind Rose

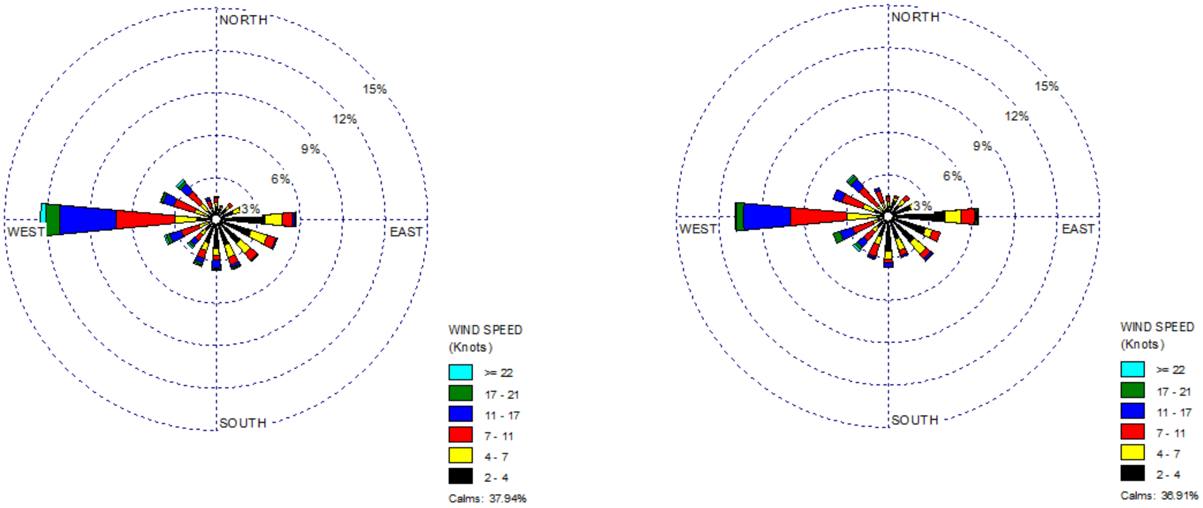
Sample Day Wind Rose

Figure 7-23. Wind Roses for the Garfield County Regional Airport Weather Station near BRCO



Location of BRCO and Weather Station

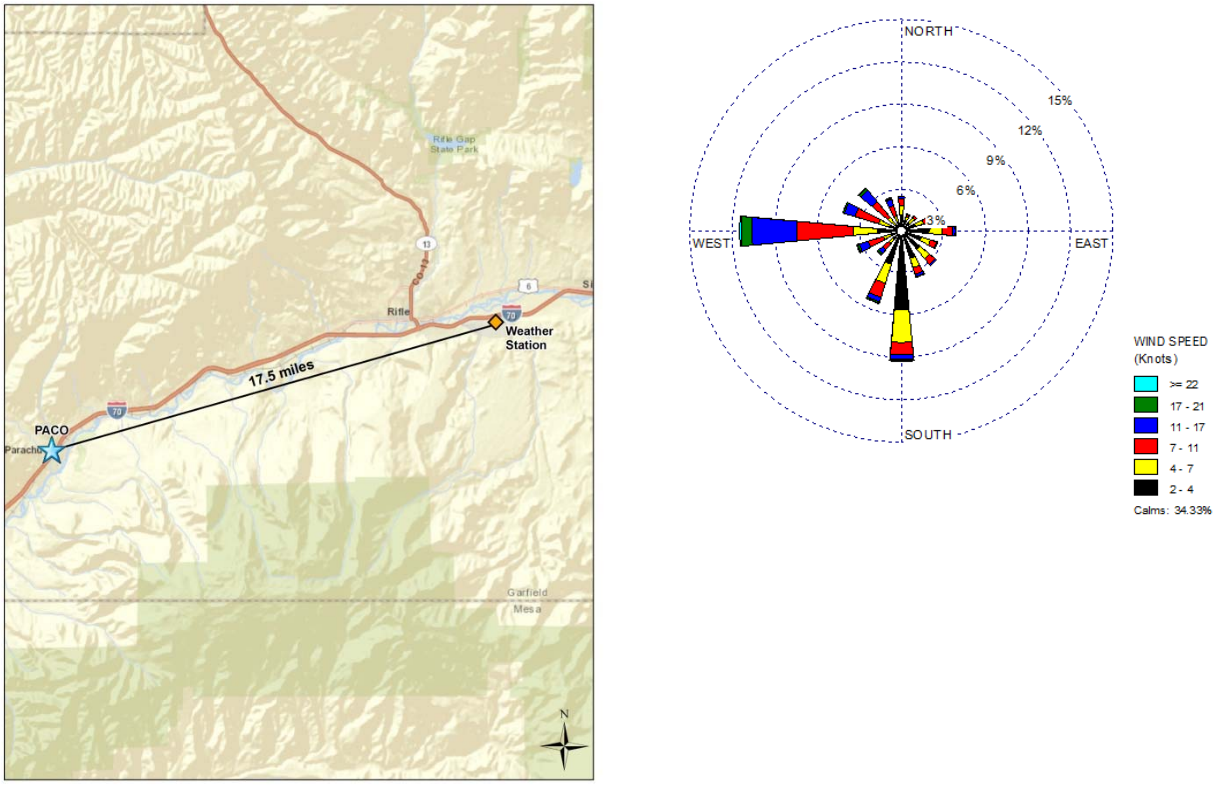
2002-2011 Historical Wind Rose



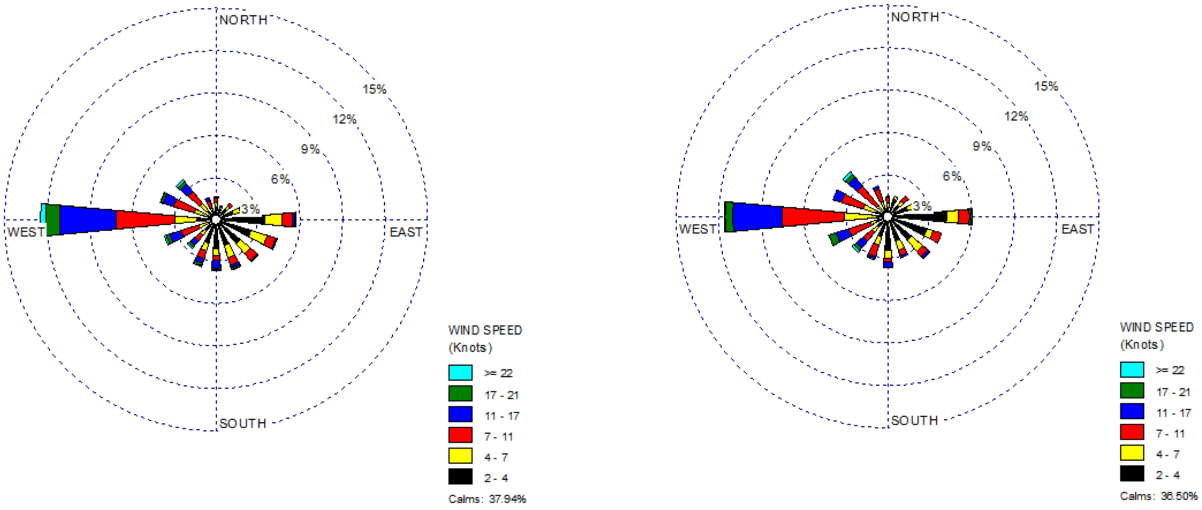
2012 Wind Rose

Sample Day Wind Rose

Figure 7-24. Wind Roses for the Garfield County Regional Airport Weather Station near PACO


Location of PACO and Weather Station

2002-2011 Historical Wind Rose

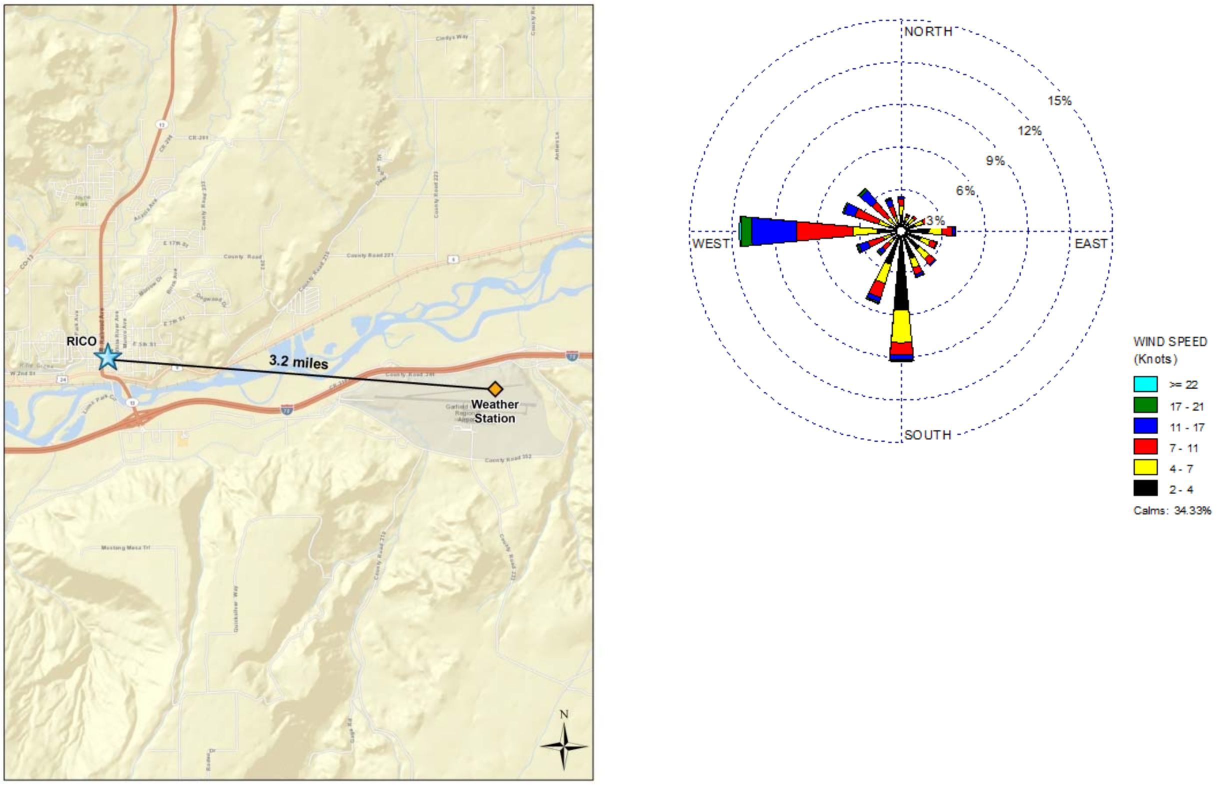

2012 Wind Rose

Sample Day Wind Rose

Figure 7-25. Wind Roses for the Garfield County Regional Airport Weather Station near RICO

Location of RICO and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

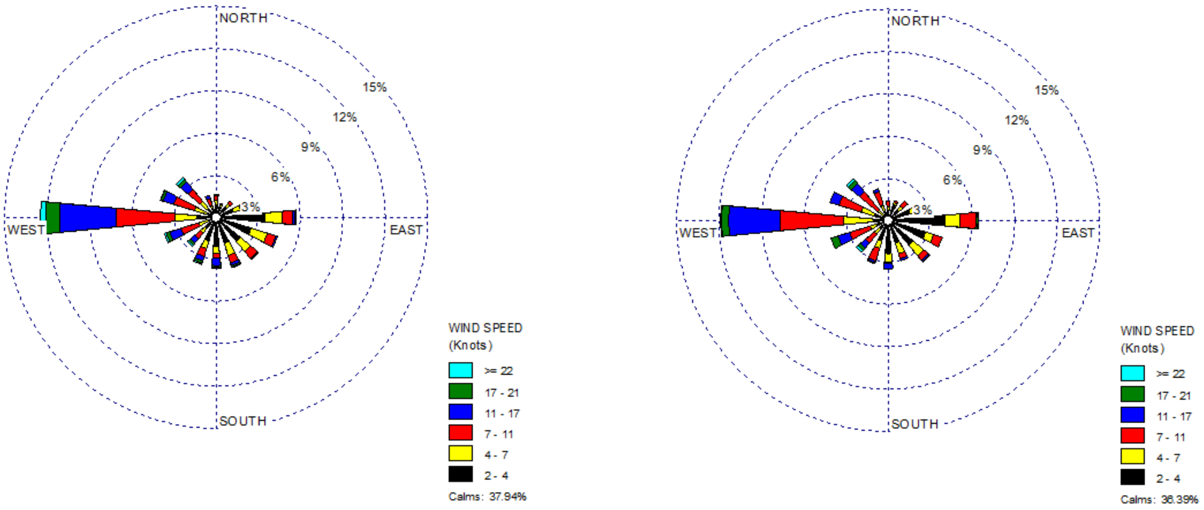
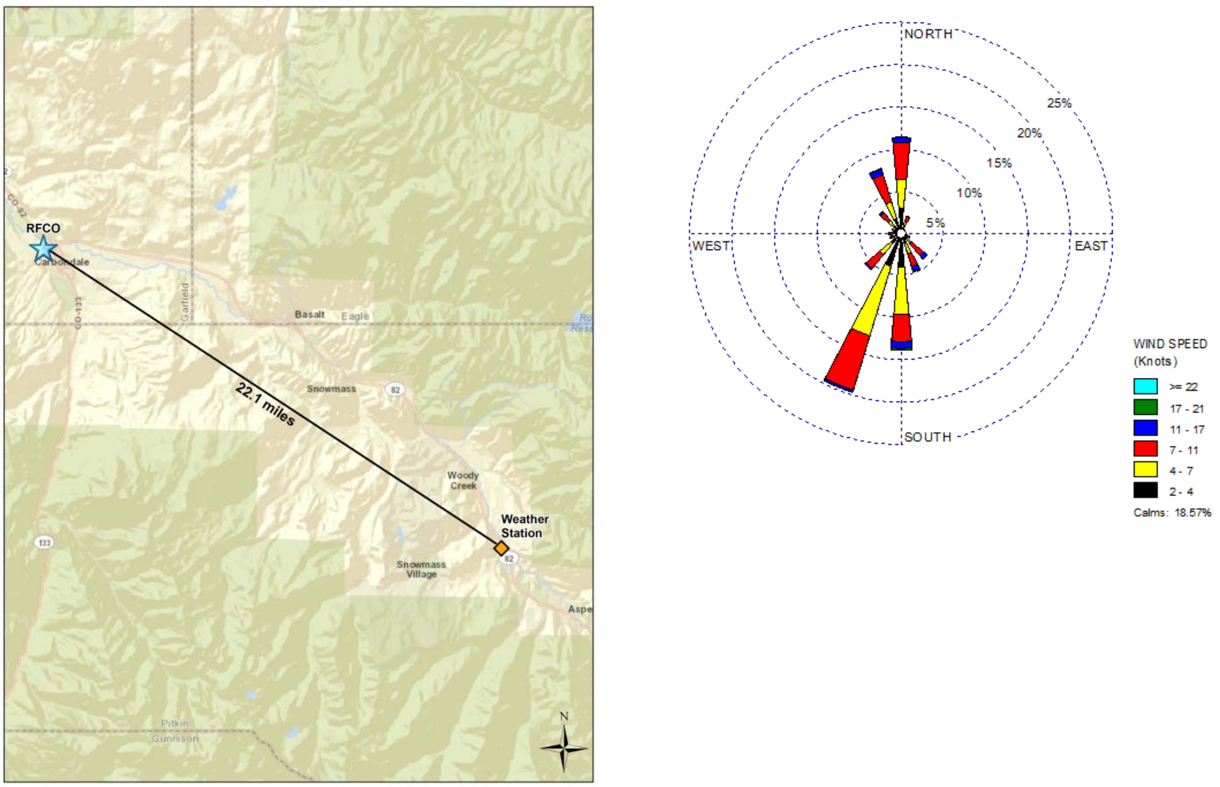
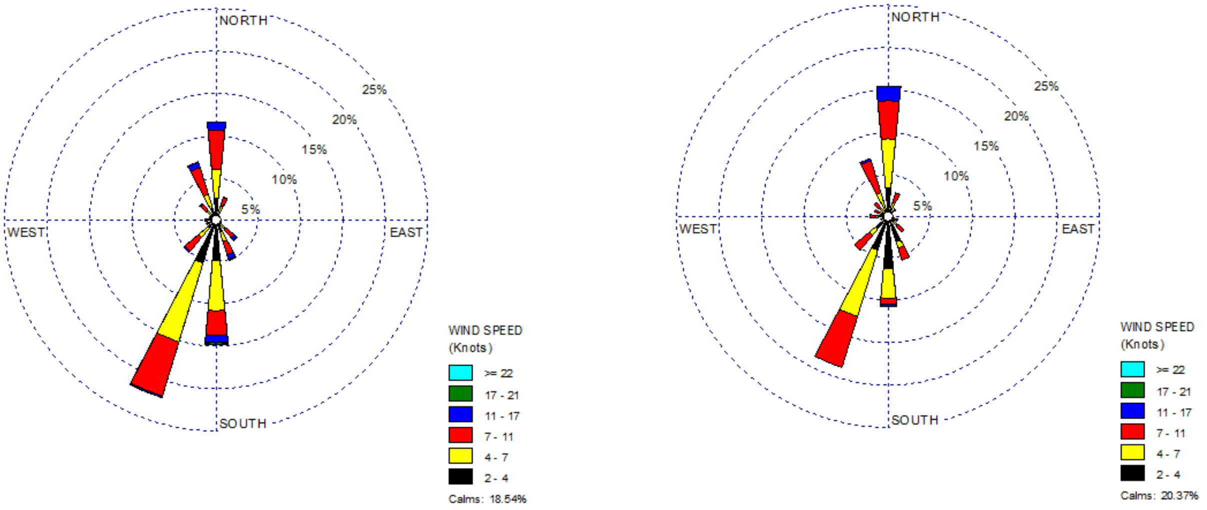


Figure 7-26. Wind Roses for the Aspen-Pitkin County Airport Weather Station near RFCO



Location of RFCO and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Observations from Figure 7-21 for GPCO include the following:

- The Walker Field Airport weather station is located approximately 5 miles north-northeast of GPCO. Most of the city of Grand Junction lies between the site and the airport. The airport property where the weather station is located is adjacent to where the elevation begins to increase on the north side of the city.

- The historical wind rose shows that easterly, east-southeasterly, and southeasterly winds were prevalent near GPCO. Winds from the west to northwest make up a secondary wind grouping. Winds from the southwest quadrant and north-northeast to northeast directions were rarely observed. Calm winds (≤ 2 knots) were observed for approximately 15 percent of the hourly wind measurements.

- The 2012 wind rose exhibits similar wind patterns as the historical wind rose. Further, the sample day wind patterns also resemble the historical and full-year wind patterns, indicating that wind conditions on sample days were representative of those experienced over the entire year and historically.

Observations from Figures 7-22 through 7-25 for BMCO, BRCO, PACO, and RICO include the following:

- The weather station at Garfield County Regional Airport is the closest weather station to four of the five monitoring sites in Garfield County. The weather station is located east of Rifle, just south of I-70. The distance from the weather station to the sites varies from about 3 miles (RICO) to greater than 17 miles (PACO).

- The historical and 2012 wind roses for these Garfield County sites are identical to each other because the wind observations come from the same weather station for all four sites.

- The historical wind roses show that calm winds were prevalent near the monitoring sites, representing one third of wind observations. Westerly and southerly winds were also common. Winds from the northeast quadrant were rarely observed.

- Calm winds were observed for 38 percent of the wind observations in 2012. Fewer southerly and south-southwesterly winds and more easterly winds were observed in 2012 near the Garfield County sites compared to the historical wind rose. A similar observation was made in the 2011 NMP report.

- The sample day wind patterns for each site resemble the full-year wind patterns. This resemblance indicates that conditions on sample days were representative of those experienced over the entire year.

Observations from Figure 7-26 for RFCO include the following:

- The Aspen-Pitkin County Airport weather station is located approximately 22 miles southeast of RFCO. The mountainous terrain surrounding the site and weather station is visible in Figure 7-26.

- The historical wind rose shows that winds from the south and south-southwest are prevalent near RFCO, accounting for one third of the wind observations from this weather station. Winds from the north-northwest and north make up another roughly 20 percent of wind observations, as do calm winds. Winds from due east and due west were not observed.

- The 2012 wind rose exhibits similar wind patterns as the historical wind rose, indicating that conditions in 2012 were similar to conditions experienced over the last 10 years.

- The sample day wind rose has a higher percentage of northerly winds and a lower percentage of southerly winds than the historical and 2012 wind rose. The differences in the sample day wind rose may be indicative of a seasonal pattern, as this wind rose includes data from June through December only.

7.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Colorado monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 7-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 7-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. GPCO sampled for VOCs, carbonyl compounds, PAHs, and hexavalent chromium; the Garfield County sites sampled for SNMOCs and carbonyl compounds only.

Table 7-4. Risk-Based Screening Results for the Colorado Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Grand Junction, Colorado - GPCO						
Benzene	0.13	62	62	100.00	10.33	10.33
1,3-Butadiene	0.03	62	62	100.00	10.33	20.67
Carbon Tetrachloride	0.17	62	62	100.00	10.33	31.00
Acetaldehyde	0.45	61	61	100.00	10.17	41.17
Formaldehyde	0.077	61	61	100.00	10.17	51.33
Naphthalene	0.029	60	60	100.00	10.00	61.33
1,2-Dichloroethane	0.038	56	56	100.00	9.33	70.67
Ethylbenzene	0.4	49	62	79.03	8.17	78.83
Acenaphthene	0.011	32	60	53.33	5.33	84.17
Fluorene	0.011	27	60	45.00	4.50	88.67
p-Dichlorobenzene	0.091	17	54	31.48	2.83	91.50
Dichloromethane	7.7	15	62	24.19	2.50	94.00
Hexachloro-1,3-butadiene	0.045	10	10	100.00	1.67	95.67
1,1,2,2-Tetrachloroethane	0.017	7	7	100.00	1.17	96.83
Benzo(a)pyrene	0.00057	6	40	15.00	1.00	97.83
1,2-Dibromoethane	0.0017	6	6	100.00	1.00	98.83
Trichloroethylene	0.2	5	25	20.00	0.83	99.67
Bromomethane	0.5	1	57	1.75	0.17	99.83
Xylenes	10	1	62	1.61	0.17	100.00
Total		600	929	64.59		
Battlement Mesa, Colorado - BMCO						
Benzene	0.13	53	53	100.00	43.80	43.80
1,3-Butadiene	0.03	28	28	100.00	23.14	66.94
Formaldehyde	0.077	24	26	92.31	19.83	86.78
Acetaldehyde	0.45	15	26	57.69	12.40	99.17
Ethylbenzene	0.4	1	53	1.89	0.83	100.00
Total		121	186	65.05		
Silt, Colorado - BRCO						
Benzene	0.13	57	57	100.00	44.88	44.88
Formaldehyde	0.077	28	28	100.00	22.05	66.93
1,3-Butadiene	0.03	22	23	95.65	17.32	84.25
Acetaldehyde	0.45	20	28	71.43	15.75	100.00
Total		127	136	93.38		
Parachute, Colorado - PACO						
Benzene	0.13	43	43	100.00	35.54	35.54
1,3-Butadiene	0.03	32	32	100.00	26.45	61.98
Formaldehyde	0.077	26	27	96.30	21.49	83.47
Acetaldehyde	0.45	19	27	70.37	15.70	99.17
Ethylbenzene	0.4	1	43	2.33	0.83	100.00
Total		121	172	70.35		

Table 7-4. Risk-Based Screening Results for the Colorado Monitoring Sites (Continued)

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Carbondale, Colorado - RFCO						
Benzene	0.13	16	16	100.00	32.65	32.65
Formaldehyde	0.077	15	15	100.00	30.61	63.27
1,3-Butadiene	0.03	12	12	100.00	24.49	87.76
Acetaldehyde	0.45	6	15	40.00	12.24	100.00
Total		49	58	84.48		
Rifle, Colorado - RICO						
Benzene	0.13	60	60	100.00	34.68	34.68
1,3-Butadiene	0.03	56	56	100.00	32.37	67.05
Formaldehyde	0.077	28	28	100.00	16.18	83.24
Acetaldehyde	0.45	24	28	85.71	13.87	97.11
Ethylbenzene	0.4	5	60	8.33	2.89	100.00
Total		173	232	74.57		

Observations from Table 7-4 include the following:

- The number of pollutants failing screens varied significantly between GPCO and the Garfield County monitoring sites; this is expected given the difference in pollutants measured at each site.

- Nineteen pollutants failed at least one screen for GPCO; nearly 65 percent of the concentrations for these 19 pollutants were greater than their associated risk screening value (or failed screens).

- Thirteen pollutants contributed to 95 percent of failed screens for GPCO and therefore were identified as pollutants of interest for GPCO. These 13 include two carbonyl compounds, eight VOCs, and three PAHs.

- GPCO failed the fourth highest number of screens (600) among all NMP sites, behind only S4MO, PXSS, and TOOK (refer to Table 4-8 of Section 4.2). However, the failure rate for GPCO, when incorporating all pollutants with screening values, is relatively low (less than 29 percent). This is due primarily to the relatively high number of pollutants sampled for at this site, as discussed in Section 4.2.

- The number of pollutants failing screens for the Garfield County sites range from four to five. Four pollutants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) failed screens for each Garfield County site. These four pollutants were identified as pollutants of interest for all five sites. Ethylbenzene also failed screens for three of the five Garfield County sites (BRCO and RFCO being the exceptions), but was not identified as a pollutant of interest for any of them.

- Benzene is the only pollutant to fail 100 percent of screens for all six Colorado sites.

- Note that carbonyl compounds were collected on a 1-in-12 day sampling schedule at BMCO, BRCO, PACO, and RICO, while SNMOCs were collected on a 1-in-6 day sampling schedule; thus, the number of carbonyl compound samples collected at these sites were often less than half the number of SNMOC samples. Both carbonyl compounds and SNMOCs were collected on a 1-in-12 day sampling schedule at RFCO, although sampling did not begin at RFCO until June.

7.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Colorado monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for the Colorado monitoring site are provided in Appendices J through M and O.

7.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Colorado monitoring site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Colorado monitoring sites are presented in Table 7-5, where applicable. Note that concentrations of the PAHs for GPCO are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 7-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Colorado Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Grand Junction, Colorado - GPCO						
Acetaldehyde	61/61	2.96 ± 0.35	3.75 ± 0.57	2.39 ± 0.44	2.49 ± 0.55	2.89 ± 0.27
Benzene	62/62	1.54 ± 0.24	1.02 ± 0.22	NA	1.40 ± 0.20	1.28 ± 0.12
1,3-Butadiene	62/62	0.18 ± 0.04	0.10 ± 0.04	NA	0.26 ± 0.05	0.18 ± 0.03
Carbon Tetrachloride	62/62	0.65 ± 0.06	0.66 ± 0.03	NA	0.68 ± 0.03	0.67 ± 0.02
1,2-Dichloroethane	56/62	0.09 ± 0.01	0.09 ± 0.01	NA	0.06 ± 0.02	0.08 ± 0.01
p-Dichlorobenzene	54/62	0.08 ± 0.01	0.10 ± 0.03	NA	0.04 ± 0.01	0.07 ± 0.01
Dichloromethane	62/62	0.68 ± 0.30	0.51 ± 0.23	NA	104.13 ± 75.41	40.23 ± 28.78
Ethylbenzene	62/62	0.58 ± 0.11	0.55 ± 0.13	NA	0.77 ± 0.17	0.70 ± 0.11
Formaldehyde	61/61	2.63 ± 0.23	2.49 ± 0.35	3.15 ± 0.29	3.81 ± 0.78	3.02 ± 0.25
Hexachloro-1,3-butadiene	10/62	0.04 ± 0.03	0.01 ± 0.02	NA	0	0.02 ± 0.01
Acenaphthene[a]	60/60	28.18 ± 28.14	26.54 ± 8.74	18.42 ± 2.54	8.32 ± 3.84	20.53 ± 7.27
Fluorene[a]	60/60	13.03 ± 10.01	17.63 ± 5.01	12.68 ± 1.67	6.49 ± 1.58	12.56 ± 2.86
Naphthalene[a]	60/60	240.71 ± 113.20	201.08 ± 47.87	148.69 ± 19.64	230.09 ± 79.34	203.78 ± 35.24
Battlement Mesa, Colorado - BMCO						
Acetaldehyde	26/26	0.62 ± 0.16	NA	0.45 ± 0.49	0.44 ± 0.10	NA
Benzene	53/53	1.21 ± 0.29	0.90 ± 0.27	1.21 ± 0.19	1.04 ± 0.17	1.09 ± 0.12
1,3-Butadiene	28/53	0.05 ± 0.03	0.01 ± 0.02	0.13 ± 0.06	0.12 ± 0.09	0.08 ± 0.03
Formaldehyde	26/26	1.05 ± 0.16	NA	0.82 ± 0.71	0.73 ± 0.12	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line for GPCO are presented in ng/m^3 for ease of viewing.

Table 7-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Colorado Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Silt, Colorado - BRCO						
Acetaldehyde	28/28	0.49 ± 0.14	0.77 ± 0.17	0.74 ± 0.39	0.49 ± 0.11	0.61 ± 0.11
Benzene	57/58	0.81 ± 0.16	0.44 ± 0.11	0.68 ± 0.12	0.72 ± 0.22	0.67 ± 0.08
1,3-Butadiene	23/58	0.04 ± 0.03	<0.01 ± 0.01	0.09 ± 0.06	0.12 ± 0.07	0.06 ± 0.03
Formaldehyde	28/28	0.8 ± 0.14	1.07 ± 0.18	1.50 ± 0.73	0.77 ± 0.20	1.02 ± 0.21
Parachute, Colorado - PACO						
Acetaldehyde	27/27	0.79 ± 0.37	0.79 ± 0.30	0.68 ± 0.47	0.54 ± 0.20	0.69 ± 0.15
Benzene	43/45	1.43 ± 0.35	1.10 ± 0.32	NA	NA	NA
1,3-Butadiene	32/45	0.10 ± 0.04	0.03 ± 0.02	NA	NA	NA
Formaldehyde	27/27	1.32 ± 0.32	1.31 ± 0.59	1.22 ± 0.75	1.03 ± 0.41	1.20 ± 0.24
Carbondale, Colorado - RFCO						
Acetaldehyde	15/15	NA	NA	0.72 ± 0.60	0.47 ± 0.27	NA
Benzene	16/17	NA	NA	0.59 ± 0.24	0.36 ± 0.09	NA
1,3-Butadiene	12/17	NA	NA	0.11 ± 0.09	0.18 ± 0.08	NA
Formaldehyde	15/15	NA	NA	1.08 ± 0.73	0.65 ± 0.25	NA
Rifle, Colorado - RICO						
Acetaldehyde	28/28	1.06 ± 0.35	NA	1.08 ± 0.49	0.75 ± 0.32	1.04 ± 0.19
Benzene	60/60	1.18 ± 0.34	0.77 ± 0.17	0.93 ± 0.11	1.08 ± 0.24	1.00 ± 0.12
1,3-Butadiene	56/60	0.21 ± 0.07	0.10 ± 0.02	0.17 ± 0.05	0.24 ± 0.06	0.18 ± 0.03
Formaldehyde	28/28	1.42 ± 0.37	NA	1.55 ± 0.64	1.06 ± 0.32	1.39 ± 0.22

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line for GPCO are presented in ng/m^3 for ease of viewing.

Observations for GPCO from Table 7-5 include the following:

- The pollutants with the highest annual average concentrations are dichloromethane (40.23 ± 28.78 µg/m^3), formaldehyde (3.02 ± 0.25 µg/m^3), acetaldehyde (2.89 ± 0.27 µg/m^3), and benzene (1.28 ± 0.12 µg/m^3). These are also the only pollutants with annual average concentrations greater than 1 µg/m^3.

- The annual average concentration of dichloromethane for GPCO is significantly higher than annual average concentrations for the other pollutants of interest and has a relatively large confidence interval associated with it. A review of the quarterly averages shows that concentrations measured during the fourth quarter of 2012 may be driving the annual average. (Note that third quarter averages for the VOCs could not be calculated due several invalidated samples during the month of August). A review of the preprocessed daily measurements shows that the highest concentrations of dichloromethane were measured at GPCO between late September and mid November. Fifteen concentrations greater than 25 µg/m^3 were measured at GPCO during this time frame and ranged from 29.5 µg/m^3 to 745 µg/m^3. Measurements collected at GPCO account for seven of the eight concentrations of dichloromethane greater than 100 µg/m^3 and 15 of the 19 concentrations greater than 25 µg/m^3 among all NMP sites sampling VOCs (with BTUT accounting for the other four).

- The fourth quarter formaldehyde concentration is higher than the other quarterly averages and has a relatively large confidence interval associated with it. A review of the data shows that the three highest concentrations of formaldehyde were measured at GPCO during the last three scheduled sample days of December, ranging from 4.59 µg/m^3 on December 30th to 8.33 µg/m^3 on December 17th. The highest formaldehyde concentrations measured at GPCO were collected during the second half of 2012. Of the 25 concentrations greater than 3 µg/m^3 measured at GPCO, only five were measured between January and June, with the other 20 measured between July and December (four in July, three each in August and September, one in October, five in November, and four in December).

- Of the PAH pollutants of interest, naphthalene has the highest annual average concentration by an order of magnitude. Each of the PAHs in Table 7-5 has a large confidence interval associated with its first quarter average concentration. Naphthalene's fourth quarter average also has a relatively large confidence interval associated with it. This indicates that outliers are likely influencing these calculations and each pollutant's measurements are discussed in the bullets that follow.

- A review of the naphthalene data shows that the two highest concentrations of this pollutant were measured on March 22nd and March 16th at GPCO (822 ng/m^3 and 633 ng/m^3, respectively). The third and fourth highest concentrations of this pollutant were measured on November 17th and November 29th (525 ng/m^3 and 475 ng/m^3, respectively). These are the four highest naphthalene concentrations measured among all NMP sites sampling PAHs. GPCO has the highest number of naphthalene measurements greater than 300 ng/m^3 (nine) among all NMP sites. These nine concentrations are split evenly among the first, second, and fourth quarters of 2012. GPCO also had some of the highest measurements of naphthalene in 2011.

- The maximum concentration of fluorene was measured at GPCO on the same day as the maximum concentration of naphthalene (68.2 ng/m^3 on March 22nd) and is the third highest fluorene concentration measured among NMP sites sampling PAHs. Three of the five highest fluorene concentrations measured at GPCO were measured in March and ranged from 30.1 ng/m^3 to 68.2 ng/m^3 (with the other two measured in April). The next highest measurement collected during the first quarter is considerably less, with the remaining concentrations ranging from 1.93 ng/m^3 to 7.33 ng/m^3. Six of the seven lowest concentrations of fluorene were also measured during the first quarter of 2012. This variability explains the large confidence interval calculated for the first quarter of 2012.

- The confidence interval for the first quarter average concentration of acetnaphthene is almost equivalent to the average itself. The two highest concentrations of acenaphthene were also measured at GPCO on March 22nd and March 16th (182 ng/m^3 and 101 ng/m^3), with the third highest measured on March 28th (86.4 ng/m^3). Similar to fluorene, the next highest acenaphthalene concentration measured during the first quarter is considerably less (14.1 ng/m^3) and 12 of the 15 lowest concentrations of acenaphthalene were measured during the first quarter. This indicates that the three highest measurements are driving the first quarter average acenaphthalene concentration. The two acenaphthene concentrations greater than 100 ng/m^3 measured at GPCO are the highest concentrations of this pollutant measured among all NMP sites sampling PAHs. Further, five of the nine acenaphthene concentrations greater than 50 ng/m^3 across the program were measured at GPCO (with the others measured at DEMI and NBIL).

Observations for the Garfield County sites from Table 7-5 include the following:

- Acetaldehyde, benzene, 1,3-butadiene, and formaldehyde are pollutants of interest for each Garfield County site.

- Because sampling at RFCO began in June, first quarter, second quarter, and annual average concentrations could not be calculated. Issues with the sampler used to collect SNMOC samples at PACO resulted in fewer than three quarterly averages and a low method completeness; thus, annual averages could not be calculated for this site for benzene or 1,3-butadiene. Sampler issues at BMCO also resulted in low carbonyl compound completeness; thus, second quarter and annual average concentrations could not be calculated for acetaldehyde and formaldehyde for this site. However, Appendix K and Appendix L provide the pollutant-specific average concentrations for all valid samples collected over the entire sample period for each site.

- Formaldehyde is the pollutant with the highest annual average concentration among the pollutants of interest for each of the Garfield County sites (except BMCO, where an annual average could not be calculated). However, the annual averages of formaldehyde for these sites, where they could be calculated, are among the lowest for NMP sites sampling carbonyl compounds, as shown in Figure 4-12b in Section 4. A similar observation can be made for acetaldehyde.

- Concentrations of acetaldehyde and formaldehyde are highest at RICO, followed by PACO and BRCO. However, the differences among the annual averages are not statistically significant, with the exception of RICO’s annual average of acetaldehyde. RICO’s annual average is about one-third higher than the other sites’ annual averages.

- All of the confidence intervals associated with the third quarter average concentrations of acetaldehyde and formaldehyde for the Garfield County sites are relatively high compared to the other quarterly averages, particularly for BMCO. A review of the data shows that the maximum acetaldehyde concentration measured at all five sites was measured on July 1, 2012. Three of the five sites measured the maximum formaldehyde concentration on this date too. For BRCO and PACO, the July 1 formaldehyde concentration was the second highest measured. However, these concentrations are generally low compared to measurements from other NMP sites. For example, the maximum formaldehyde concentration measured at a Garfield County site is 3.16 $\mu g/m^3$ (RFCO). Compared to other NMP sites sampling carbonyl compounds, this measurement ranks 519th.

- Concentrations of benzene were highest at BMCO, followed by RICO and BRCO, although BRCO's annual average is significantly less than the other two sites. Concentrations of 1,3-butadiene were highest at RICO, followed by BMCO and BRCO, although RICO's annual average concentration is significantly higher the other two sites.

- Among the Garfield County sites, only BRCO has a quarterly average for all four quarters for all four pollutants. The lack of quarterly averages across all sites and all quarters makes a seasonal trend difficult to determine for these sites.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Colorado sites from those tables include the following:

- Annual average concentrations for GPCO appear in Tables 4-9 through 4-12 a total of 10 times.

- GPCO appears in Table 4-9 for six of the seven VOCs. Its highest ranking is second for 1,2-dichloroethane. GPCO also ranks fourth for benzene, 1,3-butadiene, ethylbenzene, and hexachloro-1,3-butadiene. RICO's annual average concentration for 1,3-butadiene ranks third among NMP sites, just ahead of GPCO. BMCO's and RICO's annual average benzene concentrations rank sixth and tenth among NMP sites sampling this pollutant.

- GPCO's annual average acetaldehyde concentration ranks second highest among NMP sites sampling carbonyl compounds, as shown in Table 4-10. GPCO's annual average acetaldehyde concentration is between two and five times greater than the annual averages calculated for the Garfield County sites. GPCO's formaldehyde concentration does not appear in this table (it ranks 14th).

- GPCO has the highest annual concentration of naphthalene, acenaphthene, and fluorene among all NMP sites sampling PAHs, as shown in Table 4-11. GPCO also had the highest annual average concentration of naphthalene in the 2010 and 2011 NMP reports.

7.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for each of the pollutants shaded in gray in Table 7-4 for each site. Note that the box plots for benzene and 1,3-butadiene were split into separate figures, one for measurements sampled with Method TO-15 (GPCO) and one for measurements sampled with the SNMOC method (the Garfield County sites), where annual averages could be calculated. Figures 7-27 through 7-39 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 7-27. Program vs. Site-Specific Average Acenaphthene Concentration

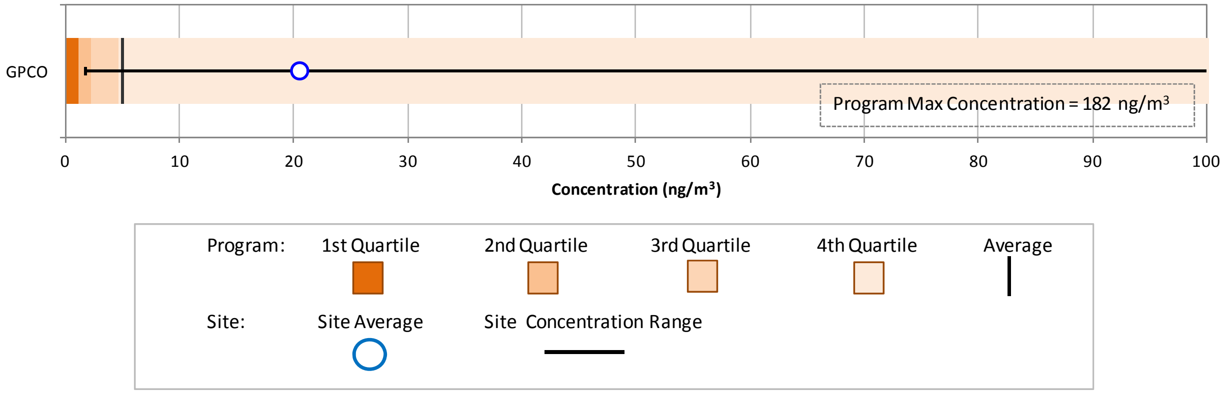


Figure 7-28. Program vs. Site-Specific Average Acetaldehyde Concentrations

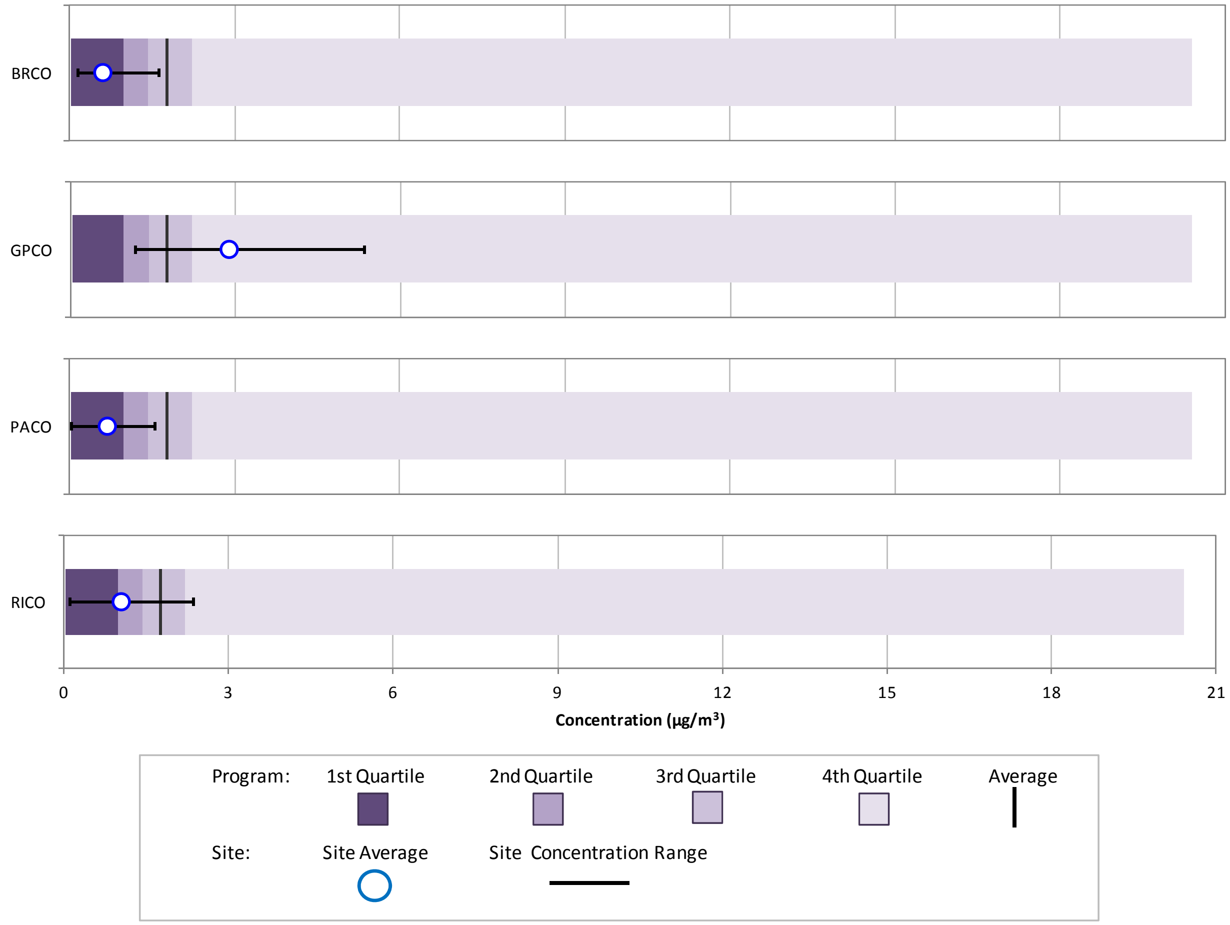


Figure 7-29a. Program vs. Site-Specific Average Benzene (Method TO-15) Concentration

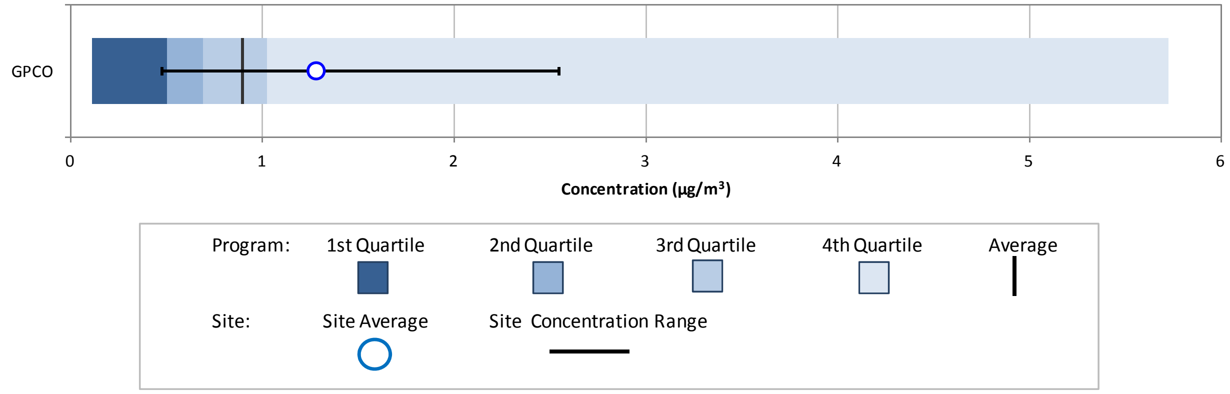


Figure 7-29b. Program vs. Site-Specific Average Benzene (SNMOC) Concentrations

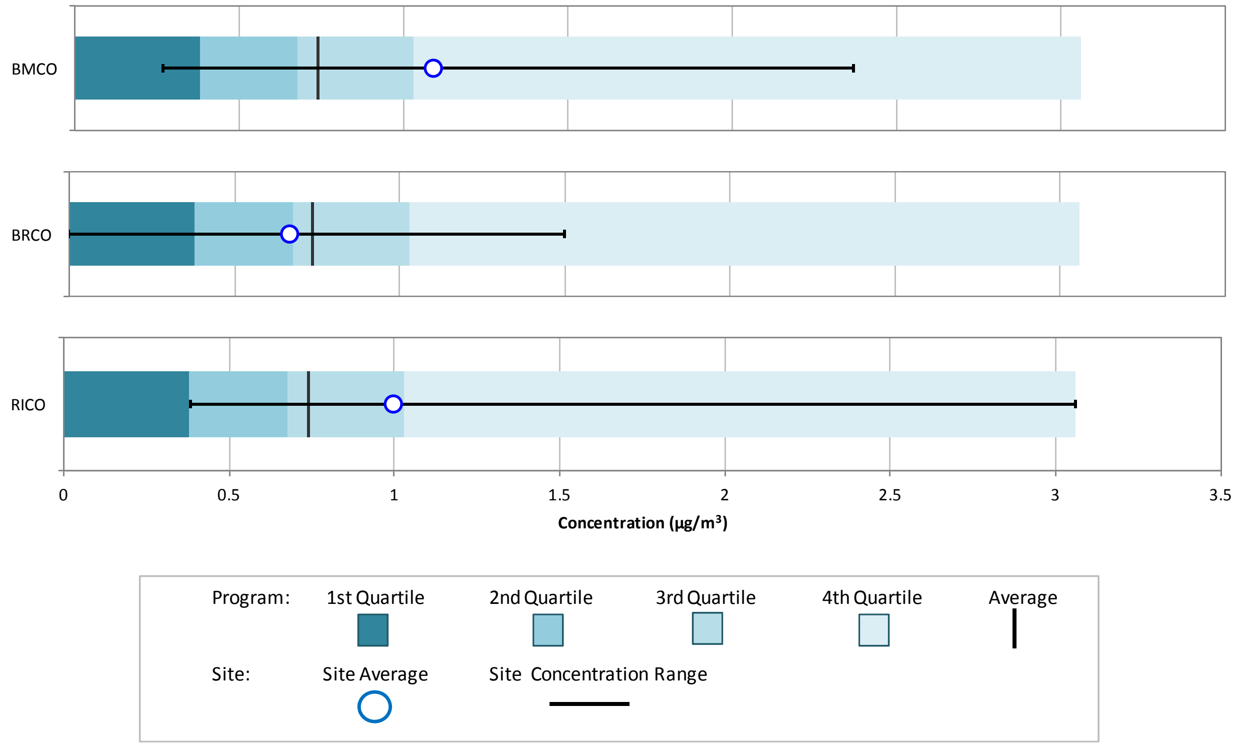


Figure 7-30a. Program vs. Site-Specific Average 1,3-Butadiene (Method TO-15) Concentration

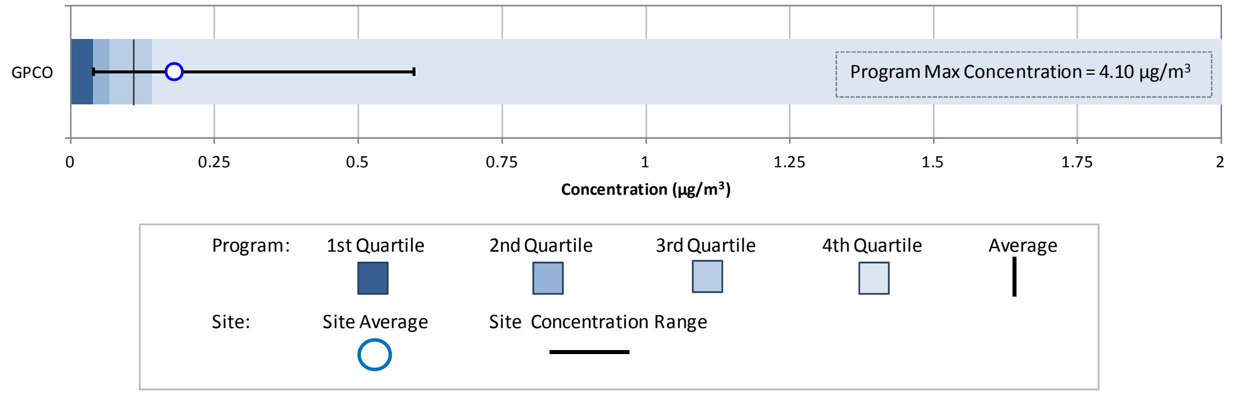


Figure 7-30b. Program vs. Site-Specific Average 1,3-Butadiene (SNMOC) Concentrations

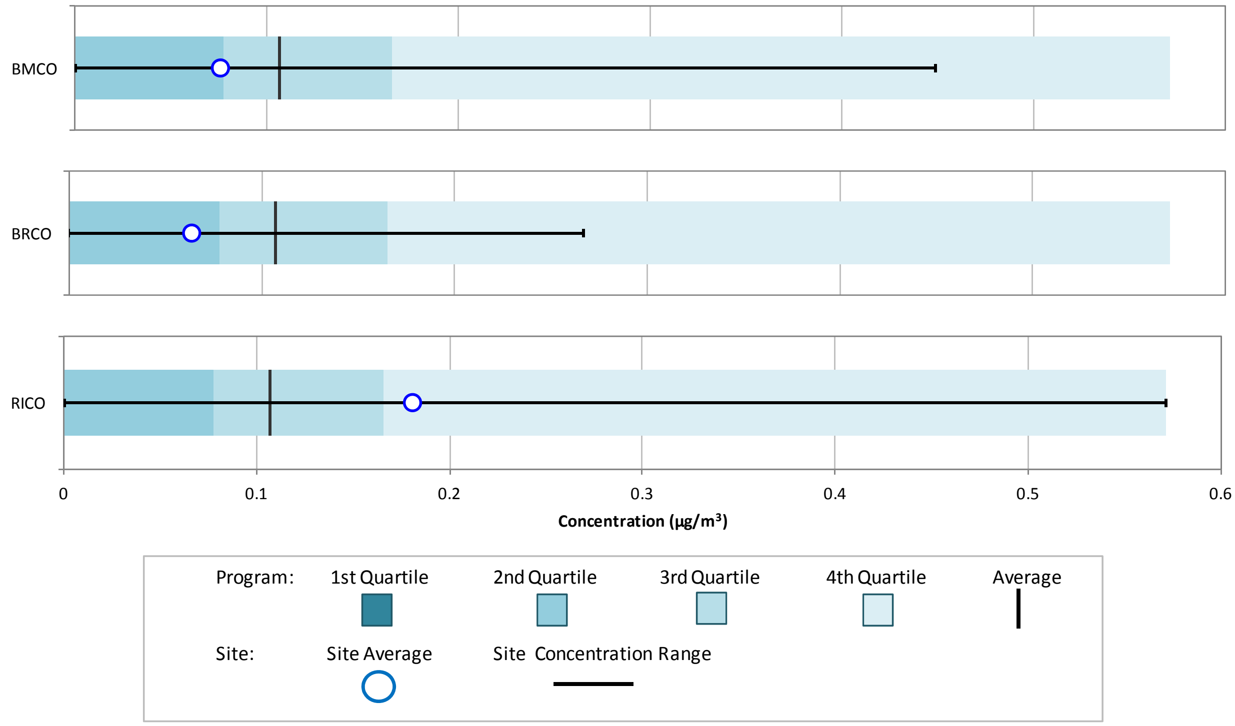


Figure 7-31. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

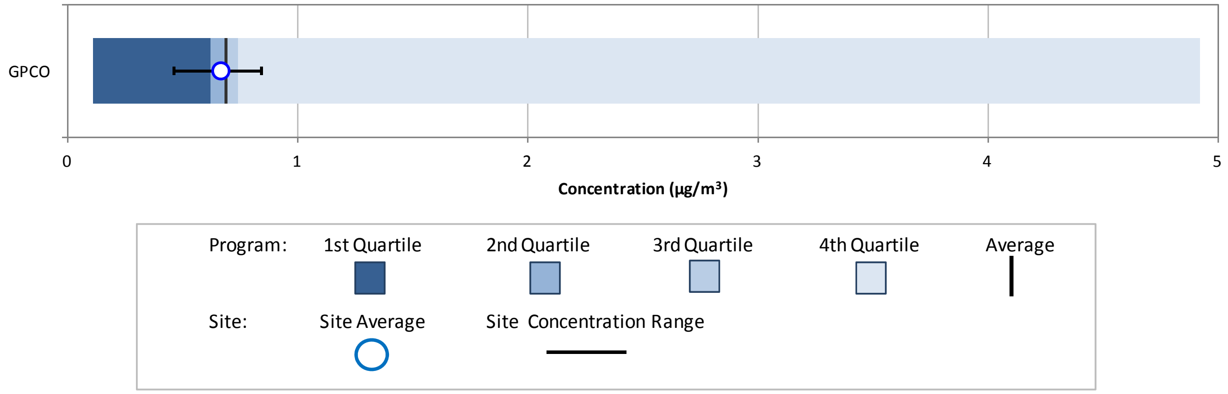


Figure 7-32. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentration

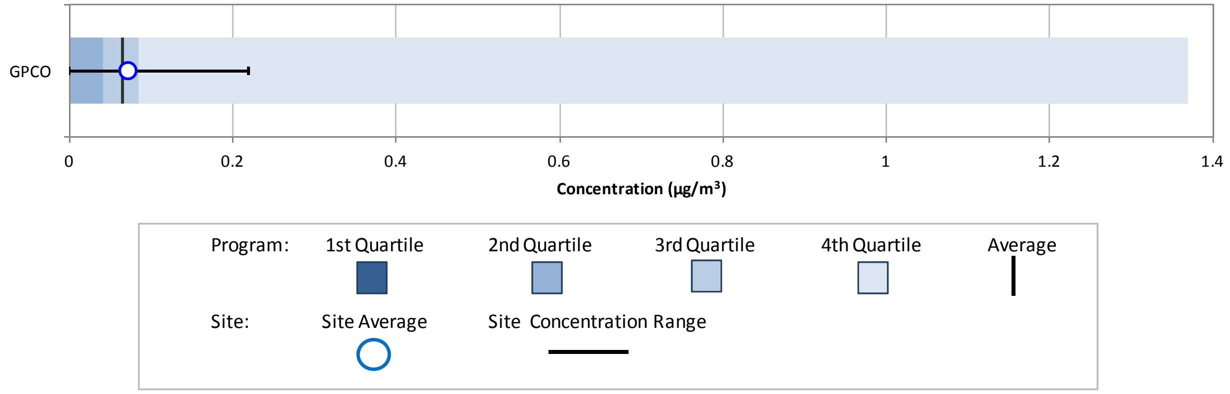


Figure 7-33. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

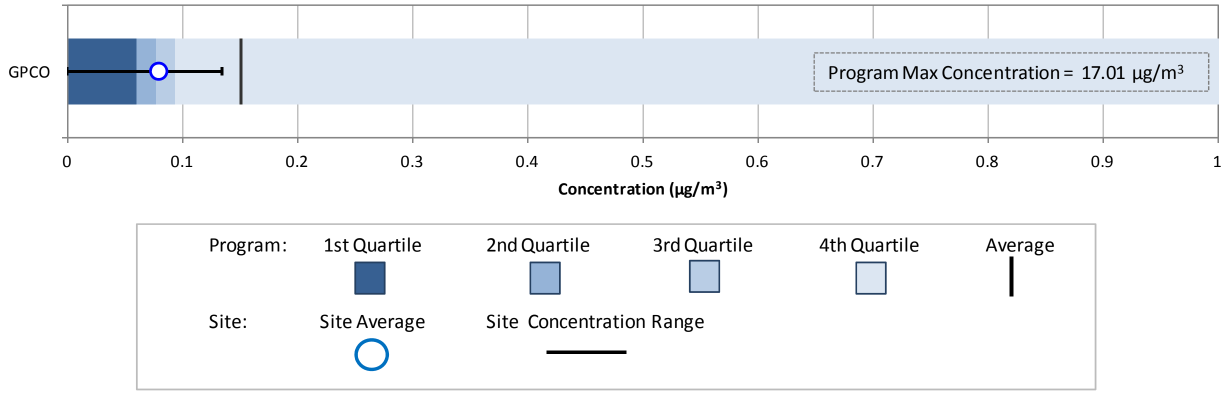


Figure 7-34. Program vs. Site-Specific Average Dichloromethane Concentration

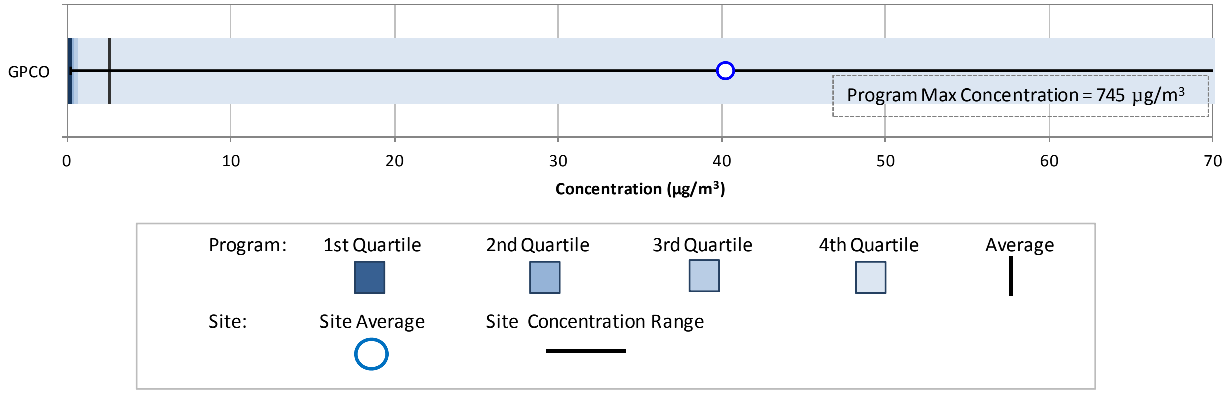


Figure 7-35. Program vs. Site-Specific Average Ethylbenzene Concentration

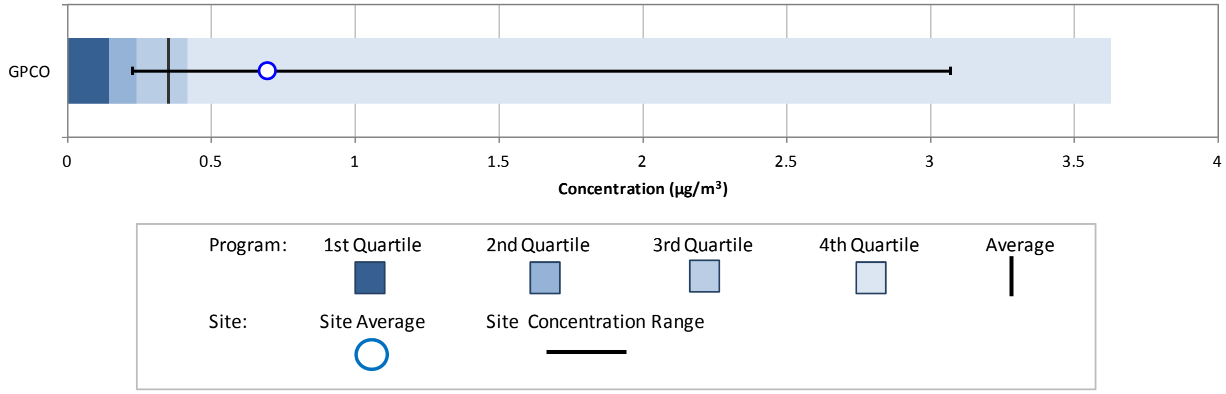


Figure 7-36. Program vs. Site-Specific Average Fluorene Concentration

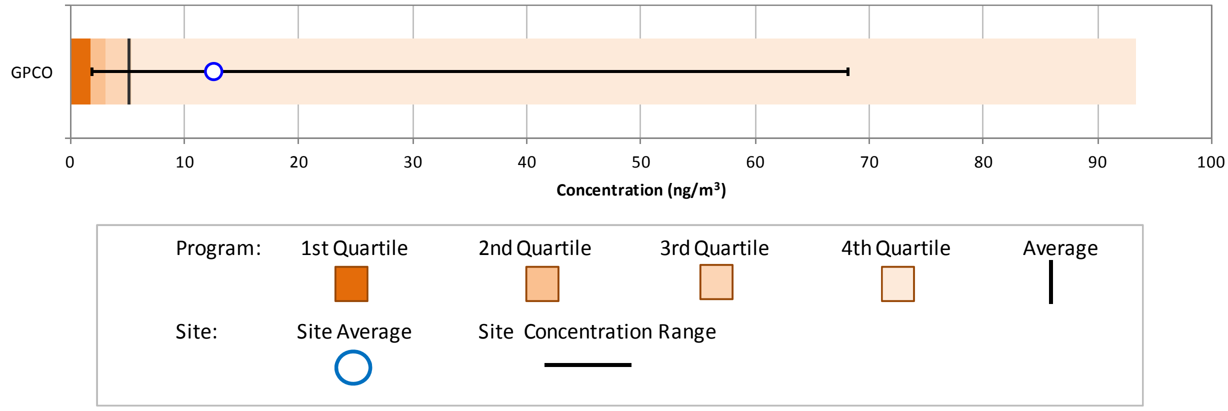


Figure 7-37. Program vs. Site-Specific Average Formaldehyde Concentrations

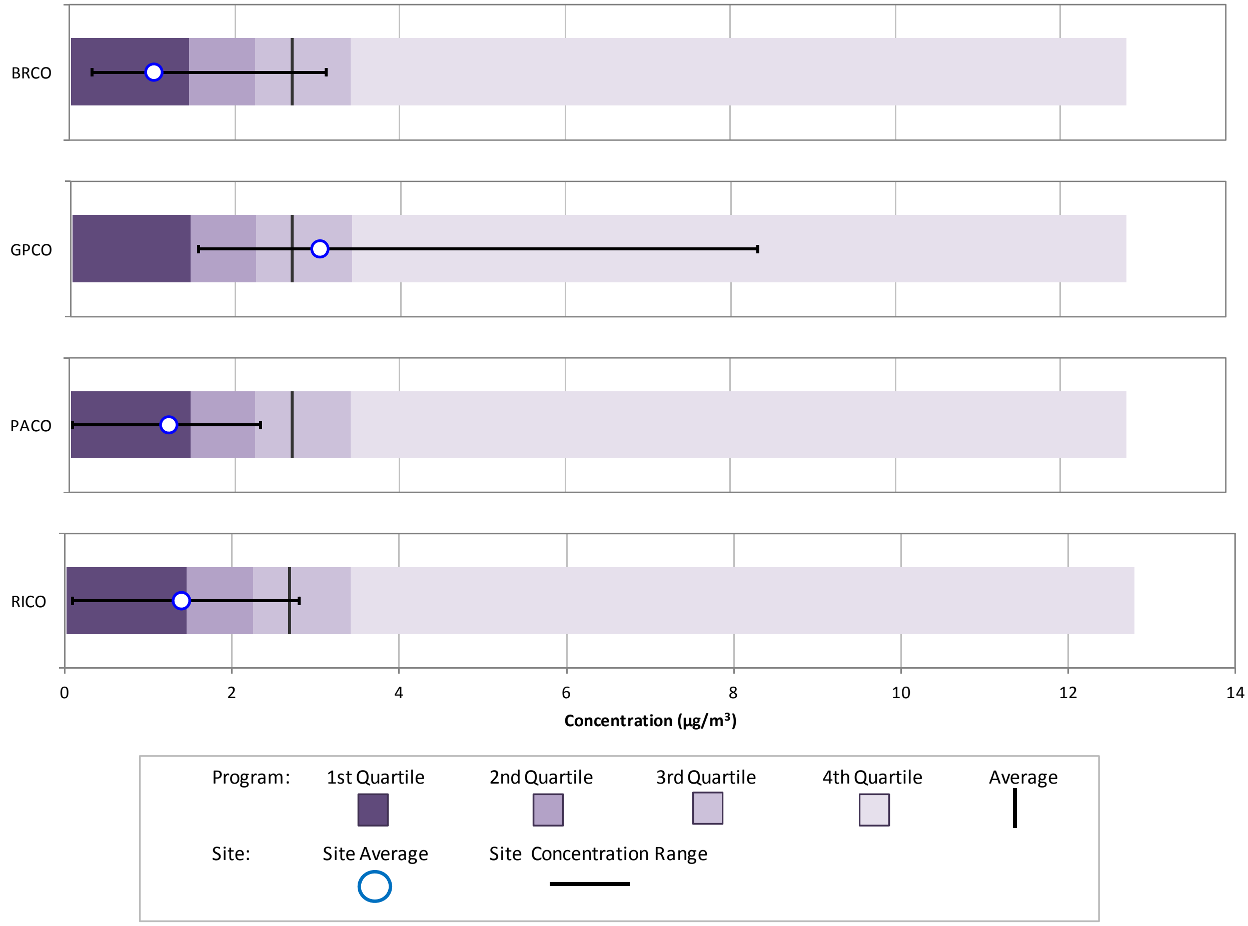


Figure 7-38. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentration

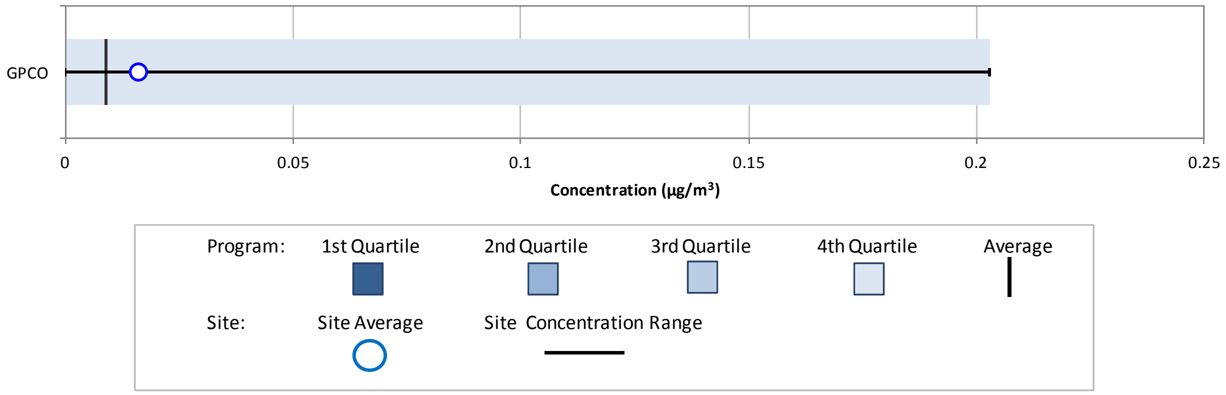
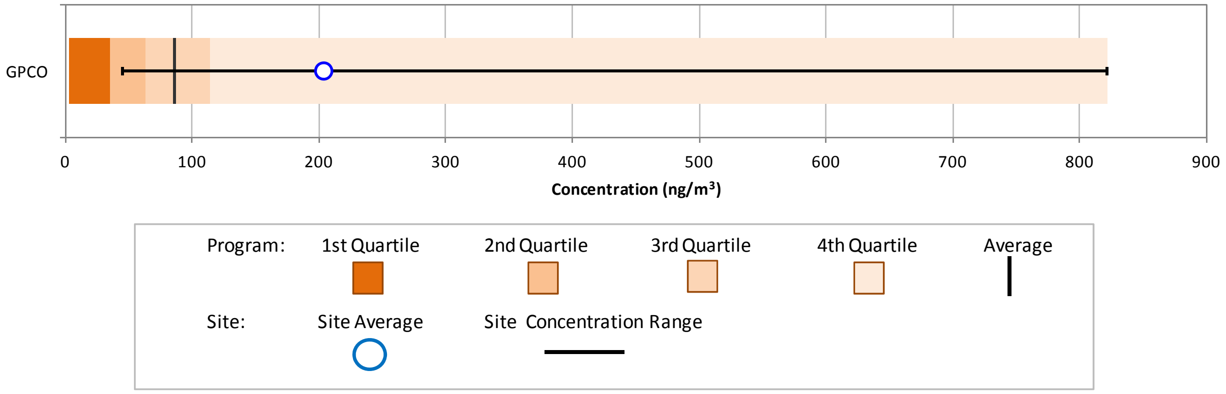


Figure 7-39. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 7-27 through 7-39 include the following:

- Figure 7-27 is the box plot for acenaphthene for GPCO. The program-level maximum concentration (182 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 100 ng/m^3. The maximum concentration of acenaphthene across the program was measured at GPCO, as discussed in the previous section, as was the second highest measurement (101 ng/m^3). Note how the first quartile, median, third quartile, and program-level average concentration are all less than 5 ng/m^3. This provides an indication of just how high these GPCO measurements are compared to the rest of the data. The annual average acenaphthalene concentration for GPCO is more than four times the program-level average. The minimum concentration measured at GPCO is greater than the program-level first quartile but less than the program-level median.

- Figure 7-28 presents the acetaldehyde box plots for the four Colorado sites for which annual averages could be calculated. The box plots show that GPCO has the highest annual average acetaldehyde concentration among the Colorado sites. The annual average for GPCO is greater than the program-level third quartile; conversely, most of the annual average concentrations for the Garfield County sites are less than the program-level first quartile (RICO is the exception; its annual average concentration is just greater than the program-level first quartile). The minimum acetaldehyde concentration measured at GPCO is greater than the annual average concentrations for all of the Garfield County sites while the maximum acetaldehyde concentration for each Garfield County site is less than the program-level average, with the exception of RICO. The maximum acetaldehyde concentration measured at GPCO is significantly less than the maximum concentration measured across the program.

- Figures 7-29a and 7-29b present the box plots for benzene. Figure 7-29a compares to the benzene concentrations measured at GPCO to those measured across the program for NMP sites sampling VOCs with Method TO-15; Figure 7-29b presents the annual average benzene concentrations for the Garfield County sites compared to the benzene concentrations measured across the program for NMP sites sampling SNMOCs. The box plots are presented this way to correspond with Tables 4-1 and 4-2 in Section 4.1, as discussed in Section 3.5.3.1.

- Figure 7-29a shows that the annual average benzene concentration for GPCO is greater than the program-level average concentration as well as the third quartile for the program. The minimum benzene concentration measured at GPCO is just less than the program-level first quartile. The maximum benzene concentration measured at GPCO is less than half the maximum benzene concentration measured across the program.

- Figure 7-29b includes a box plot for BMCO, BRCO, and RICO only because annual averages could not be calculated for PACO and RFCO. The maximum benzene concentration measured at RICO is the maximum concentration measured among the eight sites sampling SNMOCs (3.06 µg/m^3). Note that the scale in Figure 7-29b is roughly half the scale for Figure 7-29a. Of the Garfield County sites shown, BMCO has the highest annual average concentration of benzene, followed by RICO then BRCO. The annual average concentration for BMCO is greater than the program-level third quartile; the annual average for RICO is just less than the program-level third quartile but greater than the program-level average; and the annual average for BRCO is less than the program-level average but similar to the program-level median concentration.

- Similar to the box plots for benzene, Figure 7-30a presents the annual average concentration of 1,3-butadiene for GPCO compared to the 1,3-butadiene concentrations measured across the program for NMP sites sampling VOCs with Method TO-15; Figure 7-30b presents the annual average 1,3-butadiene concentrations for the Garfield County sites compared to the 1,3-butadiene concentrations measured across the program for NMP sites sampling SNMOCs.

- The program-level maximum concentration (4.10 µg/m^3) is not shown directly on the box plot in Figure 7-30a as the scale has been reduced to 2 µg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. GPCO's annual average 1,3-butadiene concentration is greater than the program-level average concentration and program-level third quartile. The minimum 1,3-butadiene concentration measured at GPCO is the same as the program-level first quartile. Even though the annual average concentration of 1,3-butadiene for GPCO is among the higher annual averages for this pollutant, the maximum concentration measured at GPCO (0.596 µg/m^3) is considerably less than the maximum concentration measured across the program.

- The program-level first quartile is zero, and thus, not shown in Figure 7-30b, indicating that at least 25 percent of the 1,3-butadiene concentrations measured by sites sampling SNMOCs were non-detects. The maximum 1,3-butadiene concentration measured at RICO is the maximum concentration measured among the eight NMP sites sampling SNMOCs (0.571 µg/m^3). Of the Garfield County sites shown, RICO has the highest annual average concentration of 1,3-butadiene, followed by BMCO then BRCO. The annual average concentration for BRCO is less than the program-level median concentration; the annual average for BMCO is similar to the program-level median concentration; and the annual average for RICO is greater than the program-level third quartile.

- Figure 7-31 is the box plot for carbon tetrachloride for GPCO and shows that the range of measurements collected is rather small as the difference between the minimum and maximum concentrations is 0.385 µg/m^3. This box plot also shows that the annual average carbon tetrachloride concentration for GPCO is just less than the program-level median and average concentrations.

- The program-level first quartile for *p*-dichlorobenzene is zero, and thus, not shown in Figure 7-32, indicating that at least 25 percent of the *p*-dichlorobenzene concentrations measured were non-detects. Eight non-detects were reported for GPCO. The annual average concentration of this pollutant for GPCO is just greater than the program-level average and just less than the program-level third quartile. The maximum *p*-dichlorobenzene concentration measured at GPCO is significantly less than the maximum concentration measured across the program.

- The program-level maximum concentration (17.01 µg/m^3) is not shown directly on the box plot for 1,2-dichloroethane in Figure 7-33 as the scale has been reduced to 1 µg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. All of GPCO's 1,2-dichloroethane measurements are less than the program-level average concentration. This, as well as the magnitude of the maximum concentration at the program-level, indicate that there are potential outliers in the 1,2-dichloroethane dataset. The annual average for GPCO is roughly half the program-level average concentration and just greater than the program-level median.

- The program-level maximum concentration (745 µg/m^3) is not shown directly on the box plot for dichloromethane in Figure 7-34 as the scale has been reduced by an order of magnitude (70 µg/m^3) in order to allow for the observation of data points at the lower end of the concentration range. Seven of GPCO's dichloromethane measurements are greater than the top of the scale in Figure 7-34. GPCO's annual average concentration of dichloromethane (40.23 ± 28.78 µg/m^3) is 16 times greater than the program-level average concentration. Eighteen individual concentrations measured at GPCO are greater than the program-level average concentration.

- Figure 7-35 for ethylbenzene shows that GPCO's annual average concentration is approximately twice the program-level average concentration. While the maximum ethylbenzene concentration was not measured at this site, GPCO's maximum ethylbenzene measurement is the second highest among sites sampling VOCs. The minimum ethylbenzene concentration measured at GPCO is just less than the program-level median concentration, indicating that nearly 50 percent of the ethylbenzene concentrations across the program are less than GPCO's minimum concentration.

- The program-level average concentration of fluorene is just less than the program-level third quartile and thus, the two cannot be differentiated in Figure 7-36. GPCO's annual average concentration is more than twice the program-level concentration. While the maximum fluorene concentration across the program was not measured at GPCO, GPCO's maximum concentration ranks third among all fluorene measurements. The minimum fluorene concentration measured at GPCO is greater than the program-level first quartile. Recall from the previous section that GPCO has the highest annual average concentration of fluorene among all NMP sites sampling PAHs.

- Figure 7-37 presents the box plots for formaldehyde. These box plots share some of the same characteristics as the box plots for acetaldehyde. The box plots show that GPCO has the highest annual average formaldehyde concentration among the Colorado sites and is the only site for which the annual average concentration is greater than the program-level average concentration. The minimum formaldehyde concentration measured at GPCO is greater than the program-level first quartile as well as the annual average concentrations for all of the Garfield County sites shown. The maximum formaldehyde concentration for each Garfield County site is less than the program-level third quartile.

- Figure 7-38 is the box plot for hexachloro-1,3-butadiene for GPCO. The program-level first, second (median), and third quartiles are all zero and therefore not visible on the box plot. This is due to the large number of non-detects of this pollutant across the program (87 percent). Hexachloro-1,3-butadiene was detected 10 times at GPCO. The maximum concentration of hexachloro-1,3-butadiene across the program was measured at GPCO (0.203 µg/m^3). The annual average concentration of hexachloro-1,3-butadiene for GPCO (0.016 ± 0.010 µg/m^3) is almost twice the program-level average concentration (0.009 µg/m^3).

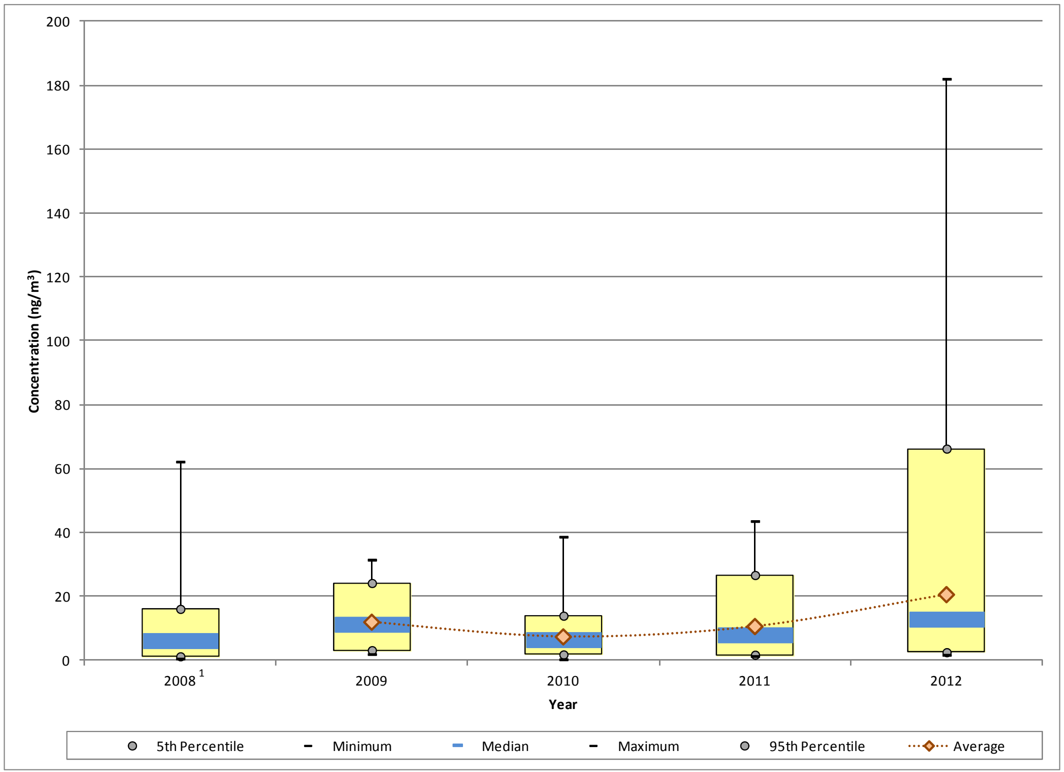
- Figure 7-39 is the box plot for naphthalene and shows that the maximum concentration of naphthalene across the program was measured at GPCO. The annual average naphthalene concentration for GPCO (203.78 ± 35.24 ng/m^3) is more than twice the program-level average concentration and is greater than the program-level third quartile. Recall from the previous section that GPCO has the highest annual average naphthalene concentration among all sites sampling PAHs.

The minimum concentration of naphthalene measured at GPCO (45.5 ng/m^3) is greater than the program-level first quartile (35.3 ng/m^3).

7.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. GPCO has sampled carbonyl compounds and VOCs under the NMP since 2004 and PAHs since 2008; BRCO, PACO, and RICO began sampling SNMOCs and carbonyl compounds under the NMP in 2008. Thus, Figures 7-40 through 7-62 present the 1-year statistical metrics for each of the pollutants of interest first for GPCO then for BRCO, PACO, and RICO. Note, however, that the 1-year statistical metrics are not provided for the carbonyl compounds for BRCO. This is because sampling was discontinued in October 2010 and did not begin again until September 2011. Thus, 5 consecutive years of data are not available for BRCO for acetaldehyde and formaldehyde. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented. BMCO began sampling SNMOCs and carbonyl compounds under the NMP at the end of 2010 and RFCO is new for 2012; thus, the trends analysis was not conducted for these sites.

Figure 7-40. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at GPCO



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

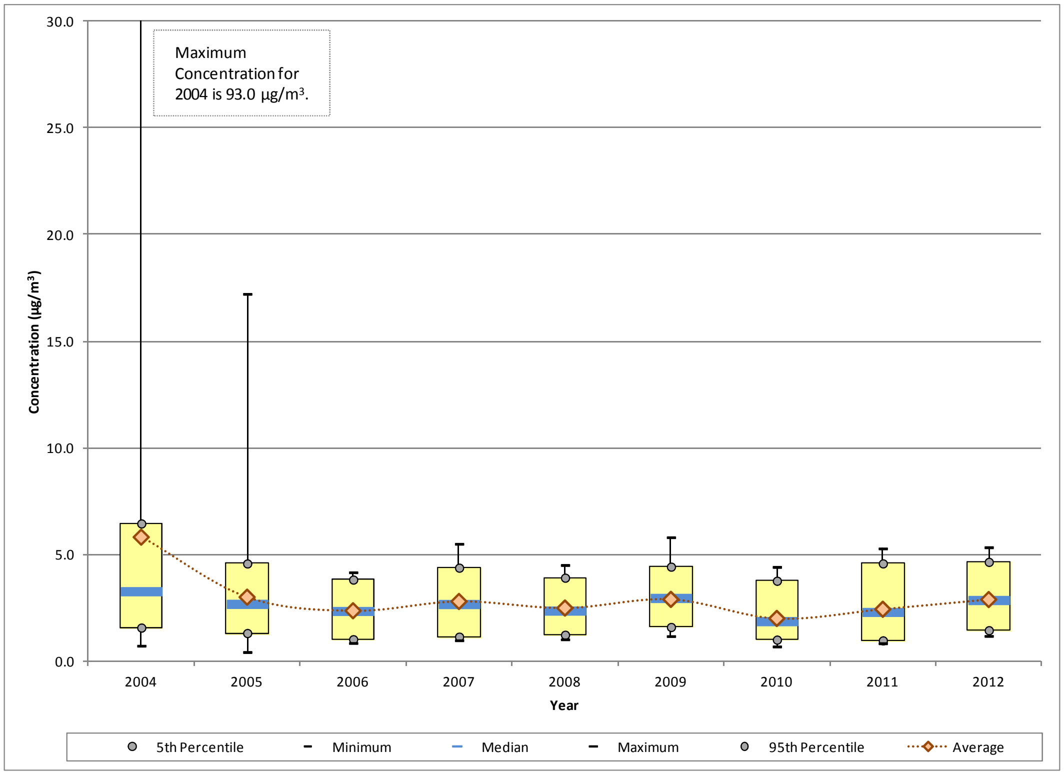
Observations from Figure 7-40 for acenaphthene measurements collected at GPCO include the following:

- Sampling for PAHs at GPCO began in April 2008. Because a full year's worth of data is not available for 2008, a 1-year average is not presented, although the range of measurements is provided.

- The three highest concentrations of acenaphthene were measured at GPCO in March 2012 and ranged from 86.4 ng/m^3 to 182 ng/m^3. Although the three highest concentrations were all measured in March, concentrations measured in 2012 were higher in general as nine of the 15 concentrations greater than 30 ng/m^3 were measured in 2012 while only one or two were measured in each of the remaining years of sampling.

- Concentrations of acenaphthene decreased significantly from 2009 to 2010, based on the 1-year averages, after which a steady increasing trend is shown. Even if the highest concentrations measured in 2012 were removed from the dataset, the 1-year average concentration for acenaphthene for 2012 would still represent more than a 50 percent increase from 2011.

Figure 7-41. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at GPCO



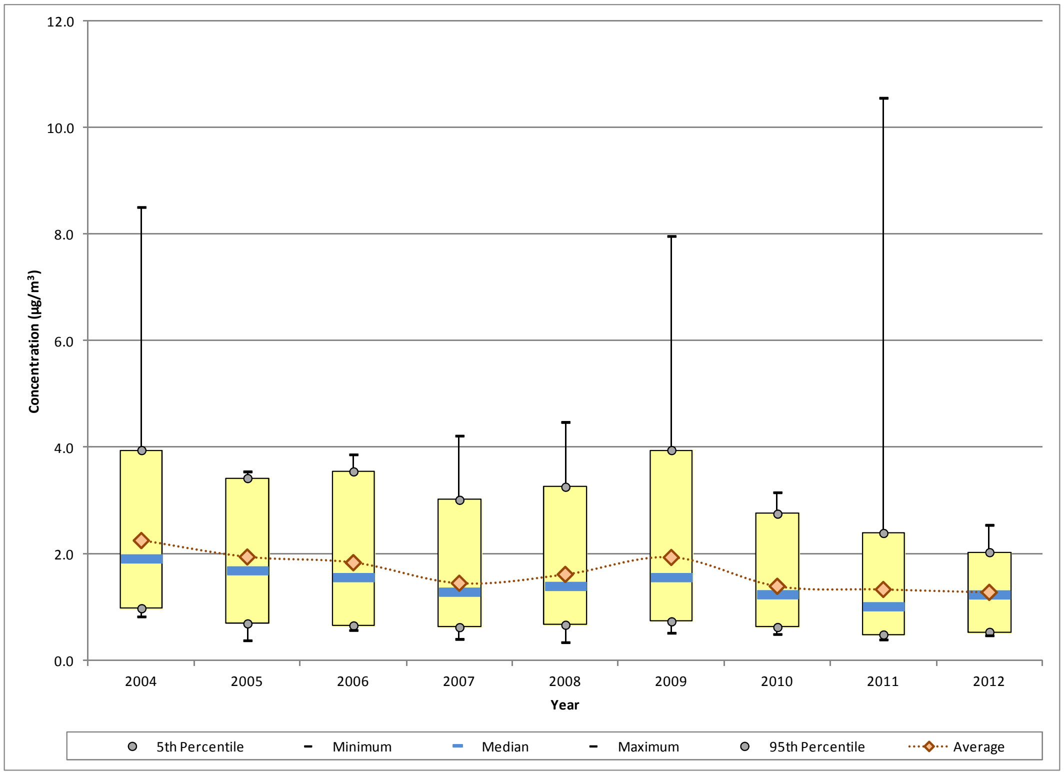
Observations from Figure 7-41 for acetaldehyde measurements collected at GPCO include the following:

- The maximum acetaldehyde concentration was measured at GPCO in 2004. The maximum concentrations measured in subsequent time periods were significantly lower. The two highest acetaldehyde concentrations (93.0 µg/m^3 and 54.9 µg/m^3) were both measured in 2004 and the six highest acetaldehyde concentrations (those greater than 6 µg/m^3) were all measured in 2004 and 2005.

- After the first two years of sampling, the 1-year average concentrations vary by less than 1 µg/m^3 from year to year. The 1-year average has ranged from 2.00 µg/m^3 (2010) to 2.90 µg/m^3 (2009). The 1-year average and median concentrations are both at a minimum for 2010, representing a statistically significant decrease from 2009. The 1-year average concedntration increases from 2010 to 2011 and again for 2012, back to 2009 levels.

- The 1-year average and median concentrations differ by less than 0.15 µg/m^3 for each year after 2005, indicating relatively little variability in the central tendency of the acetaldehyde concentrations measured over the period after 2005.

Figure 7-42. Yearly Statistical Metrics for Benzene Concentrations Measured at GPCO



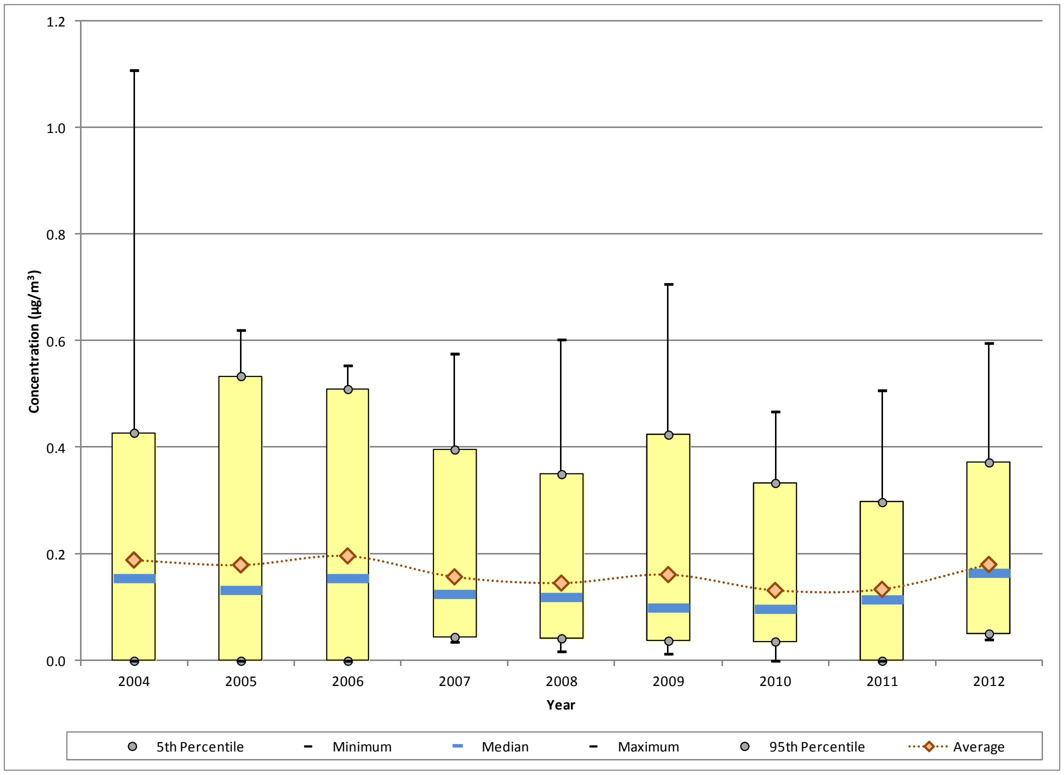
Observations from Figure 7-42 for benzene measurements collected at GPCO include the following:

- The maximum benzene concentration (10.6 µg/m^3) was measured on June 8, 2011. Only three additional concentrations greater than 5 µg/m^3 have been measured at GPCO, two in 2004 and one in 2009.

- Concentrations of benzene have a decreasing trend from 2004 through 2007, based on the 1-year averages. After a period of increasing 1-year averages through 2009, a significant decrease is shown for 2010. Although the decreasing trend continued into 2011, the maximum concentration measured in 2011 results in a higher level of variability, as indicated by the confidence intervals. The median concentrations follow a similar pattern as the 1-year averages.

- Even though the range of benzene concentrations is at a minimum for 2012 and the 1-year average decreased slightly, the median increased from 1.02 µg/m^3 to 1.24 µg/m^3 from 2011 to 2012. While the maximum concentration is driving the 1-year average for 2011, there are more concentrations at the upper end of the concentration range for 2012, even if that range is more compact. There are also fewer concentrations at the lower end of the concentration range for 2012; there is only one concentration less than 0.5 µg/m^3 for 2012 (0.48 µg/m^3) while there are five for 2011.

Figure 7-43. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at GPCO



Observations from Figure 7-43 for 1,3-butadiene measurements collected at GPCO include the following:

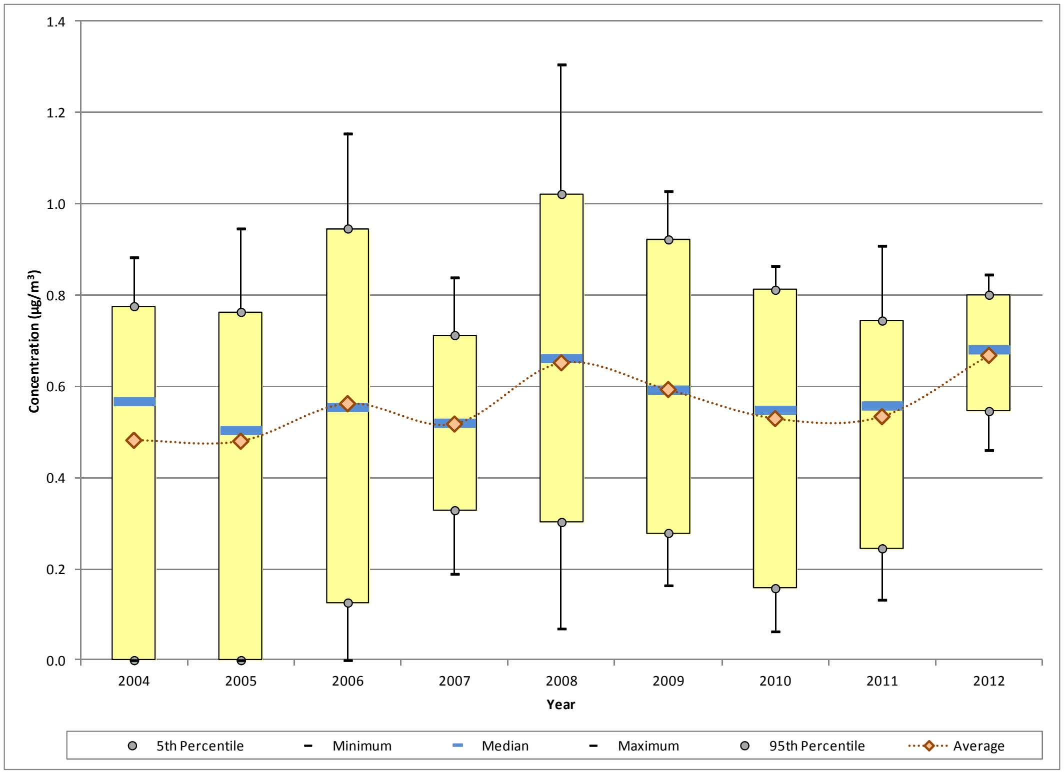
- The maximum 1,3-butadiene concentration was measured on December 11, 2004 and is the only 1,3-butadiene concentration greater than 1 µg/m^3 measured at GPCO. The second highest concentration was also measured in 2004 (0.75 µg/m^3), although a similar concentration was measured in 2009 (0.71 µg/m^3).

- The 1-year average concentrations have varied by less than 0.065 µg/m^3 over the years of sampling, ranging from 0.132 µg/m^3 (2010) to 0.197 µg/m^3 (2006).

- The increase in the 1-year average and median concentrations from 2011 to 2012 represent the largest year to year change (approximately 0.05 µg/m^3 for each). Not only are the measurements at the upper end of the concentration range higher for 2012, there were also no non-detects reported for 2012, while there were seven reported for 2011.

- The number of non-detects, and subsequently zeros substituted for non-detects, has varied significantly across the period of sampling. The number of non-detects decreased from approximately 30 percent in 2004 and 2005, to 8 percent in 2006, to none in 2007, 2008, and 2009. The number of non-detects began to increase after 2009, up to 3 percent in 2010 and 12 percent in 2011, after which non-detects were not reported for 2012.

Figure 7-44. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at GPCO



Observations from Figure 7-44 for carbon tetrachloride measurements collected at GPCO include the following:

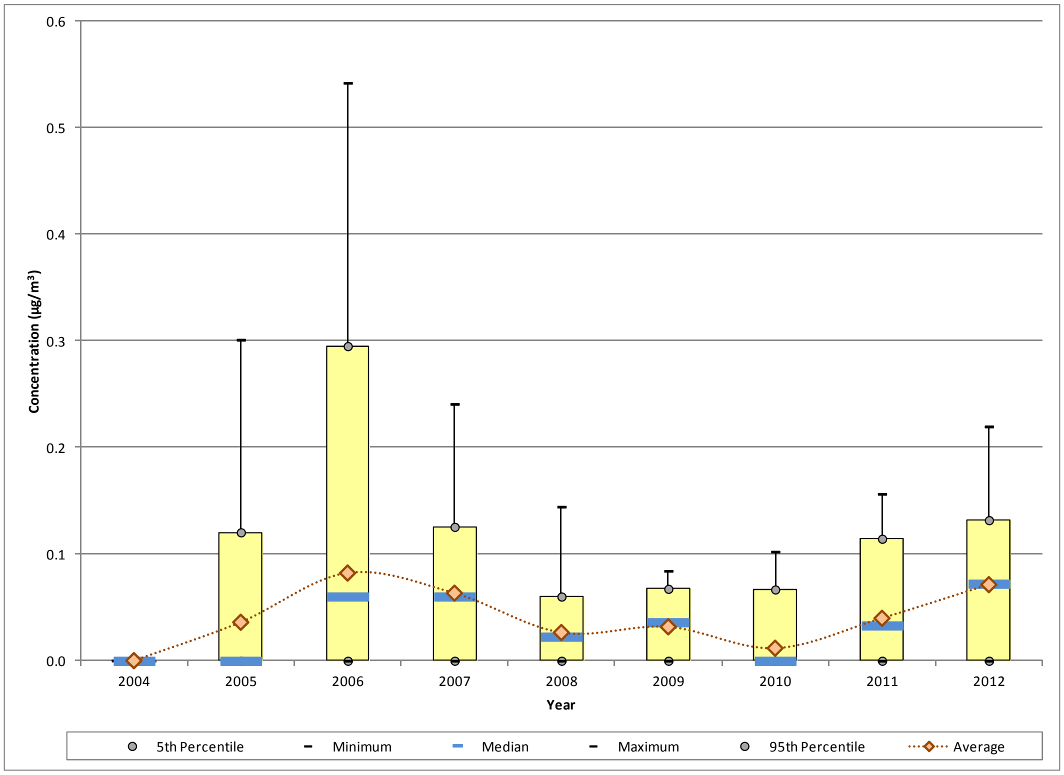
- Six concentrations of carbon tetrachloride greater than 1 µg/m^3 have been measured at GPCO (one in 2006, four in 2008, and one in 2009). Conversely, 15 non-detects have been measured (nine in 2004, five in 2005, and one in 2006).

- The year with the least variability is 2012, with the difference between the minimum and maximum concentrations less than 0.40 µg/m^3 and the difference between the 5th and 95th percentiles less than 0.26 µg/m^3. The year with the highest 1-year average and median concentrations (0.67 µg/m^3 and 0.68 µg/m^3, respectively) is also 2012.

- For most of the years of sampling, the median concentration is slightly higher than the 1-year average concentration. This indicates that the concentrations at the lower end of the sampling range are pulling down the 1-year average.

- Three significant changes in the 1-year average concentrations are shown in Figure 7-44. There is a significant increase from 2007 to 2008 as the range of concentrations measured doubled from one year to the next. After 2008, a steady decreasing trend is shown through 2010, with little change in the measurements from 2010 to 2011. The increase in the 1-year average and median concentrations from 2011 to 2012 is greater than 0.1 µg/m^3 each. Although each of these changes is statistically significant, the magnitude of the actual changes across the 1-year averages is less than 0.2 µg/m^3.

Figure 7-45. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at GPCO



Observations from Figure 7-45 for *p*-dichlorobenzene measurements collected at GPCO include the following:

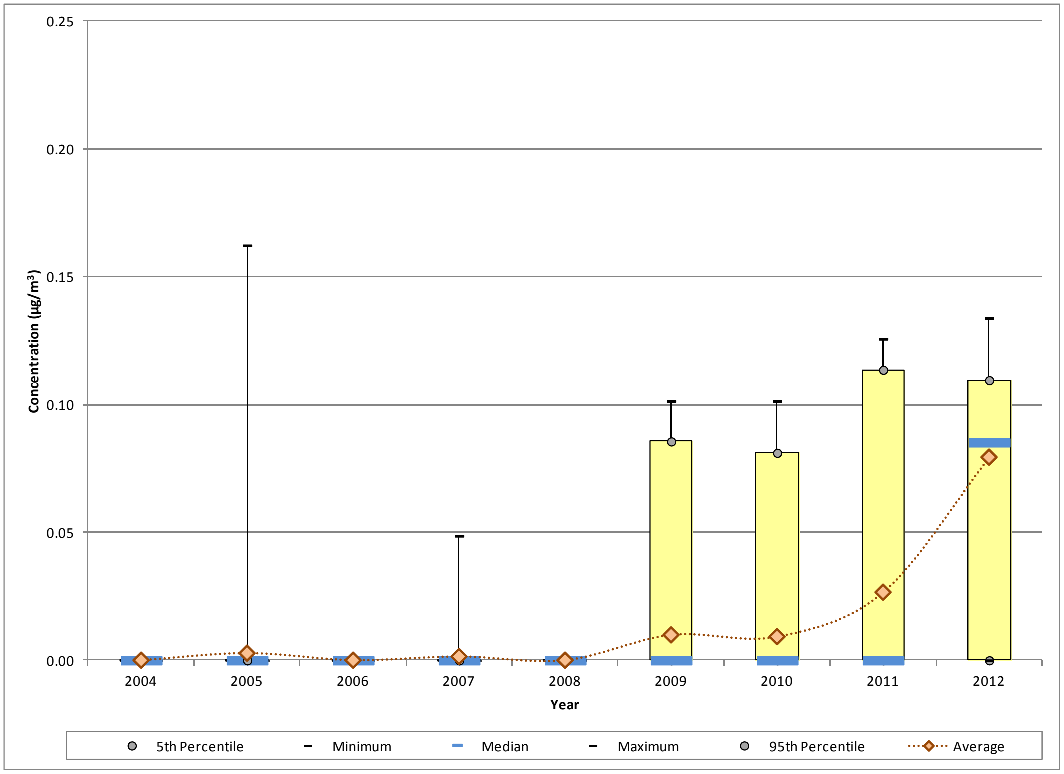
- There were no measured detections of *p*-dichlorobenzene during the first year of VOC sampling at GPCO. After 2004, the percentage of non-detects decreased to 59 percent for 2005, 39 percent for 2006, and 8 percent for 2007. This corresponds to a significant increase in the statistical parameters shown in Figure 7-45. However, the 5th percentile is still zero for all years of sampling, indicating the presence non-detects each year.

- The maximum concentration of *p*-dichlorobenzene was measured in 2006 (0.54 µg/m^3). In addition, eight of the 10 highest concentrations of this compound were measured in 2006, with the other two measured in 2005 and 2007. This is reflected in the statistical parameters shown for 2006.

- The 1-year average concentration increased from zero to 0.036 µg/m^3 from 2004 to 2005 and more than doubled for 2006. Nearly all of the statistical parameters decreased from 2006 to 2007 with additional decreases for 2008. While the change in the 1-year average from 2008 to 2009 is not significant, the decrease shown from 2009 to 2010 represents a 60 percent decrease. Even though the range of measurements is similar between 2009 and 2010, the number of measured detections decreased significantly in 2010, as indicated by the median concentration returning to zero. Thus, the 1-year average is being pulled down by the number of zeros factored into the calculation for 2010.

- The number of measured detections increased for 2011 and again for 2012; in addition, the magnitude of the measurements increased, resulting in an overall increasing trend for the most recent years of sampling.

Figure 7-46. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at GPCO



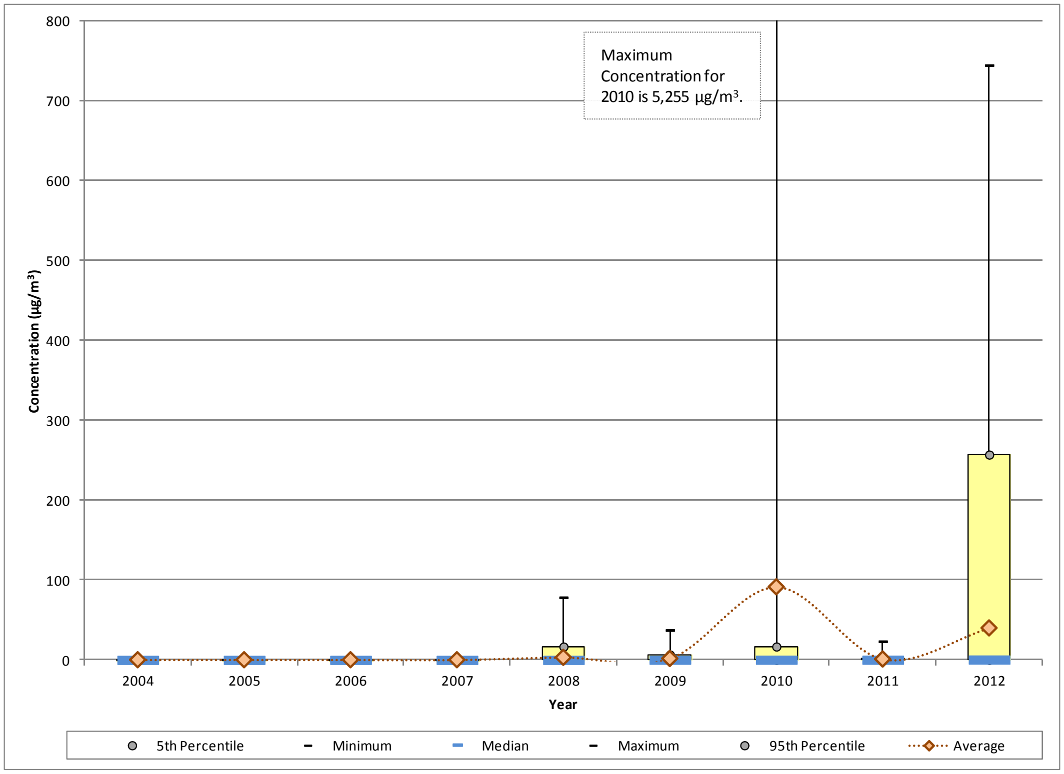
Observations from Figure 7-46 for 1,2-dichloroethane measurements collected at GPCO include the following:

- Between 2004 and 2008 there were only three measured detections of 1,2-dichloroethane measured at GPCO. The median concentration is zero for all years except 2012, indicating that at least 50 percent of the measurements were non-detects prior to 2012. The number of measured detections began to increase in 2009, from 12 percent for 2009 and 2010, to 27 percent in 2011, and 90 percent for 2012.

- As the number of measured detections increases, so do each of the corresponding statistical metrics shown in Figure 7-46.

- As the number of measured detections increased dramatically for 2012, so do the 1-year average and median concentrations. The median concentration is actually greater than the 1-year average for 2012. This is because there were still six non-detects (or zeros) factoring into the 1-year average concentration for the year. Excluding the non-detects, the minimum concentration would be 0.04 µg/m^3, with a difference between the minimum and maximum concentration measured for 2012 of less than 0.1 µg/m^3.

Figure 7-47. Yearly Statistical Metrics for Dichloromethane Concentrations Measured at GPCO



Observations from Figure 7-47 for dichloromethane measurements collected at GPCO include the following:

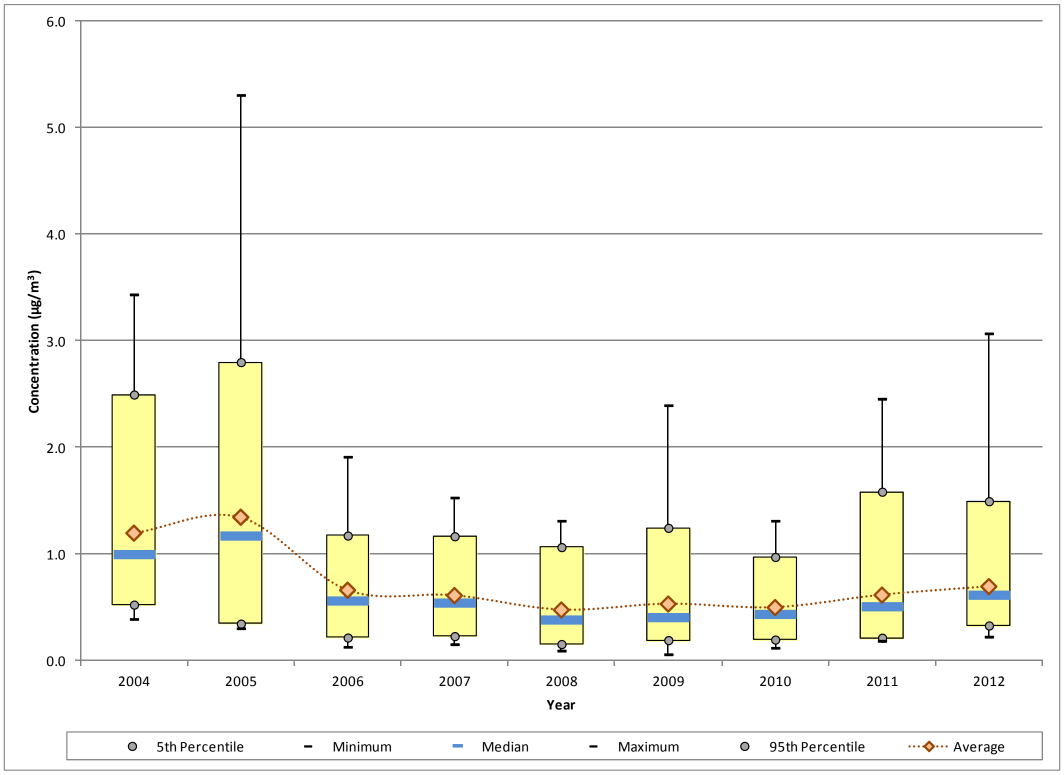
- The maximum dichloromethane concentration measured at GPCO (5,256 µg/m^3) is two orders of magnitude higher than the next highest concentration measured in 2010 (67.9 µg/m^3). This explains why the 1-year average concentration for 2010 is more than five times greater than the 95th percentile for that year (the 1-year average is being driven by the outlier).

- The second highest dichloromethane concentration measured at GPCO (745 µg/m^3) was collected in 2012, as were all six additional measurements greater than 100 µg/m^3 collected at GPCO.

- Higher measurements of dichloromethane were not measured before 2008. The 1-year average dichloromethane concentration was less than 0.5 µg/m^3 for each year through 2007, after which higher concentrations were measured more often. However, 2012 is the only year for which concentrations greater than 5 µg/m^3 account for more than 10 percent of the measurements.

- Additional years of sampling are needed in order to determine if higher dichloromethane measurements continue to be collected.

Figure 7-48. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at GPCO



Observations from Figure 7-48 for ethylbenzene measurements collected at GPCO include the following:

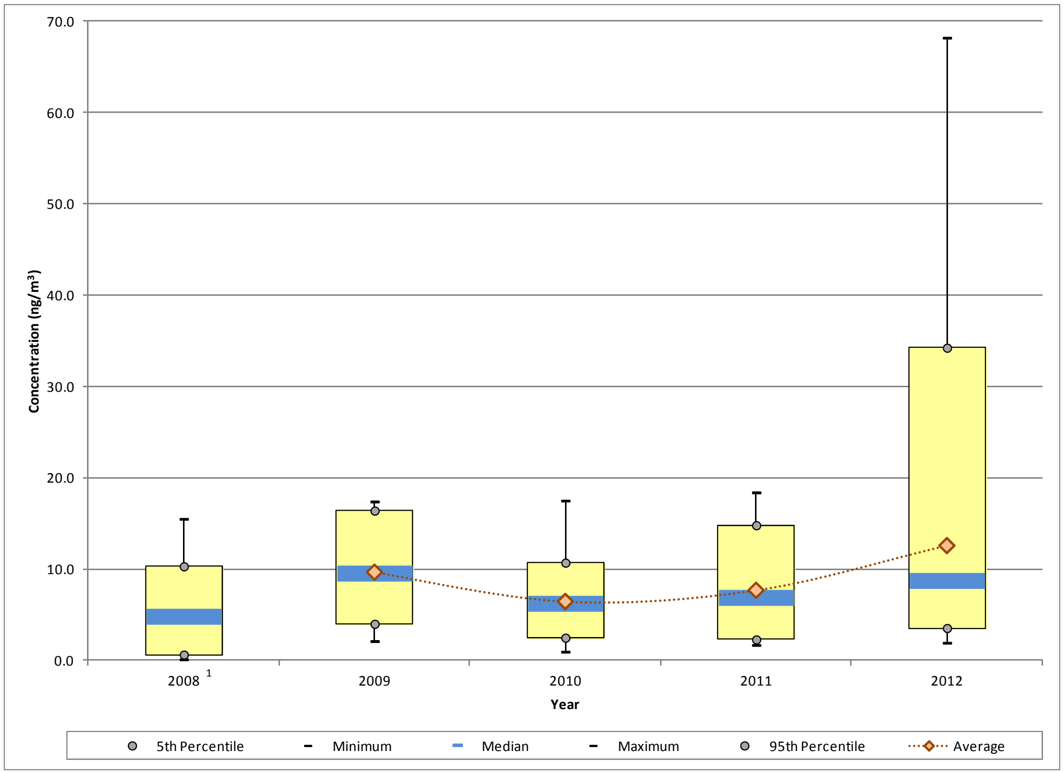
- The maximum ethylbenzene concentration was measured at GPCO in 2005 (5.31 µg/m^3), as was the second highest concentration (3.96 µg/m^3). Three additional concentrations greater than 3 µg/m^3 have been measured at GPCO, two in 2004 and one in 2012. All but three of the 15 measurements greater than 2 µg/m^3 (but less than 3 µg/m^3) were measured during these two years.

- The 1-year average concentration increased slightly from 2004 to 2005, although there is a relatively high level of variability in the measurements. A significant decrease in all of the statistical parameters is shown from 2005 to 2006, a decrease that continues through 2008.

- Although the maximum concentration measured increased from 2008 to 2009, only a slight change in the 1-year and median concentrations is exhibited for 2009. The range of concentrations measured in 2010 is similar to the range of concentrations measured in 2008.

- An increasing trend is shown from 2010 to 2011 and again for 2012. The median concentration exhibits a slight increasing trend beginning with 2009 and continuing through 2012.

Figure 7-49. Yearly Statistical Metrics for Fluorene Concentrations Measured at GPCO



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

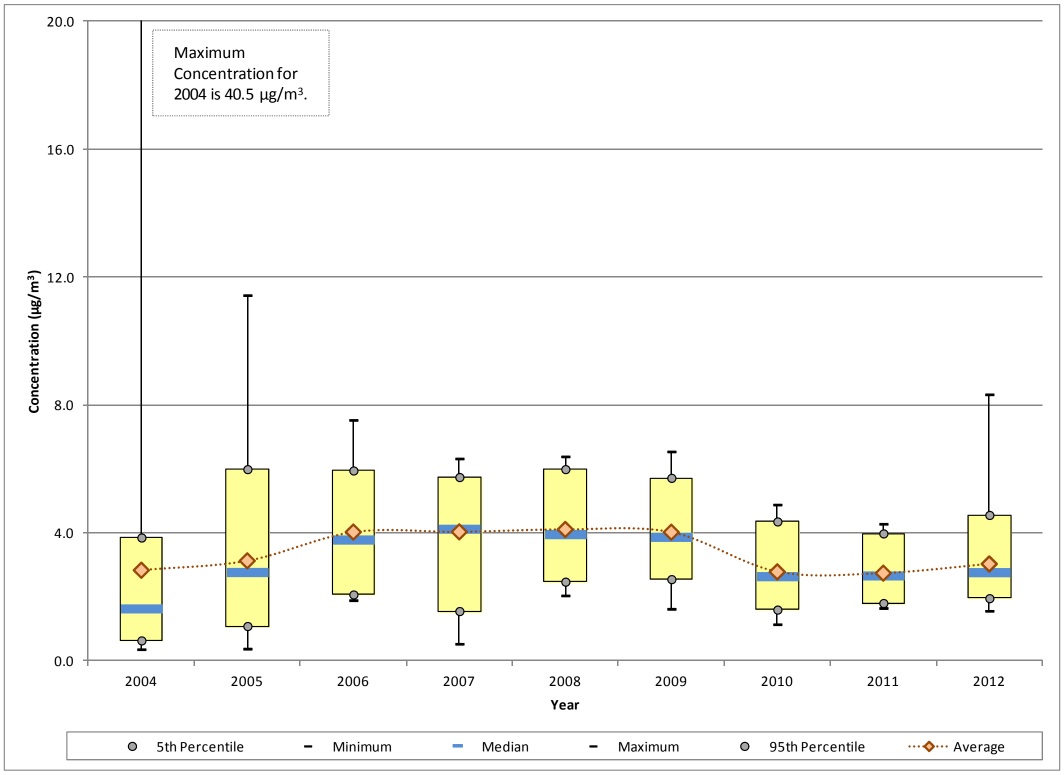
Observations from Figure 7-49 for fluorene measurements collected at GPCO include the following:

- Because sampling for PAHs at GPCO began in April 2008, a 1-year average is not presented for 2008, although the range of measurements is provided.

- The range of measurements collected at GPCO is between 15 ng/m^3 and 17 ng/m^3 for each year of sampling until 2012. For 2012, the range of measurements is significantly higher, with a maximum concentration nearly four times higher than those measured in previous years.

- The 1-year average concentration decreased significantly from 2009 to 2010. A slight increase from 2010 to 2011 is followed by a more significant increase for 2012. The nine highest concentrations measured at GPCO were all collected in 2012 and ranged from 19.9 ng/m^3 to 68.2 ng/m^3. Additional years of sampling are needed to determine if this trend will continue.

Figure 7-50. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at GPCO



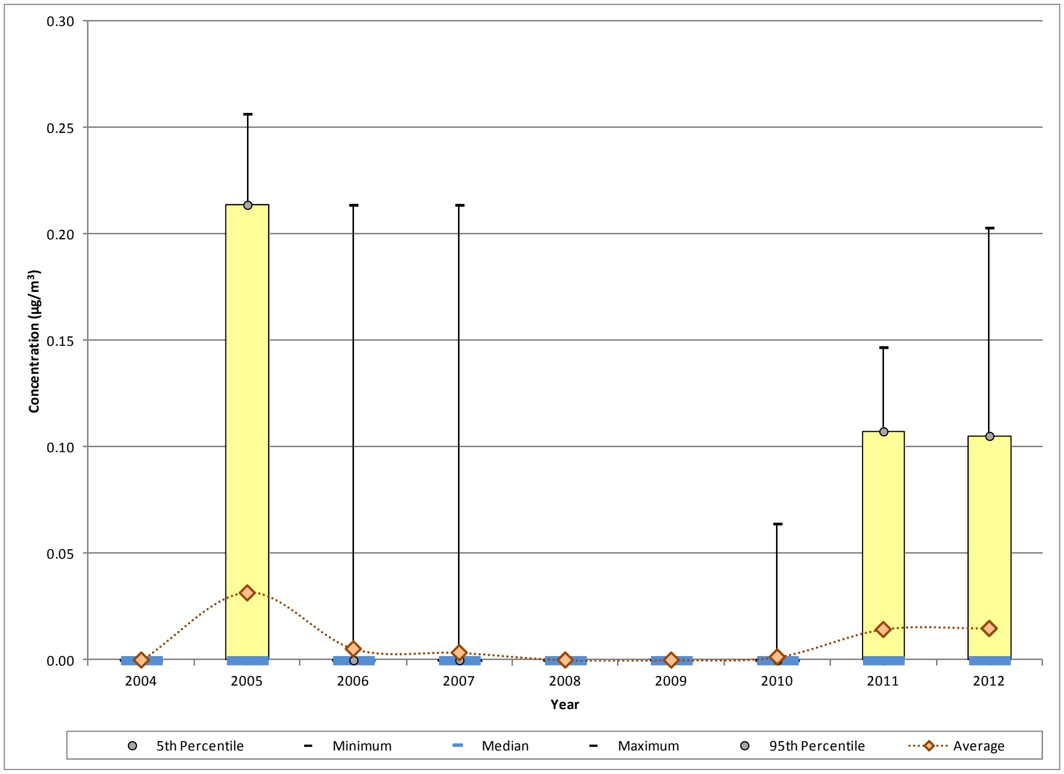
Observations from Figure 7-50 for formaldehyde measurements collected at GPCO include the following:

- The trends graph for formaldehyde resembles the trends graph for acetaldehyde in that the maximum formaldehyde concentration (40.5 µg/m^3) was measured in 2004 and is significantly higher than the maximum concentrations measured in subsequent years. The second highest concentration was also measured in 2004 (23.5 µg/m^3). The three highest concentrations of formaldehyde were measured on the same days in 2004 and 2005 as the three highest acetaldehyde concentrations.

- Even with decreasing maximum concentrations, the 1-year average concentrations have an increasing trend through 2006. The 1-year average concentration is approximately 4 µg/m^3 for each year between 2006 and 2009. A significant decrease in all of the statistical metrics is shown for 2010. Although an even smaller range of concentrations was measured in 2011, there is little change in the 1-year average.

- The maximum concentration measured in 2012 is the highest formaldehyde measurement collected since 2005. The 95th percentile for 2012 is greater than the maximum concentration measured in 2011. The 1-year average calculated for 2012 is slightly higher than the 1-year averages for the previous two years, although the increase is not statistically significant.

Figure 7-51. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at GPCO



Observations from Figure 7-51 for hexachloro-1,3-butadiene measurements collected at GPCO include the following:

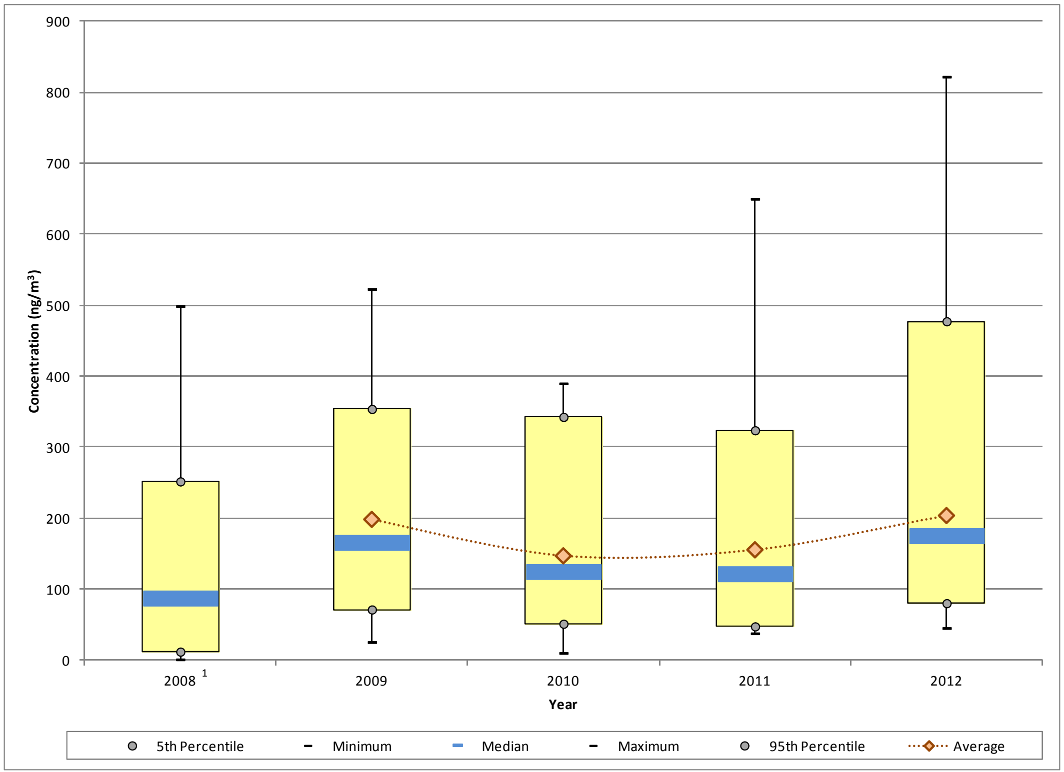
- The number of measured detections for each year is very low, from zero measured detections in 2004, 2008, and 2009 to 10 (or 17 percent) for 2005. This explains why the minimum, 5th percentile, and median concentrations (and in some cases, the 1-year averages) are all zero.

- The maximum hexachloro-1,3-butadiene concentration was measured during 2005 (0.26 µg/m^3), although nine additional measurements greater than 0.20 µg/m^3 have been measured at GPCO across the years. Not only was the maximum concentration measured in 2005, this was also the year with the greatest number of measured detections. This explains the large increase in the 1-year average from 2004 to 2005.

- The large number of non-detects, and thus zeroes substituted into the calculations, combined with few measured detections results in relatively low 1-year average concentrations with very large confidence intervals.

- The number of measured detections for 2011 is approximately 13 percent, the highest percentage since 2005. A similar number of measured detections (15 percent) were collected in 2012. Additional years of sampling are needed to determine if this trend continues.

Figure 7-52. Yearly Statistical Metrics for Naphthalene Concentrations Measured at GPCO



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

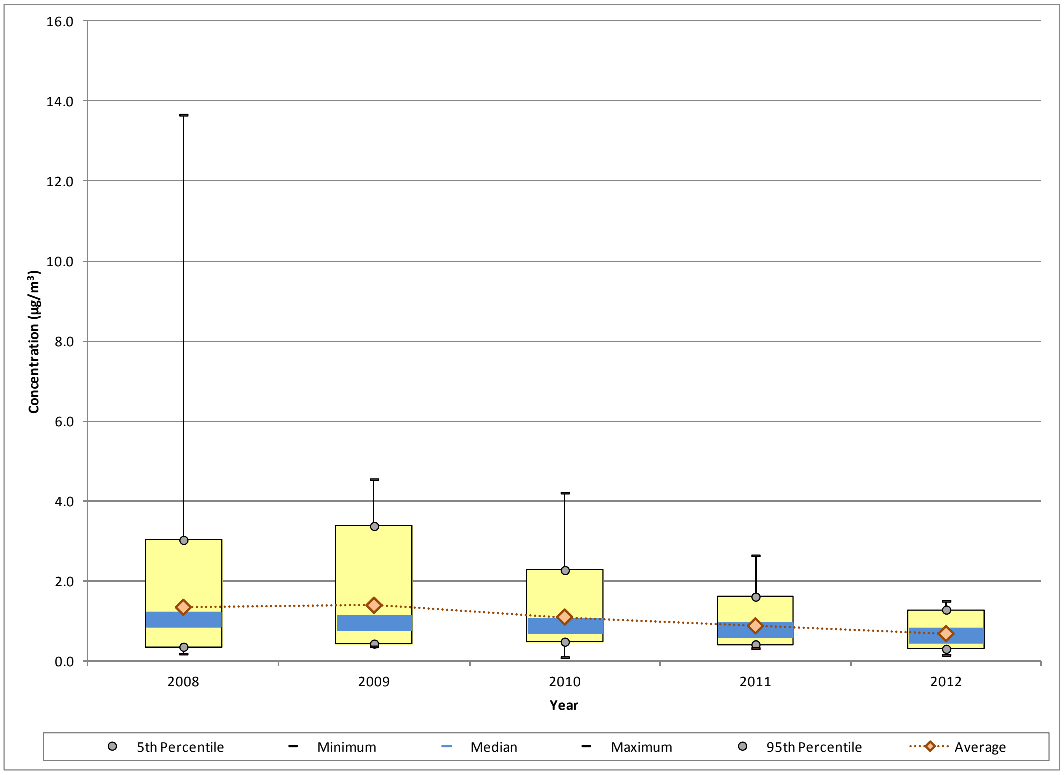
Observations from Figure 7-52 for naphthalene measurements collected at GPCO include the following:

- Because sampling for PAHs at GPCO began in April 2008, a 1-year naphthalene average is not presented for 2008, although the range of measurements is provided.

- The maximum naphthalene concentration measured at GPCO was measured in 2012 (822 ng/m^3). Concentrations of approximately 500 ng/m^3 or more have been measured in all years of sampling except 2010.

- Figure 7-52 resembles Figure 7-49 for fluorene. The 1-year average concentration decreased significantly from 2009 to 2010. A slight increase from 2010 to 2011 is followed by an additional increase for 2012. Five of the 11 concentrations greater than 400 ng/m^3 measured at GPCO were collected in 2012 and all of the statistical parameters increased from 2011 to 2012. Additional years of sampling are needed to determine if this trend continues.

Figure 7-53. Yearly Statistical Metrics for Benzene Concentrations Measured at BRCO



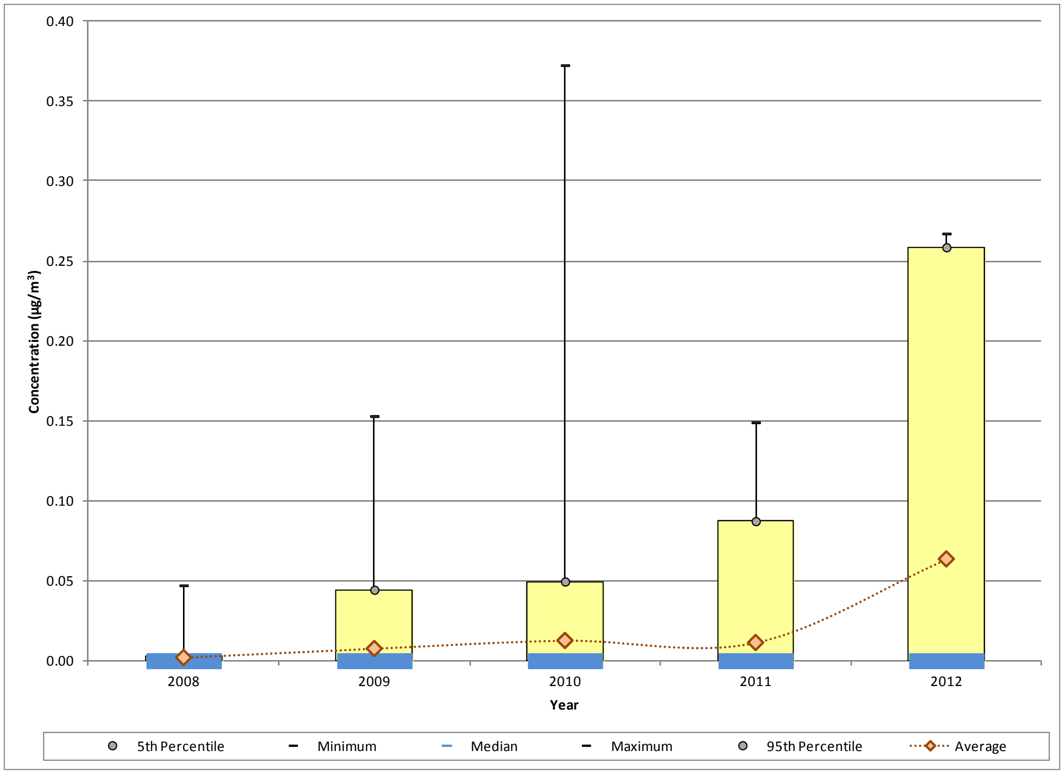
Observations from Figure 7-53 for benzene measurements collected at BRCO include the following:

- BRCO began sampling benzene under the NMP in January 2008. The maximum benzene concentration (13.66 µg/m^3) was measured on July 29, 2008 and is three times higher than the next highest concentration (4.55 µg/m^3, measured on January 7, 2009), although a similar concentration was also measured on December 21, 2009 (4.49 µg/m^3).

- The statistical parameters for benzene exhibit a steady decreasing trend over the years of sampling at BRCO. The 1-year average concentration has decreased by roughly half, from a maximum of 1.39 µg/m^3 in 2009 to a minimum of 0.68 µg/m^3 in 2012. The median concentration has also decreased, from 1.05 µg/m^3 in 2008 to 0.65 µg/m^3 in 2012.

- The difference between the 1-year average and the median concentration has decreased as well for each year, from a difference of 0.43 µg/m^3 for 2009 to 0.03 µg/m^3 for 2012. This indicates a decreasing variability in the central tendency of the measurements.

Figure 7-54. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at BRCO



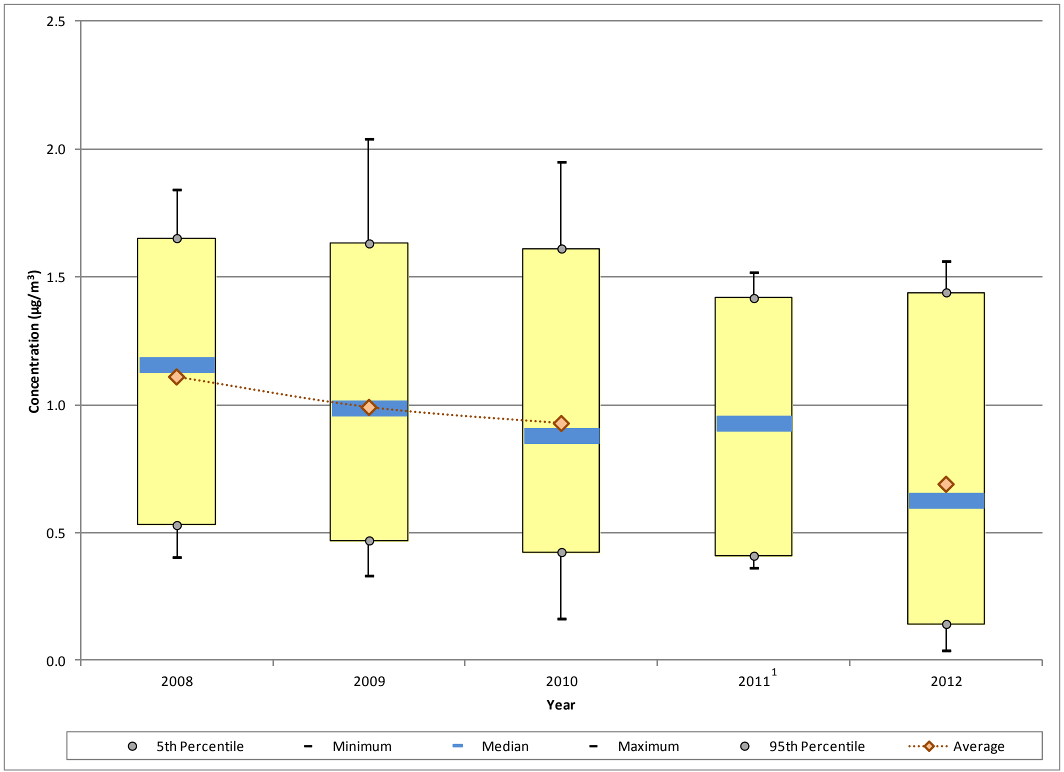
Observations from Figure 7-54 for 1,3-butadiene measurements collected at BRCO include the following:

- Although the maximum 1,3-butadiene concentration (0.37 µg/m^3) was measured at BRCO in 2010, the next 11 highest concentrations (those greater than 0.20 µg/m^3) were all measured in 2012. Of the 32 concentrations greater than 0.05 µg/m^3, none were measured in 2008, two were measured in 2009, three in 2010, six in 2011, and 21 in 2012.

- The median 1,3-butadiene concentration is zero for all five years of sampling. This indicates that at least 50 percent of the measurements are zero (or non-detects). In 2008, only three measured detections were reported; for 2009 through 2011, there were between six and seven measured detections each year; for 2012, 23 measured detections (out of 58) were reported.

- The increase in the number of detections, particularly for 2012, is reflected in the 1-year average concentrations shown. The 1-year average increased nearly six-fold from 2011 to 2012.

Figure 7-55. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at PACO



[1] A 1-year average is not presented due to low method completeness in 2011.

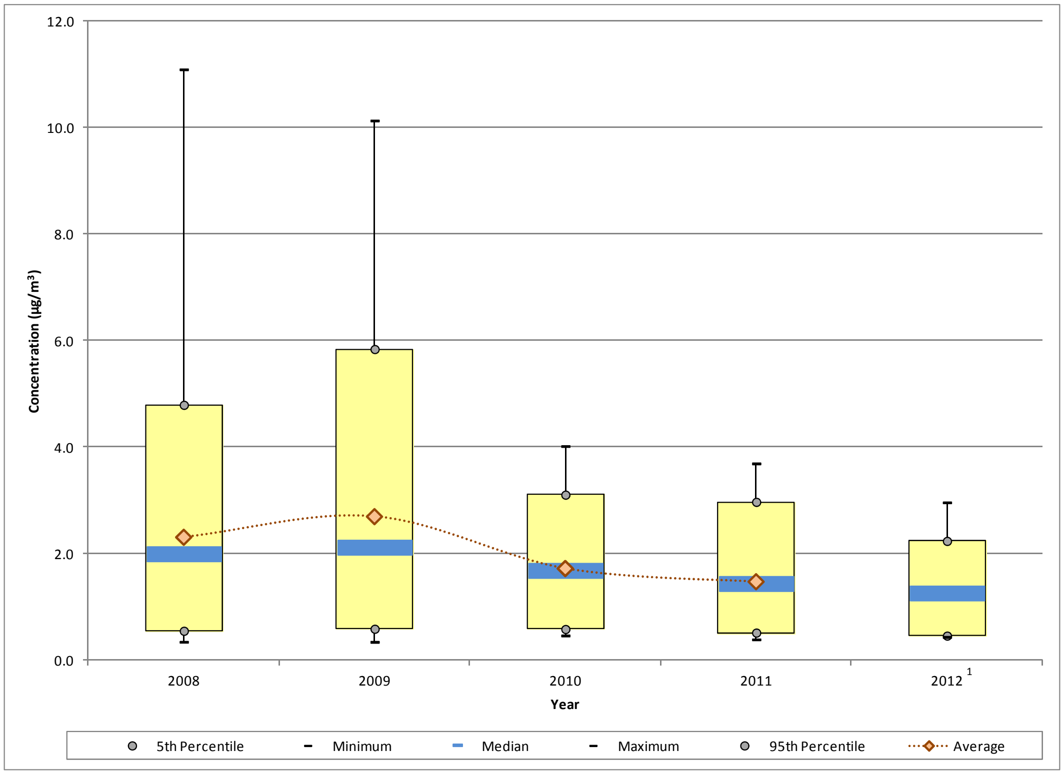
Observations from Figure 7-55 for acetaldehyde measurements collected at PACO include the following:

- PACO began sampling acetaldehyde under the NMP in February 2008. A 1-year average is not presented for 2011 due to low method completeness.

- The maximum acetaldehyde concentration (2.04 µg/m^3) was measured on January 13, 2009 and is the only acetaldehyde concentration greater than 2 µg/m^3 measured at this site.

- The 1-year averages shown have a decreasing trend, with the exception of 2011, the only year for which a 1-year average is not presented. Nearly all of the statistical parameters shown also have a decreasing trend. For 2011, the maximum, 95th percentile, and 5th percentile all exhibit decreases, while the median concentration increased. Even though the range of measurements is at a minimum for 2011, those concentrations greater than 1 µg/m^3 represent a higher percentage of measurements for 2011 compared to the previous year.

Figure 7-56. Yearly Statistical Metrics for Benzene Concentrations Measured at PACO



[1] A 1-year average is not presented due to low method completeness in 2012.

Observations from Figure 7-56 for benzene measurements collected at PACO include the following:

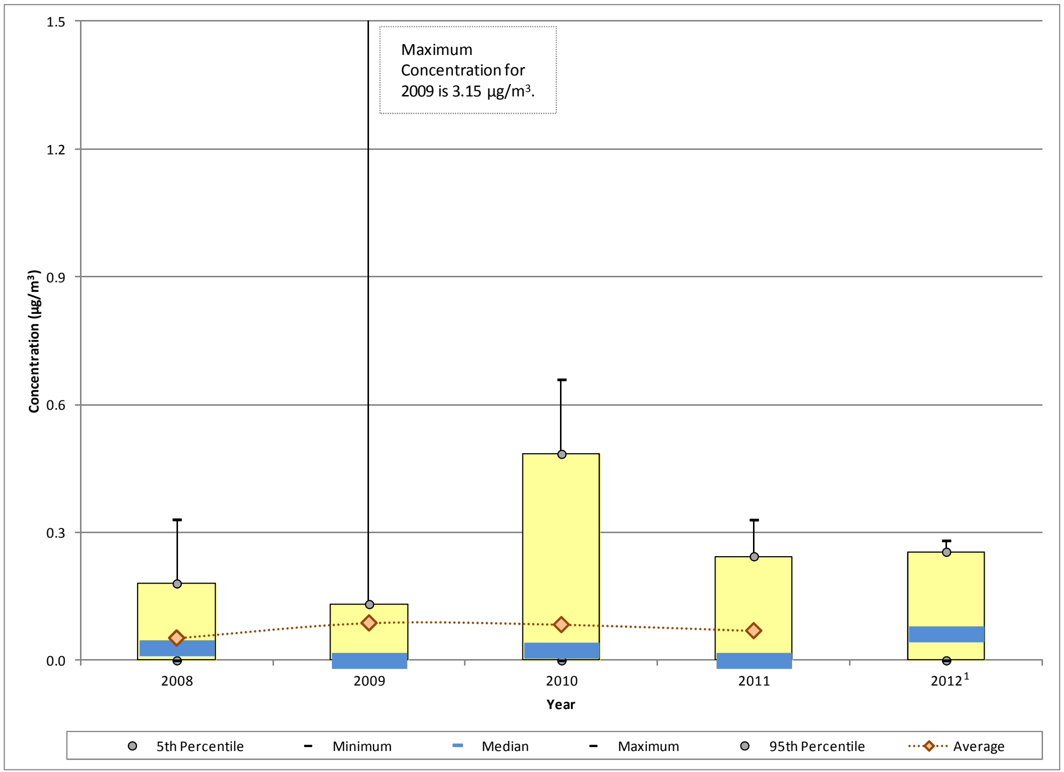
- PACO began sampling SNMOCs under the NMP in January 2008. A 1-year average is not presented for 2012 due to sampler issues resulting in low method completeness.

- The maximum benzene concentration (11.1 µg/m^3) was measured on October 15, 2008. The next highest measurement (10.1 µg/m^3) was measured three months later on January 7, 2009. The third highest concentration was measured on the next sample day in 2009 but was considerably less (7.52 µg/m^3). The 16 highest concentrations were all measured in either 2008 or 2009.

- Even though the maximum concentration was measured in 2008, benzene concentrations increased from 2008 to 2009, as indicated by the 1-year average, the median, and the 95th percentile. However, concentrations of benzene exhibit a significant decreasing trend between 2009 and 2010. The difference between the 5th and 95th percentile decreased by half from 2009 to 2010. The decreasing trend continued into 2011 and 2012, as no benzene concentrations greater than 3 µg/m^3 were measured in 2012. In addition, the maximum, 95th percentile, and median concentrations are at a minimum for 2012.

- The difference between the 1-year average and median concentrations decreased significantly from 2009 to 2010, a trend that continued into 2011. This trend indicates decreasing variability in the central tendency of the measurements.

Figure 7-57. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at PACO



[1] A 1-year average is not presented due to low method completeness in 2012.

Observations from Figure 7-57 for 1,3-butadiene measurements collected at PACO include the following:

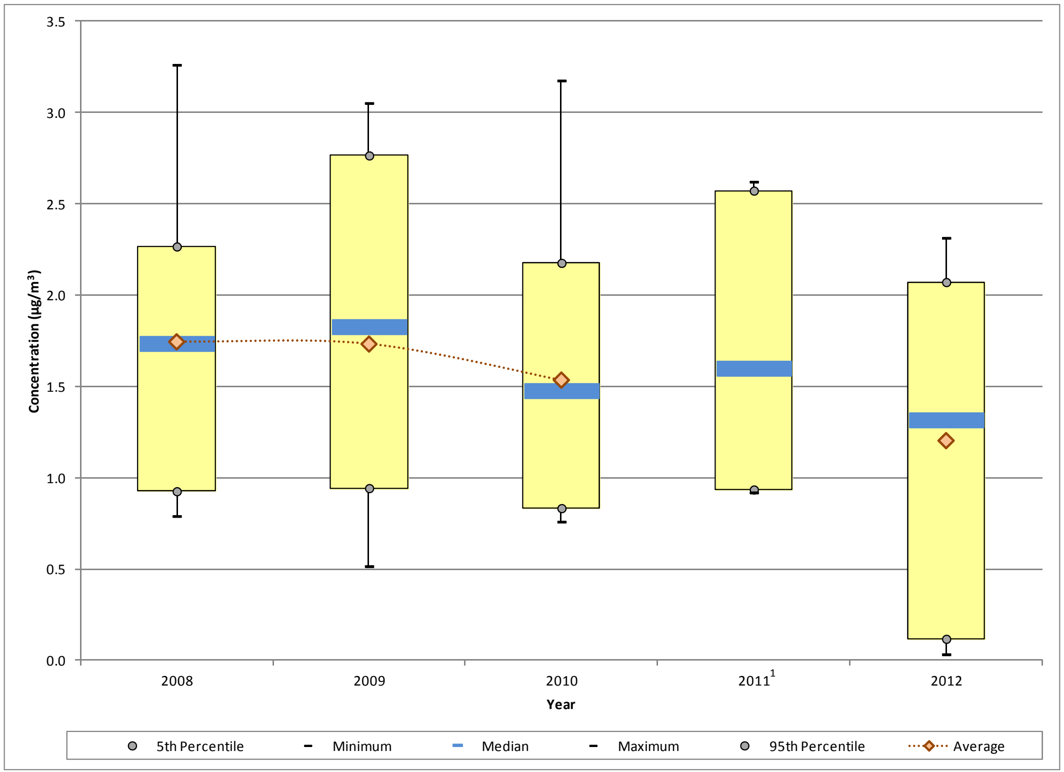
- The maximum 1,3-butadiene concentration (3.15 µg/m^3) was measured on December 27, 2009 and is the only measurement greater than 1 µg/m^3 measured at this site. The increase in the 1-year average from 2008 to 2009 is a result of this outlier concentration measured in 2009. The second highest concentration measured in 2009 is substantially less (0.19 µg/m^3). Excluding the maximum concentration for 2009 would result is a 1-year average concentration of only 0.028 µg/m^3, and a decrease in the 1-year average concentration by almost half from 2008 to 2009.

- The second, third, fourth, and fifth highest 1,3-butadiene concentrations measured at PACO were all measured in December 2010 and ranged from 0.39 µg/m^3 to 0.66 µg/m^3. The next highest concentration for this year was also measured in December but was considerably less (0.16 µg/m^3). The 95th percentile for 2010 is greater than the maximum concentration measured for all other years (except 2009) and tripled from 2009 to 2010. Even though half of the measurements in 2010 were non-detects, the December measurements for 2010 are driving the top-end statistical parameters upward.

- With the exception of 2012, the number of non-detects measured at PACO has ranged from 47 percent (2008) to 58 percent (2009 and 2011). This explains why the median concentration is at or near zero for most years. For 2012, the number of non-detects is less (29 percent) and explains why the median is greater than zero.

- Nearly all of the statistical parameters decreased from 2010 to 2011 (except the minimum and 5th percentile, which are both years for these years). Most (90 percent) of the measurements for 2012 fall into the same range as 2011, as indicated by the 5th and 95th percentiles. While the median increased as a result of fewer non-detects reported in 2012, no conclusion can be made about the 1-year average. Additional years of sampling are needed to determine if a viable trend in 1,3-butadiene concentrations measured at PACO can be identified.

Figure 7-58. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at PACO



[1] A 1-year average is not presented due to low method completeness in 2011.

Observations from Figure 7-58 for formaldehyde measurements collected at PACO include the following:

- Only four formaldehyde concentrations greater than 3 µg/m^3 have been measured at PACO (one is 2008, two in 2009, and one in 2010).

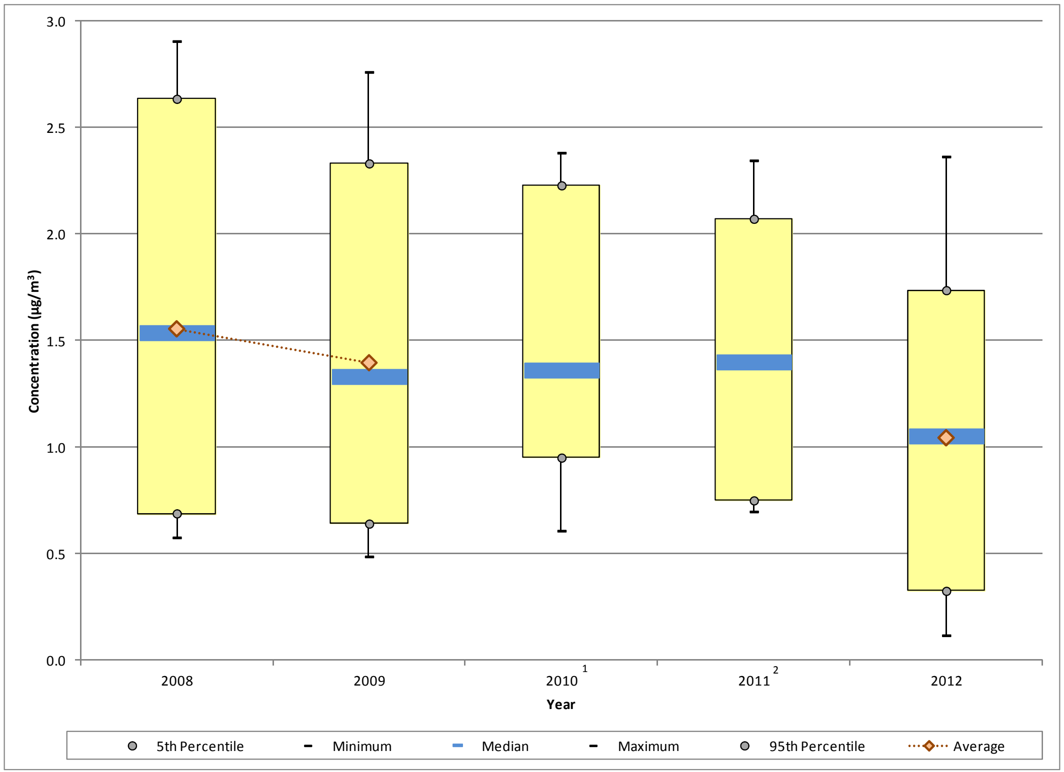
- The 1-year average concentration did not change between 2008 and 2009. The decreases in the minimum and maximum concentrations for 2009 are countered by the increase in the measurements at the higher end of the range, as indicated by the increases in the median and 95th percentile.

- The data distribution statistics for 2010 resemble those for 2008, although the 1-year average and median concentrations both exhibit decreases.

- Although the maximum concentration decreased for 2011, all of the other statistical parameters that could be calculated exhibit increases from 2010 to 2011.

- All of the statistical parameters exhibit decreases from 2011 to 2012, particularly at the lower end of the concentration range. This year has the greatest number of measurements less than 1 µg/m^3 (nine). Note that the median concentration is greater than the 1-year average for 2012. This indicates that the measurements at the lower end of the concentration range are pulling down the 1-year average. A similar observation can be made for 2009.

Figure 7-59. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at RICO



[1] A 1-year average is not presented due to low method completeness in 2010.

[2] A 1-year average is not presented due to low method completeness in 2011.

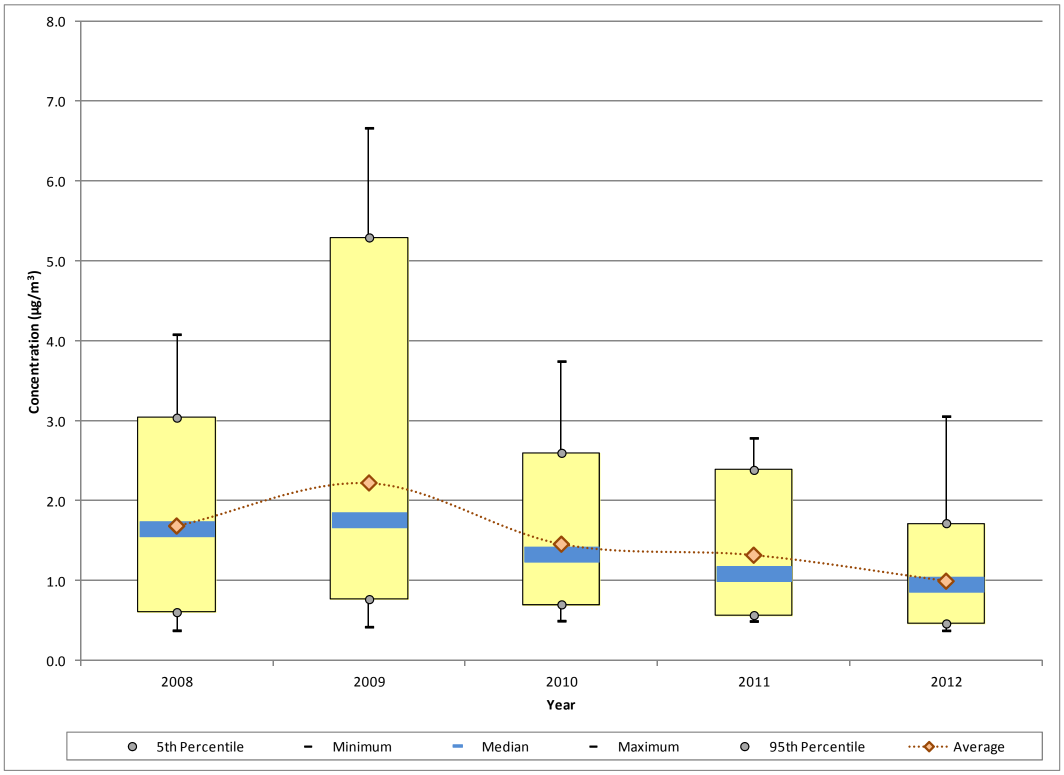
Observations from Figure 7-59 for acetaldehyde measurements collected at RICO include the following:

- RICO began sampling acetaldehyde under the NMP in February 2008. A 1-year average is not presented for 2010 or 2011 due to low method completeness. However, the range of measurements is provided for both years.

- The maximum acetaldehyde concentration (2.91 µg/m^3) was measured at RICO in July 2008, although a similar concentration was also measured one month earlier.

- Because few 1-year average concentrations are shown, a distinct trend is hard to identify. However, the measurements appear to have a decreasing trend, based on the decreases shown for nearly all of the other statistical parameters. Additional years of sampling are needed to confirm if this trend is real particularly because the median concentration does not exactly follow this trend.

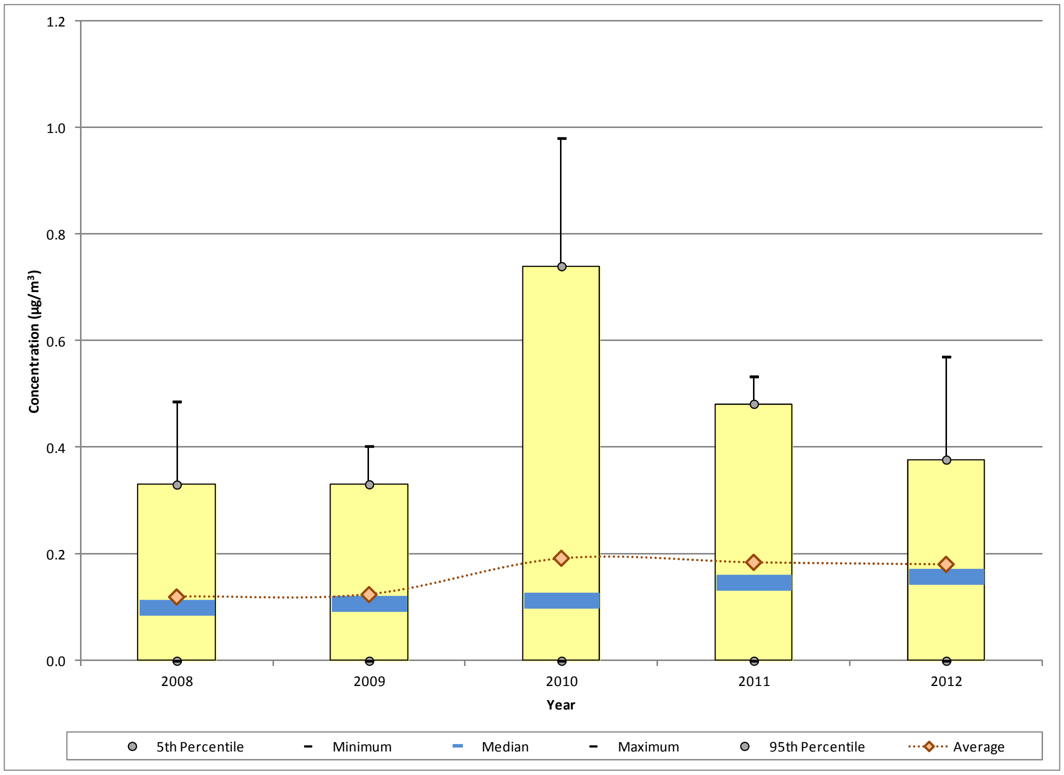
Figure 7-60. Yearly Statistical Metrics for Benzene Concentrations Measured at RICO



Observations from Figure 7-60 for benzene measurements collected at RICO include the following:

- RICO began sampling SNMOCs under the NMP in January 2008.
- The maximum benzene concentration (6.67 µg/m^3) was measured in January 2009. Seven of the nine benzene concentrations greater than 4 µg/m^3 were measured in 2009 (with the other two in 2008).
- The number of measurements greater than 2 µg/m^3 increased from 18 to 24 from 2008 to 2009, then decreased by half for 2010 and continued to decrease, reaching a minimum of two for 2012. This explains the increase in the statistical parameters from 2008 to 2009 as well as the subsequent decreases in the years that follow. The median concentration is less than 1 µg/m^3 for 2012, indicating that half of the measurements are less than this concentration. The 1-year average concentration is also less than 1 µg/m^3 for 2012.
- The statistical metrics shown for RICO's benzene concentrations resemble the ones shown for benzene concentrations measured at PACO (and to a lesser extent BRCO), as all three sites exhibit a decreasing trend.

Figure 7-61. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at RICO



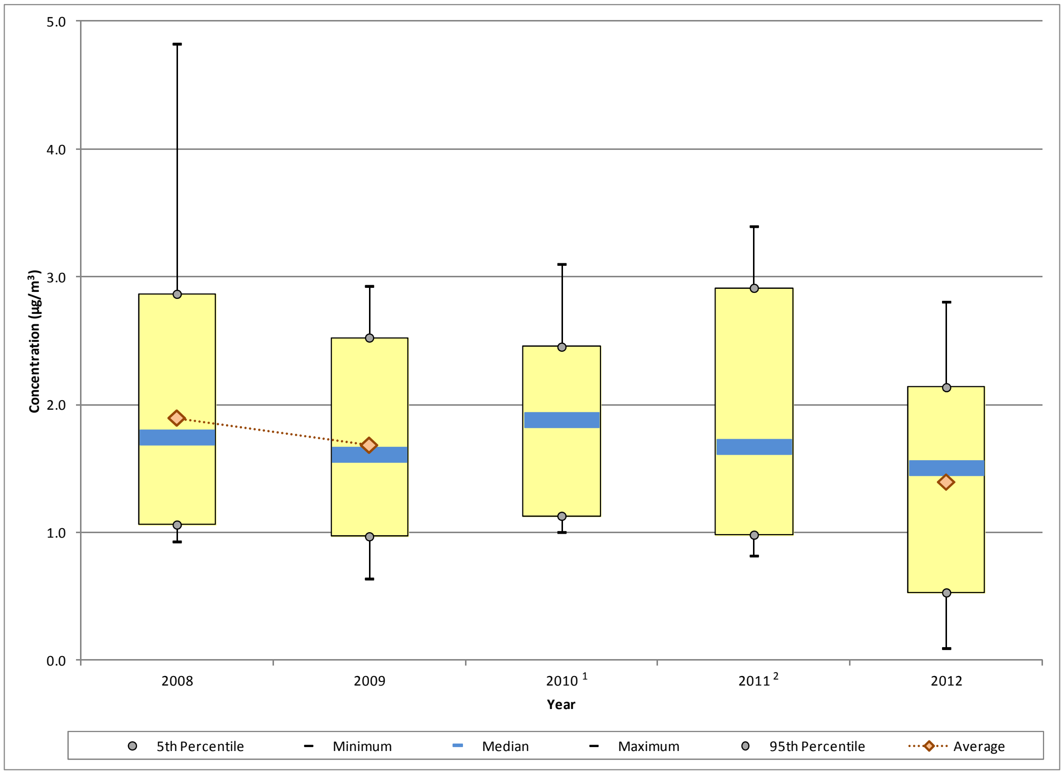
Observations from Figure 7-61 for 1,3-butadiene measurements collected at RICO include the following:

- The five highest 1,3-butadiene concentrations were all measured at RICO in December 2010 and ranged from 0.57 µg/m^3 to 0.98 µg/m^3.

- With the exception of the maximum concentration, the range of concentrations measured in 2008 and 2009 were similar to each other, as indicated by most of the statistical parameters shown. This was followed by an increase in the measurements in 2010. Even though the 95th percentile more than doubled and the 1-year average increased by more than 50 percent, the median concentration changed very little for 2010. This indicates that there are roughly the same number of measurements at the lower end of the concentration range while the measurements at the higher end of the concentration range are driving the 1-year average.

- Although the range of concentrations measured decreased from 2010 to 2011, the 1-year average concentration decreases only slightly while the median concentration increases. The 1-year average also decreases slightly for 2012 while the median continues its increase. This is a result of a decreasing maximum concentration paired with an increasing number of measurements at the mid- to upper-end of the concentration range, as well as decreasing number of non-detects (and hence zeroes) paired with an increasing number of measurements at the lower end of the concentration range.

Figure 7-62. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at RICO



[1] A 1-year average is not presented due to low method completeness in 2010.

[2] A 1-year average is not presented due to low method completeness in 2011.

Observations from Figure 7-62 for formaldehyde measurements collected at RICO include the following:

- The maximum formaldehyde concentration (4.82 µg/m^3) was measured at RICO in November 2008. The next highest concentration was measured in 2011 and is considerably less (3.40 µg/m^3). Only four concentrations measured at RICO are greater than 3 µg/m^3 with two measured in 2008 and one each in 2010 and 2011.

- The 1-year average concentrations, where they are presented, appear to have an overall decreasing trend. However, additional years of sampling are needed to confirm if this trend is real particularly because the median concentration does not exactly follow this trend. The median increases from 2009 to 2010 even though the majority of concentrations fall into a smaller concentration range, as indicated by the difference between the 5th and 95th percentiles. The minimum concentration measured for 2010 is greater than the 5th percentile for most of the years of sampling and 2010 is the only year without a concentration less than 1 µg/m^3.

7.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each Colorado monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

7.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Colorado monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

7.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Colorado monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 7-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 7-6. Risk Approximations for the Colorado Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Grand Junction, Colorado - GPCO						
Acenaphthene[a]	0.000088	--	60/60	0.02 ± 0.01	1.81	--
Acetaldehyde	0.0000022	0.009	61/61	2.89 ± 0.27	6.35	0.32
Benzene	0.0000078	0.03	62/62	1.28 ± 0.12	10.00	0.04
1,3-Butadiene	0.00003	0.002	62/62	0.18 ± 0.03	5.42	0.09
Carbon Tetrachloride	0.000006	0.1	62/62	0.67 ± 0.02	4.00	0.01
p-Dichlorobenzene	0.000011	0.8	54/62	0.07 ± 0.01	0.79	<0.01
1,2-Dichloroethane	0.000026	2.4	56/62	0.08 ± 0.01	2.06	<0.01
Dichloromethane	0.00000013	0.6	62/62	40.23 ± 28.78	5.23	0.07
Ethylbenzene	0.0000025	1	62/62	0.70 ± 0.11	1.74	<0.01
Fluorene[a]	0.000088	--	60/60	0.01 ± <0.01	1.11	--
Formaldehyde	0.000013	0.0098	61/61	3.02 ± 0.25	39.31	0.31
Hexachloro-1,3-butadiene	0.000022	0.09	10/62	0.02 ± 0.01	0.35	<0.01
Naphthalene[a]	0.000034	0.003	60/60	0.20 ± 0.04	6.93	0.07
Battlement Mesa, Colorado - BMCO						
Acetaldehyde	0.0000022	0.009	26/26	NA	NA	NA
Benzene	0.0000078	0.03	53/53	1.09 ± 0.12	8.50	0.04
1,3-Butadiene	0.00003	0.002	28/53	0.08 ± 0.03	2.28	0.04
Formaldehyde	0.000013	0.0098	26/26	NA	NA	NA
Silt, Colorado - BRCO						
Acetaldehyde	0.0000022	0.009	28/28	0.61 ± 0.11	1.34	0.07
Benzene	0.0000078	0.03	57/58	0.67 ± 0.08	5.20	0.02
1,3-Butadiene	0.00003	0.002	23/58	0.06 ± 0.03	1.91	0.03
Formaldehyde	0.000013	0.0098	28/28	1.02 ± 0.21	13.31	0.10

-- = A Cancer URE or Noncancer RfC is not available.

NA = Not available due to the criteria for calculating an annual average.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 7-5.

Table 7-6. Risk Approximations for the Colorado Monitoring Sites (Continued)

Pollutant	Cancer URE (µg/m^3)$^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (µg/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Parachute, Colorado - PACO						
Acetaldehyde	0.0000022	0.009	27/27	0.69 ± 0.15	1.52	0.08
Benzene	0.0000078	0.03	43/45	NA	NA	NA
1,3-Butadiene	0.00003	0.002	32/45	NA	NA	NA
Formaldehyde	0.000013	0.0098	27/27	1.20 ± 0.24	15.64	0.12
Carbondale, Colorado - RFCO						
Acetaldehyde	0.0000022	0.009	15/15	NA	NA	NA
Benzene	0.0000078	0.03	16/17	NA	NA	NA
1,3-Butadiene	0.00003	0.002	12/17	NA	NA	NA
Formaldehyde	0.000013	0.0098	15/15	NA	NA	NA
Rifle, Colorado - RICO						
Acetaldehyde	0.0000022	0.009	28/28	1.04 ± 0.19	2.30	0.12
Benzene	0.0000078	0.03	60/60	1.00 ± 0.12	7.77	0.03
1,3-Butadiene	0.00003	0.002	56/60	0.18 ± 0.03	5.42	0.09
Formaldehyde	0.000013	0.0098	28/28	1.39 ± 0.22	18.11	0.14

-- = A Cancer URE or Noncancer RfC is not available.
NA = Not available due to the criteria for calculating an annual average.
[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 7-5.

Observations for GPCO from Table 7-6 include the following:

- Dichloromethane, formaldehyde, acetaldehyde, and benzene have the highest annual average concentrations among GPCO's pollutants of interest.

- Formaldehyde has the highest cancer risk approximation (39.31 in-a-million) for this site, followed by benzene (10.00 in-a-million), naphthalene (6.93 in-a-million), and acetaldehyde (6.35 in-a-million).

- None of the pollutants of interest for GPCO have noncancer hazard approximations greater than 1.0, indicating no adverse health effects are expected from these individual pollutants. Acetaldehyde and formaldehyde have the highest noncancer hazard approximations (0.32 and 0.31, respectively) among the pollutants of interest for GPCO.

Observations for the Garfield County sites from Table 7-6 include the following:

- Formaldehyde has the highest annual average concentration among the four pollutants of interest for each Garfield County site, with the exception of BMCO. For BMCO, benzene has the highest annual average concentration. Recall however, that annual averages could not be calculated for the carbonyl compounds for BMCO.

- Formaldehyde also has the highest cancer risk approximation for each Garfield County site, ranging from 13.31 in-a-million (BRCO) to 18.11 in-a-million (RICO), where a cancer risk approximation could be calculate. All of these are less than half the cancer risk approximation for formaldehyde for GPCO.

- For BMCO, benzene has the highest cancer risk approximation (8.50 in-a-million). This is the highest cancer risk approximation for benzene among the Garfield County sites, where annual averages are available.

- None of the noncancer hazard approximations calculated for the Garfield County sites are greater than 1.0, indicating no adverse health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for formaldehyde for RICO (0.14).

- Annual averages, and therefore cancer risk and noncancer hazard approximations, could not be calculated for RFCO. This is also true for benzene and 1,3-butadiene for PACO and acetaldehyde and formaldehyde for BMCO.

7.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 7-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 7-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 7-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 7-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 7-7. Table 7-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 7-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Colorado Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Grand Junction, Colorado (Mesa County) - GPCO					
Benzene	108.00	Formaldehyde	1.38E-03	Formaldehyde	39.31
Formaldehyde	106.09	Benzene	8.42E-04	Benzene	10.00
Acetaldehyde	39.65	1,3-Butadiene	3.21E-04	Naphthalene	6.93
Ethylbenzene	34.52	POM, Group 3	3.04E-04	Acetaldehyde	6.35
1,3-Butadiene	10.71	Naphthalene	2.00E-04	1,3-Butadiene	5.42
Naphthalene	5.88	POM, Group 2b	1.28E-04	Dichloromethane	5.23
Dichloromethane	5.44	Acetaldehyde	8.72E-05	Carbon Tetrachloride	4.00
Tetrachloroethylene	1.86	Ethylbenzene	8.63E-05	1,2-Dichloroethane	2.06
POM, Group 2b	1.46	POM, Group 2d	8.13E-05	Acenaphthene	1.81
POM, Group 2d	0.92	POM, Group 5a	6.03E-05	Ethylbenzene	1.74
Battlement Mesa, Colorado (Garfield County) - BMCO					
Formaldehyde	385.39	Formaldehyde	5.01E-03	Benzene	8.50
Benzene	381.10	Benzene	2.97E-03	1,3-Butadiene	2.28
Acetaldehyde	94.18	1,3-Butadiene	2.75E-04		
Ethylbenzene	42.90	Acetaldehyde	2.07E-04		
1,3-Butadiene	9.16	Naphthalene	1.38E-04		
Naphthalene	4.05	Ethylbenzene	1.07E-04		
Tetrachloroethylene	1.01	POM, Group 3	1.06E-04		
POM, Group 2b	0.67	POM, Group 2b	5.94E-05		
POM, Group 2d	0.51	POM, Group 2d	4.47E-05		
Dichloromethane	0.25	1,2-Dibromoethane	2.63E-05		

Table 7-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Silt, Colorado (Garfield County) - BRCO					
Formaldehyde	385.39	Formaldehyde	5.01E-03	Formaldehyde	13.31
Benzene	381.10	Benzene	2.97E-03	Benzene	5.20
Acetaldehyde	94.18	1,3-Butadiene	2.75E-04	1,3-Butadiene	1.91
Ethylbenzene	42.90	Acetaldehyde	2.07E-04	Acetaldehyde	1.34
1,3-Butadiene	9.16	Naphthalene	1.38E-04		
Naphthalene	4.05	Ethylbenzene	1.07E-04		
Tetrachloroethylene	1.01	POM, Group 3	1.06E-04		
POM, Group 2b	0.67	POM, Group 2b	5.94E-05		
POM, Group 2d	0.51	POM, Group 2d	4.47E-05		
Dichloromethane	0.25	1,2-Dibromoethane	2.63E-05		
Parachute, Colorado (Garfield County) - PACO					
Formaldehyde	385.39	Formaldehyde	5.01E-03	Formaldehyde	15.64
Benzene	381.10	Benzene	2.97E-03	Acetaldehyde	1.52
Acetaldehyde	94.18	1,3-Butadiene	2.75E-04		
Ethylbenzene	42.90	Acetaldehyde	2.07E-04		
1,3-Butadiene	9.16	Naphthalene	1.38E-04		
Naphthalene	4.05	Ethylbenzene	1.07E-04		
Tetrachloroethylene	1.01	POM, Group 3	1.06E-04		
POM, Group 2b	0.67	POM, Group 2b	5.94E-05		
POM, Group 2d	0.51	POM, Group 2d	4.47E-05		
Dichloromethane	0.25	1,2-Dibromoethane	2.63E-05		

Table 7-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Carbondale, Colorado (Garfield County) - RFCO					
Formaldehyde	385.39	Formaldehyde	5.01E-03		
Benzene	381.10	Benzene	2.97E-03		
Acetaldehyde	94.18	1,3-Butadiene	2.75E-04		
Ethylbenzene	42.90	Acetaldehyde	2.07E-04		
1,3-Butadiene	9.16	Naphthalene	1.38E-04		
Naphthalene	4.05	Ethylbenzene	1.07E-04		
Tetrachloroethylene	1.01	POM, Group 3	1.06E-04		
POM, Group 2b	0.67	POM, Group 2b	5.94E-05		
POM, Group 2d	0.51	POM, Group 2d	4.47E-05		
Dichloromethane	0.25	1,2-Dibromoethane	2.63E-05		
Rifle, Colorado (Garfield County) - RICO					
Formaldehyde	385.39	Formaldehyde	5.01E-03	Formaldehyde	18.11
Benzene	381.10	Benzene	2.97E-03	Benzene	7.77
Acetaldehyde	94.18	1,3-Butadiene	2.75E-04	1,3-Butadiene	5.42
Ethylbenzene	42.90	Acetaldehyde	2.07E-04	Acetaldehyde	2.30
1,3-Butadiene	9.16	Naphthalene	1.38E-04		
Naphthalene	4.05	Ethylbenzene	1.07E-04		
Tetrachloroethylene	1.01	POM, Group 3	1.06E-04		
POM, Group 2b	0.67	POM, Group 2b	5.94E-05		
POM, Group 2d	0.51	POM, Group 2d	4.47E-05		
Dichloromethane	0.25	1,2-Dibromoethane	2.63E-05		

Table 7-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		**Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Grand Junction, Colorado (Mesa County) - GPCO					
Toluene	407.44	Acrolein	507,830.37	Acetaldehyde	0.32
Xylenes	181.20	Formaldehyde	10,825.37	Formaldehyde	0.31
Ethylene glycol	180.58	1,3-Butadiene	5,355.90	1,3-Butadiene	0.09
Hexane	112.50	Acetaldehyde	4,405.19	Naphthalene	0.07
Benzene	108.00	Benzene	3,600.06	Dichloromethane	0.07
Formaldehyde	106.09	Naphthalene	1,959.57	Benzene	0.04
Methanol	102.15	Xylenes	1,811.96	Carbon Tetrachloride	0.01
Acetaldehyde	39.65	Antimony, PM	1,050.00	Ethylbenzene	<0.01
Ethylbenzene	34.52	Lead, PM	767.77	Hexachloro-1,3-butadiene	<0.01
Styrene	12.68	Ethylene glycol	451.46	*p*-Dichlorobenzene	<0.01
Battlement Mesa, Colorado (Garfield County) - BMCO					
Toluene	760.37	Acrolein	3,417,970.87	1,3-Butadiene	0.04
Methanol	623.54	Formaldehyde	39,325.75	Benzene	0.04
Xylenes	550.01	Benzene	12,703.42		
Formaldehyde	385.39	Acetaldehyde	10,464.10		
Benzene	381.10	Xylenes	5,500.07		
Hexane	147.32	1,3-Butadiene	4,580.22		
Acetaldehyde	94.18	Naphthalene	1,350.07		
Ethylene glycol	69.40	Lead, PM	412.39		
Acrolein	68.36	Arsenic, PM	227.73		
Ethylbenzene	42.90	Hexane	210.45		

Table 7-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Silt, Colorado (Garfield County) - BRCO					
Toluene	760.37	Acrolein	3,417,970.87	Formaldehyde	0.10
Methanol	623.54	Formaldehyde	39,325.75	Acetaldehyde	0.07
Xylenes	550.01	Benzene	12,703.42	1,3-Butadiene	0.03
Formaldehyde	385.39	Acetaldehyde	10,464.10	Benzene	0.02
Benzene	381.10	Xylenes	5,500.07		
Hexane	147.32	1,3-Butadiene	4,580.22		
Acetaldehyde	94.18	Naphthalene	1,350.07		
Ethylene glycol	69.40	Lead, PM	412.39		
Acrolein	68.36	Arsenic, PM	227.73		
Ethylbenzene	42.90	Hexane	210.45		
Parachute, Colorado (Garfield County) - PACO					
Toluene	760.37	Acrolein	3,417,970.87	Formaldehyde	0.12
Methanol	623.54	Formaldehyde	39,325.75	Acetaldehyde	0.08
Xylenes	550.01	Benzene	12,703.42		
Formaldehyde	385.39	Acetaldehyde	10,464.10		
Benzene	381.10	Xylenes	5,500.07		
Hexane	147.32	1,3-Butadiene	4,580.22		
Acetaldehyde	94.18	Naphthalene	1,350.07		
Ethylene glycol	69.40	Lead, PM	412.39		
Acrolein	68.36	Arsenic, PM	227.73		
Ethylbenzene	42.90	Hexane	210.45		

Table 7-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Carbondale, Colorado (Garfield County) - RFCO					
Toluene	760.37	Acrolein	3,417,970.87		
Methanol	623.54	Formaldehyde	39,325.75		
Xylenes	550.01	Benzene	12,703.42		
Formaldehyde	385.39	Acetaldehyde	10,464.10		
Benzene	381.10	Xylenes	5,500.07		
Hexane	147.32	1,3-Butadiene	4,580.22		
Acetaldehyde	94.18	Naphthalene	1,350.07		
Ethylene glycol	69.40	Lead, PM	412.39		
Acrolein	68.36	Arsenic, PM	227.73		
Ethylbenzene	42.90	Hexane	210.45		
Rifle, Colorado (Garfield County) - RICO					
Toluene	760.37	Acrolein	3,417,970.87	Formaldehyde	0.14
Methanol	623.54	Formaldehyde	39,325.75	Acetaldehyde	0.12
Xylenes	550.01	Benzene	12,703.42	1,3-Butadiene	0.09
Formaldehyde	385.39	Acetaldehyde	10,464.10	Benzene	0.03
Benzene	381.10	Xylenes	5,500.07		
Hexane	147.32	1,3-Butadiene	4,580.22		
Acetaldehyde	94.18	Naphthalene	1,350.07		
Ethylene glycol	69.40	Lead, PM	412.39		
Acrolein	68.36	Arsenic, PM	227.73		
Ethylbenzene	42.90	Hexane	210.45		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 7.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 7-7 include the following:

- The 10 highest emitted pollutants with cancer UREs in Mesa County are the highest emitted pollutants in Garfield County, although not necessarily in the same order. Benzene and formaldehyde top both lists, although the emissions are more than three times higher for Garfield County than Mesa County.
- The two pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde and benzene for both Mesa and Garfield Counties. These two counties have eight pollutants in common among the pollutants with the highest toxicity-weighted emissions.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions in Mesa County; the same eight pollutants have the highest emitted pollutants and highest toxicity-weighted emissions for Garfield County.
- For GPCO, six of the 10 pollutants with the highest cancer risk approximations also appear on both emissions-based lists for Mesa County. Dichloromethane has the sixth highest cancer risk approximation and is the seventh highest emitted pollutant in Mesa County, but does not appear among those with the highest toxicity-weighted emissions (its ranks 27th). POM, Group 2b is the ninth highest emitted "pollutant" in Mesa County and ranks sixth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at GPCO including acenaphthene, which has the ninth highest cancer risk approximation for GPCO.
- The four pollutants of interest identified for each of the Garfield County sites appear on both emissions-based lists in Table 7-7.

Observations from Table 7-8 include the following:

- Toluene is the highest emitted pollutant with a noncancer RfC in both Mesa and Garfield Counties, although the emissions are higher in Garfield County. These two counties have an additional eight pollutants in common on their lists of highest emitted pollutants with noncancer RfCs.

- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties is acrolein. Although acrolein was sampled for at GPCO, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. Although acrolein has the highest toxicity-weighted emissions for every county with an NMP site, rarely does it appear among the highest emitted pollutants. Garfield County is the only county with an NMP site for which acrolein ranks among the highest emitted. A similar observation was made in the 2011 NMP report.

- Five of the highest emitted pollutants in Mesa County also have the highest toxicity-weighted emissions. Six of the 10 highest emitted pollutants in Garfield County (including acrolein) also have the highest toxicity-weighted emissions. Toluene, the highest emitted pollutant for both counties, is not among those with the highest toxicity-weighted emissions.

- Formaldehyde, acetaldehyde, and benzene appear on all three lists for GPCO. Additionally, 1,3-butadiene and naphthalene appear among the pollutants with the highest noncancer hazard approximations and highest toxicity-weighted emissions, but are not among the highest emitted pollutants with a noncancer RfC in Mesa County. Ethylbenzene appears among the pollutants with the highest noncancer hazard approximations and highest emissions, but is not among those with the highest toxicity-weighted emissions.

- Formaldehyde and acetaldehyde appear on all three lists for the Garfield County sites (except RFCO and BMCO, because noncancer hazard approximations could not be calculated for these sites). This is also true for benzene, where a noncancer hazard approximation could be calculated.

7.6 Summary of the 2012 Monitoring Data for the Colorado Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Nineteen pollutants failed screens for GPCO. The number of pollutants failing screens for the Garfield County sites ranged from four to five.*

- ❖ *Dichloromethane has highest annual average concentration for GPCO, followed by formaldehyde, acetaldehyde, and benzene. These were the only pollutants with annual average concentrations greater than 1 µg/m*^{3}*, although the annual average concentration for dichloromethane is an order of magnitude greater than the others. Formaldehyde had the highest annual average concentration for each of the Garfield County sites, except those for which an annual average could not be calculated.*

- ❖ *GPCO has the highest annual average concentrations of naphthalene, acenaphthene, and fluorene among all NMP sites sampling PAHs.*

- *Benzene concentrations at GPCO have an overall decreasing trend across the years of sampling, as do benzene concentrations measured at BRCO and, in more recent years, RICO. In recent years, concentrations of p-dichlorobenzene have an increasing trend at GPCO. The range of concentrations of naphthalene, fluorene, and acenaphthene measured at GPCO exhibit significant increases for 2012. In addition, the detection rate of 1,2-dichloroethane at GPCO has been increasing steadily over the last few years of sampling.*

8.0 Site in the District of Columbia

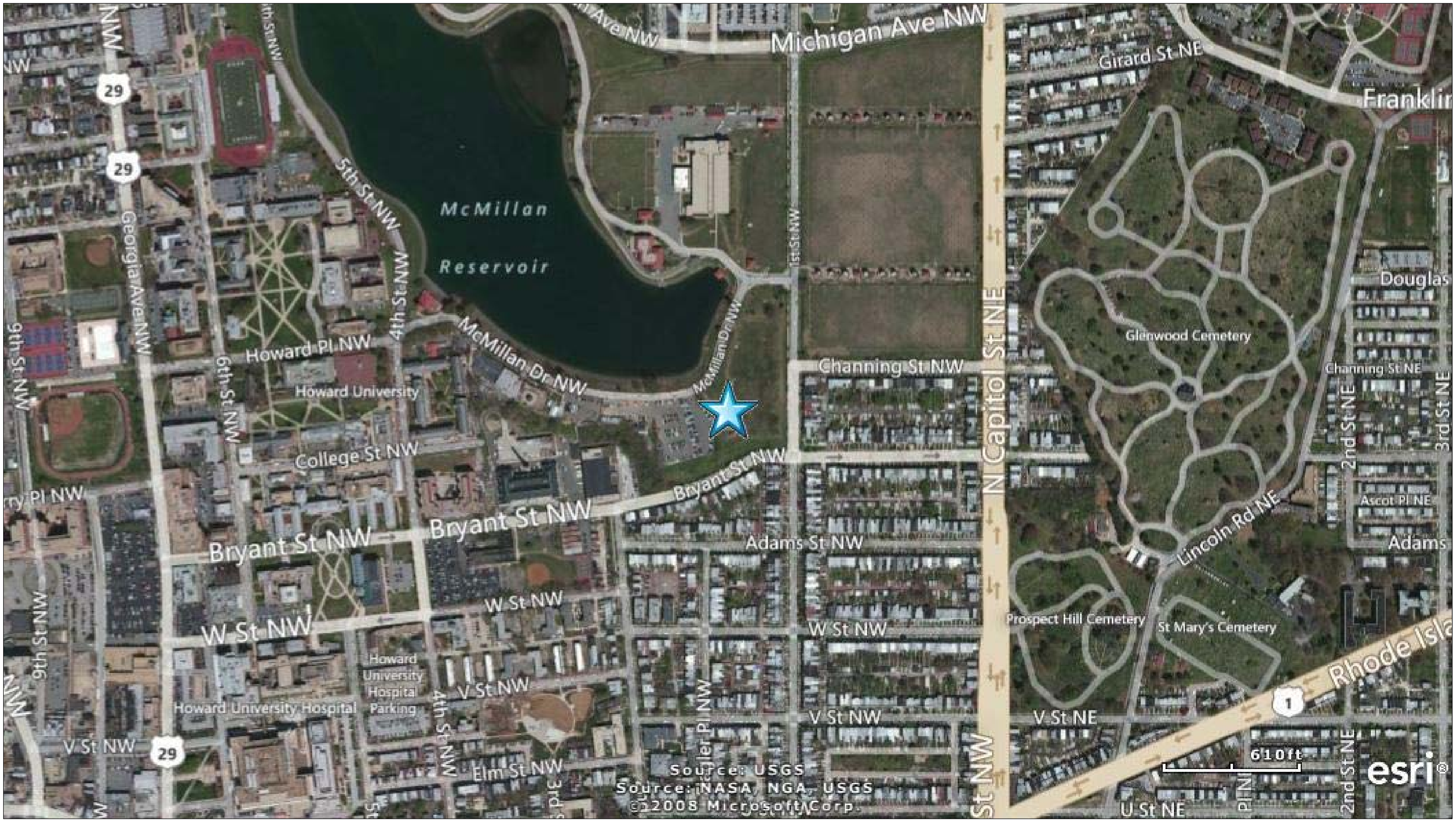
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Washington, D.C., and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

8.1 Site Characterization

This section characterizes the Washington, D.C. monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

Figure 8-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 8-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 8-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 8-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 8-1. Washington, D.C. (WADC) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 8-2. NEI Point Sources Located Within 10 Miles of WADC

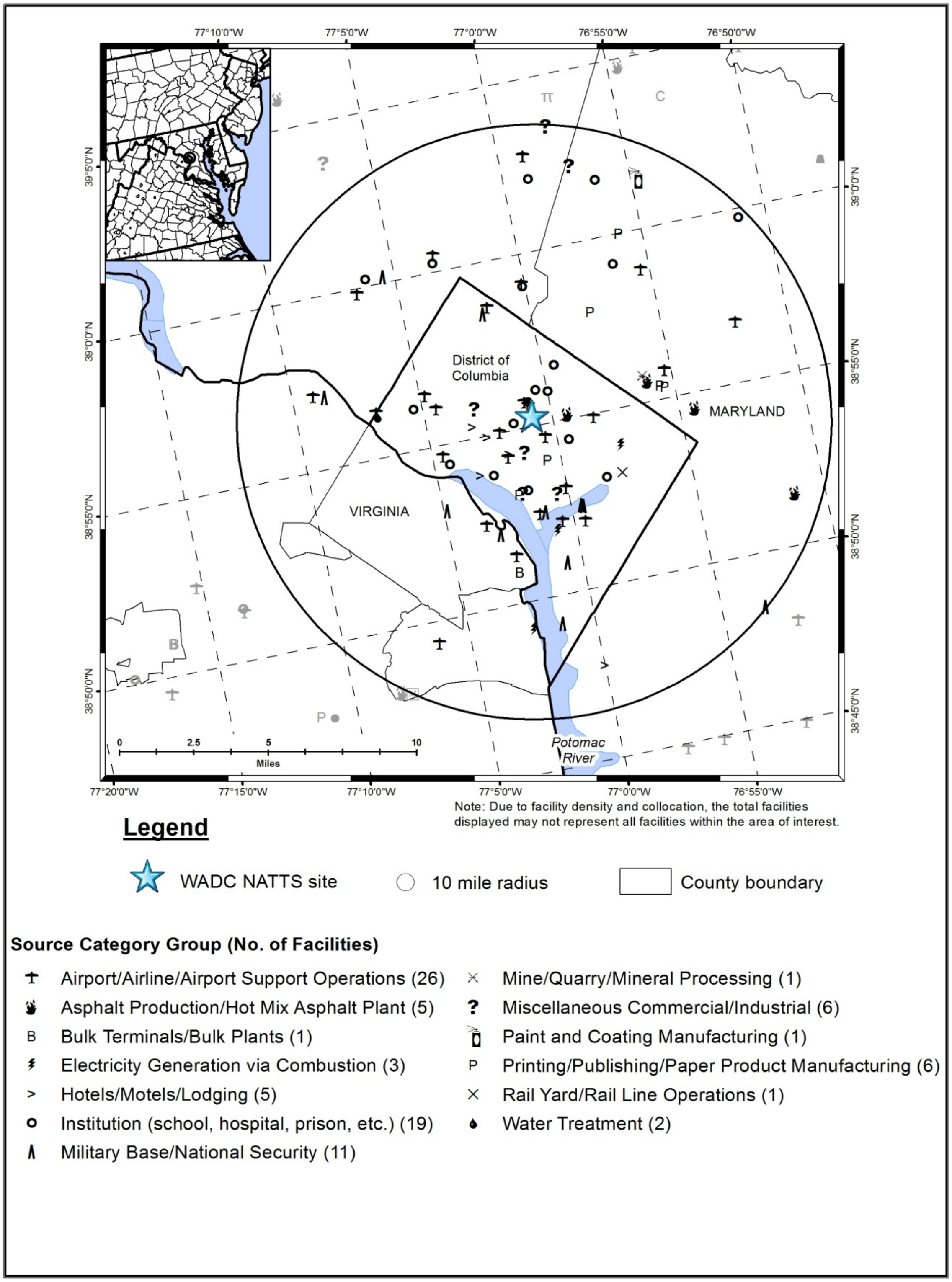


Table 8-1. Geographical Information for the Washington, D.C. Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
WADC	11-001-0043	Washington	District Of Columbia	Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	38.921847, -77.013178	Commercial	Urban/City Center	Arsenic, Lead, CO, VOCs, SO_2, NO_y, NO, NO_2, NO_x, PAMS, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, Black carbon, PM Coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for WADC (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

Figure 8-1 shows that the WADC monitoring site is located in an open field at the southeast end of the McMillan Water Reservoir in Washington, D.C. It is also located near several heavily traveled roadways. The site is located in a commercial area, and is surrounded by a hospital, a cemetery, and a university. As Figure 8-2 shows, WADC is surrounded by many sources in the airport and airport support operations source category and the institution source category. The airport source category includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or televisions stations. The institution source category includes hospital, schools, and prisons, etc. The closest sources to WADC are a wastewater treatment facility, hospitals, and heliports at hospitals.

Table 8-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Washington D.C. monitoring site. Table 8-2 includes both county-level population and vehicle registration information. Table 8-2 also contains traffic volume information for WADC, as well as the location for which the traffic volume was obtained. Additionally, Table 8-2 presents the daily VMT for the District of Columbia.

Table 8-2. Population, Motor Vehicle, and Traffic Information for the Washington, D.C. Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
WADC	632,323	316,231	7,400	1st Street between W St. and V St.	9,775,000

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2011 data (FHWA, 2013a)
[3] AADT reflects 2010 data (DC DOT, 2012a)
[4] County-level VMT reflects 2011 data (DC DOT, 2012b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 8-2 include the following:

- The District's population is in the middle of the range compared to other counties with NMP sites. The District-level vehicle registration is also in the middle of the range compared to other counties with NMP sites.

- The traffic volume experienced near WADC is in the bottom third compared to other NMP monitoring sites. The traffic volume provided is for 1st Street, the closest roadway east of the monitoring site, between W Street and V Street, three to four blocks south of the site.

- The district-level VMT is in the middle-third compared to other county-level VMT, where VMT is available.

8.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Washington, D.C. on sample days, as well as over the course of the year.

8.2.1 Climate Summary

Located on the Potomac River that divides Virginia and Maryland, the capital experiences all four seasons, although its weather is somewhat variable. Summers are warm and often humid, as southerly winds prevail. Summertime temperatures can be accentuated by the urban heat island effect. Winters are typical of the Mid-Atlantic region, where cool, blustery air masses are common followed by a fairly quick return to mild temperatures. Winds out of the northwest are prevalent in the period from December to March. Precipitation is evenly distributed across the seasons (Wood, 2004).

8.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the station closest to the Washington, D.C. monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station to WADC is located at Ronald Reagan Washington National Airport (WBAN 13743). Additional information about the Reagan National Airport weather station, such as the distance between the site and the weather station, is provided in Table 8-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 8-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 8-3 is the 95 percent confidence interval for each parameter. As shown in Table 8-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year near WADC.

Table 8-3. Average Meteorological Conditions near the Washington, D.C. Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Washington, D.C. - WADC									
Ronald Reagan Washington National Airport 13743 (38.87, -77.03)	5.2 Miles 180° (S)	Sample Days (70)	69.9 ± 3.9	61.4 ± 3.7	46.6 ± 4.1	53.8 ± 3.4	61.2 ± 3.2	1017.5 ± 1.6	7.0 ± 0.6
		2012	69.5 ± 1.7	61.2 ± 1.6	46.4 ± 1.7	53.5 ± 1.5	61.4 ± 1.4	1017.0 ± 0.7	6.9 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

8.2.3 Back Trajectory Analysis

Figure 8-3 is the composite back trajectory map for days on which samples were collected at the WADC monitoring site. Included in Figure 8-3 are four back trajectories per sample day. Figure 8-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 8-3 and 8-4 represents 100 miles.

Observations from Figures 8-3 and 8-4 include the following:

- Back trajectories originated from a variety of directions at WADC. The longest back trajectories originated from the northwest. Few back trajectories originated from the east.

- The 24-hour air shed domain for WADC was comparable in size to many other NMP monitoring sites. While the farthest away a back trajectory originated was towards Lake Michigan, or just greater than 550 miles away, the average trajectory length was 203 miles and nearly 90 percent of back trajectories originated within 350 miles of the site.

- The cluster analysis confirms that back trajectories originated from a variety of directions of WADC. Back trajectories originating from the northwest account for 20 percent of the back trajectories, but are split into two cluster trajectories based on back trajectory length. Eleven percent of these back trajectories originated over western Pennsylvania, while nine percent originated over Lake Huron, Lake Erie, Toronto, Canada, and western New York. Another 10 percent of back trajectories originated over Michigan, Ohio, and Indiana. The cluster trajectory originating over the Blue Ridge Mountains of Virginia (18 percent) represents back trajectories originating over West Virginia, central and western Virginia, and the western half of North Carolina. The short cluster trajectory originating just south of the monitoring site represents the 15 percent of back trajectories originating less than 100 miles away and over east-central Virginia. Another 18 percent originated to the south over southeastern Virginia, eastern North Carolina, and the adjacent coastal waters. Ten percent of back trajectories originated to the northeast to east of WADC, over New Jersey, the Delmarva Peninsula or farther offshore. Finally, nine percent of back trajectories originated to the north of WADC, over eastern Pennsylvania and New York City and the surrounding urban areas.

Figure 8-3. Composite Back Trajectory Map for WADC

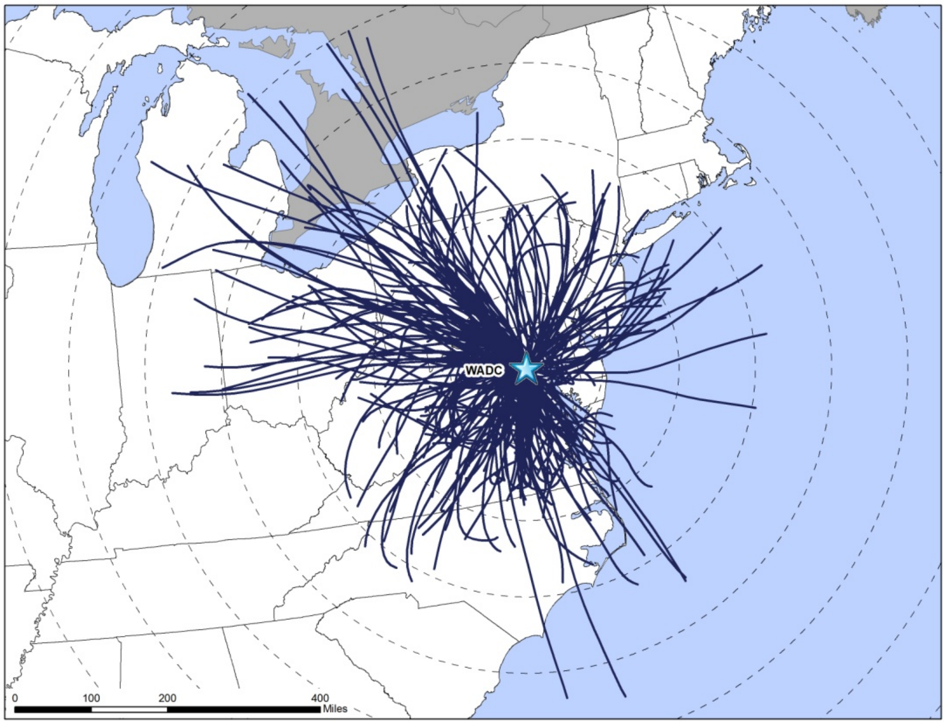


Figure 8-4. Back Trajectory Cluster Map for WADC

8.2.4 Wind Rose Comparison

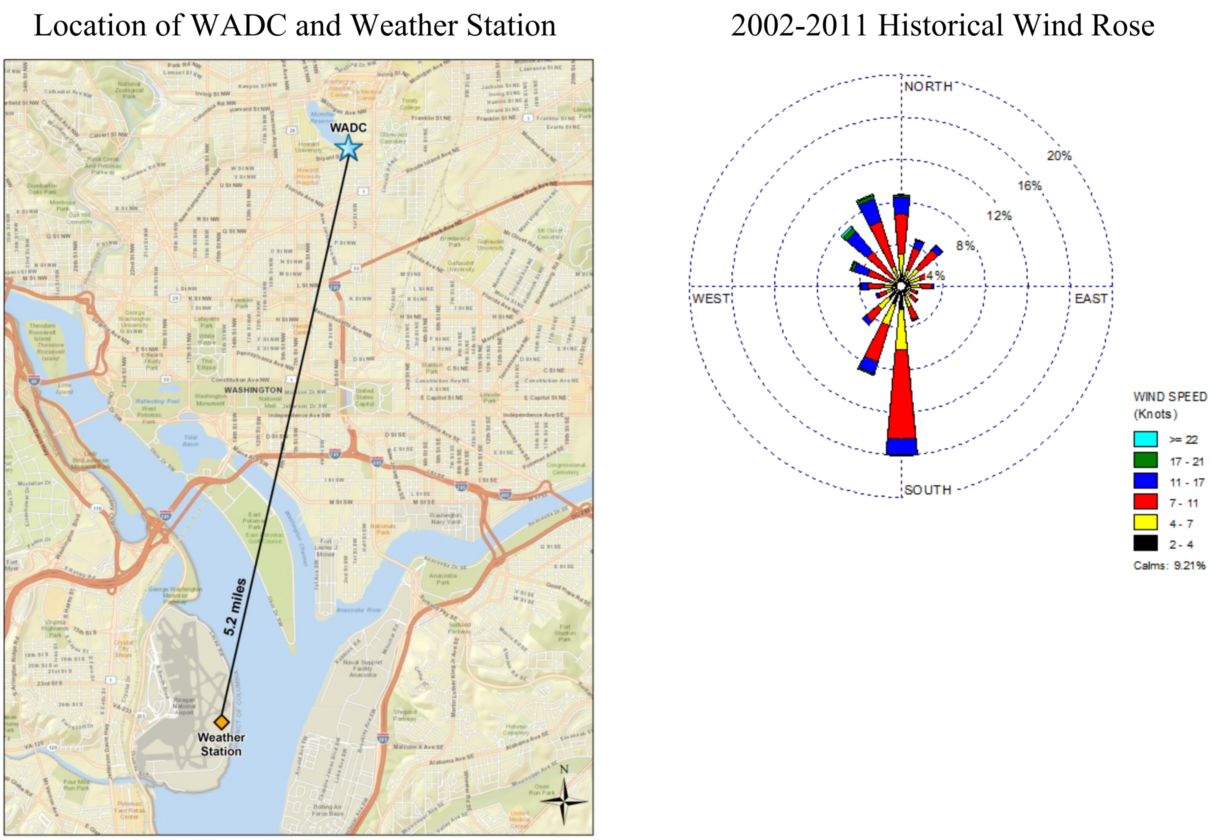
Hourly surface wind data from the weather station at Ronald Reagan Washington National Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 8-5 presents a map showing the distance between the weather station and WADC, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 8-5 also presents three different wind roses for the WADC monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 8-5 for WADC include the following:

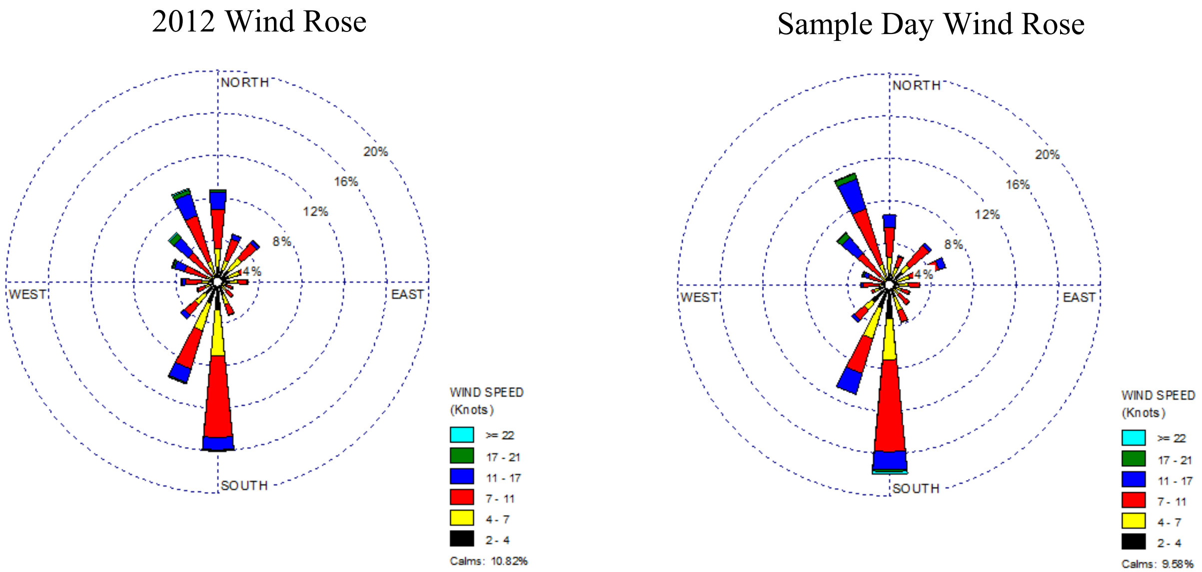
- The weather station at Reagan National Airport is located approximately 5.2 miles to the south of WADC. Between WADC and Washington National is the city of Washington and the Potomac River.
- Historically, southerly to south-southwesterly winds account for approximately 25 percent of wind observations near WADC, while northwesterly to northerly winds account for another 25 percent of observations. Calm winds (≤ 2 knots) were observed for less than 10 percent of the hourly measurements.
- The wind patterns on the full-year wind rose are similar to the wind patterns shown on the historical wind rose. The sample day wind patterns also resemble those on the historical wind rose, although there are a few differences. Northerly winds accounted for fewer wind observations on sample days while north-northwesterly winds were observed more often. Overall, though, the similarities in the three wind roses indicate that wind patterns in 2012 were similar to what is expected climatologically near this site.

Figure 8-5. Wind Roses for the Ronald Reagan Washington National Airport Weather Station near WADC



Location of WADC and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

8.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Washington, D.C. monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 8-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 8-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. WADC sampled for hexavalent chromium and PAHs.

Table 8-4. Risk-Based Screening Results for the Washington, D.C. Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Washington, D.C - WADC						
Naphthalene	0.029	61	61	100.00	96.83	96.83
Benzo(a)pyrene	0.00057	1	31	3.23	1.59	98.41
Fluorene	0.011	1	61	1.64	1.59	100.00
Total		63	153	41.18		

Observations from Table 8-4 include the following:

- Three pollutants failed screens for WADC. While naphthalene failed 100 percent of its 61 screens, benzo(a)pyrene and fluorene each failed a single screen.
- Naphthalene accounted for nearly 97 percent of the total failed screens for WADC; thus, naphthalene is WADC's only pollutant of interest.

8.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Washington, D.C. monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each site.
- Annual concentration averages are presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for WADC are provided in Appendices M and O.

8.4.1 2012 Concentration Averages

Quarterly and annual average concentrations were calculated for the pollutants of interest for the Washington, D.C. monitoring site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for WADC are presented in Table 8-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 8-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Washington, D.C. Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Washington, D.C. - WADC						
Naphthalene	61/61	NA	87.26 ± 18.49	86.81 ± 16.99	137.46 ± 64.58	104.38 ± 19.17

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for WADC from Table 8-5 include the following:

- Naphthalene was detected in every PAH sample collected at WADC. However, sampler issues experienced in February and March resulted in the invalidation of several samples and thus, no first quarter average was calculated. Many of these samples were made up later in the year.

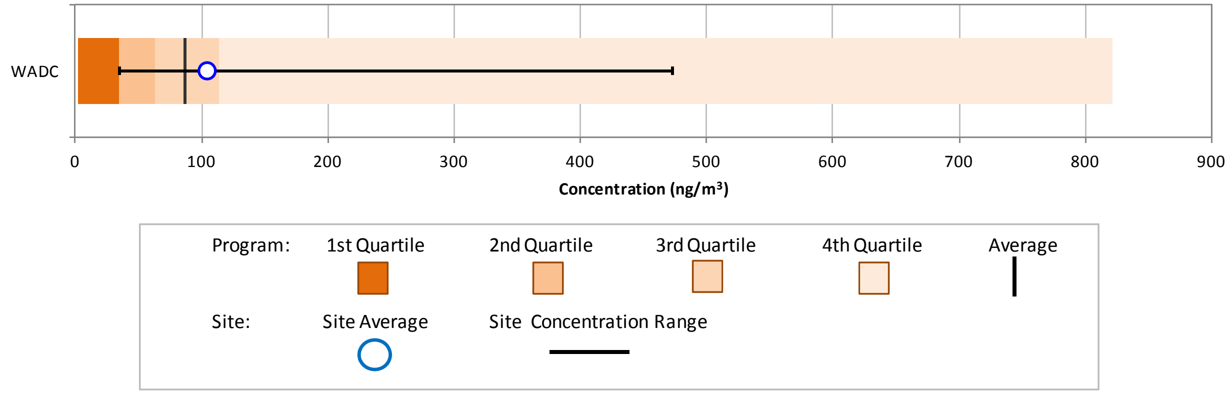
- The second and third quarter average concentrations of naphthalene are fairly similar to each other in magnitude. The fourth quarter average is higher than the other quarterly averages and has a relatively large confidence interval associated with it, indicating that outliers may be present. Two naphthalene concentrations greater than 400 ng/m^3 were measured at WADC, one in November (404 ng/m^3) and one in December (473 ng/m^3); the next highest concentration measured during the fourth quarter is considerably less (168 ng/m^3). No other naphthalene concentration measured at WADC was greater than 225 ng/m^3.

- The maximum naphthalene concentration measured at WADC is the fifth highest naphthalene concentration measured across NMP sites sampling PAHs. As shown in Table 4-11, WADC has the fifth highest annual average concentration of naphthalene and is one of only five NMP sites with annual average concentrations greater than 100 ng/m^3.

8.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for the site-specific pollutants of interest, where applicable. Thus, a box plot was created for naphthalene for WADC. Figure 8-6 overlays the site's minimum, annual average, and maximum naphthalene concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 8-6. Program vs. Site-Specific Average Naphthalene Concentration



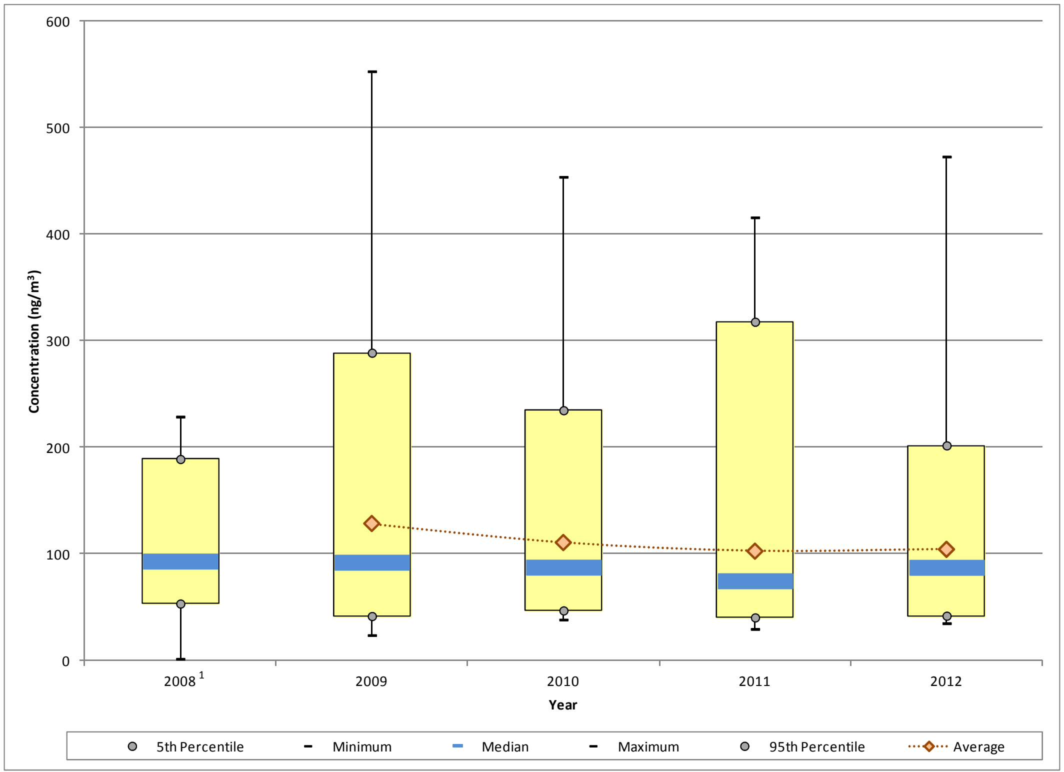
Observations from Figure 8-6 include the following:

- The annual average concentration of naphthalene for WADC is greater than the program-level average concentration but less than the program-level third quartile. The annual average concentration of naphthalene for WADC ranks fifth compared to other NMP sites sampling PAHs. The maximum naphthalene concentration measured at WADC is less than the program-level maximum concentration, although it is among the higher measurements across the program. The minimum concentration measured at WADC is similar to the program-level first quartile.

8.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. WADC has sampled PAHs under the NMP since mid-2008. Thus, Figure 8-7 presents the 1-year statistical metrics for naphthalene for WADC. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 8-7. Yearly Statistical Metrics for Naphthalene Concentrations Measured at WADC



[1] A 1-year average is not presented because sampling under the NMP did not begin until late June 2008.

Observations from Figure 8-7 for naphthalene measurements collected at WADC include the following:

- WADC began sampling PAHs under the NMP in late June 2008. Because a full year's worth of data is not available, a 1-year average is not presented for 2008, although the range of measurements is provided.

- The maximum naphthalene concentration shown was measured in 2009 and is the only concentration greater than 500 ng/m^3 measured at this site (553 ng/m^3). Concentrations greater than 400 ng/m^3 have been measured in all years of sampling except 2008 (which included only half a year's worth of samples).

- The 1-year average concentration exhibits a slight decreasing trend between 2009 and 2011. However, confidence intervals calculated for these averages indicate that the changes are not statistically significant.

- The difference between the 5th and 95th percentiles is at a minimum for 2012, excluding 2008, indicating that the majority of concentrations measured are falling into a tighter range of measurements. Although 2011 and 2012 have the same number of measurements greater than 100 ng/m^3(19), 2012 has none in the 225 ng/m^3 to 400 ng/m^3 range while 2011 has four in this concentration range. This explains why the 95th percentile for 2011 is greater than the 95th percentile for 2012. Additionally, 2011 has a greater number of measurements at the lower end of the concentration range than 2012 (almost twice as many measurements are less than 50 ng/m^3 for 2011 compared to 2012). The number of concentrations in the 75 ng/m^3 to 100 ng/m^3 range is higher in 2012 than in 2011. As a result, the median concentration is higher for 2012 than 2011.

8.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the WADC monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

8.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Washington D.C. monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

8.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for WADC and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 8-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 8-6. Risk Approximations for the Washington, D.C. Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Washington, D.C. - WADC						
Naphthalene	0.000034	0.003	61/61	104.38 ± 19.17	3.55	0.03

Observations for WADC from Table 8-6 include the following:

- As discussed in Section 8.4.1, the annual average concentration of naphthalene for WADC is among the higher annual average concentrations compared to other NMP sites sampling this pollutant.
- The cancer risk approximation for naphthalene is greater than 1.0 in-a-million (3.55 in-a-million). Its noncancer hazard approximation is significantly less than 1.0, indicating no adverse health effects are expected from this individual pollutant.

8.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 8-7 and 8-8 present an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 8-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 8-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 8-7 provides the cancer risk approximation (in-a-million) for the pollutant of interest for WADC, as presented in Table 8-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 8-7. Table 8-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 8.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 8-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Washington, D.C. Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Washington, D.C. - WADC					
Benzene	119.25	Formaldehyde	1.42E-03	Naphthalene	3.55
Formaldehyde	108.89	Benzene	9.30E-04		
Acetaldehyde	61.97	1,3-Butadiene	5.78E-04		
Ethylbenzene	58.43	POM, Group 3	4.99E-04		
Tetrachloroethylene	25.40	Naphthalene	3.79E-04		
1,3-Butadiene	19.26	POM, Group 2b	2.20E-04		
Naphthalene	11.14	Nickel, PM	1.55E-04		
POM, Group 2b	2.50	POM, Group 2d	1.55E-04		
POM, Group 2d	1.76	Ethylbenzene	1.46E-04		
Dichloromethane	0.81	Acetaldehyde	1.36E-04		

Table 8-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Washington, D.C. Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Washington, D.C. - WADC					
Toluene	1,099.24	Acrolein	264,897.44	Naphthalene	0.03
Ethylene glycol	761.10	Formaldehyde	11,110.93		
Methanol	352.77	1,3-Butadiene	9,627.53		
Xylenes	238.17	Acetaldehyde	6,885.06		
Hexane	226.27	Benzene	3,975.06		
Benzene	119.25	Naphthalene	3,712.17		
Formaldehyde	108.89	Nickel, PM	3,595.22		
Acetaldehyde	61.97	Chlorine	3,176.67		
Ethylbenzene	58.43	Xylenes	2,381.66		
Methyl isobutyl ketone	26.85	Ethylene glycol	1,902.74		

Observations from Table 8-7 include the following:

- Benzene and formaldehyde are the highest emitted pollutants with cancer UREs in the District of Columbia. Formaldehyde and benzene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs).
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions.
- Naphthalene is the only pollutant of interest for WADC. This pollutant appears on both emissions-based lists. Naphthalene is the seventh highest emitted pollutant with a cancer URE in the District of Columbia and has the fifth highest toxicity-weighted emissions (of the pollutants with cancer UREs).
- Several POM Groups are among the highest emitted "pollutants" in the District and/or rank among the pollutants with the highest toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at WADC including fluorene, which failed a single screen for WADC. POM, Group 2d includes several PAHs sampled for at WADC but none of these failed any screens. POM, Group 3 does not include any PAHs sampled for with Method TO-13.

Observations from Table 8-8 include the following:

- Toluene, ethylene glycol, and methanol are the highest emitted pollutants with noncancer RfCs in the District of Columbia.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene.
- Five of the highest emitted pollutants in the District of Columbia also have the highest toxicity-weighted emissions.
- Naphthalene has the sixth highest toxicity-weighted emissions but is not one of the 10 highest emitted pollutants (of the pollutants with noncancer RfCs).
- None of the other pollutants sampled for at WADC appear in Table 8-8.

8.6 Summary of the 2012 Monitoring Data for WADC

Results from several of the data treatments described in this section include the following:

- ❖ *Although three PAHs failed screens, naphthalene failed the majority of screens and was therefore the only pollutant of interest identified via the risk screening process.*
- ❖ *The annual average concentration of naphthalene for WADC ranks fifth among NMP sites sampling this pollutant.*

9.0 Sites in Florida

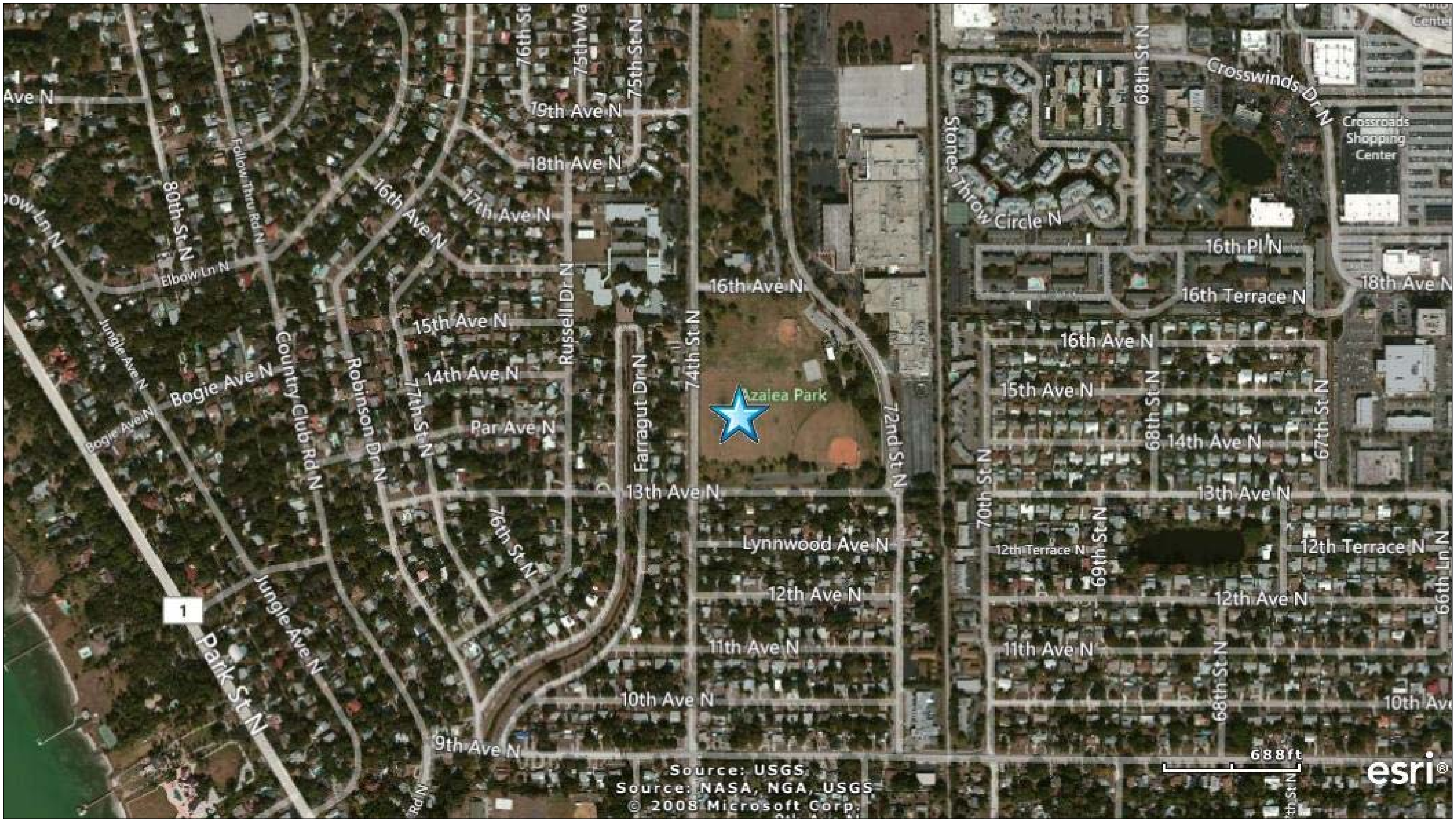
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Florida, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

9.1 Site Characterization

This section characterizes the Florida monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The five Florida sites are located in two different urban areas. Three sites (AZFL, SKFL, and SYFL) are located in the Tampa-St. Petersburg-Clearwater, FL MSA. ORFL and PAFL are located in the Orlando-Kissimmee-Sanford, FL MSA. Figures 9-1 and 9-2 are composite satellite images retrieved from ArcGIS Explorer showing the St. Petersburg monitoring sites and their immediate surroundings. Figure 9-3 identifies nearby point source emissions locations that surround these two sites by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 9-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radii are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 9-4 through 9-8 are the composite satellite images and emissions sources maps for the Tampa site and the two sites in the Orlando area. Table 9-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 9-1. St. Petersburg, Florida (AZFL) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 9-2. Pinellas Park, Florida (SKFL) Monitoring Site

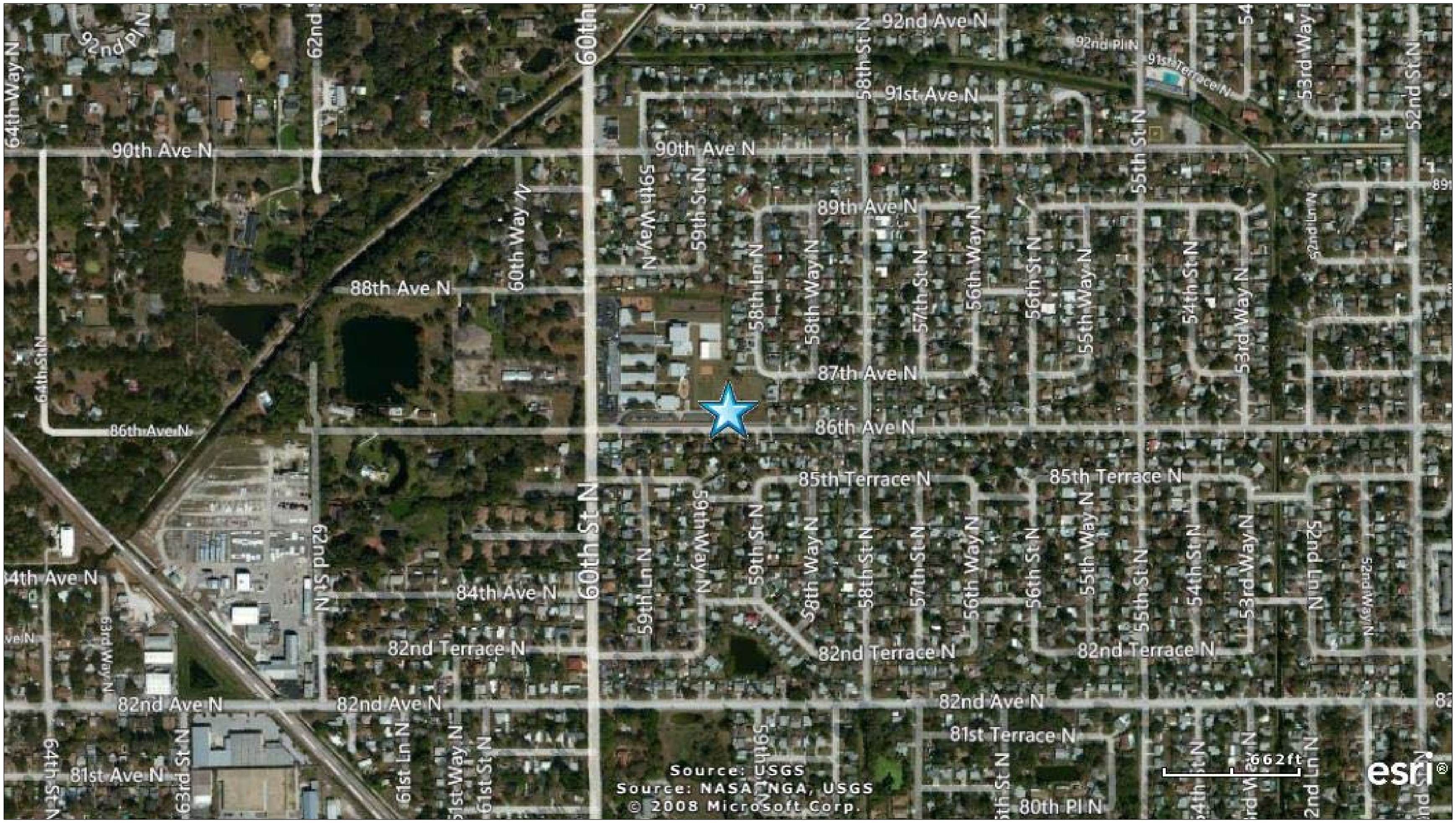


Figure 9-3. NEI Point Sources Located Within 10 Miles of AZFL and SKFL

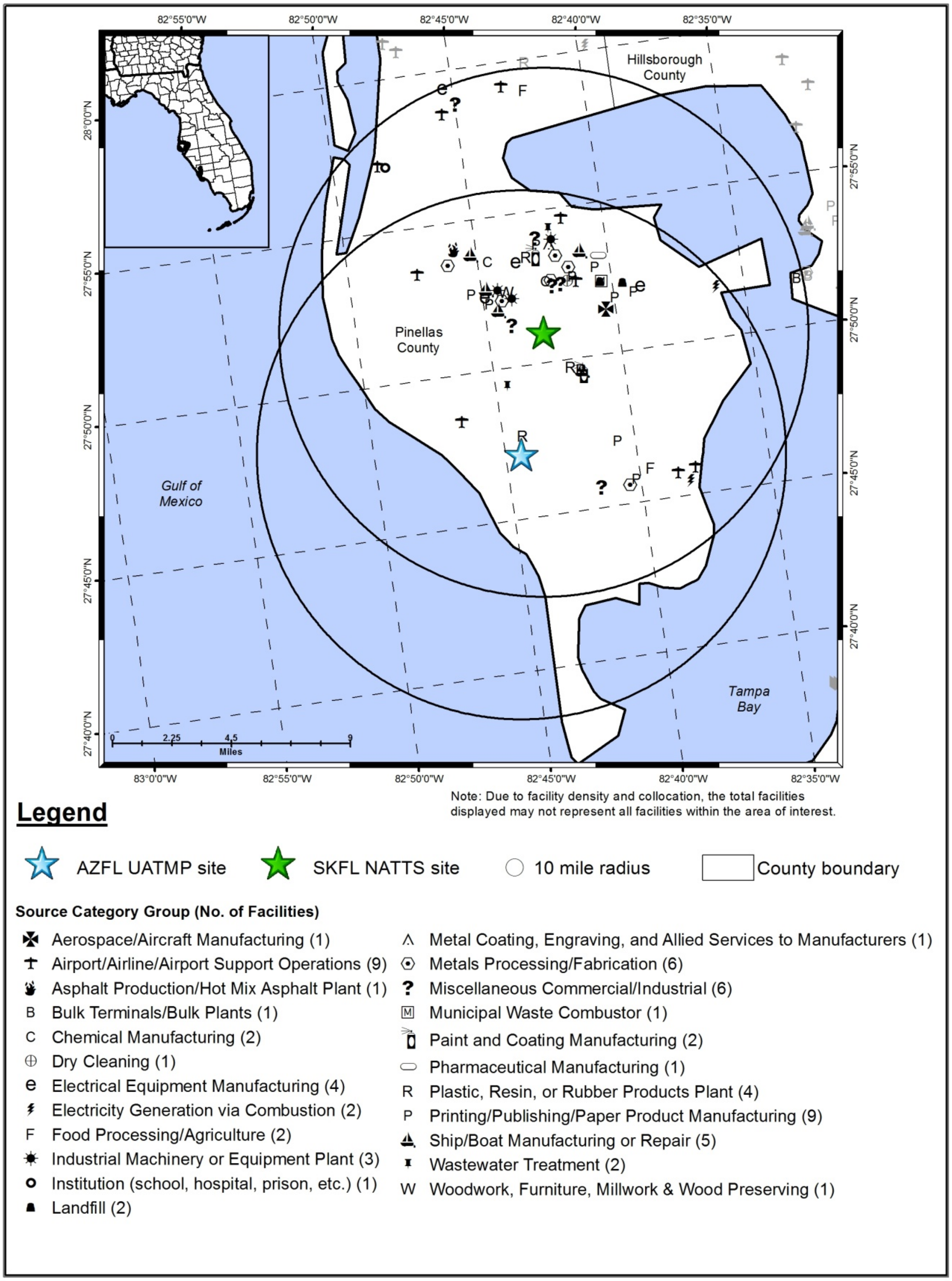


Figure 9-4. Valrico, Florida (SYFL) Monitoring Site

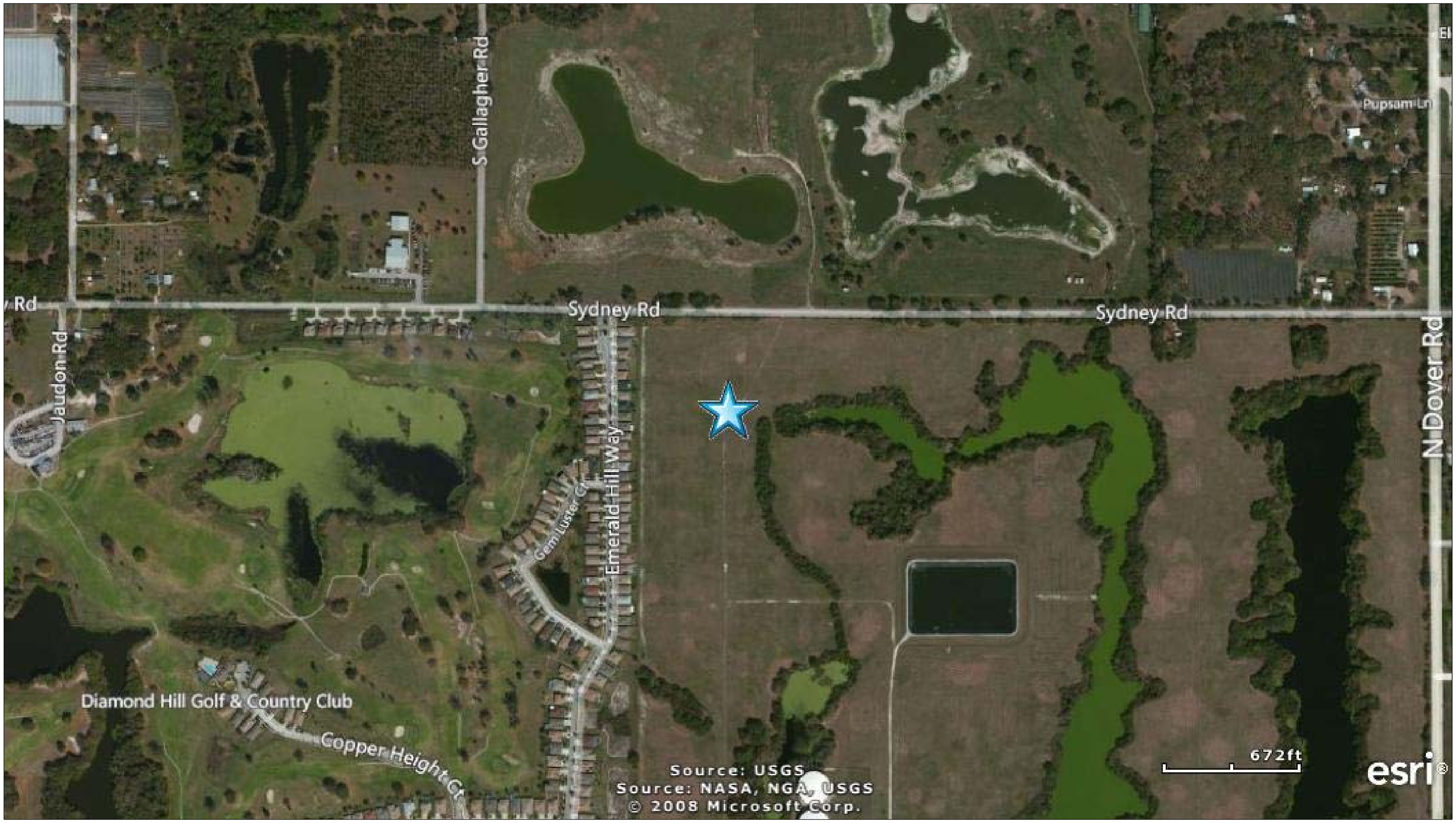


Figure 9-5. NEI Point Sources Located Within 10 Miles of SYFL

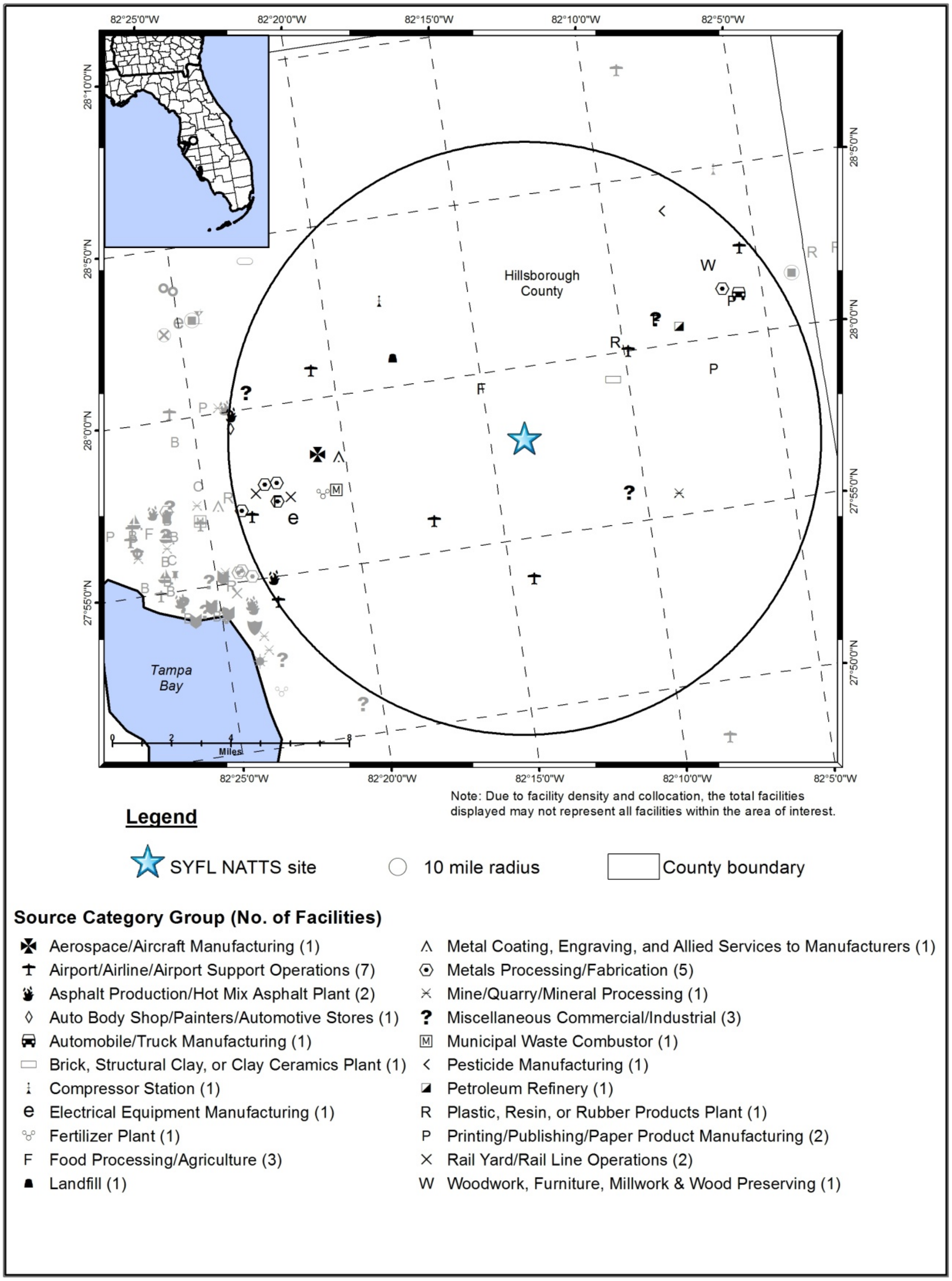


Figure 9-6. Winter Park, Florida (ORFL) Monitoring Site

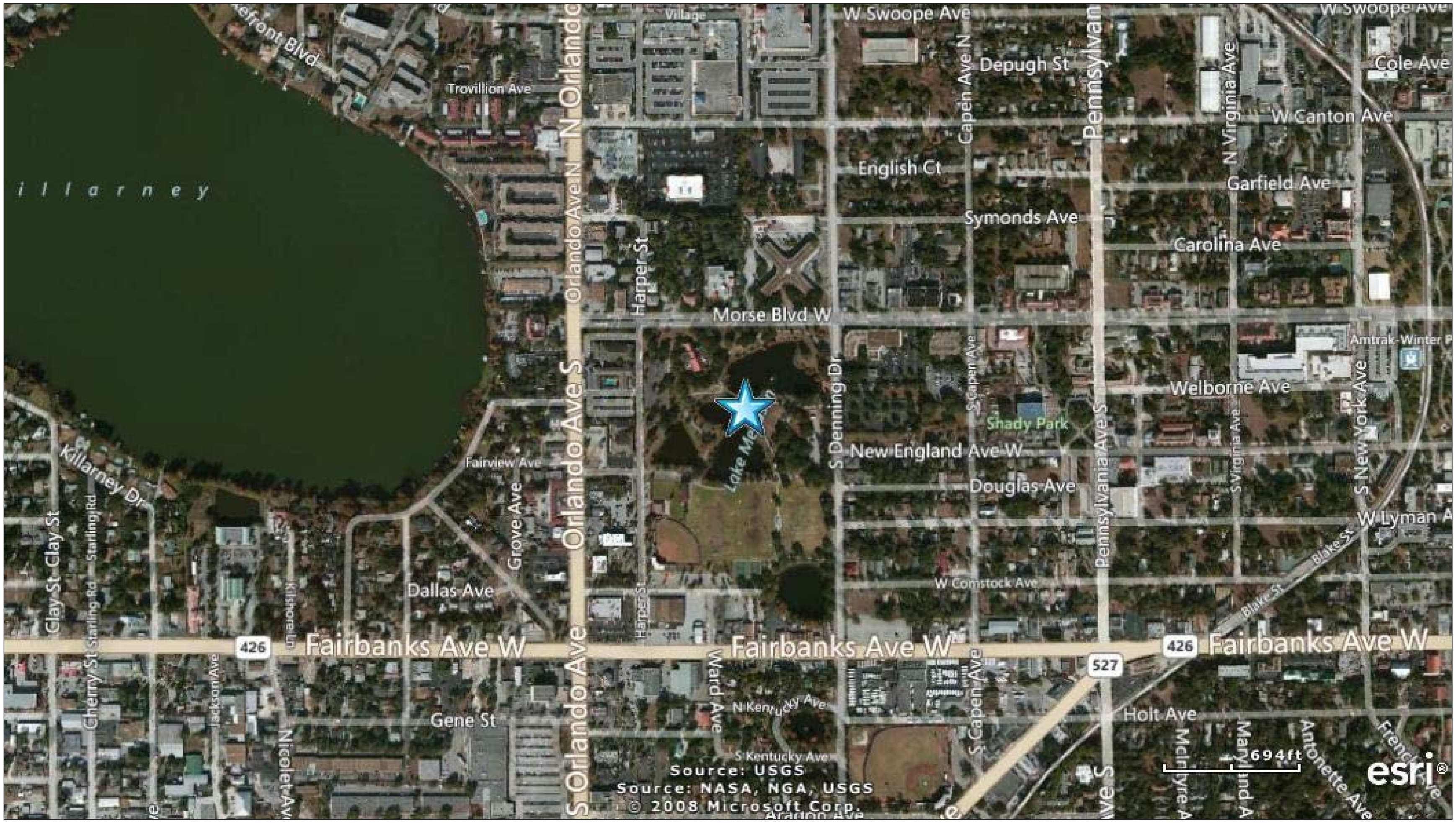


Figure 9-7. Orlando, Florida (PAFL) Monitoring Site

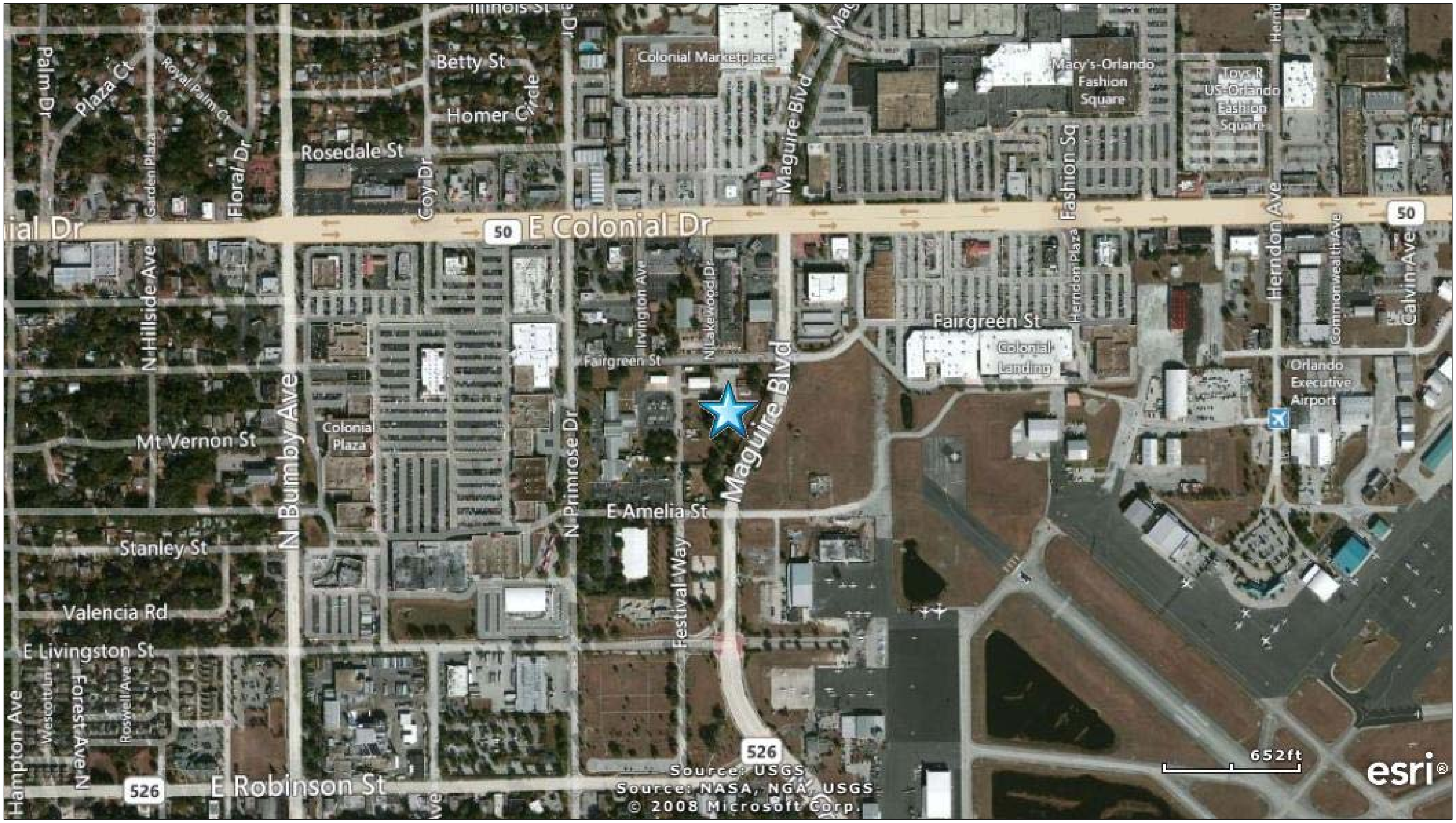
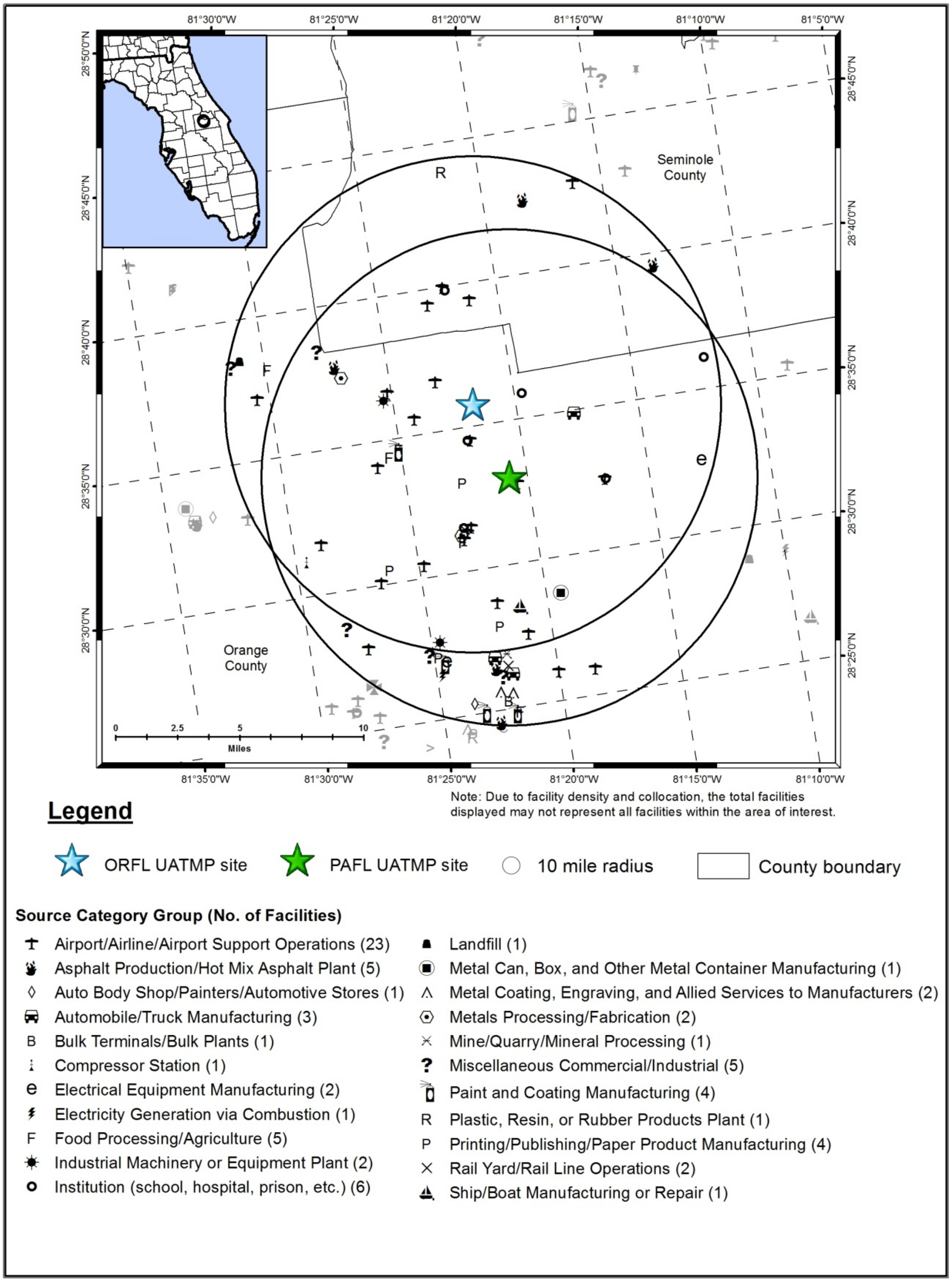


Figure 9-8. NEI Point Sources Located Within 10 Miles of ORFL and PAFL



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 9-1. Geographical Information for the Florida Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
AZFL	12-103-0018	St. Petersburg	Pinellas	Tampa-St. Petersburg-Clearwater, FL	27.785556, -82.74	Residential	Suburban	NO, NO_2, NO_x, VOCs, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$.
SKFL	12-103-0026	Pinellas Park	Pinellas	Tampa-St. Petersburg-Clearwater, FL	27.850348, -82.714465	Residential	Suburban	VOCs, Meteorological parameters, PM_{10} Speciation, Black carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
SYFL	12-057-3002	Valrico	Hillsborough	Tampa-St. Petersburg-Clearwater, FL	27.96565, -82.2304	Residential	Rural	CO, SO_2, NO_y, NO, NO_2, NO_x, VOCs, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, $PM_{2.5}$ Speciation, PM Coarse, IMPROVE Speciation.
ORFL	12-095-2002	Winter Park	Orange	Orlando-Kissimmee-Sanford, FL	28.596389, -81.3625	Commercial	Urban/City Center	CO, SO_2, NO, NO_2, NO_x, VOCs, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$.
PAFL	12-095-1004	Orlando	Orange	Orlando-Kissimmee-Sanford, FL	28.550833, -81.345556	Commercial	Suburban	PM_{10}.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

AZFL is located at Azalea Park in St. Petersburg. Figure 9-1 shows that the area surrounding AZFL consists of mixed land use, including residential, commercial, and industrial properties. The industrial property separated from Azalea Park by 72nd St. North is a former electronics manufacturer and is a permanently closed facility (EPA, 2014). Heavily traveled roadways are located less than 1 mile from the monitoring site. AZFL is located just over 1 mile east of Boca Ciega Bay, the edge of which can be seen in the bottom-left corner of Figure 9-1.

SKFL is located in Pinellas Park, north of St. Petersburg. This site is on the property of Skyview Elementary School near 86th Avenue North. Figure 9-2 shows that SKFL is located in a primarily residential area. However, a railroad intersects the Pinellas Park Ditch near a construction company in the bottom left corner of Figure 9-2. Population exposure is the purpose behind monitoring at this location. This site is the Pinellas County NATTS site.

Figure 9-3 shows the location of the St. Petersburg sites in relation to each other. AZFL is located approximately 5 miles south of SKFL. Most of the emissions sources on the Tampa Bay Peninsula are located north of SKFL. A small cluster of point sources is also located southeast of SKFL. The airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; printing, publishing, and paper product manufacturing; and metals processing and fabrication are the source categories with the greatest number of emissions sources in the St. Petersburg area (based on the areas covered by the 10-mile radii). The emissions source closest to AZFL is a plastic, resin, or rubber products plant. While the emissions source closest to SKFL falls into the miscellaneous commercial/industrial facility source category, a plastic, resin, or rubber products plant and an industrial machinery or equipment plant are also located within 2 miles of SKFL.

SYFL is located in Valrico, which is also part of the Tampa-St. Petersburg-Clearwater, FL MSA, although it is on the eastern outskirts of the area. Unlike the other Florida sites, the SYFL monitoring site is located in a rural area, although, as Figure 9-4 shows, a residential community and country club lie just to the west of the site. Located to the south of the site (and shown in the bottom-center portion of Figure 9-4) is a tank that is part of the local water treatment facility. This site serves as a background site, although the effect of increased development in the area is likely being captured by the monitoring site. This site is the Tampa NATTS site.

Figure 9-5 shows that most of the emissions sources surrounding SYFL are greater than 5 miles away from the site. The airport source category and metals processing and fabrication are the source categories with the greatest number of emissions sources near SYFL. The closest source to SYFL is the water treatment facility pictured in Figure 9-4. However, this facility is not shown in Figure 9-5 because they had no reportable air emissions in the 2011 NEI. Besides the water treatment facility, a food processing facility is the next closest emissions source to SYFL.

ORFL is located in Winter Park, north of Orlando. Figure 9-6 shows that ORFL is located near Lake Mendsen, east of Lake Killarney and south of Winter Park Village. This site lies in a commercial area and serves as a population exposure monitor.

PAFL is located in northeast Orlando, on the northwestern edge of the Orlando Executive Airport property, as shown in Figure 9-7. The area is considered commercial and experiences heavy traffic. The airport is bordered by Colonial Drive to the north and the East-West Expressway (Toll Road 408) to the south (although not shown in Figure 9-7). A large shopping complex is located to the northeast of the site, just north of the airport, between Colonial Drive and Maguire Boulevard. Interstate-4 runs north-south less than 2 miles to the west of the monitoring site.

Figure 9-8 shows that ORFL is located a few miles north of PAFL. Most of the point sources are located on the western side of the 10-mile radii. Although the emissions sources surrounding ORFL and PAFL are involved in a variety of industries and processes, the airport and airport support operations source category has the greatest number of emissions sources within 10 miles of these sites.

Table 9-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Florida monitoring sites. Table 9-2 includes both county-level population and vehicle registration information. Table 9-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 9-2 presents the county-level daily VMT for Pinellas, Hillsborough, and Orange Counties.

Table 9-2. Population, Motor Vehicle, and Traffic Information for the Florida Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
AZFL	921,319	872,813	38,500	66th Street N, north of Route 19	21,387,550
SKFL			49,000	Park Blvd, east of 66th Street N	
SYFL	1,277,746	1,143,207	10,400	E Dr. Martin Luther King Jr. Blvd, east of McIntosh Road	34,061,637
ORFL	1,202,234	1,073,682	35,000	Orlando Avenue, north of Morse Drive	34,099,958
PAFL			49,500	E Colonial Drive, between Primrose Road & Bumby Ave.	

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (FL DHSMV, 2012)
[3] AADT reflects 2012 data (FL DOT, 2012a)
[4] County-level VMT reflects 2012 data (FL DOT, 2012b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 9-2 include the following:

- Hillsborough County, where SYFL is located, is the most populous of the Florida counties with monitoring sites, although Orange County also has more than 1 million people. Pinellas County ranks slightly lower in population as these counties rank 11th, 12th, and 14th in population compared to other counties with NMP sites.

- The vehicle registration counts for two of the three Florida counties are greater than 1 million, with Hillsborough County having the most and Pinellas County having the least. The vehicle registration rankings for the Florida sites are very similar to the county population rankings compared to other NMP sites.

- The traffic volume is lowest near SYFL and highest near PAFL, among the Florida sites, although the traffic volume for SKFL is similar to the traffic volume near PALF). Traffic volumes for four of the Florida monitoring sites are in the middle of the range compared to other NMP sites, with traffic near SYFL in the bottom third compared to other NMP sites.

- VMT is highest for Orange County and lowest for Pinellas County (among the Florida sites), although the VMTs for Hillsborough County and Orange County are similar. The Hillsborough, Orange, and Pinellas County VMTs ranked eighth, ninth, and 14th highest among counties with NMP sites, respectively.

9.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Florida on sample days, as well as over the course of the year.

9.2.1 Climate Summary

The Tampa and Orlando areas experience very mild winters and warm, humid summers. Temperatures below freezing are infrequent while temperatures greater than 90°F are common from May to September. Precipitation tends to be concentrated during the summer months, as afternoon thunderstorms occur almost daily. Semi-permanent high pressure offshore over the Atlantic Ocean extends westward towards Florida in the winter, resulting in reduced precipitation amounts. Land and sea breezes affect coastal locations and the proximity to the Atlantic Ocean or Gulf of Mexico can have a marked affect on the local meteorological conditions. Florida's orientation and location between the warm waters of the Gulf of Mexico, the Atlantic Ocean, and Caribbean Sea make it susceptible to tropical systems. However, Orlando's land-locked location generally makes it less vulnerable than the Tampa/St. Petersburg area (Wood, 2004; FCC, 2014).

9.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the Florida monitoring sites (NCDC, 2012), as described in Section 3.5.2. The weather station closest to the AZFL monitoring site is located at St. Petersburg/Whitted Airport (WBAN 92806); closest to SYFL is at Plant City Municipal Airport (WBAN 92824); closest to SKFL is at St. Petersburg/Clearwater International Airport (WBAN 12873); and closest to both ORFL and PAFL is at Orlando Executive Airport (WBAN 12841). Additional information about each of these weather stations, such as the distance between the sites and the weather stations, is provided in Table 9-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 9-3. Average Meteorological Conditions near the Florida Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
St. Petersburg, Florida - AZFL									
St. Petersburg/ Whitted Airport 92806 (27.77, -82.63)	6.9 miles 95° (E)	Sample Days (61)	81.0 ± 1.9	74.8 ± 2.1	66.0 ± 2.6	69.3 ± 2.2	75.8 ± 2.6	1017.0 ± 1.2	7.6 ± 0.9
		2012	80.8 ± 0.8	74.7 ± 0.8	66.2 ± 1.0	69.3 ± 0.8	76.2 ± 1.0	1016.9 ± 0.4	7.4 ± 0.3
Pinellas Park, Florida - SKFL									
St Petersburg-Clearwater Intl. Airport 12873 (27.91, -82.69)	4.4 miles 13° (NNE)	Sample Days (63)	82.1 ± 1.9	73.8 ± 2.0	63.6 ± 2.6	67.5 ± 2.1	72.5 ± 2.4	1017.7 ± 1.2	6.6 ± 0.8
		2012	81.9 ± 0.8	73.8 ± 0.8	63.8 ± 1.0	67.6 ± 0.9	72.9 ± 1.0	1017.4 ± 0.4	6.6 ± 0.3
Valrico, Florida - SYFL									
Plant City Municipal Airport 92824 (28.00, -82.16)	4.6 miles 50° (NE)	Sample Days (68)	84.7 ± 1.8	73.8 ± 2.1	63.3 ± 2.8	68.0 ± 2.3	69.2 ± 2.3	NA	4.6 ± 0.6
		2012	84.4 ± 0.8	73.7 ± 0.9	63.5 ± 1.1	68.1 ± 1.0	69.6 ± 1.0	NA	4.4 ± 0.2
Winter Park, Florida - ORFL									
Orlando Executive Airport 12841 (28.55, -81.33)	3.9 miles 145° (SE)	Sample Days (61)	83.0 ± 2.1	73.1 ± 2.2	61.6 ± 2.9	66.2 ± 2.3	70.2 ± 2.6	1018.1 ± 1.2	6.2 ± 0.7
		2012	82.6 ± 0.8	73.0 ± 0.8	61.9 ± 1.1	66.3 ± 0.9	70.9 ± 1.1	1017.9 ± 0.5	6.0 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA= Sea level pressure was not recorded at the Plant City Municipal Airport.

Table 9-3. Average Meteorological Conditions near the Florida Monitoring Sites (Continued)

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Orlando, Florida - PAFL									
Orlando Executive Airport 12841 (28.55, -81.33)	0.8 miles 108° (ESE)	Sample Days (30)	84.0 ± 2.5	74.1 ± 2.6	63.3 ± 3.5	67.5 ± 2.7	71.9 ± 3.7	1017.8 ± 1.6	6.2 ± 0.9
		2012	82.6 ± 0.8	73.0 ± 0.8	61.9 ± 1.1	66.3 ± 0.9	70.9 ± 1.1	1017.9 ± 0.5	6.0 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA= Sea level pressure was not recorded at the Plant City Municipal Airport.

Table 9-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 9-3 is the 95 percent confidence interval for each parameter. As shown in Table 9-3, average meteorological conditions on sample days in 2012 at the Florida monitoring sites were representative of average weather conditions experienced throughout the entire year. The largest differences are shown for PAFL. However, sampling at PAFL took place on a 1-in-12 day schedule, yielding roughly half the sample days as the other Florida monitoring sites and results in more variability in the sample day averages.

The highest average dew point and wet bulb temperatures among NMP sites were calculated for the Florida monitoring sites. AZFL and SKFL also experienced some of the highest relative humidity levels among NMP sites.

9.2.3 Back Trajectory Analysis

Figure 9-9 is the composite back trajectory map for days on which samples were collected at the AZFL monitoring site in 2012. Included in Figure 9-9 are four back trajectories per sample day. Figure 9-10 is the corresponding cluster analysis. Similarly, Figures 9-11 through 9-18 are the composite back trajectory maps and corresponding cluster analyses for the remaining Florida monitoring sites. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 9-9 through 9-18 represents 100 miles.

Figure 9-9. Composite Back Trajectory Map for AZFL

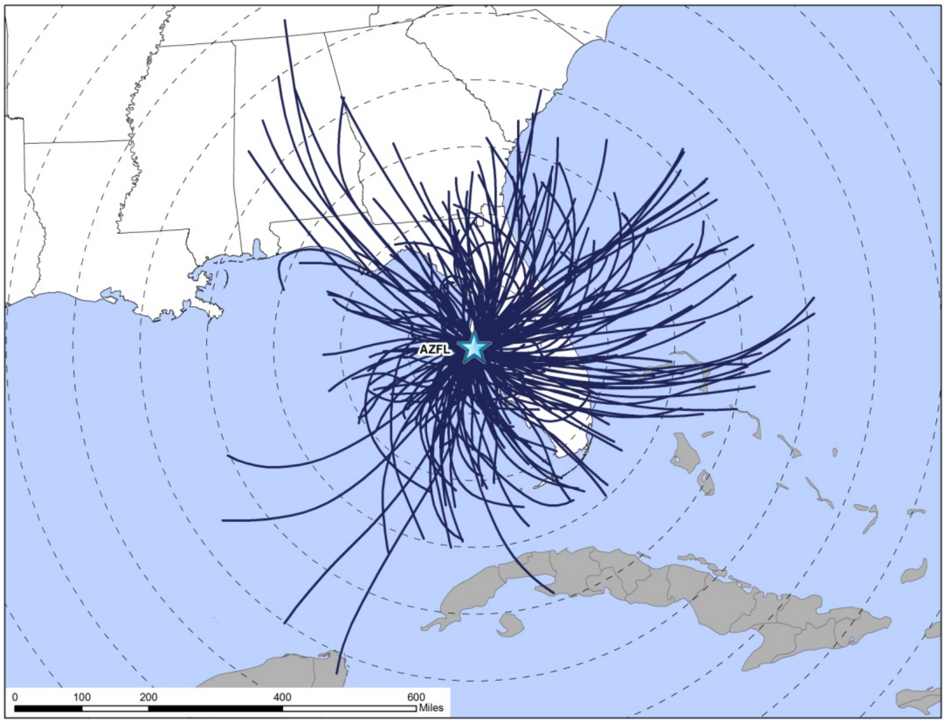


Figure 9-10. Back Trajectory Cluster Map for AZFL

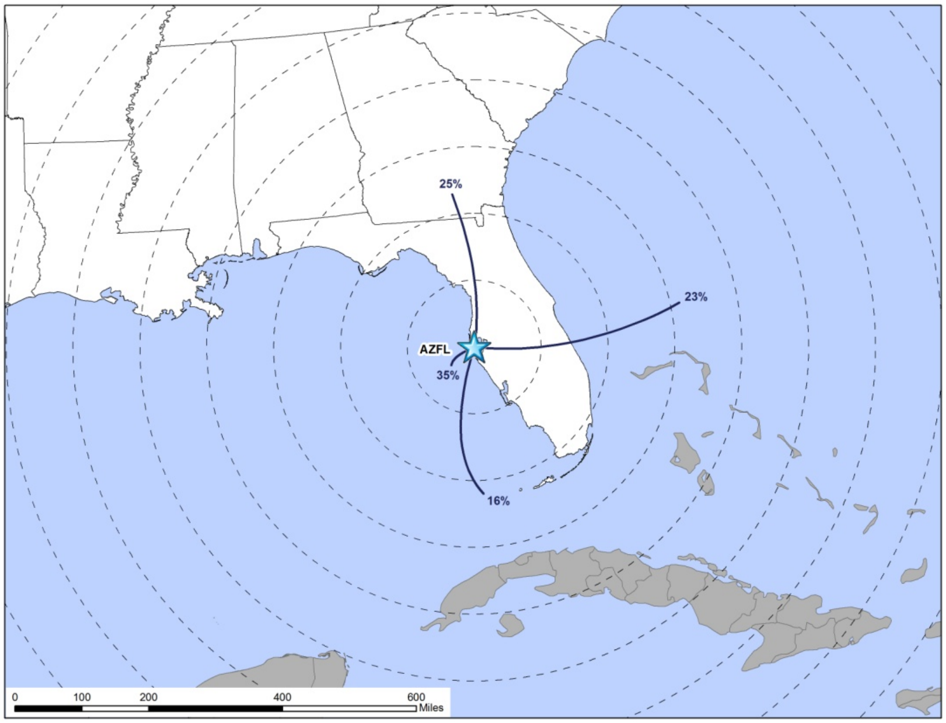


Figure 9-11. Composite Back Trajectory Map for SKFL

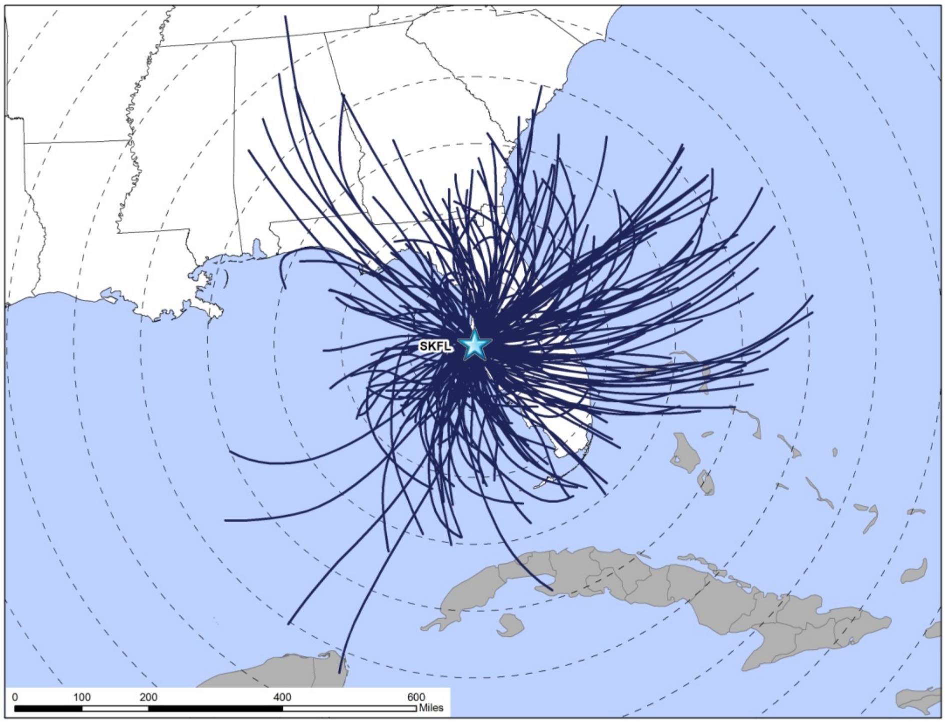


Figure 9-12. Back Trajectory Cluster Map for SKFL

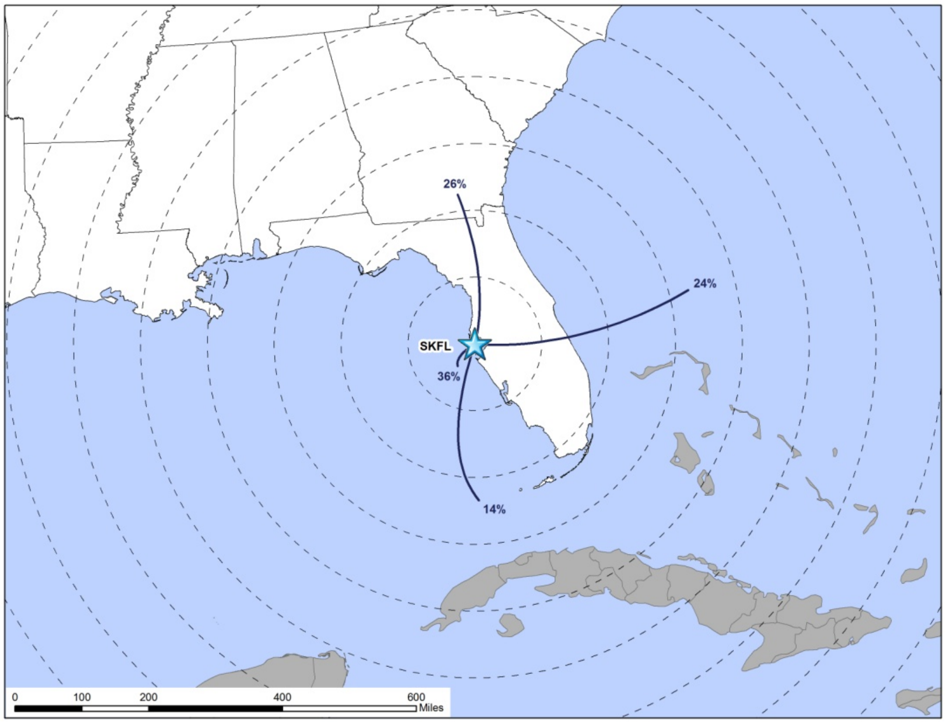


Figure 9-13. Composite Back Trajectory Map for SYFL

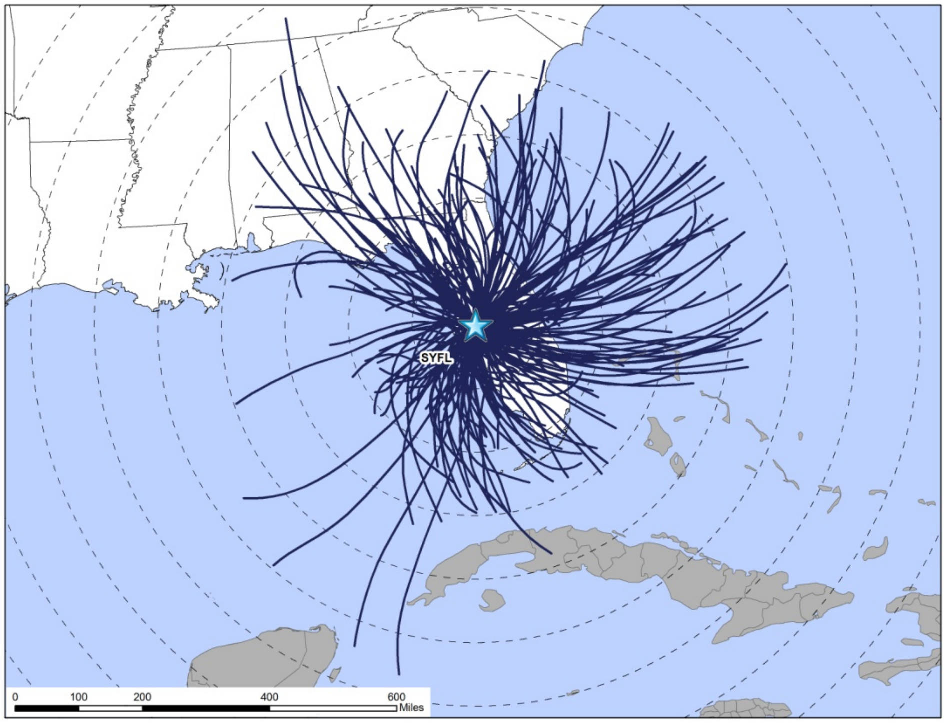


Figure 9-14. Back Trajectory Cluster Map for SYFL

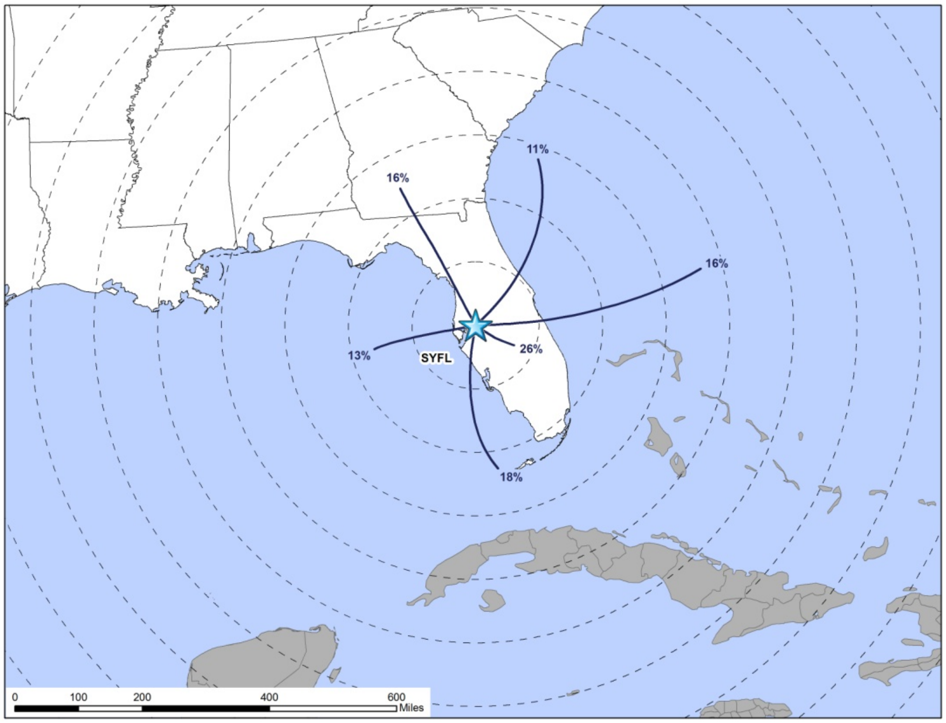


Figure 9-15. Composite Back Trajectory Map for ORFL

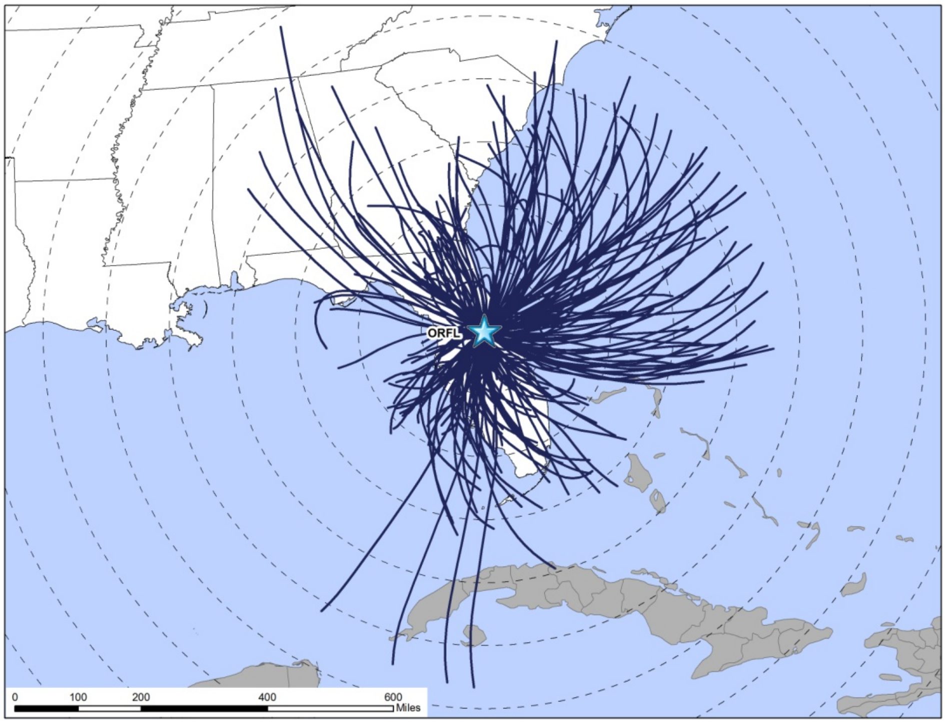


Figure 9-16. Back Trajectory Cluster Map for ORFL

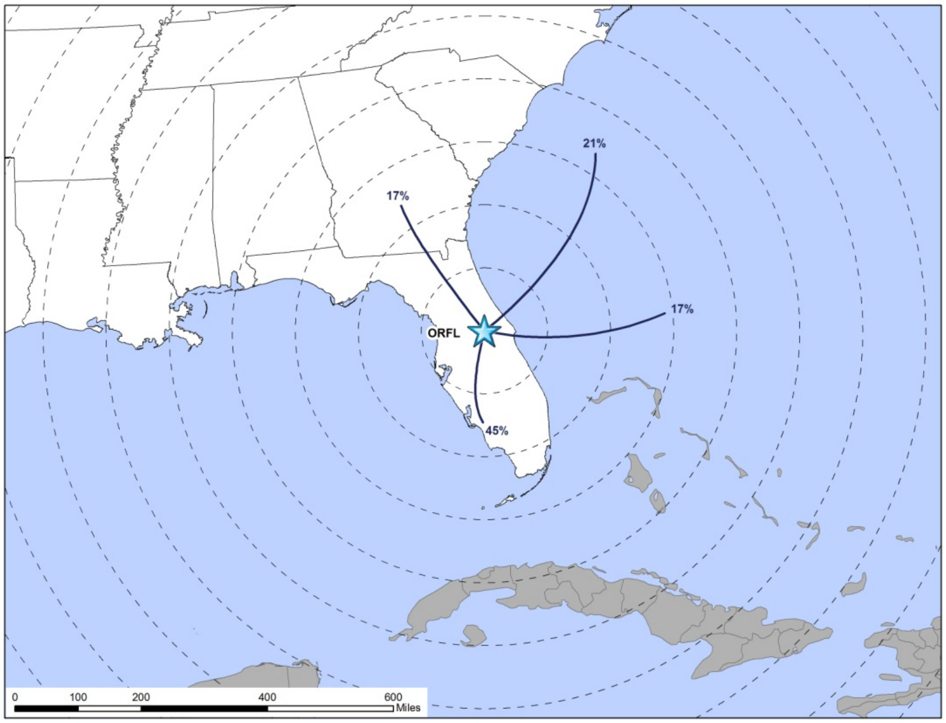


Figure 9-17. Composite Back Trajectory Map for PAFL

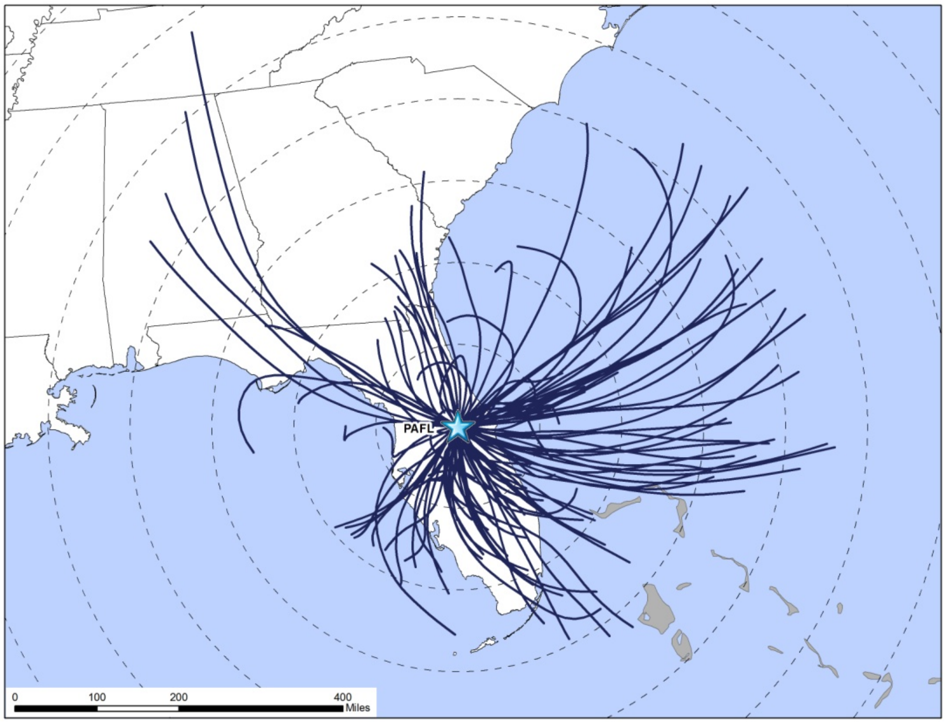
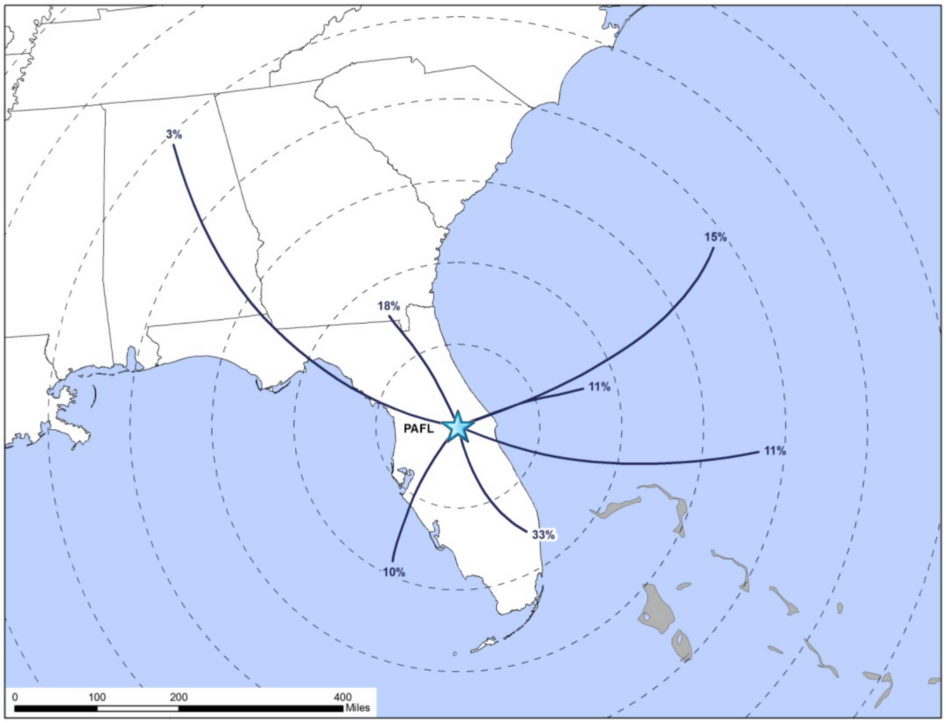


Figure 9-18. Back Trajectory Cluster Map for PAFL



Observations from Figures 9-9 through 9-14 for the Tampa/St. Petersburg sites include the following:

- The composite back trajectory maps for the Tampa/St. Petersburg sites are similar to each other in trajectory distribution, which is not unexpected given their close proximity to each other. Back trajectories originated from a variety of directions at the Tampa/St. Petersburg sites.

- The 24-hour air shed domains for these sites were comparable in size to other NMP sites, with the average trajectory length ranging from 227 miles for AZFL to 232 miles for SYFL. The farthest away a back trajectory originated was nearly 570 miles away, originating over Tennessee, although back trajectories of similar length also originated towards the Yucatan Peninsula of Mexico and eastward over the Atlantic Ocean. However, most trajectories (roughly 86 percent for each site) originated within 400 miles of the Tampa/St. Petersburg monitoring sites.

- The cluster maps for AZFL and SKFL are similar to each other in geographical breakup and the percentages differ only slightly. The cluster maps show that approximately one-quarter of back trajectories originated to the northwest, north, and northeast of the sites, primarily over Alabama, Georgia, and the offshore waters of Georgia and northeast Florida. Another one-quarter of back trajectories originated to the northeast, east, and southeast of the sites, over the Atlantic Ocean and northern Bahamas. Roughly 15 percent of back trajectories originated southward towards the Straights of Florida, western Cuba, the Gulf of Mexico, and the Yucatan Peninsula. Greater than one-third of the back trajectories are represented by the short cluster trajectory originating just west of the Tampa/St. Petersburg area and over the Gulf of Mexico. This cluster includes back trajectories of varying lengths originating over the Gulf of Mexico as well as shorter trajectories originating from a variety of directions around the sites but generally within 200 miles of the sites.

- The cluster map for SYFL has more cluster trajectories than the cluster maps for AZFL and SKFL. The cluster analysis splits the northward-originating cluster trajectory for AZFL and SKFL into two cluster trajectories for SYFL; one representing back trajectories originating over Alabama and Georgia, the other representing the back trajectories originating offshore. Similarly, the cluster analysis splits the short cluster trajectory originating just offshore the Tampa/St. Petersburg area for AZFL and SKFL into two back trajectories for SYFL; one representing the short trajectories originating over central Florida or just south of the St. Petersburg peninsula and one representing longer back trajectories originating farther westward over the Gulf of Mexico. The cluster trajectory originating eastward over the Atlantic Ocean and the cluster trajectory originating southward towards the Florida Keys are similar to the cluster trajectories for AZFL and SKFL.

Observations from Figures 9-15 through 9-18 for ORFL and PAFL include the following:

- The composite back trajectory map for PAFL has fewer back trajectories compared to the composite map for ORFL. This is because sampling at PAFL occurred on a 1-in-12 day schedule, yielding approximately half the sample days as ORFL. The long back trajectories originating over western Cuba are for the June 26, 2012 sample day; samples were not collected on this day at PAFL; thus, these back trajectories are not shown on the composite map for PAFL.

- The 24-hour air shed domain for ORFL is the largest in size compared to the other Florida monitoring sites, with an average back trajectory length of 250 miles. The longest back trajectory originated over central Tennessee, or approximately 580 miles away, with a few additional back trajectories of similar length originating over and south of western Cuba. However, greater than 90 percent of back trajectories originated with 450 miles of ORFL.

- Nearly half of all back trajectories are represented by the short cluster originating to the southwest of ORFL (45 percent), as shown on this site's cluster map. This cluster includes back trajectories originating to the south of a diagonal line drawn across the Panhandle of Florida, through ORFL, and extending across the Bahamas. The cluster map groups the remaining back trajectories into three directions: those originating northwestward over the Florida Panhandle, Georgia, and Alabama; those originating northeastward off the Southeast Coast; and those originating eastward over the Atlantic Ocean and northern Bahamas.

- The composite map for PAFL shows that the longest back trajectories originated over Alabama and Tennessee or over the Atlantic Ocean, predominantly east of the monitoring site. The back trajectories originating over northern Florida and southeast Georgia, south Florida, or the Gulf of Mexico were generally of shorter length.

- The cluster map for PAFL has almost twice the number of cluster trajectories (7) than the cluster map for ORFL (4). This can be attributed to the difference in the number of sample days. One-third of back trajectories originated over south Florida and the adjacent offshore waters. Nearly 40 percent of back trajectories originated over the Atlantic Ocean, but are represented by three separate cluster trajectories. Ten percent of back trajectories originated to the southwest of PAFL, over the waters south of the St. Petersburg Peninsula. The cluster trajectory originating over the Florida/Georgia border represents back trajectories originating over southeast Georgia and over north Florida as well as those originating over the Panhandle of Florida and the adjacent waters. Finally, the four back trajectories originating over Alabama and Tennessee are grouped together in a single cluster trajectory and represent three percent of the sample day back trajectories.

9.2.4 Wind Rose Comparison

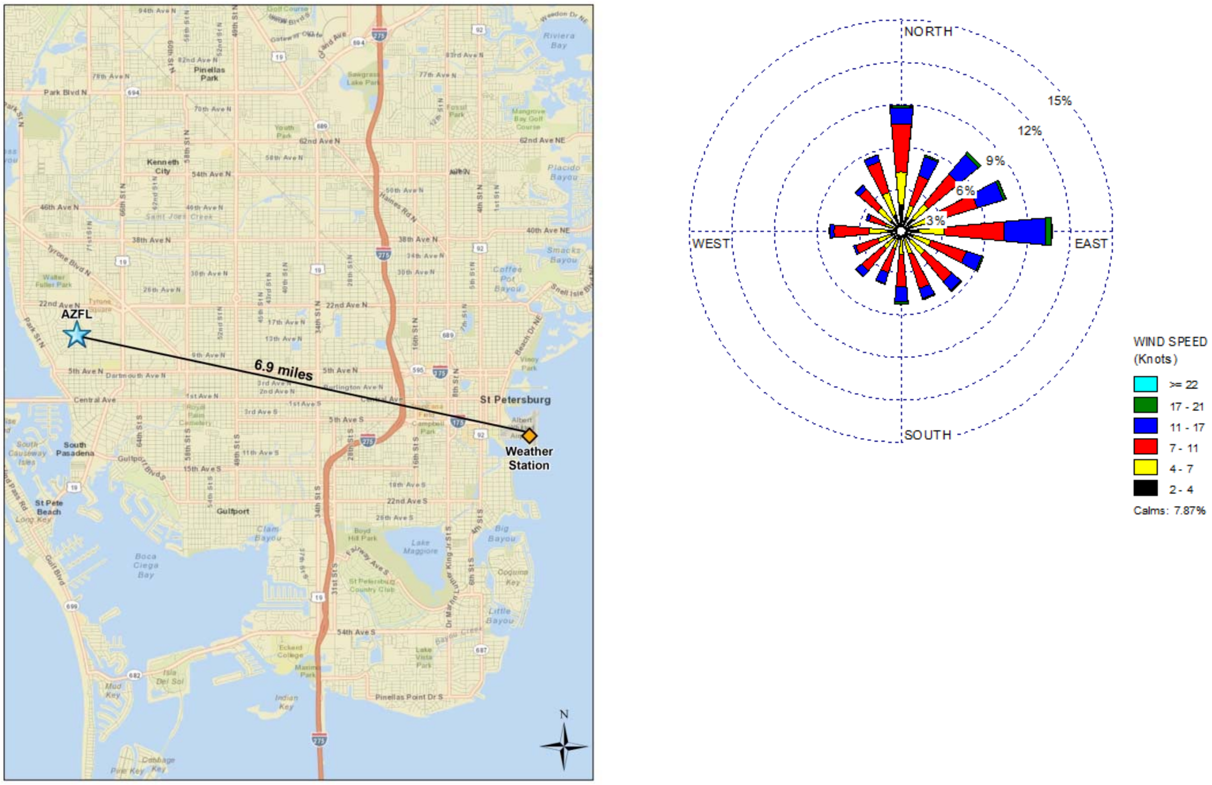
Hourly surface wind data from the weather stations nearest the Florida sites, as presented in Section 9.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 9-19 presents a map showing the distance between the weather station and AZFL, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 9-19 also presents three different wind roses for the AZFL monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 9-20 through 9-23 present the three wind roses and distance maps for SKFL, SYFL, ORFL, and PAFL, respectively.

Figure 9-19. Wind Roses for the St. Petersburg/Whitted Airport Weather Station near AZFL

Location of AZFL and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

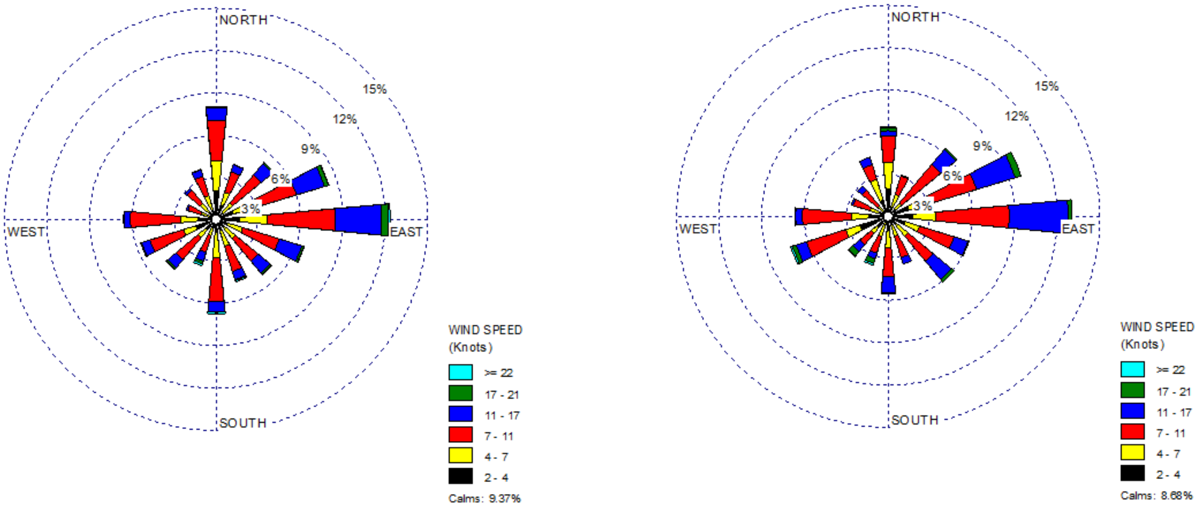
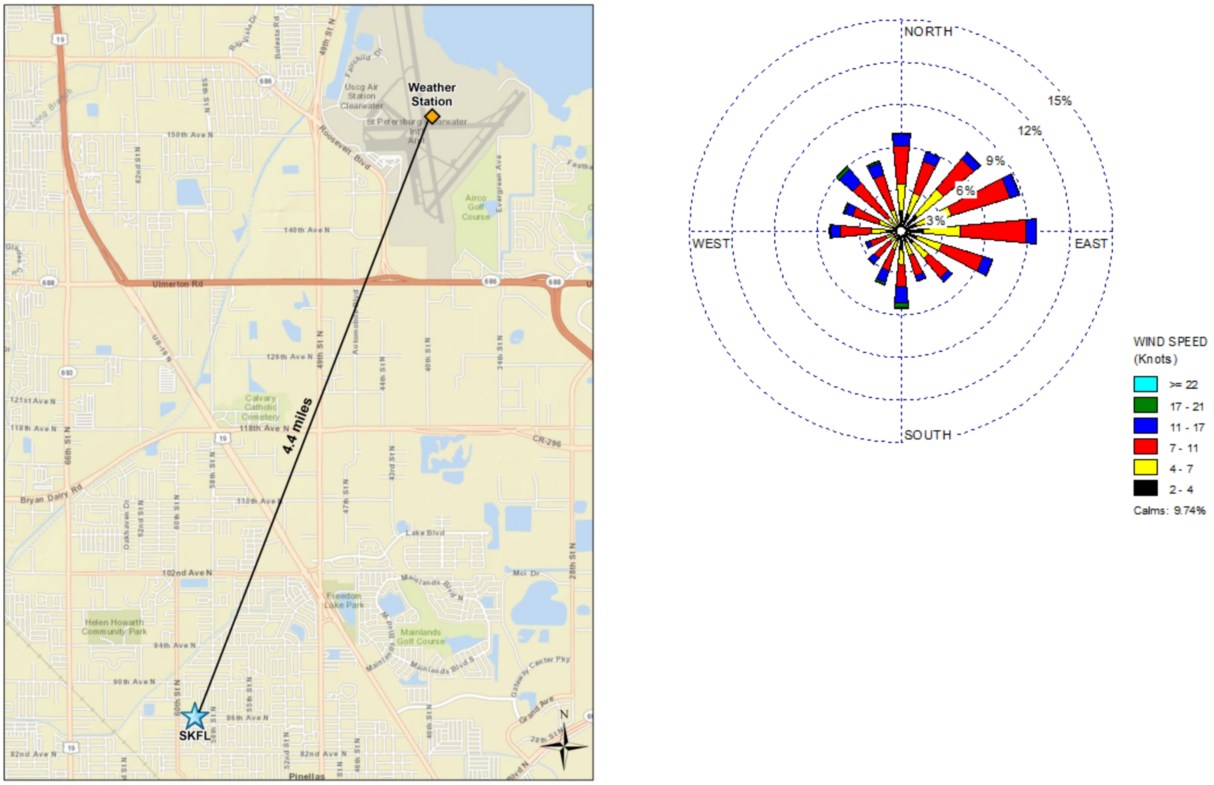


Figure 9-20. Wind Roses for the St. Petersburg/Clearwater International Airport Weather Station near SKFL



Location of SKFL and Weather Station

2002-2011 Historical Wind Rose

2012 Wind Rose

Sample Day Wind Rose

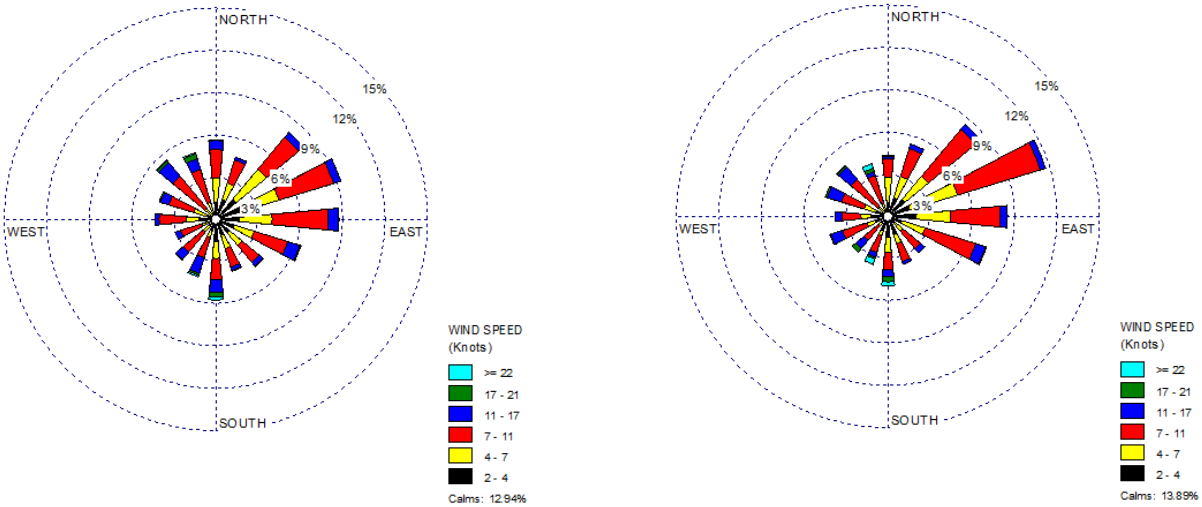
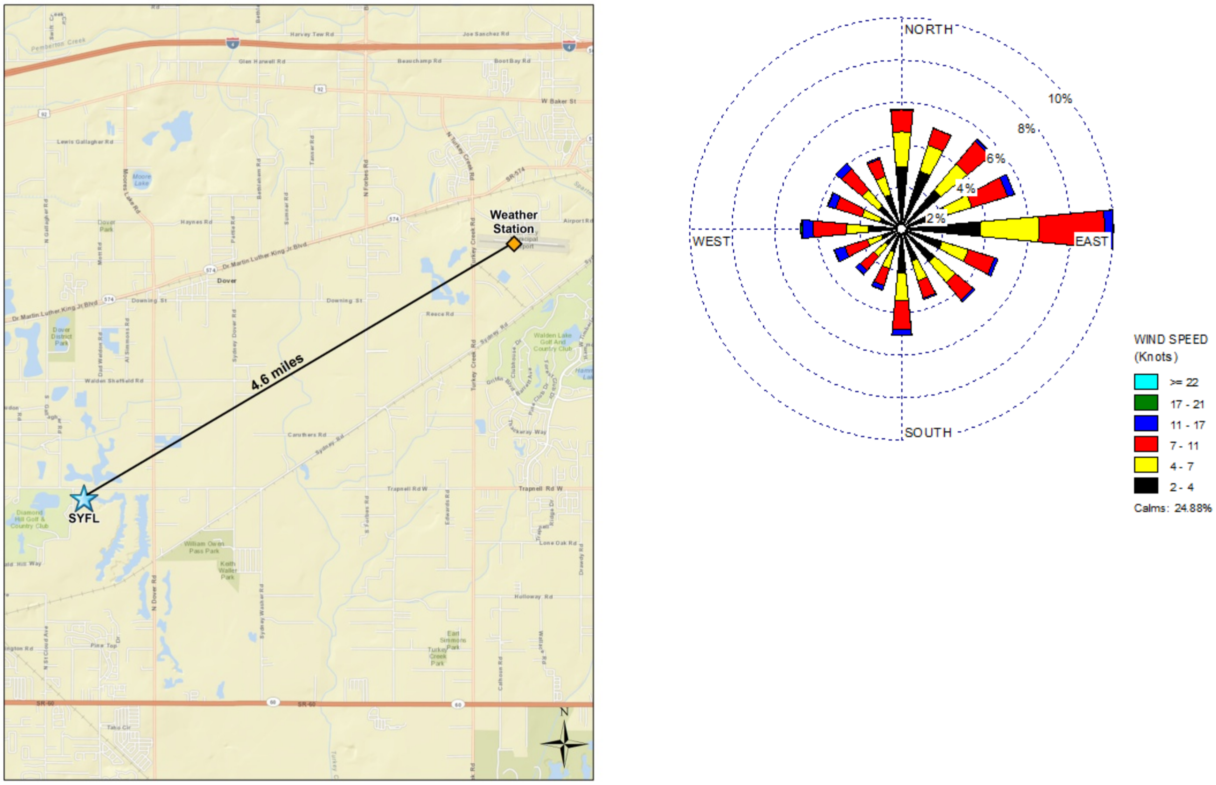


Figure 9-21. Wind Roses for the Plant City Municipal Airport Weather Station near SYFL

Location of SYFL and Weather Station

2008-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

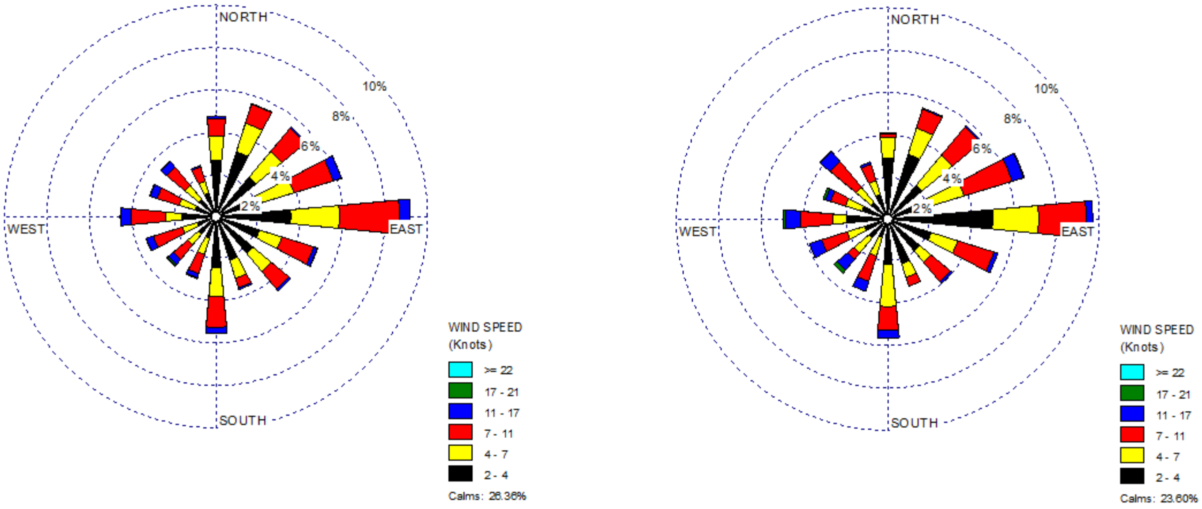
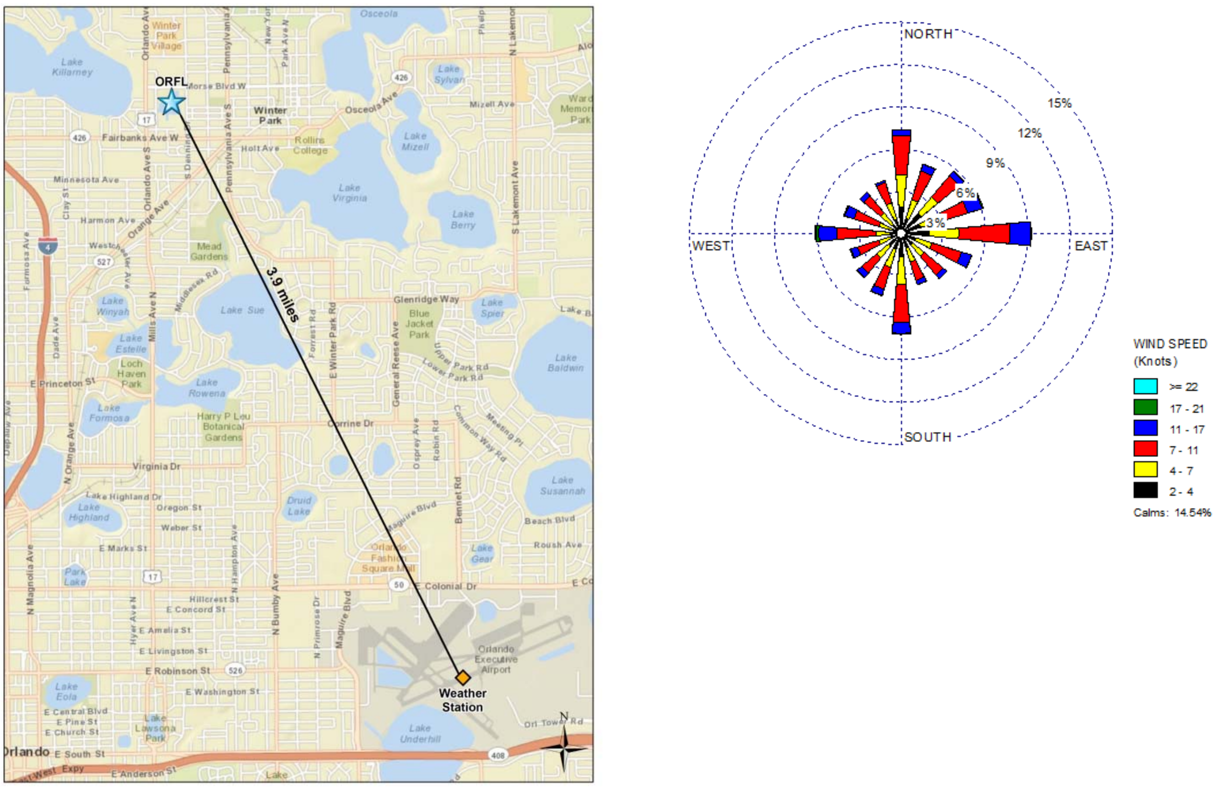


Figure 9-22. Wind Roses for the Orlando Executive Airport Weather Station near ORFL

Location of ORFL and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

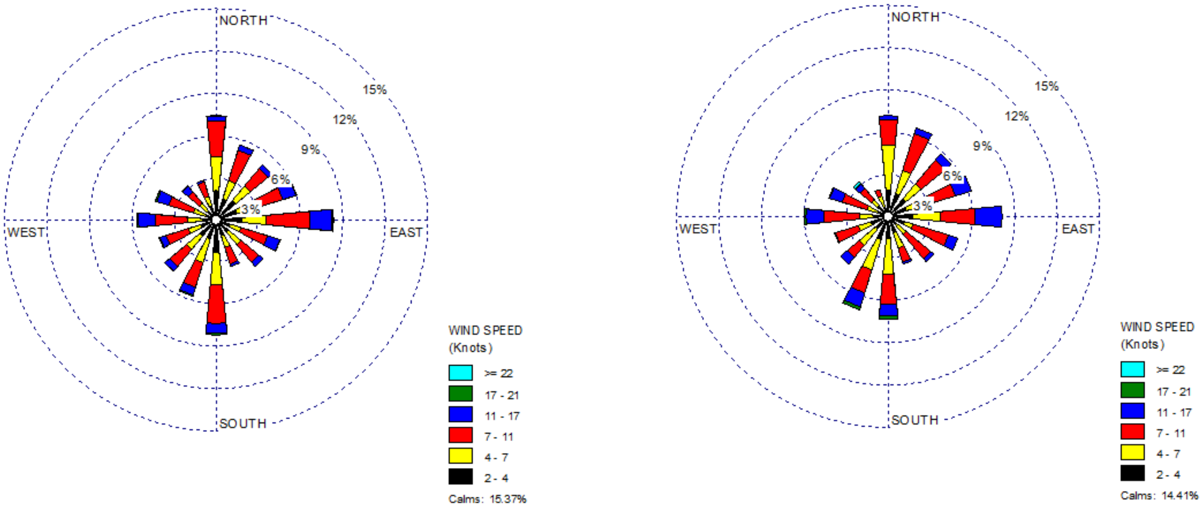
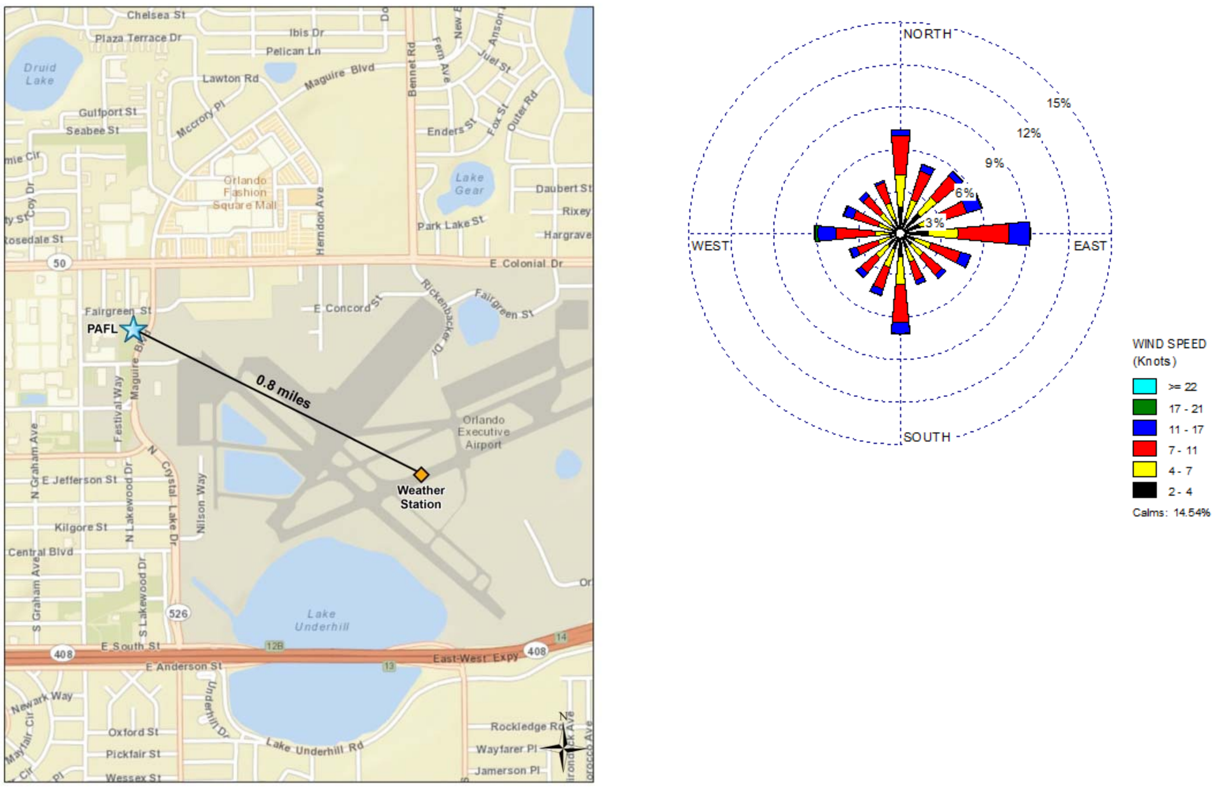


Figure 9-23. Wind Roses for the Orlando Executive Airport Weather Station near PAFL

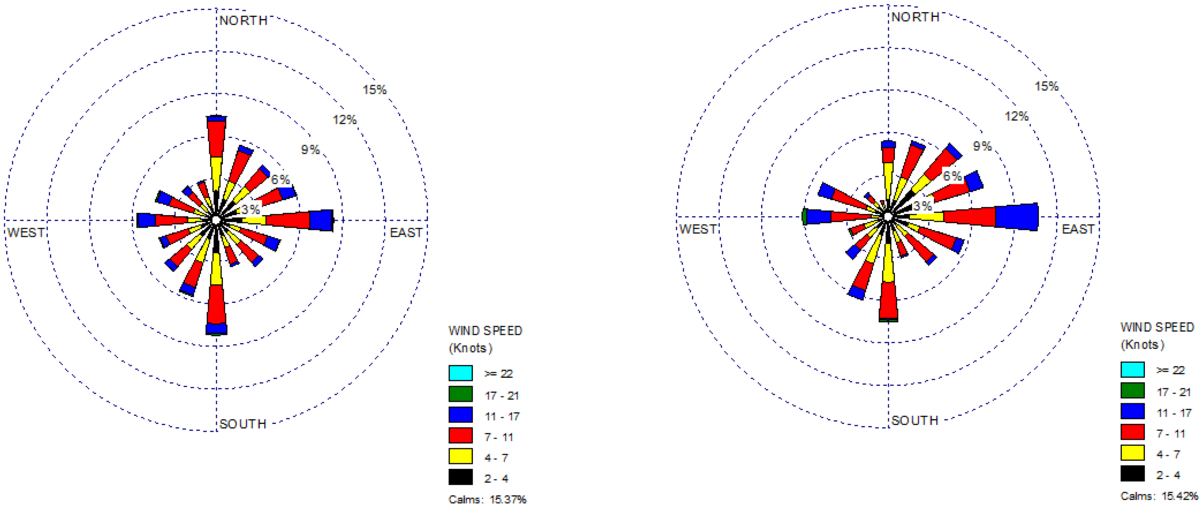
Location of PAFL and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose



Observations from Figure 9-19 for AZFL include the following:

- The weather station at St. Petersburg/Whitted Airport is located 6.9 miles east of AZFL. Between them is most of the city of St. Petersburg. Note that the Whitted Airport is located on the Tampa Bay coast while AZFL is on the west side of the peninsula near the Boca Ciega Bay.

- The historical wind rose shows that winds from the north, northeast quadrant, and east were the most commonly observed wind directions near AZFL while winds from the western quadrants were observed less frequently. Calm winds (≤ 2 knots) accounted for less than 8 percent of the hourly wind measurements.

- The full-year wind rose shows that winds from the north, east-northeast, and east are the predominant wind directions for 2012. While winds from the northwest quadrant and north-northeast to northeast were observed less frequently than in previous years, winds from the southeast and southwest quadrant were observed more often.

- The sample day wind patterns favor the full-year wind patterns, with east-northeasterly and easterly winds observed the most. However, fewer northerly winds were observed with a greater percentage of winds from the southeast and west-southwest observed on sample days.

Observations from Figure 9-20 for SKFL include the following:

- The weather station at St. Petersburg/Clearwater International Airport is located 4.4 miles north-northeast of SKFL. The St. Petersburg/Clearwater Airport is located on Old Tampa Bay while SKFL is farther inland.

- The historical wind rose shows that winds from a variety of directions were observed near SKFL, although winds from the north, northeast quadrant, east, and east-southeast were the most commonly observed wind directions. Calm winds accounted for approximately 10 percent of the hourly wind measurements.

- The 2012 wind rose resembles the historical wind rose in that winds from the northeast to east-southeast account for a majority of the wind observations. There is a higher percentage of calm winds for 2012 (nearly 13 percent) while winds from the north and north-northeast were observed less frequently.

- The predominance of winds from the northeast to east-southeast is even more evident on the sample day wind rose. With the exception of north-northeast, none of the other directions account for more than 5 percent of wind observations while calm winds account for nearly 14 percent of observations on sample days.

Observations from Figure 9-21 for SYFL include the following:

- The weather station at Plant City Municipal Airport is located 4.6 miles northeast of SYFL. Note that this weather station has less historical data than the other stations. This station did not begin operating until 2006 and data availability is intermittent until mid-2007; thus, the historical wind rose includes data from the first full-year of data (2008) through 2011.

- The historical wind rose shows that calm winds (≤ 2 knots) account for approximately 25 percent of the hourly wind measurements between 2008 and 2011. Winds from the eastern quadrants were observed more often than the western quadrants, although winds from all directions were observed near SYFL. Winds from due east account for the highest percentage of winds near SYFL (10 percent).

- Both the full-year and sample day wind patterns are similar to the historical wind patterns, indicating that conditions on sample days were representative of wind conditions experienced throughout the year and historically.

Observations from Figures 9-22 and 9-23 for ORFL and PAFL include the following:

- The closest weather station to both ORFL and PAFL is the Orlando Executive Airport. The weather station is located just less than 4 miles southeast of ORFL and less than 1 mile east-southeast of PAFL, as PAFL is located on the edge of the Orlando Executive Airport property. Thus, the historical and full-year wind roses for these sites are identical.

- The historical wind roses show that winds from all directions were observed near these sites, with easterly winds being observed the most, followed by winds from due north and due south. Winds with an easterly component were observed more often than winds with a westerly component. Calm winds were observed for less than 15 percent of the wind observations.

- The wind patterns shown on the full-year wind roses resemble the wind patterns on the historical wind roses.

- The sample day wind rose for ORFL exhibits the same prominence of easterly, northerly, and southerly winds, but winds from the entire northeast quadrant as well as winds from the south-southwest account for a higher percentage of wind observations than they do for the historical and full-year wind roses.

- The sample day wind rose for PAFL shares the easterly and southerly prominence of the full-year wind rose; however, winds from the northwest to north and southwest to west-southwest are reduced. The reductions in the wind observations from these directions are seen in additional observations in winds from the northeast to east to east-southeast as well as south-southwest. Note, however, that PAFL samples on a 1-in-12 day sampling schedule, leading to roughly half the sample days included in the sample day wind rose as ORFL.

9.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Florida monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 9-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 9-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. AZFL and ORFL sampled for carbonyl compounds only. SKFL and SYFL sampled for hexavalent chromium and PAHs in addition to carbonyl compounds. PAFL sampled for only PM_{10} metals.

Observations from Table 9-4 include the following:

- For AZFL and ORFL, the two sites sampling only carbonyl compounds, acetaldehyde and formaldehyde were the only two pollutants to fail screens. For both sites, formaldehyde failed one additional screen than acetaldehyde. Among the carbonyl compounds, only acetaldehyde, formaldehyde, and propionaldehyde have risk screening values. Propionaldehyde did not fail any screens for these two sites.

- Eight pollutants failed at least one screen for SKFL; 39 percent of concentrations for these eight pollutants were greater than their associated risk screening value (or failed screens). Three pollutants (acetaldehyde, formaldehyde, and naphthalene) contributed to 95 percent of failed screens for SKFL and therefore were identified as pollutants of interest for this site. Note that each of the remaining pollutants failed only one screen each.

- Five pollutants failed at least one screen for SYFL; 58 percent of concentrations for these five pollutants were greater than their associated risk screening value (or failed screens). Similar to SKFL, three pollutants (acetaldehyde, formaldehyde, and naphthalene) contributed to 95 percent of failed screens for SYFL and therefore were identified as pollutants of interest for this site. Note that each of the remaining pollutants failed only one screen each.

- Formaldehyde failed 100 percent of screens for all four sites sampling carbonyl compounds.

- Arsenic, manganese, and lead fail screens for PAFL, with arsenic contributing to nearly 80 percent of the total failed screens. Arsenic and manganese contributed to 95 percent of failed screens for PAFL and therefore were identified as pollutants of interest for this site.

Table 9-4. Risk-Based Screening Results for the Florida Monitoring Sites

Pollutant	Screening Value (μg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
St. Petersburg, Florida - AZFL						
Formaldehyde	0.077	59	59	100.00	50.43	50.43
Acetaldehyde	0.45	58	59	98.31	49.57	100.00
Total		117	118	99.15		
Pinellas Park, Florida - SKFL						
Acetaldehyde	0.45	59	59	100.00	33.52	33.52
Formaldehyde	0.077	59	59	100.00	33.52	67.05
Naphthalene	0.029	53	61	86.89	30.11	97.16
Acenaphthene	0.011	1	61	1.64	0.57	97.73
Benzo(a)pyrene	0.00057	1	50	2.00	0.57	98.30
Fluorene	0.011	1	60	1.67	0.57	98.86
Hexavalent Chromium	0.000083	1	48	2.08	0.57	99.43
Propionaldehyde	0.8	1	59	1.69	0.57	100.00
Total		176	457	38.51		
Valrico, Florida - SYFL						
Acetaldehyde	0.45	60	60	100.00	39.22	39.22
Formaldehyde	0.077	60	60	100.00	39.22	78.43
Naphthalene	0.029	31	59	52.54	20.26	98.69
Benzo(a)pyrene	0.00057	1	23	4.35	0.65	99.35
Propionaldehyde	0.8	1	60	1.67	0.65	100.00
Total		153	262	58.40		
Winter Park, Florida - ORFL						
Formaldehyde	0.077	61	61	100.00	50.41	50.41
Acetaldehyde	0.45	60	61	98.36	49.59	100.00
Total		121	122	99.18		
Orlando, Florida - PAFL						
Arsenic (PM_{10})	0.00023	29	30	96.67	78.38	78.38
Manganese (PM_{10})	0.005	7	30	23.33	18.92	97.30
Lead (PM_{10})	0.015	1	30	3.33	2.70	100.00
Total		37	90	41.11		

9.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Florida monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for each of the Florida monitoring sites are provided in Appendices L, M, N, and O.

9.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Florida site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Florida monitoring sites are presented in Table 9-5, where applicable. Note that concentrations of the PAHs and metals are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 9-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Florida Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (μg/m^3)	2nd Quarter Average (μg/m^3)	3rd Quarter Average (μg/m^3)	4th Quarter Average (μg/m^3)	Annual Average (μg/m^3)
St. Petersburg, Florida - AZFL						
Acetaldehyde	59/59	1.17 ± 0.16	1.11 ± 0.24	1.24 ± 0.27	2.25 ± 0.89	1.41 ± 0.24
Formaldehyde	59/59	2.27 ± 0.22	2.05 ± 0.35	1.79 ± 0.32	1.45 ± 0.24	1.90 ± 0.16
Pinellas Park, Florida - SKFL						
Acetaldehyde	59/59	1.58 ± 0.22	1.80 ± 0.53	1.04 ± 0.26	1.23 ± 0.39	1.41 ± 0.19
Formaldehyde	59/59	2.58 ± 0.27	3.13 ± 0.46	2.73 ± 1.25	2.27 ± 0.44	2.69 ± 0.36
Naphthalene [a]	61/61	89.29 ± 36.62	115.51 ± 60.39	71.88 ± 19.66	112.64 ± 49.83	96.91 ± 21.04
Valrico, Florida - SYFL						
Acetaldehyde	60/60	1.24 ± 0.34	1.66 ± 0.66	1.36 ± 0.24	1.55 ± 0.36	1.45 ± 0.20
Formaldehyde	60/60	1.77 ± 0.25	2.95 ± 0.99	2.38 ± 0.36	1.80 ± 0.26	2.24 ± 0.29
Naphthalene [a]	59/59	42.07 ± 13.19	38.46 ± 13.52	28.18 ± 6.63	39.08 ± 14.00	36.75 ± 5.79
Winter Park, Florida - ORFL						
Acetaldehyde	61/61	1.51 ± 0.55	0.93 ± 0.19	0.87 ± 0.14	1.03 ± 0.30	1.08 ± 0.17
Formaldehyde	61/61	1.74 ± 0.23	2.45 ± 0.44	2.26 ± 0.39	1.75 ± 0.32	2.05 ± 0.19
Orlando, Florida - PAFL						
Arsenic (PM_{10})[a]	30/30	1.10 ± 1.03	0.61 ± 0.32	0.86 ± 0.47	1.49 ± 0.81	1.02 ± 0.33
Manganese (PM_{10})[a]	30/30	2.02 ± 0.60	2.53 ± 1.77	7.53 ± 2.97	2.32 ± 0.97	3.69 ± 1.20

[a] Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

Observations from Table 9-5 include the following:

- The annual average concentration of formaldehyde is higher than the annual average concentration of acetaldehyde, for the sites where these two pollutants were measured.

- The annual average concentrations of formaldehyde range from 1.90 ± 0.16 μg/m^3 (AZFL) to 2.69 ± 0.36 μg/m^3 (SKFL). The annual average concentrations of acetaldehyde varied less, ranging from 1.08 ± 0.17 μg/m^3 (ORFL) to 1.45 ± 0.20 μg/m^3 (SYFL).

- The quarterly average concentrations of acetaldehyde and formaldehyde do not appear to exhibit a seasonal trend of any type. However, a few of the quarterly averages do stand out, as described in the bullets that follow.

- The fourth quarter acetaldehyde average concentration for AZFL is greater than the other quarterly average concentrations and has a relatively large confidence interval associated with it. Two concentrations greater than 5 µg/m^3 were measured at AZFL, one in November (5.69 µg/m^3) and one in December (5.43 µg/m^3). The next highest concentration was also measured during the fourth quarter but was roughly half as high (2.49 µg/m^3). Five of the eight concentrations greater than 2 µg/m^3 were measured at AZFL during the fourth quarter of 2012.

- The second quarter acetaldehyde average for SKFL is greater than the other quarterly average concentrations and has a relatively large confidence interval associated with it. The maximum acetaldehyde concentration was measured at SKFL in May (5.02 µg/m^3). The next two highest concentrations were measured on the same days in November and December as the maximum acetaldehyde concentrations measured at AZFL but were roughly half as high (2.67 µg/m^3 and 2.65 µg/m^3).

- Although the second quarter formaldehyde average for SKFL is greater than the other quarterly averages, the third quarter average has a large confidence interval associated with it. The maximum formaldehyde concentration was measured at SKFL on July 20, 2013 (11.43 µg/m^3). This concentration is two and a half times higher than the next two highest measurements, both of which were measured in May, and is among the highest formaldehyde concentrations measured across the program. No other formaldehyde measurements greater than 4 µg/m^3 were collected at this site.

- The second quarter formaldehyde average for SYFL is greater than the other quarterly averages and has a relatively large confidence interval associated with it. The maximum formaldehyde concentration was measured at SYFL on May 27, 2013 (9.08 µg/m^3). This concentration is more than twice the next highest measurement (4.02 µg/m^3 collected on September 24, 2013). No other formaldehyde measurements greater than 4 µg/m^3 were collected at this site. The highest and third highest formaldehyde concentrations were collected at SYFL on the same days in May as the second and third highest formaldehyde concentrations were collected at SKFL.

- Naphthalene was identified as a pollutant of interest for both SKFL and SYFL. The annual average concentration of naphthalene for SKFL is more than twice the annual average concentration for SYFL. A single measurement greater than 100 ng/m^3 was collected at SYFL while 19 measurements greater than 100 ng/m^3 were measured at SKFL, including seven greater than 200 ng/m^3 and one greater than 400 ng/m^3. The maximum naphthalene concentration measured at SKFL (435 ng/m^3) is among the highest concentrations of naphthalene measured across the program.

- PAFL is the only Florida monitoring site that did not sample carbonyl compounds or PAHs. The confidence interval for the first quarter average concentration of arsenic is nearly equivalent to the average itself, indicating the potential for outliers. The maximum arsenic concentration was measured at PAFL on January 22, 2012

(3.86 ng/m^3). The next highest measurement collected during this quarter was significantly less (1.21 ng/m^3). All other concentrations measured during this quarter were less than 0.65 ng/m^3.

- Not only is the third quarter average concentration of manganese significantly greater than the other quarterly averages, it also has a relatively large confidence interval. The five highest concentrations of manganese were all measured at PAFL during the third quarter and ranged from 8.05 ng/m^3 to 13.1 ng/m^3. Manganese concentrations measured at PAFL span an order of magnitude, ranging from 1.06 ng/m^3 to 13.1 ng/m^3, with a median concentration of 2.08 ng/m^3.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Florida sites from those tables include the following:

- None of the Florida monitoring sites appear in Table 4-10 for carbonyl compounds.

- SKFL has the eighth highest annual average concentration of naphthalene among NMP sites sampling this pollutant, as shown in Table 4-11. Note that the confidence interval associated with SKFL's annual average is among the larger confidence intervals, indicating more variability associated with this site's measurements.

- The annual average concentration of arsenic for PAFL ranked third highest among NMP sites sampling PM_{10} metals. This site is one of only three sites with annual average arsenic concentrations greater than 1 ng/m^3. The confidence interval associated with this annual average is also among the larger confidence intervals shown, indicating a higher level of variability associated with this site's measurements.

9.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 9-4 for each of the Florida monitoring sites. Figures 9-24 through 9-28 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 9-24. Program vs. Site-Specific Average Acetaldehyde Concentrations

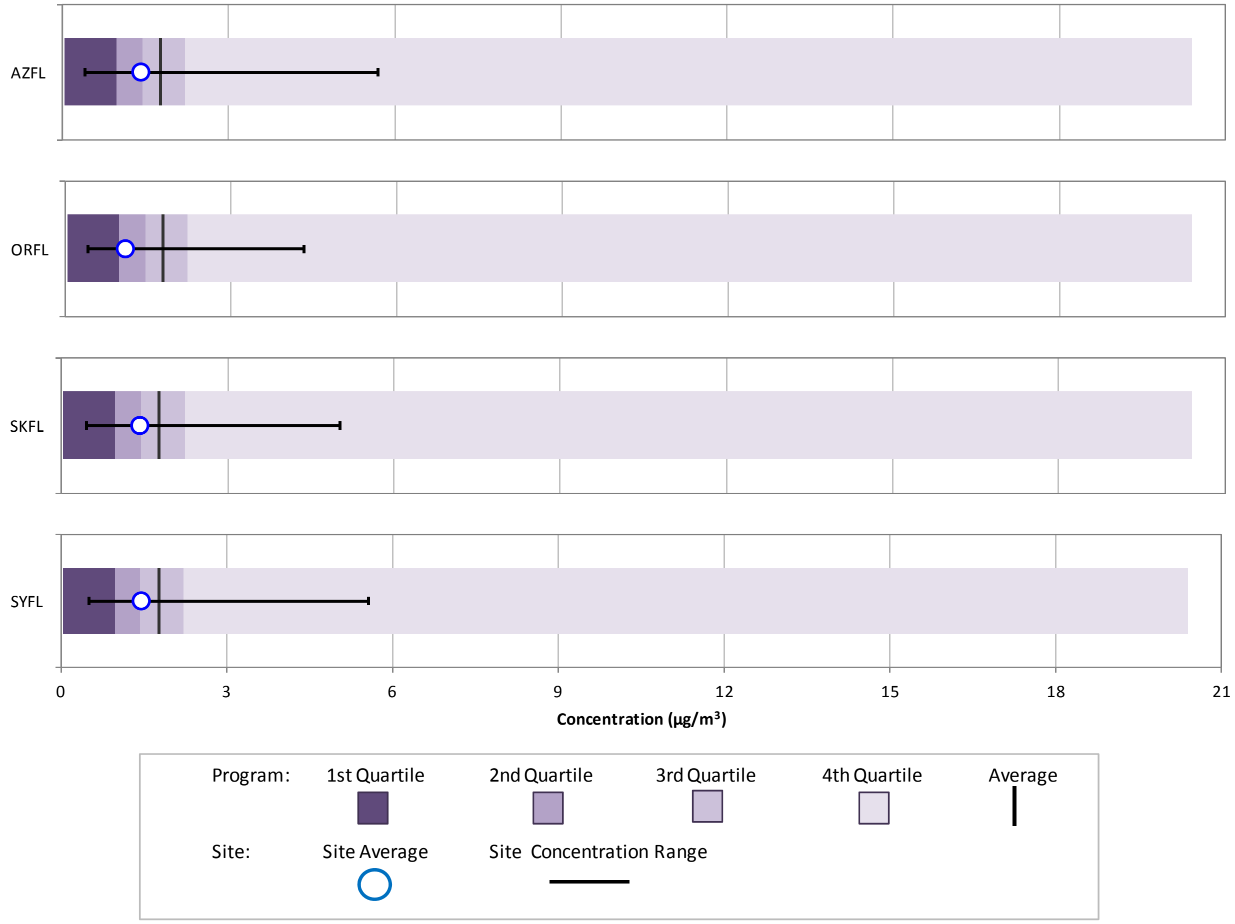


Figure 9-25. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

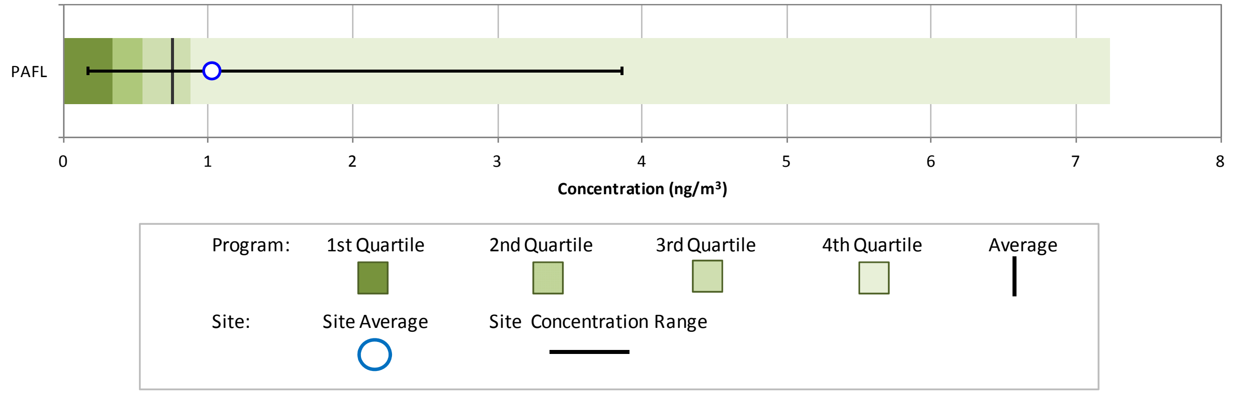


Figure 9-26. Program vs. Site-Specific Average Formaldehyde Concentrations

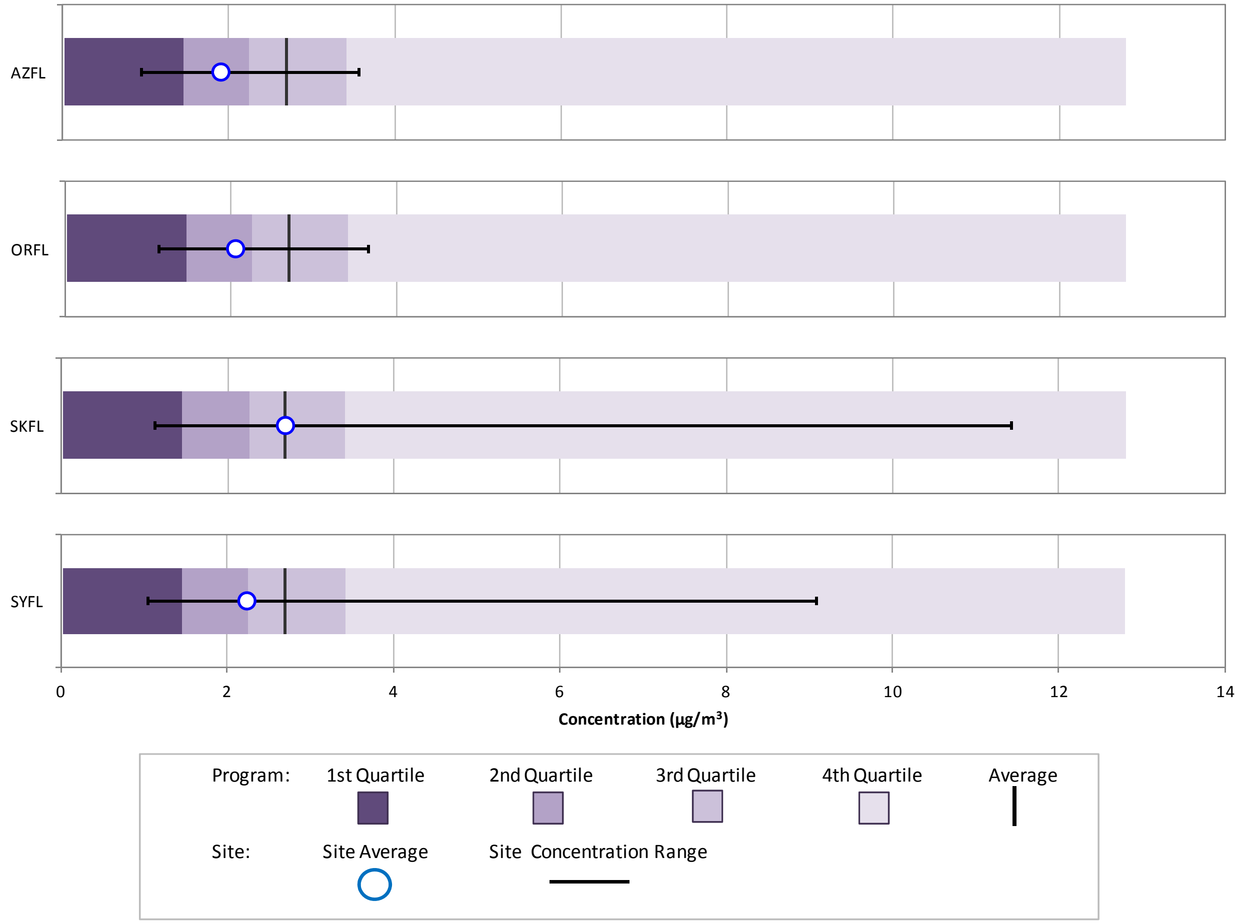


Figure 9-27. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

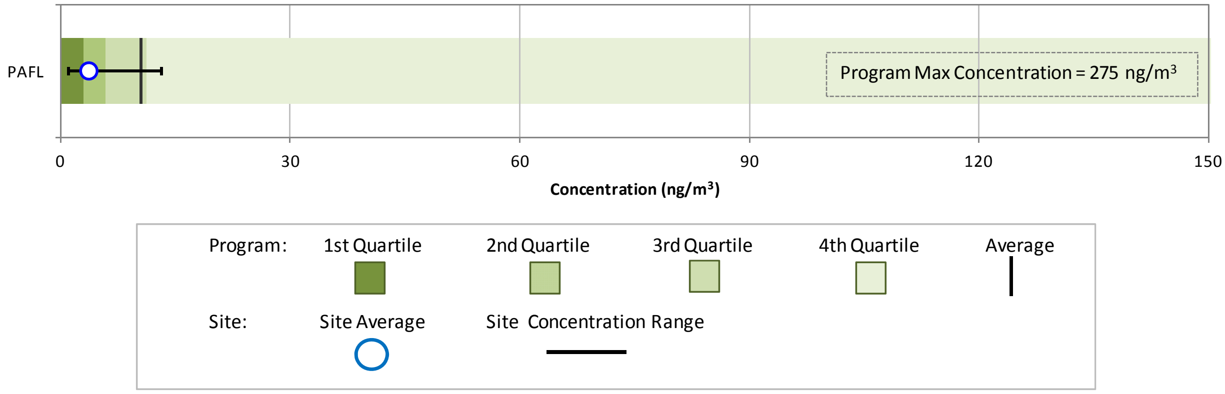
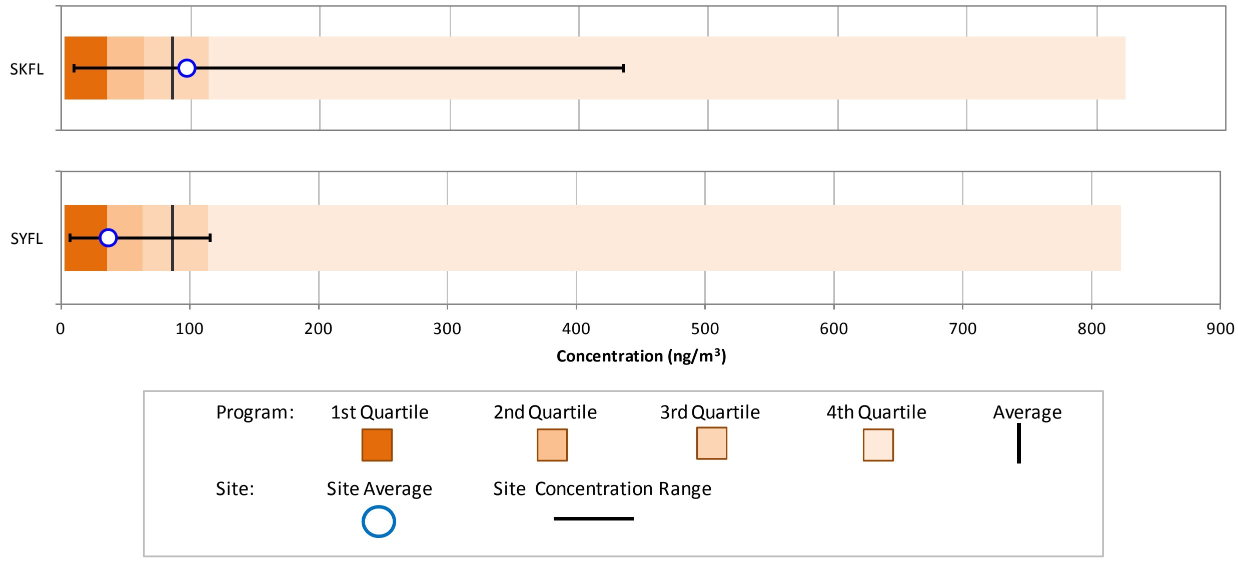


Figure 9-28. Program vs. Site-Specific Average Naphthalene Concentrations



Observations from Figures 9-24 through 9-28 include the following:

- Figure 9-24 for acetaldehyde shows that the range of acetaldehyde measurements collected at the Florida sites were not significantly different from each other. The annual average acetaldehyde concentrations for each of the Florida sites are less than the program-level average concentration. The maximum concentration measured at each site is significantly less than the maximum concentration measured across the program.

- Figure 9-25 for arsenic shows that PAFL's annual average concentration is greater than the program-level average concentration as well as the program-level third quartile. The maximum arsenic concentration measured at PAFL is roughly half the maximum concentration measured among sites sampling PM_{10} metals. There were no non-detects of arsenic measured at PAFL, although there were a few reported across the program.

- Figure 9-26 for formaldehyde shows there is more variability in the measurements of formaldehyde among the Florida sites than there is for acetaldehyde. AZFL and ORFL measured roughly the same range of measurements of formaldehyde and their annual averages are both less than the program-level average concentration. Although the maximum concentration of formaldehyde measured at SYFL is more than twice the maximum concentrations measured at AZFL or ORFL, the annual average for SYFL is just slightly greater than those calculated for AZFL or ORFL and roughly equivalent to the program-level median concentration. The maximum formaldehyde concentration measured at SKFL is one of the highest concentrations measured among NMP sites sampling this pollutant. The annual average concentration for SKFL is the only annual average among the Florida sites greater than the program-level average concentration (but just barely).

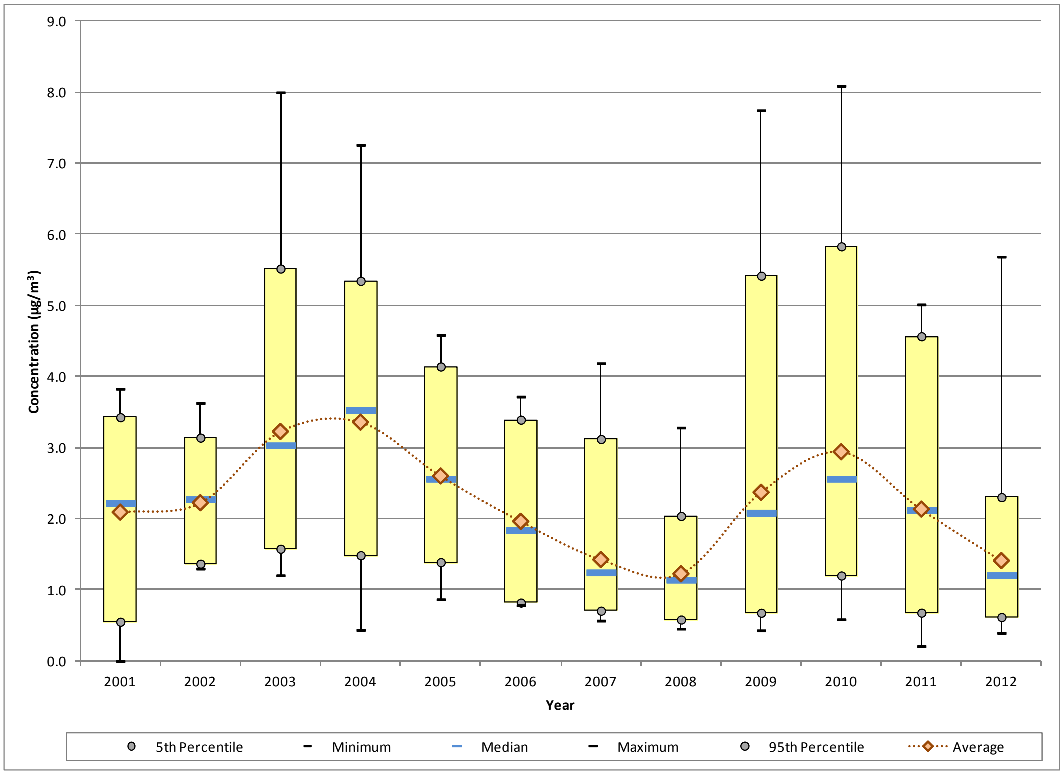
- Figure 9-27 presents the box plot for manganese. Note that the program-level maximum concentration (275 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 150 ng/m^3. Figure 9-27 for manganese shows that PAFL's annual average concentration is less than both the program-level average and median concentrations, despite the relative variability in the data set observed from the quarterly average concentrations discussed above. Compared to other NMP sites sampling manganese, this site's annual average concentration ranks 13th (out of 14). The maximum manganese concentration measured at PAFL is considerably less than the maximum concentration measured among NMP sites sampling PM_{10} metals.

- Figure 9-28 presents the box plots for naphthalene. The range of measurements collected at SKFL and SYFL are considerably different. The maximum concentration measured at SYFL is roughly equivalent to the program-level third quartile while the maximum concentration measured at SKFL is roughly four times higher. The annual average concentration for SYFL is just greater than the program-level first quartile while the annual average concentration for SKFL is greater than the program-level average concentration.

9.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. AZFL, ORFL, SKFL, and SYFL have sampled carbonyl compounds under the NMP for at least 5 consecutive years; in addition, sampling for PAHs at SKFL and SYFL and PM_{10} metals at PAFL began in 2008. Thus, Figures 9-29 through 9-40 present the 1-year statistical metrics for each of the pollutants of interest for each of the Florida monitoring sites. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 9-29. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at AZFL



Observations from Figure 9-29 for acetaldehyde measurements collected at AZFL include the following:

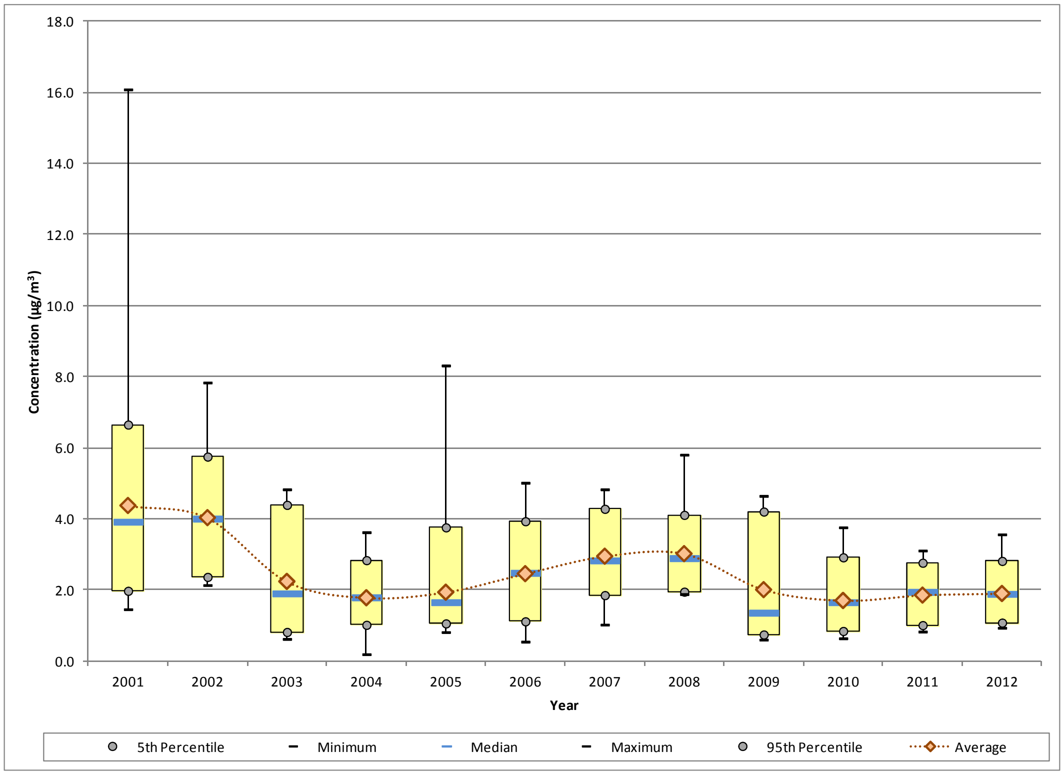
- Carbonyl compounds have been measured at AZFL under the NMP since 2001, making this site one of the longest running NMP sites.

- The maximum acetaldehyde concentration was measured in 2010 (8.09 µg/m^3), although a similar concentration was also measured in 2003 (8.00 µg/m^3).

- The 1-year average and median concentrations did not change significantly during the first 2 years of sampling, although the range of measurements is twice as large for 2001 compared to 2002. The 1-year average and median concentrations increased significantly from 2002 to 2003, stayed elevated through 2004, then began to decrease significantly, a trend that continued through 2008.

- The 1-year average and median began to increase again in 2009. This increase cannot be attributed to an outlier here or there because the trend continued into 2010 and the all statistical metrics exhibited this increase. The 95th percentile more than doubled from 2008 to 2009, as did the 1-year average concentration. A significant decrease is shown for 2011 and continues into 2012. Additional years of sampling are required to determine if this decreasing trend continues or if another round of increasing will be exhibited.

Figure 9-30. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at AZFL



Observations from Figure 9-30 for formaldehyde measurements collected at AZFL include the following:

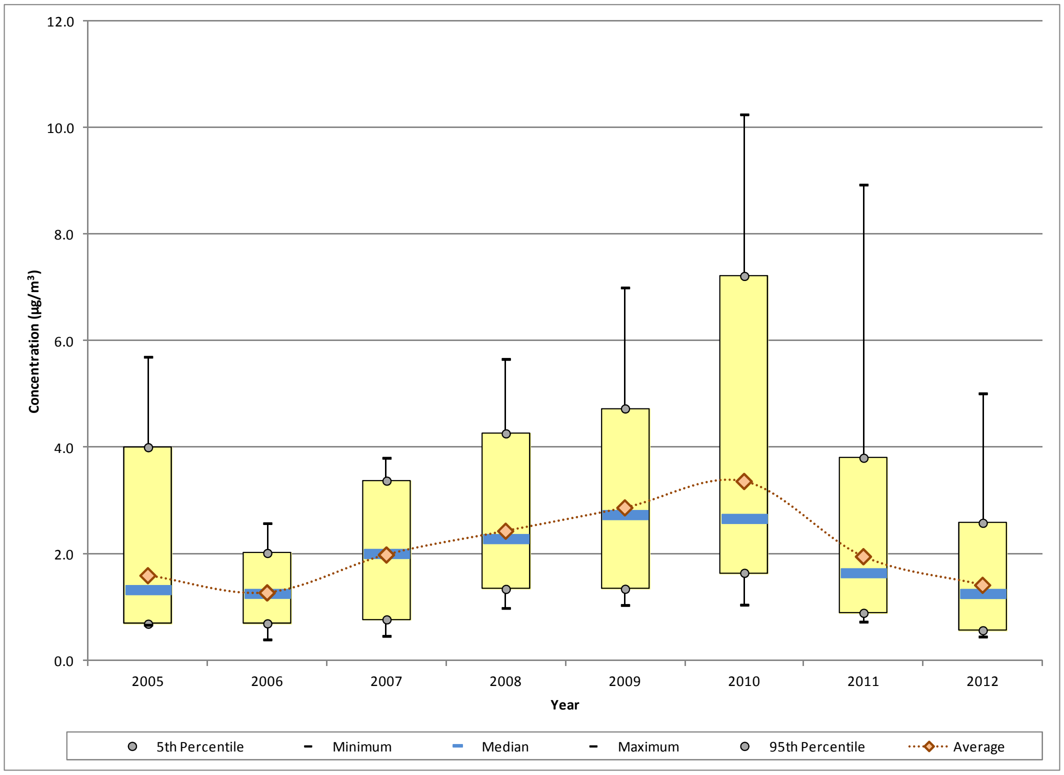
- The maximum formaldehyde concentration was measured in 2001, after which the highest concentration measured decreased by nearly half. The three highest concentrations of formaldehyde (ranging from 9.30 µg/m^3 to 16.1 µg/m^3) were all measured in 2001.

- The 1-year average and median formaldehyde concentrations decreased significantly from 2002 to 2003. The decreasing trend continued through 2004, after which an increasing trend is shown, which lasted through 2008. A second significant decrease is shown from 2008 to 2009 and into 2010. Very little change is shown for the last 2 years of sampling.

- The trends shown for formaldehyde in Figure 9-30 are almost the opposite of the trends shown for acetaldehyde in Figure 9-29, particularly for the period between 2004 through 2008.

- The difference between the 5th and 95th percentiles, the range within which the majority of the concentrations lie, is at a minimum for 2012.

Figure 9-31. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SKFL



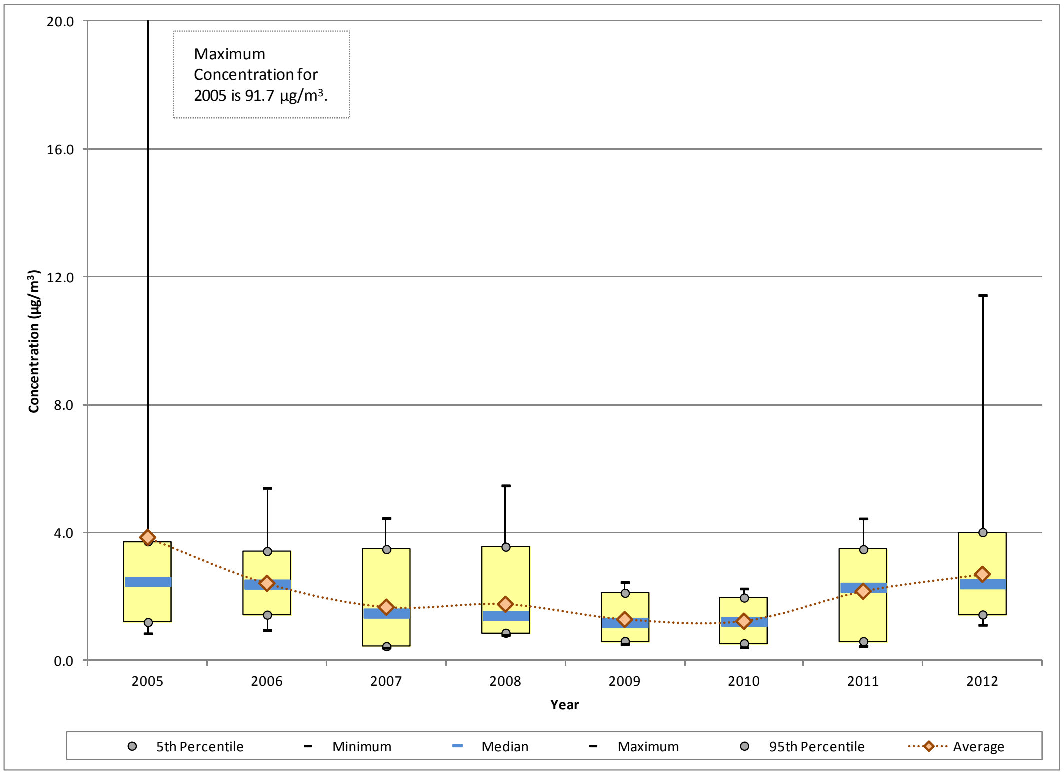
Observations from Figure 9-31 for acetaldehyde measurements collected at SKFL include the following:

- Sampling for carbonyl compounds began at SKFL under the NMP in late July 2004. Because this represents less than half of the sampling year, Figure 9-31 excludes data from 2004.

- The maximum acetaldehyde concentration shown was measured in 2010 (10.3 µg/m^3). Although the second highest concentration was measured in 2011 (8.94 µg/m^3), the third, fourth, and fifth highest concentrations of acetaldehyde were also measured in 2010.

- Even though the range of concentrations measured decreased by half from 2005 to 2006, the change in the 1-year average concentration is not statistically significant. After 2006, the 1-year average acetaldehyde concentration increased steadily, reaching a maximum in 2010. A significant decrease is shown for 2011 and continues into 2012.

Figure 9-32. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SKFL



Observations from Figure 9-32 for formaldehyde measurements collected at SKFL include the following:

- The maximum formaldehyde concentration was measured at SKFL on July 9, 2005 (91.7 µg/m^3). The second highest formaldehyde concentration was measured at SKFL in 2012, but is considerably less (11.4 µg/m^3).

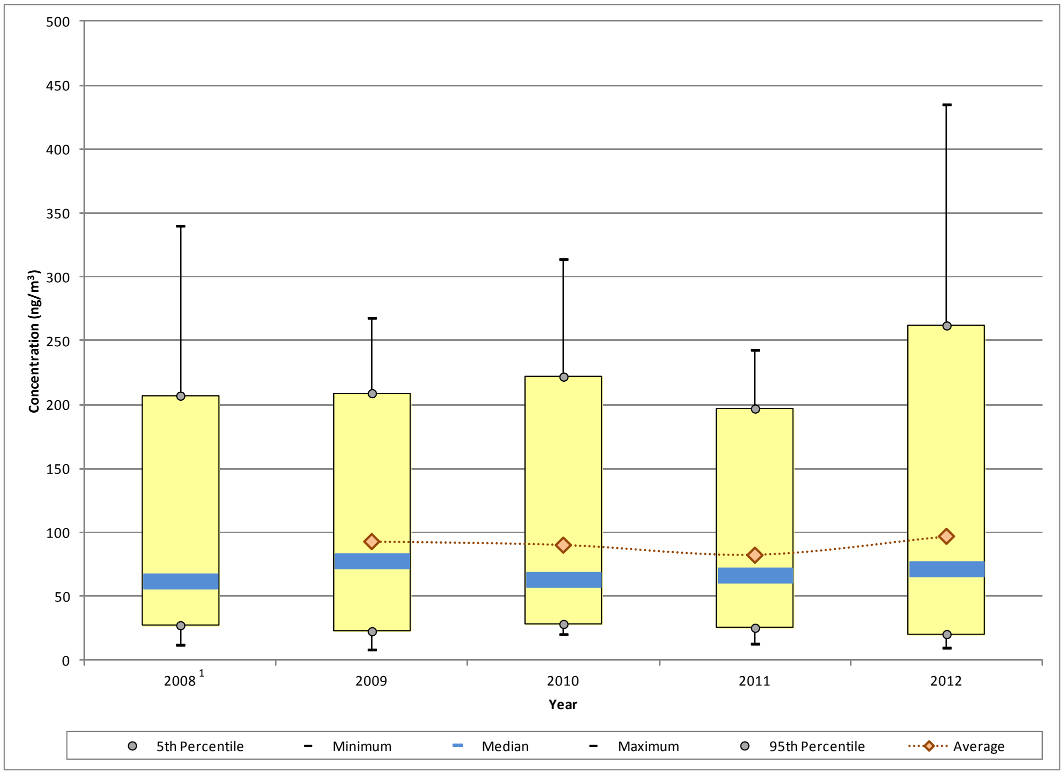
- For 2005, the 1-year average concentration is greater than the 95th percentile, reflecting the effects that an outlier can have on statistical measurements. With the exception of the maximum concentration measured in 2012, all other concentrations measured at this site were less than 6 µg/m^3 for the years shown.

- The 1-year average and median concentrations exhibit a steady decreasing trend through 2010. The range of measurements is at a minimum for 2010 and the 1-year average and median concentration are nearly equivalent, reflecting little variability in the central tendency of the measurements.

- The range of concentrations measurements increased significantly from 2010 to 2011, with the range within which 90 percent of the concentrations fall more than doubling.

- All of the statistical parameters increased from 2011 to 2012, indicating that concentrations of formaldehyde were higher overall at SKFL for 2012.

Figure 9-33. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SKFL



[1] A 1-year average is not presented because sampling under the NMP did not begin until March 2008.

Observations from Figure 9-33 for naphthalene measurements collected at SKFL include the following:

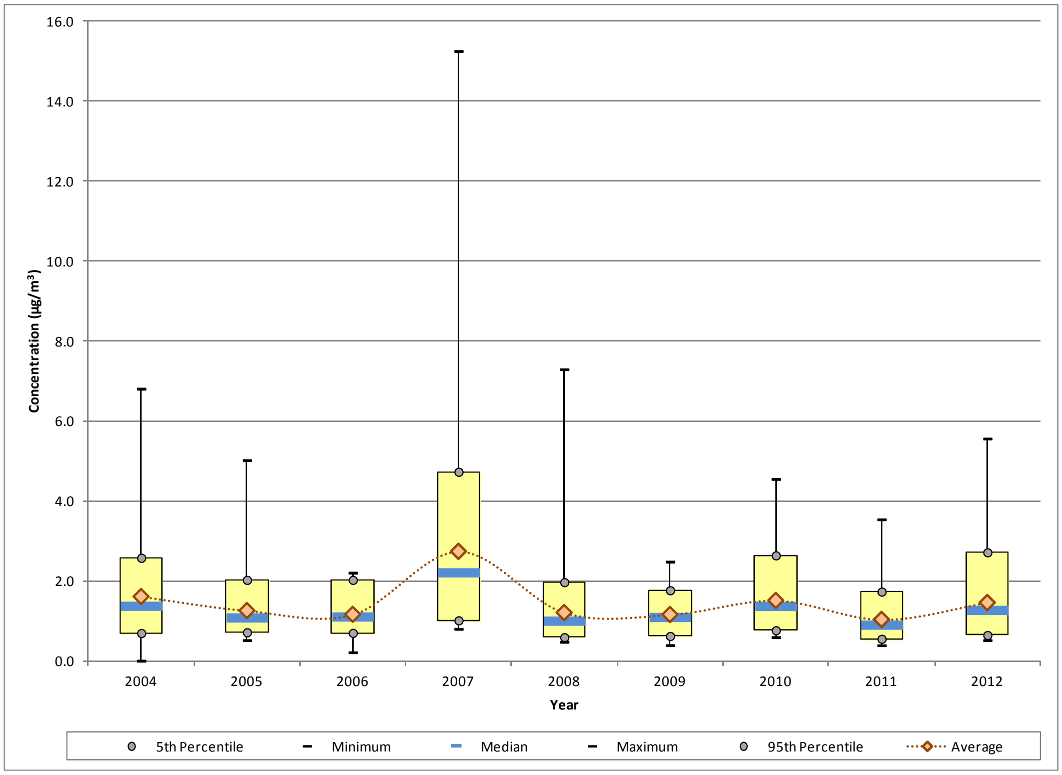
- Sampling for PAHs began at SKFL under the NMP in March 2008. A 1-year average is not presented for 2008 because a full year's worth of data is not available, although the range of measurements is provided.

- The maximum naphthalene concentration was measured at SKFL in 2012 (435 ng/m^3). Two additional measurements greater than 300 ng/m^3 have been measured at SKFL, one in 2008 and the other in 2010.

- The range within which the majority of naphthalene concentrations fall has changed very little across the years of sampling, although there is an increase shown for 2012 as 2012 has the greatest number of measurements greater than 200 ng/m^3 (seven).

- The 1-year average concentrations have varied from 82.22 ng/m^3 (2011) to 96.91 ng/m^3 (2012). Confidence intervals calculated for these averages indicate that the changes over the years are not statistically significant.

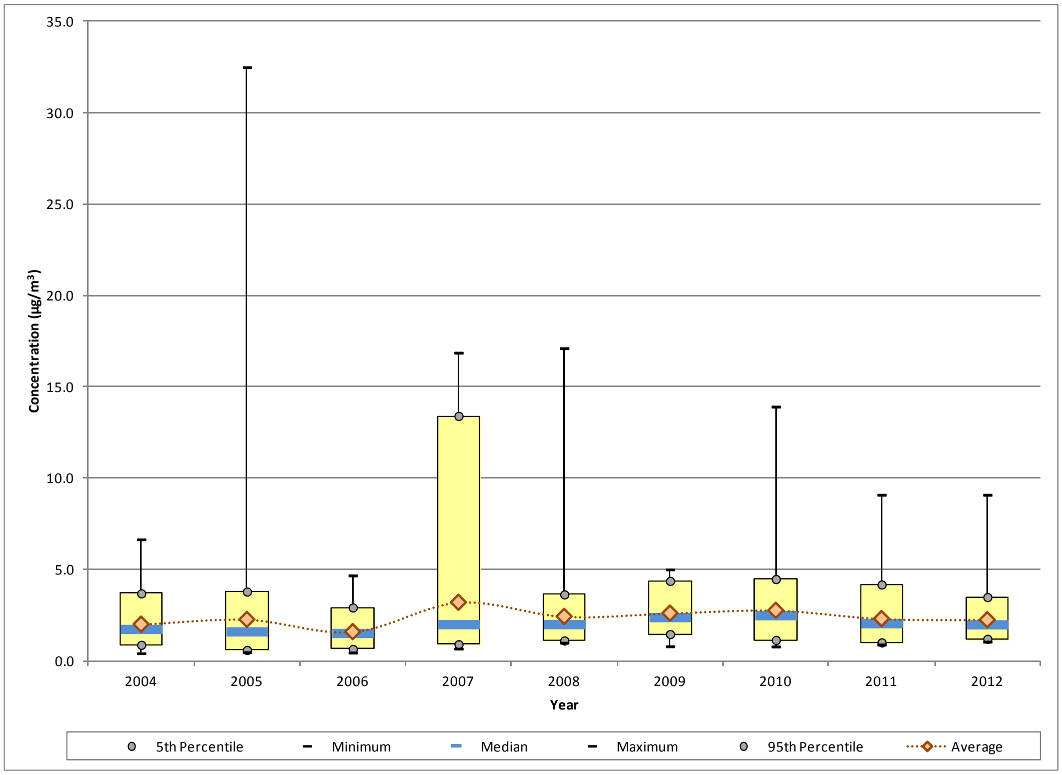
Figure 9-34. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SYFL



Observations from Figure 9-34 for acetaldehyde measurements collected at SYFL include the following:

- Carbonyl compounds have been measured at SYFL under the NMP since January 2004.
- The maximum acetaldehyde concentration was measured on January 18, 2007 (15.3 µg/m^3). The next highest concentration, also measured in 2007, is roughly half as high (7.55 µg/m^3). Only one additional acetaldehyde measurement collected at SYFL is greater than 7 µg/m^3 and was measured in 2008.
- After a decreasing trend through 2006, all of the statistical parameters increased for 2007. Even if the two measurements of acetaldehyde discussed above were removed from the calculation, the 1-year average concentration for 2007 is still 50 percent greater than the next highest 1-year average concentration. While every other year of sampling has three or less, 2007 has the greatest number of acetaldehyde concentrations greater than 3 µg/m^3 (16). Thus, it is not just the highest measurements driving this 1-year average concentration.
- With the exception of 2007, the 1-year average concentrations have fluctuated between 1.03 µg/m^3 (2011) and 1.60 µg/m^3 (2004). Confidence intervals calculated for the 1-year averages indicate that the year-to-year changes for years 2009 through 2012 are statistically significant.

Figure 9-35. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SYFL



Observations from Figure 9-35 for formaldehyde measurements collected at SYFL include the following:

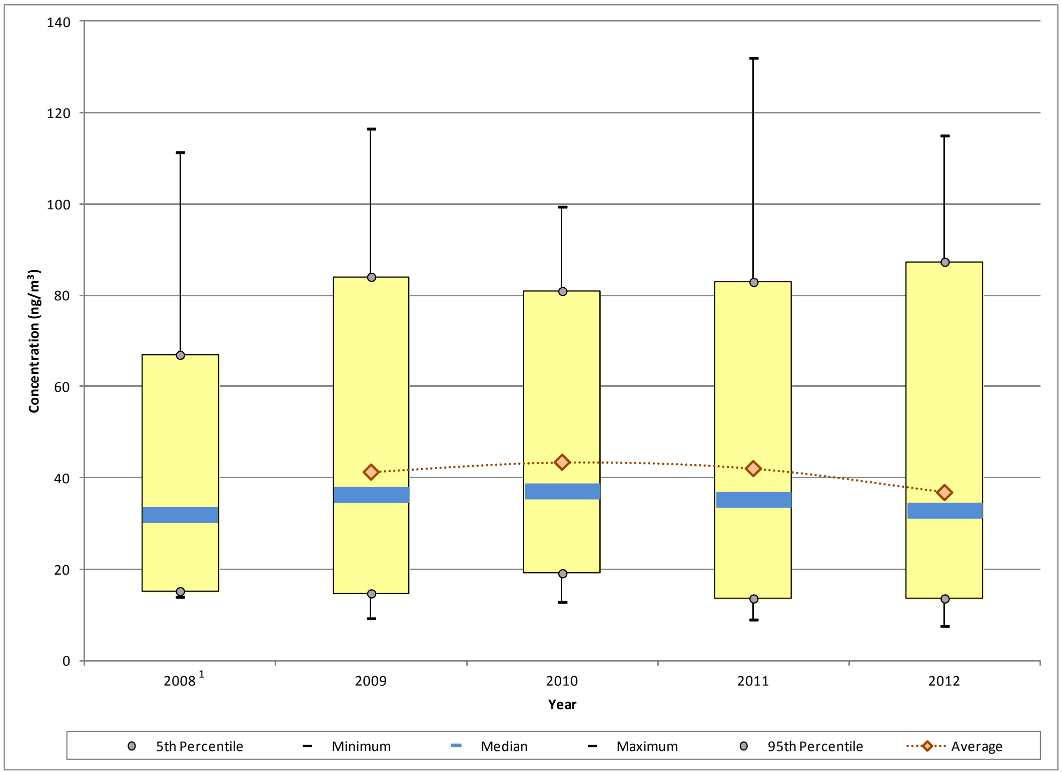
- The maximum formaldehyde concentration was measured at SYFL in 2005 (32.5 µg/m^3) and was nearly twice the next highest concentration (17.1 µg/m^3, measured in 2008), although several measurements of similar magnitude were also measured in 2007. In all, eight formaldehyde concentrations greater than 10 µg/m^3 have been measured at SYFL, five in 2007 and one each in 2005, 2008, and 2010.

- Even though the maximum concentration was measured in 2005, the next highest concentration measured that year is considerably less (4.17 µg/m^3). The 1-year average concentration exhibits a slight increase from 2004 to 2005 while the median concentration decreased slightly. The outlier measured in 2005 is mostly reflected in the confidence intervals calculated for this 1-year average concentration.

- Although the maximum concentration for 2007 is considerably less than the maximum measured in 2005, the other statistical parameters exhibit significant increases. In particular, the 95th percentile is four times higher and the 1-year average doubled from 2006 to 2007. These statistical parameters indicate that the measurements collected in 2007 were higher overall compared to other years. The number of formaldehyde concentrations greater than 5 µg/m^3 is highest for 2007 (seven), while every other year of sampling has two or less.

- The 1-year average formaldehyde concentration has fluctuated over the years, ranging from 1.58 µg/m^3 (2006) to 3.19 µg/m^3 (2007), with little change in the last 2 years.

Figure 9-36. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SYFL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 9-36 for naphthalene measurements collected at SYFL include the following:

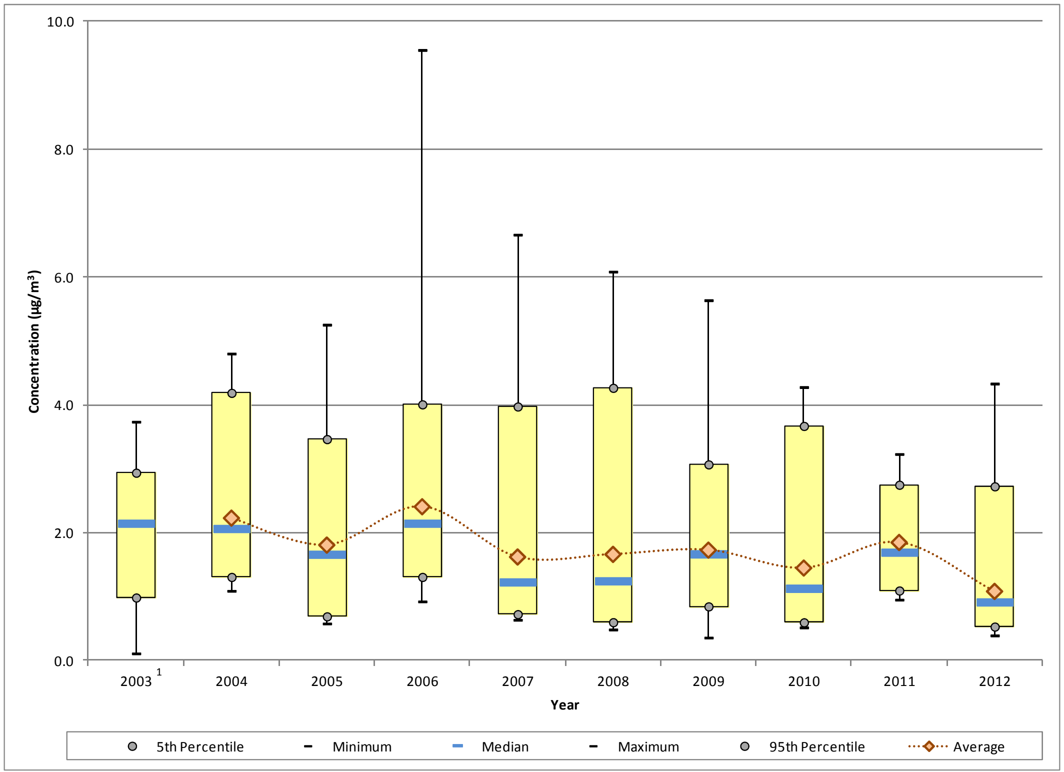
- Sampling for PAHs began at SYFL under the NMP in April 2008. A 1-year average is not presented for 2008 because a full year's worth of data is not available, although the range of measurements is provided.

- The two highest naphthalene concentrations were both measured in 2011 (132 ng/m^3 and 131 ng/m^3), although measurements greater than 100 ng/m^3 were also measured 2008, 2009, and 2012.

- The range within which the majority of naphthalene concentrations fall, as indicated by the difference between the 5th and 95th percentile for each year, has changed very little across the years of sampling. Although there is a slight increase shown for 2012, both the median and 1-year average concentrations exhibit slight decreases for 2012. This decrease is a result of a higher number of measurements at the lower end of the concentration range.

- The 1-year average concentrations have varied from 36.75 ng/m^3 (2012) to 43.38 ng/m^3 (2010), although confidence intervals calculated for these averages indicate that the changes over the years are not statistically significant.

Figure 9-37. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at ORFL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

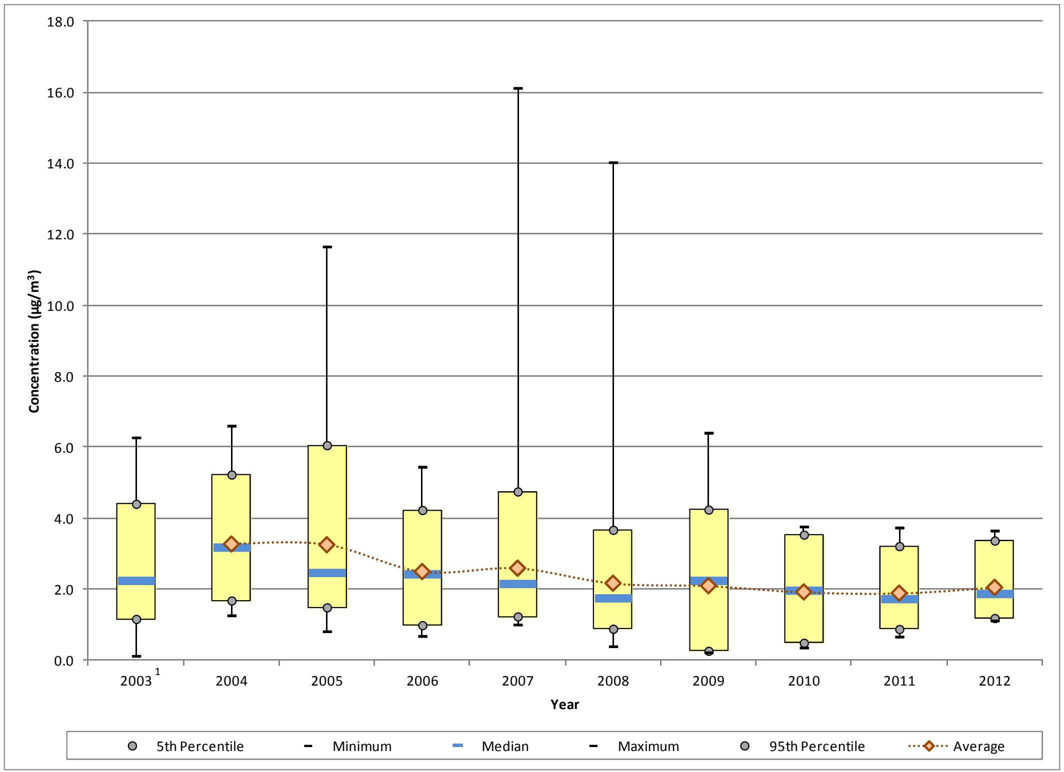
Observations from Figure 9-37 for acetaldehyde measurements collected at ORFL include the following:

- Sampling for carbonyl compounds began at ORFL under the NMP in April 2003. A 1-year average is not presented for 2003 because a full year's worth of data is not available, although the range of measurements is provided.

- The maximum acetaldehyde concentration was measured in 2006 (9.55 µg/m^3). The next three highest concentrations are the maximum concentrations shown for the three years that follow.

- Between 2007 and 2011, the 1-year average concentrations have varied from 1.45 µg/m^3 (2010) to 1.85 µg/m^3 (2011). The 1-year average concentration is at a minimum for 2012 (1.08 µg/m^3), which represents a significant decrease from 2011. The median concentration decreased by almost half from 2011 to 2012. The number of concentrations less than 1 µg/m^3 is one for 2011 but accounts for more than half of the measurements for 2012.

Figure 9-38. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at ORFL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

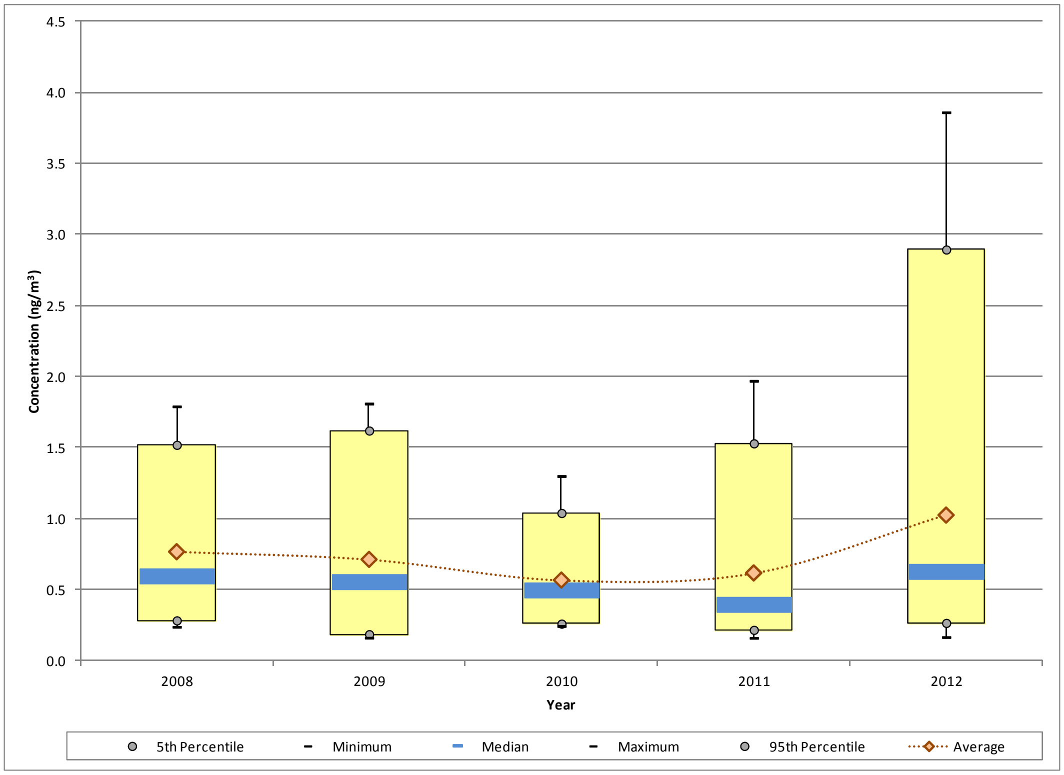
Observations from Figure 9-38 for formaldehyde measurements collected at ORFL include the following:

- The maximum formaldehyde concentration was measured in 2007 (16.1 µg/m^3), although concentrations greater than 10 µg/m^3 were also measured in 2005 and 2008.

- Even with the relatively high concentrations measured in the middle years of sampling, the 1-year average concentrations exhibit a steady decreasing trend through 2011. The median concentrations have decreased as well, but exhibited an increase in 2009, followed by additional decreases.

- The range of formaldehyde concentrations is at a minimum for 2012, and the maximum concentration for 2012 is the lowest maximum concentration shown for all years of sampling. Despite this, both the 1-year average and median concentrations increased slightly for 2012. Compared to 2011, concentrations measured in 2012 are just higher overall. There are fewer measurements at the lower end of the concentration range for 2012, as there were no measurements less than 1 µg/m^3 measured in 2012 (compared to four in 2011). In addition, the number of measurements at the upper end of the concentration range for 2012 is higher, as the number of measurements greater than 3 µg/m^3 is nearly double for 2012 than 2011.

Figure 9-39. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at PAFL



Observations from Figure 9-39 for arsenic measurements collected at PAFL include the following:

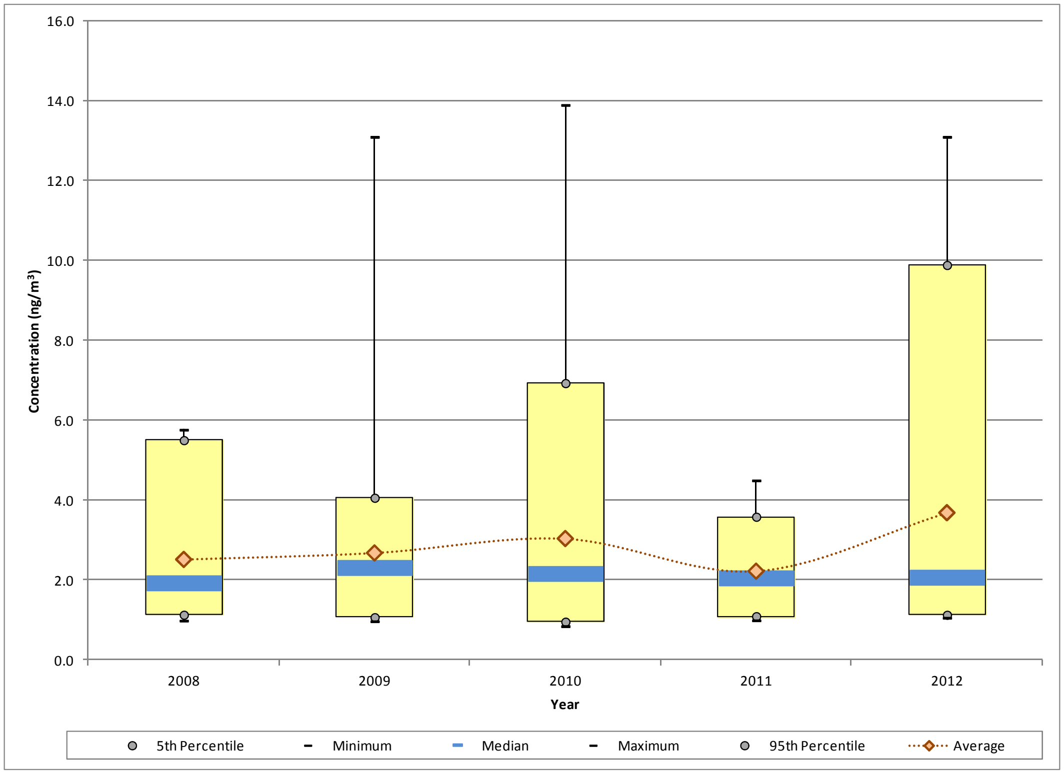
- All four of the arsenic concentrations greater than 2 ng/m^3 were measured in 2012, and ranged from 2.08 ng/m^3 to 3.86 ng/m^3.

- The range of arsenic measurements collected is at a minimum for 2010, increases for 2011, then doubles for 2012. The range within which the majority of concentrations fall, indicated by the difference between the 5th and 95th percentiles, nearly doubles from 2010 to 2011 and again for 2012.

- The 1-year average concentration has a slight decreasing trend through 2010. After a slight increase for 2011, the 1-year average increases substantially from 2011 to 2012. The median concentration exhibits a decreasing trend through 2011, even though the range of measurements increases from 2010 to 2011.

- The difference between the 1-year average and median concentrations is at a minimum for 2010. The increasing difference between these two statistical parameters for 2011 and 2012 indicates an increasing level of variability within the measurements. The number of measurements at the upper end of the concentration range has been increasing at PAFL, as the number of measurements greater than 1 ng/m^3 increased from two in 2010 to five in 2011 to nine in 2012. Conversely, the number of concentrations at the lower end of the range has been decreasing, even though the minimum concentration for each year is relatively unchanged. Additional years of sampling are needed to determine if this trend continues.

Figure 9-40. Yearly Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at PAFL



Observations from Figure 9-40 for manganese measurements collected at PAFL include the following:

- The maximum concentration of manganese was measured in 2010 (13.9 ng/m^3), although similar measurements were also collected in 2009 and 2012 (13.1 ng/m^3 for both years).

- With the exception of 2011, the 1-year average concentrations have an overall increasing trend since the onset of sampling at PAFL. However, the variability in the measurements, as indicated by confidence intervals calculated for each 1-year average concentration, indicates that the changes are not statistically significant.

- Similar to arsenic, the increase in the 95th percentile of manganese from 2011 to 2012 is substantial. But the 1-year average concentration for 2012 is greater than the 95th percentile for 2011, so this is not surprising. Eight measurements collected in 2012 are greater than the maximum concentration measured in 2011. Even if the maximum concentration was removed from the dataset for 2012, the increase in the 1-year average from 2011 to 2012 would still be greater than 1 ng/m^3.

9.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each Florida monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

9.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Florida monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

9.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Florida sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 9-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 9-6. Risk Approximations for the Florida Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
St. Petersburg, Florida - AZFL						
Acetaldehyde	0.0000022	0.009	59/59	1.41 ± 0.24	3.10	0.16
Formaldehyde	0.000013	0.0098	59/59	1.90 ± 0.16	24.76	0.19
Pinellas Park, Florida - SKFL						
Acetaldehyde	0.0000022	0.009	59/59	1.41 ± 0.19	3.11	0.16
Formaldehyde	0.000013	0.0098	59/59	2.69 ± 0.36	35.03	0.27
Naphthalene [a]	0.000034	0.003	61/61	0.10 ± 0.02	3.30	0.03
Valrico, Florida - SYFL						
Acetaldehyde	0.0000022	0.009	60/60	1.45 ± 0.20	3.20	0.16
Formaldehyde	0.000013	0.0098	60/60	2.24 ± 0.29	29.07	0.23
Naphthalene [a]	0.000034	0.003	59/59	0.04 ± 0.01	1.25	0.01
Winter Park, Florida - ORFL						
Acetaldehyde	0.0000022	0.009	61/61	1.08 ± 0.17	2.38	0.12
Formaldehyde	0.000013	0.0098	61/61	2.05 ± 0.19	26.68	0.21
Orlando, Florida - PAFL						
Arsenic (PM_{10})[a]	0.0043	0.000015	30/30	<0.01 ± <0.01	4.41	0.07
Manganese (PM_{10}) [a]		0.00005	30/30	<0.01 ± <0.01	--	0.07

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 9-5.

Observations for the Florida sites from Table 9-6 include the following:

- Formaldehyde has the highest cancer risk approximations among the sites sampling carbonyl compounds, ranging from 24.76 in-a-million (AZFL) to 35.03 in-a-million (SKFL).
- The cancer risk approximations for acetaldehyde are an order of magnitude less than the cancer risk approximations for formaldehyde, ranging from 2.38 in-a-million (ORFL) to 3.20 in-a-million (SYFL).
- The cancer risk approximation for naphthalene for SKFL (3.30 in-a-million) is twice the cancer risk approximation for naphthalene for SYFL (1.25 in-a-million), although both less than a level of concern.

- For PAFL, arsenic has a cancer risk approximation of 4.41 in-a-million. A cancer URE is not available for manganese; thus, a cancer risk approximation could not be calculated.

- All of the noncancer hazard approximations for the site-specific pollutants of interest are less than 1.0, indicating that no adverse health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for formaldehyde (0.27), based on the annual average concentration for SKFL.

9.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 9-7 and 9-8 present an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 9-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 9-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 9-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 9-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 9-7. Table 9-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 9.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 9-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Florida Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
St. Petersburg, Florida (Pinellas County) - AZFL					
Benzene	281.41	Benzene	2.19E-03	Formaldehyde	24.76
Ethylbenzene	179.80	Formaldehyde	1.95E-03	Acetaldehyde	3.10
Formaldehyde	149.82	1,3-Butadiene	1.22E-03		
Acetaldehyde	98.95	POM, Group 1a	1.02E-03		
1,3-Butadiene	40.57	Naphthalene	6.10E-04		
Naphthalene	17.93	Ethylbenzene	4.49E-04		
POM, Group 1a	11.61	Arsenic, PM	2.34E-04		
Dichloromethane	3.85	Acetaldehyde	2.18E-04		
POM, Group 2b	2.14	Hexavalent Chromium, PM	2.17E-04		
POM, Group 2d	1.93	POM, Group 2b	1.88E-04		
Pinellas Park, Florida (Pinellas County) - SKFL					
Benzene	281.41	Benzene	2.19E-03	Formaldehyde	35.03
Ethylbenzene	179.80	Formaldehyde	1.95E-03	Naphthalene	3.30
Formaldehyde	149.82	1,3-Butadiene	1.22E-03	Acetaldehyde	3.11
Acetaldehyde	98.95	POM, Group 1a	1.02E-03		
1,3-Butadiene	40.57	Naphthalene	6.10E-04		
Naphthalene	17.93	Ethylbenzene	4.49E-04		
POM, Group 1a	11.61	Arsenic, PM	2.34E-04		
Dichloromethane	3.85	Acetaldehyde	2.18E-04		
POM, Group 2b	2.14	Hexavalent Chromium, PM	2.17E-04		
POM, Group 2d	1.93	POM, Group 2b	1.88E-04		

Table 9-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Valrico, Florida (Hillsborough County) - SYFL					
Benzene	419.18	Formaldehyde	3.37E-03	Formaldehyde	29.07
Ethylbenzene	276.57	Benzene	3.27E-03	Acetaldehyde	3.20
Formaldehyde	259.18	1,3-Butadiene	1.88E-03	Naphthalene	1.25
Acetaldehyde	162.39	Cadmium, PM	1.37E-03		
1,3-Butadiene	62.74	Arsenic, PM	1.20E-03		
Naphthalene	28.97	Nickel, PM	1.15E-03		
POM, Group 1a	8.57	Naphthalene	9.85E-04		
Methyl *tert* butyl ether	7.67	POM, Group 1a	7.54E-04		
POM, Group 2b	3.78	Ethylbenzene	6.91E-04		
POM, Group 2d	3.11	Hexavalent Chromium, PM	6.78E-04		
Winter Park, Florida (Orange County) - ORFL					
Benzene	418.04	Hexavalent Chromium, PM	5.36E-03	Formaldehyde	26.68
Formaldehyde	289.94	Formaldehyde	3.77E-03	Acetaldehyde	2.38
Ethylbenzene	284.85	Benzene	3.26E-03		
Acetaldehyde	161.98	1,3-Butadiene	1.92E-03		
1,3-Butadiene	64.14	Naphthalene	1.00E-03		
Naphthalene	29.54	POM, Group 1a	9.44E-04		
POM, Group 1a	10.73	Ethylbenzene	7.12E-04		
POM, Group 2b	4.76	POM, Group 2b	4.19E-04		
POM, Group 2d	3.49	Acetaldehyde	3.56E-04		
Tetrachloroethylene	2.91	Arsenic, PM	3.49E-04		

Table 9-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Orlando, Florida (Orange County) - PAFL					
Benzene	418.04	Hexavalent Chromium, PM	5.36E-03	Arsenic	4.41
Formaldehyde	289.94	Formaldehyde	3.77E-03		
Ethylbenzene	284.85	Benzene	3.26E-03		
Acetaldehyde	161.98	1,3-Butadiene	1.92E-03		
1,3-Butadiene	64.14	Naphthalene	1.00E-03		
Naphthalene	29.54	POM, Group 1a	9.44E-04		
POM, Group 1a	10.73	Ethylbenzene	7.12E-04		
POM, Group 2b	4.76	POM, Group 2b	4.19E-04		
POM, Group 2d	3.49	Acetaldehyde	3.56E-04		
Tetrachloroethylene	2.91	Arsenic, PM	3.49E-04		

Table 9-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
St. Petersburg, Florida (Pinellas County) - AZFL					
Toluene	2,255.54	Acrolein	376,906.97	Formaldehyde	0.19
Ethylene glycol	1,129.96	1,3-Butadiene	20,283.73	Acetaldehyde	0.16
Xylenes	744.68	Formaldehyde	15,287.30		
Hexane	740.44	Acetaldehyde	10,994.91		
Methanol	533.81	Benzene	9,380.21		
Benzene	281.41	Xylenes	7,446.78		
Ethylbenzene	179.80	Naphthalene	5,976.63		
Formaldehyde	149.82	Lead, PM	4,943.69		
Acetaldehyde	98.95	Hydrochloric acid	4,371.98		
Hydrochloric acid	87.44	Arsenic, PM	3,633.59		
Pinellas Park, Florida (Pinellas County) - SKFL					
Toluene	2,255.54	Acrolein	376,906.97	Formaldehyde	0.27
Ethylene glycol	1,129.96	1,3-Butadiene	20,283.73	Acetaldehyde	0.16
Xylenes	744.68	Formaldehyde	15,287.30	Naphthalene	0.03
Hexane	740.44	Acetaldehyde	10,994.91		
Methanol	533.81	Benzene	9,380.21		
Benzene	281.41	Xylenes	7,446.78		
Ethylbenzene	179.80	Naphthalene	5,976.63		
Formaldehyde	149.82	Lead, PM	4,943.69		
Acetaldehyde	98.95	Hydrochloric acid	4,371.98		
Hydrochloric acid	87.44	Arsenic, PM	3,633.59		

Table 9-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Valrico, Florida (Hillsborough County) - SYFL					
Toluene	3,156.55	Acrolein	743,682.57	Formaldehyde	0.23
Ethylene glycol	1,555.96	Cadmium, PM	76,142.15	Acetaldehyde	0.16
Xylenes	1,077.05	1,3-Butadiene	31,371.77	Naphthalene	0.01
Hexane	951.56	Nickel, PM	26,715.11		
Methanol	723.09	Formaldehyde	26,447.31		
Benzene	419.18	Hydrochloric acid	19,484.80		
Hydrochloric acid	389.70	Arsenic, PM	18,554.76		
Ethylbenzene	276.57	Acetaldehyde	18,043.57		
Formaldehyde	259.18	Benzene	13,972.74		
Acetaldehyde	162.39	Manganese, PM	13,932.27		
Winter Park, Florida (Orange County) - ORFL					
Toluene	3,175.01	Acrolein	835,285.94	Formaldehyde	0.21
Ethylene glycol	1,451.68	1,3-Butadiene	32,071.75	Acetaldehyde	0.12
Xylenes	1,148.79	Hexamethylene-1,6-diisocyanate, gas	30,043.31		
Hexane	933.11	Formaldehyde	29,586.10		
Methanol	678.41	Acetaldehyde	17,997.24		
Benzene	418.04	Benzene	13,934.55		
Formaldehyde	289.94	Xylenes	11,487.90		
Ethylbenzene	284.85	Naphthalene	9,845.69		
Acetaldehyde	161.98	Hydrochloric acid	6,814.94		
Hydrochloric acid	136.30	Arsenic, PM	5,407.85		

Table 9-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Orlando, Florida (Orange County) - PAFL					
Toluene	3,175.01	Acrolein	835,285.94	Manganese	0.07
Ethylene glycol	1,451.68	1,3-Butadiene	32,071.75	Arsenic	0.07
Xylenes	1,148.79	Hexamethylene-1,6-diisocyanate, gas	30,043.31		
Hexane	933.11	Formaldehyde	29,586.10		
Methanol	678.41	Acetaldehyde	17,997.24		
Benzene	418.04	Benzene	13,934.55		
Formaldehyde	289.94	Xylenes	11,487.90		
Ethylbenzene	284.85	Naphthalene	9,845.69		
Acetaldehyde	161.98	Hydrochloric acid	6,814.94		
Hydrochloric acid	136.30	Arsenic, PM	5,407.85		

Observations from Table 9-7 include the following:

- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in Pinellas, Hillsborough, and Orange Counties, although not necessarily in that order.

- Benzene, formaldehyde, and 1,3-butadiene have the highest toxicity-weighted emissions for Pinellas and Hillsborough Counties. Hexavalent chromium has the highest toxicity-weighted emissions for Orange County, followed by the other three pollutants.

- Eight of the highest emitted pollutants in Pinellas and Orange Counties also have the highest toxicity-weighted emissions while six of the highest emitted pollutants in Hillsborough County also have the highest toxicity-weighted emissions.

- Formaldehyde, which has the highest cancer risk approximations for all sites sampling carbonyl compounds, is one of the highest emitted pollutants in each county and has one of the highest toxicity-weighted emissions for each county. This is also true for acetaldehyde for Pinellas and Orange Counties, but acetaldehyde does not appear among those pollutants with the highest toxicity-weighted emissions for Hillsborough County (although it ranks 11th).

- Naphthalene, which is a pollutant of interest for both SFKL and SYFL, is one of the highest emitted pollutants in both counties and has one of the highest toxicity-weighted emissions for each county.

- Arsenic is the only pollutant with a cancer risk approximation for PAFL. Arsenic ranks 10th for toxicity-weighted emissions for Orange County, but is not among the highest emitted pollutants, indicating the relative toxicity of a low quantity of emissions. Several metals appear among those with the highest toxicity-weighted emissions for Hillsborough County, but metals were not sampled for under the NMP at SYFL.

- POM, Groups 1a, 2b, and 2d are among the highest emitted “pollutants” in all three counties and appear among the pollutants with the highest toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at SKFL and SYFL including acenaphthene and fluorene, both of which failed screens for SKFL but were not identified as site-specific pollutants of interest. POM, Group 2d also includes several PAHs sampled for at SKFL and SYFL including phenanthrene and pyrene, neither of which failed any screens for these sites. POM, Group 1a does not include any PAHs sampled for with Method TO-13.

Observations from Table 9-8 include the following:

- Toluene, ethylene glycol, and xylenes are the highest emitted pollutants with noncancer RfCs in all three Florida counties.

- Acrolein has the highest toxicity-weighted emissions of the pollutants with noncancer RfCs for each county, but is not among the highest emitted pollutants in the three Florida counties. None of the Florida sites sampled VOCs under the NMP.

- Five of the highest emitted pollutants in Pinellas and Orange Counties also have the highest toxicity-weighted emissions. Four of the highest emitted pollutants in Hillsborough County also have the highest toxicity-weighted emissions.

- Formaldehyde and acetaldehyde appear on both emissions-based lists for each site/county. Naphthalene is among the pollutants with the highest toxicity-weighted emissions for Pinellas and Orange Counties but is not among the highest emitted (with a noncancer RfC) in any of the three counties.

- Several metals appear among those with the highest toxicity-weighted emissions for Hillsborough County, but are not among the highest emitted. Metals were not sampled for at SYFL under the NMP.

- Arsenic is the only metal that appears among the pollutants with the highest toxicity-weighted emissions for Orange County (ranking 10th). There are no metals among the highest emitted pollutants in Orange County.

9.6 Summary of the 2012 Monitoring Data for the Florida Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Acetaldehyde and formaldehyde failed screens for AZFL and ORFL, where only carbonyl compounds were sampled. Eight pollutants (three carbonyls, four PAHs, and hexavalent chromium) failed screens for SKFL. Five pollutants (three carbonyls and two PAHs) failed screens for SYFL. Arsenic, manganese, and lead failed screens for PAFL.*

- ❖ *Formaldehyde had the highest annual average concentration for each of the Florida sites where carbonyl compounds were sampled. The annual average concentration of naphthalene for SKFL was more than twice the annual average concentration for SYFL, the two sites where naphthalene was a pollutant of interest. Manganese had the highest annual average concentration of the metals identified as pollutants of interest for PAFL.*

- ❖ *Concentrations of formaldehyde have an overall decreasing trend at ORFL. A similar trend in formaldehyde concentrations is shown at SKFL until recent years where an increasing trend is shown. Concentrations of acetaldehyde decreased significantly between 2010 and 2012 at AZFL and SKFL with a significant decrease also shown at ORFL from 2011 and 2012. Conversely, acetaldehyde concentrations at SYFL increased significantly from 2011 to 2012. Concentrations of naphthalene have not changed significantly at SKFL or SYFL. Both arsenic and manganese exhibit increases at PAFL from 2011 to 2012.*

10.0 Site in Georgia

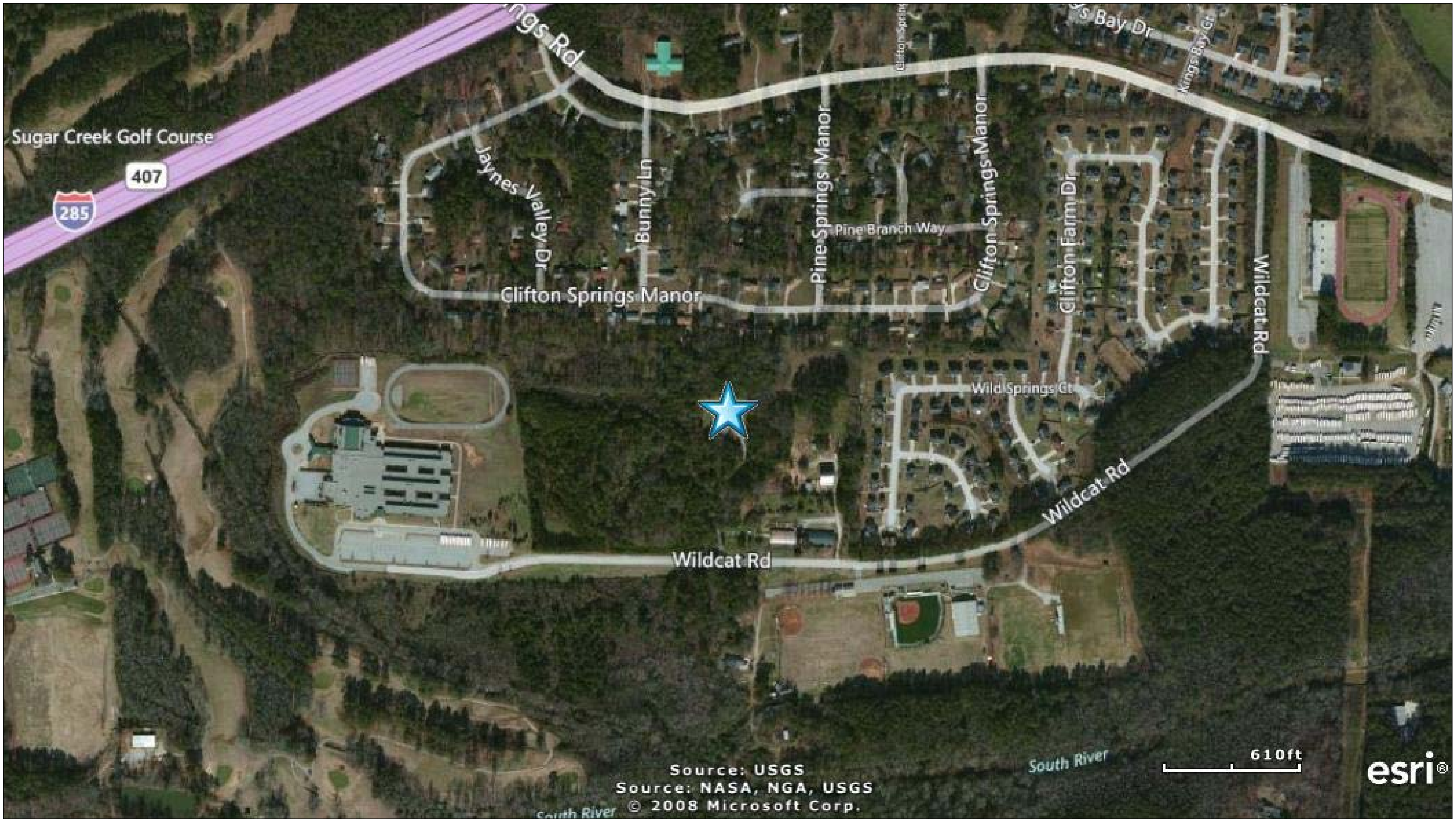
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Georgia, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

10.1 Site Characterization

This section characterizes the SDGA monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

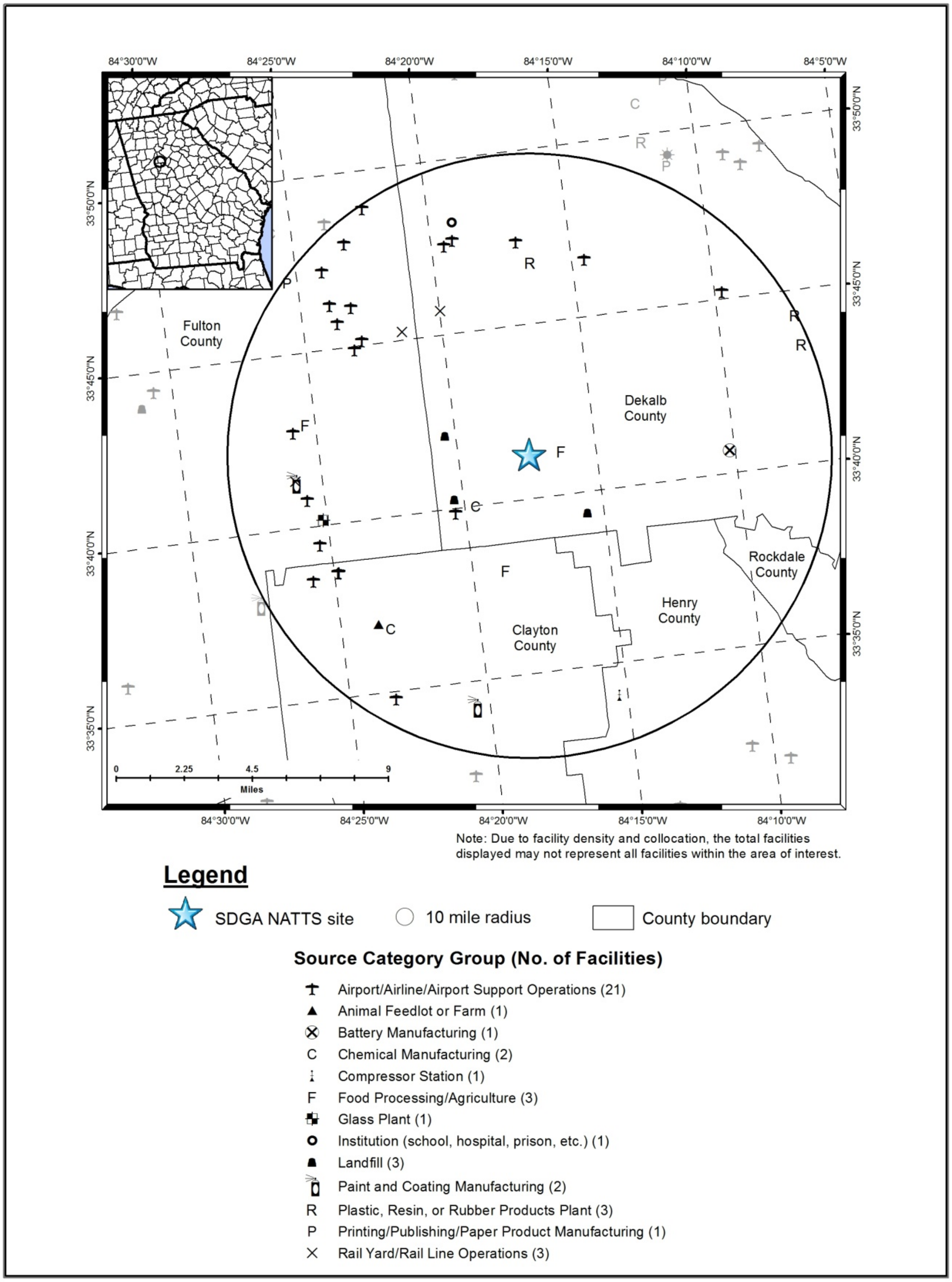
The SDGA monitoring site is located in Decatur, Georgia, a suburb of Atlanta. Figure 10-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 10-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 10-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 10-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 10-1. Decatur, Georgia (SDGA) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 10-2. NEI Point Sources Located Within 10 Miles of SDGA



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 10-1. Geographical Information for the Georgia Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
SDGA	13-089-0002	Decatur	DeKalb	Atlanta-Sandy Springs-Roswell, GA	33.68797, -84.29048	Residential	Suburban	CO, SO_2, NO_y, NO, NO_2, NO_x, PAMS, Carbonyl compounds, VOCs, O_3, Meteorological parameters, PM_{10}, PM Coarse, PM_{10} Speciation, Black carbon, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Haze, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

SDGA is located on the DeKalb County Schools Environmental Education property off Wildcat Road and is the South DeKalb NATTS site. Residential subdivisions, a greenhouse and horse barn, an athletic field, and a high school surround the monitoring site. A golf course backs up against the school property on the south and east sides. Interstate-285 is located less than 1 mile north of the site, as shown in Figure 10-1. As Figure 10-2 shows, only one point source (a food processing facility) is located in close proximity to SDGA. Additional sources are located primarily on the west side of the 10-mile radius. The airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations, is the source category with the greatest number of emissions sources within 10 miles of SDGA.

Table 10-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Georgia monitoring site. Table 10-2 includes both county-level population and vehicle registration information. Table 10-2 also contains traffic volume information for SDGA as well as the location for which the traffic volume was obtained. Additionally, Table 10-2 presents the county-level daily VMT for DeKalb County.

Table 10-2. Population, Motor Vehicle, and Traffic Information for the Georgia Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
SDGA	707,089	472,535	141,980	I-285, north of Clifton Spring Rd	20,113,000

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2011 data (GA DOR, 2011)
[3] AADT reflects 2012 data from the Georgia DOT (GA DOT, 2012a)
[4] County-level VMT reflects 2012 data (GA DOT, 2012b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 10-2 include the following:

- SDGA's county-level population and vehicle registration are in the middle of the range compared to other counties with NMP sites.
- The traffic volume experienced near SDGA ranks ninth highest compared to other NMP sites. The traffic estimate provided is for I-285, north of Clifton Spring Road.
- The daily VMT for DeKalb County is in the middle third compared to other counties with NMP sites (where VMT data were available).

10.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Georgia on sample days, as well as over the course of the year.

10.2.1 Climate Summary

Atlanta is the largest city in Georgia and is located at the base of the Blue Ridge Mountains. The Gulf of Mexico to the south is the major moisture source for weather systems that move across the region. Both topographical features, in addition to the Atlantic Ocean to the east, exert moderating influences on the area's climate, tempering cold air outbreaks from the north as well as summer heat waves. Summers are warm and humid while winters are relatively mild, although snow is not uncommon. The semi-permanent Bermuda High Pressure offshore over the Atlantic Ocean is a dominant weather feature affecting the Atlanta area, which pulls warm, moist air into the region. Precipitation is ample throughout the year, although autumn is the driest season. Westerly and northwesterly winds prevail throughout much of the year, although east winds are more common in the late summer and fall (Wood, 2004; GSCO, 1998; NCDC, 2014).

10.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Georgia monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station to SDGA is located at W. B. Hartsfield/Atlanta International Airport (WBAN 13874). Additional information about the Hartsfield weather station, such as the distance between the site and the weather station, is provided in Table 10-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 10-3. Average Meteorological Conditions near the Georgia Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Decatur, Georgia - SDGA									
W.B. Hartsfield/Atlanta Intl. Airport 13874 (33.64, -84.43)	9.2 miles 237° (WSW)	Sample Days (61)	73.8 ± 3.3	64.8 ± 3.3	50.8 ± 3.9	57.2 ± 3.2	63.7 ± 3.6	1018.1 ± 1.5	6.4 ± 0.7
		2012	74.4 ± 1.4	65.0 ± 1.3	51.0 ± 1.5	57.3 ± 1.3	63.7 ± 1.4	1017.6 ± 0.5	6.3 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 10-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 10-3 is the 95 percent confidence interval for each parameter. As shown in Table 10-3, average meteorological conditions on sample days near SDGA were representative of average weather conditions experienced throughout the year.

10.2.3 Back Trajectory Analysis

Figure 10-3 is the composite back trajectory map for days on which samples were collected at the SDGA monitoring site. Included in Figure 10-3 are four back trajectories per sample day. Figure 10-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 10-3 and 10-4 represents 100 miles.

Figure 10-3. Composite Back Trajectory Map for SDGA

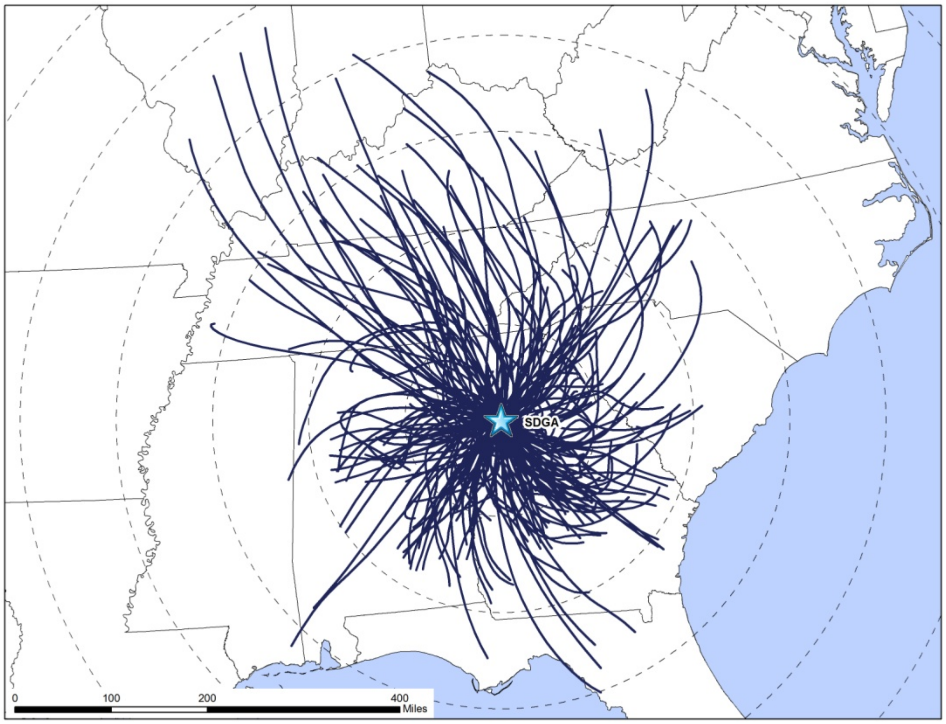
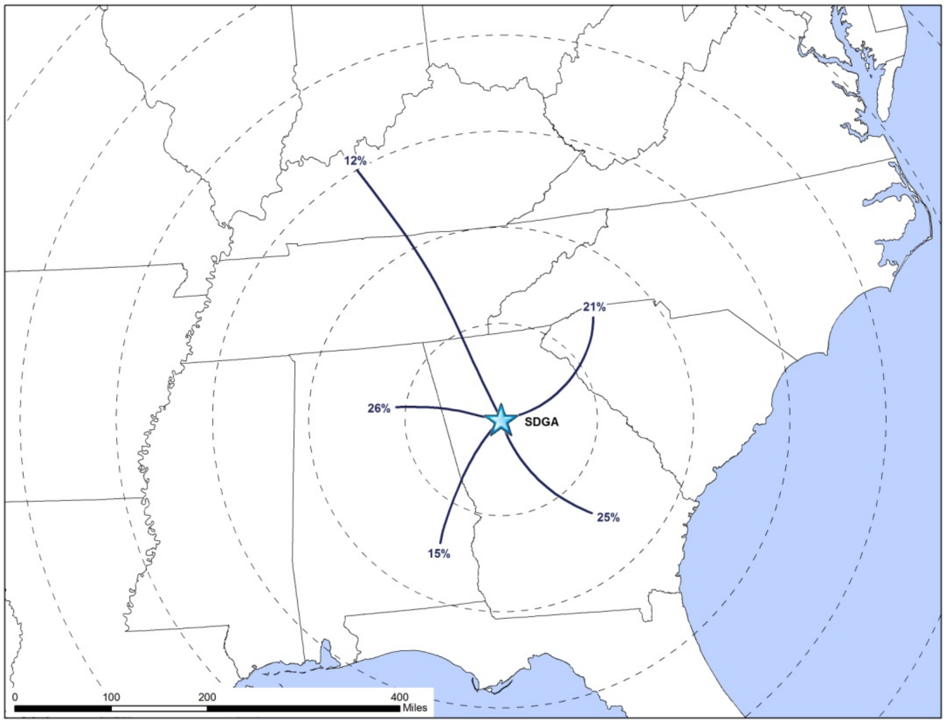


Figure 10-4. Back Trajectory Cluster Map for SDGA



Observations from Figures 10-3 and 10-4 include the following:

- The composite back trajectory map for SDGA looks like a pinwheel, indicating that back trajectories originated from a variety of directions around SDGA. Back trajectories originating from the northwest and north tended to be longer than those originating from other directions.

- Size-wise, the 24-hour air shed domain for SDGA is in the bottom-third compared to other NMP monitoring sites. While the farthest away a back trajectory originated was central Illinois, or greater than 450 miles away, the average back trajectory length is 165 miles. Three-quarters of back trajectories originated within 200 miles of SDGA and greater than 90 percent of back trajectories originated within 300 miles of the site. The four longest back trajectories originated over Illinois and represent a single sample day (October 30, 2012).

- The cluster analysis shows that 26 percent of back trajectories originated to the west, northwest, and north of SDGA and are generally less than 200 miles in length. Another 25 percent of back trajectories originated to the south of SDGA over central and southeast Georgia. The cluster trajectory originating over upstate South Carolina represents both shorter back trajectories originating to the northeast and east of SDGA over Georgia and South Carolina as well as longer trajectories originating over the mountains of North Carolina, Tennessee, Virginia, and West Virginia. Fifteen percent of back trajectories originated along Georgia's western border or the southeast portion of Alabama. Twelve percent of back trajectories originated from the northwest to north of SDGA, over Tennessee, Kentucky, Indiana, or Illinois.

10.2.4 Wind Rose Comparison

Hourly surface wind data from the weather station at Hartsfield International Airport near SDGA were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 10-5 presents a map showing the distance between the weather station and SDGA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 10-5 also presents three different wind roses for the SDGA monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 10-5 for SDGA include the following:

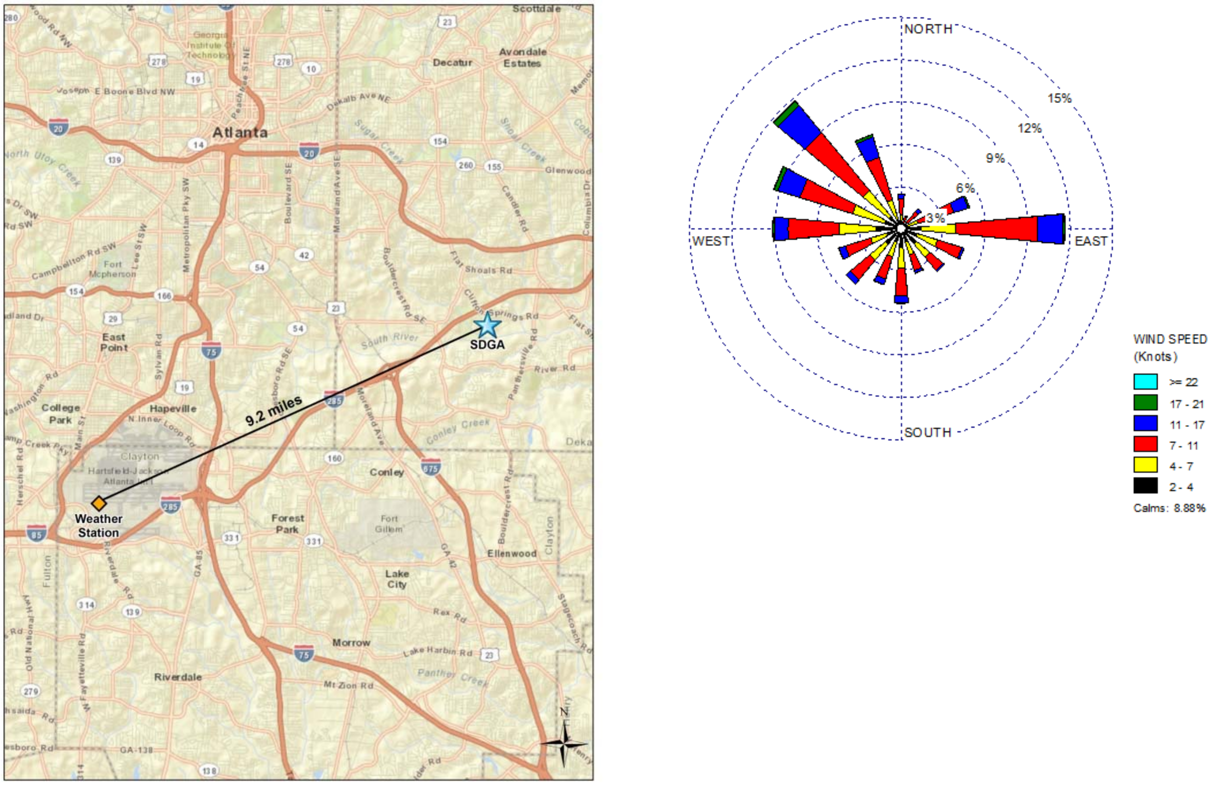
- The weather station at Hartsfield International Airport is the closest weather station to SDGA and is located 9.2 miles west-southwest of SDGA.

- The historical wind rose shows that winds from the west to north-northwest account for nearly 40 percent of wind observations. Easterly winds were also common. Winds from the northeast quadrant were rarely observed. Calm winds (≤ 2 knots) were observed for less than 10 percent of the hourly wind measurements.

- The wind patterns on the full-year wind rose are similar to those of the historical wind rose. The reduced percentage of wind observations from the west to northwest and east are accounted for in the increased percentage of calm winds.

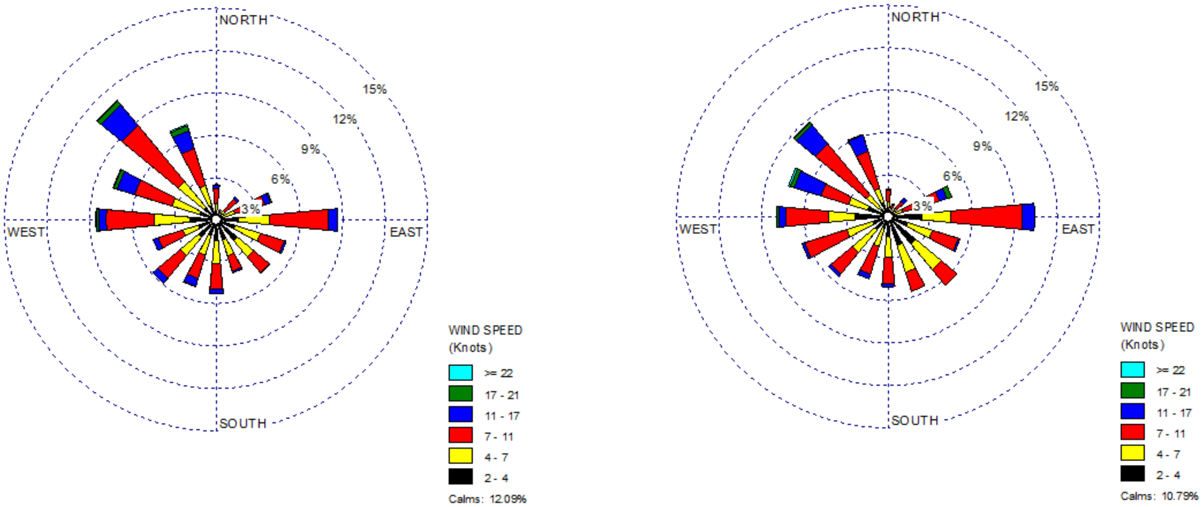
- Although the predominant wind patterns on the sample day wind rose still resemble those on the full-year wind rose, there are additional differences. Further decreases in the percentage of wind observations from the west to north-northwest are shown but are accompanied by increases in the percentage winds from the southeast quadrant.

Figure 10-5. Wind Roses for the Hartsfield International Airport Weather Station near SDGA



Location of SDGA and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

10.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Georgia monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 10-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 10-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. SDGA sampled for PAHs and hexavalent chromium only, although the sampling of PAHs was discontinued at SDGA at the end of June 2012.

Table 10-4. Risk-Based Screening Results for the Georgia Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Decatur, Georgia - SDGA						
Naphthalene	0.029	29	29	100.00	93.55	93.55
Benzo(a)pyrene	0.00057	1	16	6.25	3.23	96.77
Hexavalent Chromium	0.000083	1	32	3.13	3.23	100.00
Total		31	77	40.26		

Observations from Table 10-4 for SDGA include the following:

- Three pollutants failed at least one screen for SDGA: naphthalene, benzo(a)pyrene, and hexavalent chromium.
- Naphthalene failed 100 percent of its screens, accounting for 29 of the 31 total failed screens (or roughly 94 percent); the other two pollutants failed only one screen each.
- Although naphthalene and benzo(a)pyrene together account for more than 95 percent of the total failed screens for SDGA and are therefore identified as pollutants of interest, hexavalent chromium failed the same number of screens as benzo(a)pyrene; thus, hexavalent chromium was also added as pollutants of interest for SDGA, per the procedure described in Section 3.2.

10.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Georgia monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for the monitoring site.
- Annual concentration averages are presented graphically for SDGA to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for SDGA are provided in Appendices M and O.

10.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for SDGA, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Georgia monitoring site are presented in Table 10-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 10-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Georgia Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Decatur, Georgia - SDGA						
Benzo(a)pyrene	16/29	0.08 ± 0.05	0.05 ± 0.09	NA	NA	NA
Hexavalent Chromium	32/54	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± <0.01
Naphthalene	29/29	92.21 ± 18.02	105.82 ± 27.28	NA	NA	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for SDGA from Table 10-5 include the following:

- Naphthalene was detected in every PAH sample collected at SDGA while benzo(a)pyrene was detected in just greater than 50 percent of the samples collected. The detection rate of benzo(a)pyrene was significantly higher in the first quarter than the second. There were 12 measured detections and three non-detects for the first quarter of 2012 while there were four measured detections and 10 non-detects for the second quarter.

- Third and fourth quarter average concentrations could not be calculated for these two pollutants because sampling was discontinued at the end of June 2012. As a result, annual averages could not be calculated either.

- The second quarter average concentration of naphthalene is higher than the first quarter average concentration, although not statistically so. The two highest concentrations of naphthalene measured at SDGA were both measured in June (180 ng/m^3 and 183 ng/m^3). Aside from these two measurements, the concentrations measured during the first quarter are similar to those measured during the second quarter.

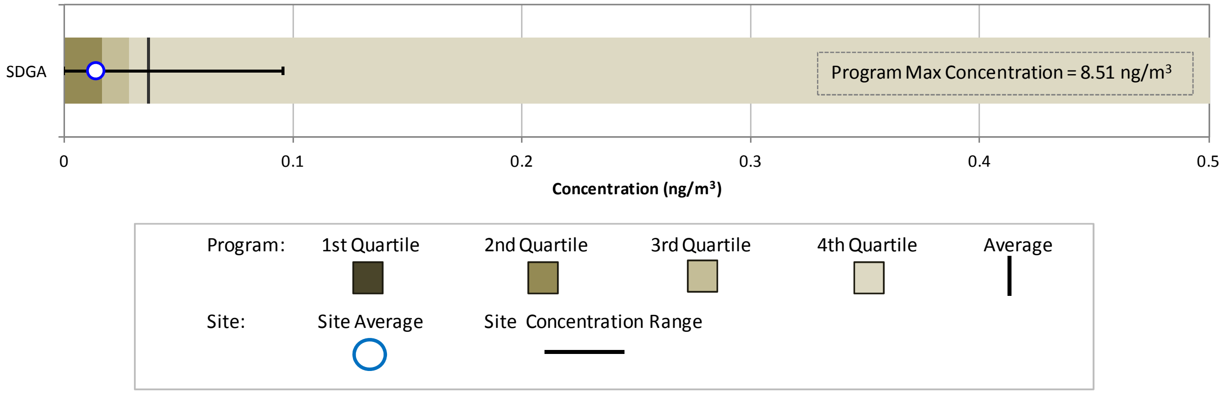
- Hexavalent chromium was detected in nearly 60 percent of the samples collected at SDGA and ranged from 0.0054 ng/m^3 to 0.0954 ng/m^3.

10.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Figure 10-6 overlays the site's minimum, annual average, and maximum hexavalent chromium concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in

Section 3.5.3. Box plots were not created for the PAHs because annual average concentrations could not be calculated due to the short sampling duration.

Figure 10-6. Program vs. Site-Specific Average Hexavalent Chromium Concentration



Observations from Figure 10-6 include the following:

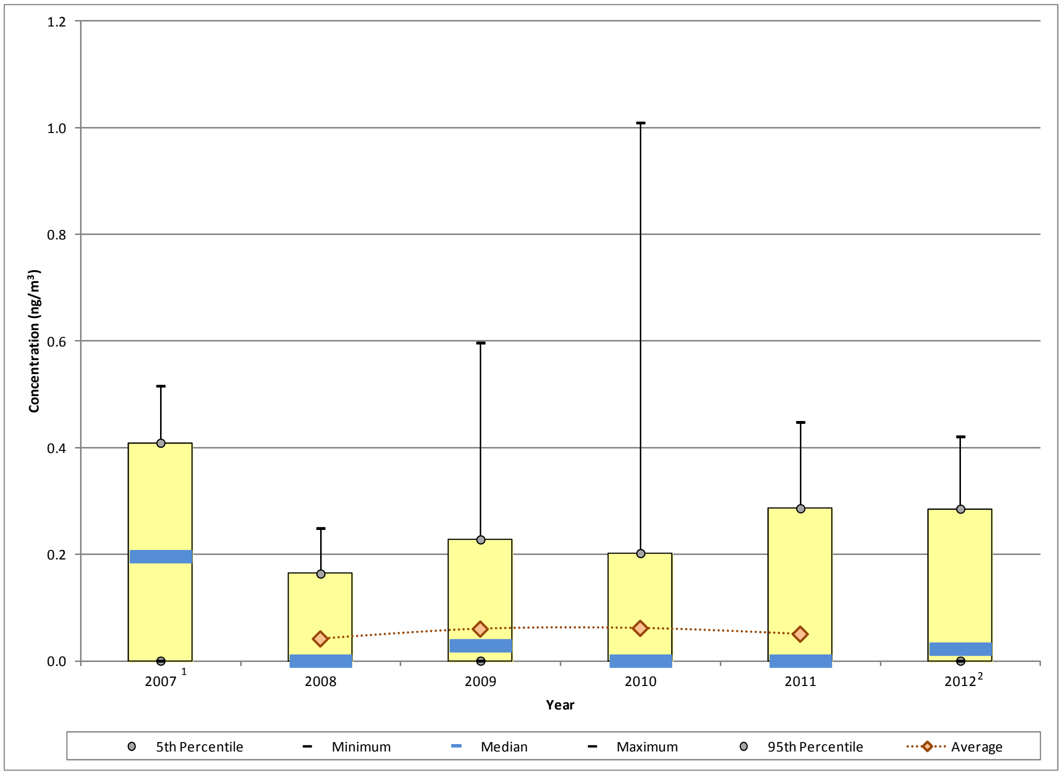
- Figure 10-6 is the box plot for hexavalent chromium. Note that the program-level maximum concentration (8.51 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to 0.5 ng/m^3. In addition, the program-level first quartile is zero and therefore not visible on the box plot.

- Figure 10-6 shows that the annual average concentration of hexavalent chromium for SDGA is less than the program-level average concentration. SDGA's annual average concentration is also less than the program-level median concentration. The maximum concentration measured at SDGA is two orders of magnitude less than the program-level maximum concentration.

10.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. SDGA has sampled hexavalent chromium under the NMP since 2005 and PAHs since 2007. Thus, Figures 10-7 through 10-9 present the 1-year statistical metrics for each of the pollutants of interest for SDGA. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began (or ended) mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 10-7. Yearly Statistical Metrics for Benzo(a)pyrene Concentrations Measured at SDGA



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2007.
[2] A 1-year average is not presented because sampling under the NMP was discontinued in June 2012.

Observations from Figure 10-7 for benzo(a)pyrene measurements collected at SDGA include the following:

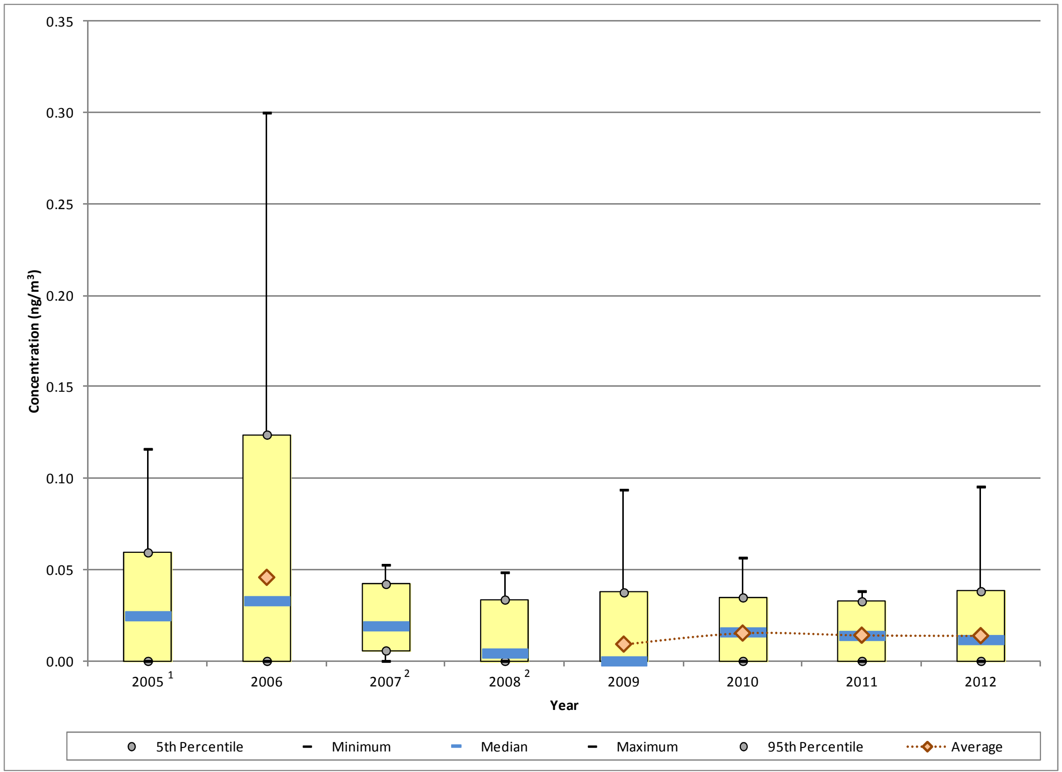
- Sampling under the NMP for PAHs began in April 2007 at SDGA. However, a 1-year average is not presented for 2007 because a full year's worth of data is not available, although the range of measurements is provided. In addition, a 1-year average is not provided for 2012 due to the discontinuation of sampling in June 2012.

- Only one benzo(a)pyrene concentration measured at SDGA is greater than 1 ng/m^3, which was measured in 2010 (1.01 ng/m^3). The next highest concentration was measured in 2009 and was nearly half as high (0.597 ng/m^3).

- The minimum, 5th percentile, and/or the median concentration has been equal to zero for each year of sampling, indicating the presence of non-detects. The number of non-detects was at a minimum in 2007, but ranged from 40 percent to 60 percent for the other years of sampling.

- The difference between the 5th and 95th percentiles is highest for 2007 then decreased by more than half for 2008, after which an increasing trend is shown.

Figure 10-8. Yearly Statistical Metrics for Hexavalent Chromium Concentrations Measured at SDGA



[1] A 1-year average is not presented because sampling under the NMP did not begin until February 2005.
[2] 1-Year averages are not presented because there was a break in sampling between Sept 2007 and May 2008.

Observations from Figure 10-8 for hexavalent chromium measurements collected at SDGA include the following:

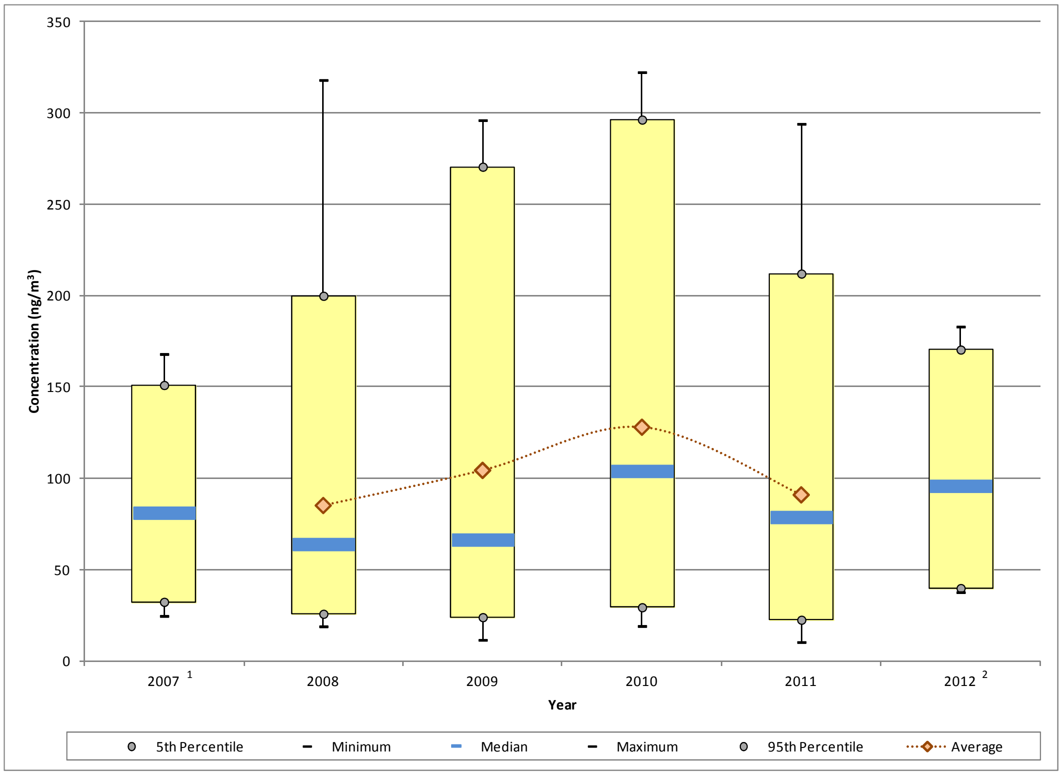
- Although hexavalent chromium sampling under the NMP began in 2005 at SDGA, a 1-year average is not presented because a full year's worth of data is not available, although the range of measurements is provided. In addition, there was a break in sampling between September 2007 and May 2008 due to sampler issues; as a result, a 1-year average is not provided for 2007 or 2008.

- The maximum concentration was measured in 2006 (0.300 ng/m^3). Only four additional concentrations greater than 0.1 ng/m^3 have been measured at SDGA, all of which were measured in either 2005 or 2006.

- The difference between the 5th and 95th percentiles exhibits little change over the last several years of sampling, indicating that a majority of the measurements fall within roughly the same range, at least since 2007.

- The median concentration decreased significantly between 2006 and 2009, reaching a minimum of zero for 2009, which indicates that at least half of the measurements were non-detects. Since 2009, the number of non-detects has varied from 23 percent (2011) to 41 percent (2012). The increase in the measured detections from 2009 to 2010 explains the increase in the 1-year average, despite the lower maximum concentration and 95th percentile.

Figure 10-9. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SDGA



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2007.
[2] A 1-year average is not presented because sampling under the NMP was discontinued in June 2012.

Observations from Figure 10-9 for naphthalene measurements collected at SDGA include the following:

- Three naphthalene concentrations greater than 300 ng/m^3 have been measured at SDGA, two in 2010 (322 ng/m^3 and 301 ng/m^3) and one in 2008 (318 ng/m^3). Ten of the 18 concentrations greater than 250 ng/m^3 were measured in 2010 (with two measured in 2008, four in 2009, and two in 2011).

- The difference between the 5th and 95th percentiles increases significantly from 2007 to 2010, more than doubling over the 4-year period. This indicates that a majority of the concentrations are falling into a wider range of measurements each year. This range decreases for 2011 and again for 2012.

- The 1-year average concentration increases from 2008 through 2010, then decreases for 2011. The median changes little from 2008 to 2009, then follows a pattern similar to the 1-year average for 2010 and 2011.

- Although the maximum and 95th percentile both decrease for 2012, the median concentration exhibits an increase. This is due to the increase in magnitude for the concentrations at the lower end of the concentration range. While 13 concentrations measured were less than 35 ng/m^3 in 2011, there were none in 2012. The number of concentrations between 35 ng/m^3 and 75 ng/m^3 decreased by half from 2011 (16) to 2012 (8). Recall, however, that 2012 includes only six months of sampling.

10.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the SDGA monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

10.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Georgia monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

10.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for SDGA and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 10-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 10-6. Risk Approximations for the Georgia Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Decatur, Georgia - SDGA						
Benzo(a)pyrene	0.00176	--	16/29	NA	NA	NA
Hexavalent Chromium	0.012	0.0001	32/54	0.01 ± <0.01	0.16	<0.01
Naphthalene	0.000034	0.003	29/29	NA	NA	NA

NA = Not available due to the criteria for calculating an annual average.
-- = A Cancer URE or Noncancer RfC is not available.

Observations for SDGA from Table 10-6 include the following:

- The cancer risk approximation for hexavalent chromium is 0.16 in-a-million, considerably less than a level of concern.
- The noncancer hazard approximation for hexavalent chromium is significantly less than 1.0, indicating that no adverse health effects are expected from this individual pollutant.
- Cancer risk and noncancer hazard approximations could not be calculated for benzo(a)pyrene or naphthalene because annual averages are not available.

10.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 10-7 and 10-8 present an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 10-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 10-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 10-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for the site, as presented in Table 10-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 10-7. Table 10-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 10-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Georgia Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Decatur, Georgia (DeKalb County) - SDGA					
Tetrachloroethylene	2,565.31	Formaldehyde	1.51E-03	Hexavalent Chromium	0.16
Benzene	167.19	Benzene	1.30E-03		
Ethylbenzene	117.84	1,3-Butadiene	8.16E-04		
Formaldehyde	115.79	Tetrachloroethylene	6.67E-04		
Acetaldehyde	74.29	Naphthalene	4.75E-04		
1,3-Butadiene	27.20	Ethylbenzene	2.95E-04		
Naphthalene	13.97	POM, Group 2b	1.70E-04		
Trichloroethylene	2.32	POM, Group 2d	1.66E-04		
Dichloromethane	2.21	Acetaldehyde	1.63E-04		
POM, Group 2b	1.93	Arsenic, PM	1.53E-04		

Table 10-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Georgia Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Decatur, Georgia (DeKalb County) - SDGA					
Tetrachloroethylene	2,565.31	Acrolein	291,469.12	Hexavalent Chromium	<0.01
Toluene	1,551.83	Tetrachloroethylene	64,132.78		
Ethylene glycol	851.66	1,3-Butadiene	13,598.64		
Hexane	472.63	Formaldehyde	11,815.64		
Xylenes	436.95	Acetaldehyde	8,254.75		
Methanol	395.07	Benzene	5,573.13		
Benzene	167.19	Naphthalene	4,656.58		
Ethylbenzene	117.84	Xylenes	4,369.46		
Formaldehyde	115.79	Lead, PM	3,306.94		
Acetaldehyde	74.29	Arsenic, PM	2,377.39		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 10.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 10-7 include the following:

- Tetrachloroethylene, benzene, and ethylbenzene are the highest emitted pollutants with cancer UREs in DeKalb County, although the tetrachloroethylene emissions are significantly higher than the emissions of the other two pollutants.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, 1,3-butadiene, and tetrachloroethylene.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for DeKalb County.
- Naphthalene, one of the pollutants of interest for SDGA, has the fifth highest toxicity-weighted emissions and seventh highest emissions for DeKalb County.
- Hexavalent chromium is not among the highest emitted pollutants in DeKalb County nor is it among those with the highest toxicity-weighted emissions. Benzo(a)pyrene is part of POM, Group 5a. POM, Group 5a does not appear on either emissions-based list in Table 10-7.
- POM, Group 2b is the tenth highest emitted "pollutant" in DeKalb County and ranks seventh for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at SDGA including acenaphthene, benzo(e)pyrene, fluorene, and perylene, although none of these pollutants failed screens for SDGA. POM, Group 2d ranks eighth for toxicity-weighted emissions and includes three PAHs sampled for at SDGA (anthracene, phenanthrene, and pyrene). None of these pollutants failed screens either.

Observations from Table 10-8 include the following:

- Tetrachloroethylene is the highest emitted pollutant with a noncancer RfC in DeKalb County, followed by toluene and ethylene glycol.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, tetrachloroethylene, and 1,3-butadiene.

- Five of the highest emitted pollutants in DeKalb County also have the highest toxicity-weighted emissions.

- While naphthalene is not one of the 10 highest emitted pollutants with a noncancer RfC in DeKalb County, its toxicity-weighted emissions rank seventh. Hexavalent chromium does not appear on either emissions-based list; nor does POM, Group 5a.

10.6 Summary of the 2012 Monitoring Data for SDGA

Results from several of the data treatments described in this section include the following:

- ❖ *Naphthalene, hexavalent chromium, and benzo(a)pyrene failed screens for SDGA, although naphthalene accounted for the majority of failed screens.*

- ❖ *PAH sampling was discontinued at SDGA at the end of June 2012.*

- ❖ *Concentrations of hexavalent chromium have not changed significantly at SDGA over the last few years of sampling.*

11.0 Sites in Illinois

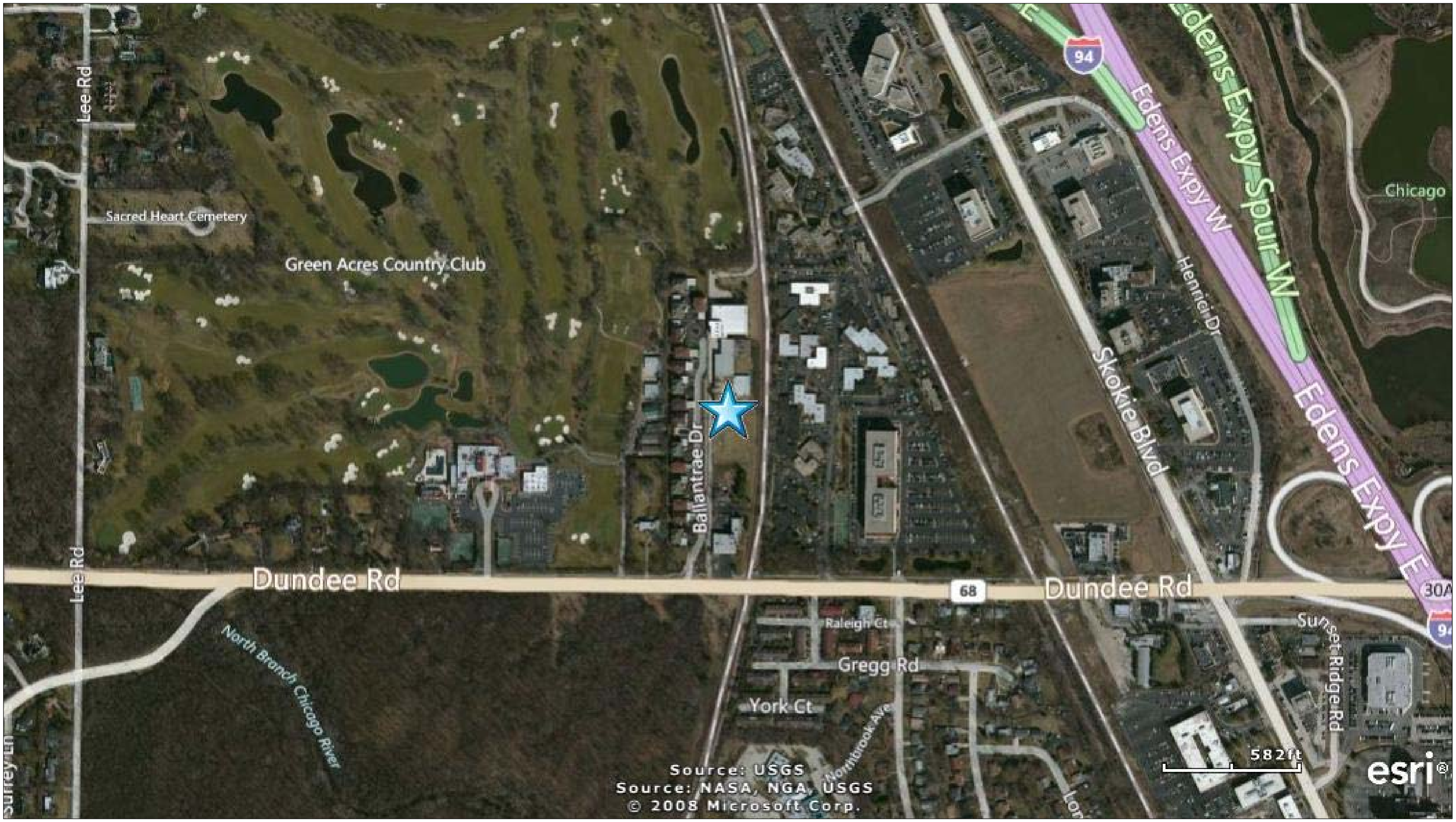
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Illinois, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

11.1 Site Characterization

This section characterizes the Illinois monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

Two monitoring sites are located in northwestern suburbs of Greater Chicago. NBIL is located in Northbrook and SPIL is located in Schiller Park. The third site (ROIL) is located in Roxana, just north of the St. Louis MSA. Figures 11-1 and 11-2 are composite satellite images retrieved from ArcGIS Explorer showing the Chicago monitoring sites and their immediate surroundings. Figure 11-3 identifies the nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources, for NBIL and SPIL. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 11-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radii are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 11-4 and 11-5 are the composite satellite image and facility map for ROIL, respectively. Table 11-1 provides supplemental geographical information such as land use, location setting, and locational coordinates for each site.

Figure 11-1. Northbrook, Illinois (NBIL) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 11-2. Schiller Park, Illinois (SPIL) Monitoring Site

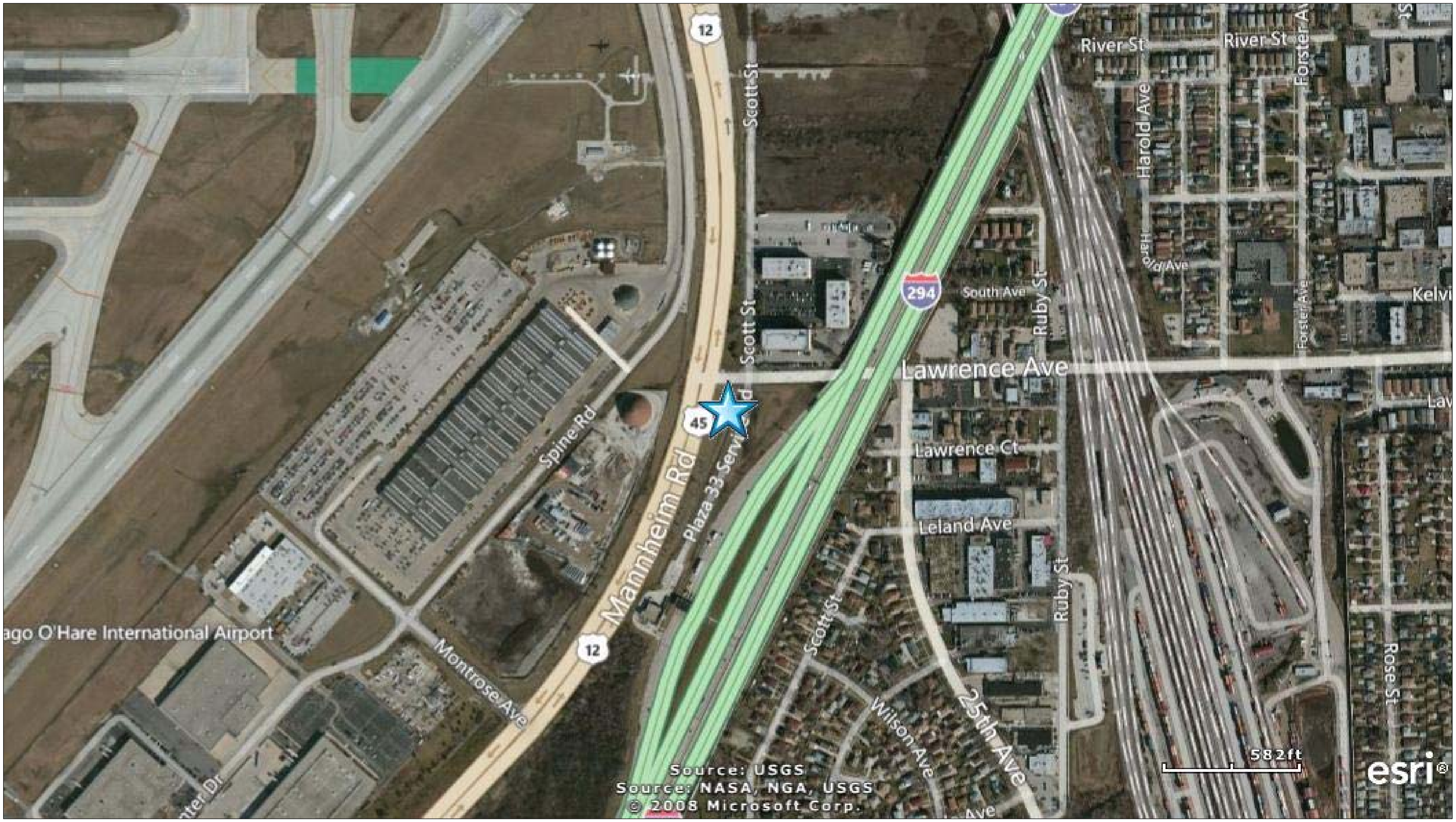
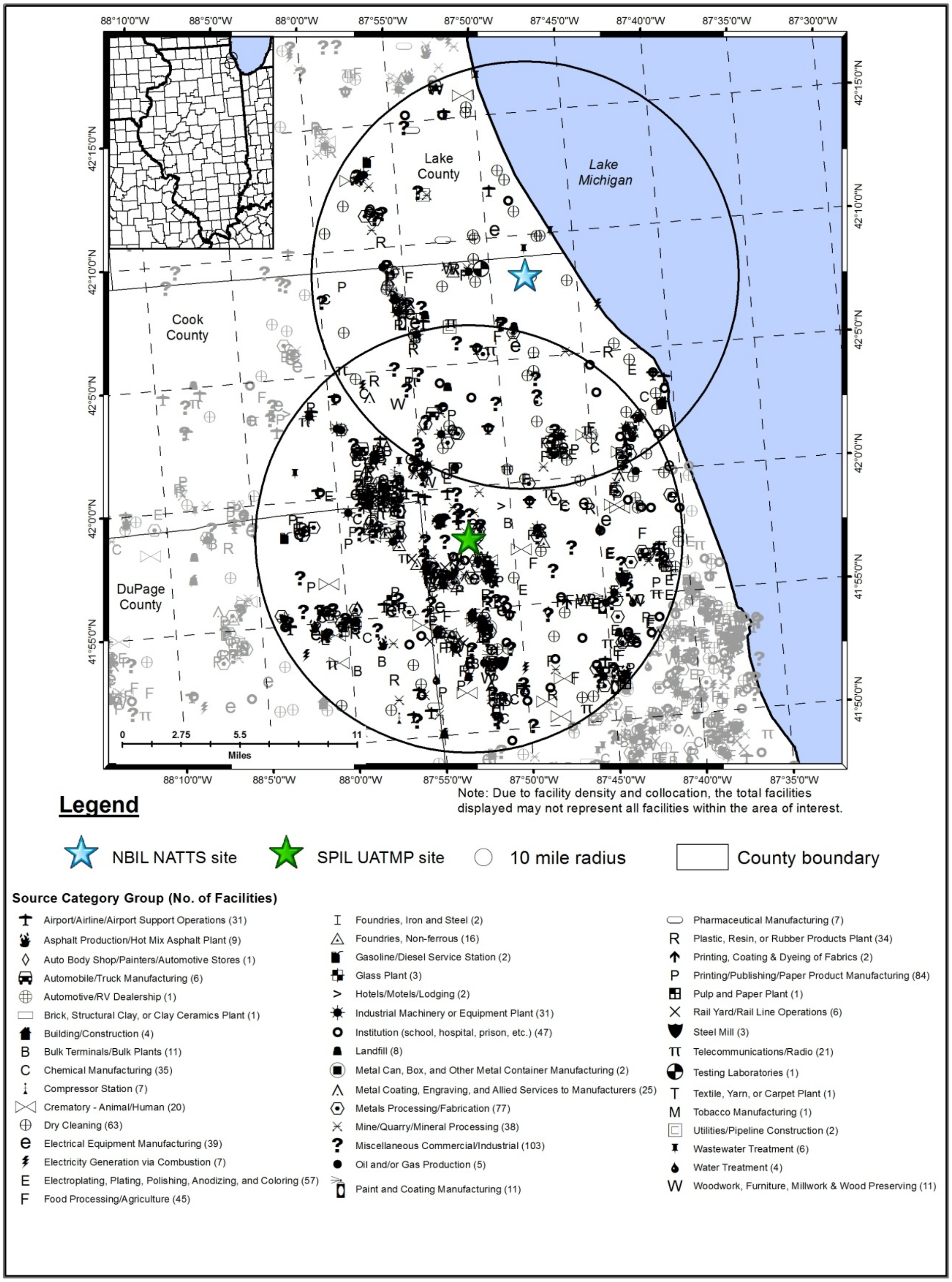


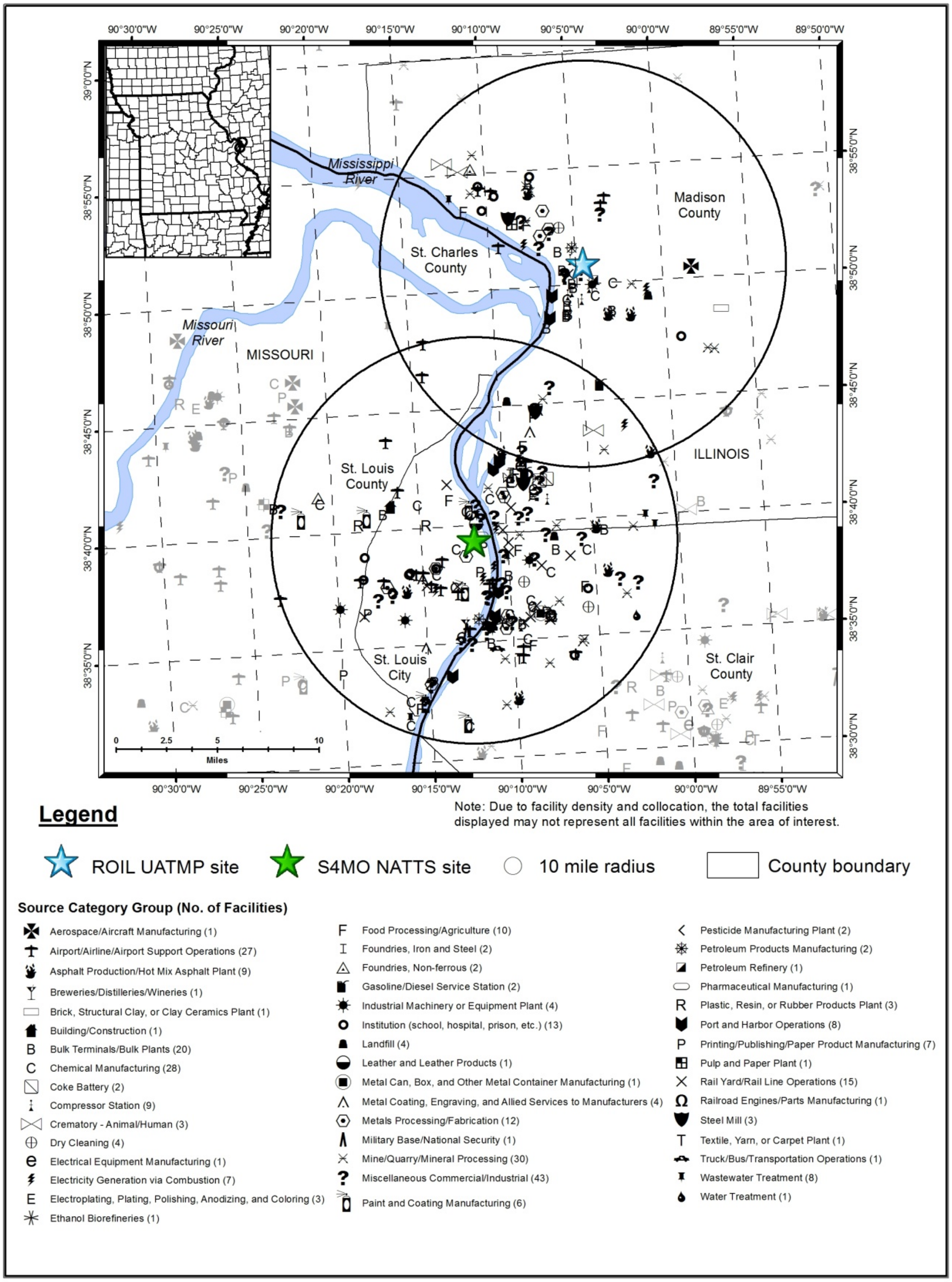
Figure 11-3. NEI Point Sources Located Within 10 Miles of NBIL and SPIL



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 11-4. Roxana, Illinois (ROIL) Monitoring Site

Figure 11-5. NEI Point Sources Located Within 10 Miles of ROIL



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 11-1. Geographical Information for the Illinois Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
NBIL	17-031-4201	Northbrook	Cook County	Chicago-Naperville-Elgin IL-IN-WI MSA	42.139996, -87.799227	Residential	Suburban	TSP, TSP Metals, CO, SO_2, NO, NO_2, NO_x, NO_y, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
SPIL	17-031-3103	Schiller Park	Cook County	Chicago-Naperville-Elgin IL-IN-WI MSA	41.965193, -87.876265	Mobile	Suburban	TSP, TSP Metals, CO, NO, NO_2, NO_x, Meteorological parameters, $PM_{2.5}$.
ROIL	17-119-9010	Roxana	Madison County	St. Louis, MO-IL MSA	38.848382, -90.076413	Industrial	Suburban	None.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.
BOLD ITALICS = EPA-designated NATTS Site

NBIL is located on the property of the Northbrook Water Filtration Station. Figure 11-1 shows that NBIL is located off State Highway 68 (Dundee Road), near Exit 30 on I-94 (the clover leaf of which is located on the lower right hand side of Figure 11-1). A railway runs north-south in front of the water filtration station and intersects Dundee Road just south of the monitoring site. The surrounding area is classified as suburban and residential. Commercial, residential, and forested areas are nearby, as well as a country club and golf course. The NBIL monitoring site is the Chicago NATTS site.

SPIL is located on the eastern edge of the Chicago-O'Hare International Airport between Mannheim Road and I-294, just north of the toll plaza. The nearest runway is less than 1/2 mile from the site. The surrounding area is classified as suburban and mobile. Commercial and residential areas are nearby and a railyard is located to the east of I-294.

NBIL and SPIL are located within approximately 12 miles of each other. Each site is located within 10 miles of numerous point sources, although the quantity of emissions sources is higher near SPIL than NBIL, as shown in Figure 11-3. The source categories with the largest number of sources within 10 miles of NBIL and SPIL are printing/publishing/paper product manufacturing; metals processing/fabrication; dry cleaning; electroplating, plating, polishing, anodizing, and coloring; institutions (schools, hospitals, prisons, etc); and food processing/agriculture. Few point sources are located within 2 miles of NBIL, with most of the sources located farther west or south. The closest source to NBIL is plotted under the symbol for the site in Figure 11-3; this source is a dry cleaning facility. Besides the airport and related operations, the closest point source to SPIL is involved in electroplating, plating, polishing, anodizing, and coloring.

The ROIL monitoring site in Roxana is located at the fence line of a petroleum refinery. Although this area is classified as industrial, a residential area is wedged between the industrial properties, as Figure 11-4 shows. Just north of the monitoring site are a junior high school and a high school, whose track and tennis courts are shown across the street from the monitoring site. Ambient monitoring data from this location will be used to assess near-field concentrations in the neighboring community, with emphasis on comparing and contrasting these data to the St. Louis NATTS site (S4MO), which is also pictured in Figure 11-5. The Mississippi River, which is the border between Missouri and Illinois, is just over a mile and a half west of the monitoring site.

In addition to showing the ROIL monitoring site's location relative to the S4MO monitoring site, Figure 11-5 also shows that there is a large cluster of emissions sources surrounding and mostly to the south of ROIL. Many of the sources within 2 miles of ROIL are involved in or related to the petroleum industry. A petroleum refinery, multiple compressor stations, and several bulk terminals surround the site. Other nearby sources include a rail yard, an industrial machinery/equipment facility, and several chemical manufacturers.

Table 11-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Illinois monitoring sites. Table 11-2 includes both county-level population and vehicle registration information. Table 11-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 11-2 presents the county-level daily VMT for Cook County and Madison County.

Table 11-2. Population, Motor Vehicle, and Traffic Information for the Illinois Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
NBIL	5,231,351	2,092,085	115,100	I-94, north of intersection with Dundee Rd	86,217,829
SPIL			191,700	I-294 at Lawrence Ave	
ROIL	267,883	286,043	9,400	Route 111 at railroad tracks, where Rt 111 becomes S. Central Ave	7,867,318

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c).
[2] County-level vehicle registration reflects 2012 data (IL SOS, 2012).
[3] AADT reflects 2011 data for SPIL and ROIL and 2012 data for NBIL (IL DOT, 2011/2012).
[4] County-level VMT reflects 2012 data (IL DOT, 2012).
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 11-2 include the following:

- Cook County has the second highest county-level population (behind Los Angeles County) and fourth highest county-level vehicle registration (behind Los Angeles County, CA; Maricopa County, AZ; and Harris County, TX) compared to other counties with NMP sites.

- Both the county-level population and vehicle registration for Madison County are an order of magnitude less than Cook County and are in the middle of the range compared to other counties with NMP sites.

- SPIL experiences the highest traffic volume compared to the other sites in Illinois, although both Chicago sites experience a significantly higher traffic volume than ROIL. SPIL's traffic volume is the fifth highest among all NMP sites, behind LBHCA, ELNJ, CELA, and SEWA. The traffic volume for NBIL is in the top third among NMP sites while traffic volume near ROIL is in the bottom third. Note that the traffic volumes presented for NBIL and SPIL are from interstates while the traffic volume for ROIL is not.

- The Cook County daily VMT ranks third highest among counties with NMP sites, behind only Los Angeles County, CA and Maricopa County, AZ. The daily VMT for Madison County is an order of magnitude less than the VMT for Cook County, ranking in the middle third among VMT for counties with NMP sites (where VMT data were available).

11.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Illinois on sample days, as well as over the course of the year.

11.2.1 Climate Summary

Daily weather fluctuations are common for the Chicago area. The proximity of Chicago to Lake Michigan offers moderating effects from the continental climate of the region. In the winter, cold air masses may be moderated by their passage over the relatively warm Lake Michigan while in the summer, afternoon lake breezes can cool the city when winds from the south and southwest push temperatures upward. The lake also influences precipitation as the origin of an air mass determines the amount and type of precipitation. The largest snowfalls tend to occur when cold air masses flow southward over Lake Michigan, most of which does not freeze in winter. Wind speeds average around 10 miles per hour, but can be greater due to winds channeling between tall buildings downtown, giving the city its nickname, "The Windy City". The urban heat island effect is another climatic feature of the Chicago area, as the highly developed urban area absorbs and retains more heat than outlying areas (IL SCO, 2014; Wood, 2004).

Roxana is northeast of St. Louis and located just north of the confluence of the Mississippi and Missouri Rivers, which acts as Illinois' western border. The area has a climate that is continental in nature, with cold, dry winters; warm, somewhat wetter summers; and significant seasonal variability. Warm, moist air flowing northward from the Gulf of Mexico alternates with cold, dry air marching southward from Canada and the northern U.S., resulting in weather patterns that do not persist for very long. Precipitation tends to be higher in the summer months than the winter months and severe weather in the form of thunderstorms, flooding, and tornadoes have been known to occur within the region. Southerly winds prevail in the summer while northwesterly winds are prevalent during the colder months of the year. (Wood, 2004; MCC, 2014).

11.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the Illinois monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather stations are located at Palwaukee Municipal Airport (near NBIL), O'Hare International Airport (near SPIL), and Lambert-St. Louis International Airport (near ROIL), WBANs 04838, 94846, and 13994, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 11-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 11-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 11-3 is the 95 percent confidence interval for each parameter. As shown in Table 11-3, average meteorological conditions on sample days near NBIL and SPIL were representative of average weather conditions experienced throughout the year. Conditions on sample days appear slightly warmer than temperatures experienced throughout the year near ROIL. However, sampling at this site did not begin until June, thereby missing the coldest months of the year. Note the difference in the temperature parameters between the Chicago sites and ROIL. These differences are expected, given the roughly 250 mile distance between these sites.

Table 11-3. Average Meteorological Conditions near the Illinois Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Northbrook, Illinois - NBIL									
Palwaukee Municipal Airport 04838 (42.12, -87.91)	5.3 miles 250° (WSW)	Sample Days (71)	62.4 ± 4.7	54.1 ± 4.3	41.0 ± 3.7	47.4 ± 3.6	64.3 ± 2.7	1016.1 ± 1.6	6.9 ± 0.8
		2012	62.8 ± 2.0	54.2 ± 1.9	41.3 ± 1.7	47.7 ± 1.6	65.0 ± 1.2	1016.3 ± 0.7	6.6 ± 0.3
Schiller Park, Illinois - SPIL									
O'Hare International Airport 94846 (41.99, -87.91)	2.5 miles 301° (WNW)	Sample Days (64)	63.6 ± 5.1	55.2 ± 4.6	41.4 ± 3.9	48.1 ± 3.8	63.3 ± 3.2	1015.2 ± 1.8	8.7 ± 0.8
		2012	63.3 ± 2.1	54.9 ± 1.9	41.5 ± 1.6	48.1 ± 1.6	64.2 ± 1.4	1015.7 ± 0.7	8.4 ± 0.3
Roxana, Illinois - ROIL									
Lambert/ St. Louis International Airport 13994 (38.75, -90.37)	16.5 miles 243° (WSW)	Sample Days (38)	72.6 ± 6.1	63.6 ± 5.9	47.5 ± 5.1	54.7 ± 4.8	59.2 ± 3.9	1016.3 ± 1.9	6.7 ± 0.9
		2012	70.7 ± 2.0	61.3 ± 1.9	45.0 ± 1.6	52.5 ± 1.5	58.7 ± 1.3	1016.2 ± 0.6	7.1 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

11.2.3 Back Trajectory Analysis

Figure 11-6 is the composite back trajectory map for days on which samples were collected at the NBIL monitoring site. Included in Figure 11-6 are four back trajectories per sample day. Figure 11-7 is the corresponding cluster analysis. Similarly, Figures 11-8 through 11-11 are the composite back trajectory maps for days on which samples were collected at SPIL and ROIL and the corresponding cluster analyses. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 11-6 through 11-11 represents 100 miles.

Figure 11-6. Composite Back Trajectory Map for NBIL

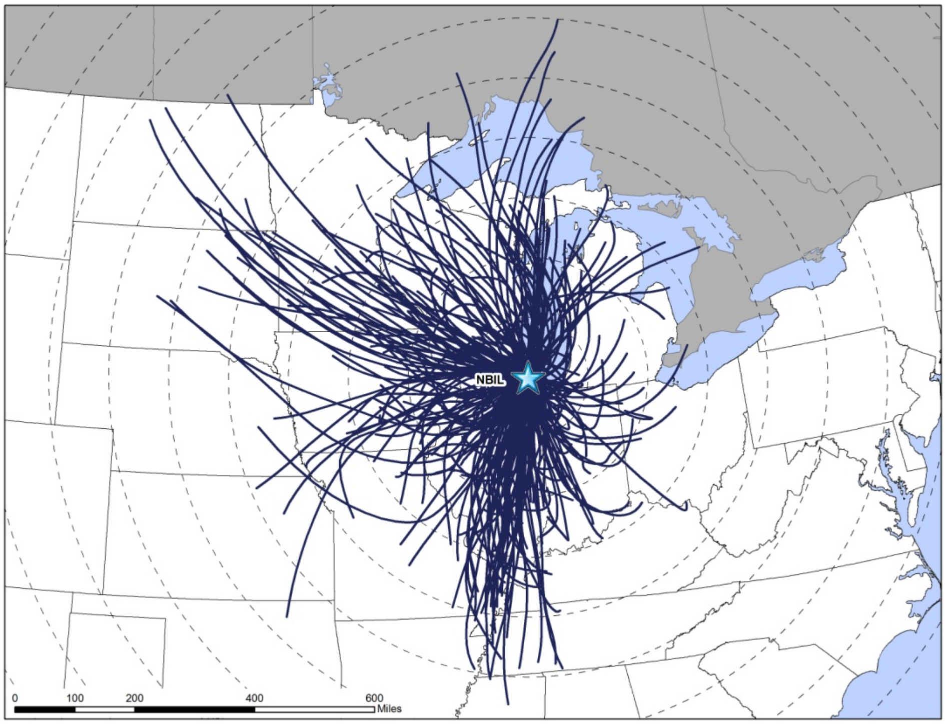


Figure 11-7. Back Trajectory Cluster Map for NBIL

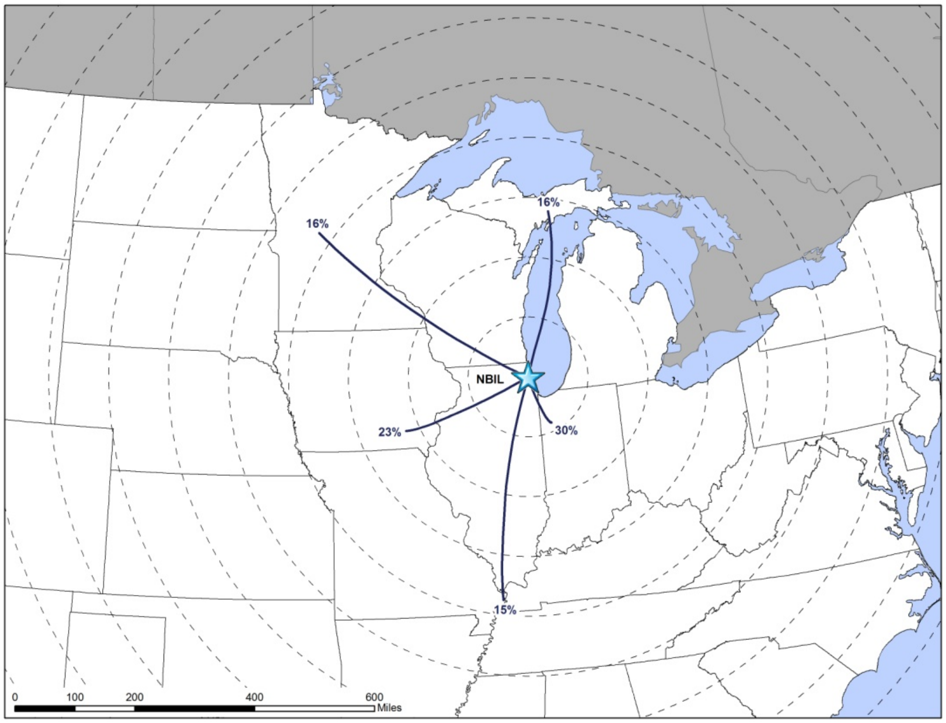


Figure 11-8. Composite Back Trajectory Map for SPIL

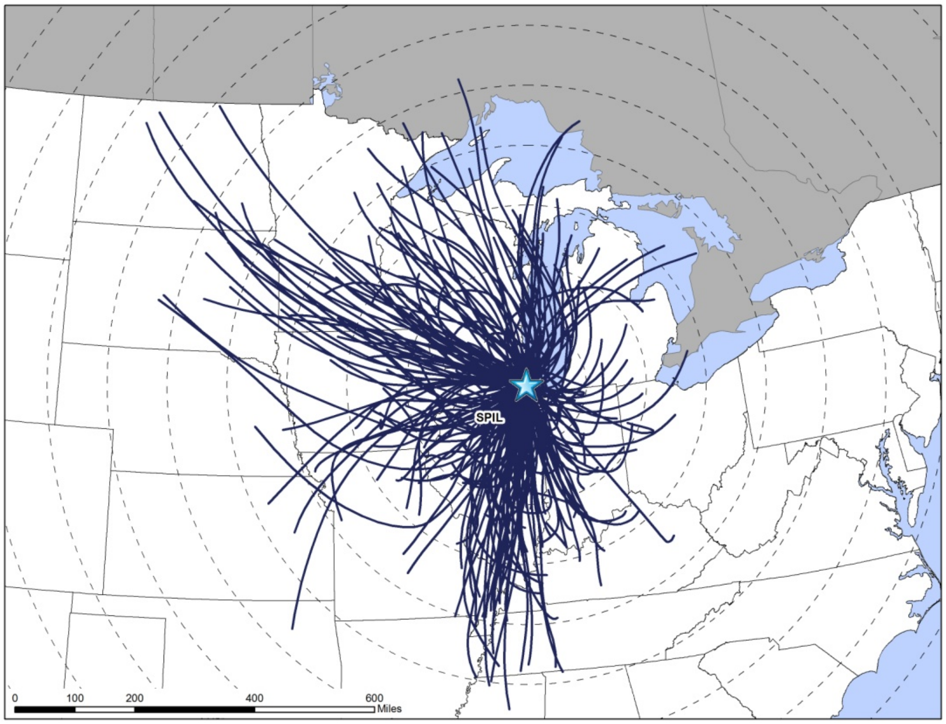


Figure 11-9. Back Trajectory Cluster Map for SPIL

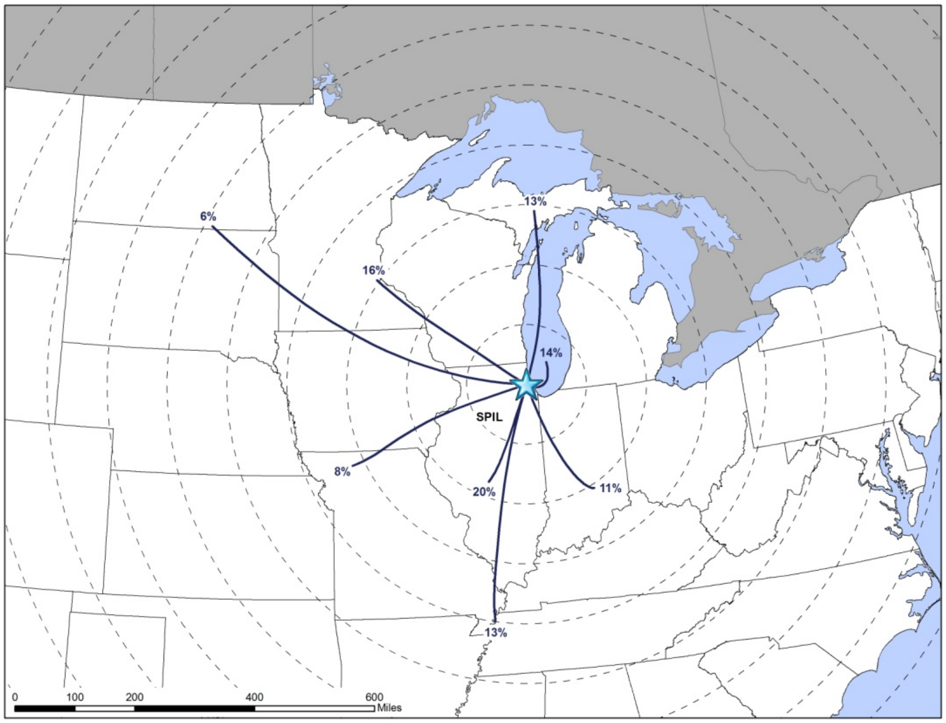


Figure 11-10. Composite Back Trajectory Map for ROIL

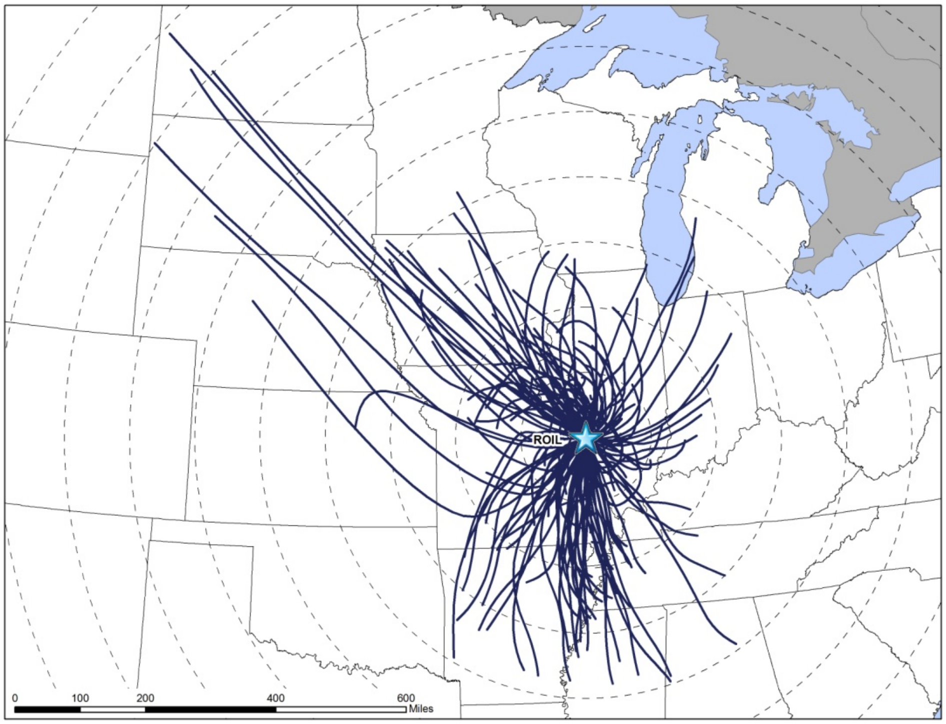
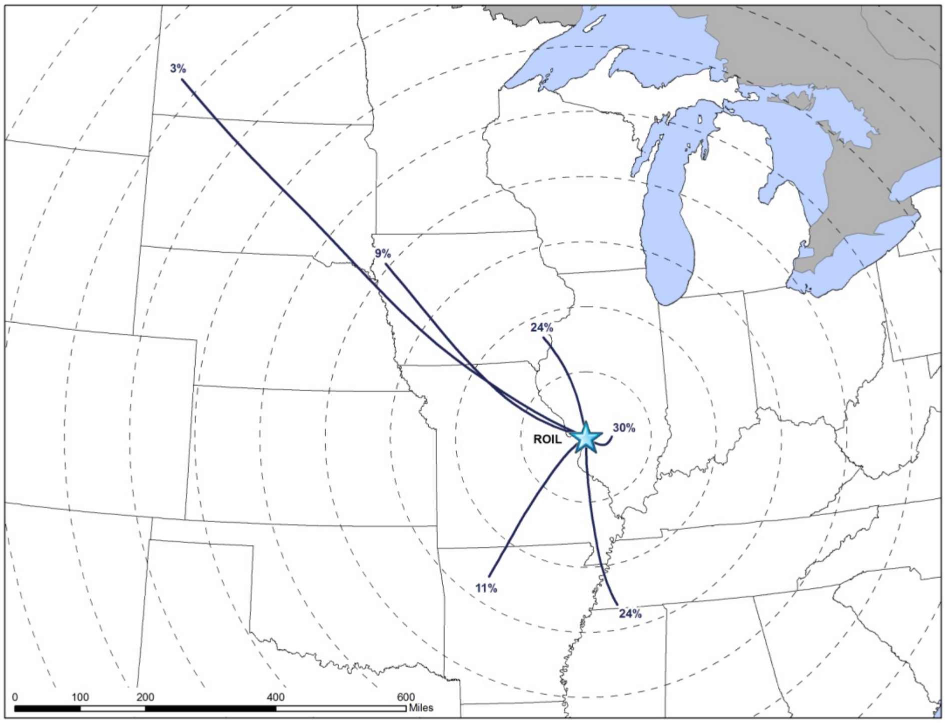


Figure 11-11. Back Trajectory Cluster Map for ROIL



Observations from Figures 11-6 through 11-9 for NBIL and SPIL include the following:

- The composite back trajectory maps for NBIL and SPIL are similar to each other in back trajectory distribution, which is expected given their proximity to each other.

- Back trajectories originated from a variety of directions at the sites, with the longest trajectories originating from the northwest and north. The predominant direction of back trajectory origin appears to be from the south, northwest, and north.

- The 24-hour air shed domains for NBIL and SPIL were among the largest in size compared to other NMP sites. The longest back trajectories for each site were greater than 750 miles in length and originated over North Dakota. These back trajectories represent the November 23, 2012 sample day. However, the average back trajectory length for these sites is approximately 280 miles and greater than 80 percent of back trajectories originated within 400 miles of the sites.

- Back trajectories often originated to the north of NBIL (16 percent) and over Lake Superior, the Upper Peninsula of Michigan, Lake Michigan, and northern Michigan. Another 16 percent of back trajectories originated to the northwest of NBIL, over Minnesota and the Dakotas. Nearly one-quarter of back trajectories originated to the west and southwest of NBIL, over Iowa, Missouri, and western Illinois, although these back trajectories tended to be shorter than those originating from the northwest or north of the site. Fifteen percent of back trajectories originated to the south of the site, over western Kentucky and Tennessee, northeastern Arkansas, or southeast Missouri. The short cluster trajectory originating over northwest Indiana represents back trajectories originating to the east, southeast, and south of the site and generally less than 300 miles in length, but also shorter back trajectories originating along the Wisconsin/Illinois border or over the southern half of Lake Michigan. The HYSPLIT model is grouping these back trajectories together due to their relatively short length rather than their directional similarities.

- The cluster analysis for SPIL has more cluster trajectories than the cluster analysis for NBIL. The differences in grouping often result in a single cluster trajectory for one site being split into two for another or vice versa. The cluster analysis shows that back trajectories originated to the north of SPIL (13 percent); to the northwest of SPIL (22 percent, although these are split into two cluster trajectories based on length); to the west and southwest of SPIL (8 percent); to the south of SPIL (13 percent); over the state of Illinois and generally less than 200 miles in length (20 percent); and over Indiana and less than 300 miles in length (11 percent). The short cluster trajectory originating over Lake Michigan and representing 14 percent of back trajectories includes those trajectories originating less than 150 miles away and looping around Lake Michigan towards the site.

Observations from Figures 11-10 and 11-11 for ROIL include the following:

- The composite back trajectory map for ROIL has fewer back trajectories than the composite maps for the Chicago sites because sampling at this site did not begin until June 2012.

- Back trajectories originated from a variety of directions at the site, with the longest trajectories originating from the northwest. Few back trajectories originated from due east or west.

- One of the longest back trajectories computed among all NMP sites was generated for ROIL. This back trajectory represents the November 23, 2012 sample day, originates over western North Dakota, and is nearly 900 miles long. This is the same date for which the longest back trajectories were generated for the Chicago sites. Yet, the 24-hour air shed domain for ROIL is similar in size to many other NMP sites. The average back trajectory length for this site is 234 miles and nearly 84 percent of back trajectories originated within 350 miles of the site.

- The cluster map for ROIL bears some resemblance to the cluster map for NBIL in the geographical distribution of the clusters. Back trajectories originating to the northwest, north, and northeast of ROIL account for nearly 25 percent of back trajectories. Another 12 percent originated to the northwest of the site, but are split into two cluster trajectories based on length. Eleven percent of back trajectories originated to the southwest of ROIL, over Missouri and Arkansas. Nearly one quarter of back trajectories originated to the south of the site, over western Kentucky and Tennessee, northeastern Arkansas, or northern Mississippi. The short cluster trajectory originating over south-central Illinois represents back trajectories originating to the northeast and east over Indiana as well as shorter back trajectories that spiraled around the southern half of Illinois on the way to ROIL.

11.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations at Palwaukee Municipal Airport (for NBIL), O’Hare International Airport (for SPIL), and Lambert/St. Louis International Airport (for ROIL) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 11-12 presents a map showing the distance between the weather station and NBIL, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 11-12 also presents three different wind roses for the NBIL monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 11-13 and 11-14 present the distance map and three wind roses for SPIL and ROIL, respectively.

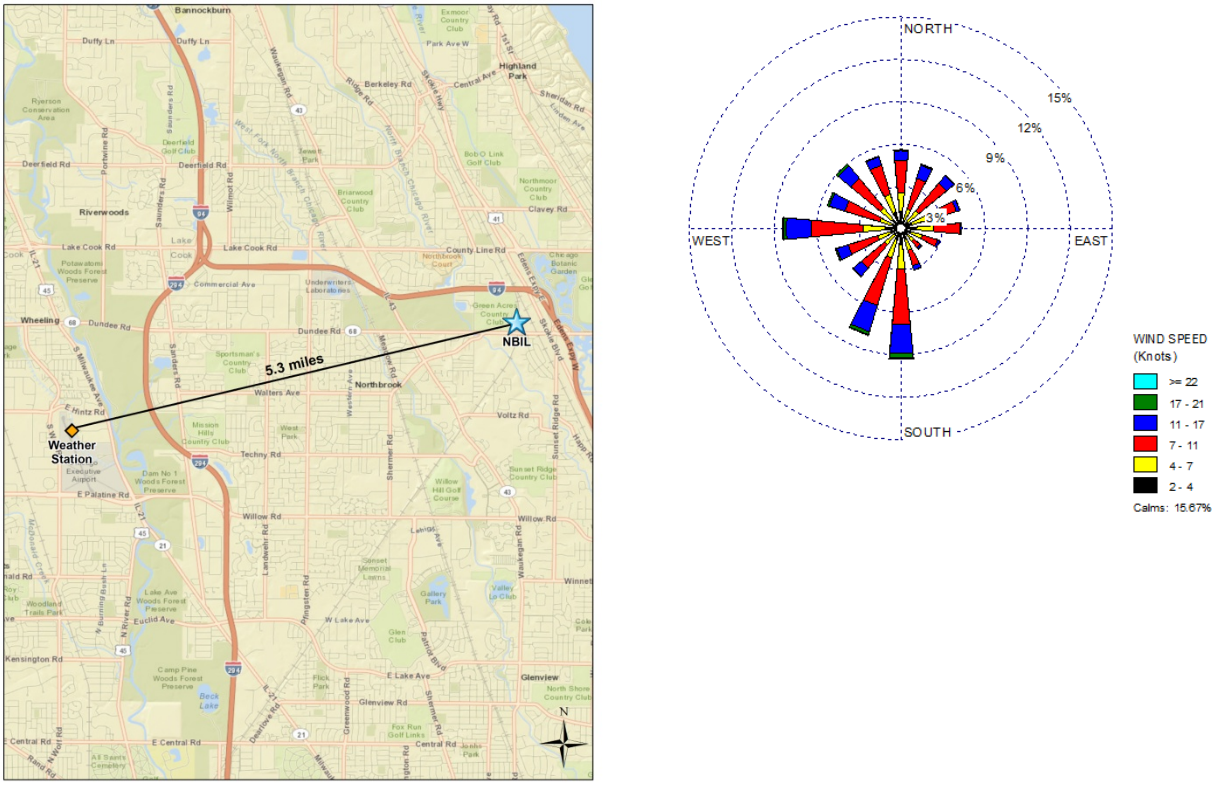
Observations from Figure 11-12 for NBIL include the following:

- The Palwaukee Municipal Airport weather station is located 5.3 miles west-southwest of NBIL.
- The historical wind rose shows that winds from a variety of directions were observed near NBIL, although winds from the south, south-southwest, and west accounted for one-quarter of wind observations. Winds from the east-southeast to south-southeast were observed the least often. Calm winds (≤ 2 knots) were observed for approximately 16 percent of the hourly measurements.
- The 2012 wind rose exhibits similar patterns in wind directions as the historical wind rose, although a higher percentage of winds from the south and south-southwest and fewer winds from the west were observed in 2012.
- The sample day wind patterns resemble the full-year wind patterns, with an even higher percentage of winds from the south and south-southwest and even fewer winds from the west.

Observations from Figure 11-13 for SPIL include the following:

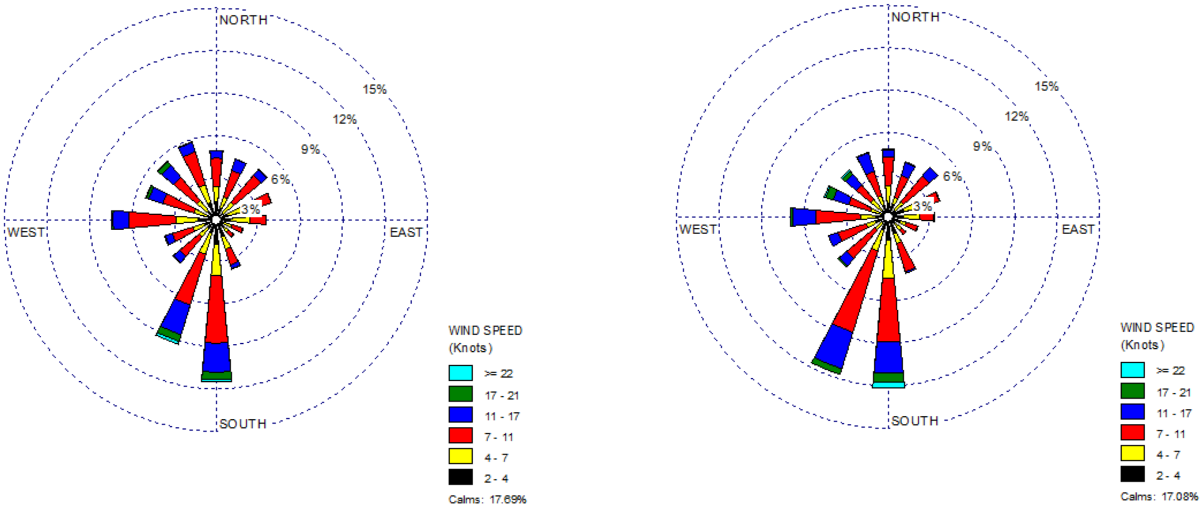
- The O’Hare International Airport weather station is located 3.5 miles west-northwest of SPIL. Most of the airport property lies between the weather station and the monitoring site.
- The historical wind rose for SPIL shows that winds from a variety of directions were observed, although winds from the south to southwest to west account for the highest percentage of observations (nearly 40 percent). Winds from the southeast quadrant were observed the least. Calm winds (≤ 2 knots) were observed for less than 8 percent of the hourly measurements.
- The 2012 wind rose exhibits similar patterns in wind directions as the historical wind rose, although winds from the predominant directions accounted for an even higher percentage of the wind observations. The strongest winds were from the south and south-southwest.
- The sample day wind pattern resemble those of the full-year wind rose, with the winds from the south to southwest to west accounting for nearly 50 percent of the wind observations.

Figure 11-12. Wind Roses for the Palwaukee Municipal Airport Weather Station near NBIL



Location of NBIL and Weather Station

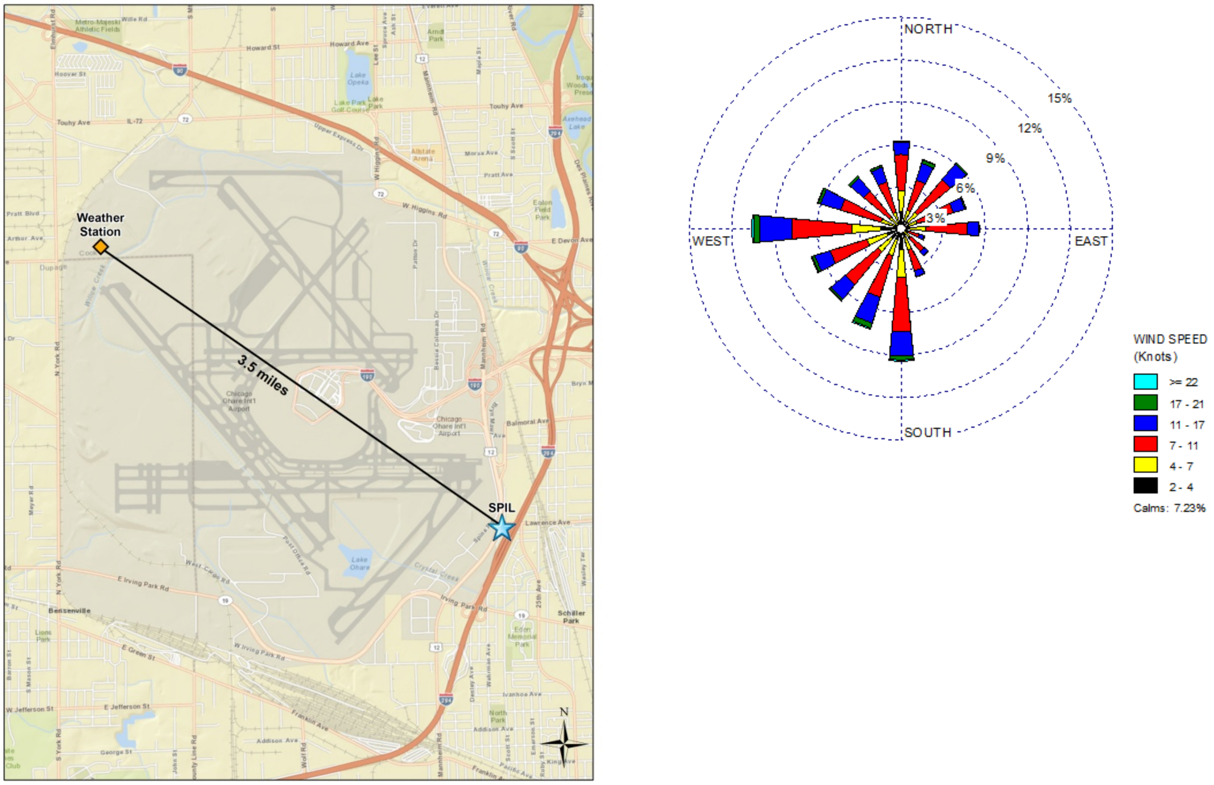
2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Figure 11-13. Wind Roses for the O'Hare International Airport Weather Station near SPIL



Location of SPIL and Weather Station

2002-2011 Historical Wind Rose

2012 Wind Rose

Sample Day Wind Rose

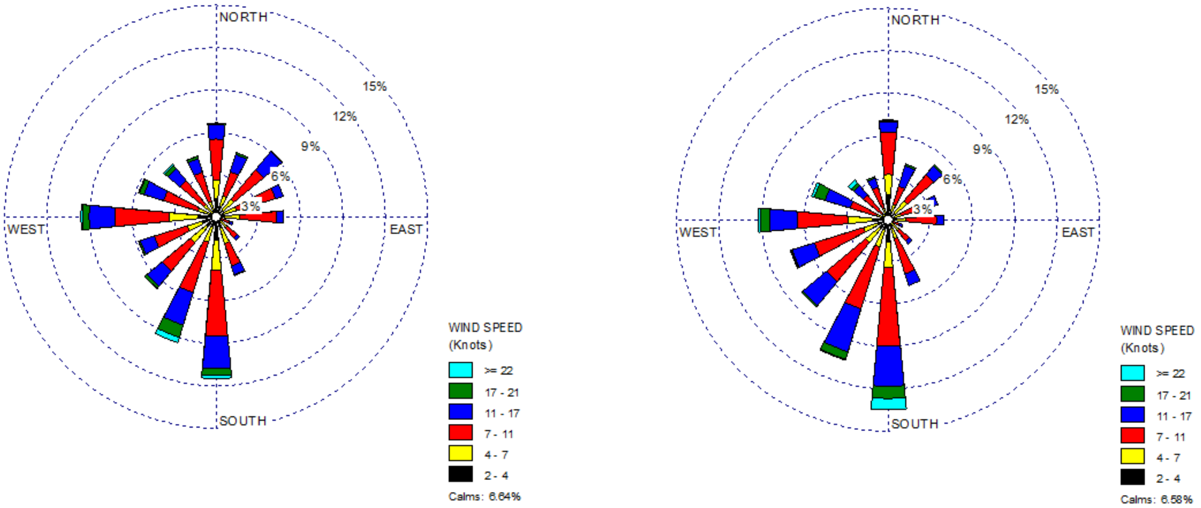
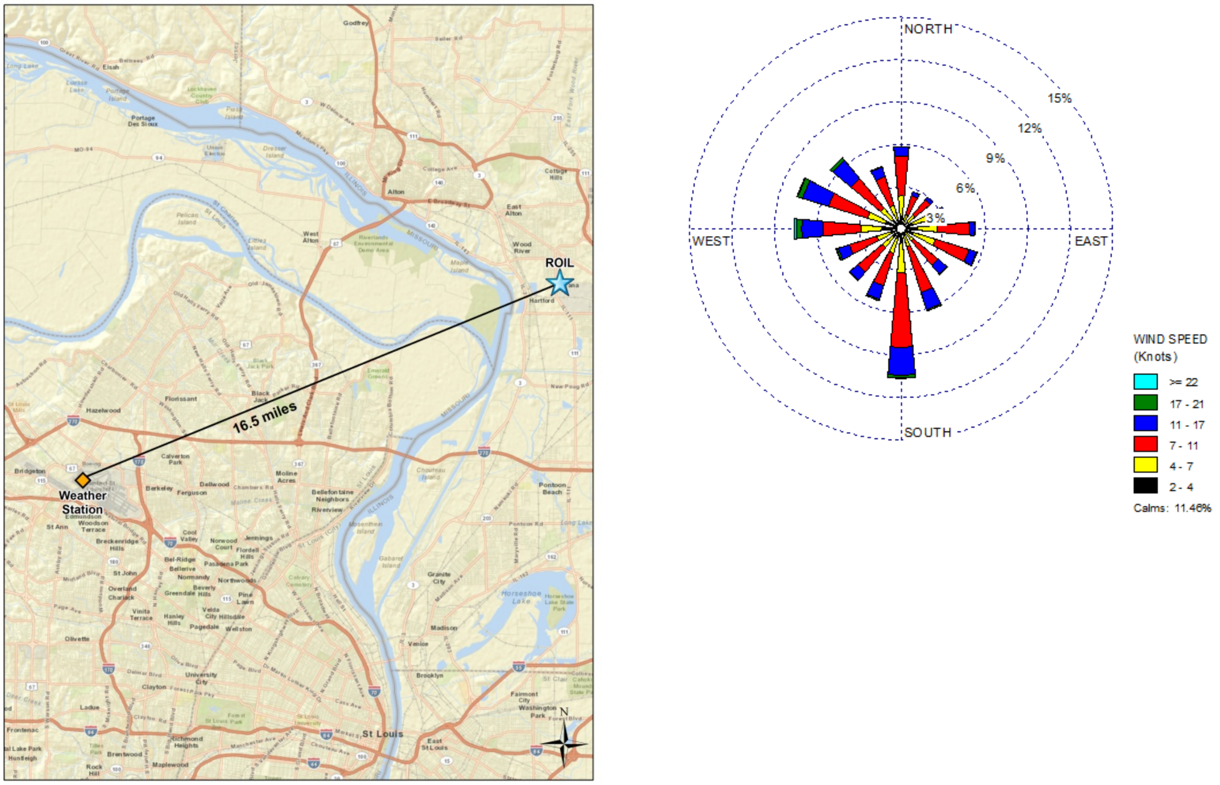
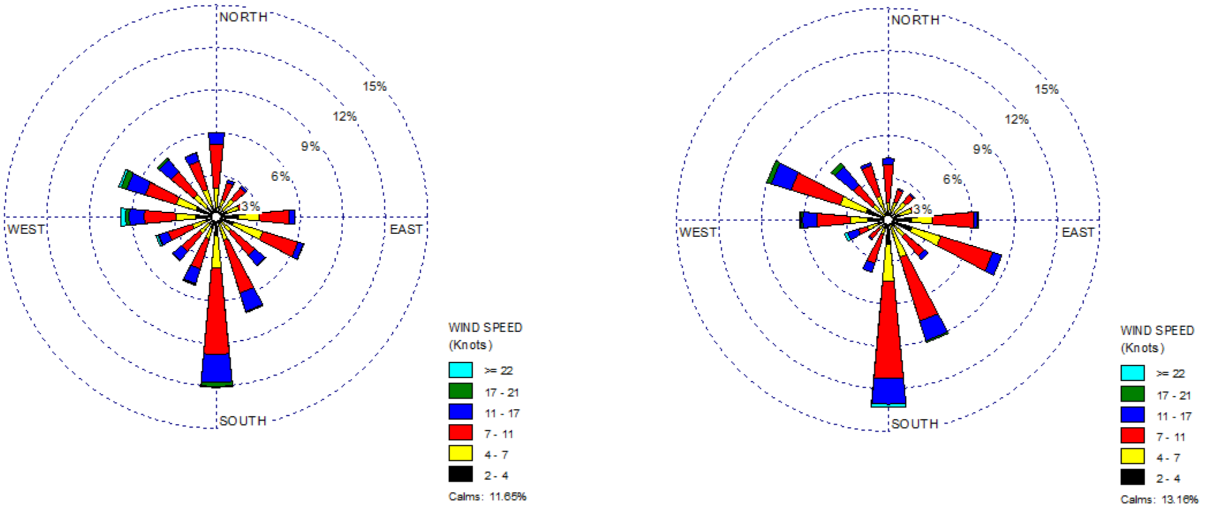


Figure 11-14. Wind Roses for the Lambert/St. Louis International Airport Weather Station near ROIL



Location of ROIL and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Observations from Figure 11-14 for ROIL include the following:

- The Lambert/St. Louis International Airport weather station is located 16.5 miles west-southwest of ROIL. The airport lies to the northwest of the city of St. Louis and south of the Missouri River.
- The historical wind rose for ROIL shows that winds from a variety of directions were observed, with winds from the south observed the most. Winds from the west to northwest were also common while winds from the northeast quadrant were observed the least. Calm winds (≤ 2 knots) were observed for less than 12 percent of the hourly measurements.
- The 2012 wind rose exhibits similar patterns in wind directions as the historical wind rose, although winds from the south accounted for an even higher percentage of the wind observations.
- The predominant wind direction on the sample day wind rose is still south, but the similarities in the wind patterns are fewer. Winds from the east, east-southeast, south-southeast, and west-northwest account for a higher percentage of wind observations than they do on the full-year wind rose. However, this sample day wind rose includes only seven months of the year as sampling at ROIL did not begin until June 2012.

11.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Illinois monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 11-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 11-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. NBIL sampled for VOCs, carbonyl compounds, SNMOCs, metals (PM_{10}), PAHs, and hexavalent chromium, while SPIL and ROIL sampled for VOCs and carbonyl compounds only.

Table 11-4. Risk-Based Screening Results for the Illinois Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Northbrook, Illinois - NBIL						
Formaldehyde	0.077	66	66	100.00	11.74	11.74
Acetaldehyde	0.45	65	66	98.48	11.57	23.31
Benzene	0.13	61	61	100.00	10.85	34.16
Carbon Tetrachloride	0.17	61	61	100.00	10.85	45.02
1,2-Dichloroethane	0.038	53	53	100.00	9.43	54.45
Arsenic (PM_{10})	0.00023	47	54	87.04	8.36	62.81
Naphthalene	0.029	44	57	77.19	7.83	70.64
1,3-Butadiene	0.03	42	45	93.33	7.47	78.11
Manganese (PM_{10})	0.005	31	54	57.41	5.52	83.63
Fluorene	0.011	22	57	38.60	3.91	87.54
Acenaphthene	0.011	19	57	33.33	3.38	90.93
Fluoranthene	0.011	14	57	24.56	2.49	93.42
p-Dichlorobenzene	0.091	12	31	38.71	2.14	95.55
Ethylbenzene	0.4	8	61	13.11	1.42	96.98
Hexachloro-1,3-butadiene	0.045	5	6	83.33	0.89	97.86
Trichloroethylene	0.2	4	25	16.00	0.71	98.58
Chloroform	9.8	3	61	4.92	0.53	99.11
Benzo(a)pyrene	0.00057	1	55	1.82	0.18	99.29
Bromoform	0.91	1	13	7.69	0.18	99.47
Dichloromethane	7.7	1	61	1.64	0.18	99.64
Hexavalent Chromium	0.000083	1	44	2.27	0.18	99.82
Nickel (PM_{10})	0.0021	1	54	1.85	0.18	100.00
Total		562	1,099	51.14		
Schiller Park, Illinois - SPIL						
Acetaldehyde	0.45	61	61	100.00	14.91	14.91
Formaldehyde	0.077	61	61	100.00	14.91	29.83
Benzene	0.13	60	60	100.00	14.67	44.50
Carbon Tetrachloride	0.17	60	60	100.00	14.67	59.17
1,3-Butadiene	0.03	58	59	98.31	14.18	73.35
1,2-Dichloroethane	0.038	55	55	100.00	13.45	86.80
Trichloroethylene	0.2	22	49	44.90	5.38	92.18
p-Dichlorobenzene	0.091	11	39	28.21	2.69	94.87
Ethylbenzene	0.4	11	60	18.33	2.69	97.56
Hexachloro-1,3-butadiene	0.045	4	9	44.44	0.98	98.53
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	0.98	99.51
1,2-Dibromoethane	0.0017	1	1	100.00	0.24	99.76
Propionaldehyde	0.8	1	61	1.64	0.24	100.00
Total		409	579	70.64		

Table 11-4. Risk-Based Screening Results for the Illinois Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Roxana, Illinois - ROIL						
Formaldehyde	0.077	35	35	100.00	15.35	15.35
Acetaldehyde	0.45	34	35	97.14	14.91	30.26
Benzene	0.13	33	33	100.00	14.47	44.74
Carbon Tetrachloride	0.17	33	33	100.00	14.47	59.21
1,3-Butadiene	0.03	30	31	96.77	13.16	72.37
1,2-Dichloroethane	0.038	29	29	100.00	12.72	85.09
Ethylbenzene	0.4	19	33	57.58	8.33	93.42
p-Dichlorobenzene	0.091	5	22	22.73	2.19	95.61
Hexachloro-1,3-butadiene	0.045	4	5	80.00	1.75	97.37
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	1.75	99.12
1,2-Dibromoethane	0.0017	2	2	100.00	0.88	100.00
Total		228	262	87.02		

Observations from Table 11-4 include the following:

- The number of pollutants failing screens for NBIL is higher than the other two monitoring sites; this is expected given the difference in the pollutants measured at each site.

- Twenty-two pollutants failed at least one screen for NBIL; 51 percent of concentrations for these 22 pollutants were greater than their associated risk screening value (or failed screens).

- Thirteen pollutants contributed to 95 percent of failed screens for NBIL and therefore were identified as pollutants of interest for this site. These 13 include two carbonyl compounds, five VOCs, two PM_{10} metals, and four PAHs.

- NBIL failed the fifth highest number of screens (562) among all NMP sites, as shown in Table 4-8 of Section 4.2. However, the failure rate for NBIL, when incorporating all pollutants with screening values, is relatively low, at 22 percent. This is due primarily to the relatively high number of pollutants sampled for at this site, as discussed in Section 4.2. NBIL is one of only two NMP sites sampling for all six pollutant groups. Recall from Section 3.2 that if a pollutant was measured by both the TO-15 and SNMOC methods at the same site, the TO-15 results were used for the risk-based screening process. As NBIL sampled both VOCs (TO-15) and SNMOCs, the TO-15 results were used for the 12 pollutants these methods have in common.

- Thirteen pollutants failed screens for SPIL; approximately 71 percent of concentrations for these 13 pollutants were greater than their associated risk screening value (or failed screens).

- Nine pollutants contributed to 95 percent of failed screens for SPIL and therefore were identified as pollutants of interest for this site. These nine include two carbonyl compounds and seven VOCs.

- Eleven pollutants failed screens for ROIL; approximately 87 percent of concentrations for these 11 pollutants were greater than their associated risk screening value (or failed screens). Although this percentage is higher for ROIL than the Chicago sites, nearly all of the measured detections for the pollutants listed for ROIL failed screens while the percentage of screens failed for each individual pollutant is more varied for the Chicago sites.

- Eight pollutants contributed to 95 percent of failed screens for ROIL and therefore were identified as pollutants of interest for this site. These eight include two carbonyl compounds and six VOCs.

- The Illinois monitoring sites have seven pollutants of interest in common: two carbonyl compounds (acetaldehyde and formaldehyde) and five VOCs (benzene, 1,3-butadiene, carbon tetrachloride, *p*-dichlorobenzene, and 1,2-dichloroethane). Of these, benzene, carbon tetrachloride, 1,2-dichloroethane, and formaldehyde failed 100 percent of screens for each site.

11.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Illinois monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.

- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for NBIL, SPIL, and ROIL are provided in Appendices J through O.

11.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Illinois site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Illinois monitoring sites are presented in Table 11-5, where applicable. Note that concentrations of the PAHs and metals for NBIL are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 11-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Illinois Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Northbrook, Illinois - NBIL						
Acetaldehyde	66/66	1.82 ± 0.41	1.89 ± 0.43	1.72 ± 0.43	1.73 ± 0.38	1.78 ± 0.19
Benzene	61/61	0.70 ± 0.18	0.54 ± 0.14	0.70 ± 0.18	0.64 ± 0.14	0.64 ± 0.08
1,3-Butadiene	45/61	0.05 ± 0.02	0.04 ± 0.02	0.08 ± 0.04	0.08 ± 0.04	0.06 ± 0.02
Carbon Tetrachloride	61/61	0.75 ± 0.18	0.73 ± 0.04	0.67 ± 0.04	0.69 ± 0.04	0.71 ± 0.04
p-Dichlorobenzene	31/61	0.03 ± 0.03	0.05 ± 0.03	0.07 ± 0.03	0.02 ± 0.02	0.04 ± 0.01
1,2-Dichloroethane	53/61	0.09 ± 0.02	0.07 ± 0.02	0.06 ± 0.02	0.06 ± 0.02	0.07 ± 0.01
Formaldehyde	66/66	1.73 ± 0.26	2.78 ± 0.82	3.52 ± 0.92	2.00 ± 0.24	2.49 ± 0.33
Acenaphthene[a]	57/57	4.49 ± 3.76	11.12 ± 5.35	20.20 ± 8.52	NA	11.51 ± 3.62
Arsenic (PM_{10})[a]	54/54	0.66 ± 0.21	0.67 ± 0.24	0.85 ± 0.23	0.72 ± 0.33	0.73 ± 0.12
Fluoranthene[a]	57/57	2.95 ± 2.00	7.69 ± 3.46	14.15 ± 5.88	NA	7.07 ± 2.27
Fluorene[a]	57/57	4.89 ± 3.99	13.09 ± 6.11	23.97 ± 11.51	NA	12.31 ± 4.18
Manganese (PM_{10})[a]	54/54	8.26 ± 3.55	10.93 ± 5.65	9.37 ± 2.91	7.92 ± 3.84	9.11 ± 1.86
Naphthalene[a]	57/57	62.56 ± 29.90	63.79 ± 22.73	98.01 ± 26.37	NA	77.94 ± 17.77

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Table 11-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Illinois Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Schiller Park, Illinois - SPIL						
Acetaldehyde	61/61	1.57 ± 0.33	1.44 ± 0.22	2.04 ± 0.62	5.65 ± 2.41	2.72 ± 0.77
Benzene	60/60	1.10 ± 0.40	0.91 ± 0.33	0.84 ± 0.17	0.96 ± 0.54	0.95 ± 0.19
1,3-Butadiene	59/60	0.13 ± 0.03	0.10 ± 0.03	0.15 ± 0.03	0.17 ± 0.12	0.14 ± 0.03
Carbon Tetrachloride	60/60	0.63 ± 0.07	0.73 ± 0.04	0.65 ± 0.04	0.71 ± 0.04	0.68 ± 0.03
p-Dichlorobenzene	39/60	0.05 ± 0.03	0.06 ± 0.02	0.06 ± 0.03	0.04 ± 0.04	0.05 ± 0.02
1,2-Dichloroethane	55/60	0.09 ± 0.01	0.09 ± 0.02	0.07 ± 0.01	0.07 ± 0.02	0.08 ± 0.01
Ethylbenzene	60/60	0.26 ± 0.09	0.28 ± 0.08	0.31 ± 0.09	0.28 ± 0.19	0.29 ± 0.06
Formaldehyde	61/61	1.94 ± 0.40	3.13 ± 0.73	4.64 ± 1.51	2.66 ± 1.36	3.09 ± 0.58
Trichloroethylene	49/60	0.64 ± 0.66	0.56 ± 0.40	0.36 ± 0.21	1.20 ± 2.24	0.71 ± 0.60
Roxana, Illinois - ROIL						
Acetaldehyde	35/35	NA	NA	5.00 ± 0.67	3.51 ± 0.78	NA
Benzene	33/33	NA	NA	1.77 ± 0.64	1.90 ± 0.53	NA
1,3-Butadiene	31/33	NA	NA	0.09 ± 0.03	0.10 ± 0.04	NA
Carbon Tetrachloride	33/33	NA	NA	0.66 ± 0.04	0.67 ± 0.04	NA
p-Dichlorobenzene	22/33	NA	NA	0.06 ± 0.02	0.03 ± 0.02	NA
1,2-Dichloroethane	29/33	NA	NA	0.08 ± 0.02	0.09 ± 0.02	NA
Ethylbenzene	33/33	NA	NA	0.56 ± 0.15	0.42 ± 0.13	NA
Formaldehyde	35/35	NA	NA	1.13 ± 0.16	0.91 ± 0.23	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for NBIL from Table 11-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde (2.49 ± 0.33 µg/m^3) and acetaldehyde (1.78 ± 0.19 µg/m^3). The annual average concentrations for the remaining pollutants of interest are less than 1 µg/m^3.

- The second and third quarter average formaldehyde concentrations are higher than the first and fourth quarter averages and have relatively large confidence intervals associated with them. The two highest formaldehyde concentrations measured at NBIL were measured on back-to-back sample days in August (7.18 µg/m^3 and 6.52 µg/m^3). The 10 highest concentrations were all measured between May and September at this site, and ranged from 3.38 µg/m^3 to 7.18 µg/m^3.

- The first quarter average concentration of carbon tetrachloride is not significantly different than the other quarterly averages but does have a relatively large confidence interval associated with it. A review of the data shows that the measurement collected on January 10, 2012 (1.88 µg/m^3) is more than twice the next highest concentration measured at NBIL. This measurement is the fourth highest concentration of carbon tetrachloride measured among all NMP sites sampling VOCs.

- Fourth quarter average concentrations could not be calculated for the PAHs because fewer than 75 percent of samples were valid during this quarter.

- The second and third quarter average concentrations of acenaphthene, fluoranthene, and fluorene were considerably higher than the first quarter averages, although all of the quarterly averages shown exhibit a relatively large amount of variability based on the confidence intervals.

- The maximum concentration of fluorene was measured on September 6, 2012 (93.4 ng/m^3) and is nearly twice the next highest concentration, which was measured on July 2, 2012 (55.0 ng/m^3). Concentrations of fluorene measured at NBIL span two orders of magnitude (0.934 ng/m^3 to 93.4 ng/m^3), with all but two of the 17 concentrations greater than 15 ng/m^3 measured in samples collected between May and September. Conversely, all 18 concentrations less than 3 ng/m^3 were measured between January and April or October and December. This seasonality in the concentrations is also apparent in the fluoranthene measurements collected at NBIL (and to some extent the acenaphthene measurements).

- Although the third quarter average concentration of naphthalene is greater than the first and second quarterly averages, the maximum concentrations of naphthalene were measured in December (359 ng/m^3), November (233 ng/m^3), and March (228 ng/m^3). Despite this, the median concentration for the third quarter is two to three times greater than the median concentrations for the other quarters. The third quarter has the greatest number of naphthalene concentrations greater than 100 ng/m^3 (five) and the least less than 40 ng/m^3 (zero).

- Concentrations of manganese also exhibit a considerable amount of variability, particularly the second quarter. Although the two highest concentrations of manganese were measured at NBIL in May (32.1 ng/m^3) and June (25.4 ng/m^3), the minimum manganese concentration was measured in April (1.87 ng/m^3).

Observations for SPIL from Table 11-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde (3.09 ± 0.58 µg/m^3) and acetaldehyde (2.72 ± 0.77 µg/m^3). These are the only pollutants with annual average concentrations greater than 1 µg/m^3.

- The fourth quarter average concentration of acetaldehyde is significantly higher than the other quarterly averages and has a relatively large confidence interval associated with it. A review of the data shows that 13 of the 15 concentrations greater than 3 µg/m^3 were measured at SPIL during the fourth quarter of 2012 and ranged from 3.19 µg/m^3 to 20.4 µg/m^3. The three highest concentrations of acetaldehyde measured among NMP sites sampling carbonyl compounds were measured at SPIL (8.74 µg/m^3, 11.8 µg/m^3, and 20.4 µg/m^3) between November and December.

- The third and fourth quarter average concentrations of formaldehyde have relatively large confidence intervals associated with them. Six of the eight highest concentrations of formaldehyde were measured at SPIL in July or August, including the maximum concentration measured (12.8 µg/m^3). The second highest concentration, however, was measured in December (12.3 µg/m^3). The next highest concentration measured during the fourth quarter of 2012 was considerably less (3.67 µg/m^3).

- Several fourth quarter averages for the VOCs have relatively large confidence intervals associated with them. The maximum concentration of benzene, 1,3-butadiene, ethylbenzene, and *p*-dichlorobenzene were all measured on November 17, 2012. The next highest concentration measured during the fourth quarter for each of these pollutants was considerably less.

- All four quarterly averages of trichloroethylene have relatively large confidence intervals associated with them, particularly the fourth quarter average concentration. This indicates that the concentrations of trichloroethylene are highly variable. A review of the data shows that the maximum trichloroethylene concentration was measured on November 17, 2012 (17.5 µg/m^3) and is the highest trichloroethylene concentration measured among NMP sites sampling VOCs. Of the 10 concentrations of trichloroethylene greater than 1 µg/m^3 across the program, eight of these were measured at SPIL. The maximum concentration of trichloroethylene measured at SPIL is nearly four times higher than the next highest concentration measured at this site (4.57 µg/m^3). Trichloroethylene concentrations measured at this site range from 0.0431 µg/m^3 to 17.5 µg/m^3, with a median concentration of 0.127 µg/m^3 (including 11 non-detects). Similar observations were also made in the 2011 NMP report.

Observations for ROIL from Table 11-5 include the following:

- First and second quarter average concentrations are not provided for ROIL because sampling did not begin until June 2012, and because at least three quarterly averages are not available, annual averages could not be calculated for this site.

- The quarterly averages for acetaldehyde are significantly higher than the quarterly averages for the other pollutants of interest for ROIL. A review of the data shows that acetaldehyde measurements collected at ROIL span an order of magnitude, ranging from 0.303 $\mu g/m^3$ to 7.47 $\mu g/m^3$. The three highest concentrations measured at ROIL are among the 10 highest acetaldehyde concentrations measured among NMP sites sampling carbonyl compounds. Interestingly, four of the five lowest acetaldehyde concentrations were measured at ROIL on the first four sample days at ROIL (in June).

- Conversely, the quarterly average concentrations of formaldehyde (that could be calculated) are among the lowest for NMP sites sampling carbonyl compounds.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for NBIL and SPIL from those tables include the following:

- NBIL and SPIL appear in Tables 4-9 through 4-12 a total of 12 times. Annual averages could not be calculated for ROIL and therefore could not appear in these tables.

- The annual average concentrations for both Chicago sites appear in Table 4-9 for carbon tetrachloride, although there is little variability in the annual average concentrations of this pollutant. SPIL also appears in Table 4-9 for 1,3-butadiene (sixth) and 1,2-dichloroethane (fifth), while NBIL appears under hexachloro-1,3-butadiene (eighth).

- SPIL has the fourth highest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds, as shown in Table 4-10. Note however, that the confidence interval for SPIL is nearly twice the confidence intervals of the other sites shown, indicating that the concentrations collected at SPIL have a higher level of variability associated with them.

- NBIL has the second highest annual average concentration of fluorene and fourth highest annual average concentration of acenaphthene among NMP sites sampling PAHs, as shown in Table 4-11. The annual average concentration of naphthalene for NBIL ranks 10th.

- As shown in Table 4-12, NBIL’s annual average concentration of manganese ranks fifth among NMP sites sampling PM_{10} metals, with NBIL’s annual average concentrations of arsenic and nickel ranking seventh and eighth, respectively.

11.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 11-4 for NBIL and SPIL. Figures 11-15 through 11-29 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1. Site-specific box plots were not created for ROIL because annual averages could not be calculated.

Figure 11-15. Program vs. Site-Specific Average Acenaphthene Concentration

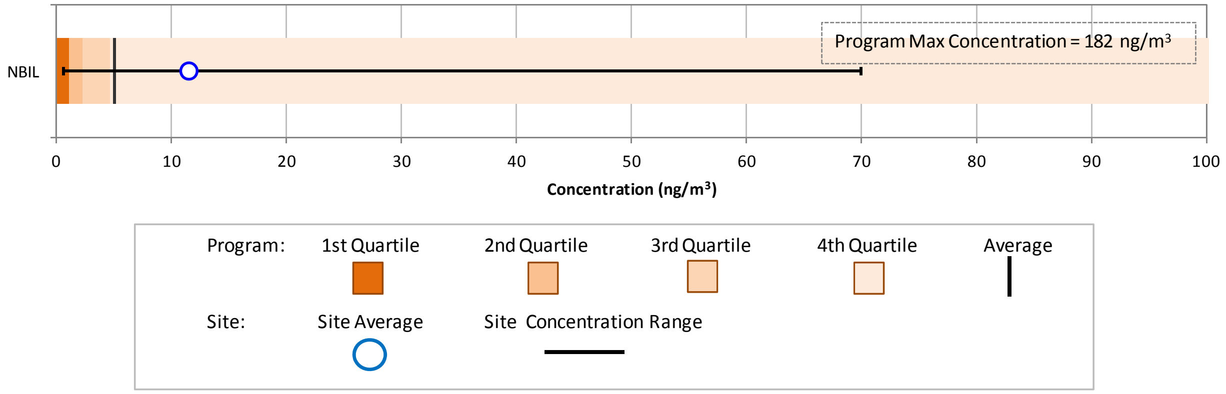


Figure 11-16. Program vs. Site-Specific Average Acetaldehyde Concentrations

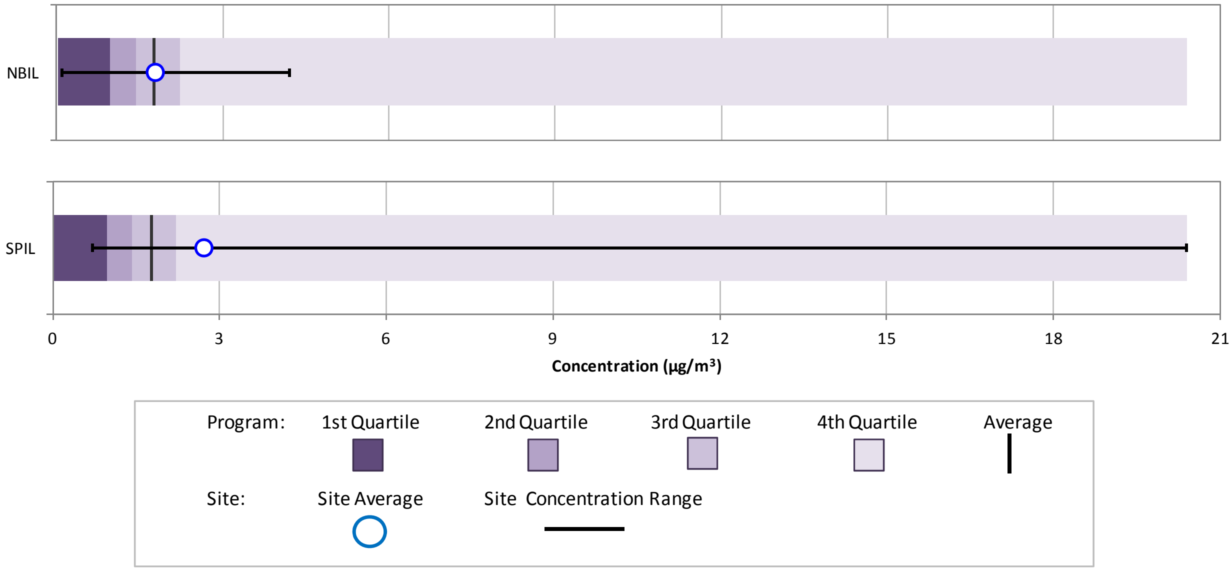


Figure 11-17. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

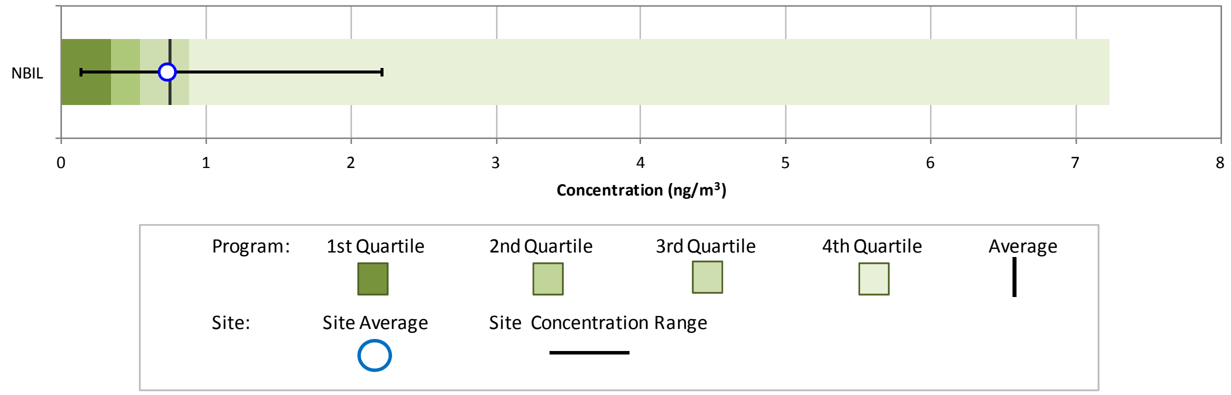


Figure 11-18. Program vs. Site-Specific Average Benzene Concentrations

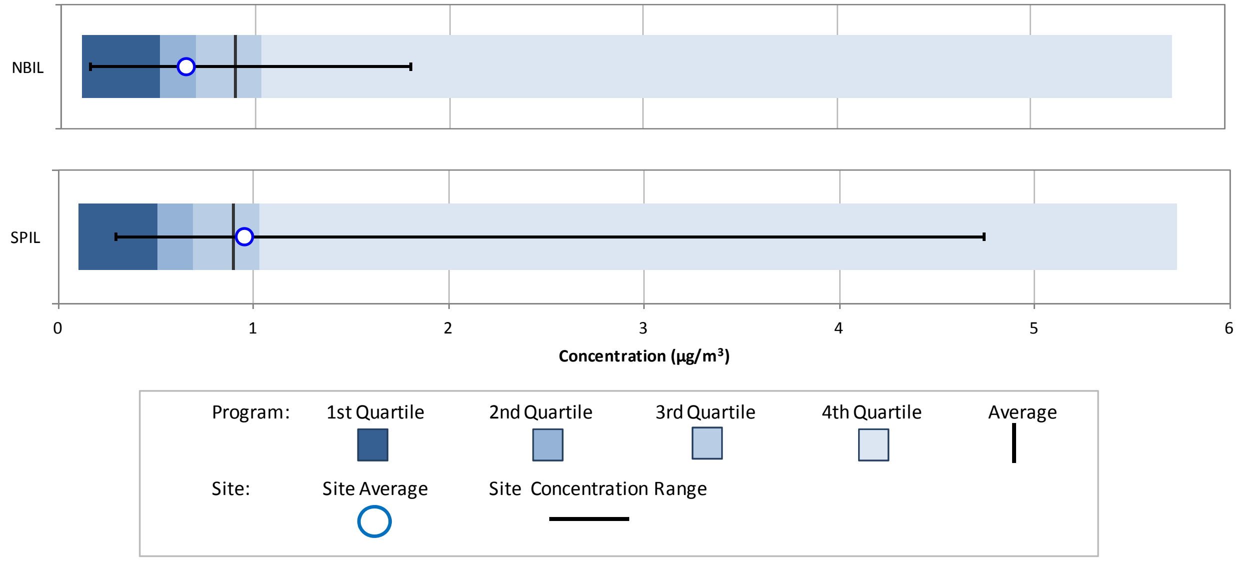


Figure 11-19 Program vs. Site-Specific Average 1,3-Butadiene Concentrations

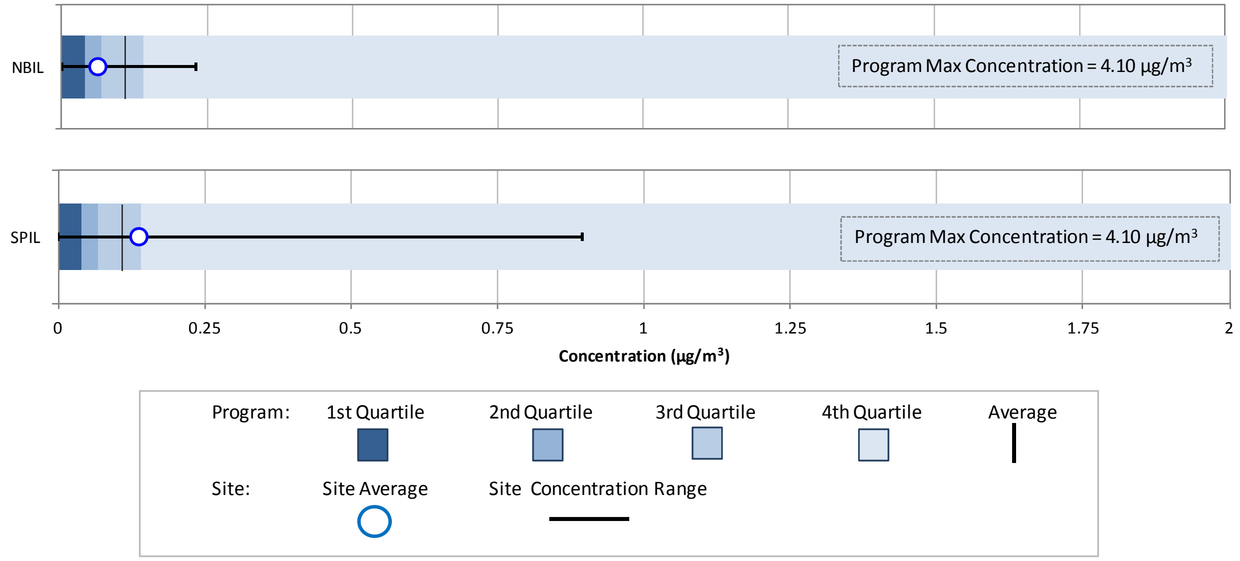


Figure 11-20. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

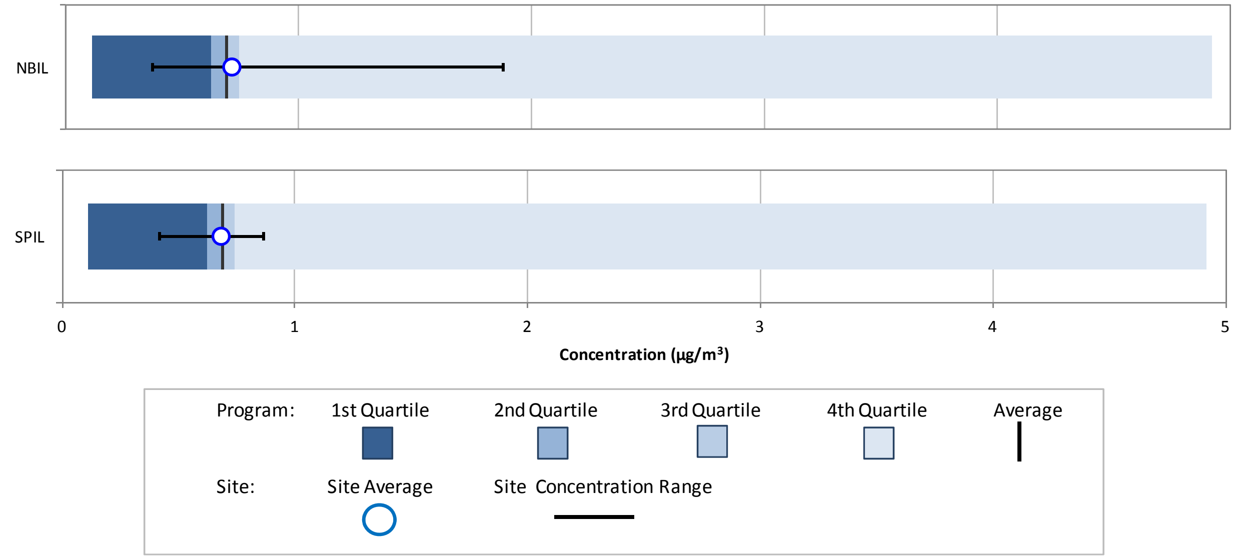


Figure 11-21. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentrations

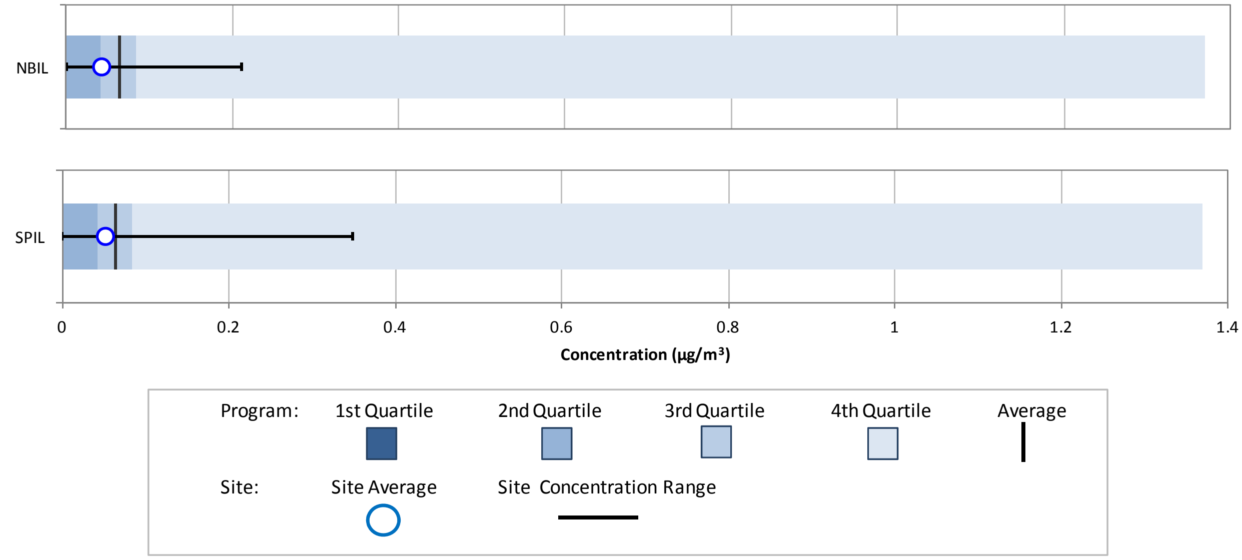


Figure 11-22. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

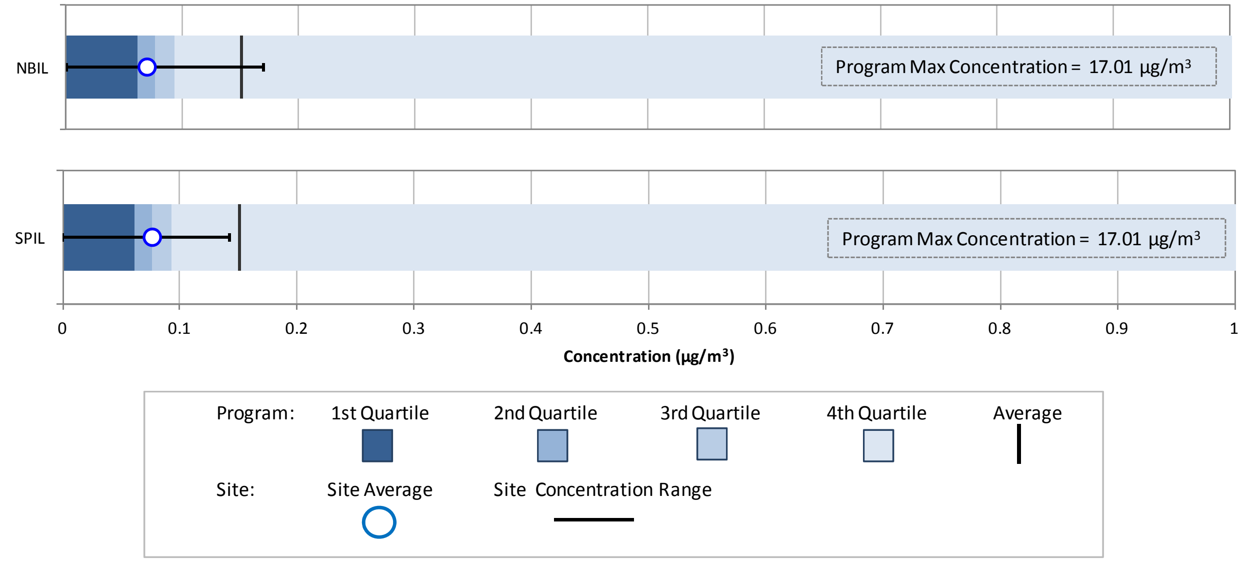


Figure 11-23. Program vs. Site-Specific Average Ethylbenzene Concentration

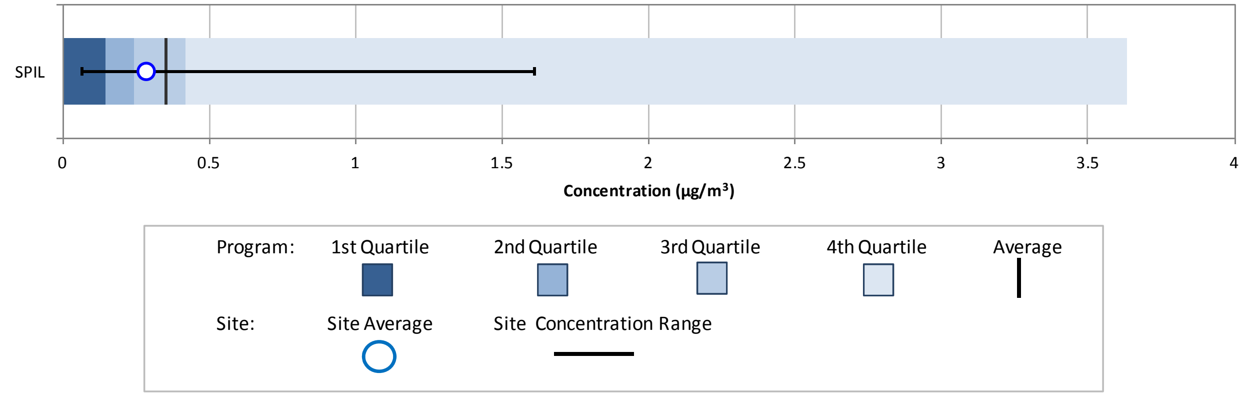


Figure 11-24. Program vs. Site-Specific Average Fluoranthene Concentration

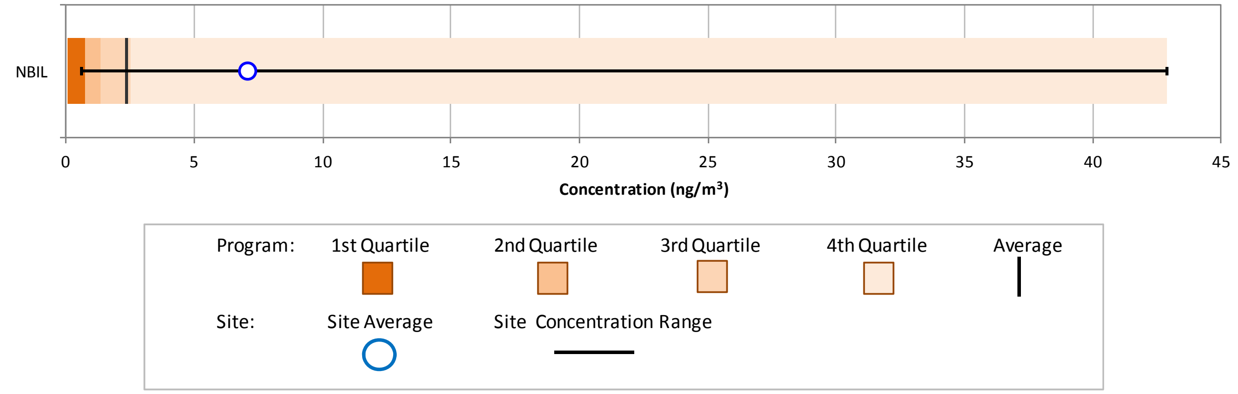


Figure 11-25. Program vs. Site-Specific Average Fluorene Concentration

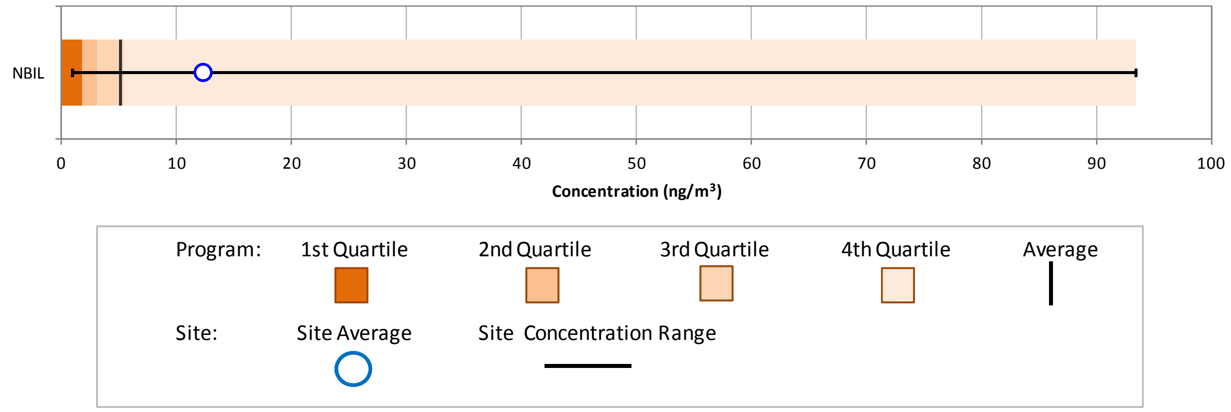


Figure 11-26. Program vs. Site-Specific Average Formaldehyde Concentrations

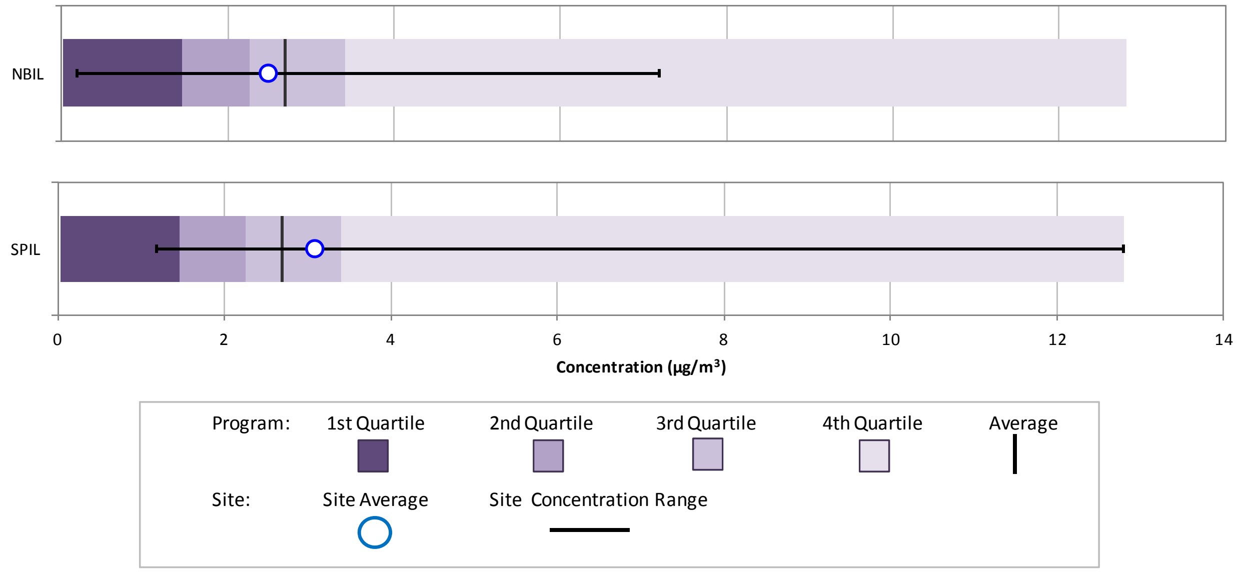


Figure 11-27. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

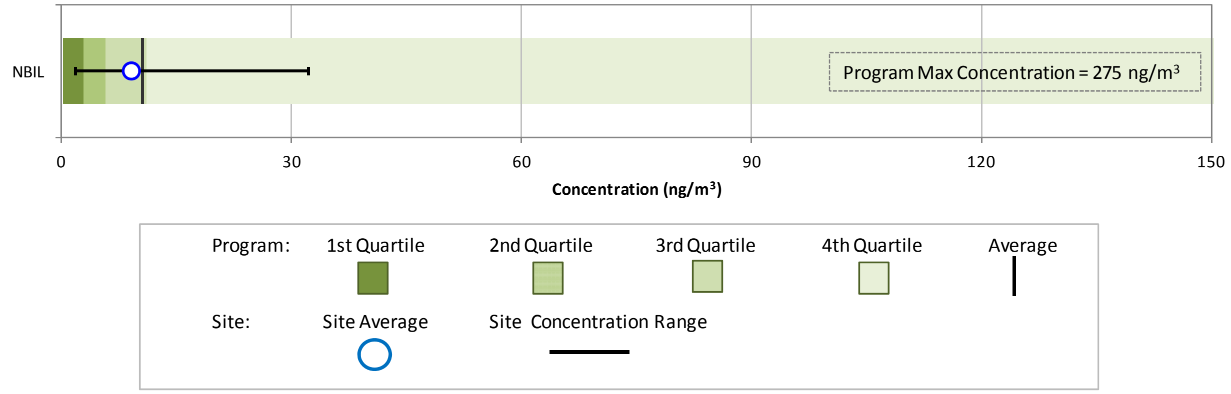


Figure 11-28. Program vs. Site-Specific Average Naphthalene Concentration

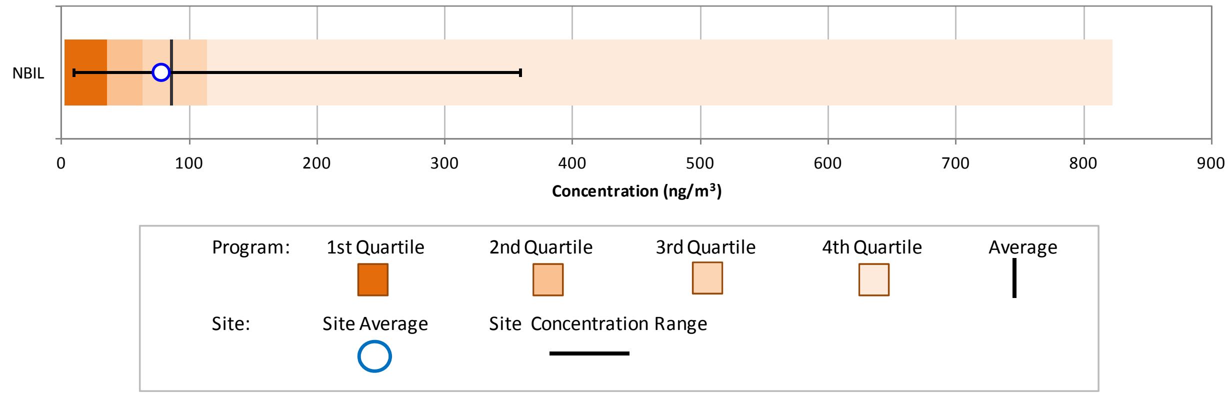
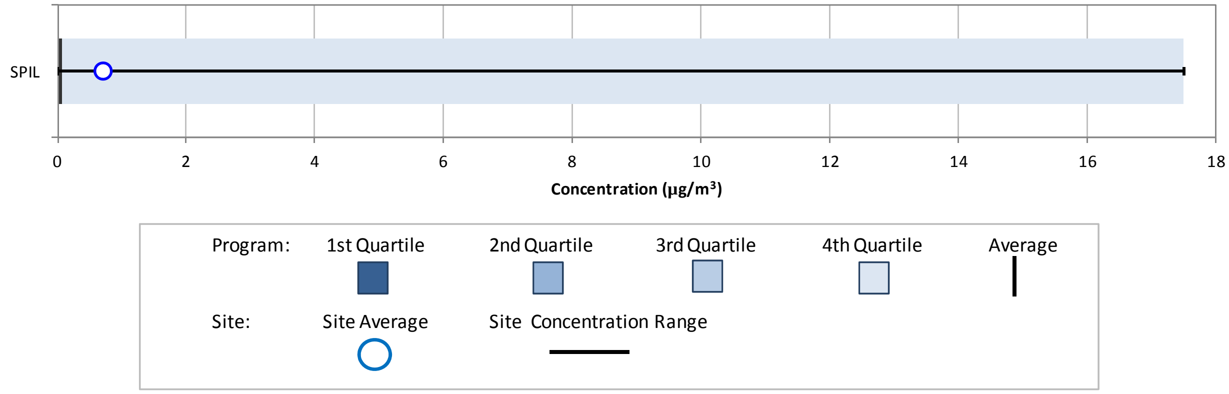


Figure 11-29. Program vs. Site-Specific Average Trichloroethylene Concentration



Observations from Figures 11-15 through 11-29 include the following:

- Figure 11-15 is the box plot for acenaphthene for NBIL. Note that the program-level maximum concentration (182 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 100 ng/m^3. Figure 11-15 shows that NBIL's annual average acenaphthene concentration is more than twice the program-level average concentration. Although the maximum concentration of acenaphthene measured at NBIL was less than the maximum concentration measured at the program-level, this measurement is among the higher concentrations of this pollutant. Note that the program-level average is greater than the program-level third quartile, an indication that the measurements at the upper end of the concentration range are driving the program-level average. Although non-detects were measured across the program, none were measured at NBIL.

- Figure 11-16 presents the acetaldehyde box plots for both Chicago sites. The box plots show that the maximum acetaldehyde concentration across the program was measured at SPIL; as discussed previously, the three highest concentrations of this pollutant were all measured at SPIL. Thus, the annual average acetaldehyde concentration for SPIL is greater than the annual average acetaldehyde concentration for NBIL and the program-level average. NBIL's annual average is similar to the program-level average concentration. Even the minimum acetaldehyde concentrations measured at these sites are significantly different. The minimum acetaldehyde concentration measured at NBIL is among the lower concentrations measured program-wide; the minimum acetaldehyde concentration measured at SPIL is nearly seven times higher.

- Figure 11-17 is the box plot for arsenic, which was measured at NBIL but not at SPIL. The box plot shows that the annual average concentration for NBIL is similar to the program-level average concentration. The maximum concentration measured at NBIL is considerably less than the maximum concentration measured across the program. While a few non-detects of arsenic were measured among sites sampling PM_{10} metals, none were measured at NBIL.

- Figure 11-18 shows the box plots for benzene. The range of concentrations measured at SPIL is more than twice the range of concentrations measured at NBIL. Thus, SPIL's annual average benzene concentration is greater than NBIL's annual average benzene concentration; in addition, the annual average benzene concentration for SPIL is greater than the program-level average concentration while NBIL's annual average is less than the program-level median concentration.

- Similar to the box plots for acenaphthene, the program-level maximum 1,3-butadiene concentration (4.10 $\mu g/m^3$) is not shown directly on the box plots as the scale has been reduced to 2 $\mu g/m^3$ in Figure 11-19 to allow for the observation of data points at the lower end of the concentration range. Figure 11-19 shows that the Chicago sites' concentrations of 1,3-butadiene follow a similar patterns as the sites' benzene concentrations. The range of concentrations measured is larger for SPIL than for NBIL. While NBIL's annual average concentration of 1,3-butadiene is less than both the program-level average and median concentrations, SPIL's annual average is greater than the program-level average and just less than the program-level third quartile. A single non-detect of 1,3-butadiene was measured at SPIL while 16 non-detects were measured at NBIL.

- Figure 11-20 presents the box plots for carbon tetrachloride. Even though the range of measurements appears much larger for NBIL, this is a result of a single "high" concentration measured at NBIL (1.88 $\mu g/m^3$). If this concentration was excluded, the range of measurements for these two sites would be very similar. Thus, the annual average concentrations of carbon tetrachloride for the Chicago sites are very similar to each other and the program-level average concentration, as discussed in the previous section.

- The first quartile for *p*-dichlorobenzene is zero due to the number of non-detects and, as a result, is not visible on the box plots in Figure 11-21. Although the annual average concentration of *p*-dichlorobenzene for NBIL is just slightly less than the annual average for SPIL, both are less than the program-level average concentration but greater than the program-level median concentration. However, less than 0.022 $\mu g/m^3$ separates these four statistical parameters. *p*-Dichlorobenzene was detected in half of the samples collected at NBIL and

65 percent of the samples collected at SPIL, which is similar to the percentage of measured detections at the program-level.

- The program-level maximum 1,2-dichloroethane concentration (17.01 $\mu g/m^3$) is significantly higher than most of the concentrations measured at NMP sites sampling VOCs. Therefore, the maximum concentration is not shown directly on the box plots in Figure 11-22 as the scale has been reduced to 1 $\mu g/m^3$. Figure 11-22 shows that the majority of the 1,2-dichloroethane measurements collected at the Chicago sites are less than the program-level average concentration of this pollutant. The wide disparity between most of the program-level statistical parameters and the maximum concentration indicates that outliers were measured at other NMP site(s).

- Figure 11-23 shows that the annual average ethylbenzene concentration for NBIL is slightly less than the program-level average concentration but greater than the program-level median concentration. The maximum ethylbenzene concentration measured at NBIL is less than program-level maximum ethylbenzene concentration. There were no non-detects of ethylbenzene measured at NBIL.

- Figures 11-24 and 11-25 present the box plots for fluoranthene and fluorene, respectively, for NBIL. These box plots show that the maximum concentrations of fluoranthene and fluorene at the program-level were measured at NBIL. Concentrations of these pollutants measured at NBIL span two orders of magnitude. For both PAHs, the annual average concentration for NBIL is more than twice the program-level average concentrations.

- Figure 11-26 presents the box plots for formaldehyde. The maximum formaldehyde concentration measured across the program was measured at SPIL, although an equivalent measurement was also collected at TOOK. SPIL’s annual average formaldehyde concentration is greater than the program-level average concentration but less than the program-level third quartile. Even though the maximum formaldehyde concentration was measured at SPIL, this site’s annual average concentration ranks 12th among other NMP sites. NBIL’s annual average formaldehyde concentration is less than the program-level average concentration but greater than the program-level median. The difference between the minimum formaldehyde concentrations measured at these two sites is similar to the differences noted for acetaldehyde.

- Figure 11-27 is the box plot for manganese (PM_{10}). Note that the program-level maximum concentration (275 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 150 ng/m^3 to allow for the observation of data points at the lower end of the concentration range. Although the maximum concentration measured at NBIL is considerably less than the maximum measured across the program, the box plot shows that the annual average concentration for NBIL is just less than the program-level average concentration.

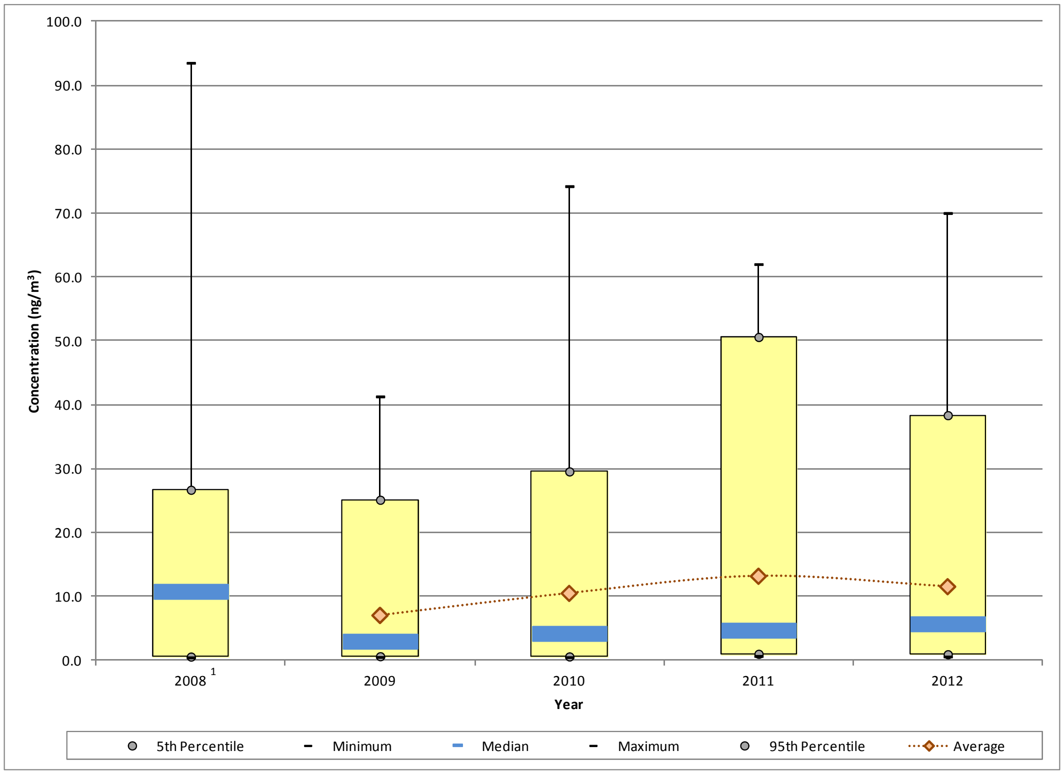
- Figure 11-28 is the box plot for naphthalene. The maximum concentration naphthalene measured at NBIL (359 ng/m^3) is less than half the maximum concentration measured across the program (822 ng/m^3). The annual average concentration for NBIL is just less than the program-level average concentration but greater than the program-level median.

- The first, second, and third quartiles for trichloroethylene are all zero in Figure 11-29 due to the large number of non-detects; thus, only the fourth quartile is visible. The maximum concentration of trichloroethylene across the program was measured at SPIL. The annual average concentration for SPIL (0.71 µg/m^3) is seven times greater than the next highest annual average concentration for this pollutant (calculated for GPCO, 0.10 µg/m^3) and an order of magnitude higher than the program-level average concentration (0.050 µg/m^3).

11.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. NBIL and SPIL have both sampled VOCs under the NMP since 2003. Both sites have also sampled carbonyl compounds since 2005. NBIL has also sampled PM_{10} metals since 2005 and began sampling PAHs under the NMP in 2008. Thus, Figures 11-30 through 11-52 present the 1-year statistical metrics for each of the pollutants of interest first for NBIL, then for SPIL. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 11-30. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until June 2008.

Observations from Figure 11-30 for acenaphthene measurements collected at NBIL include the following:

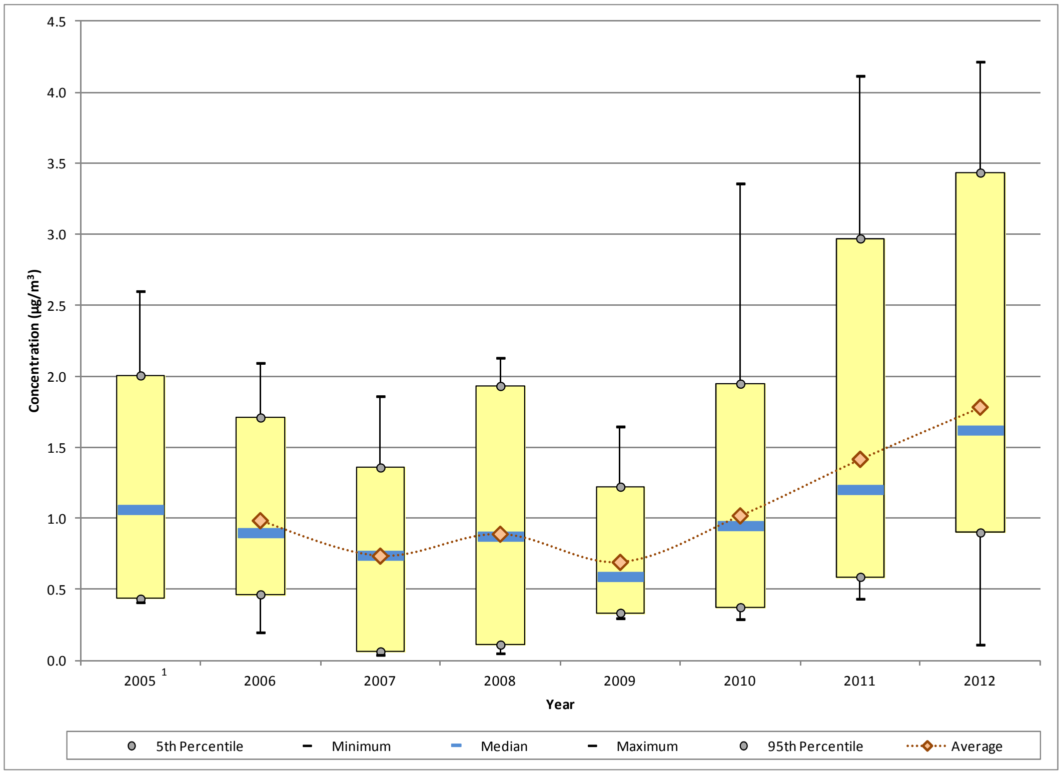
- Although PAH sampling under the NMP at NBIL began in 2008, sampling did not begin until June; because a full year's worth of data is not available for 2008, a 1-year average is not presented, although the range of measurements is provided.

- Although the maximum acenaphthene concentration was measured at NBIL in 2008 (93.5 ng/m^3), the second highest concentration measured that year was considerably less (29.0 ng/m^3). Although a concentration greater than 30 ng/m^3 has been measured each year since sampling began, nearly half of them were measured in 2011, with one measured in 2008, two in 2009, three in 2010, 10 in 2011, and five in 2012.

- The median concentration decreased significantly from 2008 to 2009. This is because there are a greater number of concentrations at the lower end of the concentration range in 2009. Recall, however, that 2008 does not include a full year's worth of sampling. The median concentration increases steadily after 2009.

- The 1-year average concentration increases between 2009 and 2011, nearly doubling over this time frame. However, confidence intervals calculated for these averages indicate that the increase is not statistically significant due to the relatively large amount of variability in the measurements. The 1-year average decreased slightly for 2012, although the median continued to increase.

Figure 11-31. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until March 2005.

Observations from Figure 11-31 for acetaldehyde measurements collected at NBIL include the following:

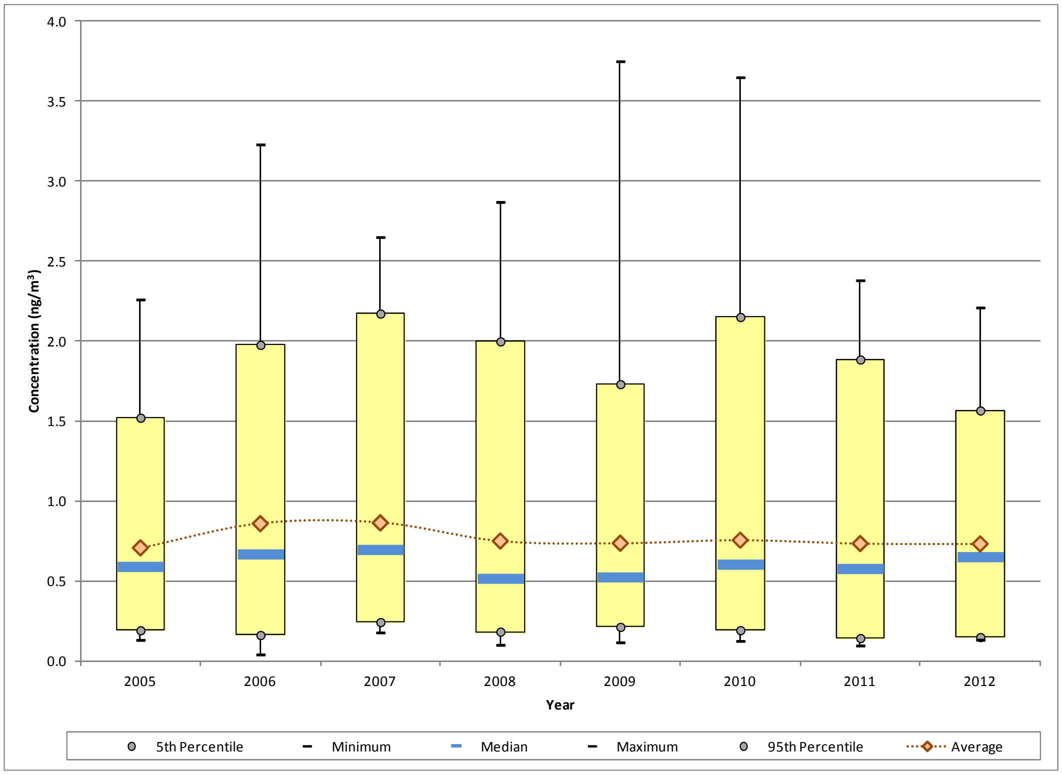
- Carbonyl compound sampling at NBIL under the NMP did not begin until March 2005; because a full year's worth of data is not available for 2005, a 1-year average is not presented, although the range of measurements is provided.

- The maximum acetaldehyde concentration (4.22 µg/m^3) was measured in 2012, although a similar concentration (4.12 µg/m^3) was measured in 2011. The highest acetaldehyde concentrations were measured in the most recent years; of the 22 acetaldehyde concentrations greater than 2.5 µg/m^3 measured at NBIL, one was measured in 2005, two in 2010, eight in 2011, and 11 were measured in 2012.

- After a decreasing trend through 2007, the 1-year average fluctuated between 0.69 µg/m^3 and 0.89 µg/m^3 between 2007 and 2009. After 2009, acetaldehyde concentrations measured at NBIL increase significantly as all of the statistical metrics exhibit an increase from 2009 to 2010 and again for 2011 and 2012 (although the minimum concentration decreased for 2012). The 95th percentile for 2012 is greater than the maximum concentration measured for most years of sampling. The 5th percentile for 2012 is greater than the median and 1-year averages for some of the earlier years of sampling.

- The increase in the 1-year average concentration of acetaldehyde between 2009 and 2012 represents a 159 percent increase.

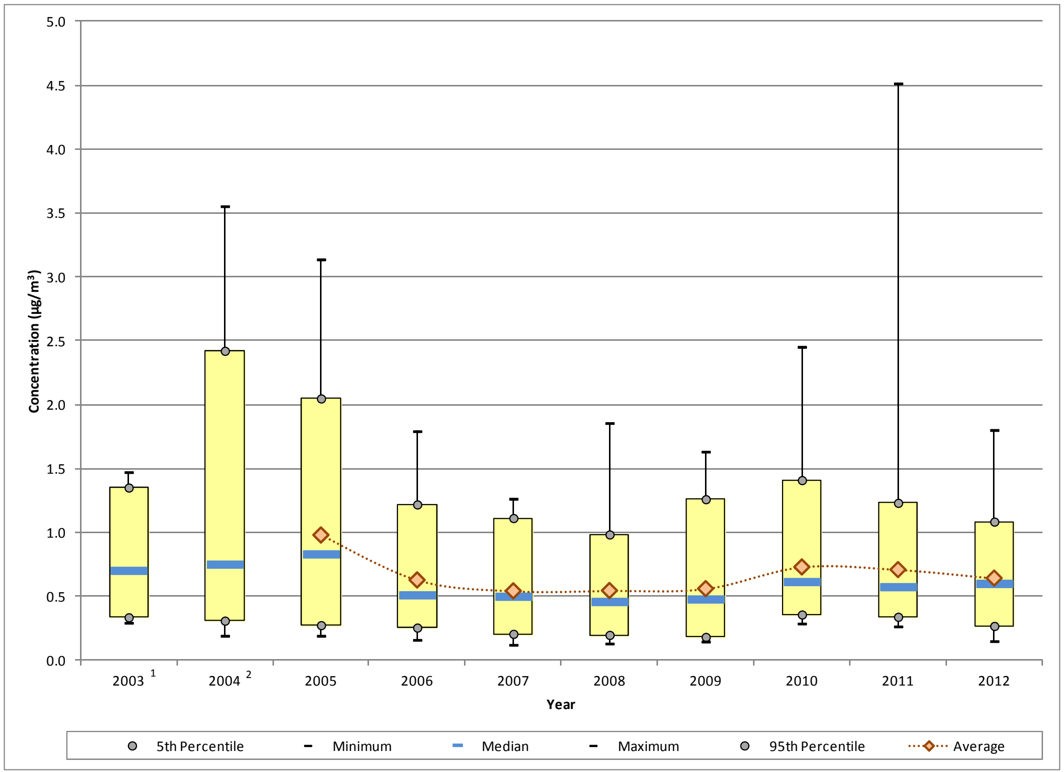
Figure 11-32. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at NBIL



Observations from Figure 11-32 for arsenic (PM_{10}) measurements collected at NBIL include the following:

- Metals sampling at NBIL began in January 2005.
- The maximum arsenic concentration was measured on July 12, 2009, although a similar concentration was also measured in 2010. Only four concentrations equal to or greater than 3 ng/m^3 have been measured at NBIL (one in 2006, one in 2009, and two in 2010).
- Although the statistical parameters representing the upper end of the concentration range has fluctuated somewhat each year, the 1-year average concentrations exhibit little significant change over the course of sampling. The 1-year average concentration increased from 2005 to 2006, reached a maximum for 2007 (0.86 ng/m^3), decreased slightly for 2008, after which the 1-year average concentration has remained steady. Since 2008, the 1-year average concentrations have ranged from 0.730 ng/m^3 (2012) to 0.753 ng/m^3 (2010).
- The minimum concentration for each year is greater than zero, indicating that there were no non-detects of arsenic reported since the onset of metals sampling.

Figure 11-33. Yearly Statistical Metrics for Benzene Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

[2] A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

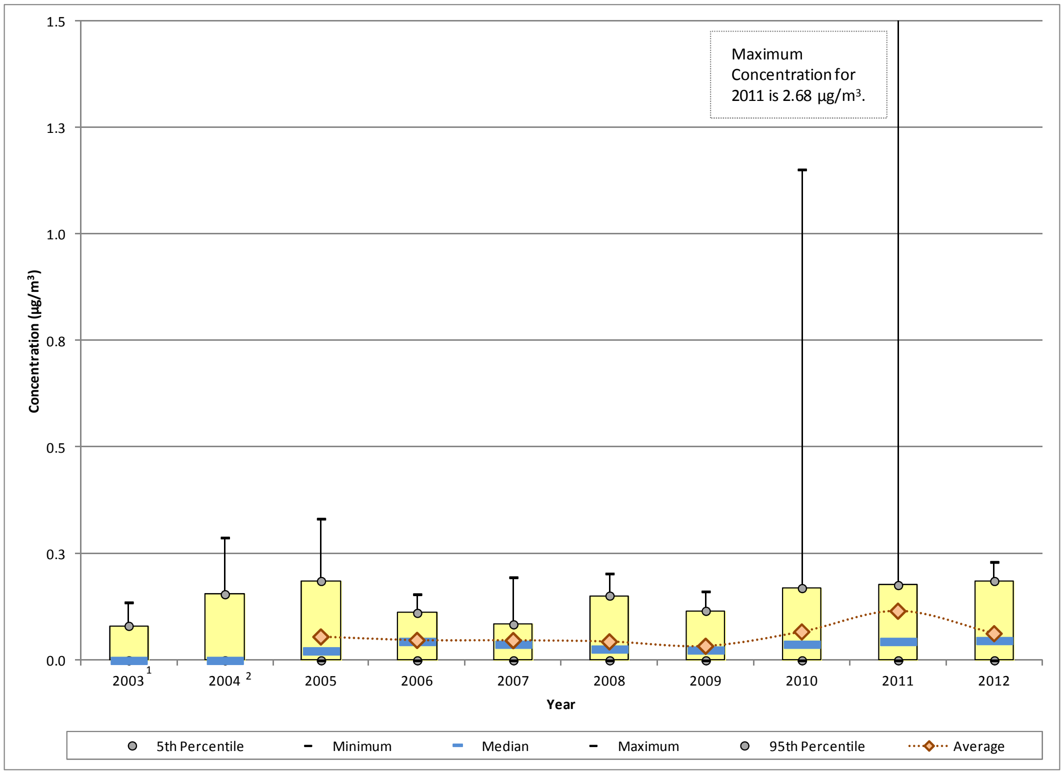
Observations from Figure 11-33 for benzene measurements collected at NBIL include the following:

- Although sampling for VOCs at NBIL began in 2003, sampling under the NMP did not begin until April; because a full year's worth of data is not available for 2004, a 1-year average is not presented, although the range of measurements is provided. In addition, sampling for VOCs was discontinued in October 2004 through the end of the year. Thus, a 1-year average is not presented for 2004 either.

- The maximum benzene concentration (4.51µg/m^3) was measured on January 9, 2011 and is the only measurement greater than 4 µg/m^3 measured at NBIL. The three benzene concentrations greater than 3 µg/m^3 were measured in 2004 and 2005 and most of the measurements greater than 2 µg/m^3 were measured in 2004.

- The 1-year average concentration decreased significantly from 2005 to 2006, and decreased slightly for 2007, then remained at the same level through 2009. All of the statistical parameters exhibit increases from 2009 to 2010. Although the maximum concentration nearly doubled from 2010 to 2011, the rest of the statistical parameters decreased for 2011. This decreasing continued into 2012, although the median concentration actually increased slightly.

Figure 11-34. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at NBIL



Maximum Concentration for 2011 is 2.68 µg/m³.

[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.
[2] A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

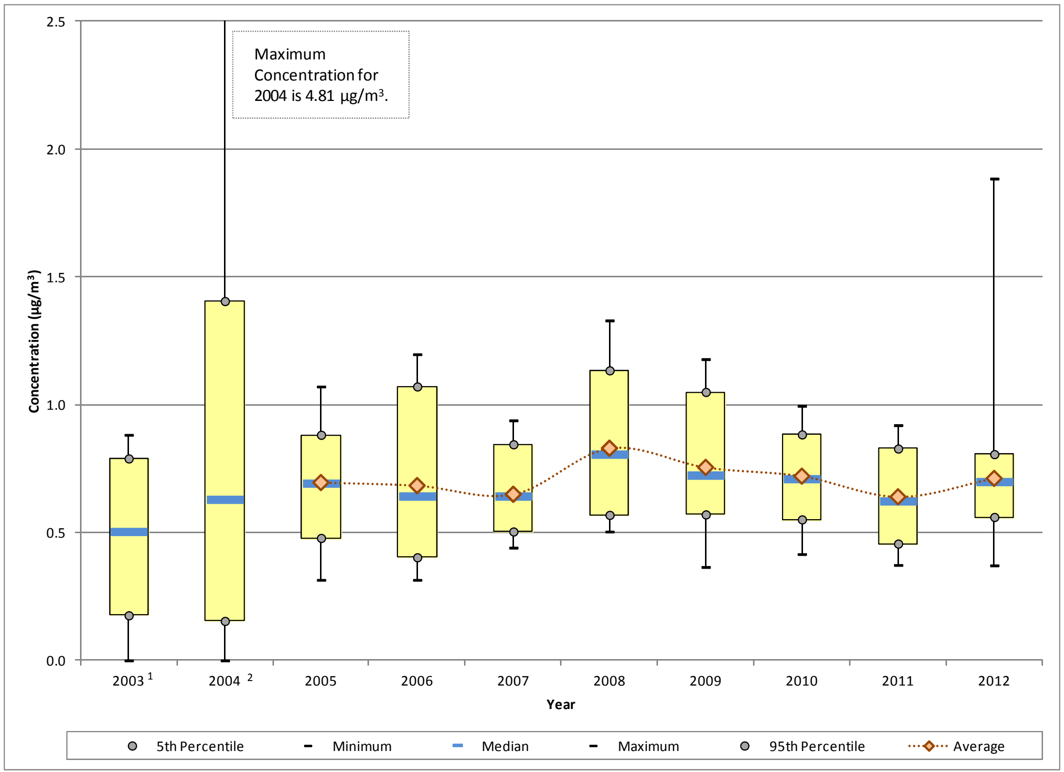
Observations from Figure 11-34 for 1,3-butadiene measurements collected at NBIL include the following:

- The maximum 1,3-butadiene concentration was measured on the same day as the maximum benzene concentration, January 9, 2011 (2.68 µg/m^3). Only three concentrations greater than 1 µg/m^3 have been measured at NBIL, two in 2011 and one in 2010. All other measurements of 1,3-butadiene are less than 0.35 µg/m^3.

- For each year shown, the minimum and 5th percentile are zero, indicating the presence of non-detects (at least 5 percent of the measurements). For the first 2 years of sampling, even the median concentration is zero. The number of non-detects reported has fluctuated over the years of sampling, from as high as 88 percent (2004) to as low as 7 percent (2007). Since 2010, the percentage of non-detects has hovered around 25 percent.

- The 1-year average concentration changed little through 2009, after which an increasing trend is shown through 2011, although there is a significant amount of variability associated with these measurements, based on the confidence intervals. Even with the relatively high concentrations measured in 2010 and 2011, the 95th percentile changed only slightly, indicating that the majority of the measurements were within the same range. For example, for 2010, only three measurements were greater than the 95th percentile; further, the maximum concentration was an order of magnitude higher than the 95th percentile for this year. This is also true for 2011.

Figure 11-35. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at NBIL



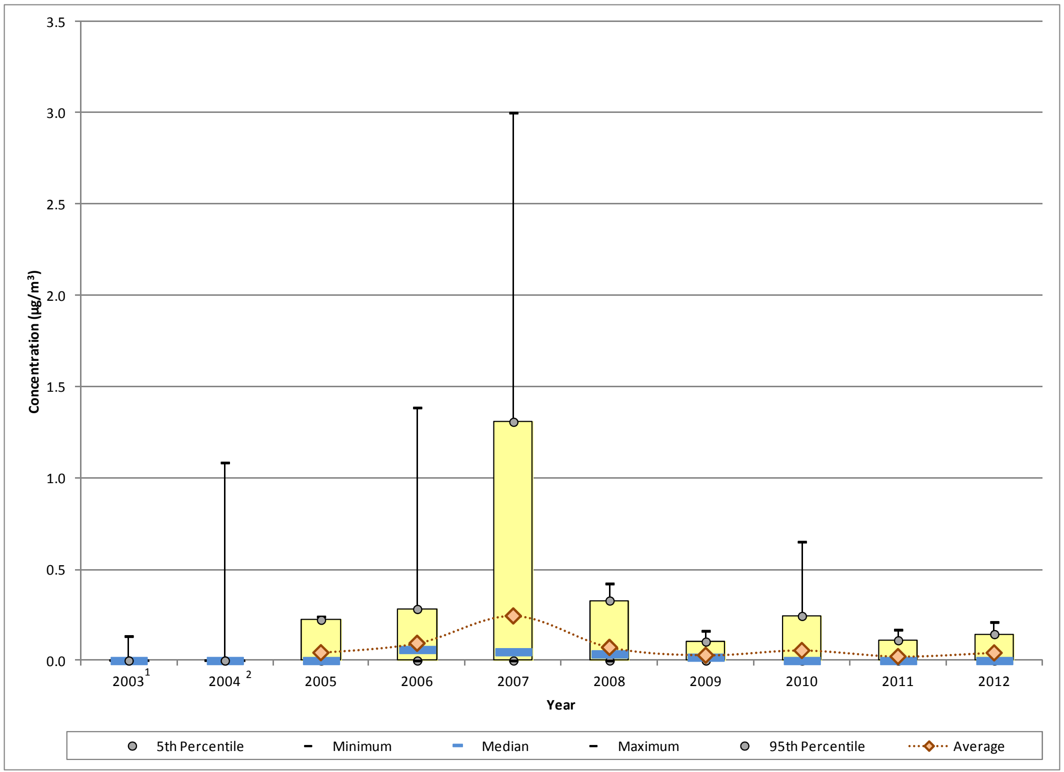
[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.
[2] A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

Observations from Figure 11-35 for carbon tetrachloride measurements collected at NBIL include the following:

- The maximum concentration of carbon tetrachloride was measured in 2004 (4.81 µg/m^3). No other measurements greater than 2.0 µg/m^3 have been measured at NBIL and only one measurement greater than 1.5 µg/m^3 has been measured (1.88 µg/m^3 in 2012).
- Five non-detects of carbon tetrachloride have been measured at NBIL. All of these were measured during the first 2 years of sampling (two in 2003 and three in 2004).
- After a slight decreasing trend between 2005 and 2007, the 1-year average increased significantly for 2008. The 1-year average concentration exhibits a decreasing trend after 2008 that continued through 2011, when the 1-year average reached a minimum (0.64 µg/m^3). The median concentration exhibits a similar pattern.

- Even though the difference between the minimum and maximum concentrations for 2012 is at the highest level since 2004, the difference between the 5th and 95th percentiles is at a minimum. This indicates that the majority of concentrations are falling within a relatively small range. That said, the increase shown for the 1-year average and median is a result of an overall increase in the measurements rather than the influence of the relatively high concentration measured in 2012. For example, the number of concentrations greater than 0.70 µg/m^3 doubled from 2011 to 2012 while the number of measurements less than 0.50 µg/m^3 dropped from six to one for 2012.

Figure 11-36. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.
[2] A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

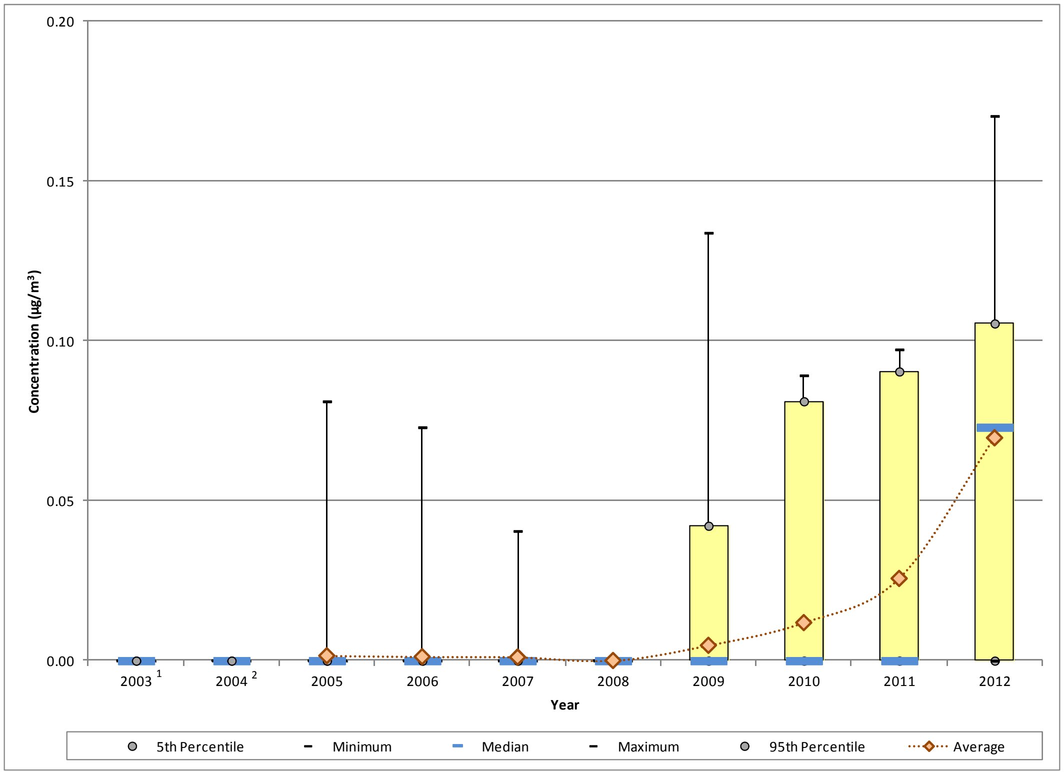
Observations from Figure 11-36 for *p*-dichlorobenzene measurements collected at NBIL include the following:

- The number of non-detects measured was greater than 95 percent for the first 2 years of sampling. The number of non-detects decreased steadily through 2007, reaching a minimum of 28 percent. After 2007, the percentage ranges from 39 percent (2009) to 73 percent (2011).

- As the number of non-detects decreases through 2007, the range of concentrations measured increases, resulting a dramatic increase in most of the statistical parameters shown. All but two of the seven measurements greater than 1 µg/m^3 were measured in 2007, with the other two measured in 2004 and 2006.

- The concentrations measured decreased significantly between 2007 and 2009. The range of measurements increased by a factor of four between 2009 and 2010 then returned to previous levels for 2011.

Figure 11-37. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.
[2] A 1-year average is not presented because there was a gap in sampling from late October 2004 until late December 2004.

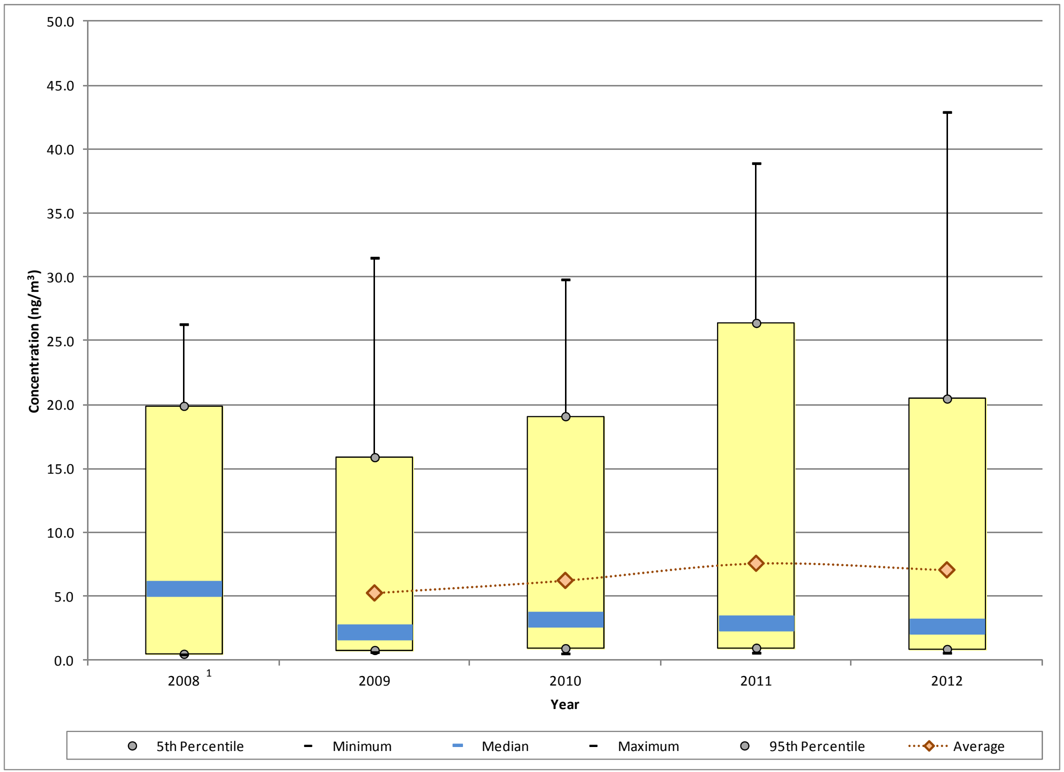
Observations from Figure 11-37 for 1,2-dichloroethane measurements collected at NBIL include the following:

- There were no measured detections of 1,2-dichloroethane in 2003, 2004, or 2008. The number of non-detects between 2005 and 2007 was greater than 95 percent. Thus, the minimum, 5th percentile, median, and in some cases, the 1-year average concentrations were zero for 2003 through 2008. The median concentration continued to be zero for all years except 2012, indicating that at least half of the measurements are non-detects.

- The number of non-detects began to decrease starting with 2009 and continued through 2012. The percentage of non-detects was at a minimum for 2012 (13 percent). As the number of measured detections increased, the 1-year average concentrations exhibit significant increases.

- For the first time, the median concentration is greater than zero for 2012 and is greater than the 1-year average for 2012. This is because the eight non-detects (or zeros) factored into the 1-year average concentration are pulling the average down (just like a maximum or outlier concentration can pull the average up) and are not contributing to the majority of measurements any longer.

Figure 11-38. Yearly Statistical Metrics for Fluoranthene Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until June 2008.

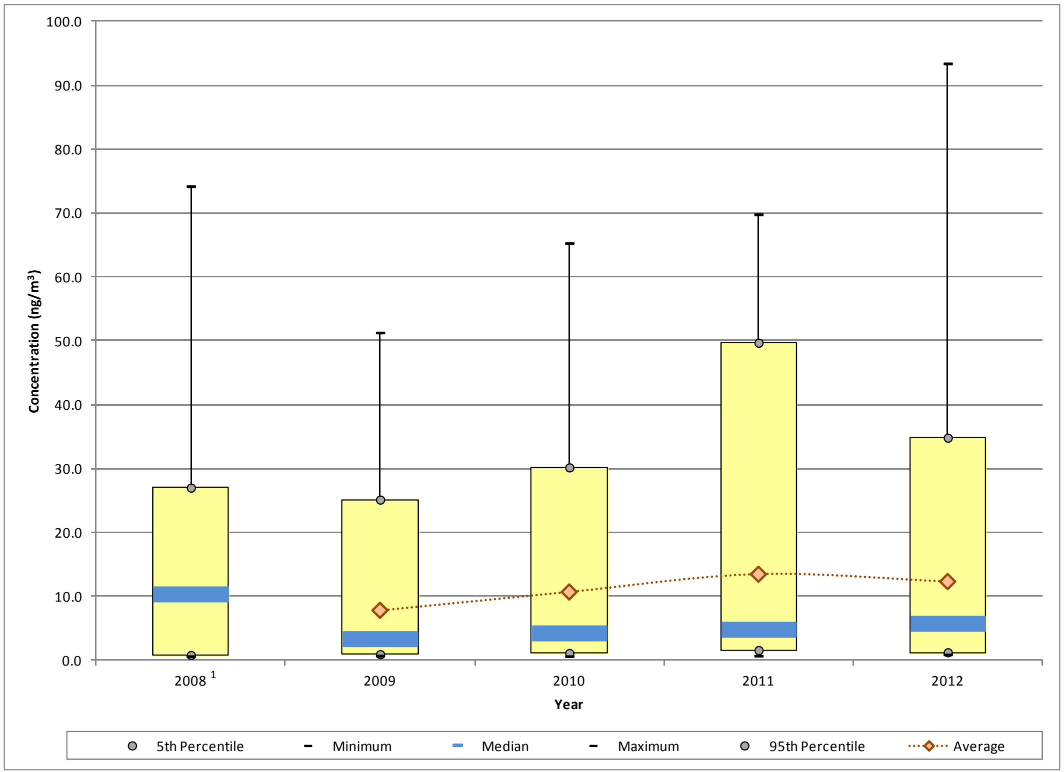
Observations from Figure 11-38 for fluoranthene measurements collected at NBIL include the following:

- The trends graph for fluoranthene resembles the trends graph for acenaphthene in that the median concentration decreased significantly from 2008 to 2009. This is because there is a greater number of fluoranthene concentrations at the lower end of the concentration range for 2009. The number of measurements less than 2 ng/m^3 tripled from 2008 to 2009 (from nine to 27). Recall, however, that 2008 does not include a full year's worth of sampling.

- Like acenaphthene, the 1-year average concentration of fluoranthene increases between 2009 and 2011 and decreases slightly for 2012. However, confidence intervals calculated for these averages indicate that the increase is not statistically significant due to the relatively large amount of variability in the measurements.

- Although the maximum fluoranthene concentration was measured in 2012 (42.9 ng/m^3), all of the other statistical parameters decreased at least slightly.

Figure 11-39. Yearly Statistical Metrics for Fluorene Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until June 2008.

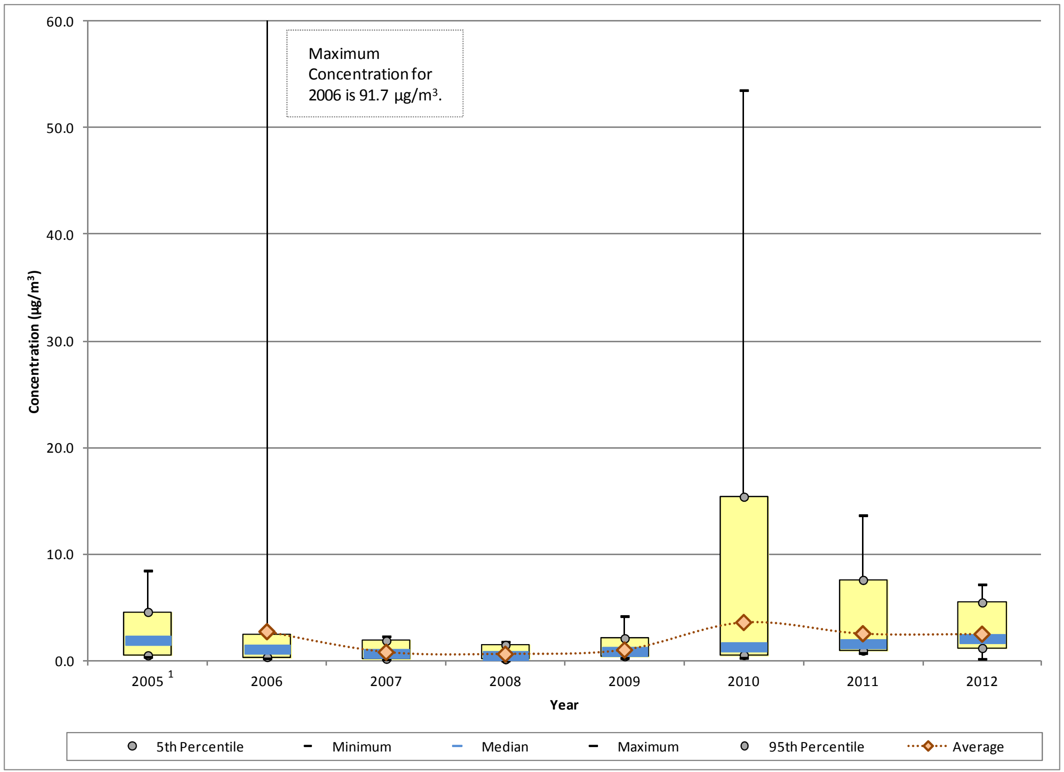
Observations from Figure 11-39 for fluorene measurements collected at NBIL include the following:

- The statistical patterns for fluorene resemble the statistical patterns shown on the trends graphs for acenaphthene and fluoranthene.

- The median concentration of fluorene also decreased significantly from 2008 to 2009 due to the number of fluorene concentrations at the lower end of the concentration range for 2009. The number of measurements less than 2 ng/m^3 more than doubled from 2008 to 2009 (from six to 16). Recall, however, that 2008 does not include a full year's worth of sampling.

- Like acenaphthene and fluoranthene, the 1-year average concentration of fluorene increases between 2009 and 2011 and decreases slightly for 2012. However, confidence intervals calculated for these averages indicate that the increase is not statistically significant due to the relatively large amount of variability in the measurements. The range of fluorene measurements spans two orders of magnitude for each year. For example, the minimum and maximum concentrations for 2012 are 0.93 ng/m^3 and 93.4 ng/m^3, respectively.

Figure 11-40. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until March 2005.

Observations from Figure 11-40 for formaldehyde measurements collected at NBIL include the following:

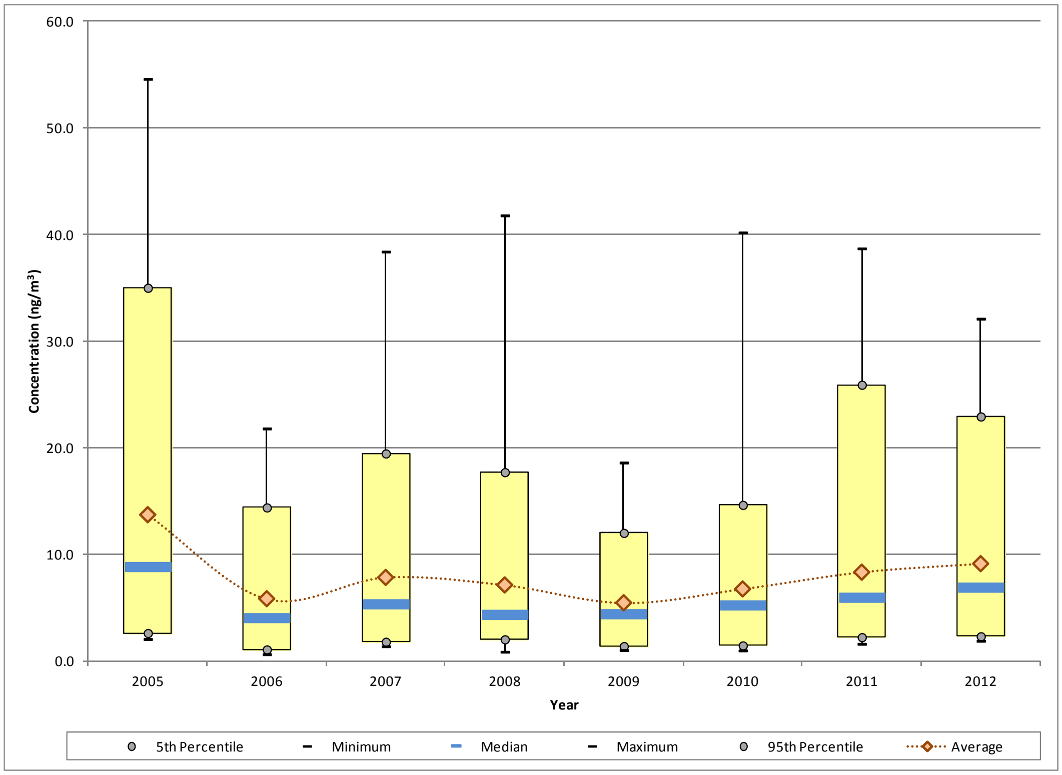
- The maximum formaldehyde concentration was measured on January 5, 2006 (91.7 µg/m^3). However, the next five highest concentrations, ranging from 14.4 µg/m^3 to 53.5 µg/m^3, were all measured in 2010. The only other formaldehyde concentration greater than 10 µg/m^3 was measured in 2011 (13.7 µg/m^3).

- The maximum concentration measured in 2006 is 20 times higher than the next highest concentration measured that year (4.46 µg/m^3). The magnitude of this outlier explains why the 1-year average concentration for 2006 is greater than the 95th percentile.

- The statistical metrics for 2010 are also affected by the higher concentrations; however, concentrations measured this year are higher overall, as indicated by seven-fold increase in the 95th percentile. Although difficult to discern in Figure 11-40, the 1-year average concentration more than tripled from 2009 to 2010 and the median increased by 50 percent. The concentrations measured in 2011 were less than those measured in 2010, although still greater than most years.

- Although the maximum concentration measured in 2012 is less than the 95th percentile for 2011, the 1-year average concentration did not change significantly for 2012. This is because the number of concentrations in the middle of the concentration range increased. The number of measurements between 2 µg/m^3 and 4 µg/m^3 doubled from 2011 to 2012.

Figure 11-41. Yearly Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at NBIL



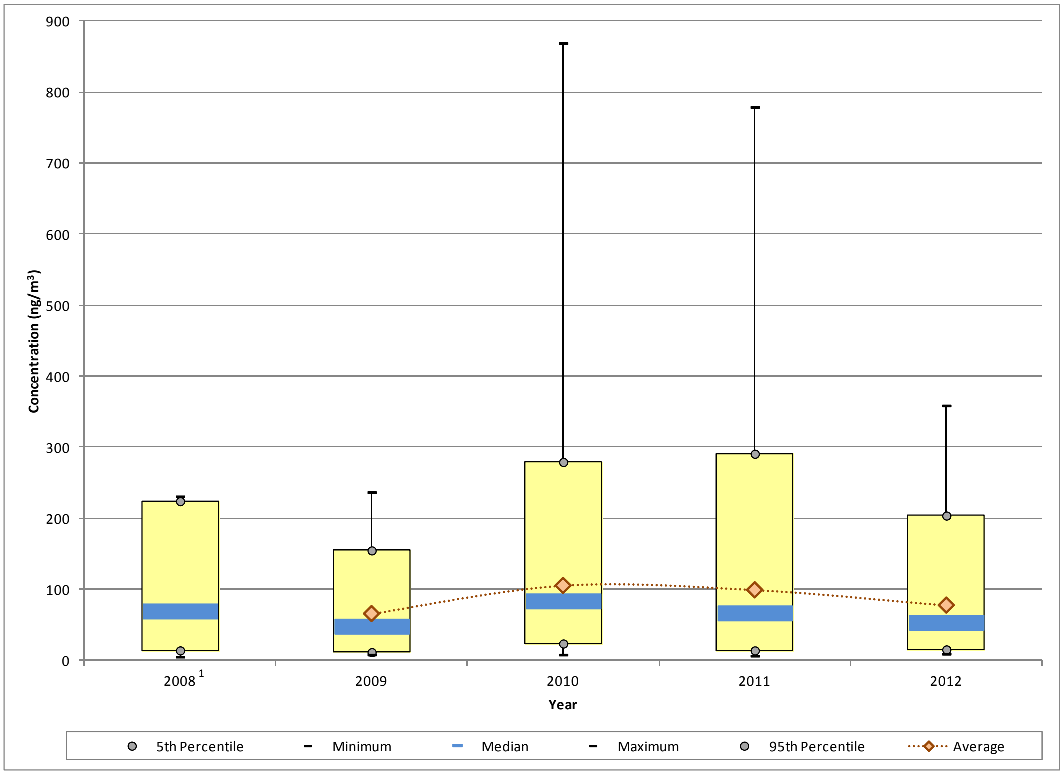
Observations from Figure 11-41 for manganese (PM_{10}) measurements collected at NBIL include the following:

- The maximum manganese concentration was measured on August 26, 2005 (54.6 ng/m^3). Concentrations in the 40 ng/m^3 to 45 ng/m^3 range have been measured in 2005, 2008, and 2010.

- The 1-year average concentration decreased significantly from 2005 to 2006. The 1-year average increased from 2006 to 2007, then decreased between 2007 and 2009. These changes, however, are statistically insignificant.

- After 2009, both the median and 1-year average concentrations increase steadily through 2012. Even though the maximum and 95th percentile decreased for 2012, the median and 1-year average increased. Although the minimum concentrations were similar, there were fewer concentrations at the lower end of the concentration range measured in 2012. The number of manganese measurements less than 3 ng/m^3 decreased from 14 in 2011 to six in 2012. There were also more concentrations in the mid- to upper-end of the concentration range. The number of measurements greater than 20 ng/m^3 increased from three in 2011 to five in 2012; the number of measurements in the 10 ng/m^3 to 20 ng/m^3 range increased from nine in 2011 to 14 in 2012.

Figure 11-42. Yearly Statistical Metrics for Naphthalene Concentrations Measured at NBIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until June 2008.

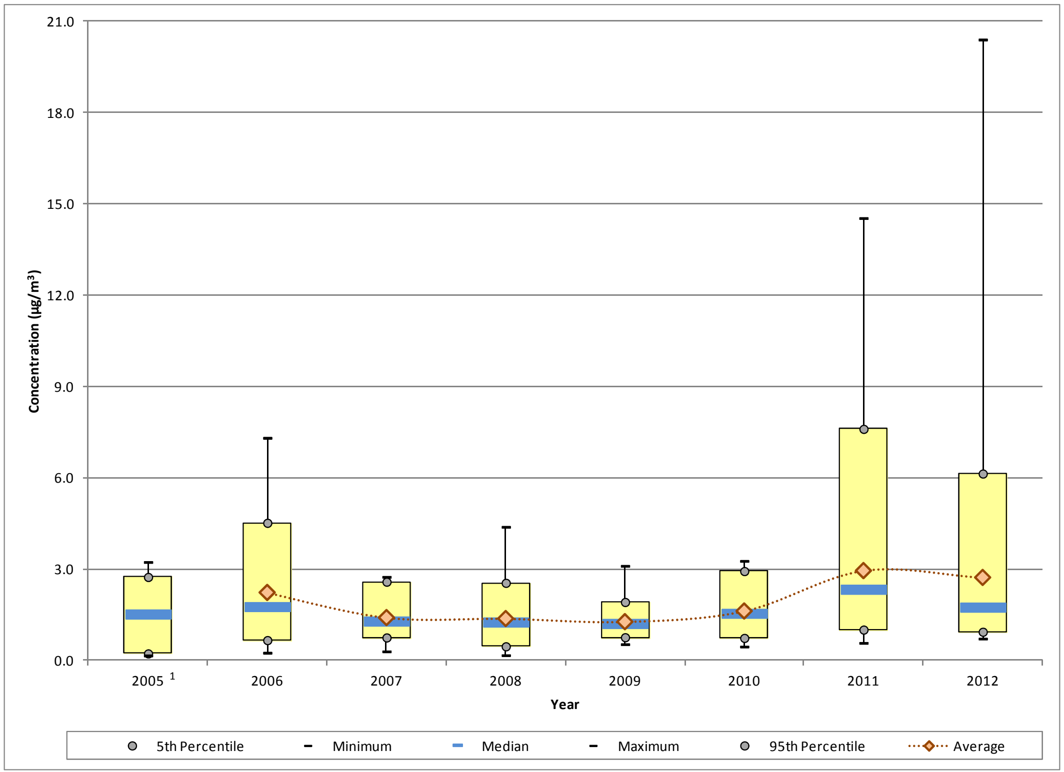
Observations from Figure 11-42 for naphthalene measurements collected at NBIL include the following:

- The maximum naphthalene concentration was measured on September 23, 2010 (869 ng/m^3). The next highest concentration measured in 2010 was considerably less (363 ng/m^3). All of the concentrations greater than 250 ng/m^3 were measured in 2010 (four), 2011 (five), or 2012 (one).

- The 1-year average concentration of naphthalene increased between 2009 and 2010. However, the large confidence interval calculated for 2010 indicates that the increase is not statistically significant due to the relatively large amount of variability in the 2010 measurements. The range of naphthalene measurements for 2010 spans two orders of magnitude, with a minimum concentration of 8.31 ng/m^3 and a maximum concentrations 869 ng/m^3. The concentrations measured in 2011 also exhibit this type of variability, ranging from 6.74 ng/m^3 to 779 ng/m^3.

- Most of the statistical parameters exhibit decreases for 2012. The maximum concentration decreased by more than half from 2011 to 2012, and the 95th percentile decrease by nearly 100 ng/m^3. The decreases shown for the 1-year average and median concentrations are less substantial.

Figure 11-43. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SPIL



[1] A 1-year average is not presented because consistent sampling did not begin until March 2005.

Observations from Figure 11-43 for acetaldehyde measurements collected at SPIL include the following:

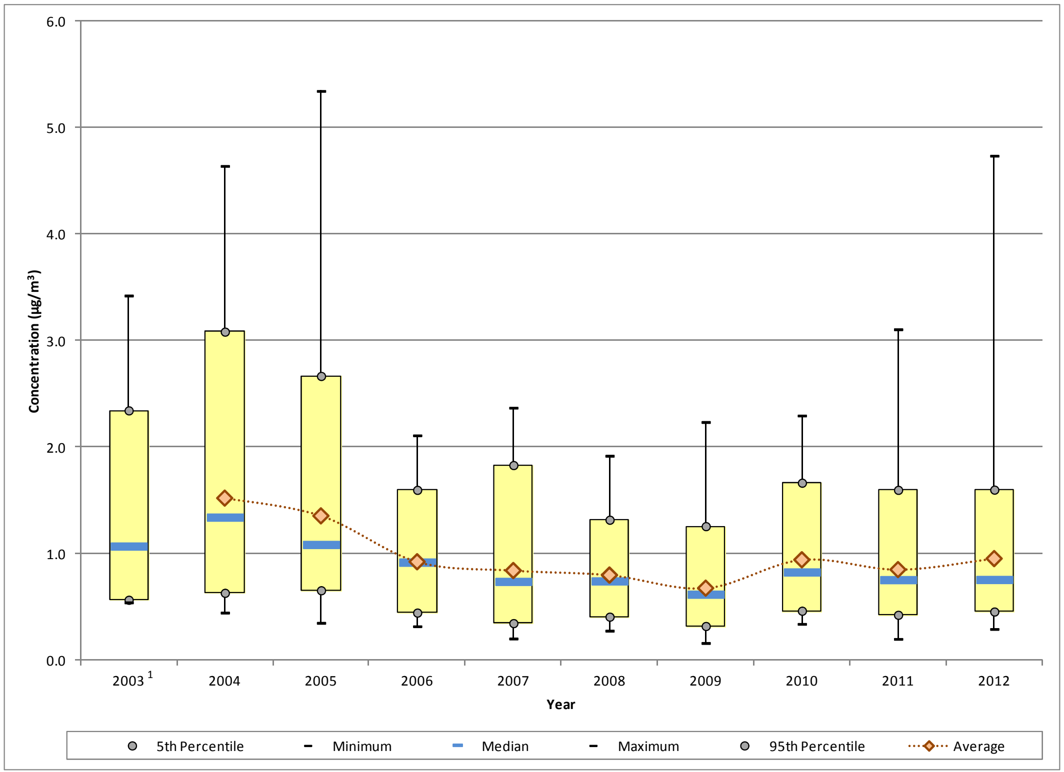
- Although carbonyl compound sampling at SPIL began in early 2005, consistent sampling did not begin until March 2005; because a full year's worth of data is not available for 2005, a 1-year average is not presented, although the range of measurements is provided.

- The maximum acetaldehyde concentration was measured at SPIL on November 17, 2012 (20.4 µg/m^3). Sixteen of the 18 concentrations of acetaldehyde greater than 5 µg/m^3 were measured in 2011 (eight) or 2012 (eight), with the other two measured in 2006.

- The 1-year average concentration decreased significantly from 2006 to 2007, then held fairly steady through 2009. The 1-year average concentration increased in 2010 then increased significantly in 2011. All of the statistical metrics increased for 2011, particularly the maximum and 95th percentile, indicating that the increases shown are not attributable to a few of outliers. As an illustration, the number of measurements greater than 2 µg/m^3 increased from three in 2009 to 15 for 2010 to 41 in 2011.

- Although the maximum concentration increased from 2011 to 2012, most of the other statistical parameters exhibit decreases.

Figure 11-44. Yearly Statistical Metrics for Benzene Concentrations Measured at SPIL

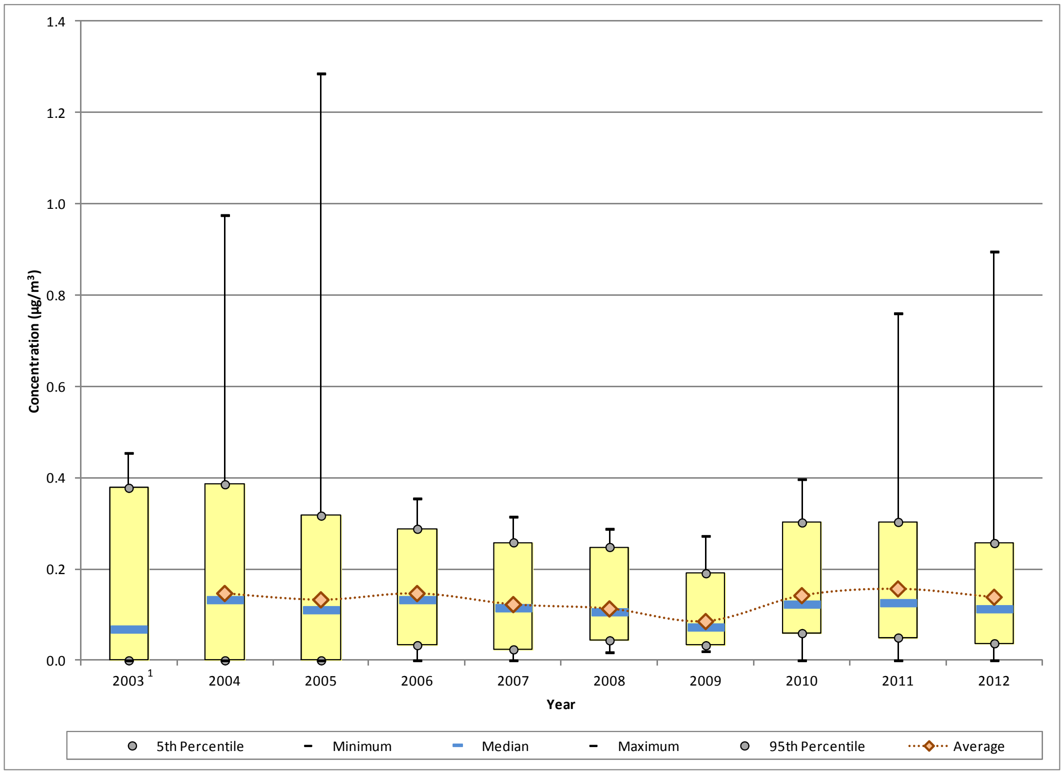


[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 11-44 for benzene measurements collected at SPIL include the following:

- The only two concentrations of benzene greater than 5 µg/m^3 were both measured in 2005.
- The 1-year average benzene concentration has decreased over the years, reaching a minimum of 0.68 µg/m^3 for 2009. The 1-year average concentration then increased for 2010 (0.94 µg/m^3).
- Even though the maximum concentration increased for 2011 and again for 2012, the majority of concentrations measured (as indicated by the 5th and 95th percentiles) fell within roughly the same range. The 1-year average decreases just slightly for 2011 and returns to 2010 levels for 2012. The median concentration decreased slightly for 2011 then held steady for 2012.

Figure 11-45. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at SPIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 11-45 for 1,3-butadiene measurements at SPIL include the following:

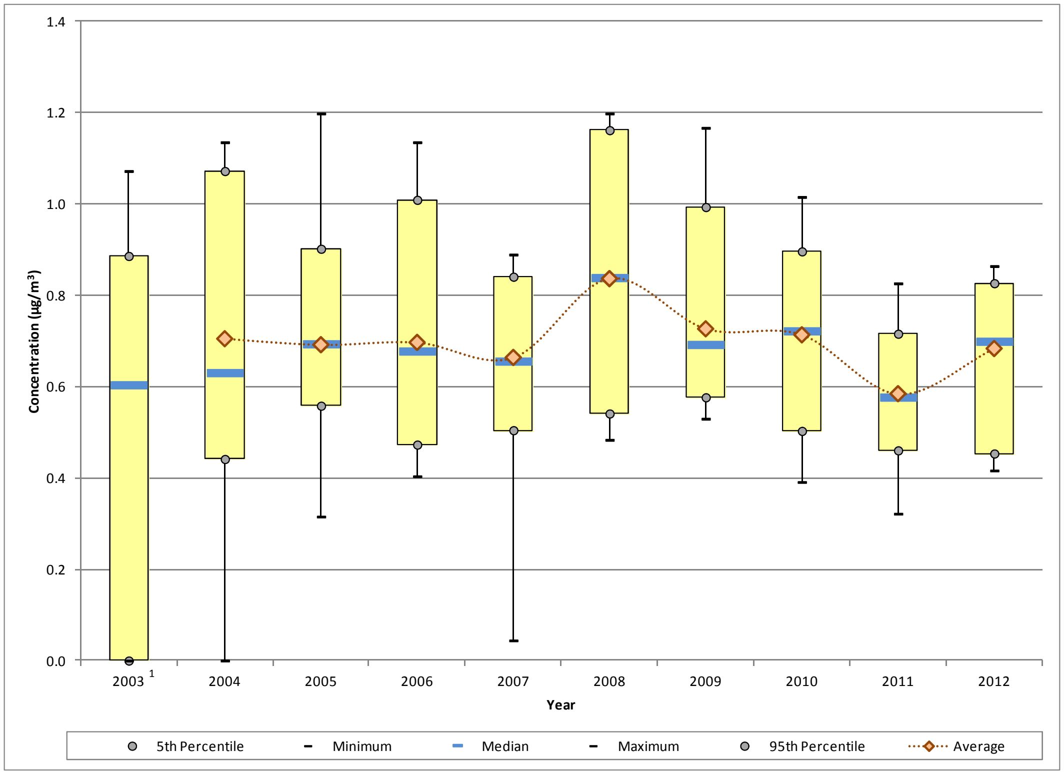
- The maximum concentration of 1,3-butadiene was measured at SPIL on February 3, 2005 (1.29 µg/m^3) and is the only measurement greater than 1 µg/m^3. In total, only six concentrations greater than 0.5 µg/m^3 have been measured at SPIL, one in 2004, two in 2005, two in 2011, and one in 2012.

- The 1-year average concentrations of 1,3-butadiene decreased from 2006 through 2009. The increase from 2009 to 2010 is significant, representing a 67 percent increase from 2009 levels. The median concentrations follow a similar pattern.

- The range of concentrations measured, as indicated by both the minimum and maximum concentrations and the 5th and 95th percentiles, decreased after the initial years of sampling through 2009, but increased significantly for 2010. Although the maximum concentration increased for 2011, the range within which the majority of concentrations fell stayed the same. Even though the maximum concentration increased further for 2012, the range within which the majority of concentrations fall decreased slightly.

- The detection rate for 1,3-butadiene has increased over time, ranging from approximately 45 percent non-detects in 2004 to zero in 2008 and 2009, with one non-detect each for 2010, 2011, and 2012.

Figure 11-46. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at SPIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 11-46 for carbon tetrachloride measurements collected at SPIL include the following:

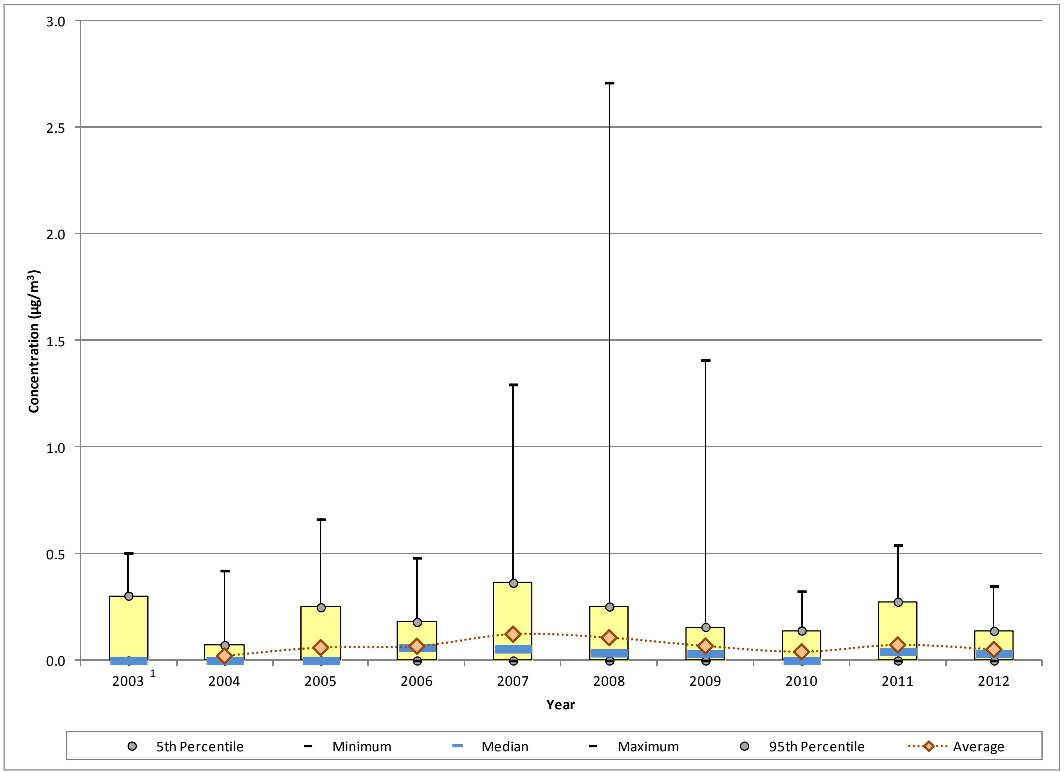
- The maximum concentration of carbon tetrachloride was measured three times, once in 2005 and twice in 2008 (1.20 µg/m^3).

- Six non-detects of carbon tetrachloride have been measured at SPIL. All of these were measured during the first 2 years of sampling (four in 2003 and two in 2004).

- The 1-year average concentration changed very little between 2004 and 2007. The 1-year average then increased significantly for 2008. The 1-year average concentration exhibits a decreasing trend after 2008 that continued through 2011, when the 1-year average reached a minimum (0.584 µg/m^3). The increase shown for 2012 brings the 1-year average carbon tetrachloride concentration near 2010 levels. A similar change was exhibited by the carbon tetrachloride concentrations measured at NBIL.

- For most of the years of sampling, the 1-year average and median concentrations are similar to each other. The difference between these two parameters is less than 0.075 µg/m^3 for all years of sampling and less than 0.020 µg/m^3 for most years. This indicates that there is not much variability in the central tendency of the carbon tetrachloride concentrations.

Figure 11-47. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at SPIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 11-47 for *p*-dichlorobenzene measurements collected at SPIL include the following:

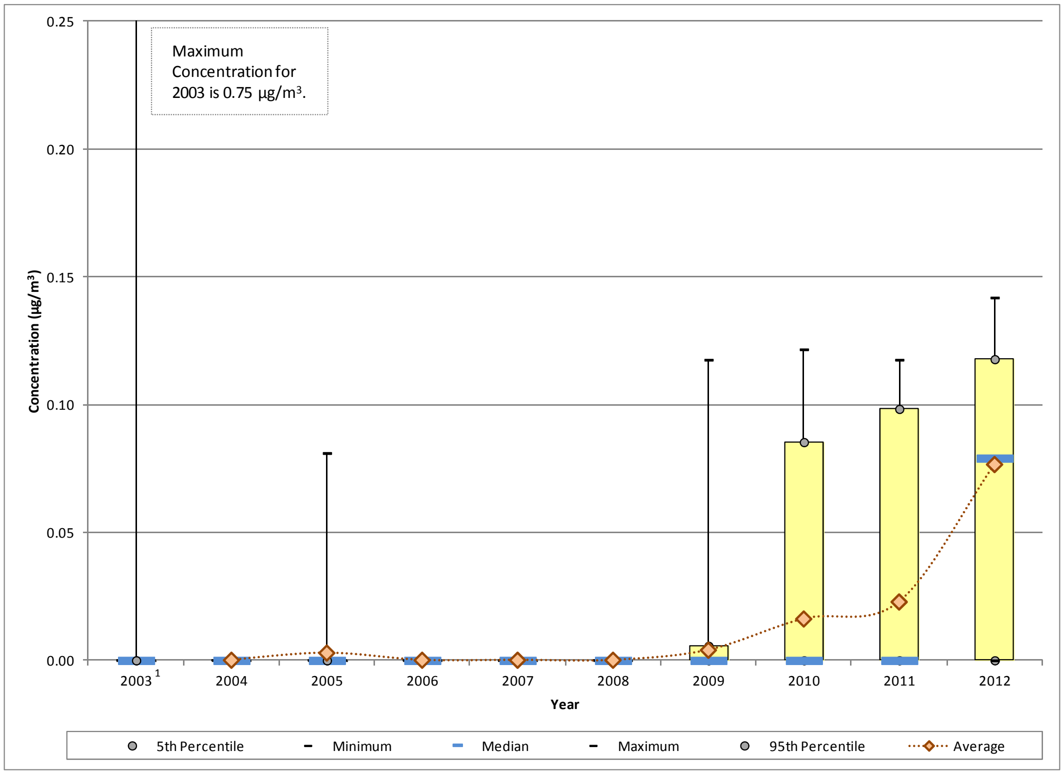
- The median concentration for the first 3 years of sampling was zero, indicating that at least half of the measurements are non-detects. Nearly 90 percent of the measurements were non-detects for 2003 and 2004, after which the number of non-detects began to decrease, reaching a minimum of 16 percent for 2007. After 2007, the percentage of non-detects ranged from 27 percent (2009) to 55 percent (2010).

- The maximum concentration was measured at SPIL in 2008 (2.71 µg/m^3). Only two additional concentrations greater than 1 µg/m^3 have been measured at SPIL, one in 2007 and one in 2009.

- The 1-year average concentration increased steadily through 2007, then decreased steadily through 2010. An increase in the 1-year average concentration is shown for 2011 followed by another decrease. However, due to the wide range of concentrations measured each year, the confidence intervals calculated are relatively large, indicating a high level of variability in the measurements and that the changes are not statistically significant.

- The difference between the 5th and 95th percentiles, or the range within which the majority of concentrations fall, is at a minimum for 2012 (aside from 2004 when 95 percent of the measurements were non-detects).

Figure 11-48. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at SPIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

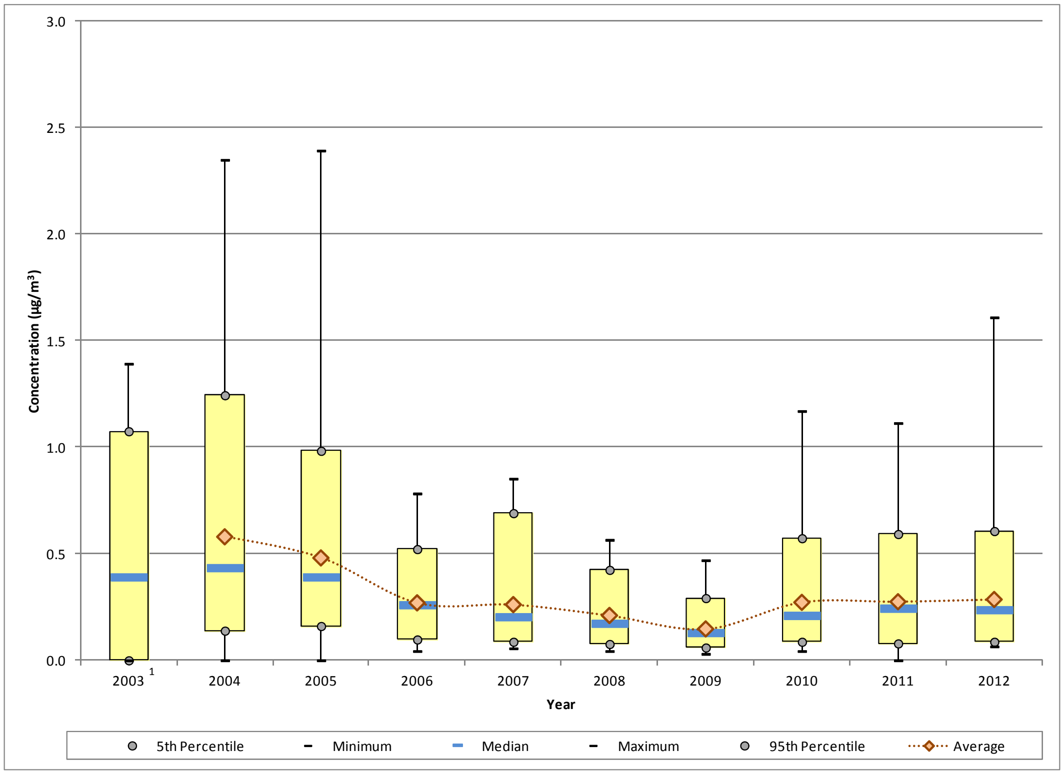
Observations from Figure 11-48 for 1,2-dichloroethane measurements collected at SPIL include the following:

- There were no measured detections of 1,2-dichloroethane in 2004, 2006, 2007, or 2008. For 2003, 2005, and 2009, the number of non-detects was 95 percent or greater. Thus, the minimum, 5th percentile, median, and in some cases, the 1-year average concentrations were zero through 2009. The median concentration continued to be zero for 2010 and 2011, indicating that at least half the measurements are non-detects. However, the percentage of non-detects decreased to 80 percent for 2010 and 73 percent for 2011. For 2012, the percentage of non-detects decreased to 8 percent of samples collected.

- The maximum concentration of 1,2-dichloroethane was measured at SPIL in 2003 (0.75 µg/m^3). This is the only measured detection for 2003 as all other measurements were non-detects. The next three highest concentrations (ranging from 0.12 µg/m^3 to 0.14 µg/m^3) were all measured in 2012, although similar concentrations were also measured in 2009, 2010, and 2011.

- As the number of non-detects decreases and the number of measured detections increase, the statistical parameters begin to increase correspondingly. The median concentration is greater than zero for the first time for 2012. The sharp decrease in the number of non-detects from 73 percent to 8 percent from 2011 to 2012 results in the sharp increase in the 1-year average concentration shown for 2012.

Figure 11-49. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at SPIL

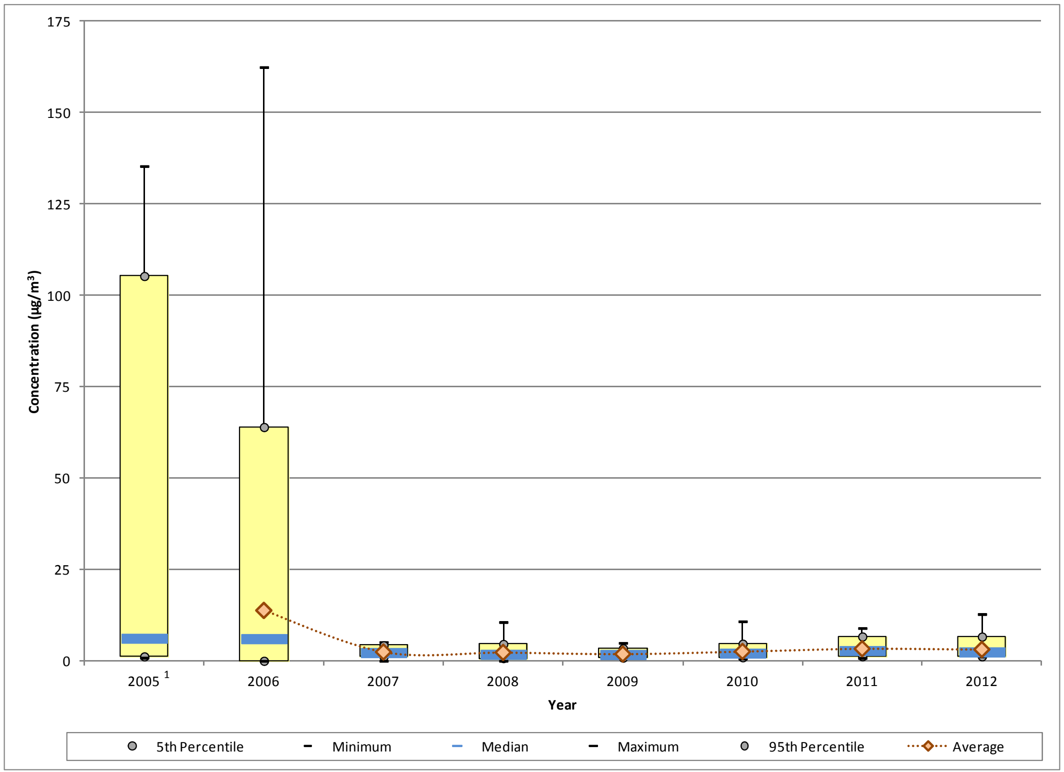


[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 11-49 for ethylbenzene measurements collected at SPIL include the following:

- The maximum concentration of ethylbenzene was measured at SPIL in 2005 (2.39 µg/m^3), although a similar measurement was also collected in 2004. The five highest concentrations of ethylbenzene were measured in 2004 or 2005.
- The 1-year average concentration has a steady decreasing trend between 2004 and 2009, although the largest decreases were between 2004 and 2006.
- The 1-year average increased significantly from 2009 to 2010, nearly doubling. The range of measurements collected doubled from 2009 to 2010 as did the range within which the majority of measurements fall.
- Little change in the measurements is shown after 2010.

Figure 11-50. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SPIL



[1] A 1-year average is not presented because consistent sampling did not begin until March 2005.

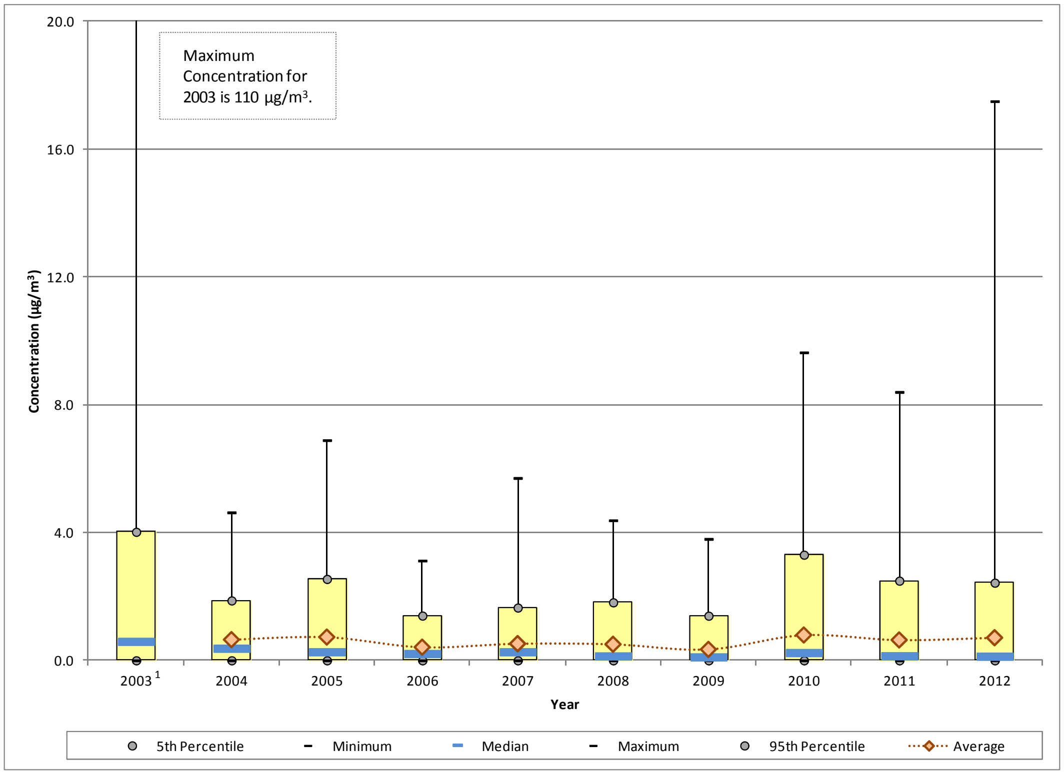
Observations from Figure 11-50 for formaldehyde measurements collected at SPIL include the following:

- The maximum formaldehyde concentration (162 µg/m^3) was measured on May 29, 2006 and is more than 10 times the maximum concentrations for any of the other years shown in Figure 11-50 other than 2005. Of the 29 formaldehyde concentrations greater than 15 µg/m^3, 12 were measured in 2005, 17 were measured in 2006, and none were measured in the years that followed.

- The 1-year average concentration for 2006 is 13.76 µg/m^3. After 2006, the 1-year average concentration decreased each year, reaching a minimum of 1.85 µg/m^3 for 2009. Although difficult to discern in Figure 11-50, an increasing trend in the 1-year average concentration is shown between 2009 and 2011.

- Although the maximum concentration increased and the difference between the 5th and 95th percentiles did not change, both the median and 1-year average concentration exhibit slight decreases for 2012.

Figure 11-51. Yearly Statistical Metrics for Trichloroethylene Concentrations Measured at SPIL



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2003.

Observations from Figure 11-51 for trichloroethylene measurements collected at SPIL include the following:

- The minimum and 5th percentile are both zero for all years of sampling, indicating that at least 5 percent of the measurements were non-detects for each year since sampling began at SPIL. The percentage of non-detects has ranged from 14 percent (2007) to 39 percent (2004).
- The maximum concentration of trichloroethylene (110 µg/m^3) was measured at SPIL in 2003 and is an order of magnitude greater than the next highest measurement (17.5 µg/m^3), which was measured in 2012.
- The concentrations of trichloroethylene exhibit considerable variability, as indicated by confidence intervals calculated for the 1-year average concentrations, particularly for 2012, where the maximum concentration is more than twice the maximum concentrations for previous years (except 2003).
- The 1-year average concentrations have fluctuated between 0.34 µg/m^3 (2009) to 0.79 µg/m^3 (2010), with no distinct trend in the concentrations.

11.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each Illinois monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

11.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Illinois monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

11.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Illinois sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 11-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 11-6. Risk Approximations for the Illinois Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Northbrook, Illinois - NBIL						
Acenaphthene [a]	0.000088	--	57/57	0.01 ± <0.01	1.01	--
Acetaldehyde	0.0000022	0.009	66/66	1.78 ± 0.19	3.92	0.20
Arsenic (PM_{10}) [a]	0.0043	0.000015	54/54	<0.01 ± <0.01	3.14	0.05
Benzene	0.0000078	0.03	61/61	0.64 ± 0.08	5.01	0.02
1,3-Butadiene	0.00003	0.002	45/61	0.06 ± 0.02	1.87	0.03
Carbon Tetrachloride	0.000006	0.1	61/61	0.71 ± 0.04	4.27	0.01
p-Dichlorobenzene	0.000011	0.8	31/61	0.04 ± 0.01	0.47	<0.01
1,2-Dichloroethane	0.000026	2.4	53/61	0.07 ± 0.01	1.81	<0.01
Fluoranthene [a]	0.000088	--	57/57	0.01 ± <0.01	0.62	--
Fluorene [a]	0.000088	--	57/57	0.01 ± <0.01	1.08	--
Formaldehyde	0.000013	0.0098	66/66	2.49 ± 0.33	32.31	0.25
Manganese (PM_{10}) [a]	--	0.00005	54/54	0.01 ± <0.01	--	0.18
Naphthalene [a]	0.000034	0.003	57/57	0.08 ± 0.02	2.65	0.03
Schiller Park, Illinois - SPIL						
Acetaldehyde	0.0000022	0.009	61/61	2.72 ± 0.77	5.99	0.30
Benzene	0.0000078	0.03	60/60	0.95 ± 0.19	7.44	0.03
1,3-Butadiene	0.00003	0.002	59/60	0.14 ± 0.03	4.14	0.07
Carbon Tetrachloride	0.000006	0.1	60/60	0.68 ± 0.03	4.10	0.01
p-Dichlorobenzene	0.000011	0.8	39/60	0.05 ± 0.02	0.57	<0.01
1,2-Dichloroethane	0.000026	2.4	55/60	0.08 ± 0.01	1.99	<0.01
Ethylbenzene	0.0000025	1	60/60	0.29 ± 0.06	0.71	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.09 ± 0.58	40.12	0.31
Trichloroethylene	0.0000048	0.002	49/60	0.71 ± 0.60	3.39	0.35

-- = a Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 11-5.

NA = Not available due to the criteria for calculating an annual average.

Table 11-6. Risk Approximations for the Illinois Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Roxana, Illinois - ROIL						
Acetaldehyde	0.0000022	0.009	35/35	NA	NA	NA
Benzene	0.0000078	0.03	33/33	NA	NA	NA
1,3-Butadiene	0.00003	0.002	31/33	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	33/33	NA	NA	NA
p-Dichlorobenzene	0.000011	0.8	22/33	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	29/33	NA	NA	NA
Ethylbenzene	0.0000025	1	33/33	NA	NA	NA
Formaldehyde	0.000013	0.0098	35/35	NA	NA	NA

-- = a Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 11-5.

NA = Not available due to the criteria for calculating an annual average.

Observations for the Illinois sites from Table 11-6 include the following:

- Formaldehyde and acetaldehyde are the pollutants with the highest annual average concentrations for both NBIL and SPIL, although the annual averages were higher for SPIL.

- Formaldehyde has the highest cancer risk approximation for both sites (40.12 in-a-million for SPIL and 32.31 in-a-million for NBIL). There were no other pollutants for which a cancer risk approximation greater than 10 in-a-million was calculated.

- None of the pollutants of interest for NBIL or SPIL have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for NBIL is formaldehyde (0.25), although acetaldehyde has a noncancer hazard approximation of similar magnitude (0.20). The pollutant with the highest noncancer hazard approximation for SPIL is trichloroethylene (0.35), although formaldehyde and acetaldehyde have noncancer hazard approximations of similar magnitudes (0.31 and 0.30, respectively).

- Cancer risk and noncancer hazard approximations could not be calculated for ROIL because annual average concentrations are not available.

11.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 11-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 11-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 11-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 11-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 11-7. Table 11-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 11.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 11-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Illinois Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Northbrook, Illinois (Cook County) - NBIL					
Benzene	961.69	Formaldehyde	1.07E-02	Formaldehyde	32.31
Formaldehyde	821.78	Arsenic, PM	8.12E-03	Benzene	5.01
Ethylbenzene	565.60	Benzene	7.50E-03	Carbon Tetrachloride	4.27
Acetaldehyde	463.56	Hexavalent Chromium, PM	5.42E-03	Acetaldehyde	3.92
Tetrachloroethylene	257.15	1,3-Butadiene	4.65E-03	Arsenic	3.14
1,3-Butadiene	155.11	Naphthalene	3.08E-03	Naphthalene	2.65
Trichloroethylene	99.56	Nickel, PM	2.05E-03	1,3-Butadiene	1.87
Naphthalene	90.61	Ethylbenzene	1.41E-03	1,2-Dichloroethane	1.81
Dichloromethane	35.41	POM, Group 2b	1.36E-03	Fluorene	1.08
POM, Group 2b	15.48	Acetaldehyde	1.02E-03	Acenaphthene	1.01
Schiller Park, Illinois (Cook County) - SPIL					
Benzene	961.69	Formaldehyde	1.07E-02	Formaldehyde	40.12
Formaldehyde	821.78	Arsenic, PM	8.12E-03	Benzene	7.44
Ethylbenzene	565.60	Benzene	7.50E-03	Acetaldehyde	5.99
Acetaldehyde	463.56	Hexavalent Chromium, PM	5.42E-03	1,3-Butadiene	4.14
Tetrachloroethylene	257.15	1,3-Butadiene	4.65E-03	Carbon Tetrachloride	4.10
1,3-Butadiene	155.11	Naphthalene	3.08E-03	Trichloroethylene	3.39
Trichloroethylene	99.56	Nickel, PM	2.05E-03	1,2-Dichloroethane	1.99
Naphthalene	90.61	Ethylbenzene	1.41E-03	Ethylbenzene	0.71
Dichloromethane	35.41	POM, Group 2b	1.36E-03	*p*-Dichlorobenzene	0.57
POM, Group 2b	15.48	Acetaldehyde	1.02E-03		

Table 11-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Illinois Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Roxana, Illinois (Madison County) - ROIL					
Coke Oven Emissions, PM	137.23	Coke Oven Emissions, PM	1.36E-01		
Benzene	115.44	Hexavalent Chromium, PM	8.20E-03		
Formaldehyde	114.84	Formaldehyde	1.49E-03		
Ethylbenzene	50.92	Arsenic, PM	1.03E-03		
Acetaldehyde	48.47	Benzene	9.00E-04		
Naphthalene	13.98	POM, Group 1a	5.80E-04		
1,3-Butadiene	13.21	Naphthalene	4.75E-04		
Dichloromethane	12.11	1,3-Butadiene	3.96E-04		
POM, Group 1a	6.59	Nickel, PM	3.23E-04		
Tetrachloroethylene	3.60	POM, Group 3	2.95E-04		

Table 11-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Illinois Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Northbrook, Illinois (Cook County) - NBIL					
Toluene	9,526.78	Acrolein	3,182,872.70	Formaldehyde	0.25
Ethylene glycol	6,437.35	Arsenic, PM	125,965.03	Acetaldehyde	0.20
Methanol	3,042.16	Cyanide Compounds, gas	86,973.50	Manganese	0.18
Hexane	2,625.12	Formaldehyde	83,855.56	Arsenic	0.05
Xylenes	2,404.38	1,3-Butadiene	77,557.35	1,3-Butadiene	0.03
Benzene	961.69	Manganese, PM	70,630.83	Naphthalene	0.03
Formaldehyde	821.78	Cadmium, PM	52,253.81	Benzene	0.02
Ethylbenzene	565.60	Acetaldehyde	51,506.84	Carbon Tetrachloride	0.01
Acetaldehyde	463.56	Trichloroethylene	49,780.32	*p*-Dichlorobenzene	<0.01
Methyl isobutyl ketone	342.65	Nickel, PM	47,566.89	1,2-Dichloroethane	<0.01
Schiller Park, Illinois (Cook County) – SPIL					
Toluene	9,526.78	Acrolein	3,182,872.70	Trichloroethylene	0.35
Ethylene glycol	6,437.35	Arsenic, PM	125,965.03	Formaldehyde	0.31
Methanol	3,042.16	Cyanide Compounds, gas	86,973.50	Acetaldehyde	0.30
Hexane	2,625.12	Formaldehyde	83,855.56	1,3-Butadiene	0.07
Xylenes	2,404.38	1,3-Butadiene	77,557.35	Benzene	0.03
Benzene	961.69	Manganese, PM	70,630.83	Carbon Tetrachloride	0.01
Formaldehyde	821.78	Cadmium, PM	52,253.81	Ethylbenzene	<0.01
Ethylbenzene	565.60	Acetaldehyde	51,506.84	*p*-Dichlorobenzene	<0.01
Acetaldehyde	463.56	Trichloroethylene	49,780.32	1,2-Dichloroethane	<0.01
Methyl isobutyl ketone	342.65	Nickel, PM	47,566.89		

Table 11-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Illinois Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Roxana, Illinois (Madison County) – ROIL					
Toluene	600.92	Acrolein	243,888.11		
Ethylene glycol	331.04	Manganese, PM	99,821.87		
Hexane	190.00	Chlorine	95,420.68		
Xylenes	187.92	Hexamethylene-1,6-diisocyanate, gas	25,000.00		
Methanol	178.11	Arsenic, PM	16,018.46		
Hydrochloric acid	128.58	Lead, PM	14,477.27		
Benzene	115.44	Formaldehyde	11,717.88		
Formaldehyde	114.84	Cyanide Compounds, PM	7,689.48		
Ethylbenzene	50.92	Cyanide Compounds, gas	7,489.00		
Acetaldehyde	48.47	Nickel, PM	7,480.96		

Observations from Table 11-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Cook County. Coke oven emissions is the highest emitted "pollutant" with a cancer URE in Madison County, followed by benzene, formaldehyde, and ethylbenzene.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Cook County are formaldehyde, arsenic, and benzene. Coke oven emissions top Madison County's toxicity-weighted emissions, followed by hexavalent chromium and formaldehyde.

- Seven of the highest emitted pollutants in Cook County also have the highest toxicity-weighted emissions while six of the highest emitted pollutants in Madison County also have the highest toxicity-weighted emissions.

- For NBIL and SPIL, formaldehyde is the pollutant with the highest cancer risk approximation. This pollutant also has the highest toxicity-weighted emissions and ranks second for quantity emitted. Benzene, acetaldehyde, and 1,3-butadiene also appear on all three list for both sites.

- Carbon tetrachloride, which has the third highest cancer risk approximation for NBIL and sixth highest cancer risk approximation for SPIL, does not appear on either emissions-based list.

- Trichloroethylene has the seventh highest cancer risk approximation for SPIL and is the seventh highest emitted pollutant in Cook County, but does not appear among the pollutants with the highest toxicity-weighted emissions (this pollutant ranks 14th).

- Several metals appear among the pollutants with the highest toxicity-weighted emissions for Cook County, including arsenic, which has the fifth highest cancer risk approximation for NBIL (SPIL did not sample metals). None of these metals appear among the highest emitted pollutants for Cook County.

- POM, Group 2b ranks tenth for quantity emitted and ninth for toxicity-weighted emissions in Cook County. POM, Group 2b includes acenaphthene, fluorene, and fluoranthene, all three of which are pollutants of interest for NBIL.

- NBIL is one of two NMP sites that sampled pollutants from all six methods. At least one pollutant from each of the six methods appears among the pollutants with the highest toxicity-weighted emissions.

- While seven of the 10 highest emitted pollutants in Madison County are sampled for at ROIL, only three of the pollutants with the highest toxicity-weighted emissions are sampled for at ROIL.

Observations from Table 11-8 include the following:

- Toluene and ethylene glycol are the highest emitted pollutants with noncancer RfCs in both Cook and Madison Counties, although the quantity emitted is significantly higher in Cook County.

- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties is acrolein. Although acrolein was sampled for at all three sites, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Only two of the highest emitted pollutants also have the highest toxicity-weighted emissions (formaldehyde, and acetaldehyde) for Cook County. The highest emitted pollutants and the pollutants with the highest toxicity-weighted emissions for Madison County have only one pollutant in common (formaldehyde).

- Formaldehyde and acetaldehyde have the highest noncancer hazard approximations for NBIL (albeit less than an HQ of 1.0) and are the only pollutants that appear on both emissions-based lists for Cook County.

- Trichloroethylene has the highest noncancer hazard approximation for SPIL; this pollutant has the ninth highest toxicity-weighted emissions, but is not among the highest emitted pollutants in Cook County (with a noncancer RfC).

- Several metals appear among the pollutants with the highest toxicity-weighted emissions for Cook County, including manganese and arsenic, which have the third and fourth highest noncancer hazard approximations for NBIL. (SPIL did not sample metals). None of these metals appear among the highest emitted pollutants.

- While seven of the 10 highest emitted pollutants in Madison County (with noncancer RfCs) are sampled for at ROIL, only two of the pollutants with the highest toxicity-weighted emissions are sampled for at ROIL.

11.6 Summary of the 2012 Monitoring Data for NBIL, SPIL, and ROIL

Results from several of the data treatments described in this section include the following:

- ❖ *Twenty-two pollutants (two carbonyl compounds, 11 VOCs, five PAHs, three metals, and hexavalent chromium) failed screens for NBIL; 13 pollutants (three carbonyl compounds and 10 VOCs) failed screens for SPIL; and 11 pollutants (two carbonyl compounds and nine VOCs) failed screens for ROIL.*

- ❖ *Formaldehyde had the highest annual average concentration among the pollutants of interest for NBIL and SPIL. Although ROIL did not sample long enough for annual averages to be calculated, the quarterly averages of acetaldehyde are significantly higher than the quarterly averages for the remaining pollutants of interest.*

- *The maximum concentrations of several pollutants of interest across the program were measured at the Chicago sites. The maximum concentrations of acetaldehyde, formaldehyde, and trichloroethylene program-wide were measured at SPIL. The maximum concentrations of fluorene and fluoranthene program-wide were measured at NBIL.*

- *Concentrations of acetaldehyde and manganese have been increasing in recent years at NBIL. Like many other NMP sites, a significant decrease in the number of non-detects reported for 1,2-dichloroethane has occurred at both Chicago sites.*

12.0 Sites in Indiana

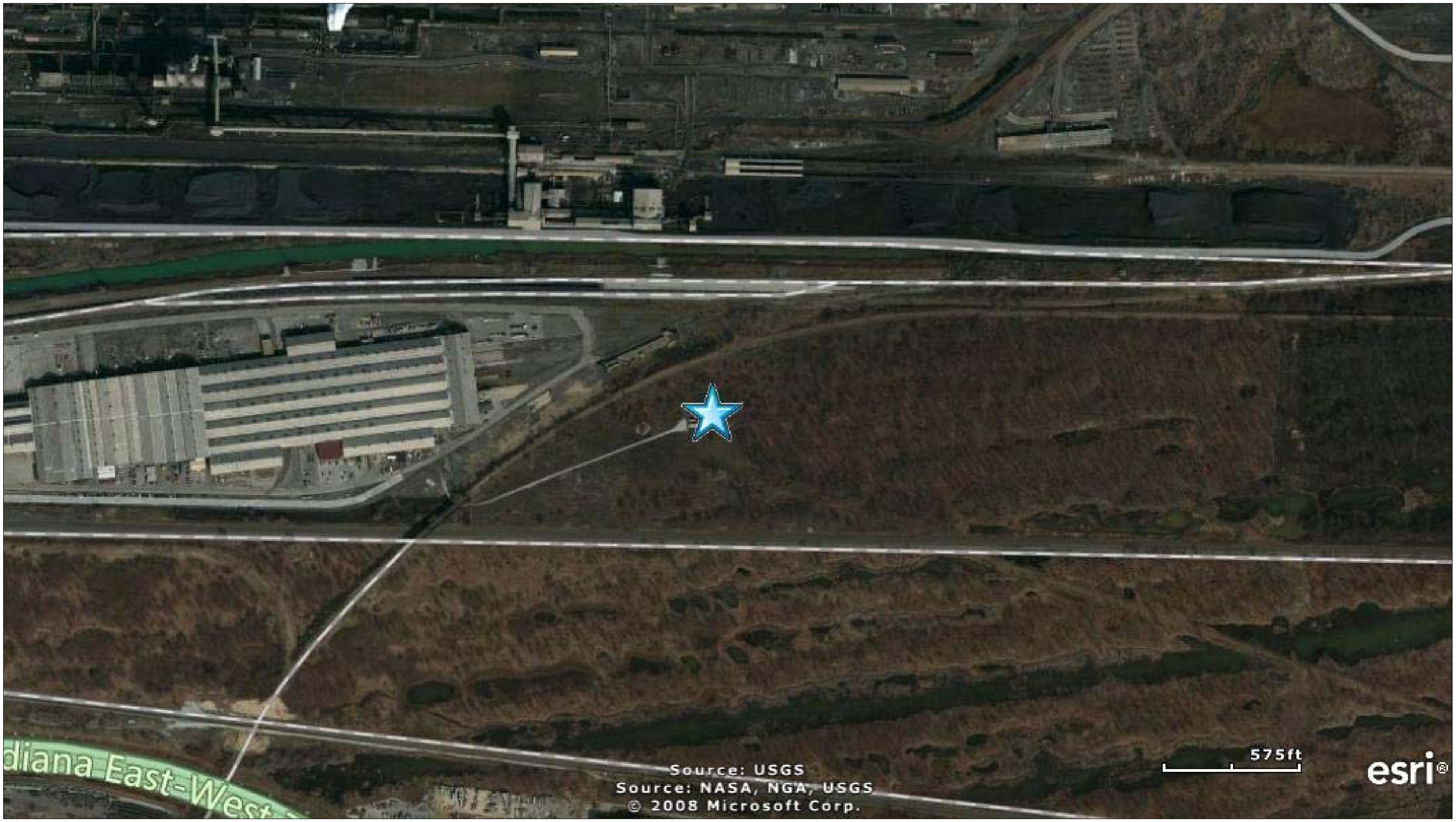
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP sites in Indiana, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

12.1 Site Characterization

This section characterizes the Indiana monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

One Indiana monitoring site (INDEM) is located in the Chicago-Naperville-Elgin, IL-IN-WI MSA, while a second site (WPIN) is located in the Indianapolis-Carmel-Anderson, IN MSA. Figures 12-1 and 12-3 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites and their immediate surroundings. Figures 12-2 and 12-4 identify nearby point source emissions locations by source category near INDEM and WPIN, respectively, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figures 12-2 and 12-4. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radius are still visible on each map, but have been grayed out in order to show emissions sources just outside the boundary. Table 12-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 12-1. Gary, Indiana (INDEM) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 12-2. NEI Point Sources Located Within 10 Miles of INDEM

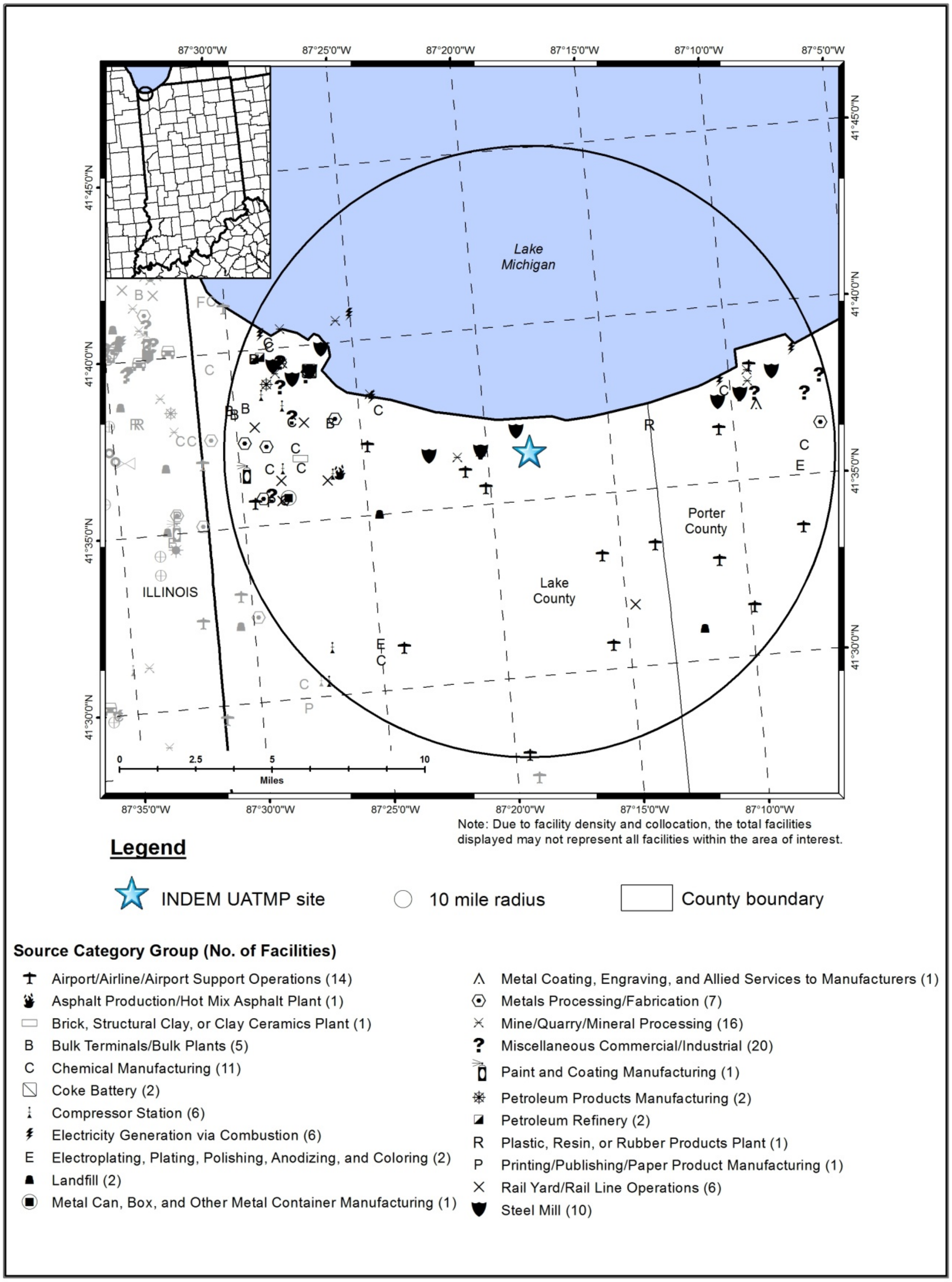


Figure 12-3. Indianapolis, Indiana (WPIN) Monitoring Site

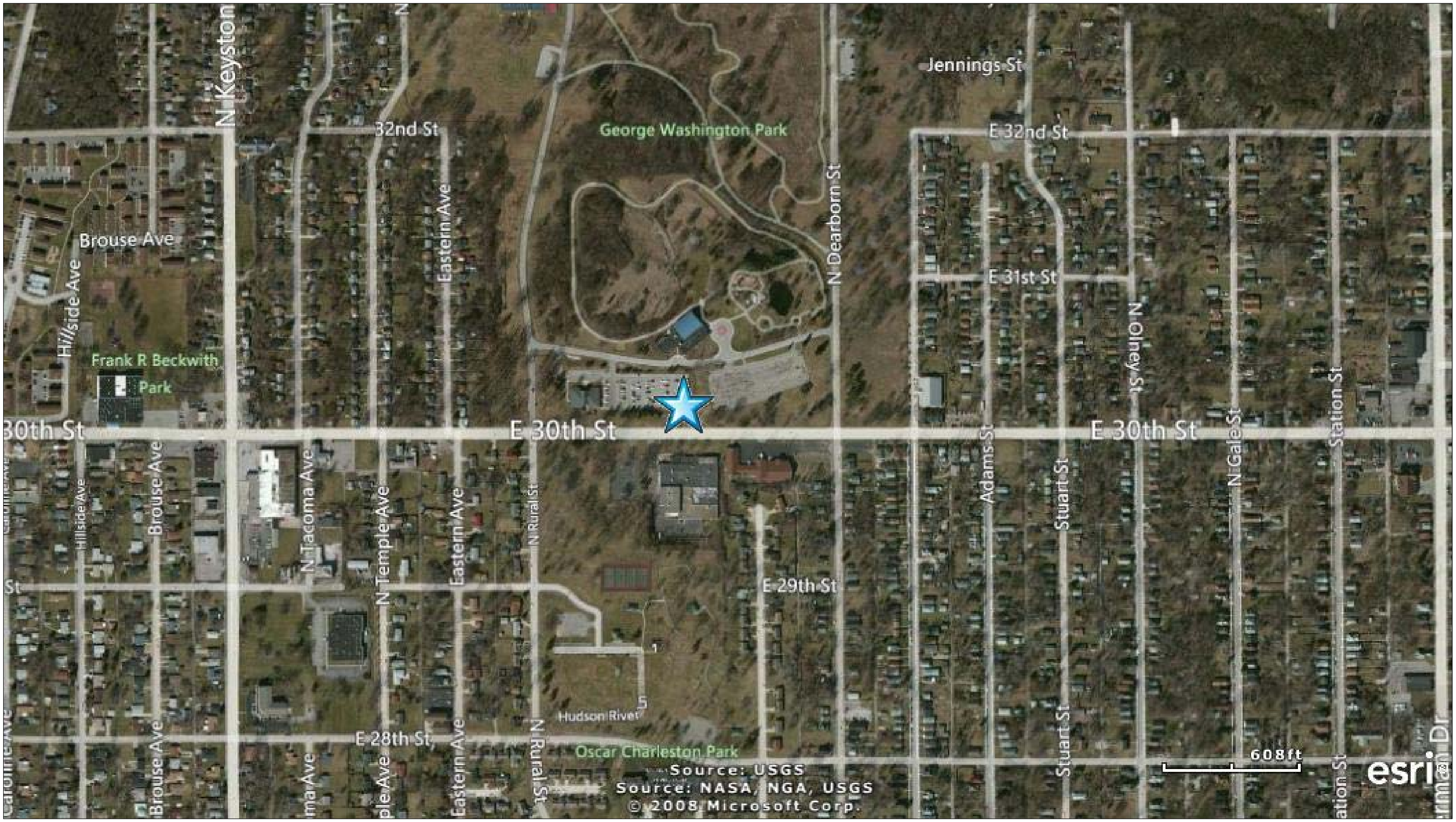
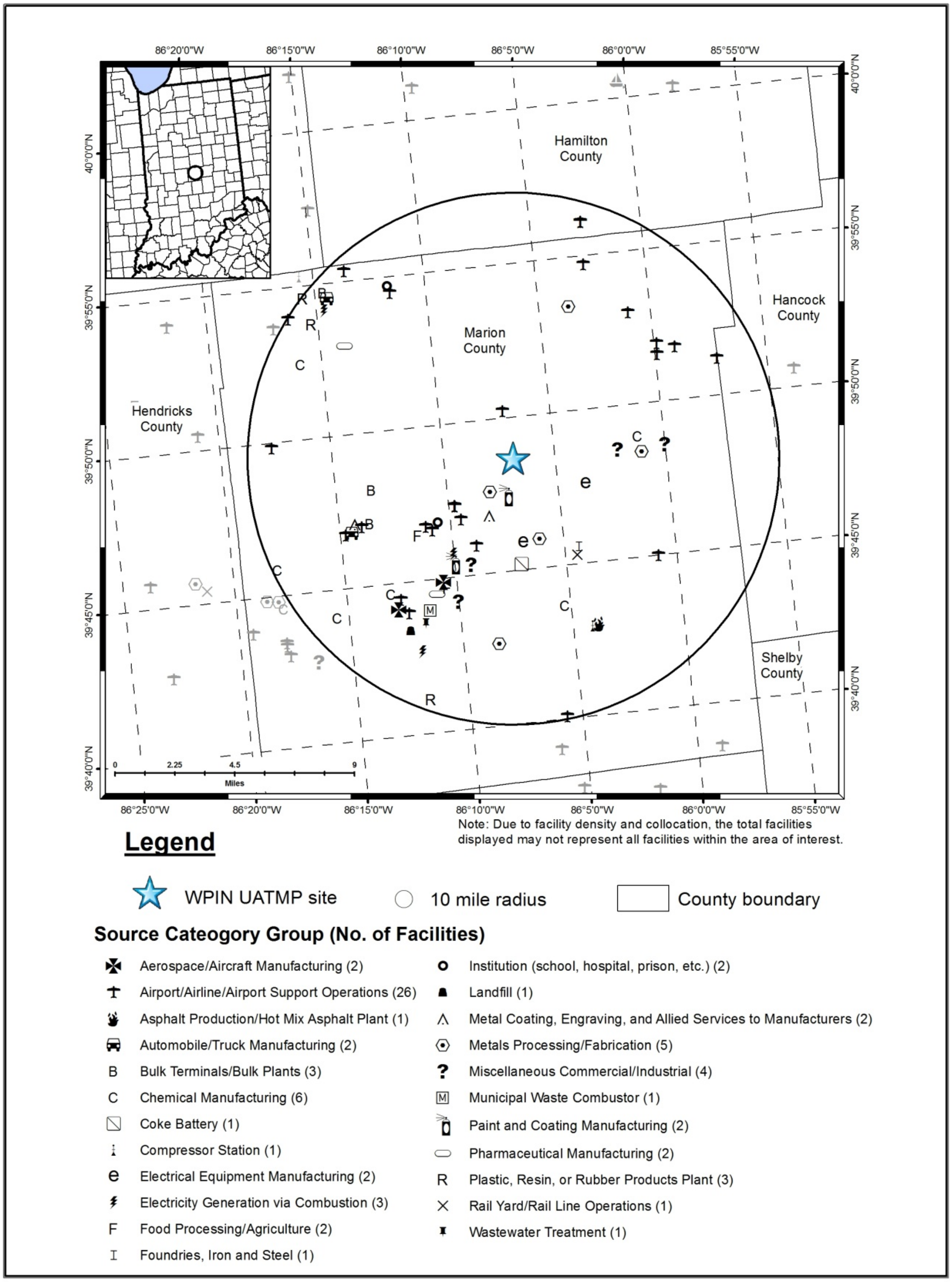


Figure 12-4. NEI Point Sources Located Within 10 Miles of WPIN



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 12-1. Geographical Information for the Indiana Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
INDEM	18-089-0022	Gary	Lake	Chicago-Naperville-Elgin, IL-IN-WI MSA	41.606680, -87.304729	Industrial	Urban/City Center	VOCs, SO_2, NO, NO_2, NO_x, PAMS, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
WPIN	18-097-0078	Indianapolis	Marion	Indianapolis-Carmel-Anderson, IN MSA	39.811097, -86.114469	Residential	Suburban	TSP Metals, CO, VOCs, SNMOCs, SO_2, NO_y, NO, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, $PM_{2.5}$ Speciation, PM Coarse, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

INDEM is located in Gary, Indiana, a few miles east of the Indiana-Illinois border and southeast of Chicago. Gary is located on the southernmost bank of Lake Michigan. The site is located just north of I-90, the edge of which can be seen in the bottom left portion of Figure 12-1, and I-65. Although INDEM resides on the Indiana Dunes National Lakeshore, the surrounding area is highly industrialized, as shown in Figure 12-1, and several railroads transverse the area. Figure 12-2 shows that the majority of point sources within 10 miles of INDEM are located to the west of the site. There is also a second cluster of facilities located to the east of INDEM in Porter County. The emissions source categories with the highest number of sources within 10 miles of INDEM include steel mills; aircraft operations, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or TV stations; chemical manufacturing; and mine/quarry/mineral processing. The sources closest to INDEM include a steel mill; an industrial complex that includes several facilities that fall into the miscellaneous commercial/industrial category as well as a mine/quarry and another steel mill; a heliport at a police station and a hospital; and a mine/quarry.

WPIN is located in the parking lot of George Washington Park, near East 30th Street in northeast Indianapolis. Figure 12-3 shows that the area surrounding WPIN is suburban and residential, with little industry in close proximity. A church and a charitable organization are located across the street from Washington Park, as is Oscar Charleston Park. Figure 12-4 shows that the majority of point sources are located to the south and southwest of WPIN, towards the center of Marion County. The source category with the highest number of sources near WPIN is the airport operations source category. The sources closest to WPIN are a painting and coating manufacturer, a metals processing/fabrication facility, a heliport, and a fabricated metal products facility. Each of these facilities is greater than 1 mile from WPIN but less than 2 miles out.

Table 12-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Indiana monitoring sites. Table 12-2 includes both county-level population and vehicle registration information. Table 12-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 12-2 presents the county-level daily VMT for Marion and Lake Counties.

Table 12-2. Population, Motor Vehicle, and Traffic Information for the Indiana Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
INDEM	493,618	419,431	34,754	I-90, north of I-65 interchange	16,226,000
WPIN	918,977	820,767	143,970	I-70 between Exits 85 & 87	32,005,000

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2011 data (IN BMV, 2012)
[3] AADT reflects 2011 data (IN DOT, 2011)
[4] County-level VMT reflects 2011 data (IN DOT, 2012)

Observations from Table 12-2 include the following:

- Marion County has almost twice the county-level population and vehicle registration as Lake County.

- The county-level population for Marion County rounds out the top third among county-level populations for other NMP sites, while the population for Lake County is in the middle of the range. The county-level vehicle registrations mimic these rankings.

- WPIN experiences a significantly higher traffic volume than INDEM. The traffic estimate for WPIN is based on data from I-70 between exits 85 and 87. Interstate-70 is just over 1 mile south of WPIN. Traffic data were not available for a location closer to WPIN. The traffic volume near WPIN is the eighth highest among NMP sites.

- The traffic volume for INDEM is based on data from the I-90 toll road. Traffic near INDEM is in the middle of the range among traffic volumes for all NMP sites.

- The VMT for Marion County is almost twice the VMT for Lake County. The Marion County VMT ranks 10th among counties with NMP sites, while the VMT for Lake County is in the middle of the range (19th).

12.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Indiana on sample days, as well as over the course of the year.

12.2.1 Climate Summary

The city of Gary is located to the southeast of Chicago, at the southern-most tip of Lake Michigan. Gary’s proximity to Lake Michigan is an important factor controlling the weather of the area. In the summer, warm temperatures can be suppressed, while cold winter temperatures are often moderated. Winds that blow across Lake Michigan and over Gary in the winter can provide abundant amounts of lake-effect snow while lake breezes can bring relief from summer heat (Wood, 2004; ISCO, 2002).

The city of Indianapolis is located in the center of Indiana, and experiences a temperate continental climate and frequently changing weather patterns. Summers are warm and often humid, as moist air flows northward out of the Gulf of Mexico. Winters are chilly with occasional Arctic outbreaks. Precipitation is spread rather evenly throughout the year, with much of the spring and summer precipitation resulting from showers and thunderstorms. Annual snowfall totals average around 30 inches, with winters receiving less than 10 inches being uncommon. The prevailing wind direction is southwesterly (Wood, 2004; ISCO, 2002).

12.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved NCDC for the weather stations closest to the Indiana monitoring sites (NCDC, 2012), as described in Section 3.5.2. The two closest weather stations are located at Lansing Municipal Airport (near INDEM) and Eagle Creek Airpark (near WPIN), WBAN 04879 and 53842, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 12-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 12-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 12-3 is the 95 percent confidence interval for each parameter. As shown in Table 12-3, average meteorological conditions on sample days at WPIN and INDEM were representative of average weather conditions experienced throughout the year near these locations. For both sites, the meteorological parameter with the largest difference is relative humidity, although the differences are not statistically significant.

Table 12-3. Average Meteorological Conditions near the Indiana Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Gary, Indiana - INDEM									
Lansing Municipal Airport 04879 (41.54, -87.52)	12.0 miles 242° (WSW)	Sample Days (61)	63.2 ± 5.1	54.1 ± 4.5	42.5 ± 3.9	48.1 ± 3.8	68.6 ± 3.2	NA	7.3 ± 0.9
		2012	62.5 ± 2.0	53.5 ± 1.8	42.6 ± 1.6	47.9 ± 1.6	70.1 ± 1.3	NA	6.8 ± 0.4
Indianapolis, Indiana - WPIN									
Eagle Creek Airpark 53842 (39.83, -86.30)	9.1 miles 270° (W)	Sample Days (63)	64.4 ± 4.6	55.4 ± 4.4	42.1 ± 3.8	48.6 ± 3.7	64.6 ± 3.3	1016.3 ± 1.5	5.8 ± 0.7
		2012	64.8 ± 2.0	55.8 ± 1.8	43.4 ± 1.6	49.3 ± 1.6	67.0 ± 1.3	1016.5 ± 0.6	5.4 ± 0.3

[1] Sample day averages are shaded in orange help differentiate the sample day averages from the full-year averages.

NA= Sea level pressure was not recorded at the Lansing Municipal Airport.

12.2.3 Back Trajectory Analysis

Figure 12-5 is the composite back trajectory map for days on which samples were collected at the INDEM monitoring site. Included in Figure 12-5 are four back trajectories per sample day. Figure 12-6 is the corresponding cluster analysis. Similarly, Figure 12-7 is the composite back trajectory map for days on which samples were collected at WPIN and Figure 12-8 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 12-5 through 12-8 represents 100 miles.

Observations from Figures 12-5 and 12-6 for INDEM include the following:

- Back trajectories originated from a variety of directions at INDEM, with the south, northwest, and north appearing to be the predominant directions of trajectory origin.

- The 24-hour air shed domain for INDEM was among the larger in size compared to other NMP sites, with an average back trajectory length of 279 miles. The farthest away a back trajectory originated was over central North Dakota, or nearly 800 miles away. However, most trajectories (approximately 88 percent) originated within 450 miles of INDEM, with the longest trajectories originating from the northwest and north.

- The cluster analysis shows that less than 20 percent of back trajectories originated to the north of INDEM, primarily over eastern Wisconsin or Upper Peninsula of Michigan, the Great Lakes, or northwest Michigan. Another 18 percent of back trajectories originated to the northwest of INDEM. Back trajectories originating to the west and southwest of INDEM, over Illinois, Iowa, and Missouri, account for more than one-quarter of back trajectories.

- Back trajectories originating to the south of INDEM are split into two cluster trajectories. Fifteen percent of back trajectories originated over western Kentucky and Tennessee and are represented by the cluster trajectory originating south of Paducah, Kentucky. This cluster includes back trajectories greater than 200 miles in length. The short cluster trajectory originating over Indianapolis represents relatively short back trajectories (generally less than 200 miles in length), originating to the east, southeast, and south of INDEM, predominantly over western Ohio, northern Kentucky, and Indiana.

Figure 12-5. Composite Back Trajectory Map for INDEM

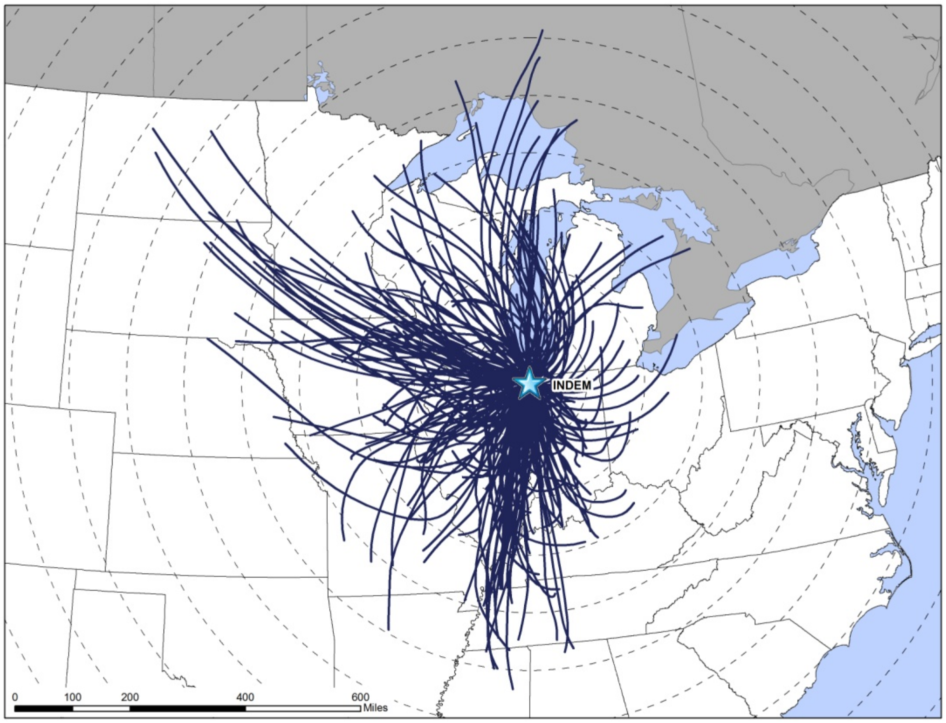


Figure 12-6. Back Trajectory Cluster Map for INDEM

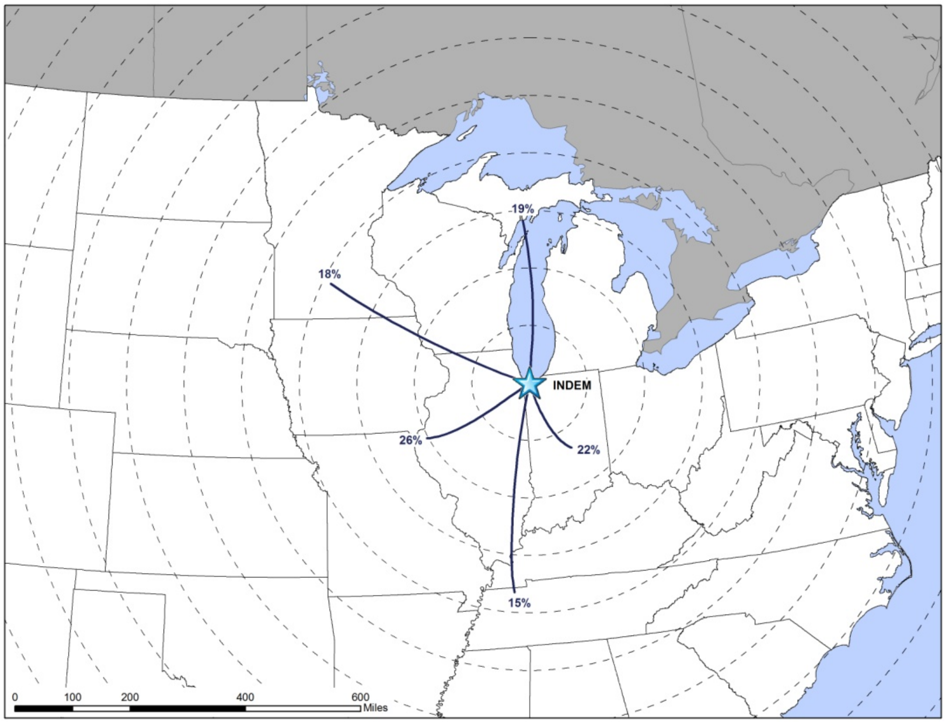


Figure 12-7. Composite Back Trajectory Map for WPIN

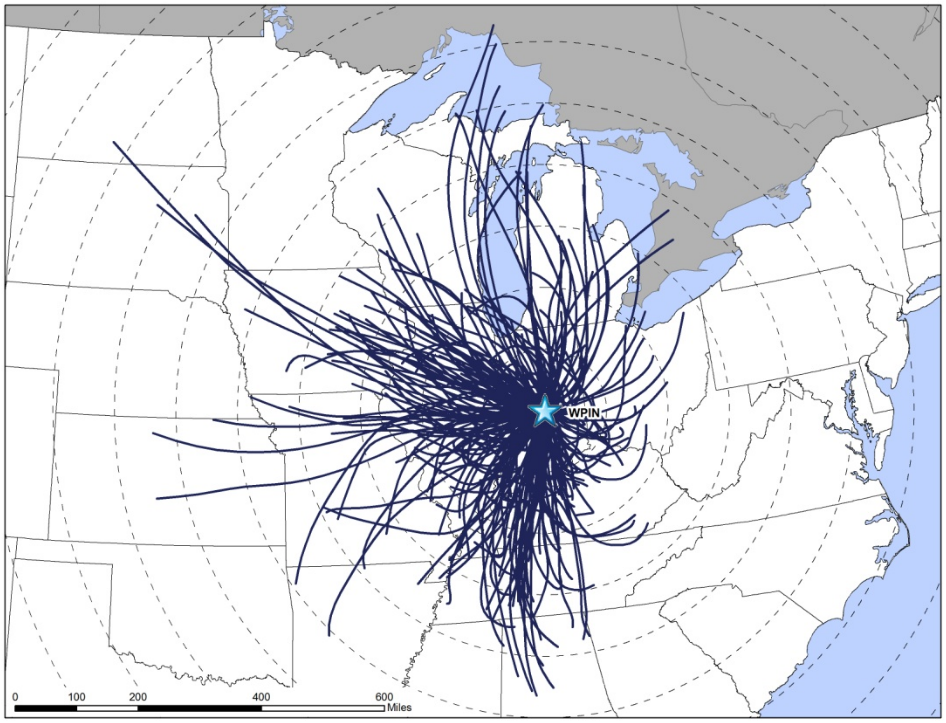
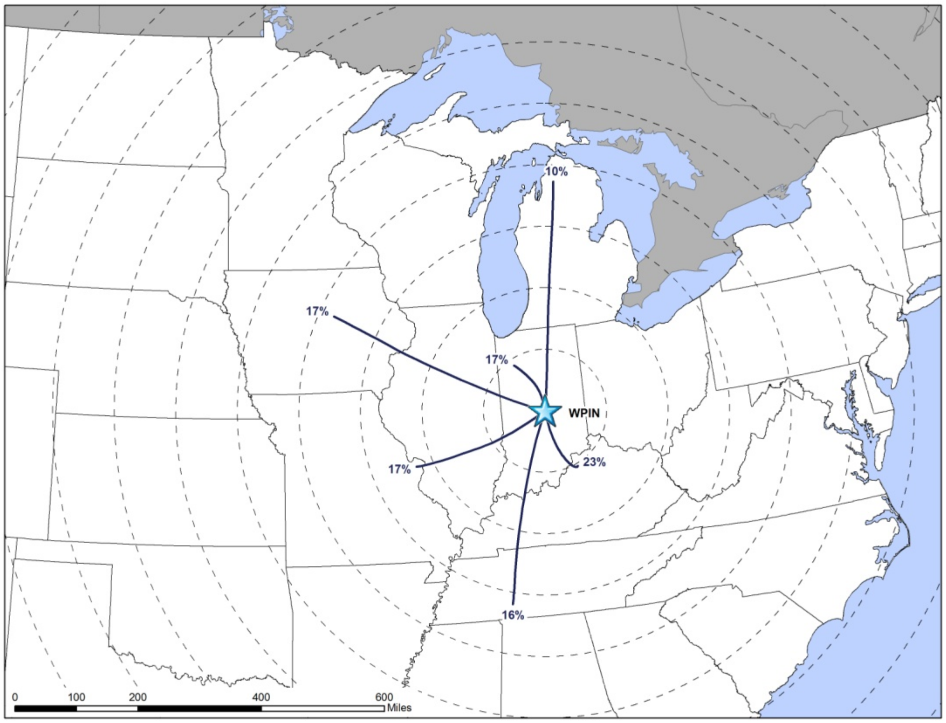


Figure 12-8. Back Trajectory Cluster Map for WPIN



Observations from Figures 12-7 and 12-8 for WPIN include the following:

- The composite back trajectory map for WPIN resembles the composite back trajectory map for INDEM in the geographic distribution of back trajectories.

- The 24-hour air shed domain for WPIN is similar in size to many other NMP monitoring sites, with an average trajectory length of 252 miles. The farthest away a back trajectory originated was over south-central North Dakota, or greater than 800 miles away, although most trajectories (nearly 90 percent) originated within 400 miles of WPIN. The longest back trajectories tended to originate from west, northwest, and north.

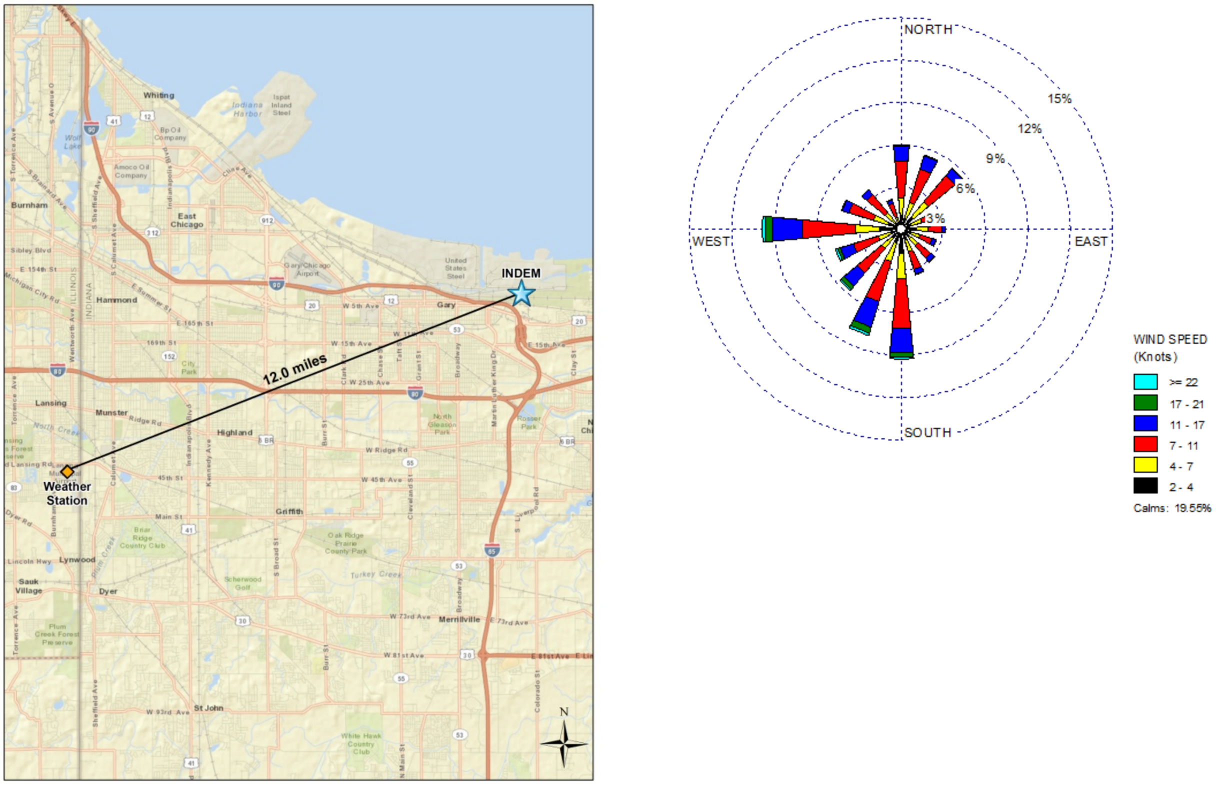
- The cluster analysis for WPIN resembles the cluster analysis for INDEM. One major difference is the additional cluster trajectory originating over the northwest corner of Indiana and representing 17 percent of back trajectories. This cluster represents the relatively short back trajectories originating over the northern half of Indiana and Illinois. Common back trajectory origination includes from the north (10 percent), northwest (17 percent), west and southwest (17 percent), and south (16 percent). Similar to INDEM, the short cluster trajectory originating to the southeast of WPIN represents the relatively short back trajectories (less than 250 miles in length) originating from the northeast, east, southeast, and south of the monitoring site.

12.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations nearest the Indiana sites, as presented in Section 12.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

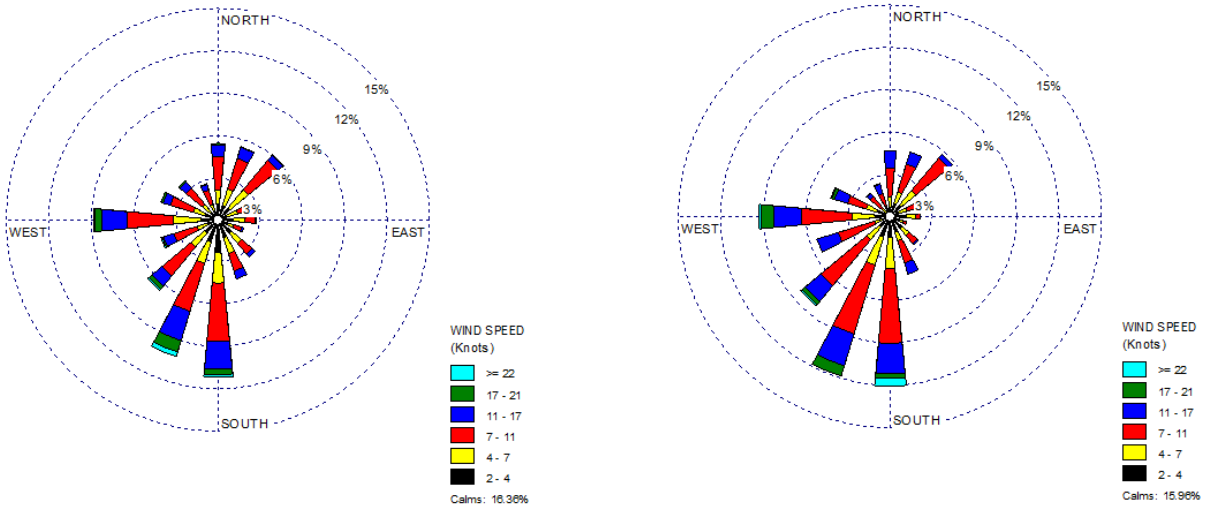
Figure 12-9 presents a map showing the distance between the weather station and INDEM, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 12-9 also presents three different wind roses for the INDEM monitoring site. First, a historical wind rose representing 2003 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 12-10 presents the distance map and three wind roses for WPIN.

Figure 12-9. Wind Roses for the Lansing Municipal Airport Weather Station near INDEM



Location of INDEM and Weather Station

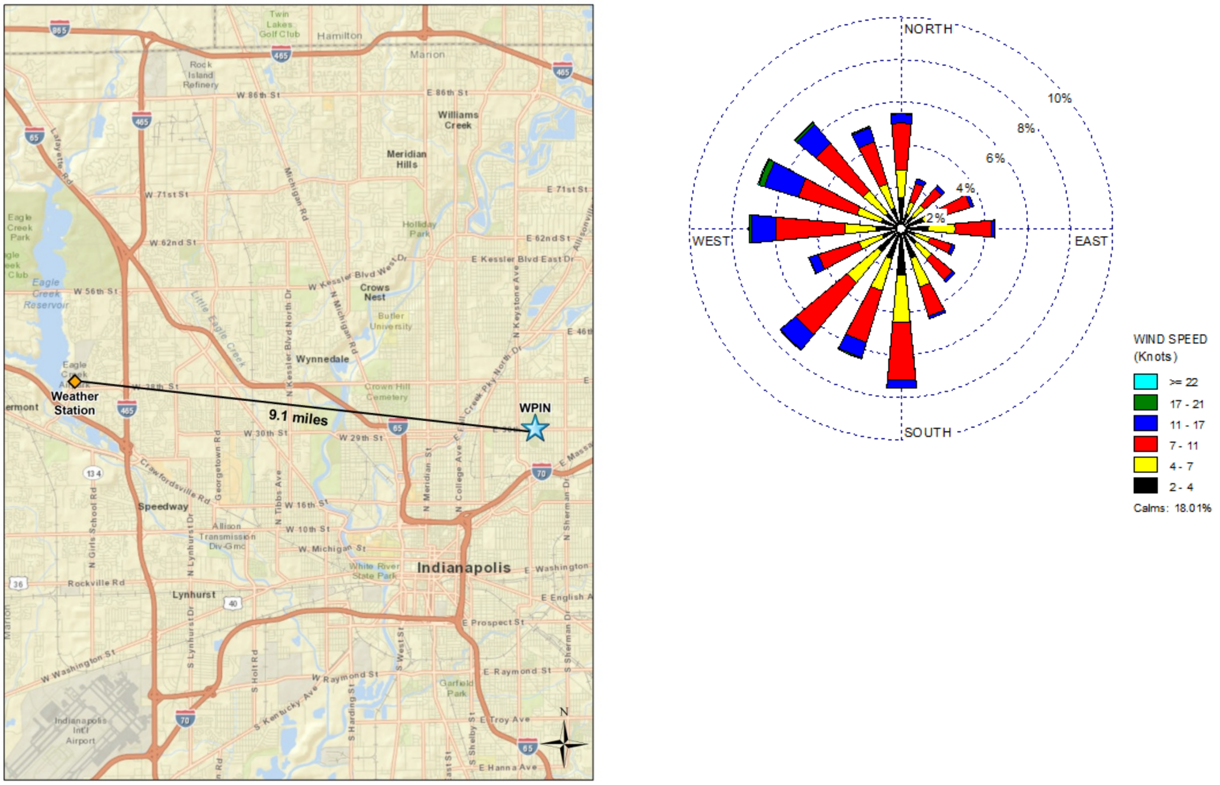
2003-2011 Historical Wind Rose



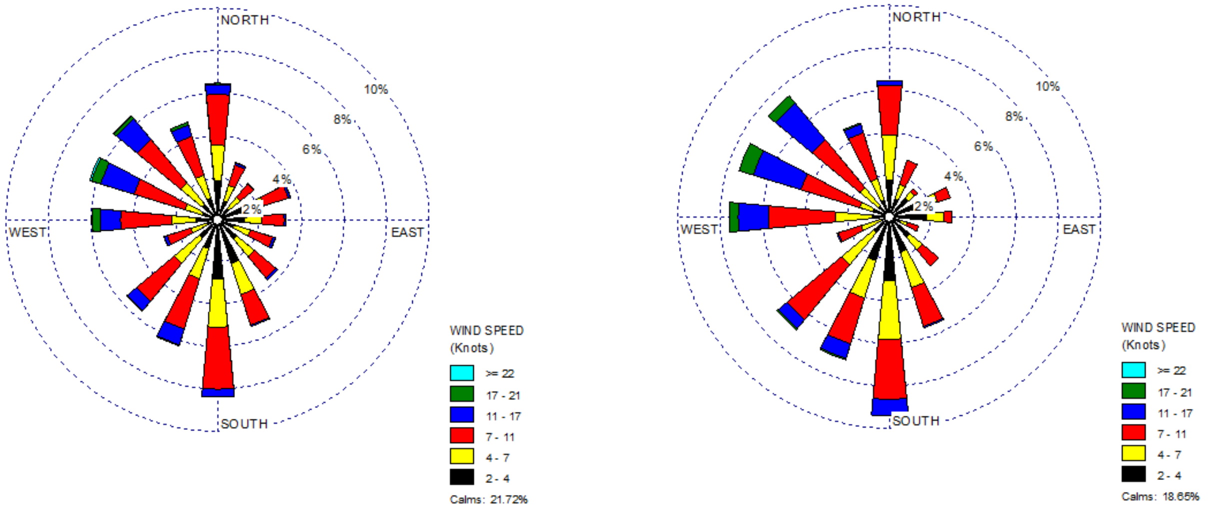
2012 Wind Rose

Sample Day Wind Rose

Figure 12-10. Wind Roses for the Indianapolis International Airport Weather Station near WPIN


Location of WPIN and Weather Station

2002-2011 Historical Wind Rose


2012 Wind Rose

Sample Day Wind Rose

Observations from Figure 12-9 for INDEM include the following:

- The weather station at Lancing Municipal Airport is the closest weather station to INDEM, although it is located 12 miles west-southwest of INDEM. The location of the weather station is just east of the Illinois-Indiana state line and farther inland than INDEM and thus, farther away from the influences of Lake Michigan than INDEM.

- The historical wind rose for INDEM shows that winds from the south to south-southwest and west are the predominant wind directions over the 2003-2011 time frame. Northerly to northeasterly winds off Lake Michigan accounted for less than 20 percent of the wind measurements, as did calm winds (≤ 2 knots). The strongest winds were those from the south to southwest to west.

- The wind patterns shown on the 2012 wind rose generally resemble the wind patterns shown on the historical wind rose. There were, however, slightly fewer calm winds and a higher percentage of winds from the south to southwest.

- The differences in the wind patterns shown on the full-year wind rose continue on the sample day wind rose. The calm rate is slightly lower and there is an even higher percentage of winds from the south, south-southwest, and southwest.

Observations from Figure 12-10 for WPIN include the following:

- The weather station at Eagle Creek Airpark is the closest weather station to WPIN and is located approximately 9 miles west of WPIN. Eagle Creek Airpark is located on the southeast edge of the Eagle Creek Reservoir.

- Winds from the south, from the western quadrants, and from the north account for the majority (nearly 60 percent) of wind observations from 2002 to 2011, while winds from the eastern quadrants were observed for approximately one-quarter of the observations. Calm winds were observed for 18 percent of observations. The strongest winds tended to flow from the northwest.

- The wind patterns on the 2012 wind rose resemble the historical wind patterns, although there were more southerly and south-southwesterly winds and fewer southwesterly and west-southwesterly winds. The calm rate was also higher (accounting for nearly 22 percent of observations).

- The sample day wind rose resembles the full-year wind rose but with fewer calm winds and a higher percentage of winds from the south to southwest and west to northwest.

12.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Indiana monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 12-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 12-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. INDEM and WPIN sampled for carbonyl compounds only.

Table 12-4. Risk-Based Screening Results for the Indiana Monitoring Sites

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Gary, Indiana - INDEM						
Formaldehyde	0.077	59	59	100.00	50.43	50.43
Acetaldehyde	0.45	58	59	98.31	49.57	100.00
Total		117	118	99.15		
Indianapolis, Indiana - WPIN						
Acetaldehyde	0.45	58	58	100.00	49.57	49.57
Formaldehyde	0.077	58	58	100.00	49.57	99.15
Propionaldehyde	0.8	1	58	1.72	0.85	100.00
Total		117	174	67.24		

Observations from Table 12-4 include the following:

- Formaldehyde, acetaldehyde, and propionaldehyde are the only carbonyl compounds with risk screening values.

- Acetaldehyde and formaldehyde failed screens for INDEM. Acetaldehyde failed 58 out of 59 screens while formaldehyde failed 100 percent of screens for this site. Both pollutants were identified as pollutants of interest for INDEM.

- All three carbonyl compounds with risk screening values failed screens for WPIN. Acetaldehyde and formaldehyde each failed 100 percent of screens while propionaldehyde failed only one screen. Acetaldehyde and formaldehyde were also identified as pollutants of interest for WPIN.

12.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Indiana monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries are provided in Appendix L.

12.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Indiana site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Indiana monitoring sites are presented in Table 12-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 12-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Indiana Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Gary, Indiana - INDEM						
Acetaldehyde	59/59	1.06 ± 0.16	1.25 ± 0.26	1.44 ± 0.25	1.04 ± 0.29	1.20 ± 0.12
Formaldehyde	59/59	1.82 ± 0.33	3.16 ± 0.87	3.32 ± 0.60	1.66 ± 0.29	2.50 ± 0.33
Indianapolis, Indiana - WPIN						
Acetaldehyde	58/58	1.62 ± 0.57	2.39 ± 0.45	3.17 ± 0.48	1.81 ± 0.32	2.28 ± 0.27
Formaldehyde	58/58	3.07 ± 1.26	5.19 ± 1.21	5.91 ± 0.99	2.73 ± 0.45	4.31 ± 0.61

Observations for the Indiana sites from Table 12-5 include the following:

- For both sites, acetaldehyde and formaldehyde were detected in all of the carbonyl compound samples collected.

- The annual average concentration of formaldehyde is greater than the annual average concentration of acetaldehyde for INDEM. The same is true for WPIN. In both cases, the acetaldehyde averages are almost half the formaldehyde average.

- The annual average concentrations of acetaldehyde and formaldehyde are higher at WPIN than INDEM.

- The second and third quarter average concentrations of formaldehyde are significantly higher than the first and fourth quarter averages for INDEM. This is also true for acetaldehyde, although the differences are not statistically significant. The 13 highest formaldehyde concentrations were measured between May and September at INDEM and ranged from 3.46 µg/m^3 to 6.83 µg/m^3; conversely, the 19 lowest concentrations (those less than 1.70 µg/m^3) were measured between January and April or October and December. This supports the trend identified in Section 4.4.2 where formaldehyde concentrations tended to be higher during the warmer months of the year.

- With the exception of the fourth quarter, the quarterly averages of formaldehyde for WPIN have rather large confidence intervals associated with them. A review of the data shows that the two highest formaldehyde concentrations for WPIN were measured on March 10, 2012 (10.7 µg/m^3) and May 27, 2012 (10.5 µg/m^3). Fifteen additional concentrations of formaldehyde greater than 6 µg/m^3 were measured at WPIN between May and September. Conversely, the 19 lowest concentrations of formaldehyde (those less than 3 µg/m^3) were measured between January and April or October through December, again supporting the seasonal trend discussed in Section 4.4.2.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Indiana sites from those tables include the following:

- WPIN's annual average concentration of formaldehyde is the second highest annual average of this pollutant among NMP sites sampling carbonyl compounds, behind only BTUT. The confidence interval for WPIN's annual average is among the largest shown in Table 4-10, indicating a relatively high level of variability in this site's measurements. Concentrations measured at this site range from 1.62 µg/m^3 to 10.7 µg/m^3, with a median concentration of 3.58 µg/m^3.
- INDEM does not appear in Table 4-10. Its annual average concentration of formaldehyde ranks 17th and its annual average concentration of acetaldehyde ranks 23rd among NMP sites sampling carbonyl compounds.

12.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 12-4 for INDEM and WPIN. Figures 12-11 and 12-12 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 12-11. Program vs. Site-Specific Average Acetaldehyde Concentrations

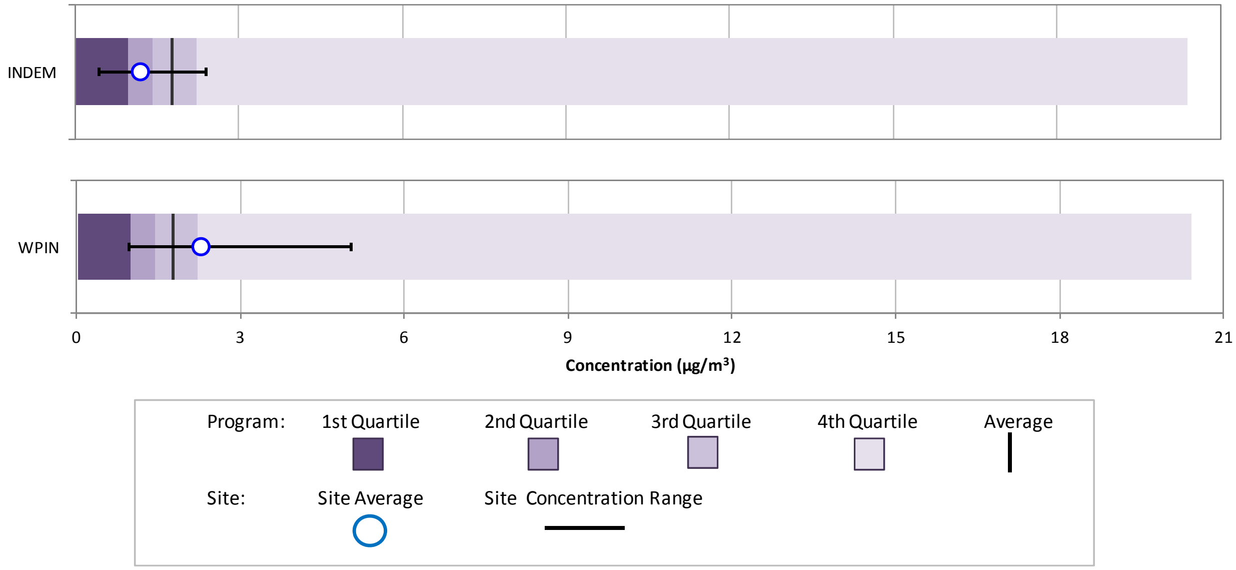
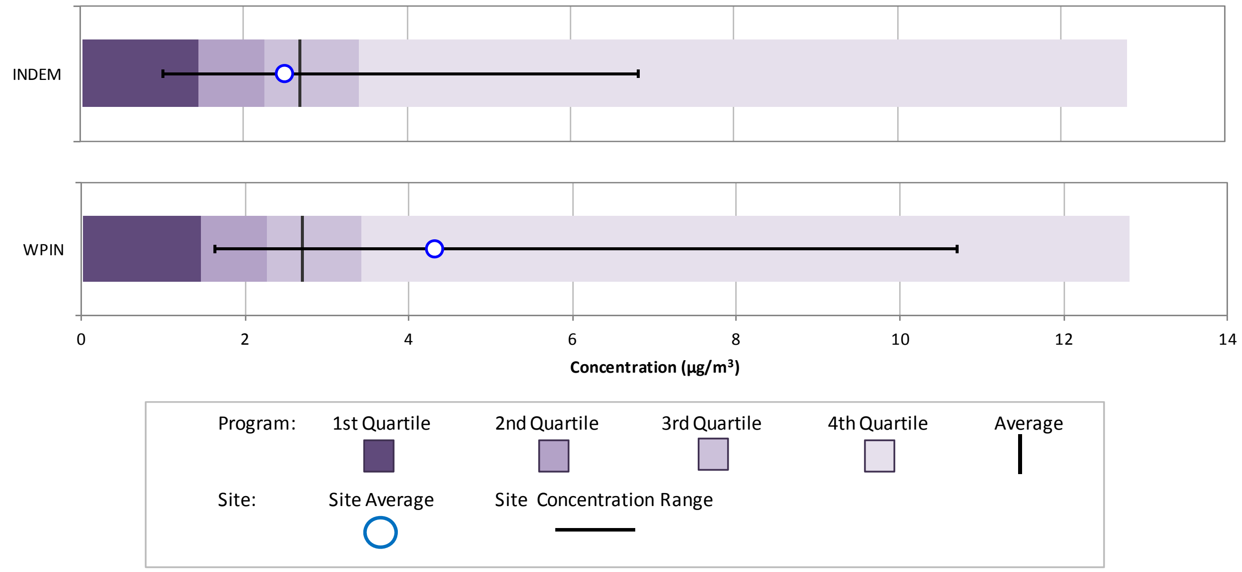


Figure 12-12. Program vs. Site-Specific Average Formaldehyde Concentrations



Observations from Figures 12-11 and 12-12 include the following:

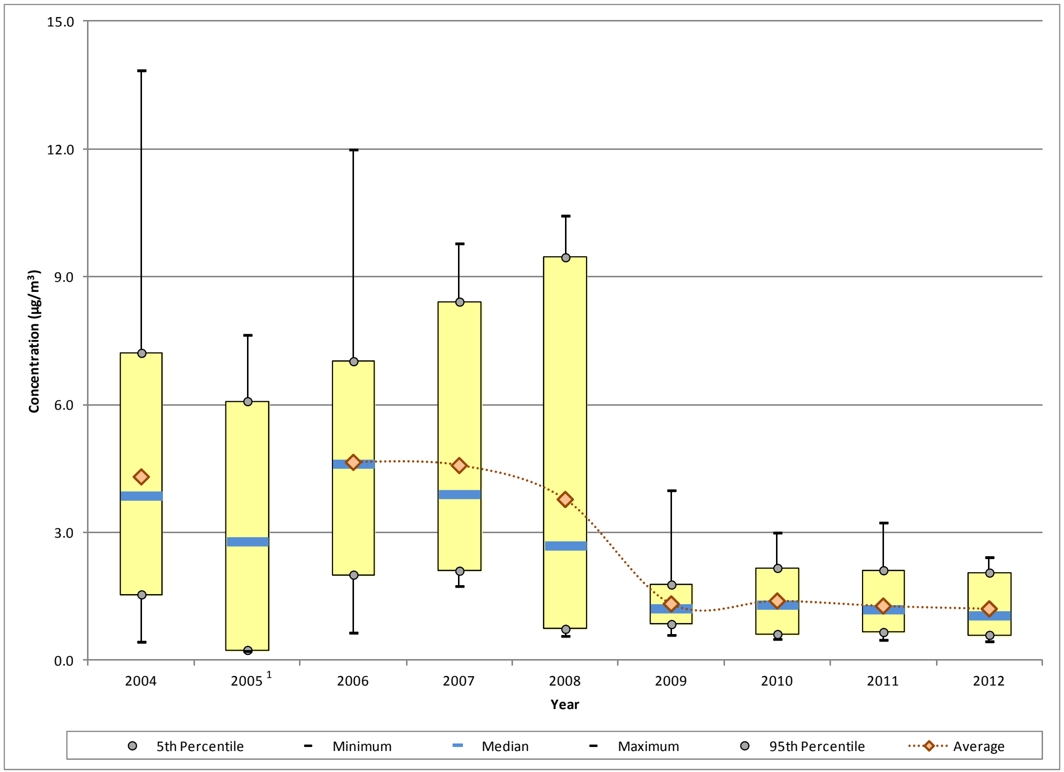
- Figure 12-11 presents the box plots for both sites for acetaldehyde. The box plots show that the annual average concentration for INDEM is less than both the program-level average and median concentrations. The maximum concentration of acetaldehyde measured at INDEM is similar to the annual average concentration for WPIN. WPIN’s annual average is greater than the program-level average and third quartile. The minimum concentration measured at WPIN is similar to the program-level first quartile.

- Figure 12-12 presents the box plots for formaldehyde for both sites. Although the range of concentrations measured at each site is higher for formaldehyde than acetaldehyde, these box plots share similarities with the acetaldehyde box plots. The annual average concentration for INDEM is less than the program-level average while the annual average for WPIN is greater than both the program-level average and third quartile. Although the maximum formaldehyde concentration measured at WPIN is not the maximum concentration measured across the program, it is among the top 10. The minimum formaldehyde concentration measured at WPIN is also greater than the program-level first quartile.

12.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. INDEM and WPIN have sampled carbonyl compounds under the NMP since 2004 and 2007, respectively. Thus, Figures 12-13 through 12-16 present the 1-year statistical metrics for each of the pollutants of interest first for INDEM, then for WPIN. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 12-13. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at INDEM



[1] A 1-year average is not presented due to a break in sampling between September 2005 and November 2005.

Observations from Figure 12-13 for acetaldehyde measurements collected at INDEM include the following:

- Although carbonyl compound sampling under the NMP began in 2003, samples were only collected for three months. Carbonyl compound sampling began in earnest at INDEM at the beginning of 2004; thus, Figure 12-13 begins with 2004. However, a 1-year average is not presented for 2005 due to a break in sampling between September 2005 and November 2005, although the range of measurements is provided.

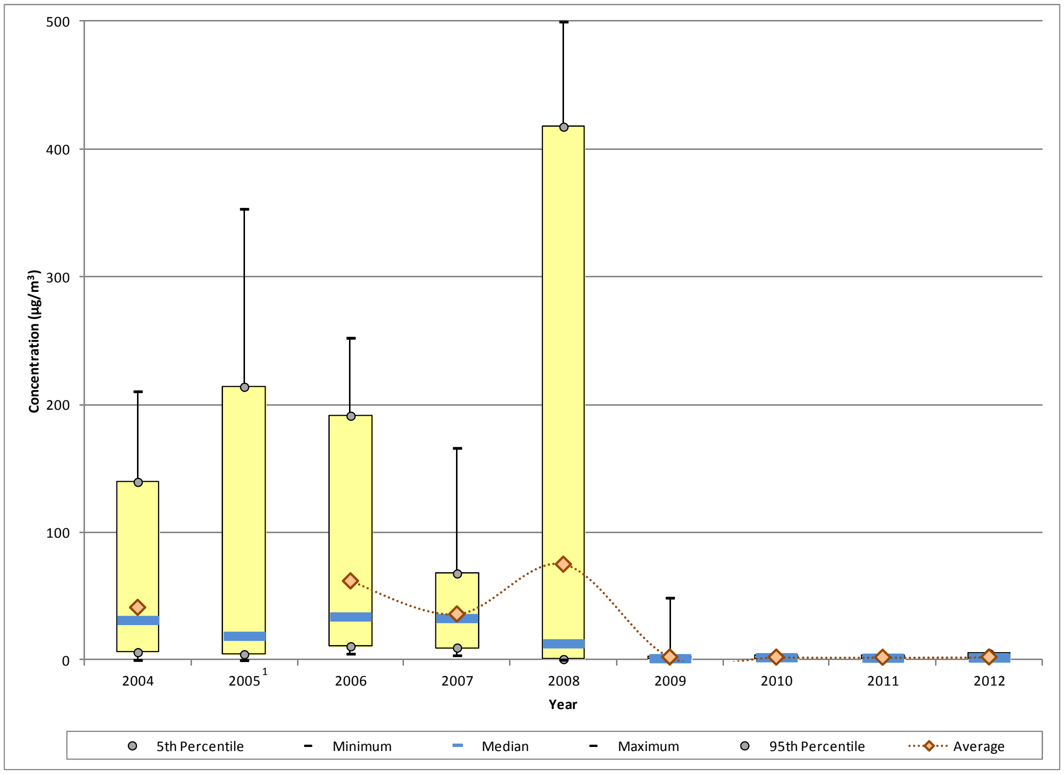
- The maximum acetaldehyde concentration shown (13.8 µg/m^3) was measured at INDEM on June 14, 2004. Four additional concentrations greater than 10 µg/m^3 have been measured at INDEM (one in 2006 and three in 2008).

- Although the maximum and 95th percentile increased from 2007 to 2008, the 1-year average, median, 5th percentile and minimum concentrations of acetaldehyde all exhibit decreases from 2007 to 2008. Although three concentrations greater than

10 µg/m^3 were measured in 2008 (compared to zero in 2007), the number of measurements at the lower end of the concentration range increased significantly. The number of acetaldehyde concentrations less than 1.50 µg/m^3 increased from zero for 2007 to 15 for 2008 and the number of concentrations between 1.50 µg/m^3 and 2 µg/m^3 increased from three to six.

- With the exception of the minimum and 5th percentile, the statistical parameters decreased significantly from 2008 to 2009. The 1-year average and median concentrations decreased by more than half and the 95th percentile decreased by more than 80 percent during this time. The carbonyl compound samplers were switched out in 2009, which seems to have had a significant impact on the concentrations measured, particularly with respect to formaldehyde, which is discussed in more detail below.
- The statistical parameters shown for 2010, 2011, and 2012 are similar in magnitude to each other (although the maximum concentration decreased for 2012). The 1-year averages range from 1.20 µg/m^3 (2012) to 1.39 µg/m^3 (2010) over the period from 2009 to 2012.

Figure 12-14. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at INDEM



1 A 1-year average is not presented due to a break in sampling between September 2005 and November 2005.

Observations from Figure 12-14 for formaldehyde measurements collected at INDEM include the following:

- Five formaldehyde concentrations greater than 400 μg/m^3 were measured in the summer of 2008 (ranging from 414 μg/m^3 to 500 μg/m^3). While these are extremely high values of formaldehyde, concentrations of formaldehyde have been historically high at this site, as shown by the statistics in Figure 12-14. There have been 38 concentrations of formaldehyde greater than 100 μg/m^3 measured at INDEM.

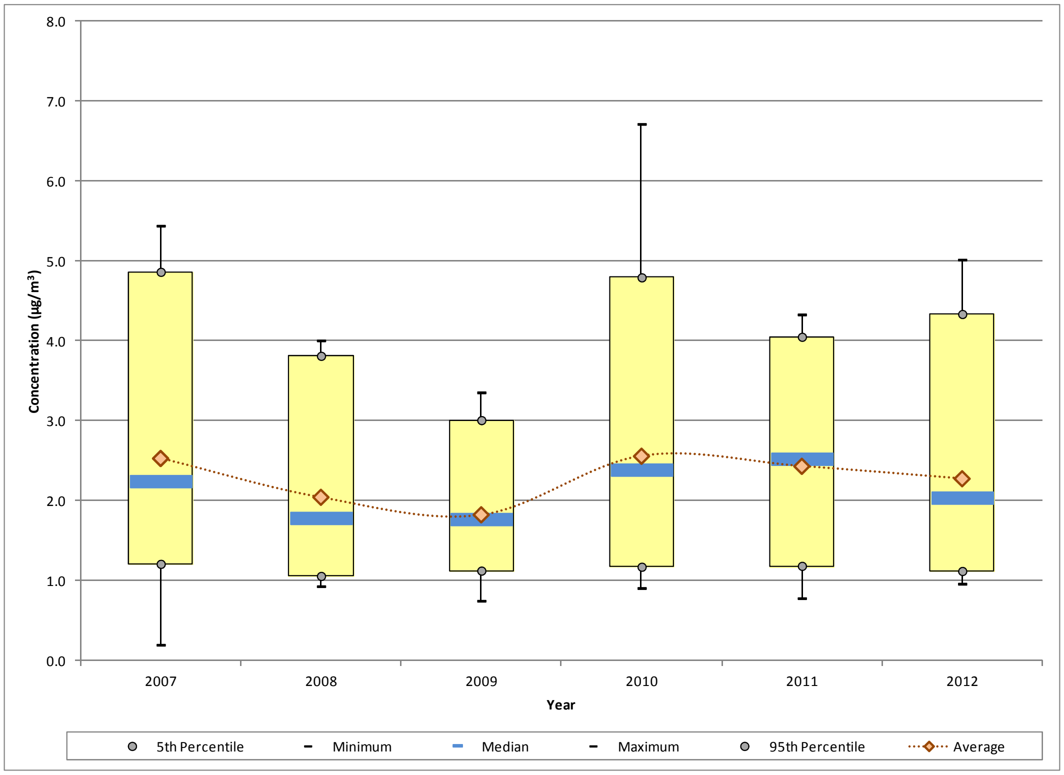
- Prior to 2009, the maximum concentration for each year is greater than 100 μg/m^3. Further, the median concentrations for 2004, 2006, and 2007 are greater than 30 μg/m^3, indicating that at least half of the concentrations were greater than 30 μg/m^3.

- Although the 1-year average concentration doubled from 2007 to 2008, the median concentration decreased by more than half. This means that although the magnitude of the outliers is driving the 1-year average concentration upward, there were a larger number of concentrations at the lower end of the concentration range as well. For 2008, 40 percent of measurements were less than 5 μg/m^3; for the years prior to 2008, the number of measurements less than 5 μg/m^3 ranged from zero (2006) to three (2005).

- All the statistical metrics decreased significantly for 2009 and the years that follow. The 1-year average concentration ranged from 2.30 μg/m^3 (2011) to 2.58 μg/m^3 (2009). In contrast to the previous bullet, the number of measurements greater than 5 μg/m^3 ranged from one to four for each year between 2009 and 2012 (with the most measured in 2012).

- INDEM's formaldehyde concentrations have historically been higher than any other NMP site sampling carbonyl compounds. During the summer PAMS season, which begins on June 1, a state-owned multi-channel collection system was used at INDEM to collect multiple samples per day. At the end of each PAMS season, sample collection goes back to a state-owned single-channel collection system. The multi-channel sampler used at INDEM during the PAMS season was replaced in 2009 and their formaldehyde concentrations decreased substantially (as did their acetaldehyde concentrations, but the difference is less dramatic). Given that the elevated concentrations of formaldehyde were typically measured during the summer, this sampler change could account for the differences in the concentrations for 2009-2012 compared to previous years. Thus, the elevated concentrations from previous years were likely related to the multi-channel collection equipment and may not reflect the actual levels in ambient air. However, concentrations in the earlier years of sampling must have still been higher based on the number of concentrations greater than 5 μg/m^3 before and after 2009, as discussed in the previous bullets.

Figure 12-15. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at WPIN



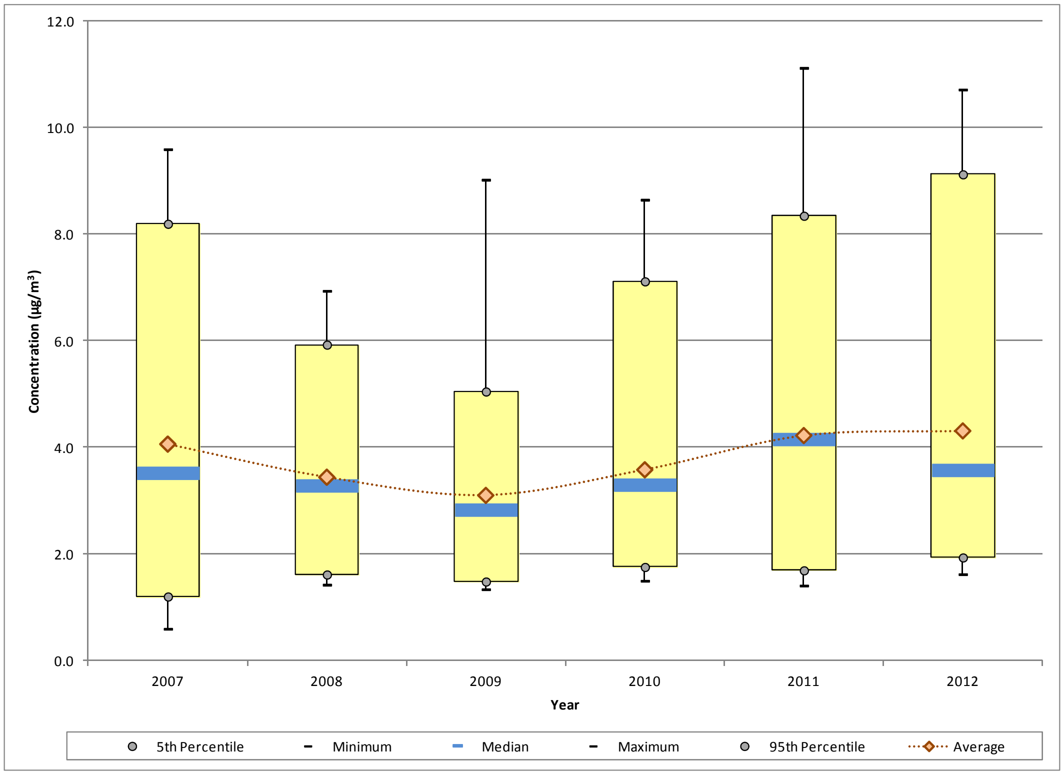
Observations from Figure 12-15 for acetaldehyde measurements collected at WPIN include the following:

- Although carbonyl compound sampling under the NMP began in 2006, samples were collected intermittently. Carbonyl compound sampling began in earnest at WPIN at the beginning of 2007; thus, Figure 12-15 begins with 2007.

- The three highest acetaldehyde concentrations were measured at WPIN in 2010 and ranged from 5.96 µg/m^3 to 6.72 µg/m^3. Three additional concentrations greater than 5 µg/m^3 have been measured at WPIN (two in 2007 and one in 2012).

- The 1-year average concentration has a decreasing trend through 2009, after which a significant increase is shown. For 2010, all of the statistical parameters increased, particularly the maximum (which doubled) and the 95th percentile (which increased by 60 percent). The 1-year average has a slight decreasing trend again after 2010.

Figure 12-16. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at WPIN



Observations from Figure 12-16 for formaldehyde measurements collected at WPIN include the following:

- The maximum concentration of formaldehyde measured at WPIN was measured in 2011 (11.1 µg/m^3). The next three highest concentrations were measured at WPIN in 2012 and ranged from 9.87 µg/m^3 to 10.7 µg/m^3.

- The 1-year average concentration has a decreasing trend through 2009, similar to acetaldehyde, after which an increasing trend is shown through 2011. Although the 95th percentile increased for 2012 and the 1-year average did not change significantly, the median concentration decreased. A review of the data for 2011 and 2012 shows that the number of concentrations in the 3 µg/m^3 to 4 µg/m^3 range doubled from 2011 to 2012 (from seven to 15); in addition, the number of concentrations in the 4 µg/m^3 to 6 µg/m^3 range decreased by nearly half (from 20 to 11). These changes explain the change in the median concentration while a few additional measurements in the upper end of the concentration range explain the increase in the 95th percentile.

12.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each Indiana monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

12.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Indiana monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

12.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Indiana sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 12-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 12-6. Risk Approximations for the Indiana Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Gary, Indiana - INDEM						
Acetaldehyde	0.0000022	0.009	59/59	1.20 ± 0.12	2.65	0.13
Formaldehyde	0.000013	0.0098	59/59	2.50 ± 0.33	32.55	0.26
Indianapolis, Indiana - WPIN						
Acetaldehyde	0.0000022	0.009	58/58	2.28 ± 0.27	5.01	0.25
Formaldehyde	0.000013	0.0098	58/58	4.31 ± 0.61	56.06	0.44

Observations for the Indiana sites from Table 12-6 include the following:

- For both sites, the annual average concentration of formaldehyde is greater than the annual average concentration of acetaldehyde. The annual averages for WPIN are greater than the annual averages for INDEM.

- The cancer risk approximation for formaldehyde is an order of magnitude higher than the cancer risk approximation for acetaldehyde for both sites. The cancer risk approximations for WPIN are nearly twice the cancer risk approximations for INDEM.

- The cancer risk approximation for formaldehyde for WPIN is the second highest cancer risk approximation among all pollutants of interest program-wide.

- Neither pollutant of interest for INDEM or WPIN have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. The noncancer hazard approximation for WPIN ranks seventh highest among all pollutants of interest program-wide.

12.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 12-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 12-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 12-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 12-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 12-7. Table 12-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site’s annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 12.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 12-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the three highest emitted pollutants with cancer UREs in both Marion and Lake County, although the quantity emitted is roughly twice as high in Marion County.

- Coke oven emissions, formaldehyde, and POM, Group 1b are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Lake County. Formaldehyde, benzene, and hexavalent chromium are the pollutants with the highest toxicity-weighted emissions for Marion County.

- Seven of the highest emitted pollutants in Lake County also have the highest toxicity-weighted emissions; six of the highest emitted pollutants in Marion County also have the highest toxicity-weighted emissions.

- Acetaldehyde and formaldehyde are the only pollutants of interest for INDEM and WPIN. Acetaldehyde and formaldehyde appear among the highest emitted pollutants for both counties, with only formaldehyde appearing among the pollutants with the highest toxicity-weighted emissions.

- While several metals (arsenic, nickel, and hexavalent chromium) are among the pollutants with the highest toxicity-weighted emissions for both counties, none of these are among the highest emitted pollutants for either county. This demonstrates that a pollutant does not have to be emitted in large quantities to be toxic.

- Several POM Groups and naphthalene appear among the highest emitted pollutants and the pollutants with the highest toxicity-weighted emissions for both counties. Neither site sampled PAHs.

Table 12-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Indiana Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Gary, Indiana (Lake County) - INDEM					
Benzene	153.11	Coke Oven Emissions, PM	2.38E-03	Formaldehyde	32.55
Formaldehyde	135.29	Formaldehyde	1.76E-03	Acetaldehyde	2.65
Ethylbenzene	81.19	POM, Group 1b	1.20E-03		
Acetaldehyde	73.26	Benzene	1.19E-03		
1,3-Butadiene	23.02	Hexavalent Chromium, PM	1.02E-03		
POM, Group 1b	21.84	1,3-Butadiene	6.91E-04		
Naphthalene	12.14	Arsenic, PM	6.55E-04		
Coke Oven Emissions, PM	2.41	Naphthalene	4.13E-04		
POM, Group 2d	2.39	Nickel, PM	2.50E-04		
POM, Group 2b	2.02	POM, Group 2d	2.10E-04		
Indianapolis, Indiana (Marion County) - WPIN					
Benzene	364.14	Formaldehyde	3.99E-03	Formaldehyde	56.06
Formaldehyde	306.72	Benzene	2.84E-03	Acetaldehyde	5.01
Ethylbenzene	235.70	Hexavalent Chromium, PM	2.41E-03		
Acetaldehyde	177.27	1,3-Butadiene	1.71E-03		
1,3-Butadiene	56.98	Naphthalene	1.11E-03		
Naphthalene	32.73	Arsenic, PM	1.10E-03		
Tetrachloroethylene	16.40	Ethylbenzene	5.89E-04		
POM, Group 2b	5.64	POM, Group 2b	4.97E-04		
Propylene oxide	4.72	Nickel, PM	4.60E-04		
Trichloroethylene	4.71	POM, Group 3	4.09E-04		

Table 12-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Indiana Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Gary, Indiana (Lake County) - INDEM					
Toluene	1,162.14	Acrolein	412,327.83	Formaldehyde	0.26
Ethylene glycol	610.79	Manganese, PM	134,984.66	Acetaldehyde	0.13
Hexane	421.01	Lead, PM	52,706.82		
Xylenes	390.84	Hydrochloric acid	16,187.23		
Methanol	327.88	Formaldehyde	13,805.18		
Hydrochloric acid	323.74	1,3-Butadiene	11,511.05		
Benzene	153.11	Chlorine	11,183.33		
Formaldehyde	135.29	Arsenic, PM	10,154.19		
Ethylbenzene	81.19	Acetaldehyde	8,139.87		
Acetaldehyde	73.26	Nickel, PM	5,794.59		
Indianapolis, Indiana (Marion County) - WPIN					
Toluene	2,485.16	Acrolein	1,142,806.73	Formaldehyde	0.44
Ethylene glycol	1,135.51	Formaldehyde	31,298.11	Acetaldehyde	0.25
Xylenes	889.12	1,3-Butadiene	28,488.29		
Hexane	741.29	Hydrochloric acid	23,337.36		
Methanol	532.81	Acetaldehyde	19,697.08		
Hydrochloric acid	466.75	Arsenic, PM	17,076.36		
Benzene	364.14	Lead, PM	13,691.58		
Formaldehyde	306.72	Benzene	12,138.08		
Ethylbenzene	235.70	Naphthalene	10,908.60		
Acetaldehyde	177.27	Nickel, PM	10,648.54		

Observations from Table 12-8 include the following:

- While toluene is the highest emitted pollutant with a noncancer RfC in both counties, the toluene emissions in Marion County are more than twice that of Lake County. Ethylene glycol is the second highest emitted pollutant in both counties, with a similar pattern in the quantity emitted.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties. Manganese and lead rank second and third for Lake County, while formaldehyde and 1,3-butadiene rank second and third for Marion County.

- Only three of the highest emitted pollutants in Lake County also have the highest toxicity-weighted emissions (formaldehyde, acetaldehyde, and hydrochloric acid). Several metals (manganese, lead, nickel, and arsenic) are among the pollutants with the highest toxicity-weighted emissions for Lake County, although none of these appear among the highest emitted pollutants.

- Four of the highest emitted pollutants in Marion County also have the highest toxicity-weighted emissions (formaldehyde, acetaldehyde, hydrochloric acid, and benzene). Nickel, lead, and arsenic are also among the pollutants with the highest toxicity-weighted emissions for Marion County, although none of these appear among the highest emitted pollutants.

12.6 Summary of the 2012 Monitoring Data for INDEM and WPIN

Results from several of the data treatments described in this section include the following:

- *Two carbonyl compounds failed screens for INDEM and three failed screens for WPIN.*

- *The annual average concentration of formaldehyde is greater than the annual average concentration of acetaldehyde for both sites, with the annual averages for WPIN nearly twice the annual averages for INDEM.*

- *Concentrations of formaldehyde and acetaldehyde exhibited a significant decreasing trend at INDEM from 2008 to 2009, after which concentrations appear to be holding steady. These changes may be explained by a sampler change out.*

13.0 Sites in Kentucky

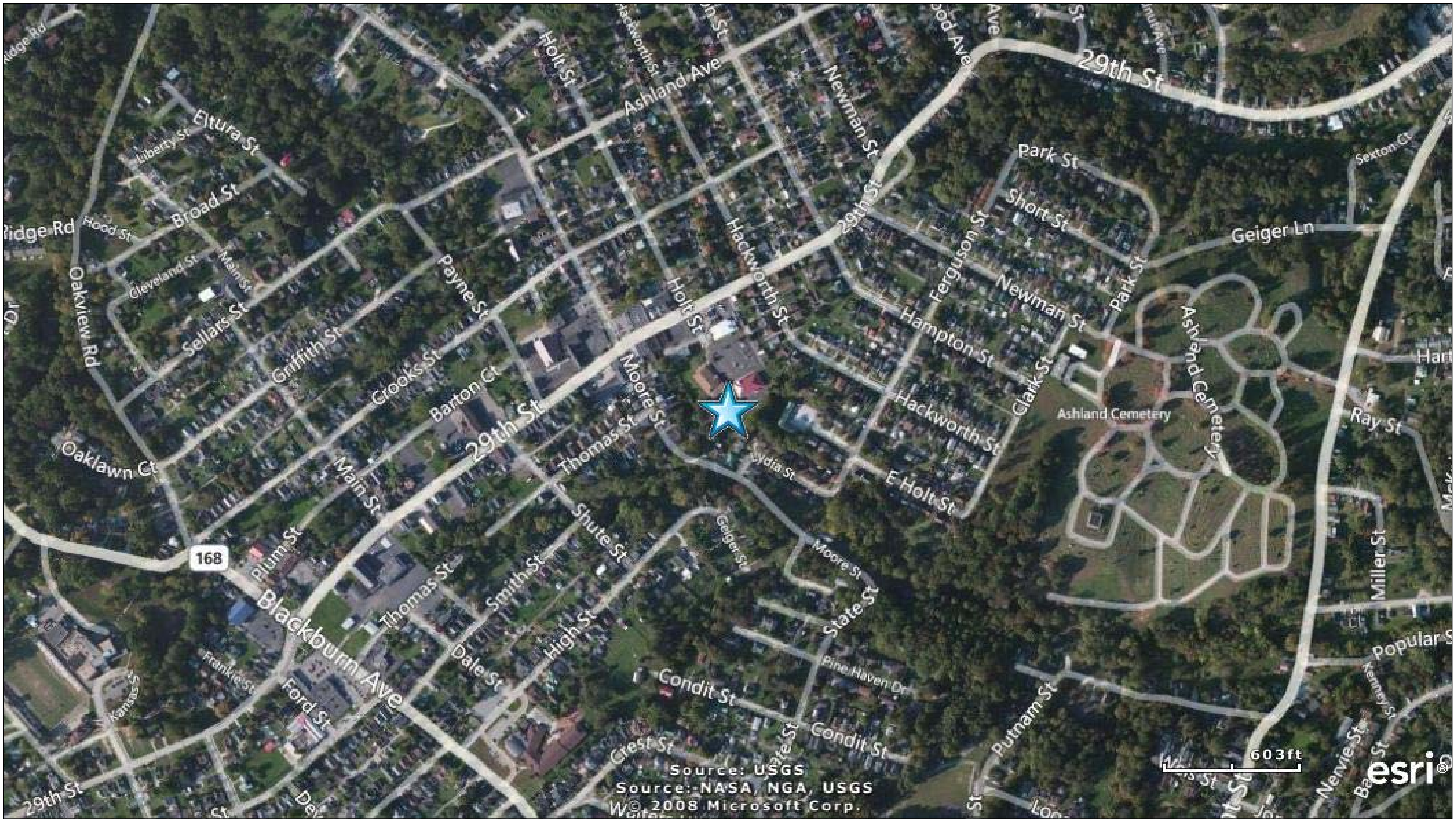
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Kentucky, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

13.1 Site Characterization

This section characterizes the Kentucky monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

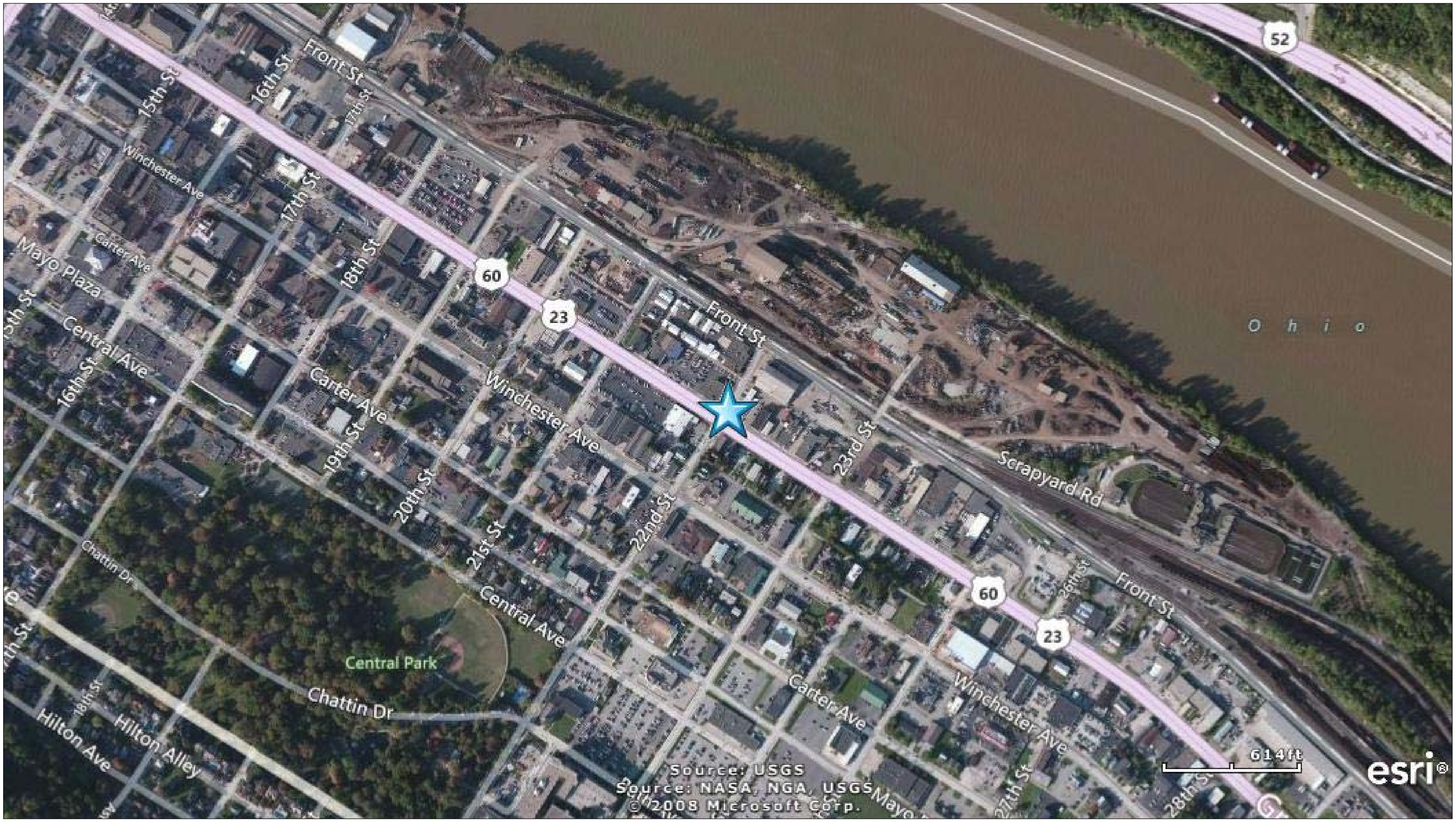
Data from 10 monitoring sites in Kentucky are included in this section. Three monitoring sites are located in northeast Kentucky, two in Ashland and one near Grayson Lake. One monitoring site is located south of Evansville, Indiana. Five monitoring sites are located in or near the Calvert City area. The final monitoring site is located in Lexington, in north-central Kentucky. A composite satellite image and facility map is provided for each site in Figures 13-1 through 13-15. The composite satellite images were retrieved from ArcGIS Explorer and show each monitoring site in its respective location. The facility maps identify nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of each site are included in the facility counts provided. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at each monitoring site. Further, this boundary provides both the proximity of emissions sources to each monitoring site as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radius are still visible on the maps, but have been grayed out in order to show emissions sources just outside the boundary. Table 13-1 provides supplemental geographical information such as land use, location setting, and locational coordinates for each site.

Figure 13-1. Ashland, Kentucky (ASKY) Monitoring Site



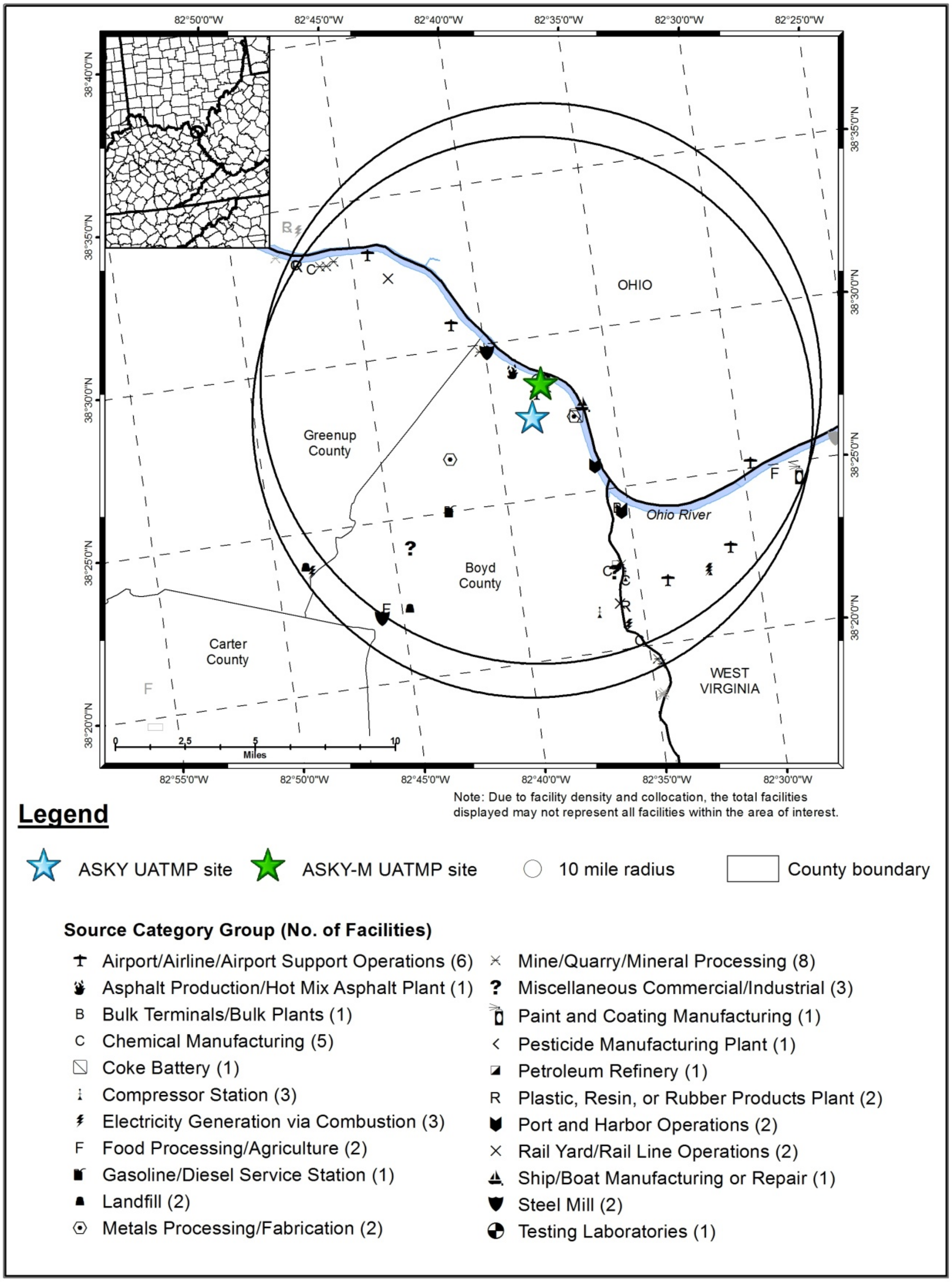
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 13-2. Ashland, Kentucky (ASKY-M) Monitoring Site



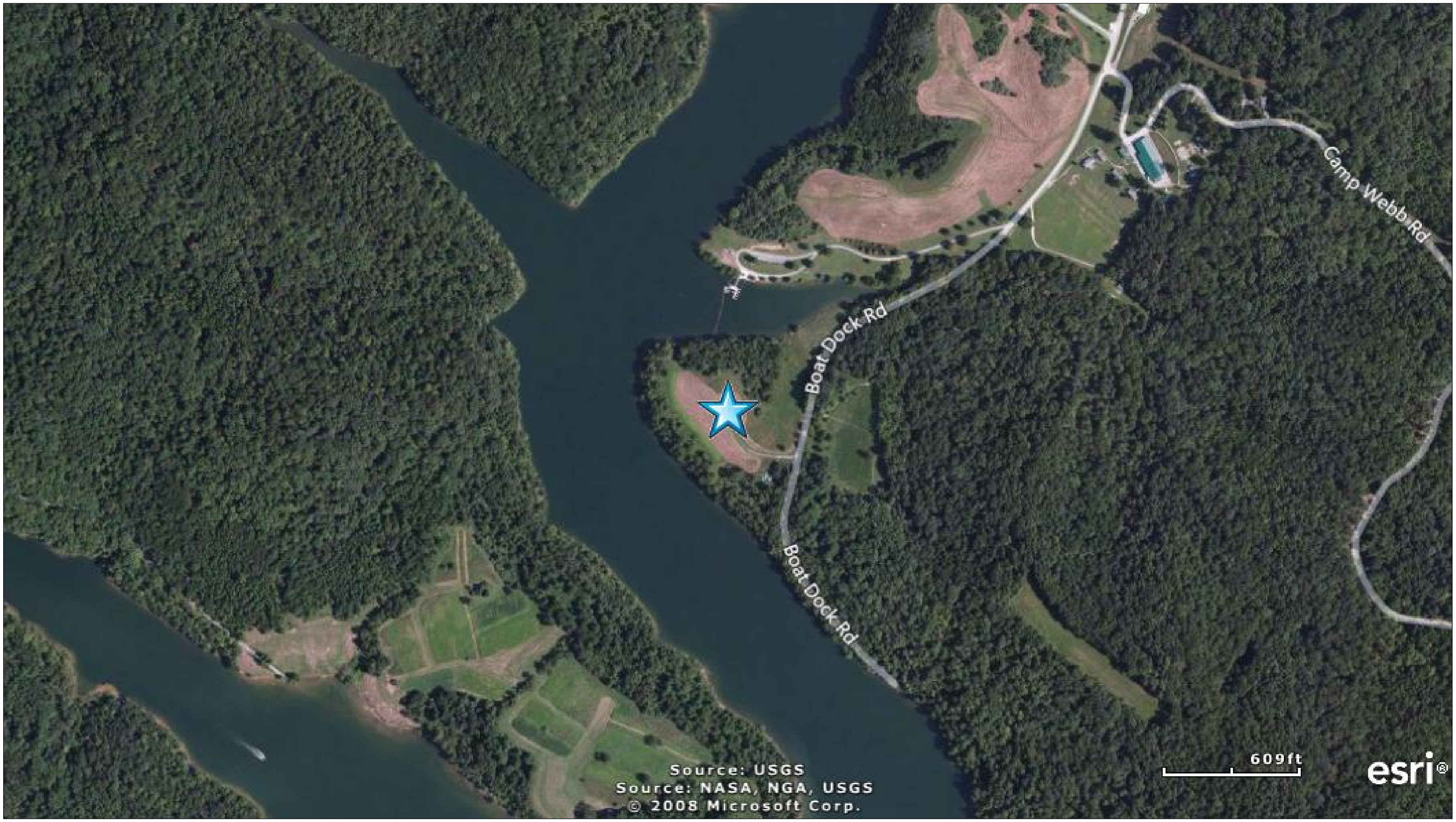
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 13-3. NEI Point Sources Located Within 10 Miles of ASKY and ASKY-M



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 13-4. Grayson, Kentucky (GLKY) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 13-5. NEI Point Sources Located Within 10 Miles of GLKY

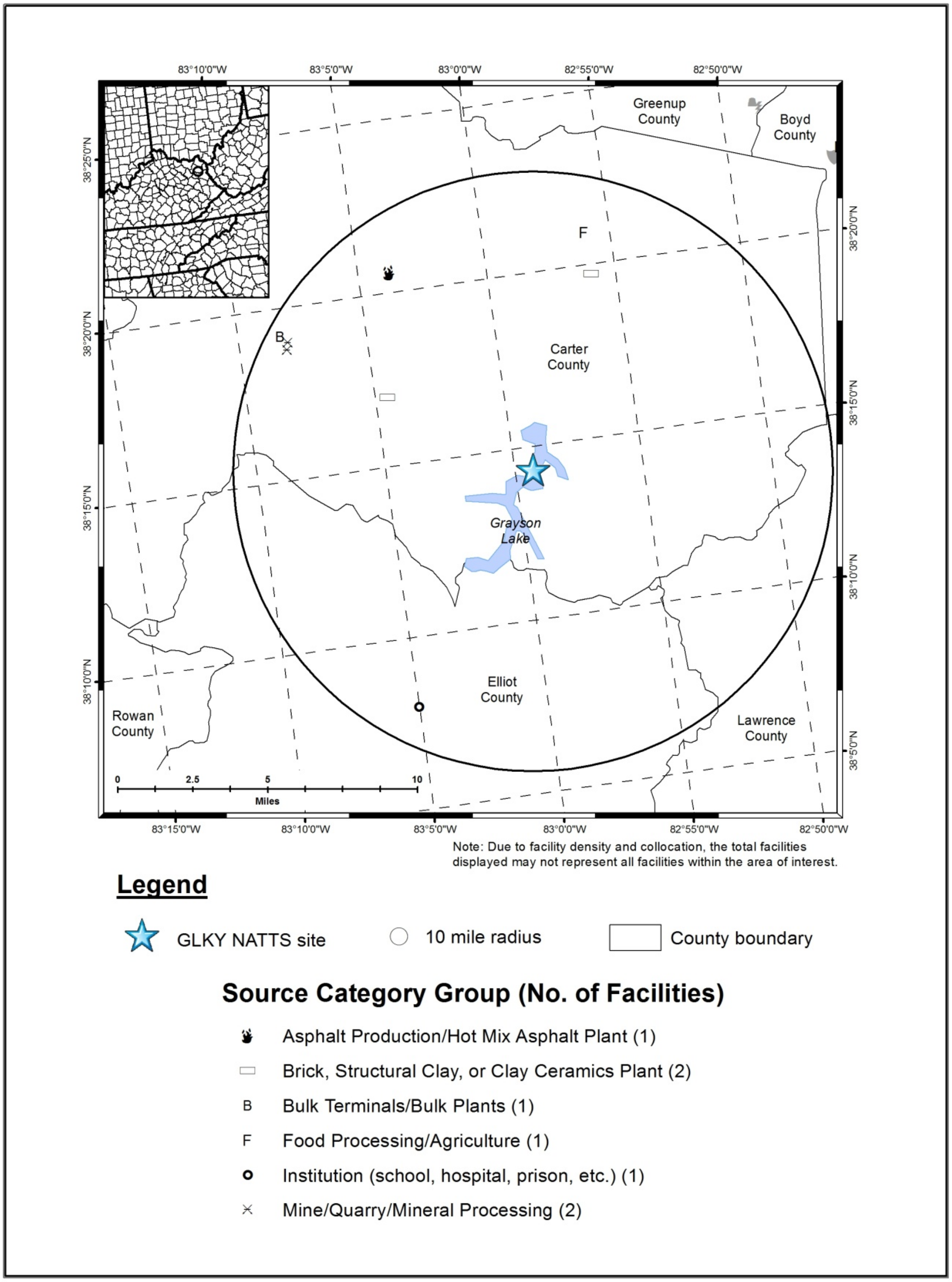
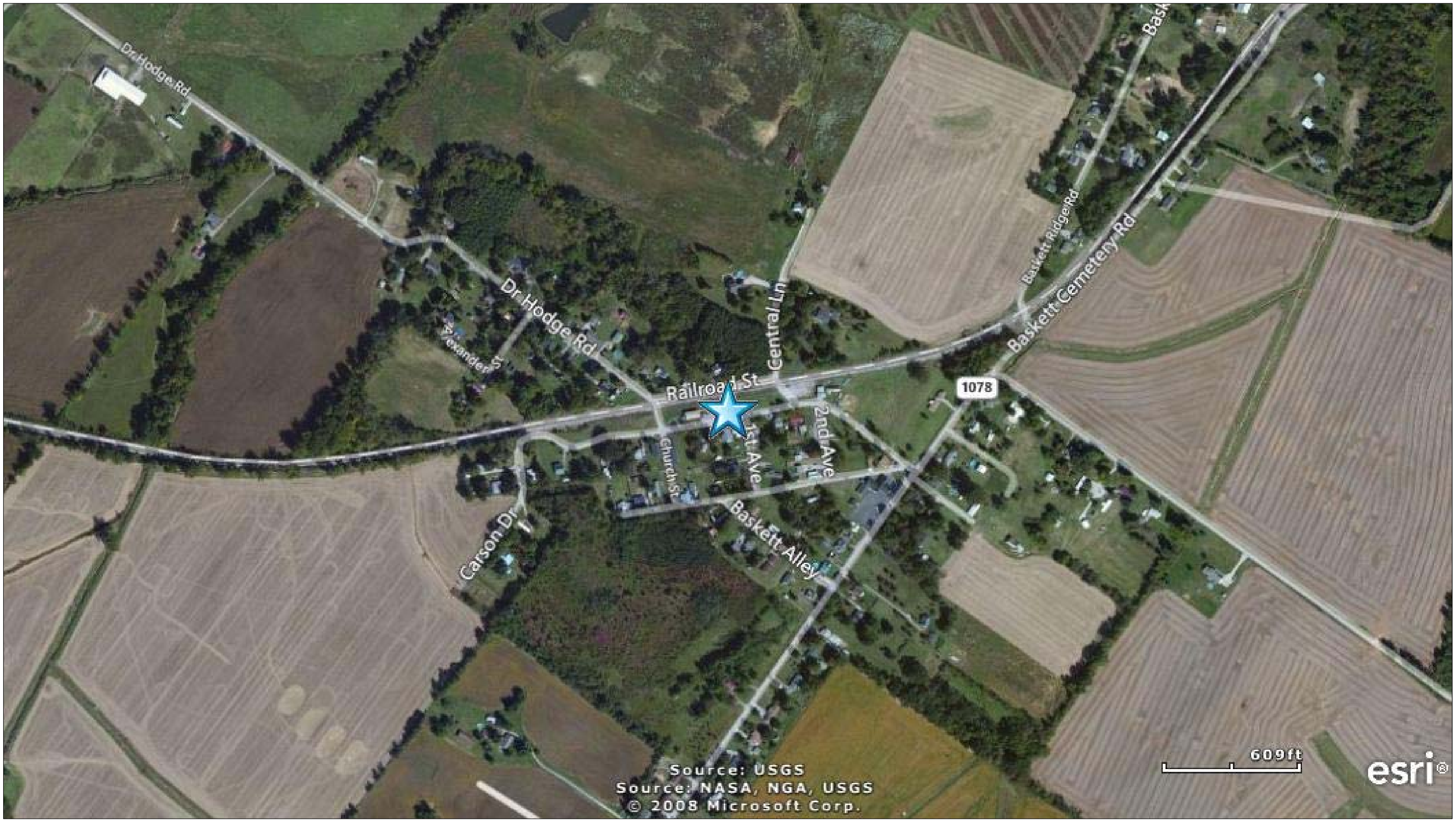


Figure 13-6. Baskett, Kentucky (BAKY) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 13-7. NEI Point Sources Located Within 10 Miles of BAKY

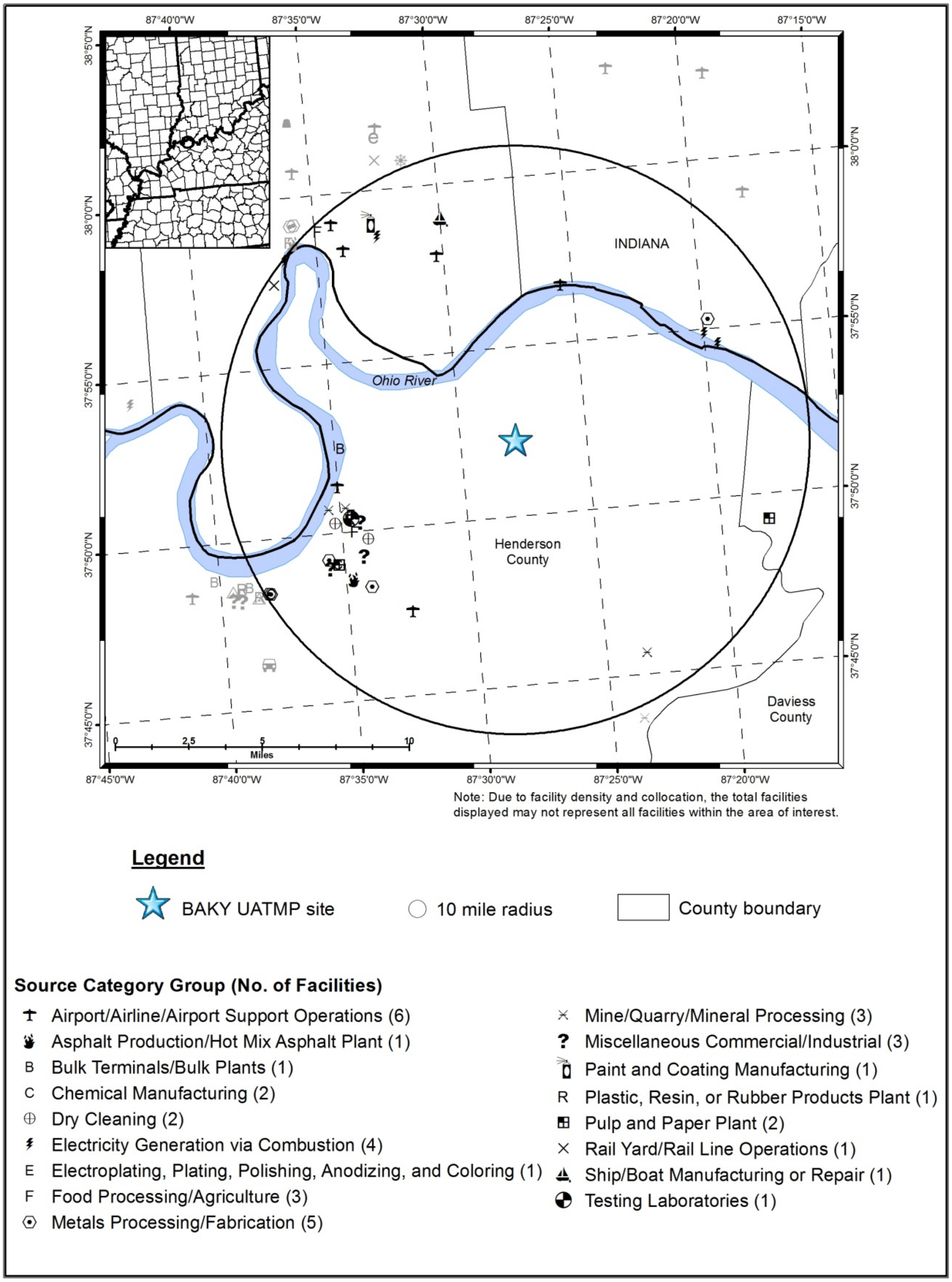

Figure 13-8. Calvert City, Kentucky (ATKY) Monitoring Site

Source: USGS
Source: NASA, NGA, USGS
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Figure 13-9. Smithland, Kentucky (BLKY) Monitoring Site

Source: USGS
Source: NASA, NGA, USGS
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Figure 13-10. Calvert City, Kentucky (CCKY) Monitoring Site

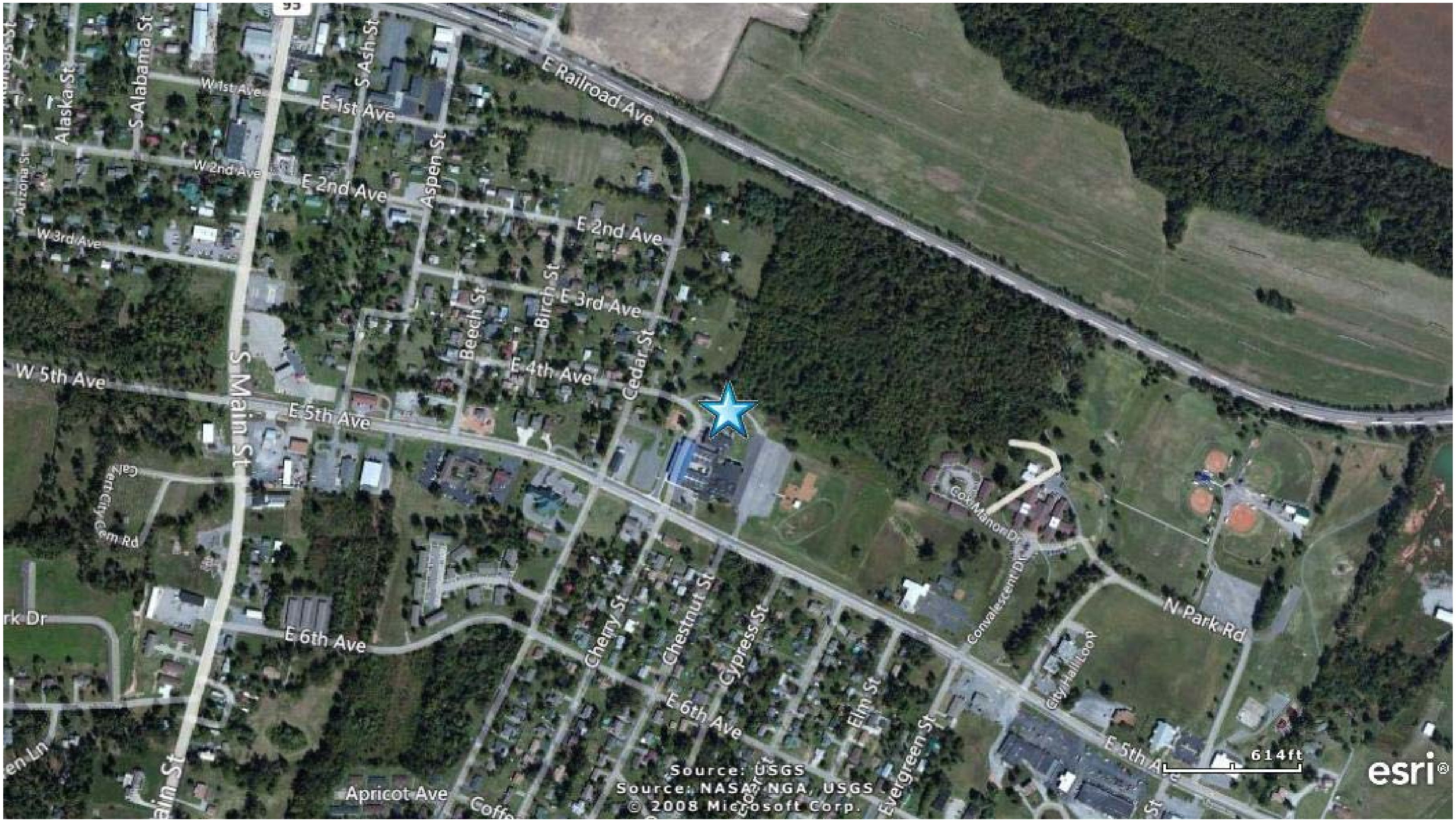

Figure 13-11. Calvert City, Kentucky (LAKY) Monitoring Site

Source: USGS
Source: NASA, NGA, USGS
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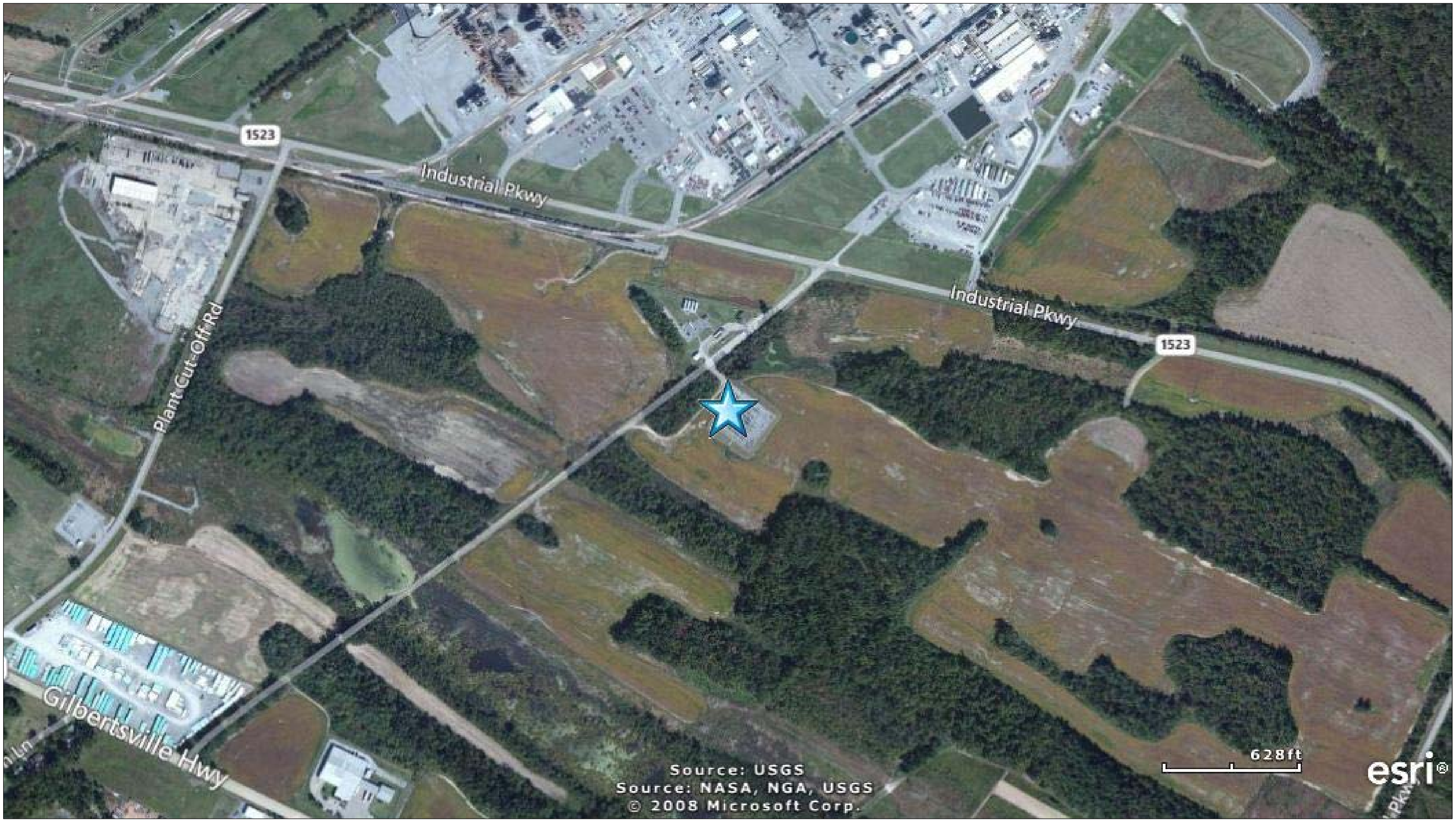
Figure 13-12. Calvert City, Kentucky (TVKY) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 13-13. NEI Point Sources Located Within 10 Miles of ATKY, BLKY, CCKY, LAKY, and TVKY

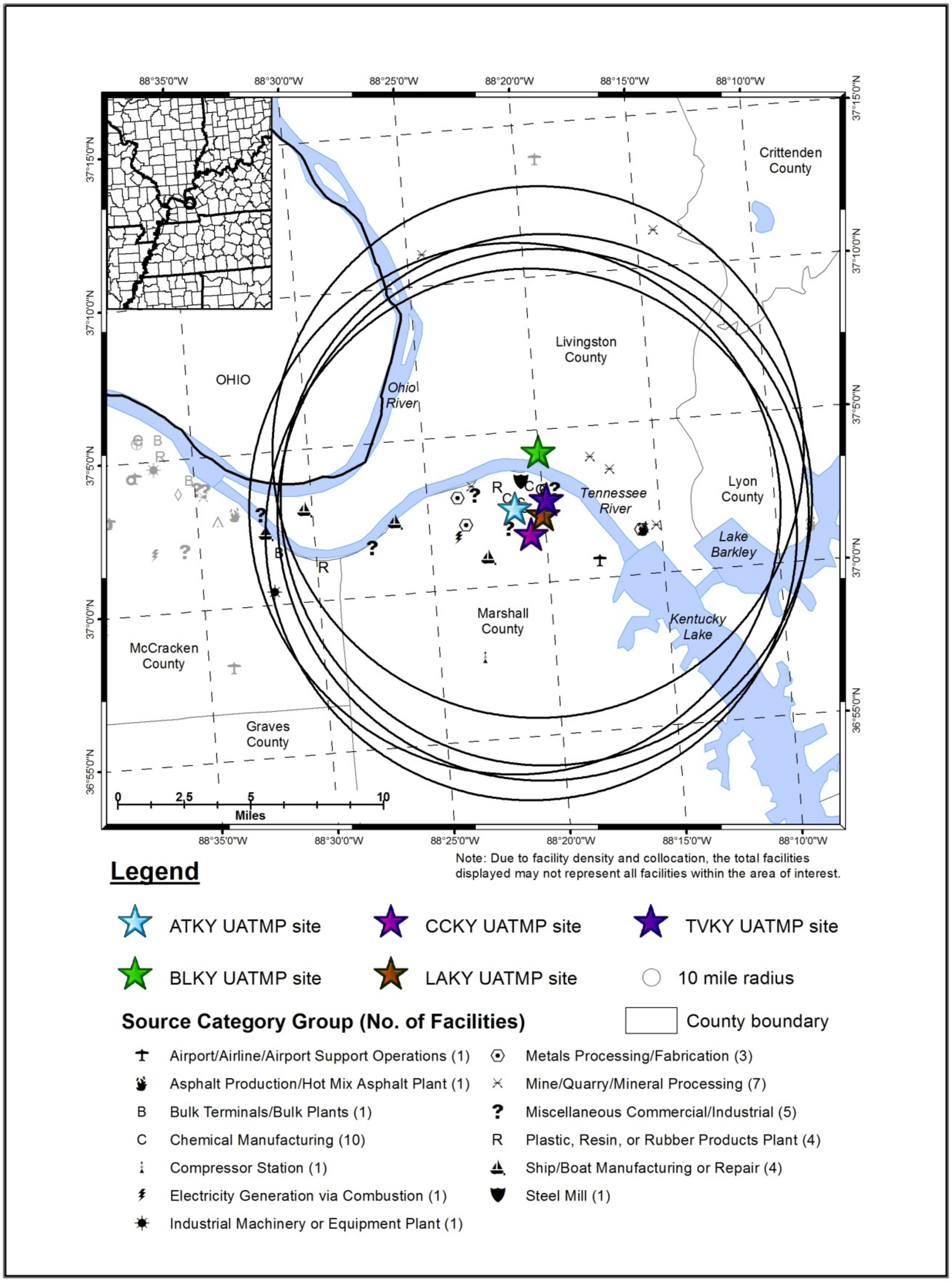
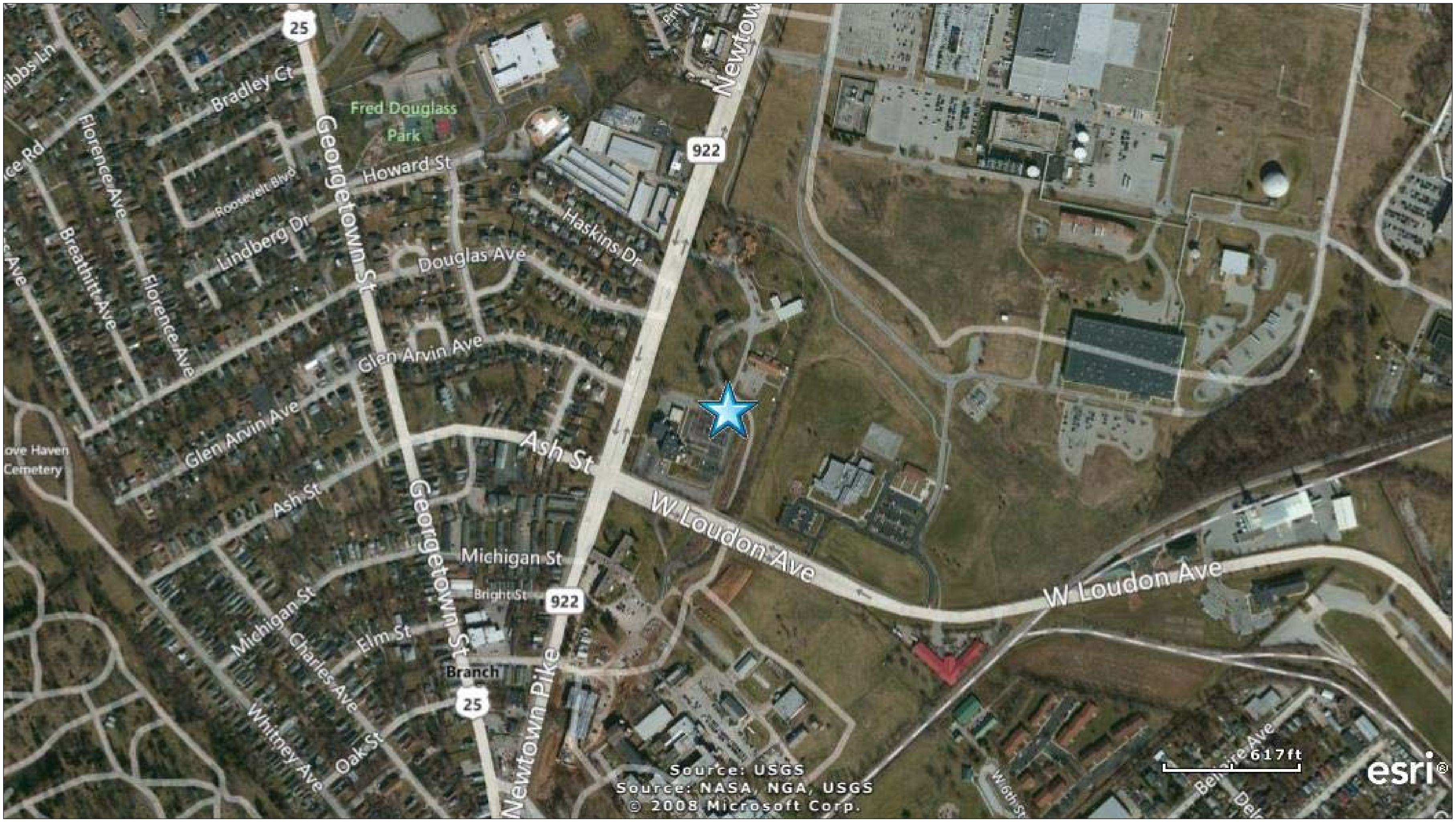


Figure 13-14. Lexington, Kentucky (LEKY) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 13-15. NEI Point Sources Located Within 10 Miles of LEKY

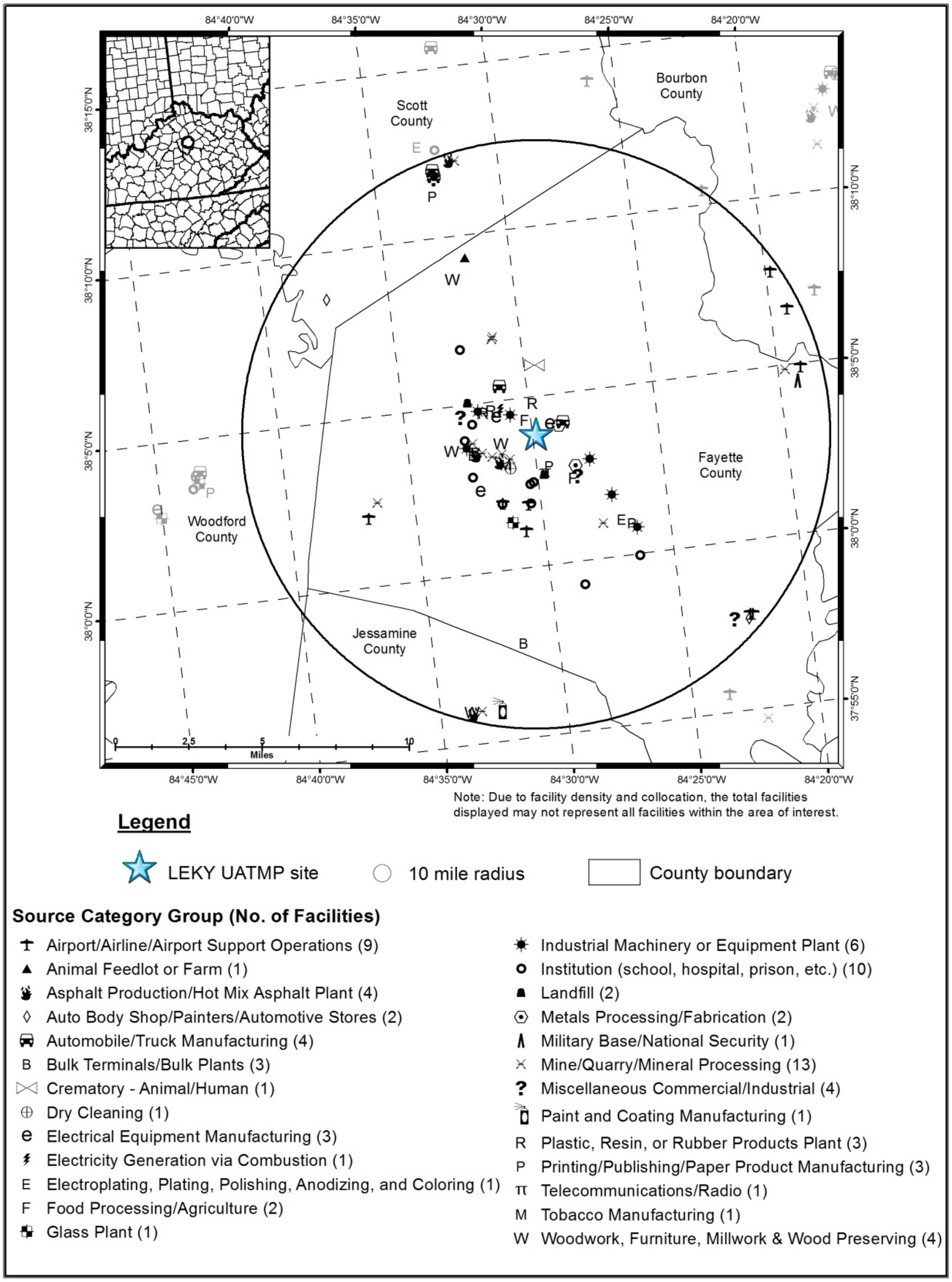


Table 13-1. Geographical Information for the Kentucky Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
ASKY	21-019-0017	Ashland	Boyd	Huntington-Ashland, WV-KY-OH	38.45934, -82.64041	Residential	Suburban	SO_2, NO, NO_2, O_3, Meteorological parameters, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
ASKY-M	21-019-0002	Ashland	Boyd	Huntington-Ashland, WV-KY-OH	38.476, -82.63137	Industrial	Urban/City Center	PM_{10}.
GLKY	21-043-0500	Grayson	Carter	Not in an MSA	38.23887, -82.9881	Residential	Rural	O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, and $PM_{2.5}$ Speciation, IMPROVE Speciation.
BAKY	21-101-0014	Baskett	Henderson	Evansville, IN-KY	37.8712, -87.46375	Commercial	Rural	SO_2, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$.
ATKY	21-157-0016	Calvert City	Marshall	Not in an MSA	37.04176, -88.35407	Industrial	Suburban	None.
BLKY	21-139-0004	Smithland	Livingston	Paducah, KY-IL	37.07151, -88.33389	Agricultural	Rural	Meteorological parameters.
CCKY	21-157-0018	Calvert City	Marshall	Not in an MSA	37.02702, -88.34387	Residential	Suburban	Meteorological parameters, PM_{10}.
LAKY	21-157-0019	Calvert City	Marshall	Not in an MSA	37.03718, -88.33411	Residential	Suburban	None.
TVKY	21-157-0014	Calvert City	Marshall	Not in an MSA	37.0452, -88.33087	Industrial	Suburban	None.
LEKY	21-067-0012	Lexington	Fayette	Lexington-Fayette, KY	38.06503, -84.49761	Residential	Suburban	SO_2, NO, NO_2, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

There are two Kentucky monitoring sites in the town of Ashland. Ashland is located on the Ohio River, just north of where the borders of Kentucky, West Virginia, and Ohio meet, and is part of the Huntington-Ashland, WV-KY-OH MSA. The ASKY site is located behind the county health department which is nestled in a residential area in the center of town, as shown in Figure 13-1. The ASKY-M site is located on the roof of an oil company complex in the northern part of Ashland, which is more industrial. The monitoring site is located less than one-quarter mile from the Ohio River, and between the two lie a rail yard, a scrap yard, and other industries, as shown in Figure 13-2. The ASKY-M monitoring site is located on Greenup Road (Route 60/23), a major thoroughfare through downtown Ashland.

Figure 13-3 shows that ASKY and ASKY-M are approximately 1.25 miles apart. Most of the emissions sources near these sites are located along the Ohio River and its tributary to the south, the Big Sandy River. These emissions sources are involved in a variety of industries including asphalt production, chemical manufacturing, food processing, metals processing/fabrication, pesticide manufacturing, petroleum refining, and ship/boat manufacturing. A cluster of emissions sources are located very close to ASKY-M, such that the symbol for the site hides the symbols for the facilities. This cluster includes a testing laboratory, a miscellaneous commercial/industrial facility, a mine/quarry, a heliport at a hospital, and an asphalt production plant. There are no emissions sources within 1 mile of ASKY. The closest sources to ASKY are the same ones under the symbol for ASKY-M, although a metals processing/fabrication facility and coke battery are located a little farther to the east of ASKY.

Grayson Lake is located in northeast Kentucky, south of the town of Grayson, and southwest of the Huntington-Ashland, WV-KY-OH MSA. The Little Sandy River feeds into Grayson Lake, which is a U.S. Army Corps of Engineers-managed project, and part of the Kentucky State Parks system. The lake is narrow and winding, with sandstone cliffs rising to up to 200 feet above the lake surface (KY, 2014; ACE, 2014). The closest road to the monitoring site is a service road feeding into Camp Grayson, as shown in Figure 13-4. This site serves as the Grayson Lake NATTS site. Figure 13-5 shows that few point sources surround GLKY and that most of them are on the outer periphery of the 10-mile radius around GLKY. This is not surprising given the rural nature of the area and that Grayson Lake is located roughly in the center of the 10-mile radius in Figure 13-5. Sources within 10 miles of GLKY are involved in asphalt production, brick/structural clay/clay ceramics manufacturing, food processing, and mining, among others.

The BAKY monitoring site is located at the Baskett Fire Department in Baskett, a small rural town in northwest Kentucky. Baskett is northeast of Henderson and south of Evansville, Indiana. The Ohio River is the border between Kentucky and Indiana and meanders through the area, with the Green River, a tributary of the Ohio River, just over 1 mile north of the site at the closest point. The fire department property backs up to a railroad that runs through town. Open fields surround the town, as shown in Figure 13-6, and there are no emissions sources within a few miles of BAKY, as shown in Figure 13-7. The cluster of emissions sources to the southwest of BAKY are located in or near Henderson, while the sources to the northwest are located in Evansville.

There are five monitoring sites in and around the Calvert City area. Calvert City is located on the Tennessee River, east of the Paducah metro area, approximately 6 miles southeast of the Ohio River and the Kentucky/Illinois border. The northern half of the city is highly industrialized while the southern half is primarily residential, with a railroad that transverses the area acting as a geographical boundary. The city is home to some 17 industrial plants, including metal, steel, and chemical plants (Calvert City, 2014).

The ATKY monitoring site is located off Main Street (State Road 95), just south of the entrance to a chemical manufacturing plant. The majority of the city’s industry lies north and east of ATKY. Approximately 1 mile east down Gilbertsville Highway is the LAKY monitoring site. LAKY is located behind a mobile home park. Although located in a residential area, industrial areas are located to the west and north. Just over one-half mile north of LAKY is the TVKY monitoring site. This monitoring site is located at a power substation just south of another chemical manufacturing plant. The fourth monitoring site in Calvert City is located at Calvert City Elementary School. The CCKY site is located behind the school, which backs up to a forested area just south of the aforementioned railroad. The BLKY site is located across the Tennessee River, north of Calvert City, in Smithland. The site is located on a residential property in an agricultural area. This site is potentially downwind of the Calvert City industrial area. The composite satellite images for these sites are provided in alphabetical order by site in Figures 13-8 through 13-12.

Figure 13-13 is the facility map for the Calvert City sites and provides an indication of how close these sites are to one another. Most of the emissions sources in Calvert City are located between ATKY and the Tennessee River. Many of the emissions sources closest to the Calvert City sites are in the chemical manufacturing source category. There are also several plastic, resin, or rubber product plants located between these sites. Industries located farther away from the sites but within 10 miles include ship/boat manufacturing or repair; mine, quarry, or mineral processing, metals processing/fabrication, and an asphalt production/hot mix asphalt plant.

The LEKY monitoring site is located in the city of Lexington in north-central Kentucky. The site is located on the property of the county health department in a primarily residential area of northern Lexington. A YMCA is located adjacent to the health department along W. Loudon Avenue and a hospital is located immediately to the south. Although the area is classified as residential and suburban, most of the residences are located to the west of Newtown Pike (922). A major electrical equipment and ink manufacturer is located to the northeast of the site, as shown in Figure 13-14. LEKY is located just over a half-mile south of New Circle Road, a loop encircling the city of Lexington.

Figure 13-15 shows that most of the emissions sources within 10 miles of LEKY are within a few miles of the site. Emissions sources in the immediate vicinity of LEKY include a food processing plant, the aforementioned electrical equipment manufacturing plant, and a metals processing and fabrication facility.

Table 13-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Kentucky monitoring sites. Table 13-2 includes both county-level population and vehicle registration information. Table 13-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 13-2 presents the county-level daily VMT for Boyd, Carter, Henderson, Marshall, Livingston, and Fayette Counties.

Table 13-2. Population, Motor Vehicle, and Traffic Information for the Kentucky Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
ASKY	49,164	39,227	7,229	29th Street between Newman St and Lynwood Ave	1,281,000
ASKY-M			12,842	Greenup (23rd) between 16th St and 17th St	
GLKY	27,348	25,391	303	State Hwy 1496, south of Camp Webb Rd	1,080,000
BAKY	46,513	38,518	922	Route 1078, north of Highway 60	1,417,000
ATKY	31,344	30,297	3,262	Main St, south of Johnson Riley Road	1,292,000
CCKY			4,742	Industrial Pkwy, south of E. 5th Ave	
LAKY			1,189	Route 282, east of Industrial Lane	
TVKY			2,231	Industrial Pkwy, east of Plant Cut-off Road	
BLKY	9,423	8,281	2,280	Route 93/453	398,000
LEKY	305,489	207,043	10,083	W Loudon Ave, east of Newton Pike	7,545,000

[1] County-level population estimates reflects 2012 data (Census Bureau, 2013c)

[2] County-level vehicle registration reflects 2012 data (KYTC, 2013a)

[3] AADT reflects 2010, 2011, or 2012 data (KYTC, 2013b)

[4] County-level VMT reflects 2012 data (KYTC, 2013c)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 13-2 include the following:

- Fayette County (LEKY) is the most populous of the Kentucky counties with monitoring sites (by an order of magnitude). Yet this county ranks 29th in population compared to other counties with NMP sites. The remaining Kentucky counties are among the least populated compared to other counties with NMP sites. Livingston County (BLKY) is the least populated of all counties with NMP sites, followed by Carter County (GLKY) as the second least populated, Marshall County (the Calvert City sites) third, Henderson County (BAKY) sixth, and Boyd County (ASKY/ASKY-M) seventh.

- The corresponding vehicle ownership data mimicked these rankings, with Fayette County in the middle of the range compared to other counties with NMP sites and the remaining Kentucky counties accounting for the bottom five county-level vehicle counts.

- Traffic is highest near ASKY-M and LEKY and lowest near GLKY and BAKY. Traffic counts for all of the Kentucky sites are in the bottom half of the range compared to other NMP sites, with the traffic near GLKY the lowest among all NMP sites.

- The daily VMT for Fayette County is significantly higher than the VMT for the other Kentucky counties. The VMT for Fayette Count is in the middle of the range compared to other counties with NMP sites (where VMT data were available), while the other five Kentucky counties account for five of the six lowest county-level VMT.

13.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Kentucky on sample days, as well as over the course of the year.

13.2.1 Climate Summary

The monitoring sites in Kentucky are spread across four different regions across the state. Elevation generally increases from west to east, with the famed Bluegrass Region in the north-central portion of the state. The state of Kentucky experiences a continental climate, where conditions tend to be slightly cooler and drier in the northeast portion of the state and warmer and wetter in the southwest portion. Kentucky's mid-latitude location ensures an active weather pattern, in a convergence zone between cooler air from the north and warm, moist air from the south. The state enjoys all four seasons. Summers are persistently warm and humid; winters are cloudy but not harsh; and spring and fall are considered pleasant. Precipitation is well distributed throughout the year, although fall tends to be driest and spring wettest (NCDC, 2014).

13.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the Kentucky monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather station to each site is as follows: For ASKY, ASKY-M, and GLKY, Tri-State/M.J. Ferguson Field Airport (WBAN 03860); for BAKY, Evansville Regional Airport (WBAN 93817); for BLKY, ATKY, CCKY, LAKY, and TVKY, Barkley Regional Airport (WBAN 03816); and for LEKY, Blue Grass Airport (WBAN 93820). Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 13-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 13-3. Average Meteorological Conditions near the Kentucky Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Health Department, Ashland, Kentucky - ASKY									
Tri-St/M.J. Ferguson Field Airport 03860 (38.38, -82.56)	7.8 miles 138° (SE)	Sample Days (29)	68.0 ± 6.6	57.9 ± 5.9	48.1 ± 6.1	52.7 ± 5.6	73.1 ± 3.8	1016.7 ± 2.8	3.6 ± 0.8
		2012	68.0 ± 1.8	57.5 ± 1.6	46.2 ± 1.7	51.6 ± 1.5	69.7 ± 1.3	1017.0 ± 0.6	4.0 ± 0.2
21st and Greenup, Ashland, Kentucky - ASKY-M									
Tri-St/M.J. Ferguson Field Airport 03860 (38.38, -82.56)	8.6 miles 145° (SE)	Sample Days (52)	72.3 ± 4.6	61.3 ± 4.1	49.4 ± 4.2	54.8 ± 3.8	69.0 ± 3.3	1016.3 ± 1.8	3.7 ± 0.6
		2012	68.0 ± 1.8	57.5 ± 1.6	46.2 ± 1.7	51.6 ± 1.5	69.7 ± 1.3	1017.0 ± 0.6	4.0 ± 0.2
Grayson, Kentucky - GLKY									
Tri-St/M.J. Ferguson Field Airport 03860 (38.38, -82.56)	23.8 miles 60° (ENE)	Sample Days (69)	66.8 ± 4.2	56.0 ± 3.8	44.2 ± 3.8	50.0 ± 3.4	68.6 ± 3.0	1017.1 ± 1.6	4.0 ± 0.6
		2012	68.0 ± 1.8	57.5 ± 1.6	46.2 ± 1.7	51.6 ± 1.5	69.7 ± 1.3	1017.0 ± 0.6	4.0 ± 0.2
Baskett, Kentucky - BAKY									
Evansville Regional Airport 93817 (38.04, -87.52)	12.3 miles 341° (NNW)	Sample Days (51)	73.7 ± 4.7	63.0 ± 4.3	48.8 ± 4.0	55.2 ± 3.7	63.4 ± 2.9	1016.8 ± 1.5	5.2 ± 0.7
		2012	70.4 ± 1.9	60.0 ± 1.8	46.9 ± 1.6	52.9 ± 1.5	65.5 ± 1.1	1017.0 ± 0.6	5.3 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 13-3. Average Meteorological Conditions near the Kentucky Monitoring Sites (Continued)

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Atmos Energy, Calvert City, Kentucky - ATKY									
Barkley Regional Airport 03816 (37.06, -88.77)	21.9 miles 268° (W)	Sample Days (29)	71.6 ± 6.9	61.3 ± 6.3	48.8 ± 5.8	54.5 ± 5.5	67.1 ± 3.8	1016.6 ± 2.3	5.6 ± 1.1
		2012	71.8 ± 1.8	61.2 ± 1.7	48.2 ± 1.6	54.1 ± 1.5	66.0 ± 1.2	1016.5 ± 0.6	5.6 ± 0.3
Smithland, Kentucky - BLKY									
Barkley Regional Airport 03816 (37.06, -88.77)	23.0 miles 263° (W)	Sample Days (29)	71.6 ± 6.9	61.3 ± 6.3	48.8 ± 5.8	54.5 ± 5.5	67.1 ± 3.8	1016.6 ± 2.3	5.6 ± 1.1
		2012	71.8 ± 1.8	61.2 ± 1.7	48.2 ± 1.6	54.1 ± 1.5	66.0 ± 1.2	1016.5 ± 0.6	5.6 ± 0.3
Calvert City Elementary, Calvert City, Kentucky - CCKY									
Barkley Regional Airport 03816 (37.06, -88.77)	22.5 miles 270° (W)	Sample Days (50)	74.7 ± 4.7	63.9 ± 4.3	49.9 ± 4.0	56.1 ± 3.7	64.5 ± 3.2	1016.2 ± 1.5	5.6 ± 0.7
		2012	71.8 ± 1.8	61.2 ± 1.7	48.2 ± 1.6	54.1 ± 1.5	66.0 ± 1.2	1016.5 ± 0.6	5.6 ± 0.3
Lazy Daze, Calvert City, Kentucky - LAKY									
Barkley Regional Airport 03816 (37.06, -88.77)	23.0 miles 269° (W)	Sample Days (29)	71.7 ± 6.9	61.8 ± 6.1	49.5 ± 5.6	55.0 ± 5.3	67.6 ± 4.0	1016.0 ± 2.0	5.7 ± 1.0
		2012	71.8 ± 1.8	61.2 ± 1.7	48.2 ± 1.6	54.1 ± 1.5	66.0 ± 1.2	1016.5 ± 0.6	5.6 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 13-3. Average Meteorological Conditions near the Kentucky Monitoring Sites (Continued)

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
TVA Substation, Calvert City, Kentucky - TVKY									
Barkley Regional Airport 03816 (37.06, -88.77)	23.1 miles 267° (W)	Sample Days (29)	71.6 ± 6.9	61.3 ± 6.3	48.8 ± 5.8	54.5 ± 5.5	67.1 ± 3.8	1016.6 ± 2.3	5.6 ± 1.1
		2012	71.8 ± 1.8	61.2 ± 1.7	48.2 ± 1.6	54.1 ± 1.5	66.0 ± 1.2	1016.5 ± 0.6	5.6 ± 0.3
Lexington, Kentucky - LEKY									
Blue Grass Airport 93820 (38.04, -84.61)	5.8 miles 246° (WSW)	Sample Days (53)	70.9 ± 4.7	60.9 ± 4.3	49.4 ± 4.0	54.5 ± 3.8	69.2 ± 3.3	1016.9 ± 1.6	6.2 ± 0.7
		2012	67.4 ± 1.8	57.6 ± 1.7	47.1 ± 1.6	52.0 ± 1.5	71.0 ± 1.3	1017.2 ± 0.6	6.4 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 13-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 13-3 is the 95 percent confidence interval for each parameter. GLKY is the only Kentucky site for which sampling was conducted year-round. Table 13-3 shows that average meteorological conditions on sample days near GLKY were generally representative of average weather conditions experienced throughout the year. Although sample days appear slightly cooler and drier, this is probably due to the majority of the make-up days occurring in the cooler months of the year (two in the first quarter, one in the second quarter, and five in the fourth quarter).

The difference between the full-year and sample day temperature and moisture parameters is wider for those Kentucky sites that began sampling under the NMP in March (ASKY-M, BAKY, CCKY, and LEKY) than those sites that began sampling in July (ASKY, ATKY, BLKY, LAKY, and TVKY). For those sites that began sampling in July, the largest differences are seen in the moisture parameters. This is because the cooler months of the year, which are not included in the sample day calculations, also tend to be the driest. For those sites that began sampling in March, the largest differences are seen in the temperature parameters, although the moisture parameters differ too. For these sites, the sample days appear warmer than the full-year averages. This is because January and February, traditionally the coldest months of the year, are not included in the sample day averages.

13.2.3 Back Trajectory Analysis

A composite back trajectory map representing days on which samples were collected is presented for each site. Included on each composite map are four back trajectories per sample day. Where sampling occurred for a long enough duration (30 sample days), per the criteria described in Section 3.5.2.1, a corresponding cluster analysis is presented. Thus, Figures 13-16 through 13-30 are the composite back trajectory maps and corresponding cluster analyses for the Kentucky monitoring sites. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 13-16 and 13-30 represents 100 miles.

Figure 13-16. Composite Back Trajectory Map for ASKY

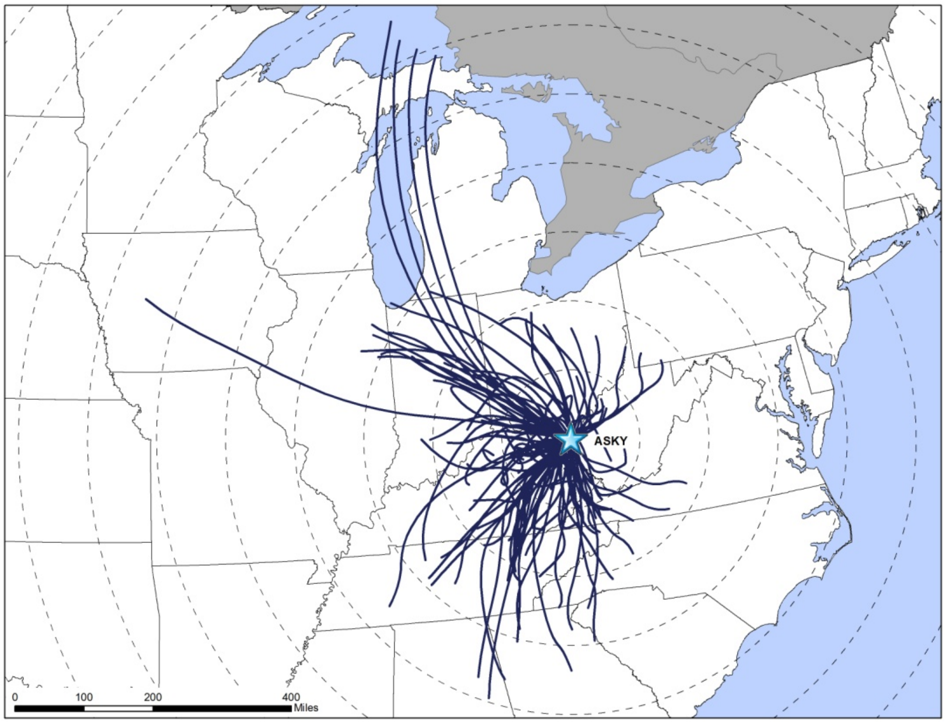


Figure 13-17. Composite Back Trajectory Map for ASKY-M

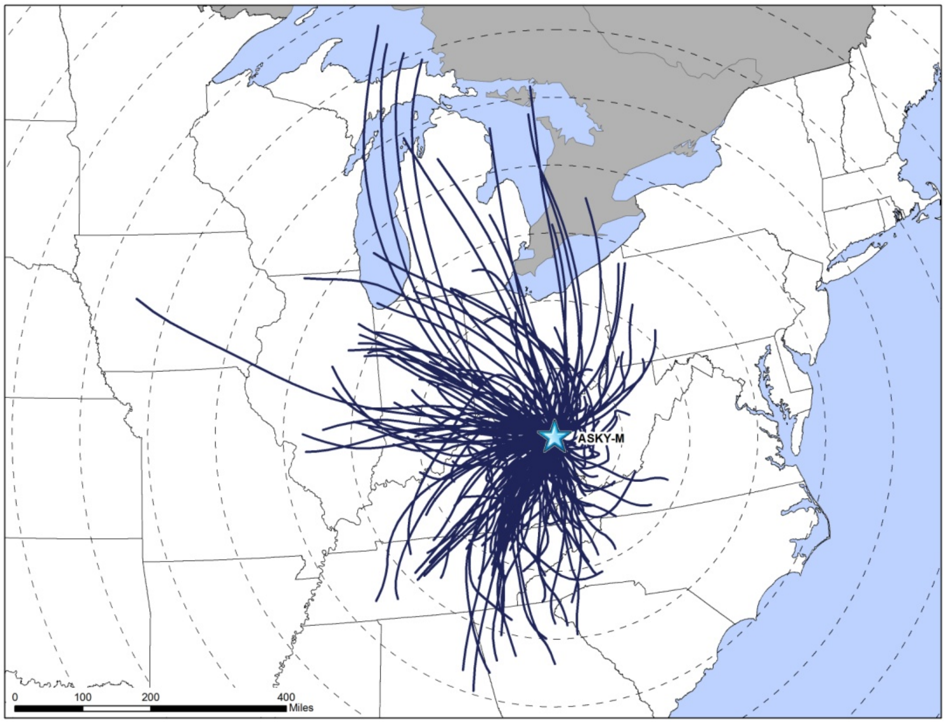


Figure 13-18. Back Trajectory Cluster Map for ASKY-M

Figure 13-19. Composite Back Trajectory Map for GLKY

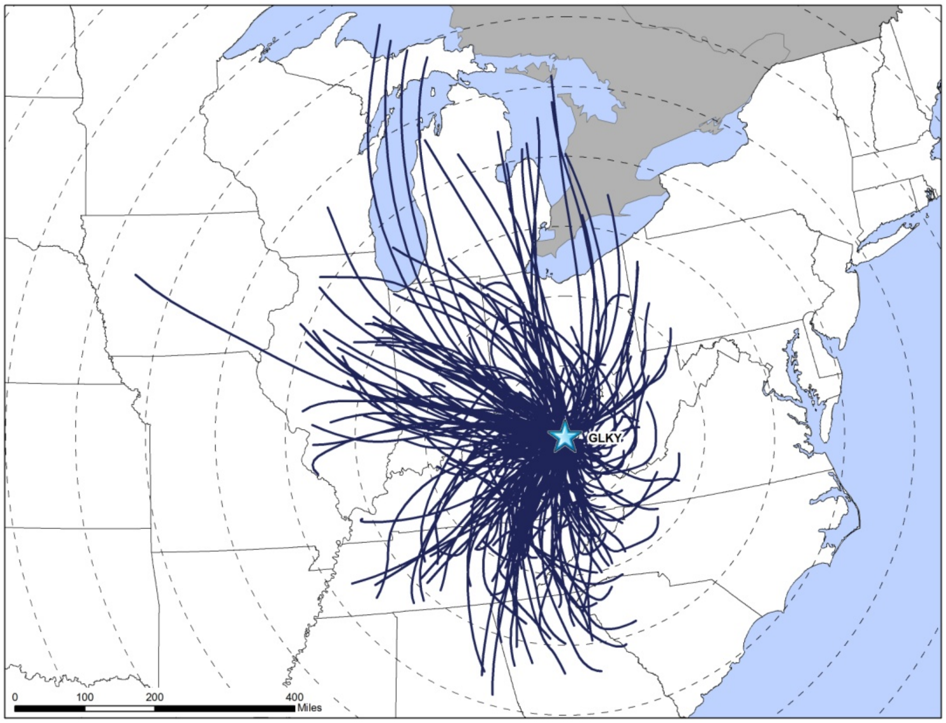


Figure 13-20. Back Trajectory Cluster Map for GLKY

Figure 13-21. Composite Back Trajectory Map for BAKY

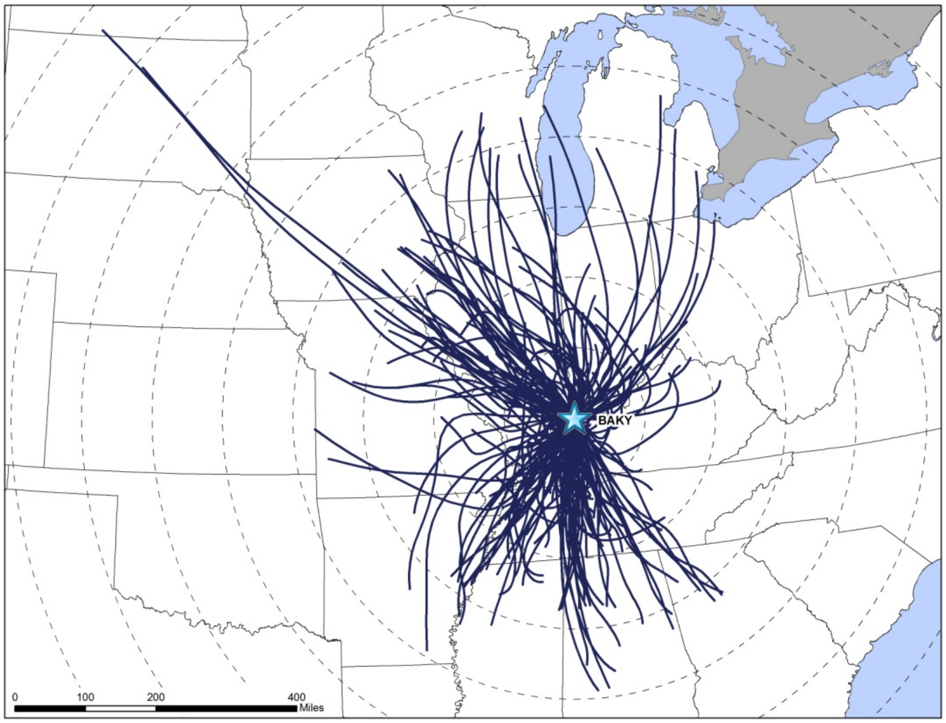


Figure 13-22. Back Trajectory Cluster Map for BAKY

Figure 13-23. Composite Back Trajectory Map for ATKY

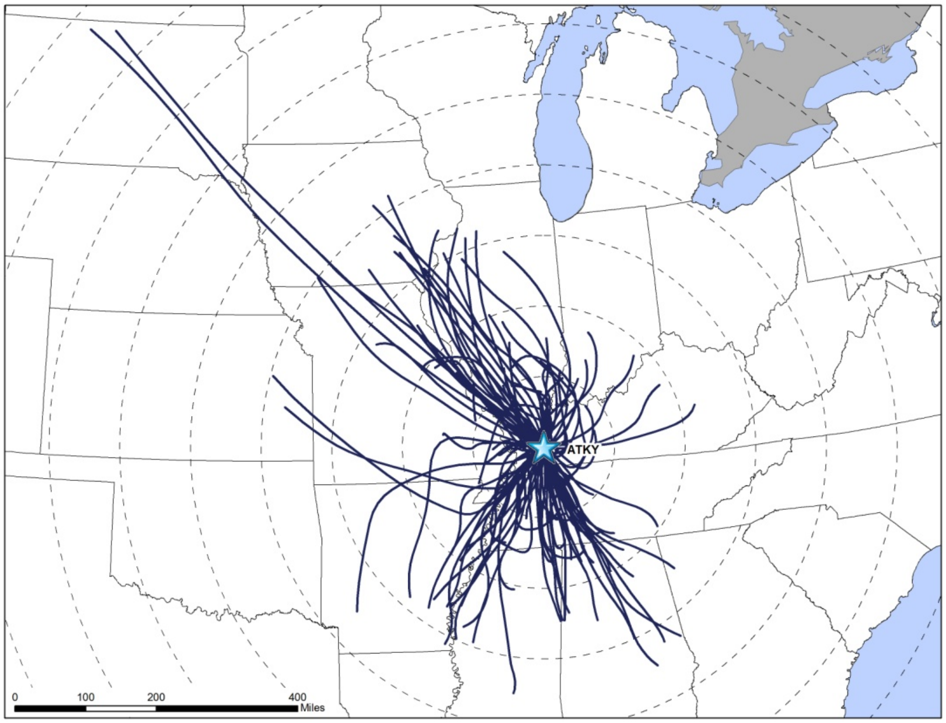


Figure 13-24. Composite Back Trajectory Map for BLKY

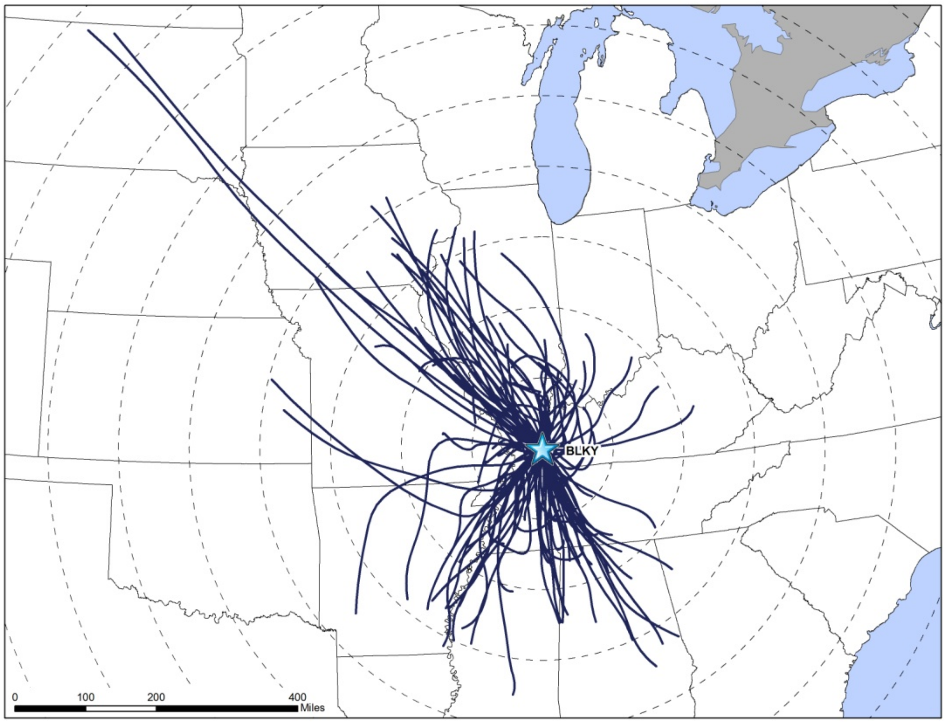


Figure 13-25. Composite Back Trajectory Map for CCKY

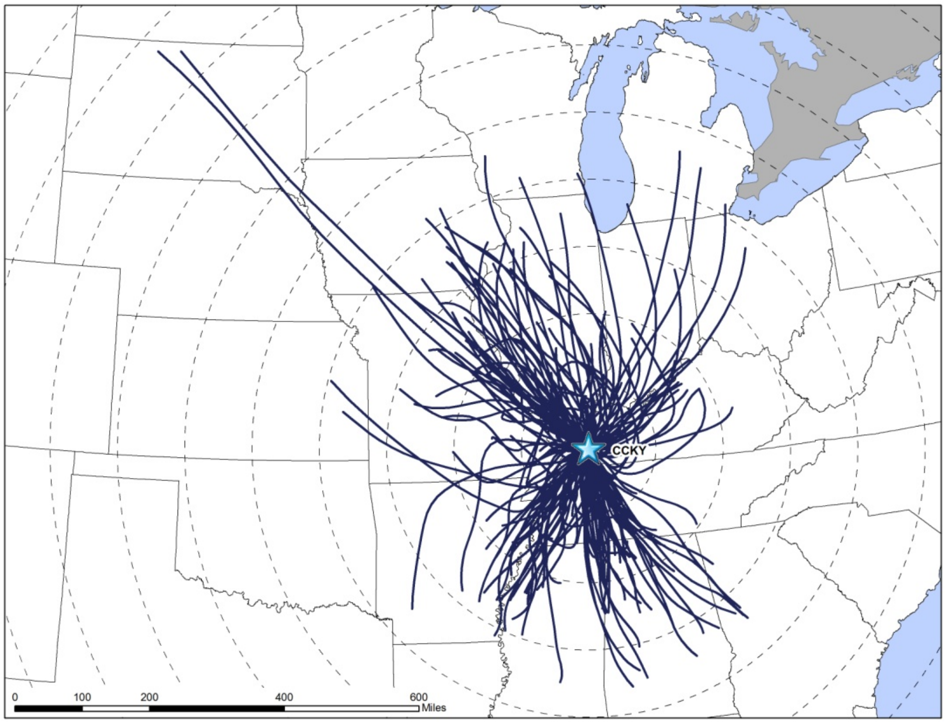


Figure 13-26. Back Trajectory Cluster Map for CCKY

Figure 13-27. Composite Back Trajectory Map for LAKY

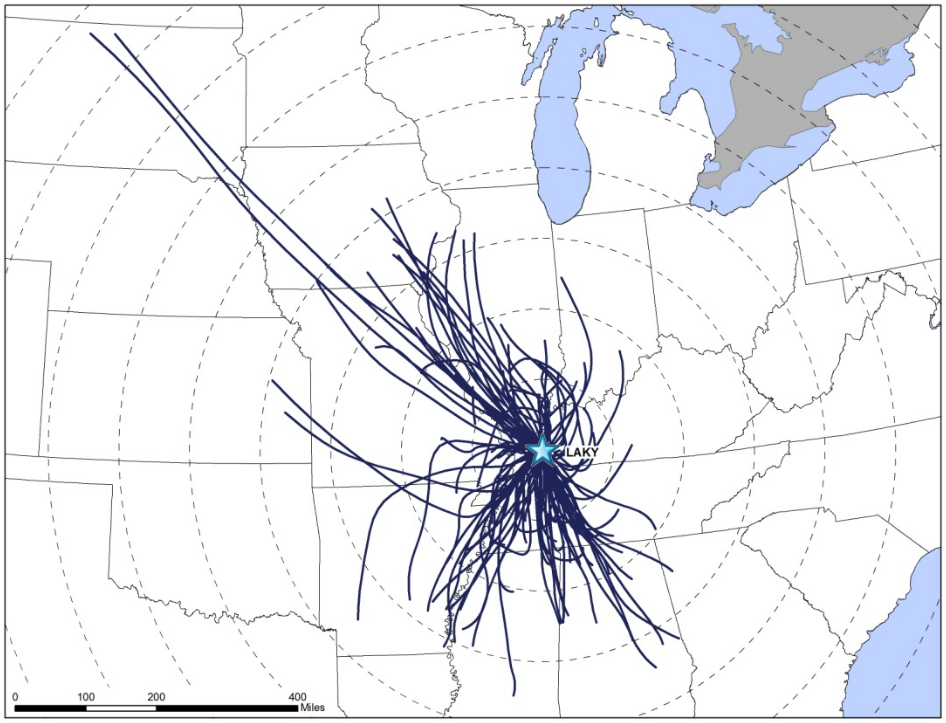


Figure 13-28. Composite Back Trajectory Map for TVKY

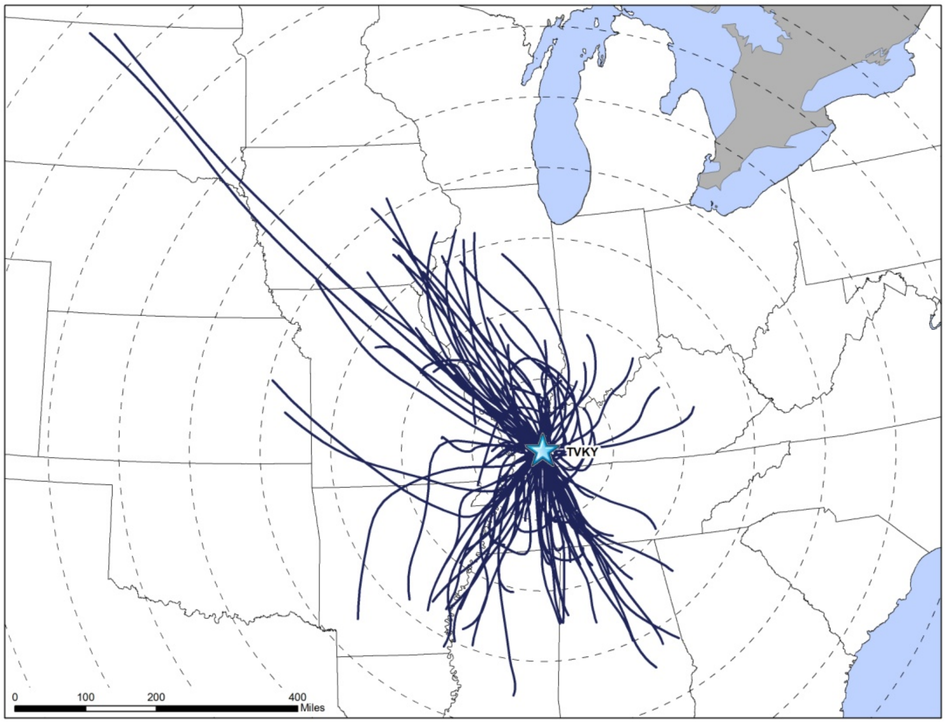


Figure 13-29. Composite Back Trajectory Map for LEKY

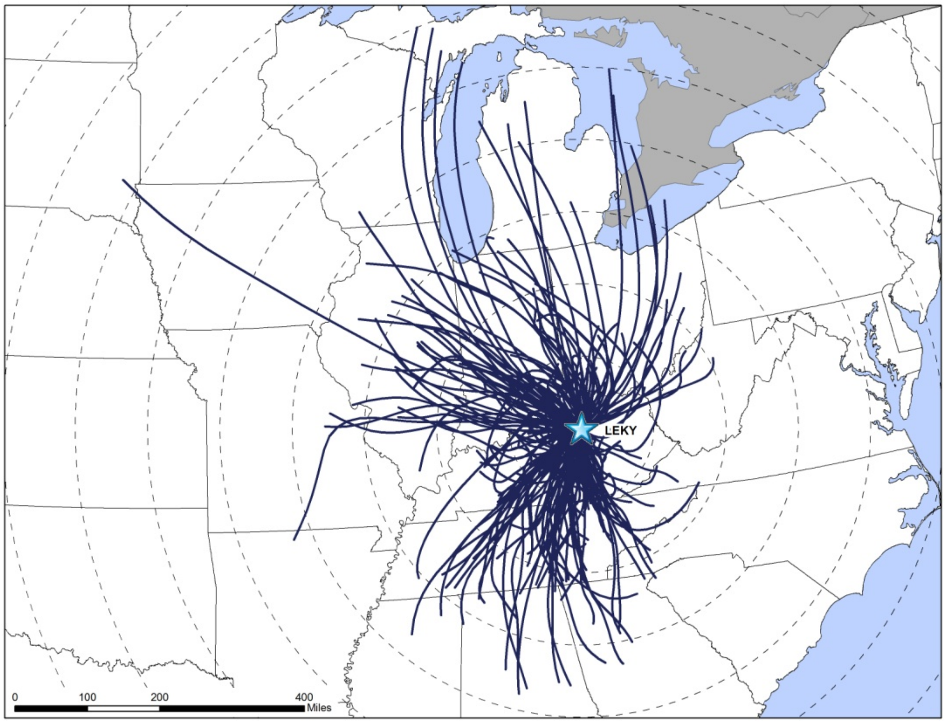


Figure 13-30. Back Trajectory Cluster Map for LEKY

Observations from Figures 13-16 through 13-18 for ASKY and ASKY-M include the following:

- The composite map for ASKY has fewer back trajectories than the composite map for ASKY-M. This is because sampling at ASKY began in July while sampling at ASKY-M began in March. Because there are fewer than 30 sample days for ASKY (29), a cluster analysis is not presented for this site.

- The composite maps show that back trajectories originated from a variety of directions at the Ashland sites, although fewer back trajectories originated from the east of the sites. Back trajectories originating from the west, northwest, and north tended to be the longest.

- The farthest away a back trajectory originated from the Ashland sites was over Lake Superior, or greater than 650 miles away. A back trajectory of similar distance also originated over central Iowa. The four long back trajectories originating over Lake Superior are the four back trajectories representing October 30, 2012. The average back trajectory length for ASKY (193 miles) is slightly less than the average trajectory length for ASKY-M (202 miles). Recall, though, that the composite map for ASKY includes four less months of sampling than the composite map for ASKY-M.

- The four long back trajectories originating over Lake Superior are represented by their own cluster trajectory in Figure 13-8, representing only 2 percent of back trajectories. Nineteen percent of back trajectories originated to the west and northwest of ASKY-M, primarily over Indiana and Illinois. Nearly one third of back trajectories originated to the southwest of the site, primarily over Tennessee and northern Georgia. Eleven percent of back trajectories originated over the Appalachian Mountains of Virginia, North Carolina, and Tennessee and generally less than 200 miles away. Thirteen percent of back trajectories originated to the northeast of ASKY, over southeast Ohio, western Pennsylvania, and West Virginia. Only 7 percent of back trajectories originated to the north of ASKY-M, primarily over Michigan, Lake Huron, Lake Erie, and southwest Ontario, Canada. The short cluster trajectory originating over the Bluegrass Region of Kentucky represents those back trajectories with a westerly component, originating over northeast Kentucky and south-central Ohio, and generally less than 100 miles in length.

Observations from Figures 13-19 and 13-20 for GLKY include the following:

- The composite map for GLKY is similar in the geographic distribution of back trajectories to the composite map for ASKY-M. This is not unexpected as these sites are only 25 miles apart.

- The composite map shows that back trajectories originated from a variety of directions at GLKY. Back trajectories with an easterly component appear to be shorter than those originating from other directions.

- The farthest away a back trajectory originated from GLKY was over west-central Iowa, or greater than 650 miles away. A back trajectory of similar distance also originated over Lake Superior. The four long back trajectories originating over Lake Superior and the Upper Peninsula of Michigan are the four back trajectories representing October 30, 2012, similar to those shown for the Ashland sites. The average back trajectory length for GLKY (205 miles) is just greater than the average back trajectory length for ASKY-M (202 miles). More than 90 percent of back trajectories were less than 400 miles in length.

- For GLKY, the four long back trajectories originating over Lake Superior are represented by the same cluster trajectory representing other back trajectories originating to the north of the site. Together, these represent 6 percent of back trajectories. Nearly 40 percent of back trajectories originated to the west and northwest of GLKY, but are split into two cluster trajectories. One (30 percent) represents shorter back trajectories originating primarily over Indiana while the other (9 percent) represents longer back trajectories originating primarily over Illinois. One-quarter of back trajectories originated to the southwest of the site, primarily over Tennessee and northern Georgia. The short cluster trajectory originating over the Appalachian Plateau of Virginia represents the 18 percent of back trajectories originating over the Appalachian Mountains of Virginia, North Carolina, and Tennessee and southern West Virginia and generally within 200 miles of GLKY. Back trajectories originating to the northeast of GLKY, over southeast Ohio, western Pennsylvania, and West Virginia, account for 11 percent of back trajectories.

Observations from Figures 13-21 and 13-22 for BAKY include the following:

- The composite map for BAKY shows that although most back trajectories originated within 400 miles of the site, one back trajectory originated from greater than 850 miles away and another from nearly 800 miles away. These back trajectories represent the November 23, 2012 sample day. The average back trajectory length for BAKY is 223 miles, which is the highest average among the Kentucky sites.

- An imaginary line drawn east-west through the site on the composite map shows that most back trajectories have either a northerly or a southerly component and that few back trajectories originated from the east or west.

- Eighteen percent of back trajectories originated from the northwest of BAKY, with the long cluster trajectory representing the two back trajectories originating over the Dakotas and the shorter one representing back trajectories originating over Iowa, Illinois, and Missouri. Nearly 30 percent of back trajectories originated to the southwest of BAKY, primarily over western Tennessee or along the Mississippi River. Another 22 percent of back trajectories originated to the southeast to south of BAKY, over central Tennessee and northern Mississippi and Georgia. Nearly 10 percent of back trajectories originated to the north of BAKY but are split into two cluster trajectories based on which side of Lake Michigan they originate. The short cluster trajectory originating to the north of BAKY represents the 25 percent of back trajectories originating less than 200 miles away from the site and with a northerly component. These back trajectories originated over north-central Kentucky, the southern half of Indiana, and southeast Illinois.

Observations from Figures 13-23 through 13-28 for the five sites in or near Calvert City include the following:

- With the exception of CCKY, the composite maps for the Calvert City sites include only half a year's worth of sample days due to the July start date. Thus, CCKY is the only Calvert City site for which a cluster analysis could be performed.

- The composite maps for the Calvert City sites resemble each other, which is expected given the relatively close proximity of these site to each other. These composite maps also resemble the composite map for BAKY, which is located 75 miles northeast of Calvert City. The composite maps show that most back trajectories originated within 400 miles of the sites and primarily to the northwest to northeast or southeast to southwest of the sites.

- The average back trajectory length ranged from 201 miles to 207 miles for the four sites that started sampling under the NMP in July; the average back trajectory length for CCKY is 219 miles.

- Each composite map includes the two long back trajectories originating over South Dakota, or greater than 800 miles away. These back trajectories represent the November 23, 2012 sample day.

- Nineteen percent of back trajectories originated to the northwest of CCKY, with the long cluster trajectory representing the two back trajectories originating over South Dakota and the shorter one representing back trajectories originating over Iowa, Illinois, and Missouri. The short cluster trajectory originating to the northwest of CCKY represents the 23 percent of back trajectories originating less than 200 miles away from the site and over southern Illinois and southeast Missouri. Fifteen percent of back trajectories originated to the southwest of CCKY, primarily along the Mississippi River. Although 35 percent of back trajectories originated to the southeast of CCKY, these are split into two cluster trajectories. One cluster trajectory represents the longer back trajectories originating primarily over Alabama, and one cluster trajectory represents the short back trajectories originating over central Tennessee and northern Alabama. Ten percent of back trajectories originated to the northeast of CCKY, but includes back trajectories of varying lengths.

Observations from Figures 13-29 and 13-30 for LEKY include the following:

- The composite map shows that back trajectories originated from a variety of directions at LEKY, although few back trajectories originated from the east of the site. The longest back trajectories tended to originate from the north, although the longest back trajectory originated over South Dakota, or greater than 700 miles away. This back trajectory also represents the November 23, 2012 sample day. The average back trajectory length for LEKY is 202 miles.

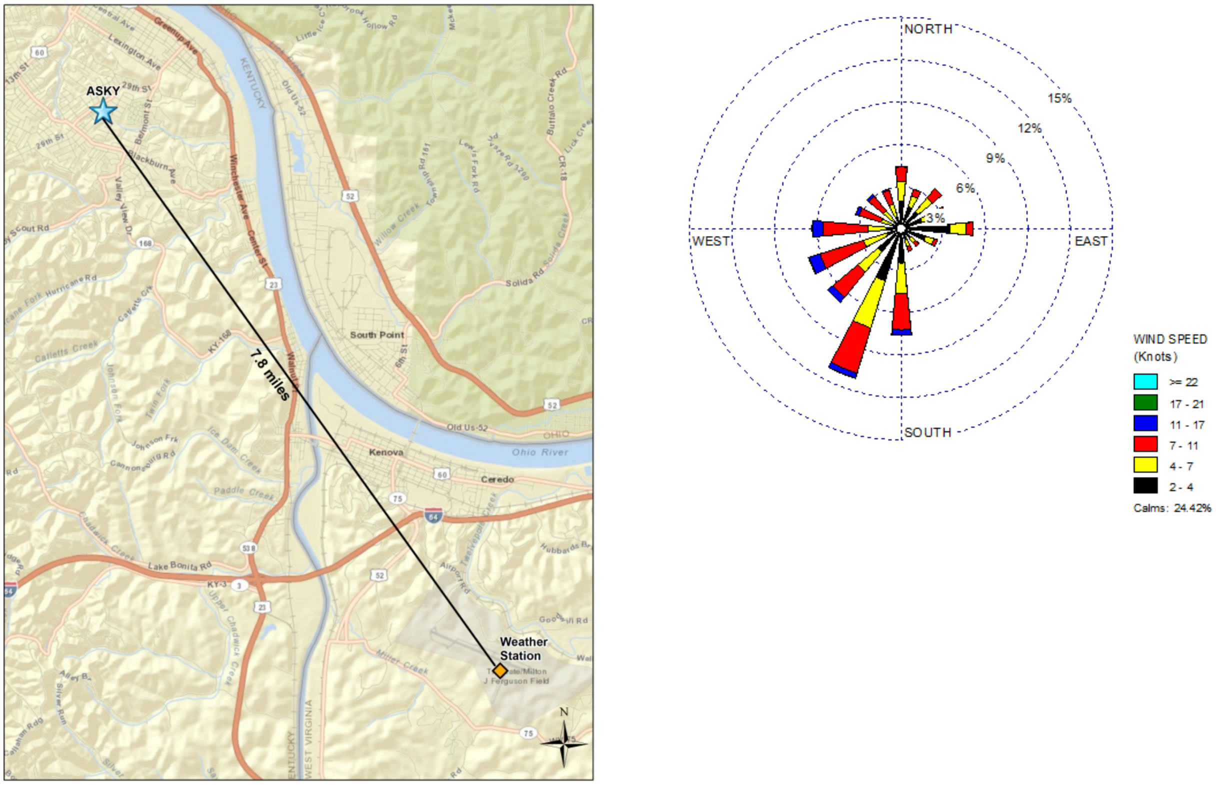
- The cluster analysis for LEKY shows that 12 percent of back trajectories originated to the north of the site, but these are split into two clusters, one representing the longer back trajectories originating over the Upper Peninsula of Michigan, and one representing the back trajectories east of Lake Michigan. Another 12 percent of back trajectories originated to the northwest of LEKY, primarily over Illinois but as far away as South Dakota. Twenty-five percent of back trajectories are represented by the short cluster trajectory originating towards Louisville, Kentucky. These back trajectories originated within 200 miles of LEKY and generally over southern Indiana and central Kentucky. Nearly one-quarter of back trajectories originated to the southwest of LEKY, over Tennessee and northern Georgia, Alabama, and Mississippi. Sixteen percent of back trajectories originated over southeastern Kentucky and northeastern Tennessee. The final 13 percent of back trajectories originated to the north and northeast of LEKY, primarily over the southern half of Ohio and West Virginia.

13.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations nearest the Kentucky sites, as presented in Section 13.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

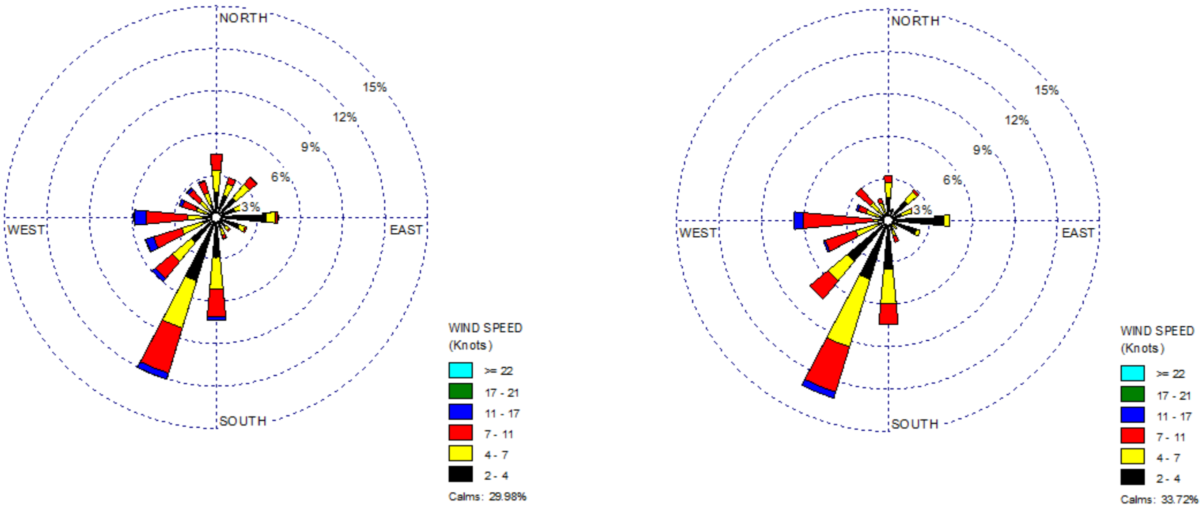
Figure 13-31 presents a map showing the distance between the Tri-State/M.J. Ferguson Field Airport weather station and ASKY, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 13-31 also presents three different wind roses for the ASKY monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 13-32 through 13-40 present the distance maps and wind roses for the remaining Kentucky monitoring sites.

Figure 13-31. Wind Roses for the Tri-State/M.J. Ferguson Field Airport Weather Station near ASKY



Location of ASKY and Weather Station

2002-2012 Historical Wind Rose

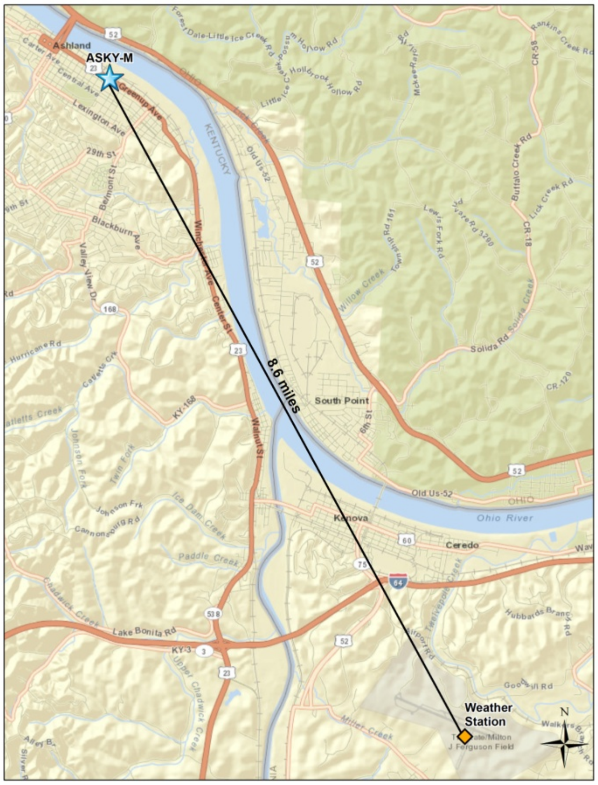


2012 Wind Rose

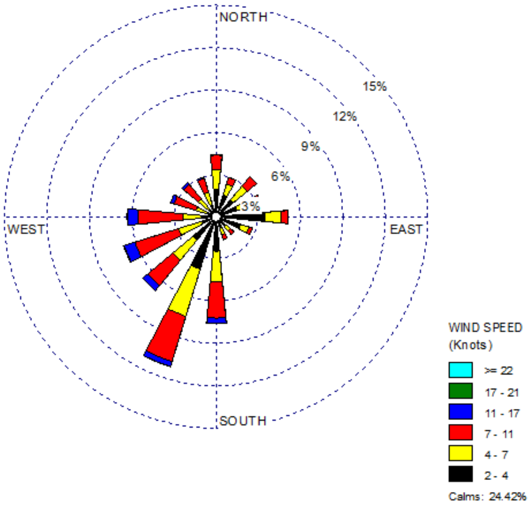
Sample Day Wind Rose

Figure 13-32. Wind Roses for the Tri-State/M.J. Ferguson Field Airport Weather Station near ASKY-M

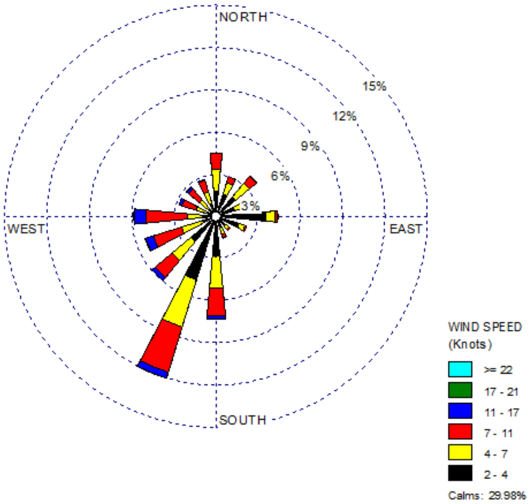
Location of ASKY-M and Weather Station



2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

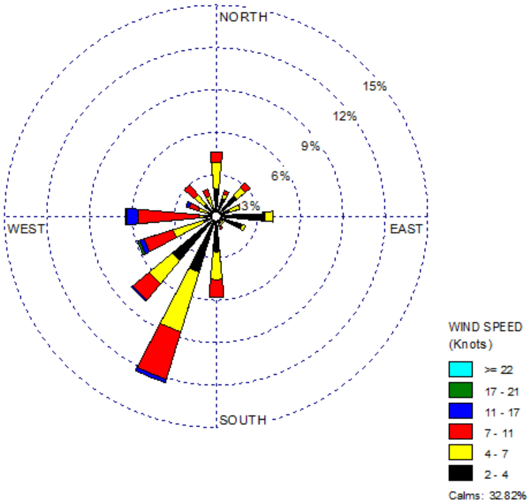
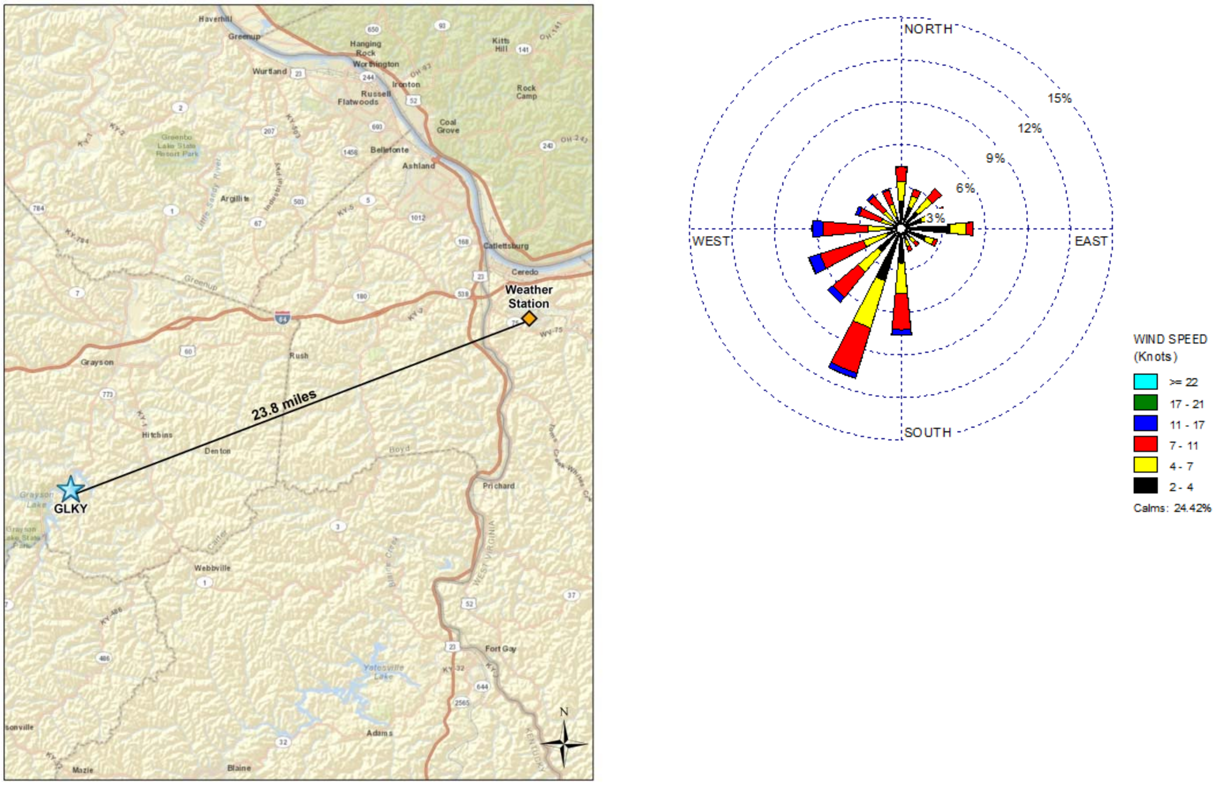


Figure 13-33. Wind Roses for the Tri-State/M.J. Ferguson Field Airport Weather Station near GLKY

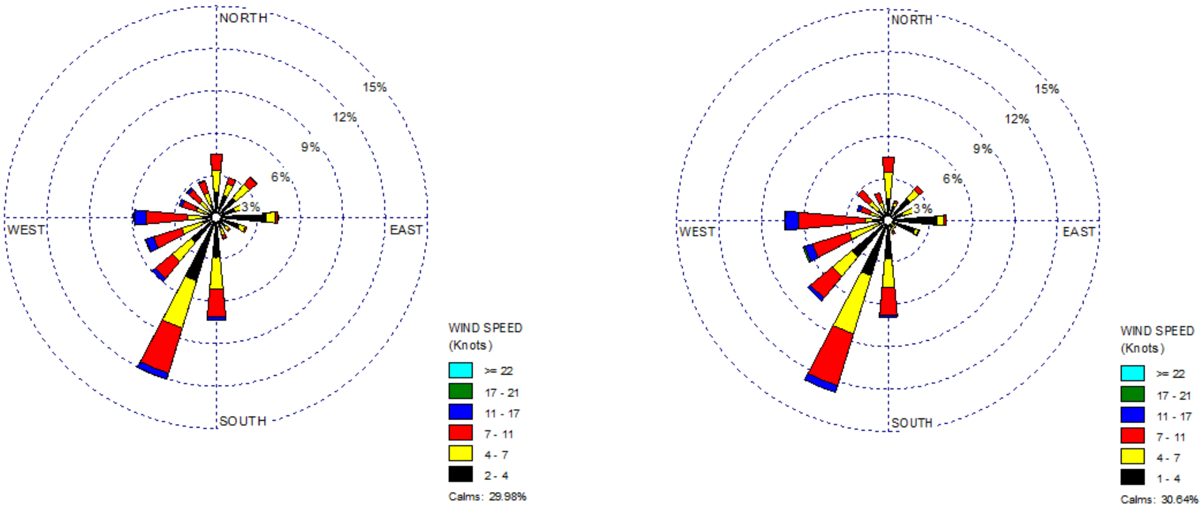
Location of GLKY and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose



Observations from Figures 13-31 through 13-33 for ASKY, ASKY-M, and GLKY include the following:

- The Tri-State/M.J. Ferguson Field weather station is the closest weather station to both Ashland sites and GLKY. The weather station is located approximately 8 miles southeast of the Ashland sites and nearly 24 miles to the east-northeast of GLKY. This weather station is in West Virginia, south of the Ohio River and east of the Big Sandy River.

- Because these three sites share the same weather station, the historical and full-year wind roses are identical across the sites.

- The historical wind rose shows that winds from the south, southwest quadrant, and west account for nearly half of the wind observations near these sites, particularly those from south-southwest. Calm winds (≤ 2 knots) account for nearly 25 percent of the hourly measurements.

- The wind patterns on the full-year wind rose are similar to those on the historical wind rose, although calm winds accounted for a slightly higher percentage of the wind observations in 2012 (30 percent). There were slightly fewer wind observations from the southwest to west but additional wind observations from the south-southwest.

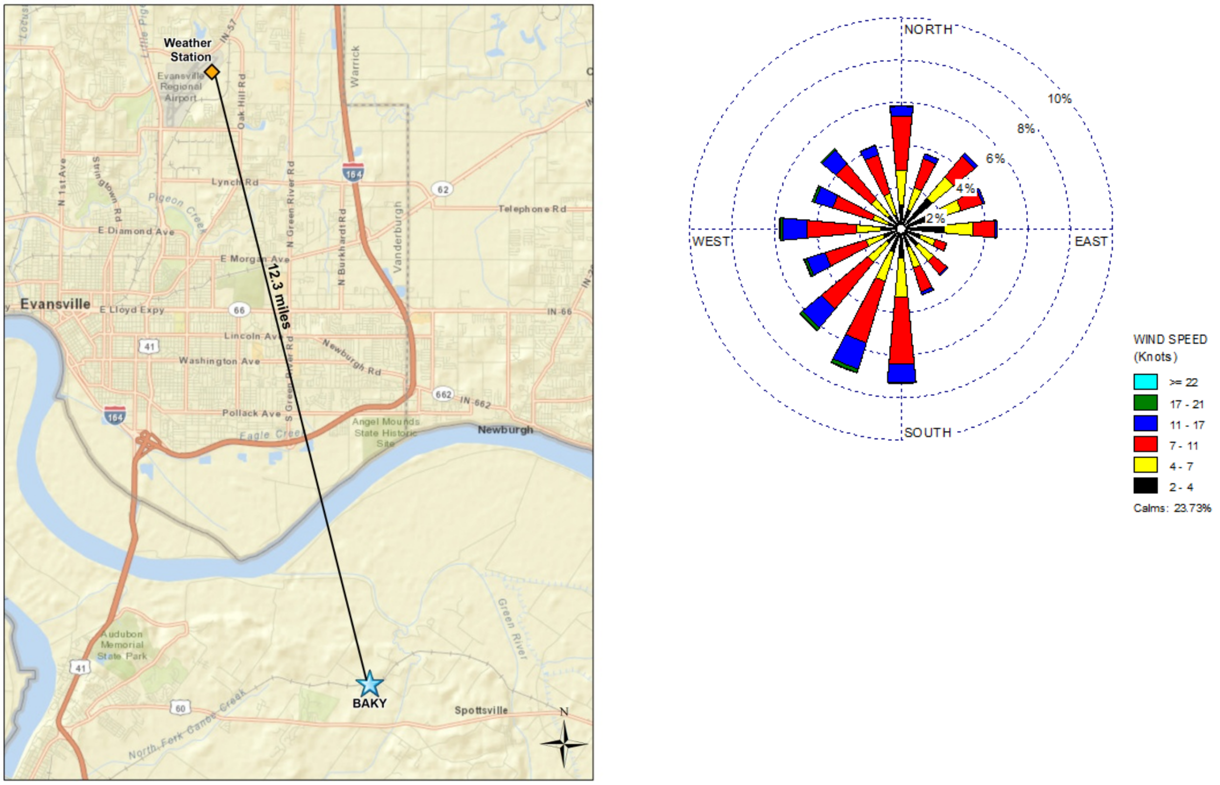
- The sample day wind rose for ASKY resembles both the historical and full-year wind roses, although there is a higher percentage of south-southwesterly winds as well as calm winds (up nearly 10 percent from the historical wind rose). Recall that the sample day wind rose includes only six months worth of sample days as ASKY did not begin sampling under the NMP until July.

- The sample day wind rose for ASKY-M also resembles both the historical and full-year wind roses, although there is a slightly higher percentage of southwesterly winds and fewer southerly winds. The calm rate is also higher on the sample day wind rose. Recall that ASKY-M began sampling under the NMP in March.

- The sample day wind rose for GLKY also resembles both the historical and full-year wind roses.

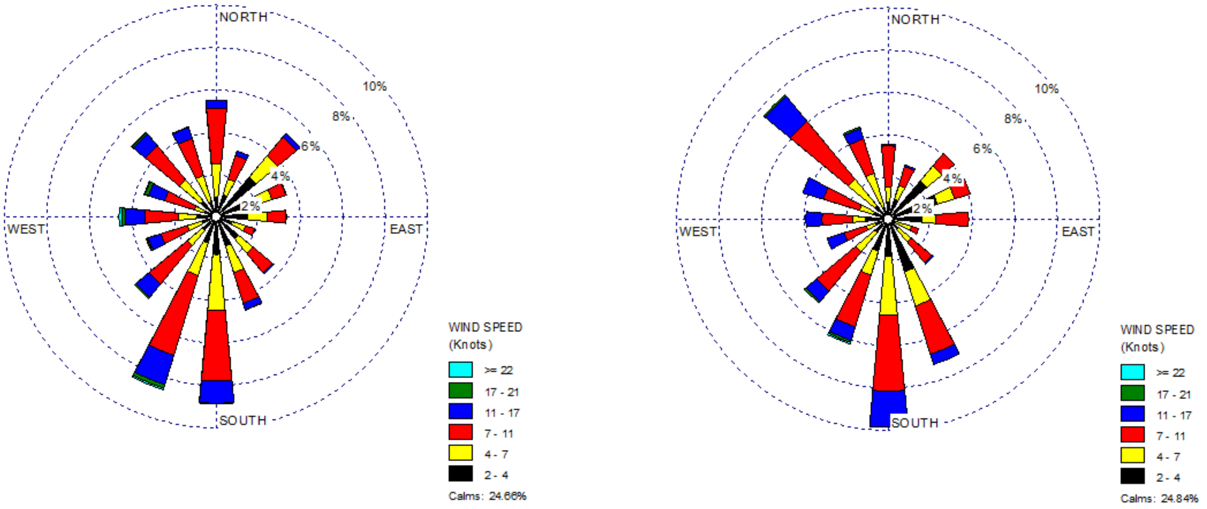
- The sample day wind roses for all three sites have fewer winds on the top half of the wind rose. The historical and full-year wind roses show that most of the directions with a northerly component account for roughly 3 percent to 4 percent of observations. These percentages are more variable for the sample day wind roses.

Figure 13-34. Wind Roses for the Evansville Regional Airport Weather Station near BAKY



Location of BAKY and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Observations from Figure 13-34 for BAKY include the following:

- The Evansville Regional Airport weather station is located approximately 12 miles north-northwest of BAKY. This weather station is in Ohio, with most of the city of Evansville between the site and the station.

- The historical wind rose shows that winds from a variety of directions are observed near BAKY, although winds from the south and southwest quadrant are observed the most and winds from the southeast quadrant are observed the least. Calm winds account for just less than one-quarter of the observations.

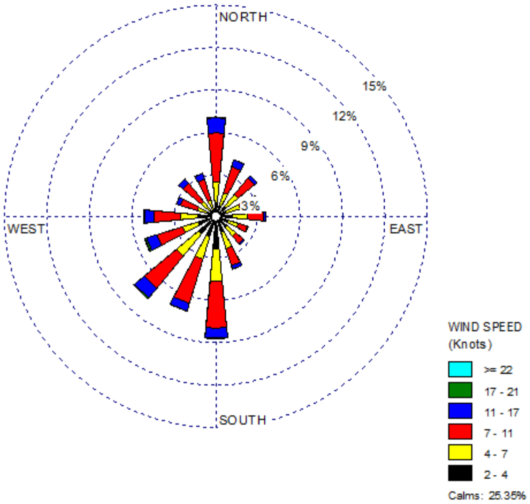
- The full-year wind rose shows that winds from all directions were observed, with winds from the south and south-southwest accounting for the highest percentage of winds greater than 2 knots. Calm winds account for approximately one-quarter of the observations.

- The sample day wind rose for BAKY shares some similarities with the full-year and historical wind roses, but exhibits some differences as well. Although southerly winds are prevalent and calm winds still account for one-quarter of the observations, there is a higher percentage of winds from the south-southeast and northwest, while fewer south-southwesterly winds were observed. BAKY did not begin sampling until March; thus, a full year's worth of wind observations may look different.

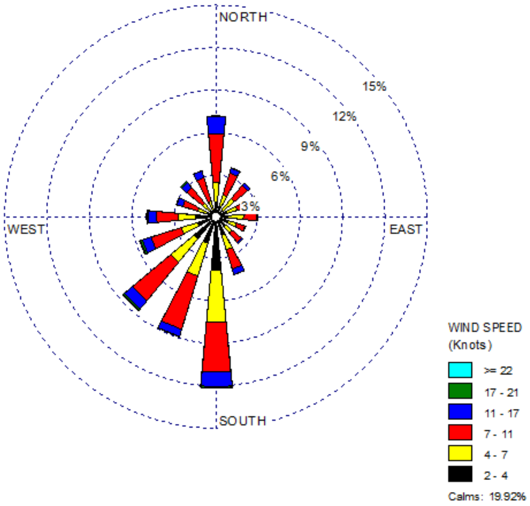
Figure 13-35. Wind Roses for the Barkley Regional Airport Weather Station near ATKY

Location of ATKY and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

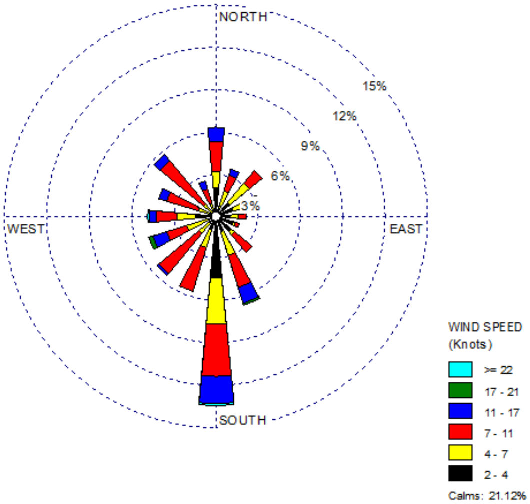
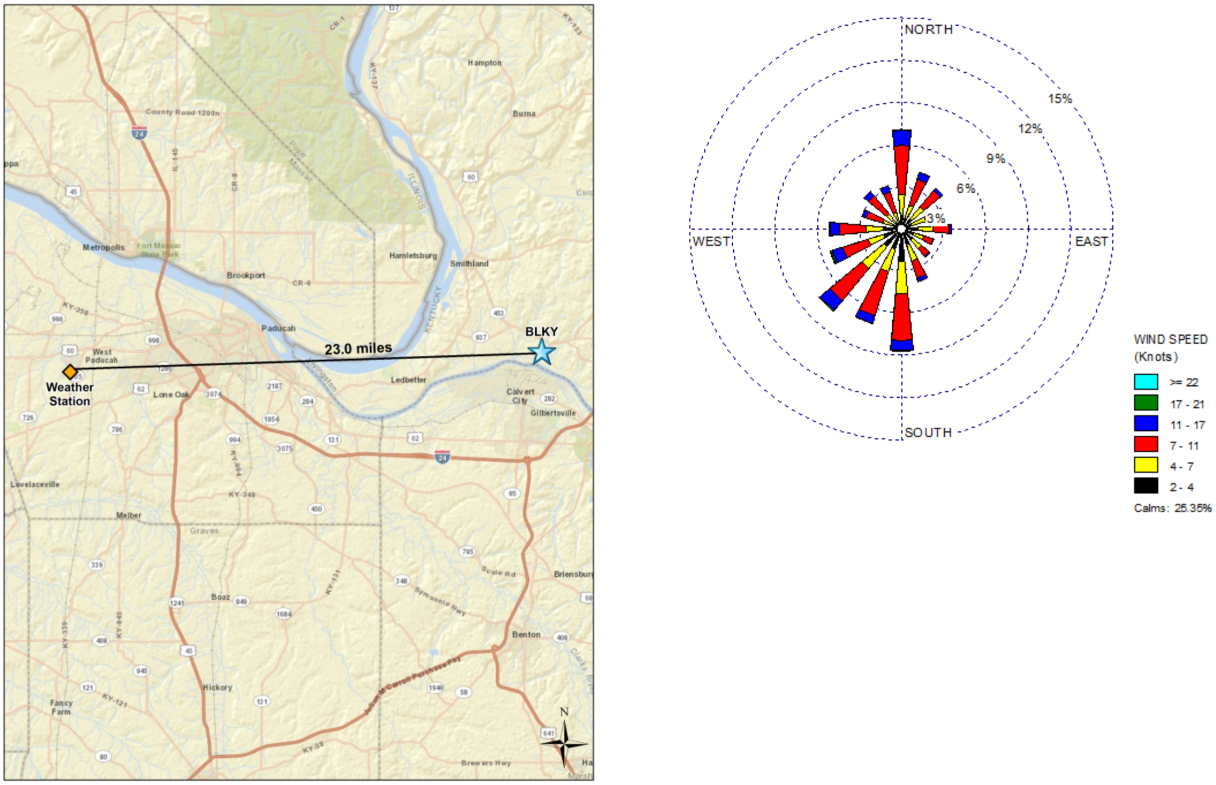


Figure 13-36. Wind Roses for the Barkley Regional Airport Weather Station near BLKY

Location of BLKY and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

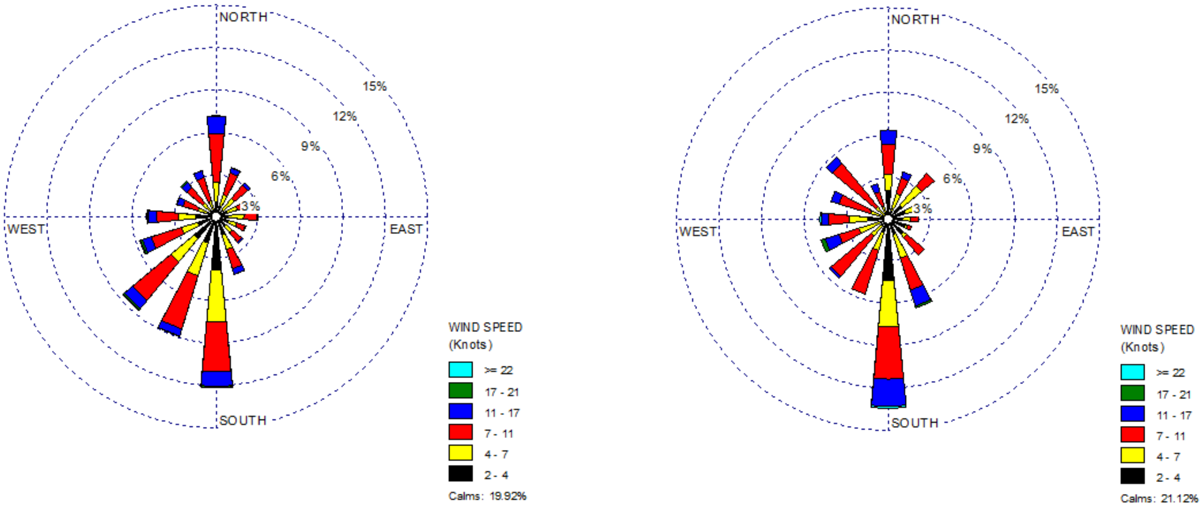
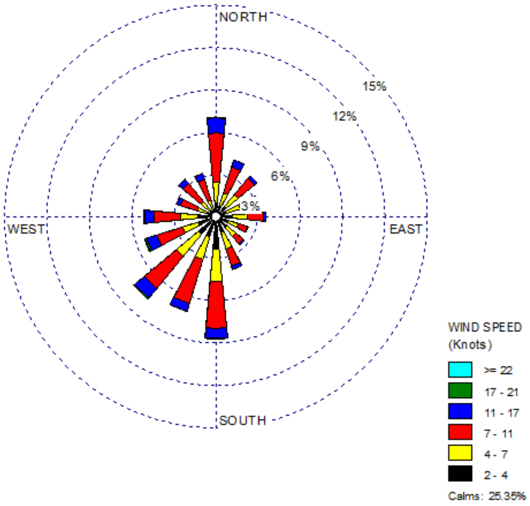


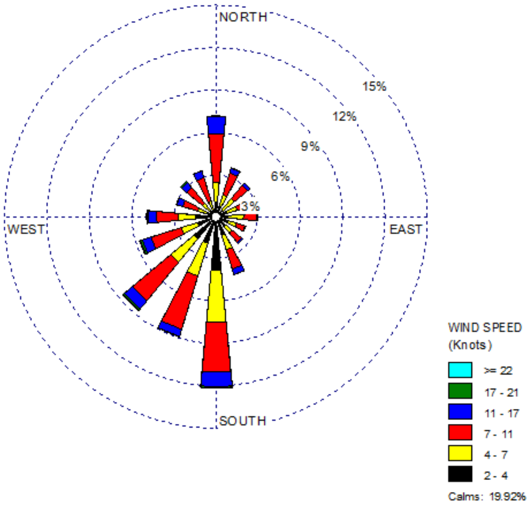
Figure 13-37. Wind Roses for the Barkley Regional Airport Weather Station near CCKY

Location of CCKY and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

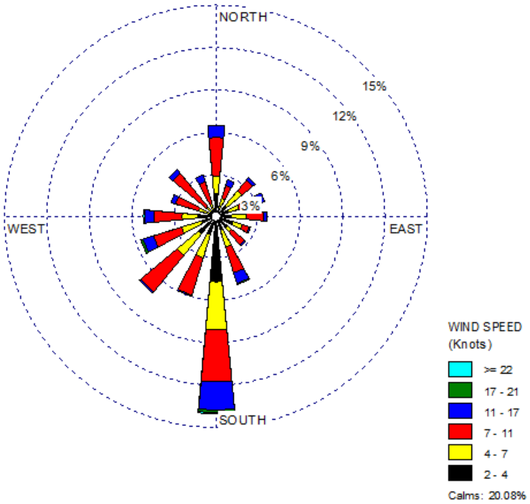
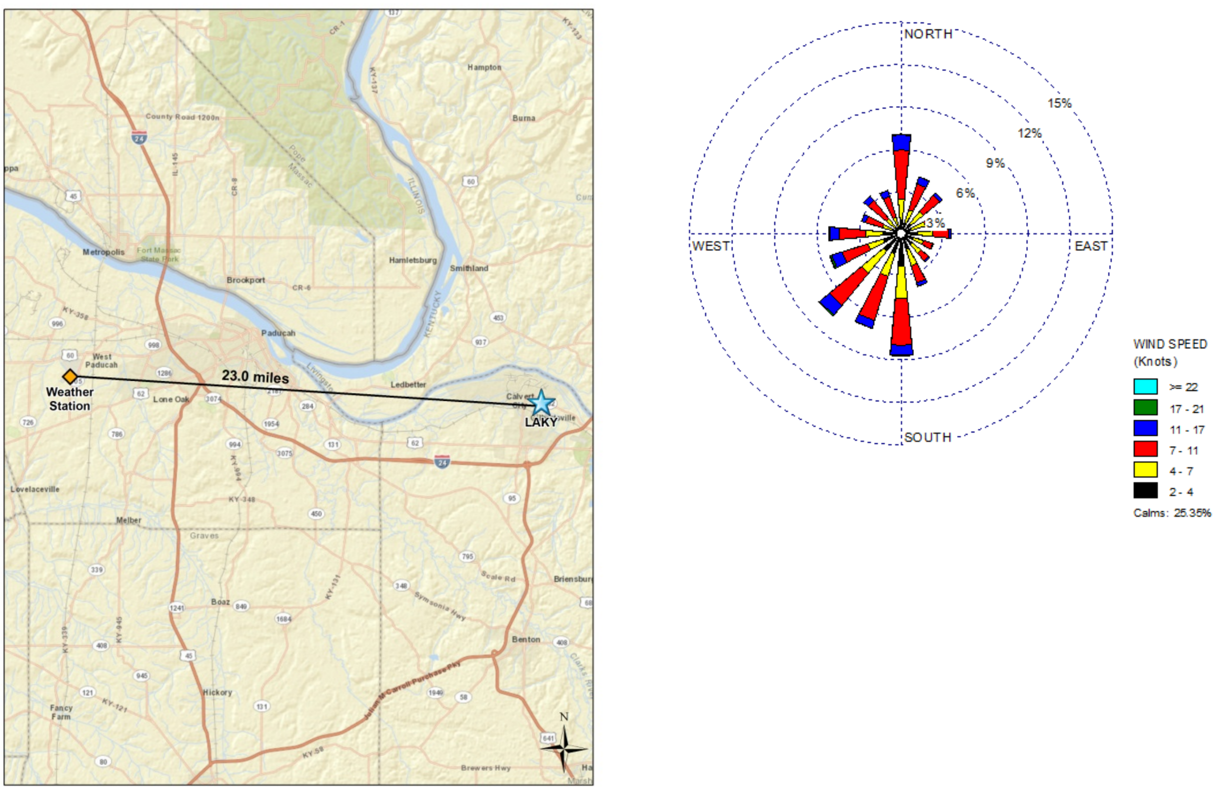
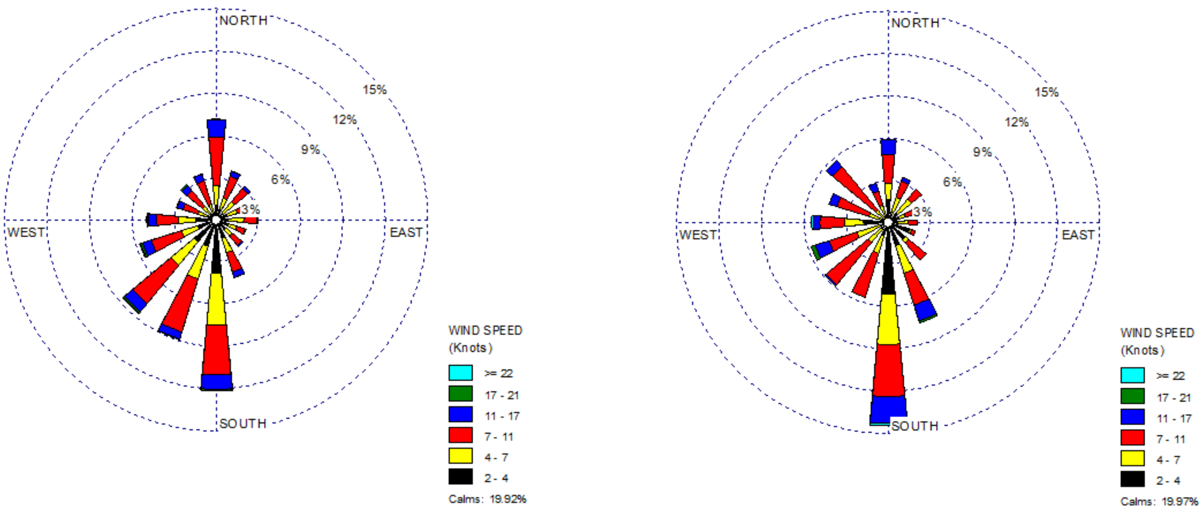


Figure 13-38. Wind Roses for the Barkley Regional Airport Weather Station near LAKY



Location of LAKY and Weather Station

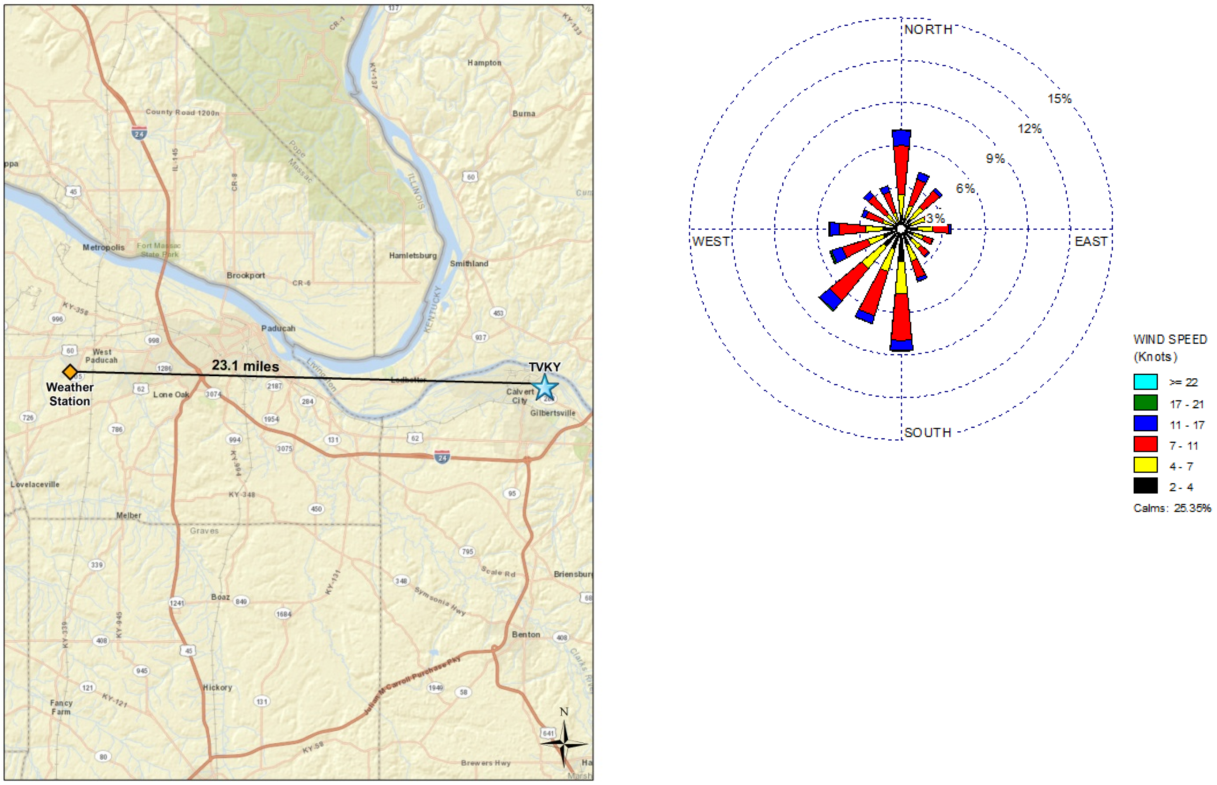
2002-2011 Historical Wind Rose



2012 Wind Rose

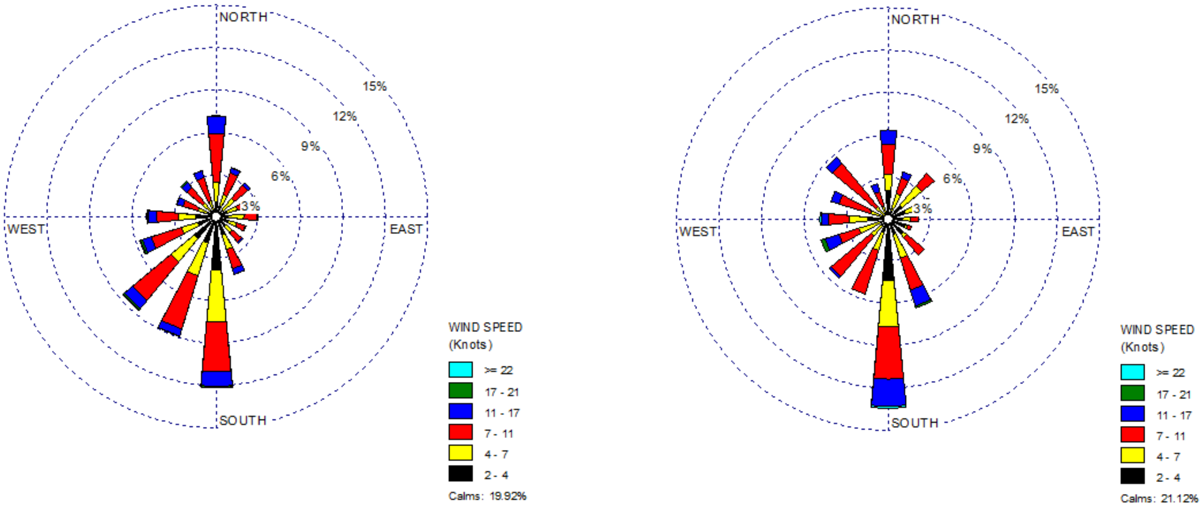
Sample Day Wind Rose

Figure 13-39. Wind Roses for the Barkley Regional Airport Weather Station near TVKY



Location of TVKY and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Observations from Figures 13-35 through 13-39 for the Calvert City sites include the following:

- The Barkley Regional Airport weather station is the closest weather station to all five sites in and near Calvert City. The weather station is located between 20 miles and 25 miles west of the Calvert City monitoring sites and just west of the Paducah metro area.

- The historical and full-year wind roses are identical across the sites because these five sites share the same weather station.

- The historical wind rose shows that winds from the south, southwest quadrant, and north account for the majority of wind observations near these sites, although calm winds account for approximately 25 percent of the hourly measurements.

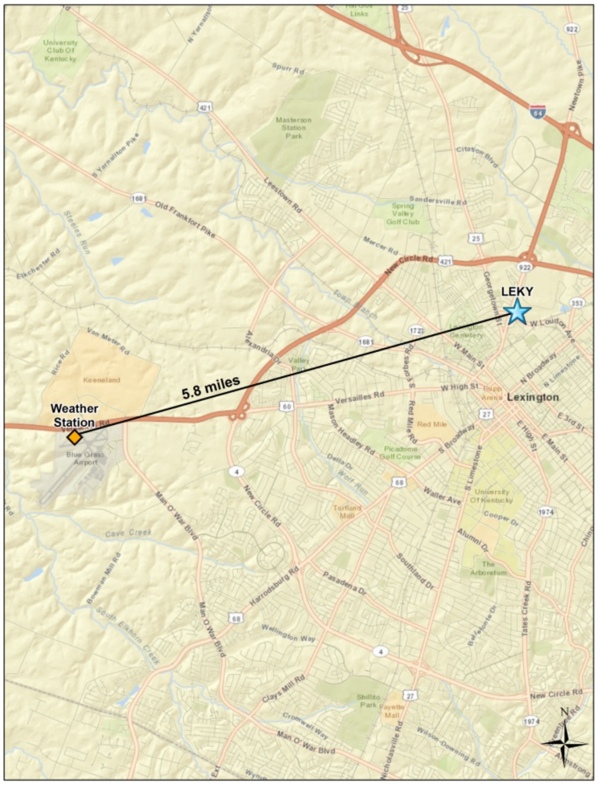
- The full-year wind rose resembles the historical wind rose, but has a higher percentage of winds from the south to south-west and slightly fewer calm observations (20 percent).

- The sample day wind roses for ATKY, BLKY, and TVKY are identical because these three sites all began sampling in July and sampled on all the same days. Sampling at LAKY also began in July but differs slightly from the other three sites because of make-up days. The sample day wind roses for these sites show that southerly winds were prevalent on sample days during the second half of 2012. In addition, the percentage of winds from the south-southwest and southwest is less while the percentage of winds from the south-southeast and northwest is higher. Calm winds account for approximately 20 percent to 21 percent of the wind observations.

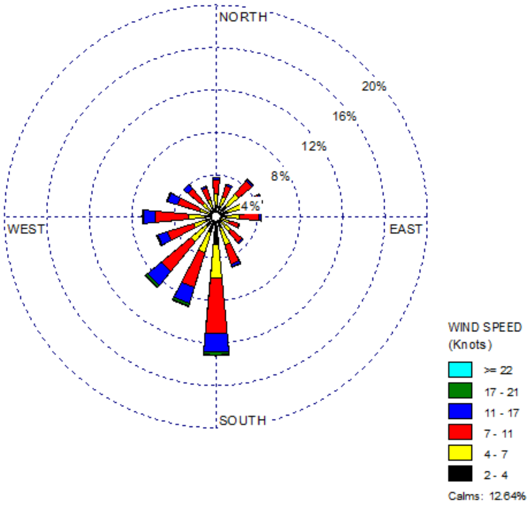
- Sampling at CCKY under the NMP began in March; thus, the sample day wind rose reflects wind observations for an additional four months of sample days compared to the other Calvert City sites. Yet, the differences between the sample day wind rose for CCKY and the other Calvert City sites are not significant as southerly winds were prevalent near CCKY and calm winds accounted for 20 percent of the observations.

Figure 13-40. Wind Roses for the Blue Grass Airport Weather Station near LEKY

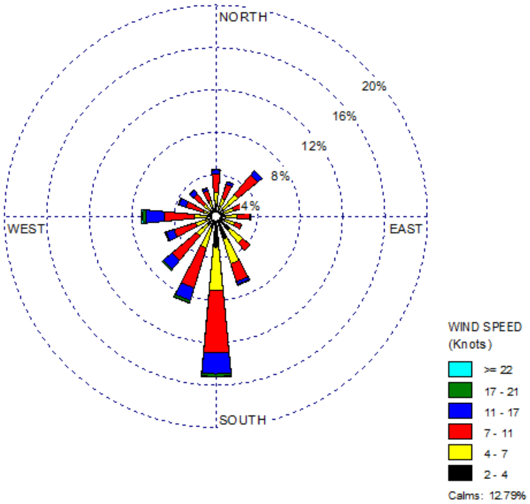
Location of LEKY and Weather Station



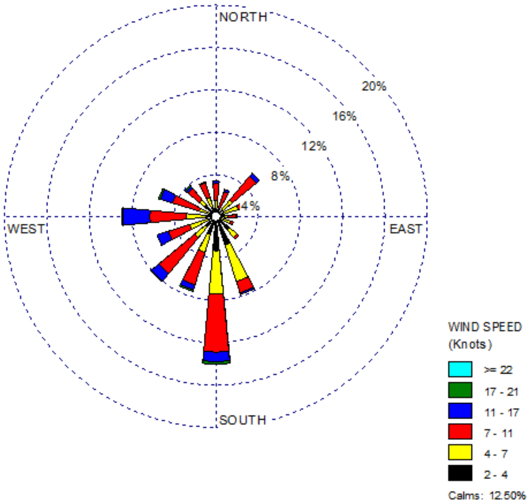
2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose



Observations from Figure 13-40 for LEKY include the following:

- The Blue Grass Airport weather station is located approximately 6 miles west-southwest of the LEKY monitoring site. As shown, the airport is located on the western edge of the Lexington metro area.

- The historical wind rose shows that winds from the south, southwest quadrant, and west account for the majority of wind observations near LEKY, particularly winds from the south, which account for roughly 13 percent of observations. Winds from other directions account for 5 percent of wind observations or less each. Calm winds account for nearly 13 percent of the hourly measurements.

- The full-year wind rose resembles the historical wind rose, although the decrease in the wind observations from the southwest to west-southwest is offset by the additional wind observations from the south-southeast and south.

- Sampling at LEKY under the NMP began in March; thus, the sample day wind rose reflects wind observations for 10 months of the year. The wind patterns on the sample day wind rose for LEKY resemble the wind patterns on both the historical and full-year wind roses. While southerly winds were still prevalent on sample days, an even higher percentage of winds from the south-southeast were observed.

13.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Kentucky monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens.

It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Table 13-4 provides an overview of which analyses were performed at each site and when each site began sampling under the NMP, as there are 10 monitoring sites in Kentucky and their respective start dates are variable. The site-specific results of the risk-based screening process are presented in Table 13-5, with the pollutants of interest shaded in gray.

Table 13-4. Overview of Sampling Performed at the Kentucky Monitoring Sites

Site	VOCs	Carbonyl Compounds	PAHs	PM_{10} Metals	Hexavalent Chromium
ASKY	7/14/12	7/14/12	--	--	--
ASKY-M	--	--	--	3/4/12	--
GLKY	1/4/12	1/4/12	1/4/12	1/4/12	1/4/12
BAKY	--	--	--	3/4/12	--
ATKY	7/14/12	--	--	--	--
BLKY	7/14/12	--	--	--	--
CCKY	7/14/12	--	--	3/4/12	--
LAKY	7/14/12	--	--	--	--
TVKY	7/14/12	--	--	--	--
LEKY	7/17/12	7/14/12	--	3/4/12	--

-- = This pollutant group was not sampled for at this site.
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 13-4 include the following:

- GLKY sampled carbonyl compounds, VOCs, PAHs, PM_{10} metals, and hexavalent chromium throughout 2012.
- Those additional sites sampling PM_{10} metals (ASKY-M, BAKY, CCKY, and LEKY) began sampling under the NMP in March 2012.
- Those additional sites sampling VOCs (ASKY, ATKY, BLKY, CCKY, LAKY, TVKY, and LEKY) began sampling under the NMP in July 2012.
- Those additional sites sampling carbonyl compounds (ASKY and LEKY) also began sampling under the NMP in July 2012.

Table 13-5. Risk-Based Screening Results for the Kentucky Monitoring Sites

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Health Department, Ashland, Kentucky - ASKY						
Acetaldehyde	0.45	29	29	100.00	16.02	16.02
Benzene	0.13	29	29	100.00	16.02	32.04
Carbon Tetrachloride	0.17	29	29	100.00	16.02	48.07
Formaldehyde	0.077	29	29	100.00	16.02	64.09
1,3-Butadiene	0.03	26	28	92.86	14.36	78.45
1,2-Dichloroethane	0.038	24	24	100.00	13.26	91.71
Ethylbenzene	0.4	9	29	31.03	4.97	96.69
p-Dichlorobenzene	0.091	2	21	9.52	1.10	97.79
Hexachloro-1,3-butadiene	0.045	2	3	66.67	1.10	98.90
1,2-Dibromoethane	0.0017	1	1	100.00	0.55	99.45
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.55	100.00
Total		181	223	81.17		

Table 13-5. Risk-Based Screening Results for the Kentucky Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
21st and Greenup, Ashland, Kentucky - ASKY-M						
Arsenic (PM$_{10}$)	0.00023	47	50	94.00	30.32	30.32
Manganese (PM$_{10}$)	0.005	46	50	92.00	29.68	60.00
Nickel (PM$_{10}$)	0.0021	24	50	48.00	15.48	75.48
Cadmium (PM$_{10}$)	0.00056	19	50	38.00	12.26	87.74
Lead (PM$_{10}$)	0.015	18	50	36.00	11.61	99.35
Antimony (PM$_{10}$)	0.02	1	50	2.00	0.65	100.00
Total		155	300	51.67		
Grayson, Kentucky - GLKY						
Benzene	0.13	61	61	100.00	14.39	14.39
Carbon Tetrachloride	0.17	61	61	100.00	14.39	28.77
Formaldehyde	0.077	61	61	100.00	14.39	43.16
1,2-Dichloroethane	0.038	56	56	100.00	13.21	56.37
Acetaldehyde	0.45	52	61	85.25	12.26	68.63
Arsenic (PM$_{10}$)	0.00023	51	59	86.44	12.03	80.66
1,3-Butadiene	0.03	51	59	86.44	12.03	92.69
Manganese (PM$_{10}$)	0.005	13	59	22.03	3.07	95.75
Naphthalene	0.029	6	61	9.84	1.42	97.17
1,1,2,2-Tetrachloroethane	0.017	5	5	100.00	1.18	98.35
Hexachloro-1,3-butadiene	0.045	3	4	75.00	0.71	99.06
1,2-Dibromoethane	0.0017	2	2	100.00	0.47	99.53
Cadmium (PM$_{10}$)	0.00056	1	55	1.82	0.24	99.76
Ethylbenzene	0.4	1	61	1.64	0.24	100.00
Total		424	665	63.76		
Baskett, Kentucky - BAKY						
Arsenic (PM$_{10}$)	0.00023	46	50	92.00	55.42	55.42
Manganese (PM$_{10}$)	0.005	36	50	72.00	43.37	98.80
Cadmium (PM$_{10}$)	0.00056	1	50	2.00	1.20	100.00
Total		83	150	55.33		
Atmos Energy, Calvert City, Kentucky - ATKY						
Benzene	0.13	29	29	100.00	23.97	23.97
Carbon Tetrachloride	0.17	29	29	100.00	23.97	47.93
1,2-Dichloroethane	0.038	26	26	100.00	21.49	69.42
1,3-Butadiene	0.03	22	25	88.00	18.18	87.60
Vinyl chloride	0.11	11	16	68.75	9.09	96.69
1,1,2-Trichloroethane	0.0625	3	3	100.00	2.48	99.17
Hexachloro-1,3-butadiene	0.045	1	5	20.00	0.83	100.00
Total		121	133	90.98		

Table 13-5. Risk-Based Screening Results for the Kentucky Monitoring Sites (Continued)

Pollutant	Screening Value (μg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Smithland, Kentucky - BLKY						
Benzene	0.13	26	26	100.00	25.49	25.49
Carbon Tetrachloride	0.17	26	26	100.00	25.49	50.98
1,2-Dichloroethane	0.038	23	23	100.00	22.55	73.53
1,3-Butadiene	0.03	17	21	80.95	16.67	90.20
Vinyl chloride	0.11	7	14	50.00	6.86	97.06
1,1,2-Trichloroethane	0.0625	2	2	100.00	1.96	99.02
Hexachloro-1,3-butadiene	0.045	1	1	100.00	0.98	100.00
Total		102	113	90.27		
Calvert City Elementary, Calvert City, Kentucky - CCKY						
Arsenic (PM_{10})	0.00023	45	47	95.74	26.01	26.01
Manganese (PM_{10})	0.005	28	47	59.57	16.18	42.20
Carbon Tetrachloride	0.17	26	26	100.00	15.03	57.23
Benzene	0.13	25	26	96.15	14.45	71.68
1,2-Dichloroethane	0.038	23	23	100.00	13.29	84.97
1,3-Butadiene	0.03	19	24	79.17	10.98	95.95
Vinyl chloride	0.11	4	11	36.36	2.31	98.27
1,1,2-Trichloroethane	0.0625	2	2	100.00	1.16	99.42
Hexachloro-1,3-butadiene	0.045	1	4	25.00	0.58	100.00
Total		173	210	82.38		
Lazy Daze, Calvert City, Kentucky - LAKY						
Benzene	0.13	29	29	100.00	21.17	21.17
Carbon Tetrachloride	0.17	29	29	100.00	21.17	42.34
1,2-Dichloroethane	0.038	27	27	100.00	19.71	62.04
1,3-Butadiene	0.03	24	28	85.71	17.52	79.56
Vinyl chloride	0.11	12	19	63.16	8.76	88.32
1,1,2,2-Tetrachloroethane	0.017	6	6	100.00	4.38	92.70
1,2-Dibromoethane	0.0017	3	3	100.00	2.19	94.89
Hexachloro-1,3-butadiene	0.045	3	7	42.86	2.19	97.08
1,1,2-Trichloroethane	0.0625	3	5	60.00	2.19	99.27
p-Dichlorobenzene	0.091	1	12	8.33	0.73	100.00
Total		137	165	83.03		

Table 13-5. Risk-Based Screening Results for the Kentucky Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
TVA Substation, Calvert City, Kentucky - TVKY						
Carbon Tetrachloride	0.17	28	28	100.00	21.54	21.54
Benzene	0.13	27	28	96.43	20.77	42.31
1,2-Dichloroethane	0.038	27	27	100.00	20.77	63.08
1,3-Butadiene	0.03	22	24	91.67	16.92	80.00
Vinyl chloride	0.11	14	19	73.68	10.77	90.77
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	3.08	93.85
1,1,2-Trichloroethane	0.0625	4	6	66.67	3.08	96.92
Hexachloro-1,3-butadiene	0.045	2	5	40.00	1.54	98.46
1,2-Dibromoethane	0.0017	1	1	100.00	0.77	99.23
p-Dichlorobenzene	0.091	1	9	11.11	0.77	100.00
Total		130	151	86.09		
Lexington, Kentucky - LEKY						
Arsenic (PM$_{10}$)	0.00023	45	49	91.84	17.79	17.79
Manganese (PM$_{10}$)	0.005	32	49	65.31	12.65	30.43
Benzene	0.13	29	29	100.00	11.46	41.90
Carbon Tetrachloride	0.17	29	29	100.00	11.46	53.36
Acetaldehyde	0.45	27	27	100.00	10.67	64.03
1,3-Butadiene	0.03	27	27	100.00	10.67	74.70
Formaldehyde	0.077	27	27	100.00	10.67	85.38
1,2-Dichloroethane	0.038	24	24	100.00	9.49	94.86
p-Dichlorobenzene	0.091	3	14	21.43	1.19	96.05
Ethylbenzene	0.4	3	29	10.34	1.19	97.23
1,2-Dibromoethane	0.0017	2	2	100.00	0.79	98.02
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.79	98.81
Beryllium (PM$_{10}$)	0.00042	1	48	2.08	0.40	99.21
Hexachloro-1,3-butadiene	0.045	1	3	33.33	0.40	99.60
Nickel (PM$_{10}$)	0.0021	1	49	2.04	0.40	100.00
Total		253	408	62.01		

Observations for the Ashland sites from Table 13-5 include the following:

- The number of pollutants failing screens varied significantly among the monitoring sites; this is expected given the different pollutants measured at each site, as shown in Table 13-4. VOCs and carbonyl compounds were sampled for at ASKY while only PM$_{10}$ metals were sampled for at ASKY-M.

- Eleven pollutants failed at least one screen for ASKY, with 81 percent of concentrations for these 11 pollutants greater than their associated risk screening value (or failed screens).

- Seven pollutants contributed to 95 percent of failed screens for ASKY and therefore were identified as pollutants of interest. These seven include two carbonyl compounds and five VOCs.

- Six metals failed at least one screen for ASKY-M, with 52 percent of concentrations for these six pollutants greater than their associated risk screening value (or failed screens).

- Five metals contributed to 95 percent of failed screens for ASKY-M and therefore were identified as pollutants of interest (arsenic, cadmium, lead, manganese, and nickel).

Observations for GLKY from Table 13-5 include the following:

- GLKY sampled for all five pollutant groups shown in Table 13-4.

- Fourteen pollutants failed at least one screen for GLKY, with nearly 64 percent of concentrations for these 14 pollutants greater than their associated risk screening value (or failed screens).

- Eight pollutants contributed to 95 percent of failed screens for GLKY and therefore were identified as pollutants of interest. These include two carbonyl compounds, four VOCs, and two metals.

Observations for BAKY from Table 13-5 include the following:

- Like ASKY-M, BAKY sampled for PM_{10} metals only.

- Three pollutants failed at least one screen for BAKY, with 55 percent of concentrations for these three pollutants greater than their associated risk screening value (or failed screens). This site had the fewest pollutants fail screens among the Kentucky monitoring sites.

- Arsenic and manganese contributed to 95 percent of failed screens for BAKY and therefore were identified as pollutants of interest for this site.

Observations for the Calvert City sites from Table 13-5 include the following:

- VOCs were sampled for at all five Calvert City sites. PM_{10} metals were also sampled for at CCKY.

- The number of pollutants whose concentrations were greater than their associated risk screening value varied from seven (ATKY and BLKY) to 10 (LAKY and TVKY).

- Five pollutants contributed to 95 percent of failed screens for ATKY and therefore were identified as pollutants of interest for this site.

- Five pollutants contributed to 95 percent of failed screens for BLKY and therefore were identified as pollutants of interest for this site.

- Six pollutants contributed to 95 percent of failed screens for CCKY and therefore were identified as pollutants of interest for this site. The pollutants of interest for

CCKY include two metals and four VOCs. Although arsenic and manganese failed the greatest number of screens for CCKY, PM_{10} metals sampling under the NMP began 3 months before sampling for VOCs began.

- Nine pollutants contributed to 95 percent of failed screens for LAKY and therefore were identified as pollutants of interest for this site. Although the pollutants through hexachloro-1,3-butadiene together account for more than 95 percent of the total failed screens for LAKY,1,1,2-trichloroethane failed the same number of screens as hexachloro-1,3-butadiene; thus, 1,1,2-trichloroethane was added as pollutants of interest for LAKY, per the procedure described in Section 3.2.

- Seven pollutants contributed to 95 percent of failed screens for TVKY and therefore were identified as pollutants of interest for this site.

- Benzene, carbon tetrachloride, 1,2-dichloroethane, and 1,3-butadiene were identified as pollutants of interest for all five Calvert City sites.

Observations for LEKY from Table 13-5 include the following:

- Aside from GLKY, LEKY sampled for the most pollutant groups. Carbonyl compounds, VOCs, and PM_{10} metals were sampled for at LEKY.

- Fifteen pollutants failed at least one screen for LEKY, with 62 percent of concentrations for these 15 pollutants greater than their associated risk screening value (or failed screens).

- Ten pollutants contributed to 95 percent of failed screens for LEKY and therefore were identified as pollutants of interest. These include two carbonyl compounds, six VOCs, and two metals.

- Although arsenic and manganese failed the greatest number of screens for LEKY, it should be noted that PM_{10} metals sampling under the NMP began 3 months before sampling for VOCs and carbonyl compounds began.

13.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Kentucky monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.

- Annual concentration averages are presented graphically for each site to illustrate how the site’s concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for the Kentucky monitoring sites are provided in Appendices J, L, M, N, and O.

13.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Kentucky sites, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Kentucky monitoring sites are presented in Table 13-6, where applicable. Many of the pollutants of interest for the Kentucky sites do not have annual averages due to the relatively short sampling duration (those sites/methods that began in July). However, pollutant-specific average concentrations for all valid VOC and carbonyl compound samples collected over the entire sample period are provided in Appendix J and Appendix L. Note that concentrations of the PAHs and metals are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 13-6. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Health Department, Ashland, Kentucky - ASKY						
Acetaldehyde	29/29	NA	NA	1.30 ± 0.20	1.44 ± 0.47	NA
Benzene	29/29	NA	NA	0.76 ± 0.21	1.15 ± 0.30	NA
1,3-Butadiene	28/29	NA	NA	0.08 ± 0.03	0.15 ± 0.05	NA
Carbon Tetrachloride	29/29	NA	NA	0.64 ± 0.03	0.71 ± 0.03	NA
1,2-Dichloroethane	24/29	NA	NA	0.05 ± 0.01	0.07 ± 0.02	NA
Ethylbenzene	29/29	NA	NA	0.32 ± 0.09	0.37 ± 0.11	NA
Formaldehyde	29/29	NA	NA	3.67 ± 0.80	1.82 ± 0.40	NA
21st and Greenup, Ashland, Kentucky - ASKY-M						
Arsenic (PM$_{10}$)[a]	50/50	NA	1.95 ± 0.56	1.83 ± 0.81	1.39 ± 0.59	1.79 ± 0.37
Cadmium (PM$_{10}$)[a]	50/50	NA	0.69 ± 0.26	0.41 ± 0.13	0.51 ± 0.41	0.56 ± 0.16
Lead (PM$_{10}$)[a]	50/50	NA	18.31 ± 7.06	11.21 ± 5.11	8.43 ± 3.64	14.35 ± 4.60
Manganese (PM$_{10}$)[a]	50/50	NA	46.19 ± 15.74	22.93 ± 7.05	21.70 ± 10.23	34.09 ± 10.53
Nickel (PM$_{10}$)[a]	50/50	NA	3.36 ± 1.23	2.51 ± 1.55	1.85 ± 0.88	2.94 ± 0.90
Grayson, Kentucky - GLKY						
Acetaldehyde	61/61	0.65 ± 0.14	0.92 ± 0.14	0.76 ± 0.18	0.74 ± 0.26	0.77 ± 0.09
Benzene	61/61	0.55 ± 0.10	0.41 ± 0.08	0.34 ± 0.06	0.57 ± 0.11	0.46 ± 0.05
1,3-Butadiene	59/61	0.05 ± 0.01	0.04 ± 0.02	0.05 ± 0.03	0.11 ± 0.04	0.06 ± 0.01
Carbon Tetrachloride	61/61	0.66 ± 0.09	0.71 ± 0.04	0.65 ± 0.04	0.73 ± 0.03	0.69 ± 0.03
1,2-Dichloroethane	56/61	0.08 ± 0.02	0.07 ± 0.01	0.05 ± 0.01	0.07 ± 0.01	0.07 ± 0.01
Formaldehyde	61/61	0.80 ± 0.24	2.27 ± 0.54	2.44 ± 0.78	1.00 ± 0.19	1.64 ± 0.31
Arsenic (PM$_{10}$)[a]	59/59	0.49 ± 0.15	0.58 ± 0.23	0.59 ± 0.24	0.69 ± 0.24	0.58 ± 0.10
Manganese (PM$_{10}$)[a]	59/59	2.57 ± 1.03	5.56 ± 3.16	3.23 ± 1.14	3.48 ± 2.02	3.71 ± 0.98

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Table 13-6. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Baskett, Kentucky - BAKY						
Arsenic (PM_{10})[a]	50/50	NA	0.76 ± 0.23	1.10 ± 0.46	1.00 ± 0.42	0.93 ± 0.19
Manganese (PM_{10})[a]	50/50	NA	7.42 ± 1.48	6.48 ± 1.32	6.71 ± 1.91	6.74 ± 0.84
Atmos Energy, Calvert City, Kentucky - ATKY						
Benzene	29/29	NA	NA	0.58 ± 0.15	0.63 ± 0.15	NA
1,3-Butadiene	25/29	NA	NA	0.11 ± 0.10	0.10 ± 0.05	NA
Carbon Tetrachloride	29/29	NA	NA	0.70 ± 0.04	0.78 ± 0.09	NA
1,2-Dichloroethane	26/29	NA	NA	0.71 ± 0.84	0.48 ± 0.44	NA
Vinyl chloride	16/29	NA	NA	0.43 ± 0.48	1.05 ± 1.35	NA
Smithland, Kentucky - BLKY						
Benzene	26/26	NA	NA	0.50 ± 0.16	0.55 ± 0.15	NA
1,3-Butadiene	21/26	NA	NA	0.24 ± 0.39	0.38 ± 0.59	NA
Carbon Tetrachloride	26/26	NA	NA	0.70 ± 0.06	0.78 ± 0.09	NA
1,2-Dichloroethane	23/26	NA	NA	0.78 ± 1.11	0.89 ± 0.85	NA
Vinyl chloride	14/26	NA	NA	0.11 ± 0.09	0.11 ± 0.11	NA
Calvert City Elementary, Calvert City, Kentucky - CCKY						
Benzene	26/26	NA	NA	0.51 ± 0.16	0.57 ± 0.10	NA
1,3-Butadiene	24/26	NA	NA	0.06 ± 0.03	0.09 ± 0.04	NA
Carbon Tetrachloride	26/26	NA	NA	0.69 ± 0.04	0.77 ± 0.04	NA
1,2-Dichloroethane	23/26	NA	NA	0.46 ± 0.35	0.17 ± 0.11	NA
Arsenic (PM_{10})[a]	47/47	NA	0.65 ± 0.19	1.22 ± 0.86	0.78 ± 0.24	0.86 ± 0.28
Manganese (PM_{10})[a]	47/47	NA	7.20 ± 1.25	6.85 ± 1.67	6.35 ± 2.39	6.50 ± 0.96

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Table 13-6. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Lazy Daze, Calvert City, Kentucky - LAKY						
Benzene	29/29	NA	NA	0.72 ± 0.27	0.61 ± 0.09	NA
1,3-Butadiene	28/29	NA	NA	0.09 ± 0.05	0.14 ± 0.09	NA
Carbon Tetrachloride	29/29	NA	NA	0.77 ± 0.07	0.76 ± 0.06	NA
1,2-Dibromoethane	3/29	NA	NA	0.01 ± 0.01	<0.01 ± 0.01	NA
1,2-Dichloroethane	27/29	NA	NA	0.80 ± 0.51	0.30 ± 0.23	NA
Hexachloro-1,3-butadiene	7/29	NA	NA	0.03 ± 0.02	0.01 ± 0.01	NA
1,1,2,2-Tetrachloroethane	6/29	NA	NA	0.02 ± 0.01	0.02 ± 0.02	NA
1,1,2-Trichloroethane	5/29	NA	NA	0.02 ± 0.02	0.03 ± 0.06	NA
Vinyl chloride	19/29	NA	NA	0.19 ± 0.13	0.14 ± 0.12	NA
TVA Substation, Calvert City, Kentucky - TVKY						
Benzene	28/28	NA	NA	1.15 ± 0.79	0.71 ± 0.32	NA
1,3-Butadiene	24/28	NA	NA	0.24 ± 0.23	0.17 ± 0.15	NA
Carbon Tetrachloride	28/28	NA	NA	1.14 ± 0.57	1.28 ± 0.60	NA
1,2-Dichloroethane	27/28	NA	NA	2.77 ± 2.75	1.91 ± 2.07	NA
1,1,2,2-Tetrachloroethane	4/28	NA	NA	0.01 ± 0.01	0.01 ± 0.02	NA
1,1,2-Trichloroethane	6/28	NA	NA	0.06 ± 0.08	0.01 ± 0.01	NA
Vinyl chloride	19/28	NA	NA	0.87 ± 1.02	0.28 ± 0.26	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Table 13-6. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Lexington, Kentucky - LEKY						
Acetaldehyde	27/27	NA	NA	NA	1.19 ± 0.26	NA
Benzene	29/29	NA	NA	0.61 ± 0.11	0.63 ± 0.13	NA
1,3-Butadiene	27/29	NA	NA	0.10 ± 0.04	0.12 ± 0.05	NA
Carbon Tetrachloride	29/29	NA	NA	0.63 ± 0.03	0.66 ± 0.03	NA
p-Dichlorobenzene	14/29	NA	NA	0.06 ± 0.03	0.01 ± 0.01	NA
1,2-Dichloroethane	24/29	NA	NA	0.04 ± 0.02	0.06 ± 0.01	NA
Ethylbenzene	29/29	NA	NA	0.28 ± 0.07	0.22 ± 0.07	NA
Formaldehyde	27/27	NA	NA	NA	2.03 ± 0.44	NA
Arsenic (PM_{10})[a]	49/49	NA	0.67 ± 0.23	0.86 ± 0.30	1.25 ± 0.42	0.92 ± 0.17
Manganese (PM_{10})[a]	49/49	NA	7.01 ± 1.69	6.85 ± 1.64	6.62 ± 2.33	6.69 ± 0.96

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for the Ashland sites from Table 13-6 include the following:

- First and second quarter and annual average concentrations could not be calculated for the pollutants of interest for ASKY because sampling did not begin until July 2012. However, Appendix J and Appendix L provide the pollutant-specific average concentrations for all valid VOC and carbonyl compound samples collected over the entire sample period.

- With the exception of 1,3-butadiene and 1,2-dichloroethane, each of the pollutants of interest for ASKY were detected in all the valid VOC samples collected.

- With the exception of formaldehyde, concentrations of the pollutants of interest were higher in the fourth quarter than the third quarter, although in most cases, the difference is not statistically significant.

- The third quarter formaldehyde concentration for ASKY is twice the fourth quarter average. A review of the data shows that all eight measurements greater than 3.50 µg/m^3 were measured between July and September while four of the five concentrations less than 1.50 µg/m^3 were measured in December (with the fifth measured in October).

- Sampling of PM_{10} metals began in March at ASKY-M. Each of the five metal pollutants of interest was detected in all of the samples collected. Thus, three quarterly averages and an annual average are presented for ASKY-M.

- The pollutant of interest with the highest annual average concentration for ASKY-M is manganese (34.09 ± 10.53 ng/m^3), followed by lead (14.35 ± 4.60 ng/m^3), and nickel (2.94 ± 0.90 ng/m^3).

- For each of the pollutants of interest for ASKY-M, the highest quarterly average was calculated for the second quarter of 2012. However, with the exception of arsenic, the maximum concentration for each of the pollutants of interest was measured on March 22, 2012. This date is part of the first quarter, for which quarterly averages could not be calculated.

- The second quarter manganese average is nearly twice the other quarterly averages, although the confidence intervals for these averages indicate that there is a considerable amount of variability associated with these averages. The manganese concentrations range from 1.07 ng/m^3 to 236 ng/m^3, with a median concentration of 25.2 ng/m^3. The maximum concentration measured at ASKY-M is the second highest manganese concentration measured program-wide. Of the 18 concentrations greater than 50 ng/m^3 measured across the program (PM_{10} only), 10 were measured at ASKY-M (with three measured at PXSS and five measured at S4MO).

- Similarly, some of the highest concentrations of arsenic program-wide were measured at ASKY-M. Of the 13 concentrations greater than 3 ng/m^3 measured across the program (PM_{10} only), seven were measured at ASKY-M. Arsenic concentrations measured at ASKY-M range from 0.10 ng/m^3 to 5.90 ng/m^3, with a median concentration of 1.61 ng/m^3. The maximum concentration measured at ASKY-M is the second highest concentration measured program-wide.

- Some of the highest concentrations of lead measured program-wide were also measured at ASKY-M. Of the 21 lead concentrations greater than 20 ng/m^3 measured across the program (PM_{10} only), 12 were measured at ASKY-M (with one measured at PAFL and eight measured at S4MO). Lead concentrations measured at ASKY-M range from 1.27 ng/m^3 to 100.1 ng/m^3, with a median concentration of 9.38 ng/m^3. The maximum concentration measured at ASKY-M is again the second highest concentration measured program-wide, with only S4MO and ASKY-M measuring concentrations of lead greater than 100 ng/m^3. However, the second highest concentration measured at ASKY-M is considerably less (42.5 ng/m^3).

- Concentrations of nickel measured at ASKY-M range from 0.14 ng/m^3 to 17.3 ng/m^3, with a median concentration of 1.88 ng/m^3. The maximum concentration measured at ASKY-M is the highest nickel concentration measured program-wide. Of the four nickel concentrations greater than 10 ng/m^3 measured across the program (PM_{10} only), two were measured at ASKY-M (with the other two measured at SEWA).

- Table 4-12 presents the sites with the 10 highest annual average concentrations for each of the metal program-level pollutants of interest. This table shows that the highest annual averages for arsenic, manganese, and nickel calculated across the program were all calculated for ASKY-M.

Observations for GLKY from Table 13-6 include the following:

- The only pollutant of interest with an annual average concentration greater than 1 $\mu g/m^3$ is formaldehyde (1.64 ± 0.31 $\mu g/m^3$). However, this is one of the lowest annual averages of formaldehyde calculated for NMP sites sampling carbonyl compounds.

- Concentrations of formaldehyde were considerably higher during the warmer months of the year, based on the quarterly averages. All but one of the 15 measurements greater than 2 $\mu g/m^3$ were measured during the second or third quarters, with the three highest concentrations all measured in July. Conversely, all but one of the 16 concentrations less than 0.75 $\mu g/m^3$ were measured in the first or fourth quarters.

- Concentrations of acetaldehyde do not exhibit the same tendency as formaldehyde. Concentrations of this pollutant were highest during the second quarter (although not significantly so). The second quarter is the quarter during which the greatest number of concentrations greater than 1 $\mu g/m^3$ were measured (eight), with three measured during the third quarter (all in July), and two in the fourth quarter. Although the maximum acetaldehyde concentration (2.28 $\mu g/m^3$) was measured at GLKY in October, the next highest concentration measured during the fourth quarter was roughly half as high (1.18 $\mu g/m^3$) and no other measurements greater than 1 $\mu g/m^3$ were measured that quarter. This explains the higher confidence interval calculated for the fourth quarter.

- The second quarter average concentration of manganese is higher than the other quarterly averages and has a relatively high confidence interval associated with it. The maximum concentration of manganese was measured at GLKY on April 3, 2012 (24.4 ng/m^3). The next highest concentration measured at GLKY was considerably less (13.6 ng/m^3) and the second highest concentration measured during the second quarter was roughly half as high (13.0 ng/m^3). No other manganese measurements greater than 10 ng/m^3 were measured at this site.

Observations for BAKY from Table 13-6 include the following:

- BAKY has only two pollutants of interest: arsenic and manganese.

- Concentrations of manganese are considerably higher than the concentrations of arsenic measured at this site.

- Among NMP sites sampling PM_{10} metals, BAKY has the fourth highest annual average concentration of arsenic (0.93 ± 0.20 ng/m^3). Arsenic concentrations measured at BAKY range from 0.003 ng/m^3 to 3.71 ng/m^3. The maximum arsenic concentration measured at BAKY is one of the top 10 concentrations measured among NMP sites sampling arsenic.

- BAKY also has the seventh highest annual average concentration of manganese among NMP sites sampling PM_{10} metals (6.74 ± 0.84 ng/m^3). Manganese concentrations measured at BAKY range from 0.99 ng/m^3 to 13.5 ng/m^3.

Observations for the Calvert City monitoring sites from Table 13-6 include the following:

- The only annual averages that could be calculated for the Calvert City sites are for the metal pollutants of interest for CCKY. This is because CCKY is the only site sampling PM_{10} metals, for which sampling began in March. VOC sampling at all five Calvert City sites began in July. However, Appendix J provides the pollutant-specific average concentrations for all valid VOC samples collected over the entire sample period for each site.

- CCKY has two metal pollutants of interest: arsenic and manganese. Concentrations of manganese are considerably higher than the concentrations of arsenic measured at this site.

- Among NMP sites sampling PM_{10} metals, CCKY has the sixth highest annual average concentration of arsenic (0.86 ± 0.28 ng/m^3). Arsenic concentrations measured at CCKY range from 0.15 ng/m^3 to 5.86 ng/m^3. The maximum arsenic concentration measured at CCKY is the third highest concentration among NMP sites sampling arsenic, behind only two measurements (from S4MO and ASKY-M).

- Among NMP sites sampling PM_{10} metals, CCKY has the ninth highest annual average concentration of manganese (6.50 ± 0.96 ng/m^3). Manganese concentrations measured at CCKY range from 1.55 ng/m^3 to 17.9 ng/m^3 with a median concentration of 5.66 ng/m^3.

- Some of the highest concentrations of VOCs were measured at the Calvert City sites and these data are reviewed in the bullets that follow.

- Vinyl chloride is an infrequently detected pollutant under the NMP. Across the program, this pollutant was detected in less than 12 percent of the total samples collected. Together, the five Calvert City sites account for more than half (79) of the 154 measured detections of this pollutant. The Calvert City sites account for all 43 concentrations of vinyl chloride greater than 0.15 µg/m^3 measured across the program. The maximum concentration of vinyl chloride was measured at ATKY (9.81 µg/m^3), with 10 additional measurements greater than 1 µg/m^3 measured at these sites (four at ATKY, one at CCKY, and five at TVKY). All of the quarterly average concentrations of vinyl chloride for these sites, where they could be calculated, have relatively large confidence intervals, indicating the relatively large amount of variability associated with these measurements.

- Another pollutant for which the highest concentrations program-wide were measured at the Calvert City sites is 1,2-dichloroethane. The 56 highest concentrations of 1,2-dichloroethane across the program (those greater than 0.18 $\mu g/m^3$) were all measured at the Calvert City sites. This includes all 29 measurements greater than 1 $\mu g/m^3$ and two greater than 10 $\mu g/m^3$. The four highest concentrations of 1,2-dichloroethane were measured at TVKY and ranged from 7.17 $\mu g/m^3$ to 17.1 $\mu g/m^3$. In many cases, the quarterly average concentrations of 1,2-dichloroethane for these sites have confidence intervals similar to or greater in magnitude than the quarterly averages themselves, indicating the relatively large amount of variability associated with these measurements. This is particularly true for ATKY, BLKY, and TVKY.

- Some of the highest measurements of carbon tetrachloride were also measured at the Calvert City sites, particularly TVKY. Of the 17 carbon tetrachloride concentrations greater than 1 $\mu g/m^3$ measured across the program, 13 were measured at the Calvert City sites (nine at TVKY, two at LAKY, and one each at BLKY and ATKY). The quarterly average concentrations of carbon tetrachloride for TVKY are the two highest quarterly averages of this pollutant among all NMP sites sampling VOC (and the only ones greater than 1 $\mu g/m^3$). The fourth quarter averages of this pollutant for BLKY and ATKY rank third and fourth, respectively. The third and fourth quarter averages for LAKY and the fourth quarter average for CCKY are the only other quarterly averages program-wide that are greater than 0.75 $\mu g/m^3$ besides the second quarter average for PROK.

- The highest quarterly average concentrations of benzene among the Calvert City sites were calculated for TVKY and LAKY. The maximum benzene concentration was measured at TVKY on July 20, 2012 (5.24 $\mu g/m^3$) and is the fourth highest benzene concentration measured among NMP sites sampling for this pollutant. The next highest concentration measured at TVKY is roughly half as high (2.83 $\mu g/m^3$). The maximum benzene concentration measured at LAKY was also measured on July 20, 2012 but was considerably less (2.04 $\mu g/m^3$).

- The confidence intervals for both quarterly averages of 1,3-butadiene for BLKY are greater than the averages themselves, indicating that outliers may be affecting these averages. The two highest 1,3-butadiene concentrations measured at BLKY are the maximum concentrations measured across the program (4.10 $\mu g/m^3$ and 2.31 $\mu g/m^3$). The next highest concentration measured at BLKY is an order of magnitude less (0.344 $\mu g/m^3$). The third and fifth highest 1,3-butadiene measurements program-wide were collected at TVKY. Thus, measurements from BLKY and TVKY account for four of the five 1,3-butadiene measurements greater than 1 $\mu g/m^3$ across the program.

- The two highest 1,1,2,2-tetrachloroethylene concentrations measured program-wide were both measured at LAKY and TVKY on October 12, 2012 (0.179 $\mu g/m^3$ and 0.169 $\mu g/m^3$, respectively). The next highest concentrations measured at these sites were considerably less.

- The Calvert City sites also measured some of the highest concentrations of 1,1,2-trichloroethane across the program, as these sites account for all 15 measurements greater than 0.06 μg/m^3. This pollutant was detected in only 38 samples across the program in 2012, and 18 of them were collected at the Calvert City sites.

Observations for LEKY from Table 13-6 include the following:

- The only annual averages that could be calculated for LEKY are for the metal pollutants of interest. This is because sampling of PM_{10} metals began under the NMP in March 2012 while sampling for VOCs and carbonyl compounds did not begin until July. However, Appendix J and Appendix L provide the pollutant-specific average concentrations for all valid VOC and carbonyl compound samples collected over the entire sample period.

- The annual average concentration of arsenic for LEKY is the fifth highest annual average concentration for this pollutant among NMP sites sampling PM_{10} metals. Arsenic concentrations measured at LEKY range from 0.03 ng/m^3 to 2.35 ng/m^3, with a median concentration of 0.76 ng/m^3. The fourth quarter average arsenic concentration is greater than the other available quarterly averages for LEKY. Four of the five highest concentrations of arsenic were measured at LEKY during the fourth quarter of 2012.

- The annual average concentration of manganese for LEKY is the eighth highest annual average for this pollutant among NMP sites sampling PM_{10} metals. Manganese concentrations measured at LEKY range from 0.66 ng/m^3 to 16.6 ng/m^3, with a median concentration of 6.67 ng/m^3. Although the fourth quarter average manganese concentration is not the highest of the quarterly averages for LEKY, it has a relatively large confidence interval, indicating a relatively large amount of variability is associated with the measurements. Both the minimum and maximum concentrations of manganese were measured at LEKY during this quarter.

- The third quarter average concentration of *p*-dichlorobenzene for LEKY is considerably higher than the fourth quarter average concentration. The two highest *p*-dichlorobenzene concentrations measured at LEKY (those greater than 0.1 μg/m^3) were both measured during the third quarter of 2012. In addition, the detection rate of *p*-dichlorobenzene was considerably higher during the third quarter than the fourth quarter. There were two non-detects of this pollutant reported for the third quarter while there were 13 for the fourth quarter.

- The third quarter average concentrations did not vary significantly from the fourth quarter average concentrations for the remaining pollutant of interest.

Additional observations for the Kentucky monitoring sites from Table 13-6 include:

- Some of the highest arsenic concentrations program-wide were measured at the Kentucky sites. Of the 46 concentrations of arsenic greater than 2 ng/m^3, 23 were measured at ASKY-M, three were measured at BAKY, two at CCKY, and six at

LEKY, with the Kentucky sites accounting for 34 of these measurements. Kentucky sites account for half of the highest annual average concentrations of arsenic, as shown in Table 4-12.

13.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where annual averages are available. Thus, box plots were created for the pollutants of interest for GLKY and the PM_{10} metals shaded in gray in Table 13-5 for ASKY-M, BAKY, CCKY, and LEKY. Figures 13-41 through 13-51 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 13-41. Program vs. Site-Specific Average Acetaldehyde Concentration

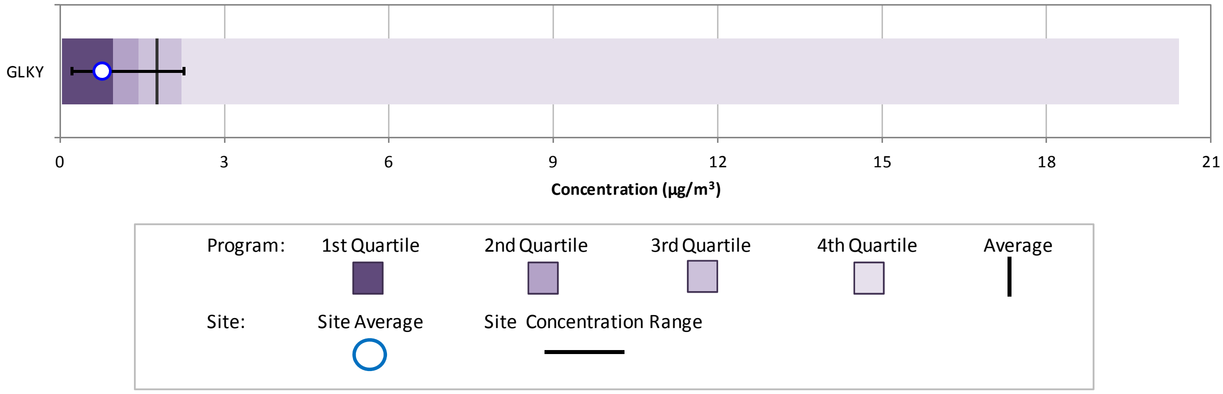


Figure 13-42. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentrations

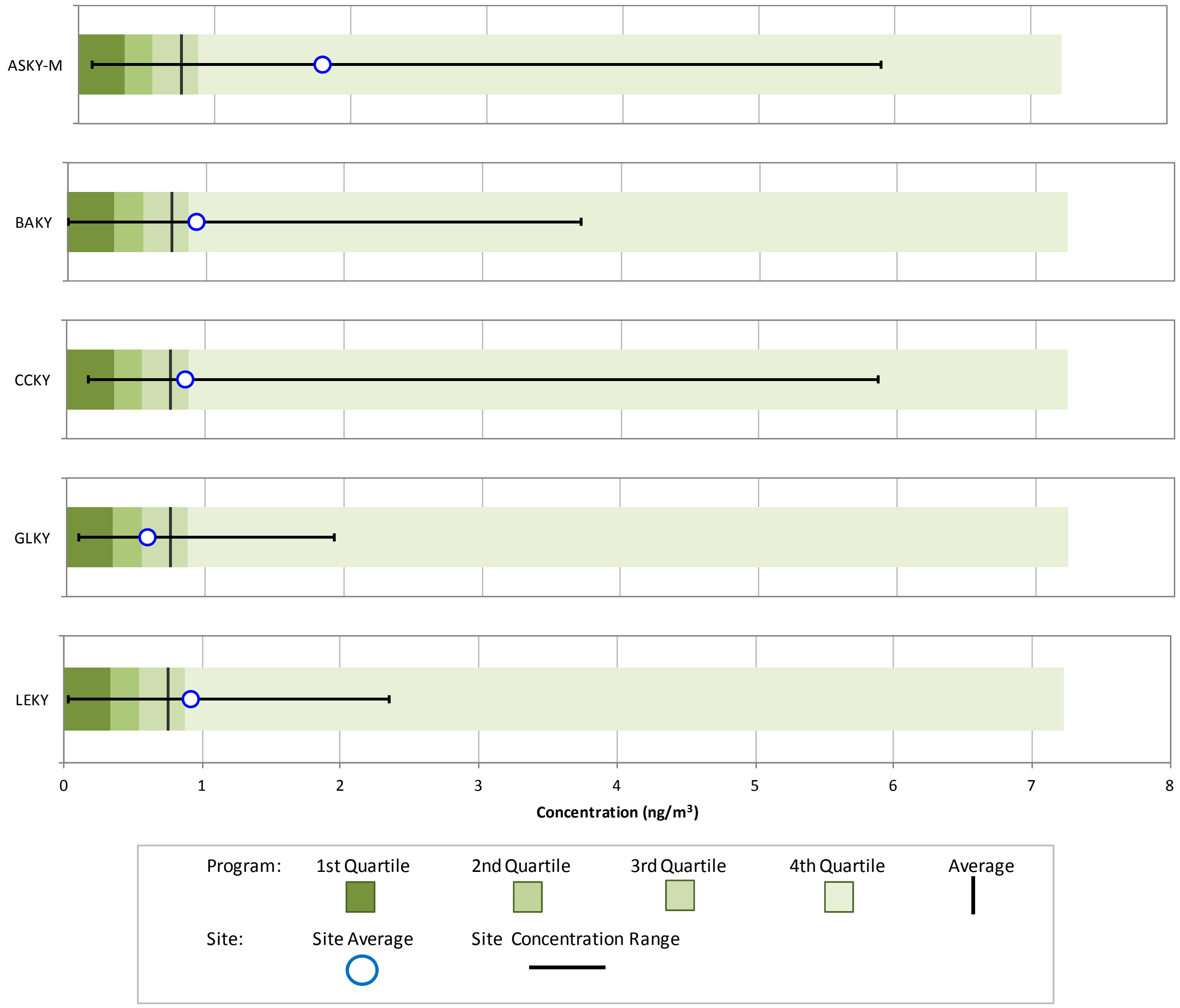


Figure 13-43. Program vs. Site-Specific Average Benzene Concentration

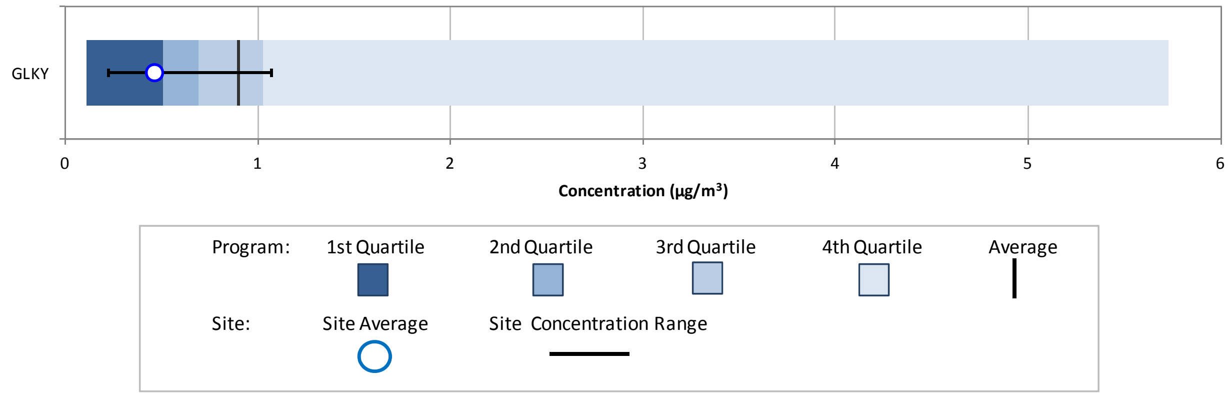


Figure 13-44. Program vs. Site-Specific Average 1,3-Butadiene Concentration

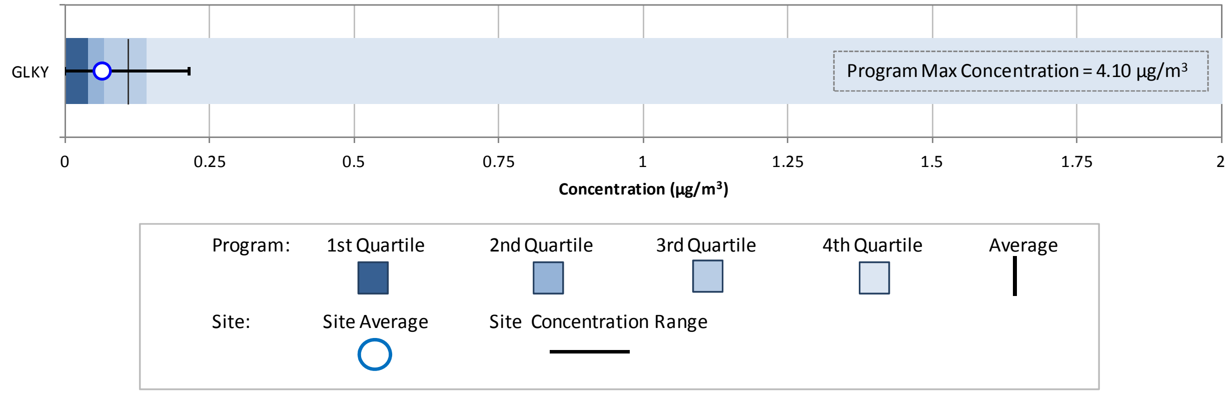


Figure 13-45. Program vs. Site-Specific Average Cadmium Concentration

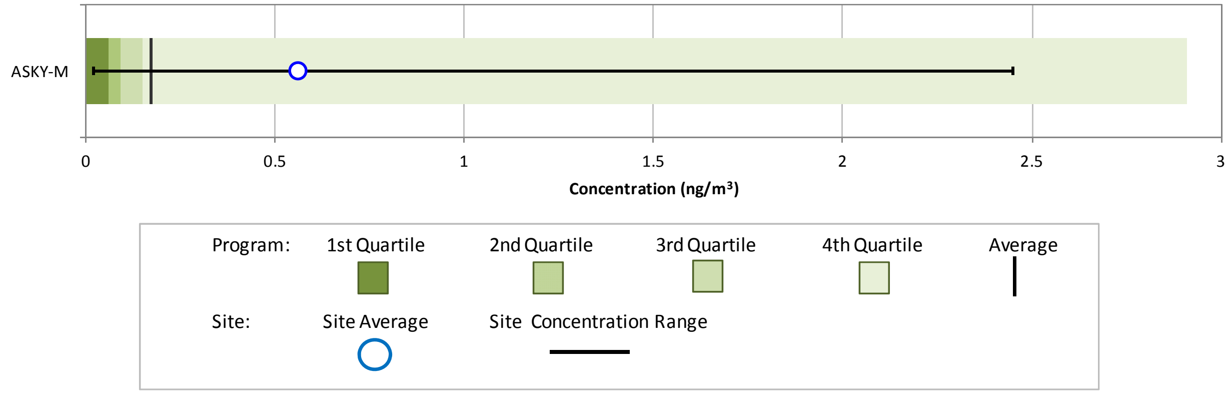


Figure 13-46. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

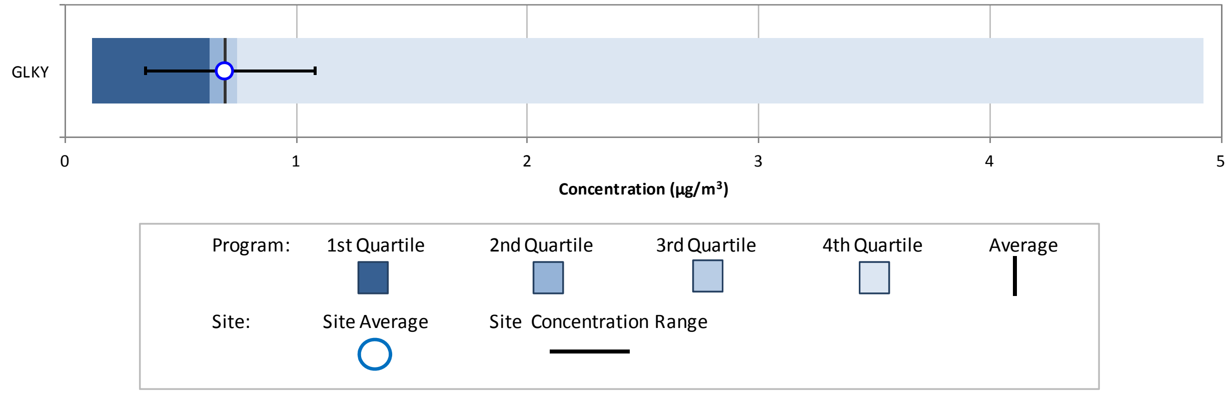


Figure 13-47. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

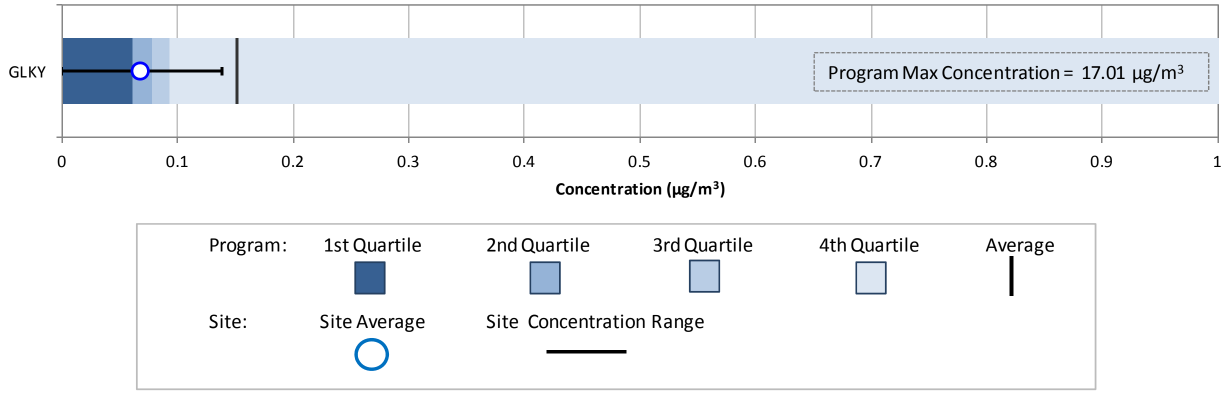


Figure 13-48. Program vs. Site-Specific Average Formaldehyde Concentration

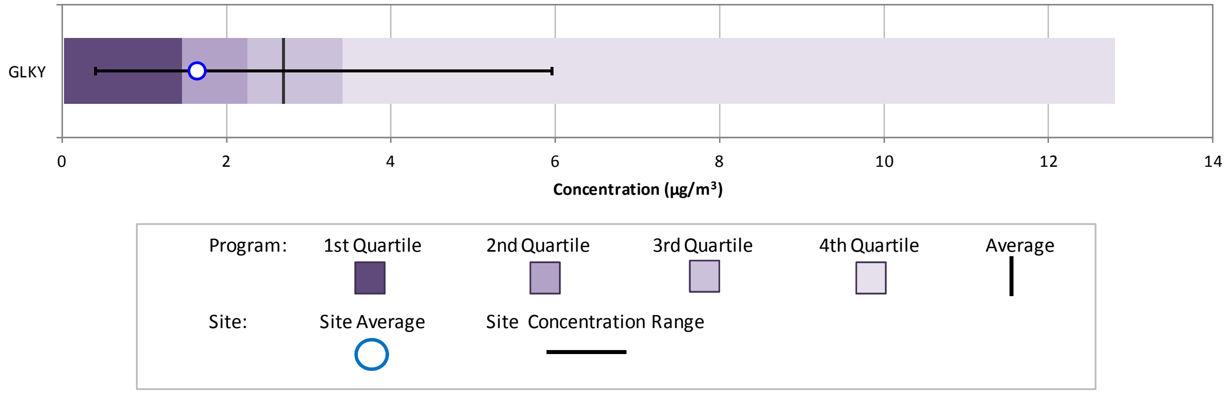


Figure 13-49. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

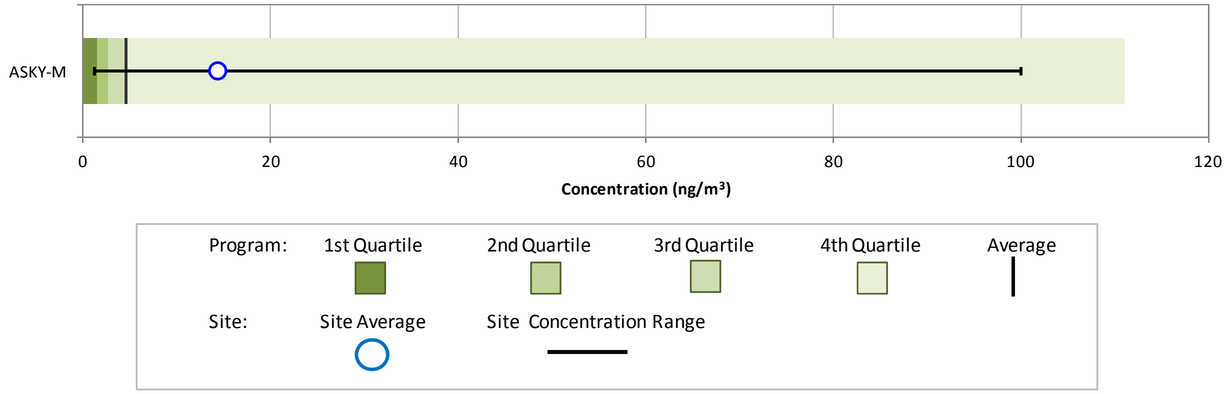


Figure 13-50. Program vs. Site-Specific Average Manganese (PM_{10}) Concentrations

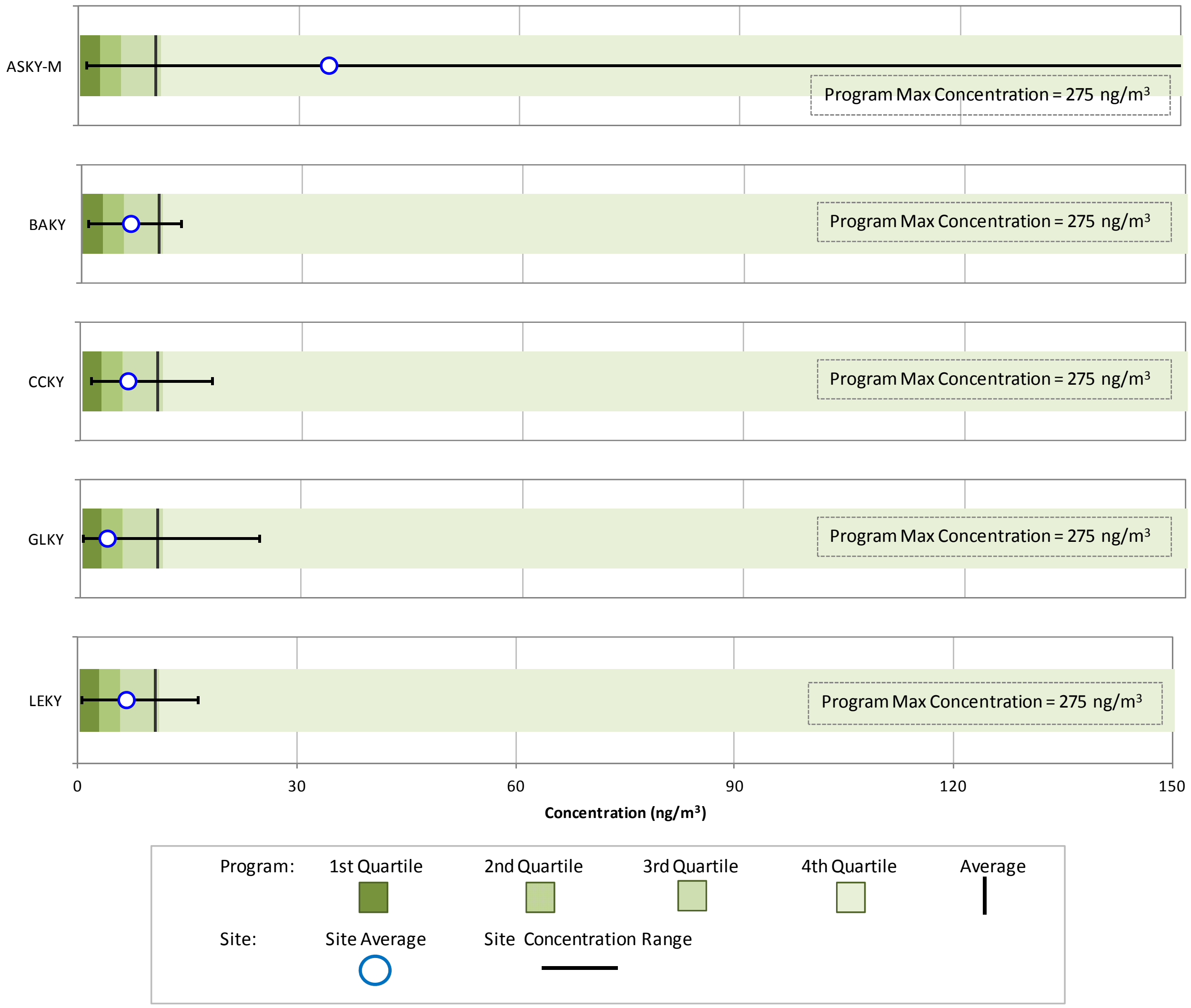
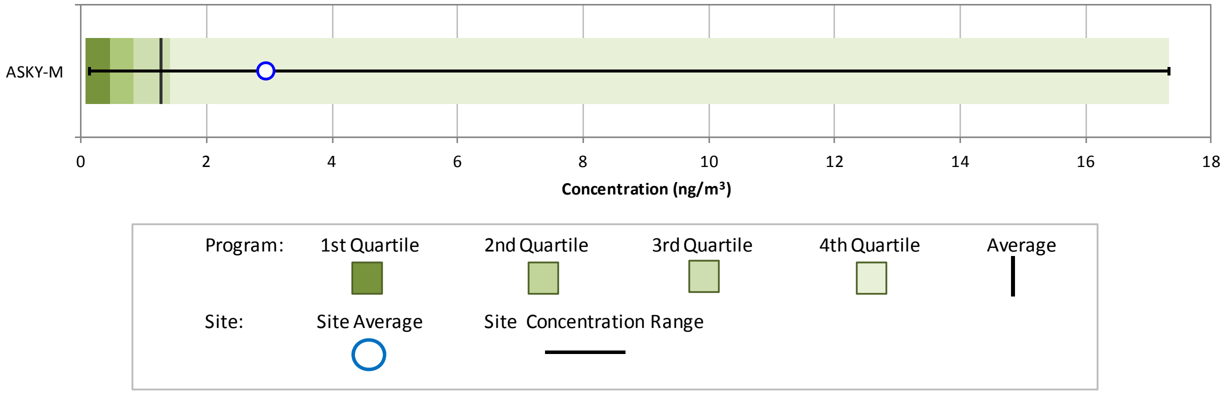


Figure 13-51. Program vs. Site-Specific Average Nickel (PM_{10}) Concentration



Observations from Figures 13-41 through 13-51 include the following:

- Figure 13-41 is the box plot for acetaldehyde for GLKY. The range of acetaldehyde concentrations measured at GLKY is rather small, as the maximum concentration measured at GLKY is just greater than the program-level third quartile. The annual average acetaldehyde concentration for GLKY is less than the program-level first quartile and ranks among the lowest annual averages of this pollutant for NMP sites sampling carbonyl compounds.

- Figure 13-42 presents the box plots for the five Kentucky sites for which arsenic is a pollutant of interest and an annual average concentration could be calculated. The box plots show that the range of arsenic concentrations measured was smallest for GLKY and largest for ASKY-M and CCKY. With the exception of GLKY, all of the annual average concentrations of arsenic were greater than the program-level average concentration. With the exception of CCKY, these annual averages are also greater than the program-level third quartile. Note however, that the maximum arsenic concentration across the program was not measured at any of the Kentucky sites shown.

- Figure 13-43 is the box plot for benzene for GLKY. Similar to acetaldehyde, the maximum concentration measured at GLKY is just greater than the program-level third quartile and the annual average concentration for benzene is less than the program-level first quartile.

- Figure 13-44 is the box plot for 1,3-butadiene for GLKY. Note that the program-level maximum concentration (4.10 $\mu g/m^3$) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to 2 $\mu g/m^3$. The annual average concentration for GLKY is similar to the program-level median concentration but less than the program-level average concentration. The maximum 1,3-butadiene concentration measured at GLKY is an order of magnitude less than the maximum concentration measured across the program. Note that the maximum concentration of 1,3-butadiene across the program was measured at BLKY, as discussed in the previous section. Two non-detects of 1,3-butadiene were measured at GLKY.

- Figure 13-45 is the box plot for cadmium for ASKY-M. Although cadmium was sampled for by the other Kentucky sites sampling PM_{10} metals, this is the only site for which cadmium was identified as a pollutant of interest. Although the maximum concentration across the program was not measured at ASKY-M, this site does have one of the higher measurements. The annual average concentration of cadmium for ASKY-M is more than three times greater than the program-level average concentration. This site has the second highest annual average concentration of cadmium, behind only S4MO.

- Figure 13-46 is the box plot for carbon tetrachloride for GLKY. This box plots shows that the annual average concentration of this pollutant is nearly equivalent to the program-level average concentration, both of which are similar in magnitude to the program-level median concentration.

- Figure 13-47 is the box plot for 1,2-dichloroethane for GLKY. Note that the program-level maximum concentration (17.01 µg/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to 1 µg/m^3. The entire range of 1,2-dichloroethane concentrations measured at GLKY is less than the program-level average concentration. The annual average concentration for GLKY is greater than the program-level first quarter but less than the program level median concentration. Note that the maximum concentration across the program was measured at TVKY, as discussed in the previous section.

- Figure 13-48 is the box plot for formaldehyde for GLKY. The maximum concentration measured at GLKY is roughly half the maximum concentration measured across the program. The annual average formaldehyde concentration for GLKY is less than both the program-level average and median concentrations and just greater than the program-level first quartile.

- Figure 13-49 is the box plot for lead for ASKY-M. Although lead was sampled for by the other Kentucky sites sampling PM$_{10}$ metals, ASKY-M is the only site for which lead was identified as a pollutant of interest. Although the maximum concentration across the program was not measured at ASKY-M, this site does have one of the higher measurements. The annual average concentration of lead for ASKY-M is more than three times greater than the program-level average concentration and is the highest annual average concentration of lead calculated among NMP sites sampling PM$_{10}$ metals.

- Figure 13-50 presents the box plots for the five Kentucky sites for which manganese is a pollutant of interest and an annual average concentration could be calculated. Note that the program-level maximum concentration (275 ng/m^3) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to 150 ng/m^3. The box plots show that the range of manganese concentrations measured was smallest for BAKY and largest for ASKY-M. Although the maximum manganese concentration across the program was not measured at ASKY-M, this site's maximum concentration is greater than the scale in Figure 13-50. With the exception of ASKY-M, all of the annual average concentrations of manganese are less than the program-level average concentration. The annual average for ASKY-M is more than three times greater than the program-level average concentration.

- Figure 13-51 is the box plot for nickel, and like lead and cadmium, is a pollutant of interest for only ASKY-M. This box plot shows that the annual average concentration of nickel for ASKY-M is more than two times greater than the program-level average concentration. The maximum concentration measured across the program was measured at ASKY-M and this site has the highest annual average concentration of nickel calculated among NMP sites sampling PM$_{10}$ metals.

13.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. The only pollutant group for which GLKY has sampled under the NMP since at least 2008 is hexavalent chromium and PAHs; however, hexavalent chromium did not fail any screens and none of the PAHs that failed screens were identified as pollutants of interest for GLKY. Thus, a trends analysis was not performed for this site.

13.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the Kentucky monitoring sites. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

13.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Kentucky monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

13.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Kentucky monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 13-7, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 13-7. Risk Approximations for the Kentucky Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Health Department, Ashland, Kentucky - ASKY						
Acetaldehyde	0.0000022	0.009	29/29	NA	NA	NA
Benzene	0.0000078	0.03	29/29	NA	NA	NA
1,3-Butadiene	0.00003	0.002	28/29	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	29/29	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	24/29	NA	NA	NA
Ethylbenzene	0.0000025	1	29/29	NA	NA	NA
Formaldehyde	0.000013	0.0098	29/29	NA	NA	NA
21st and Greenup, Ashland, Kentucky - ASKY-M						
Arsenic (PM_{10})[a]	0.0043	0.000015	50/50	<0.01 ± <0.01	7.70	0.12
Cadmium (PM_{10})[a]	0.0018	0.00001	50/50	<0.01 ± <0.01	1.01	0.06
Lead (PM_{10})[a]	--	0.00015	50/50	0.01 ± <0.01	--	0.10
Manganese (PM_{10})[a]	--	0.00005	50/50	0.03 ± 0.01	--	0.68
Nickel (PM_{10})[a]	0.00048	0.00009	50/50	<0.01 ± <0.01	1.41	0.03

NA = Not available due to the criteria for calculating an annual average.
-- = A Cancer URE or Noncancer RfC is not available.
[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 13-6.

Table 13-7. Risk Approximations for the Kentucky Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Grayson, Kentucky - GLKY						
Acetaldehyde	0.0000022	0.009	61/61	0.77 ± 0.09	1.68	0.09
Arsenic (PM_{10})[a]	0.0043	0.000015	59/59	<0.01 ± <0.01	2.51	0.04
Benzene	0.0000078	0.03	61/61	0.46 ± 0.05	3.62	0.02
1,3-Butadiene	0.00003	0.002	59/61	0.06 ± 0.01	1.92	0.03
Carbon Tetrachloride	0.000006	0.1	61/61	0.69 ± 0.03	4.13	0.01
1,2-Dichloroethane	0.000026	2.4	56/61	0.07 ± 0.01	1.75	<0.01
Formaldehyde	0.000013	0.0098	61/61	1.64 ± 0.31	21.34	0.17
Manganese (PM_{10}) [a]	--	0.00005	59/59	<0.01 ± <0.01	--	0.07
Baskett, Kentucky - BAKY						
Arsenic (PM_{10})[a]	0.0043	0.000015	50/50	<0.01 ± <0.01	4.00	0.06
Manganese (PM_{10}) [a]	--	0.00005	50/50	0.01 ± <0.01	--	0.13
Atmos Energy, Calvert City, Kentucky - ATKY						
Benzene	0.0000078	0.03	29/29	NA	NA	NA
1,3-Butadiene	0.00003	0.002	25/29	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	26/29	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	29/29	NA	NA	NA
Vinyl chloride	0.0000088	0.1	16/29	NA	NA	NA
Smithland, Kentucky - BLKY						
Benzene	0.0000078	0.03	26/26	NA	NA	NA
1,3-Butadiene	0.00003	0.002	21/26	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	26/26	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	23/26	NA	NA	NA
Vinyl chloride	0.0000088	0.1	14/26	NA	NA	NA

NA = Not available due to the criteria for calculating an annual average.

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 13-6.

Table 13-7. Risk Approximations for the Kentucky Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Calvert City Elementary, Calvert City, Kentucky - CCKY						
Arsenic (PM_{10})[a]	0.0043	0.000015	47/47	<0.01 ± <0.01	3.68	0.06
Benzene	0.0000078	0.03	26/26	NA	NA	NA
1,3-Butadiene	0.00003	0.002	24/26	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	26/26	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	23/26	NA	NA	NA
Manganese (PM_{10}) [a]	--	0.00005	47/47	0.01 ± <0.01	--	0.13
Lazy Daze, Calvert City, Kentucky - LAKY						
Benzene	0.0000078	0.03	29/29	NA	NA	NA
1,3-Butadiene	0.00003	0.002	28/29	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	29/29	NA	NA	NA
1,2-Dibromoethane	0.0006	0.009	3/29	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	27/29	NA	NA	NA
Hexachloro-1,3-butadiene	0.000022	0.09	7/29	NA	NA	NA
1,1,2,2-Tetrachloroethane	0.000058	--	6/29	NA	NA	NA
1,1,2-Trichloroethane	0.000016	0.4	5/29	NA	NA	NA
Vinyl chloride	0.0000088	0.1	19/29	NA	NA	NA

NA = Not available due to the criteria for calculating an annual average.

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 13-6.

Table 13-7. Risk Approximations for the Kentucky Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
TVA Substation, Calvert City, Kentucky - TVKY						
Benzene	0.0000078	0.03	28/28	NA	NA	NA
1,3-Butadiene	0.00003	0.002	24/28	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	28/28	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	27/28	NA	NA	NA
1,1,2,2-Tetrachloroethane	0.000058	--	4/28	NA	NA	NA
1,1,2-Trichloroethane	0.000016	0.4	6/28	NA	NA	NA
Vinyl chloride	0.0000088	0.1	19/28	NA	NA	NA
Lexington, Kentucky - LEKY						
Acetaldehyde	0.0000022	0.009	27/27	NA	NA	NA
Arsenic $(PM_{10})^{a}$	0.0043	0.000015	49/49	<0.01 ± <0.01	3.94	0.06
Benzene	0.0000078	0.03	29/29	NA	NA	NA
1,3-Butadiene	0.00003	0.002	27/29	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	29/29	NA	NA	NA
p-Dichlorobenzene	0.000011	0.8	14/29	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	24/29	NA	NA	NA
Ethylbenzene	0.0000025	1	29/29	NA	NA	NA
Formaldehyde	0.000013	0.0098	27/27	NA	NA	NA
Manganese $(PM_{10})^{a}$	--	0.00005	49/49	0.01 ± <0.01	--	0.13

NA = Not available due to the criteria for calculating an annual average.
-- = A Cancer URE or Noncancer RfC is not available.
[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 13-6.

Observations for the Kentucky monitoring sites from Table 13-7 include the following:

- Few annual averages, and thus, cancer risk and noncancer hazard approximations, could be calculated for the Kentucky monitoring sites due to a relatively short sampling duration.

- The pollutants with the highest annual average concentrations for GLKY are formaldehyde, acetaldehyde, and carbon tetrachloride. The pollutants with the highest cancer risk approximations for GLKY are formaldehyde, carbon tetrachloride, and benzene. All of the noncancer hazard approximations for the pollutants of interest for GLKY are considerably less than an HQ of 1.0 (0.20 or less), indicating that no adverse health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for formaldehyde.

- The cancer risk approximations for arsenic range from 2.51 in-a-million (GLKY) to 7.70 in-a-million (ASKY-M). All of the noncancer hazard approximations for arsenic are less than an HQ of 1.0 (0.12 or less), indicating that no adverse health effects are expected from arsenic individually.

- A cancer risk factor is not available for manganese. All of the noncancer hazard approximations for manganese are less than an HQ of 1.0 (0.68 or less), indicating that no adverse health effects are expected from manganese individually. ASKY-M's noncancer hazard approximation for manganese is the second highest noncancer hazard approximation calculated for any program-wide pollutant of interest, behind only TOOK's noncancer hazard approximation for manganese (0.77).

13.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 13-8 and 13-9 present an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 13-8 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 13-8 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 13-8 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 13-7. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 13-8. Table 13-9 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 13-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Health Department, Ashland, Kentucky (Boyd County) - ASKY					
Benzene	55.37	Coke Oven Emissions, PM	7.25E-03		
Formaldehyde	20.84	POM, Group 1a	1.28E-03		
POM, Group 1a	14.58	Hexavalent Chromium, PM	9.89E-04		
Acetaldehyde	11.02	Nickel, PM	6.72E-04		
Ethylbenzene	10.16	Benzene	4.32E-04		
Coke Oven Emissions, PM	7.32	Formaldehyde	2.71E-04		
1,3-Butadiene	2.89	2,4-Dinitrotoluene	1.96E-04		
2,4-Dinitrotoluene	2.20	1,3-Butadiene	8.67E-05		
Naphthalene	2.16	POM, Group 3	7.99E-05		
Nickel, PM	1.40	Naphthalene	7.34E-05		
21st and Greenup, Ashland, Kentucky (Boyd County) - ASKY-M					
Benzene	55.37	Coke Oven Emissions, PM	7.25E-03	Arsenic	7.70
Formaldehyde	20.84	POM, Group 1a	1.28E-03	Nickel	1.41
POM, Group 1a	14.58	Hexavalent Chromium, PM	9.89E-04	Cadmium	1.01
Acetaldehyde	11.02	Nickel, PM	6.72E-04		
Ethylbenzene	10.16	Benzene	4.32E-04		
Coke Oven Emissions, PM	7.32	Formaldehyde	2.71E-04		
1,3-Butadiene	2.89	2,4-Dinitrotoluene	1.96E-04		
2,4-Dinitrotoluene	2.20	1,3-Butadiene	8.67E-05		
Naphthalene	2.16	POM, Group 3	7.99E-05		
Nickel, PM	1.40	Naphthalene	7.34E-05		

Table 13-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Grayson, Kentucky (Carter County) - GLKY					
Formaldehyde	22.49	Formaldehyde	2.92E-04	Formaldehyde	21.34
Benzene	16.98	Benzene	1.32E-04	Carbon Tetrachloride	4.13
Acetaldehyde	11.95	Naphthalene	8.40E-05	Benzene	3.62
Ethylbenzene	6.80	1,3-Butadiene	6.13E-05	Arsenic	2.51
Naphthalene	2.47	POM, Group 2d	4.67E-05	1,3-Butadiene	1.92
1,3-Butadiene	2.04	POM, Group 2b	4.41E-05	1,2-Dichloroethane	1.75
POM, Group 2d	0.53	POM, Group 3	4.20E-05	Acetaldehyde	1.68
POM, Group 2b	0.50	Acetaldehyde	2.63E-05		
POM, Group 6	0.04	POM, Group 5a	1.71E-05		
Trichloroethylene	0.03	Ethylbenzene	1.70E-05		
Baskett, Kentucky (Henderson County) - BAKY					
Formaldehyde	50.13	POM, Group 1a	1.79E-03	Arsenic	4.00
Benzene	40.75	Formaldehyde	6.52E-04		
Acetaldehyde	25.97	Naphthalene	5.68E-04		
POM, Group 1a	20.37	POM, Group 2d	3.68E-04		
Naphthalene	16.70	Benzene	3.18E-04		
Ethylbenzene	15.75	Hexavalent Chromium, PM	2.89E-04		
1,3-Butadiene	6.55	Nickel, PM	2.70E-04		
Tetrachloroethylene	4.75	POM, Group 2b	2.44E-04		
POM, Group 2d	4.19	1,3-Butadiene	1.96E-04		
POM, Group 2b	2.77	POM, Group 3	6.53E-05		

Table 13-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Atmos Energy, Calvert City, Kentucky (Marshall County) - ATKY					
Benzene	61.70	Benzene	4.81E-04		
Ethylbenzene	37.84	Formaldehyde	2.99E-04		
Vinyl chloride	30.93	Vinyl chloride	2.72E-04		
Acetaldehyde	26.73	Hexavalent Chromium, PM	2.64E-04		
Formaldehyde	23.00	1,2-Dichloroethane	2.41E-04		
1,2-Dichloroethane	9.25	POM, Group 1a	2.34E-04		
1,3-Butadiene	7.11	1,3-Butadiene	2.13E-04		
Naphthalene	2.78	Naphthalene	9.47E-05		
POM, Group 1a	2.66	Ethylbenzene	9.46E-05		
Carbon tetrachloride	2.32	Nickel, PM	7.93E-05		
Calvert City Elementary, Calvert City, Kentucky (Marshall County) - CCKY					
Benzene	61.70	Benzene	4.81E-04	Arsenic	3.68
Ethylbenzene	37.84	Formaldehyde	2.99E-04		
Vinyl chloride	30.93	Vinyl chloride	2.72E-04		
Acetaldehyde	26.73	Hexavalent Chromium, PM	2.64E-04		
Formaldehyde	23.00	1,2-Dichloroethane	2.41E-04		
1,2-Dichloroethane	9.25	POM, Group 1a	2.34E-04		
1,3-Butadiene	7.11	1,3-Butadiene	2.13E-04		
Naphthalene	2.78	Naphthalene	9.47E-05		
POM, Group 1a	2.66	Ethylbenzene	9.46E-05		
Carbon tetrachloride	2.32	Nickel, PM	7.93E-05		

Table 13-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Lazy Daze, Calvert City, Kentucky (Marshall County) - LAKY					
Benzene	61.70	Benzene	4.81E-04		
Ethylbenzene	37.84	Formaldehyde	2.99E-04		
Vinyl chloride	30.93	Vinyl chloride	2.72E-04		
Acetaldehyde	26.73	Hexavalent Chromium, PM	2.64E-04		
Formaldehyde	23.00	1,2-Dichloroethane	2.41E-04		
1,2-Dichloroethane	9.25	POM, Group 1a	2.34E-04		
1,3-Butadiene	7.11	1,3-Butadiene	2.13E-04		
Naphthalene	2.78	Naphthalene	9.47E-05		
POM, Group 1a	2.66	Ethylbenzene	9.46E-05		
Carbon tetrachloride	2.32	Nickel, PM	7.93E-05		
TVA Substation, Calvert City, Kentucky (Marshall County) - TVKY					
Benzene	61.70	Benzene	4.81E-04		
Ethylbenzene	37.84	Formaldehyde	2.99E-04		
Vinyl chloride	30.93	Vinyl chloride	2.72E-04		
Acetaldehyde	26.73	Hexavalent Chromium, PM	2.64E-04		
Formaldehyde	23.00	1,2-Dichloroethane	2.41E-04		
1,2-Dichloroethane	9.25	POM, Group 1a	2.34E-04		
1,3-Butadiene	7.11	1,3-Butadiene	2.13E-04		
Naphthalene	2.78	Naphthalene	9.47E-05		
POM, Group 1a	2.66	Ethylbenzene	9.46E-05		
Carbon tetrachloride	2.32	Nickel, PM	7.93E-05		

Table 13-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Smithland, Kentucky (Livingston County) - BLKY					
Benzene	12.70	Formaldehyde	1.56E-04		
Formaldehyde	12.00	Benzene	9.90E-05		
Acetaldehyde	6.63	1,3-Butadiene	5.02E-05		
Ethylbenzene	4.46	Naphthalene	2.39E-05		
1,3-Butadiene	1.67	POM, Group 3	1.68E-05		
Naphthalene	0.70	POM, Group 2b	1.51E-05		
POM, Group 2b	0.17	Acetaldehyde	1.46E-05		
POM, Group 2d	0.16	POM, Group 2d	1.43E-05		
POM, Group 6	0.03	Nickel, PM	1.26E-05		
Nickel, PM	0.03	Ethylbenzene	1.11E-05		
Lexington, Kentucky (Fayette County) - LEKY					
Benzene	120.89	Formaldehyde	1.18E-03	Arsenic	3.94
Formaldehyde	91.00	Benzene	9.43E-04		
Ethylbenzene	74.64	1,3-Butadiene	5.16E-04		
Acetaldehyde	51.93	POM, Group 3	4.28E-04		
1,3-Butadiene	17.21	Naphthalene	3.57E-04		
Naphthalene	10.50	POM, Group 2b	2.09E-04		
POM, Group 2b	2.38	Ethylbenzene	1.87E-04		
Tetrachloroethylene	2.24	Hexavalent Chromium, PM	1.84E-04		
Trichloroethylene	1.94	POM, Group 2d	1.44E-04		
POM, Group 2d	1.64	Arsenic, PM	1.27E-04		

Table 13-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Health Department, Ashland, Kentucky (Boyd County) - ASKY					
Toluene	128.66	Manganese, PM	203,096.87		
Ethylene glycol	60.98	Acrolein	66,362.90		
Benzene	55.37	Chlorine	45,169.74		
Hexane	45.73	Nickel, PM	15,550.33		
Xylenes	40.30	Lead, PM	11,227.98		
Methanol	39.10	Cadmium, PM	3,311.75		
Hydrochloric acid	27.65	Formaldehyde	2,126.16		
Formaldehyde	20.84	Benzene	1,845.80		
Acetaldehyde	11.02	1,3-Butadiene	1,444.19		
Ethylbenzene	10.16	Hydrochloric acid	1,382.51		
21st and Greenup, Ashland, Kentucky (Boyd County) – ASKY-M					
Toluene	128.66	Manganese, PM	203,096.87	Manganese	0.68
Ethylene glycol	60.98	Acrolein	66,362.90	Arsenic	0.12
Benzene	55.37	Chlorine	45,169.74	Lead	0.10
Hexane	45.73	Nickel, PM	15,550.33	Cadmium	0.06
Xylenes	40.30	Lead, PM	11,227.98	Nickel	0.03
Methanol	39.10	Cadmium, PM	3,311.75		
Hydrochloric acid	27.65	Formaldehyde	2,126.16		
Formaldehyde	20.84	Benzene	1,845.80		
Acetaldehyde	11.02	1,3-Butadiene	1,444.19		
Ethylbenzene	10.16	Hydrochloric acid	1,382.51		

Table 13-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Grayson, Kentucky (Carter County) - GLKY					
Toluene	75.43	Acrolein	74,382.78	Formaldehyde	0.17
Ethylene glycol	34.12	Formaldehyde	2,295.36	Acetaldehyde	0.09
Xylenes	26.97	Acetaldehyde	1,328.25	Manganese	0.07
Hexane	23.33	Cyanide Compounds, gas	1,278.36	Arsenic	0.04
Formaldehyde	22.49	1,3-Butadiene	1,021.17	1,3-Butadiene	0.03
Benzene	16.98	Naphthalene	823.24	Benzene	0.02
Methanol	15.68	Benzene	566.08	Carbon Tetrachloride	0.01
Acetaldehyde	11.95	Xylenes	269.67	1,2-Dichloroethane	<0.01
Ethylbenzene	6.80	Propionaldehyde	118.11		
Naphthalene	2.47	Arsenic, PM	91.35		
Baskett, Kentucky (Henderson County) - BAKY					
Toluene	161.88	Acrolein	65,506.85	Manganese	0.13
Carbonyl sulfide	128.78	Manganese, PM	43,233.90	Arsenic	0.06
Xylenes	77.22	Nickel, PM	6,258.97		
Ethylene glycol	56.92	Naphthalene	5,566.87		
Hexane	54.77	Formaldehyde	5,115.54		
Formaldehyde	50.13	1,3-Butadiene	3,274.37		
Benzene	40.75	Chlorine	3,245.93		
Methanol	28.37	Acetaldehyde	2,885.41		
Acetaldehyde	25.97	Cadmium, PM	2,792.02		
Naphthalene	16.70	Methylenediphenyl diisocyanate, 4,4'- (MDI), gas	2,483.57		

Table 13-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Atmos Energy, Calvert City, Kentucky (Marshall County) - ATKY					
Methanol	677.58	Chlorine	210,803.93		
Toluene	205.25	Acrolein	77,112.59		
Xylenes	183.68	Manganese, PM	5,023.60		
Hydrochloric acid	83.48	Hydrochloric acid	4,173.99		
Vinyl acetate	73.28	1,3-Butadiene	3,557.33		
Benzene	61.70	Acetaldehyde	2,970.22		
Hexane	45.87	Acrylic acid	2,916.21		
Ethylene glycol	39.87	Formaldehyde	2,346.51		
Ethylbenzene	37.84	Benzene	2,056.78		
Chlorine	31.62	Xylenes	1,836.76		
Calvert City Elementary, Calvert City, Kentucky (Marshall County) - CCKY					
Methanol	677.58	Chlorine	210,803.93	Manganese	0.13
Toluene	205.25	Acrolein	77,112.59	Arsenic	0.06
Xylenes	183.68	Manganese, PM	5,023.60		
Hydrochloric acid	83.48	Hydrochloric acid	4,173.99		
Vinyl acetate	73.28	1,3-Butadiene	3,557.33		
Benzene	61.70	Acetaldehyde	2,970.22		
Hexane	45.87	Acrylic acid	2,916.21		
Ethylene glycol	39.87	Formaldehyde	2,346.51		
Ethylbenzene	37.84	Benzene	2,056.78		
Chlorine	31.62	Xylenes	1,836.76		

Table 13-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Lazy Daze, Calvert City, Kentucky (Marshall County) - LAKY					
Methanol	677.58	Chlorine	210,803.93		
Toluene	205.25	Acrolein	77,112.59		
Xylenes	183.68	Manganese, PM	5,023.60		
Hydrochloric acid	83.48	Hydrochloric acid	4,173.99		
Vinyl acetate	73.28	1,3-Butadiene	3,557.33		
Benzene	61.70	Acetaldehyde	2,970.22		
Hexane	45.87	Acrylic acid	2,916.21		
Ethylene glycol	39.87	Formaldehyde	2,346.51		
Ethylbenzene	37.84	Benzene	2,056.78		
Chlorine	31.62	Xylenes	1,836.76		
TVA Substation, Calvert City, Kentucky (Marshall County) - TVKY					
Methanol	677.58	Chlorine	210,803.93		
Toluene	205.25	Acrolein	77,112.59		
Xylenes	183.68	Manganese, PM	5,023.60		
Hydrochloric acid	83.48	Hydrochloric acid	4,173.99		
Vinyl acetate	73.28	1,3-Butadiene	3,557.33		
Benzene	61.70	Acetaldehyde	2,970.22		
Hexane	45.87	Acrylic acid	2,916.21		
Ethylene glycol	39.87	Formaldehyde	2,346.51		
Ethylbenzene	37.84	Benzene	2,056.78		
Chlorine	31.62	Xylenes	1,836.76		

Table 13-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Smithland, Kentucky (Livingston County) - BLKY					
Toluene	48.42	Acrolein	21,504.21		
Xylenes	35.09	Formaldehyde	1,224.76		
Benzene	12.70	Manganese, PM	1,211.46		
Formaldehyde	12.00	1,3-Butadiene	836.35		
Ethylene glycol	11.72	Acetaldehyde	736.97		
Hexane	11.09	Cyanide Compounds, gas	527.46		
Acetaldehyde	6.63	Benzene	423.20		
Methanol	5.38	Xylenes	350.93		
Ethylbenzene	4.46	Nickel, PM	291.64		
1,3-Butadiene	1.67	Naphthalene	234.01		
Lexington, Kentucky (Fayette County) - LEKY					
Toluene	777.20	Acrolein	261,778.93	Manganese	0.13
Ethylene glycol	364.42	Formaldehyde	9,286.02	Arsenic	0.06
Xylenes	288.28	1,3-Butadiene	8,604.26		
Hexane	237.91	Acetaldehyde	5,769.93		
Methanol	176.71	Benzene	4,029.83		
Benzene	120.89	Naphthalene	3,500.50		
Formaldehyde	91.00	Xylenes	2,882.83		
Ethylbenzene	74.64	Hexamethylene-1,6-diisocyanate, gas	2,051.30		
Acetaldehyde	51.93	Arsenic, PM	1,974.60		
Methyl isobutyl ketone	29.90	Methylenediphenyl diisocyanate, 4,4'- (MDI), gas	1,757.48		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 13.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 13-8 include the following:

- Among the Kentucky counties with monitoring sites, emissions (for pollutants with cancer UREs) are highest in Fayette County (LEKY) and least in Livingston County (BLKY).
- Benzene, formaldehyde, and POM, Group 1a are the highest emitted pollutants with cancer UREs in Boyd County, where the Ashland sites are located. Coke oven emissions, POM Group 1a, and hexavalent chromium are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Boyd County. Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Boyd County.
- Cancer risk approximations could be calculated for arsenic, nickel, and cadmium for ASKY-M. Although arsenic has the highest cancer risk approximation for ASKY-M, this pollutant appears on neither emissions-based list (arsenic ranks 26th for total emissions and 17th for toxicity-weighted emissions). This is also true for cadmium. Conversely, nickel appears on both emissions based lists, ranking 10th for total emissions and fourth for toxicity-weighted emissions.
- Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs in Carter County, where GLKY is located. Formaldehyde, benzene, and naphthalene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for this county. Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Carter County.
- Formaldehyde has the highest cancer risk approximation for GLKY, and ranks first on all three lists in Table 13-8. Benzene, 1,3-butadiene, and acetaldehyde also appear on all three lists. The three remaining pollutants of interest appear on neither emissions-based list.
- Three POM Groups appear among the highest emitted pollutants in Carter County (POM, Groups 2b, 2d, and 6) and four POM Groups appear among the pollutants with the highest toxicity-weighted emissions (POM, Groups 2b, 2d, 3, and 5a). Many

of the PAHs sampled using Method TO-13 are part of POM, Groups 2b, 2d, 5a, and 6. However, none of these pollutants failed screens for GLKY.

- Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs in Henderson County, where BAKY is located. POM, Group 1a, formaldehyde, and naphthalene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for this county. Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Henderson County.

- Arsenic is the only pollutant of interest for BAKY for which a cancer risk approximation could be calculated. Arsenic appears on neither emissions-based list for Henderson County (arsenic ranks 23th for total emissions and 16th for toxicity-weighted emissions). Several POM Groups appear on the emissions-based lists for Henderson County, but PAHs were not sampled at BAKY.

- Benzene, ethylbenzene, and vinyl chloride are the highest emitted pollutants with cancer UREs in Marshall County, where four of the five Calvert City sites are located. Marshall County is the only county with NMP sites for which vinyl chloride appears among the highest emitted pollutants. The quantity of vinyl chloride emitted in Marshall County (31 tpy) is the highest emissions for this pollutant among NMP counties and is twice the quantity of the next highest emissions (16 tpy in Harris County, Texas). This is also true for carbon tetrachloride. There are only three counties with NMP sites that have carbon tetrachloride emissions greater than 1 tpy, Marshall County, Kentucky (2.32 tpy), Harris County, Texas (1.25 tpy), and Harrison County, Texas (1.06 tpy). Marshall County is also the only county with NMP sites for which 1,2-dichloroethane appears among the highest emitted pollutants. The quantity of 1,2-dichloroethane emitted in Marshall County (9.25 tpy) is the second highest emissions for this pollutant among NMP sites, behind only Harris County, Texas (16 tpy).

- Benzene, formaldehyde, and vinyl chloride are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Marshall County. Marshall County is the only county for which vinyl chloride and 1,2-dichloroethane appear among the pollutants with the highest toxicity-weighted emissions. Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Marshall County.

- Arsenic is the only pollutant of interest for CCKY for which a cancer risk approximation could be calculated. Arsenic appears on neither emissions-based list for Marshall County (arsenic ranks 27th for total emissions and 16th for toxicity-weighted emissions).

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in Livingston County, where BLKY is located. Benzene, formaldehyde, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for this county. Nine of the highest emitted pollutants also have the highest toxicity-weighted emissions for Livingston County.

Several POM Groups appear on the emissions-based lists for Livingston County, but PAHs were not sampled at BLKY.

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Fayette County, where LEKY is located. Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for this county. Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Fayette County. Several POM Groups appear on the emissions-based lists for Fayette County, but PAHs were not sampled at LEKY.

- Arsenic is the only pollutant of interest for LEKY for which a cancer risk approximation could be calculated. Arsenic has the 10th highest toxicity-weighted emissions but does not appear among the highest emitted for Fayette County (arsenic ranks 23rd for total emissions).

Observations from Table 13-9 include the following:

- Among the Kentucky counties with monitoring sites, emissions (for pollutants with noncancer RfCs) are highest in Fayette County (LEKY) and least in Livingston County (BLKY).

- Toluene, ethylene glycol, and benzene are the highest emitted pollutants with noncancer RfCs in Boyd County. Manganese, acrolein, and chlorine are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for Boyd County. Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Boyd County.

- Nonancer hazard approximations could be calculated for all five metal pollutants of interest for ASKY-M. Manganese, which has the highest nonancer hazard approximation, also has the highest toxicity-weighted emissions. Nickel, lead, and cadmium are also among the pollutants with the highest toxicity-weighted emissions. None of the metal pollutants of interest for ASKY-M are among the highest emitted in Boyd County.

- Toluene, ethylene glycol, and xylenes are the highest emitted pollutants with noncancer RfCs in Carter County. Acrolein, formaldehyde, and acetaldehyde are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for Carter County. Although acrolein was sampled for at GLKY, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. Acrolein does not appear among Carter County's highest emitted pollutants. Five of the highest emitted pollutants also have the highest toxicity-weighted emissions for Carter County.

- Formaldehyde and acetaldehyde have the highest nonancer hazard approximations for GLKY and appear on both emissions-based lists. Benzene also appears on all three lists. Arsenic and 1,3-butadiene are among the pollutants with the highest toxicity-weighted emissions but are not among the highest emitted in Carter County. Manganese, which has the third highest nonancer hazard approximation, appears on neither emissions-based list. This is also true for carbon tetrachloride and 1,2-dichloroethane.

- Toluene, carbonyl sulfide, and xylenes are the highest emitted pollutants with noncancer RfCs in Henderson County. Acrolein, manganese, and nickel are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for this county. Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Henderson County.

- Manganese, which has the highest nonancer hazard approximation for BAKY, has the second highest toxicity-weighted emissions but is not among the highest emitted. Arsenic, the only other pollutant of interest for BAKY, appears on neither emissions-based list.

- Methanol, toluene, and xylenes are the highest emitted pollutants with noncancer RfCs in Marshall County. Chlorine, acrolein, and manganese are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for this county. This is the only county with an NMP site for which acrolein was not the pollutant with the highest toxicity-weighted emissions. Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Marshall County.

- Manganese, which has the highest nonancer hazard approximation for CCKY, has the third highest toxicity-weighted emissions but is not among the highest emitted. Arsenic, the only other pollutant of interest for CCKY for which a noncancer hazard approximation could be calculated, appears on neither emissions-based list.

- Toluene, xylenes, and benzene are the highest emitted pollutants with noncancer RfCs in Livingston County. Acrolein, formaldehyde, and manganese are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for this county. Five of the highest emitted pollutants also have the highest toxicity-weighted emissions for Livingston County.

- Toluene, ethylene glycol, and xylenes are the highest emitted pollutants with noncancer RfCs in Fayette County. Acrolein, formaldehyde, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for this county. Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Fayette County.

- Manganese, which has the highest nonancer hazard approximation for LEKY, appears on neither emissions-based list for Fayette County. Arsenic, the only other pollutant of interest for LEKY for which a noncancer hazard approximation could be calculated, has the ninth highest toxicity-weighted emissions but does not appear among the highest emitted.

13.6 Summary of the 2012 Monitoring Data for the Kentucky Monitoring Sites

Results from several of the data treatments described in this section include the following:

- *Four monitoring sites (ASKY-M, BAKY, CCKY, and LEKY) began sampling PM_{10} metals under the NMP in March 2012. Seven monitoring sites began sampling VOCs in July. Two monitoring sites (ASKY and LEKY) also began sampling carbonyl compounds in July. GLKY sampled VOCs, PAHs, carbonyl compounds, PM_{10} metals and hexavalent chromium year-round.*

- *The number of pollutants failing screens for the Kentucky sites varies from three (BAKY) to 15 (LEKY).*

- *Because the start dates for sampling were staggered, annual average concentrations could only be calculated for GLKY and those sites sampling PM_{10} metals.*

- *ASKY-M had the highest annual average concentrations of arsenic, manganese, and nickel among NMP sites sampling PM_{10} metals. Four additional Kentucky sites were among the sites with the highest annual average concentrations of arsenic; three additional Kentucky sites were among those with the highest annual average concentrations of manganese; LEKY was also among the sites with the highest annual average concentrations of nickel.*

- *Some of the highest concentrations of VOCs were measured at the Calvert City sites, particularly vinyl chloride, carbon tetrachloride, and 1,2-dichloroethane.*

14.0 Site in Massachusetts

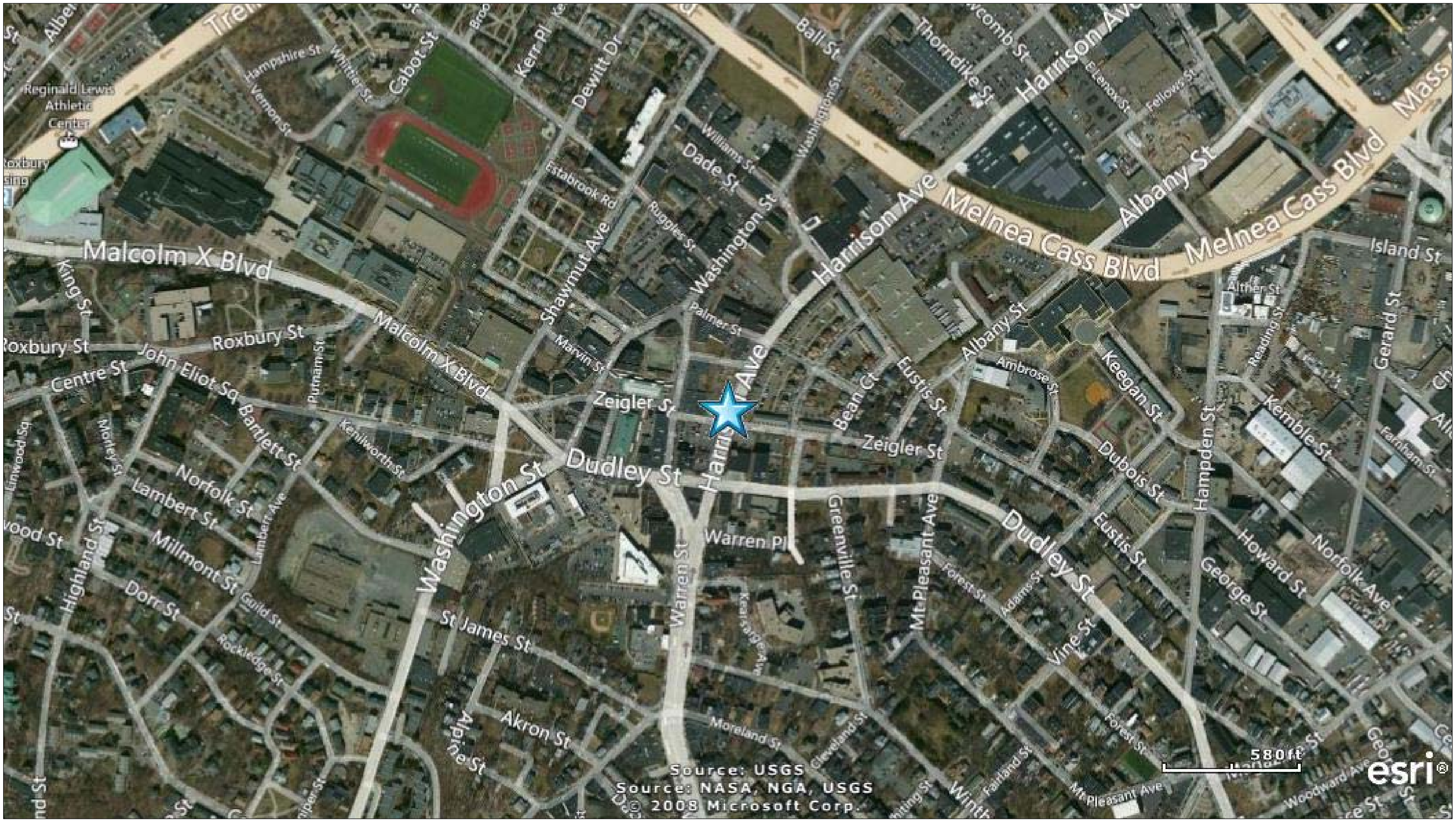
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Massachusetts, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

14.1 Site Characterization

This section characterizes the BOMA monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The BOMA monitoring site is located in Boston. Figure 14-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 14-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 14-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 14-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 14-1. Boston, Massachusetts (BOMA) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 14-2. NEI Point Sources Located Within 10 Miles of BOMA

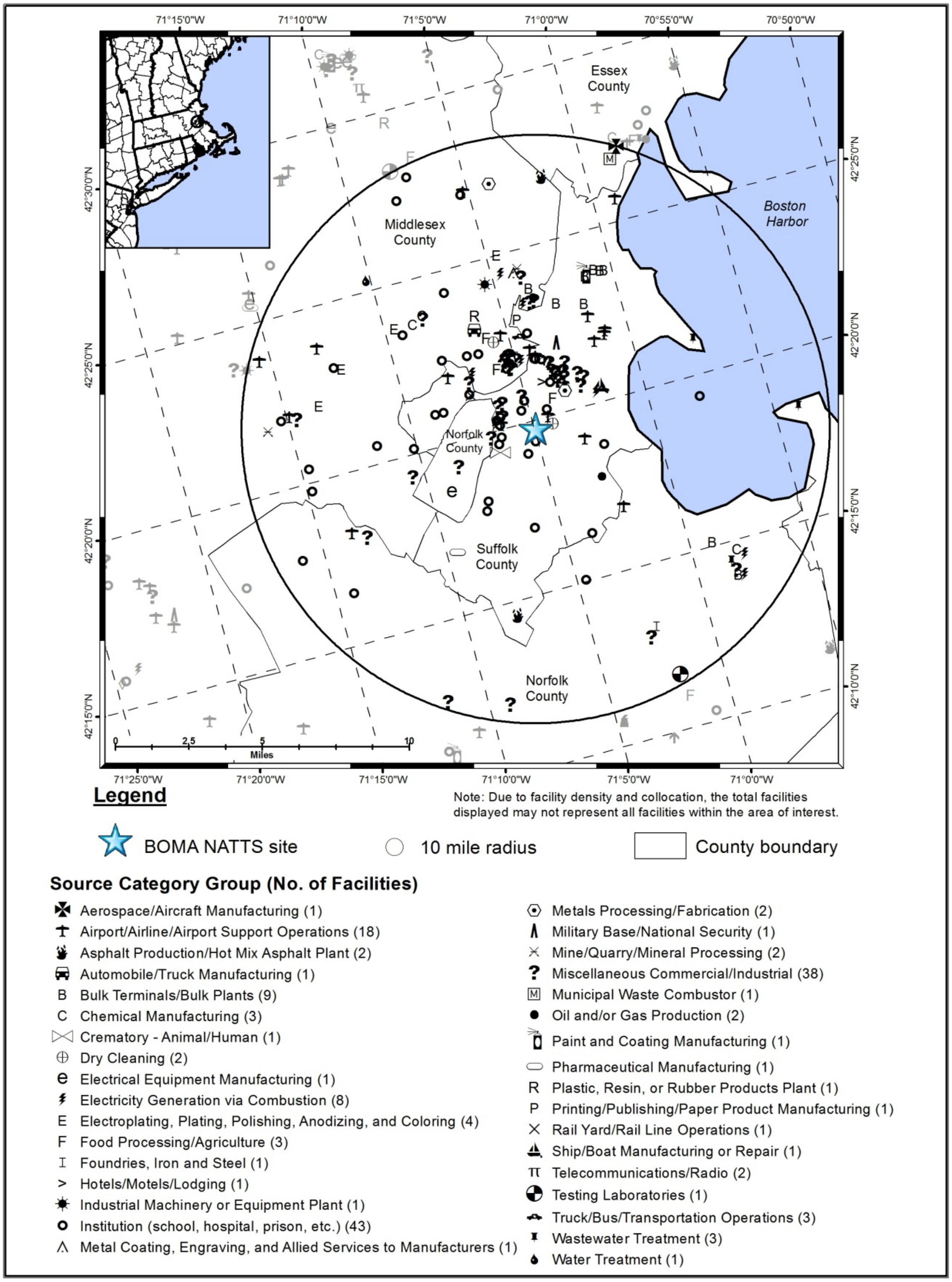


Table 14-1. Geographical Information for the Massachusetts Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
BOMA	25-025-0042	Boston	Suffolk	Boston-Cambridge-Newton, MA-NH MSA	42.3295, -71.0826	Commercial	Urban/City Center	CO, VOCs, SO_2, NO, NO_2, NO_x, NO_y, PAMS/NMOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, Black carbon, PM coarse, PM2.5, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The BOMA monitoring site is located at Dudley Square in Roxbury, a southwest neighborhood of Boston and is the Roxbury NATTS site. The surrounding area is commercial as well as residential, as shown in Figure 14-1. The monitoring site is 1.25 miles south of I-90 and 1 mile west of I-93. The original purpose for the location of this site was to measure population exposure to a city bus terminal located across the street from the monitoring site. In recent years, the buses servicing the area were converted to compressed natural gas (CNG). As Figure 14-2 shows, BOMA is located near a large number of point sources, with a high density of sources located a few miles to the west, northwest, and north of the site. The source category with the highest number of emissions sources surrounding BOMA is the institution category, which includes schools, hospitals, and prisons. There are also numerous airport and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; electricity generating units (via combustion); and bulk terminals and bulk plants.

Table 14-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Massachusetts monitoring site. Table 14-2 includes both county-level population and vehicle registration information. Table 14-2 also contains traffic volume information for BOMA as well as the location for which the traffic volume was obtained. Additionally, Table 14-2 presents the county-level daily VMT for Suffolk County.

Table 14-2. Population, Motor Vehicle, and Traffic Information for the Massachusetts Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
BOMA	744,426	362,899	27,654	Melnea Cass Blvd, near Shawmut Ave	10,890,178

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (MA RMV, 2013)
[3] AADT reflects 2010 data (MA DOT, 2010)
[4] County-level VMT reflects 2012 data (MA DOT, 2013)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 14-2 include the following:

- The Suffolk County population is in the middle of the range, ranking 18th among other counties with NMP sites.

- The Suffolk County vehicle registration is also in the middle of the range, ranking 24th among other counties with NMP sites.

- The traffic volume experienced near BOMA is in the middle of the range compared to other NMP sites. The traffic estimate provided is for Melnea Cass Boulevard near Shawmut Avenue.

- The daily VMT for Suffolk County is also in the middle of the range compared to other counties with NMP sites (where VMT data were available). The VMT for Suffolk County ranks 23rd.

14.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Massachusetts on sample days, as well as over the course of the year.

14.2.1 Climate Summary

Boston's New England location ensures that the city experiences a fairly active weather pattern. Storm systems frequently track across the region, bringing ample precipitation to the area. The proximity to the Atlantic Ocean helps moderate temperatures, both in the summer and the winter, while at the same time allowing winds to gust higher than they would farther inland. Winds generally flow from the northwest in the winter and southwest in the summer. Coastal storm systems called "Nor'easters," strong low pressure systems that produce heavy rain or snow and winds up to hurricane strength along the Mid-Atlantic and northeast coastal states, often produce the heaviest snowfalls for the area. This coastal location may also be affected by tropical systems, approximately one every 5 years on average (Wood, 2004; NCDC, 2014).

14.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Massachusetts monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station to BOMA is located at Logan International Airport (WBAN 14739). Additional information about the Logan Airport weather station, such as the distance between the site and the weather station, is provided in Table 14-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 14-3. Average Meteorological Conditions near the Massachusetts Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Boston, Massachusetts - BOMA									
Logan International Airport 14739 (42.36, -71.01)	4.1 Miles 42° (NE)	Sample Day (74)	58.8 ± 3.9	52.2 ± 3.7	40.2 ± 4.1	46.8 ± 3.4	66.3 ± 3.7	1015.5 ± 1.8	8.6 ± 0.7
		2012	60.8 ± 1.7	53.9 ± 1.6	41.5 ± 1.8	48.1 ± 1.5	65.8 ± 1.6	1015.3 ± 0.8	8.8 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 14-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 14-3 is the 95 percent confidence interval for each parameter. As shown in Table 14-3, temperatures on sample days at BOMA appear slightly cooler than temperatures experienced throughout 2012, although the differences are not significant. This is due to the number of make-up sample days. The majority of make-up samples were collected during the colder months of the year, specifically in January or February or between October and December.

14.2.3 Back Trajectory Analysis

Figure 14-3 is the composite back trajectory map for days on which samples were collected at the BOMA monitoring site. Included in Figure 14-3 are four back trajectories per sample day. Figure 14-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 14-3 and 14-4 represents 100 miles.

Observations from Figures 14-3 and 14-4 include the following:

- The composite back trajectory map shows that back trajectories originated from a variety of directions at BOMA. The predominant direction of back trajectory origin is from the northwest quadrant, with the longest trajectories originating offshore.

- The size of the 24-hour air shed domain for BOMA is in the upper end of the range compared to other NMP sites. The farthest away a back trajectory originated was approximately 800 miles, well offshore of the southeast coast. This back trajectory and the others originating over eastern North Carolina that appear to spiral in towards the site are those associated with the October 30, 2012 sample day, as Hurricane Sandy moved onshore. The average back trajectory length was 255 miles with the majority of back trajectories (86 percent) originating within 400 miles of the monitoring site.

- More than half of back trajectories originated to the west, northwest, and north of BOMA, but are split into four cluster trajectories in Figure 14-4. One-quarter of back trajectories originated over Maine, Vermont, New Hampshire, northeast New York, and along the U.S./Canada border; another 10 percent originated over southeast Ontario and Quebec, Canada; 5 percent of these back trajectories reach as far as Lake Huron and central Ontario; and the 13 percent of back trajectories originating to the west include shorter trajectories originating over New York and Pennsylvania, as well as longer ones originating as far west as Indiana. One-third of back trajectories originated to the southwest of the site, but are split into two back trajectories: those relatively short in length (< 200 miles) and those originating toward the Delmarva Peninsula, Virginia, and North Carolina. Six percent of back trajectories originated to the south of the site over the Atlantic Ocean and another 9 percent originated to the east of BOMA over the Gulf of Maine.

Figure 14-3. Composite Back Trajectory Map for BOMA

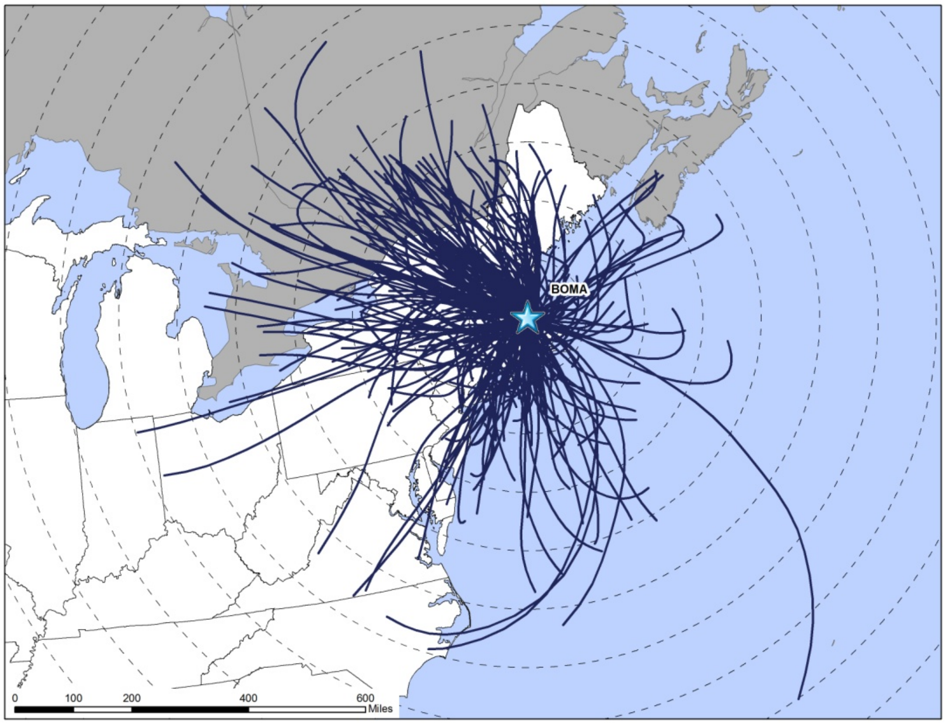
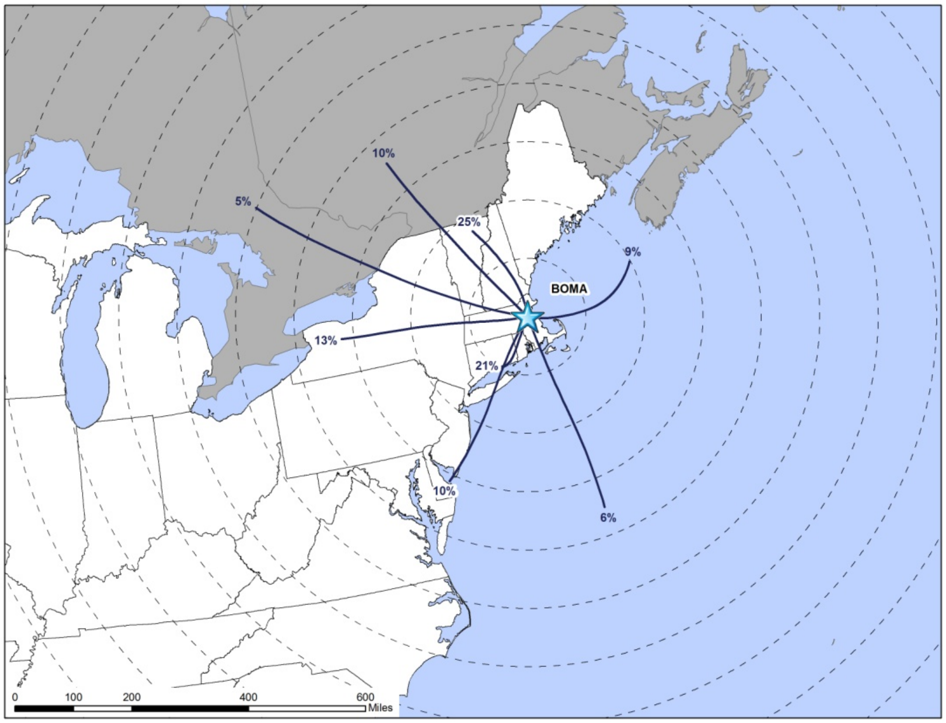


Figure 14-4. Back Trajectory Cluster Map for BOMA

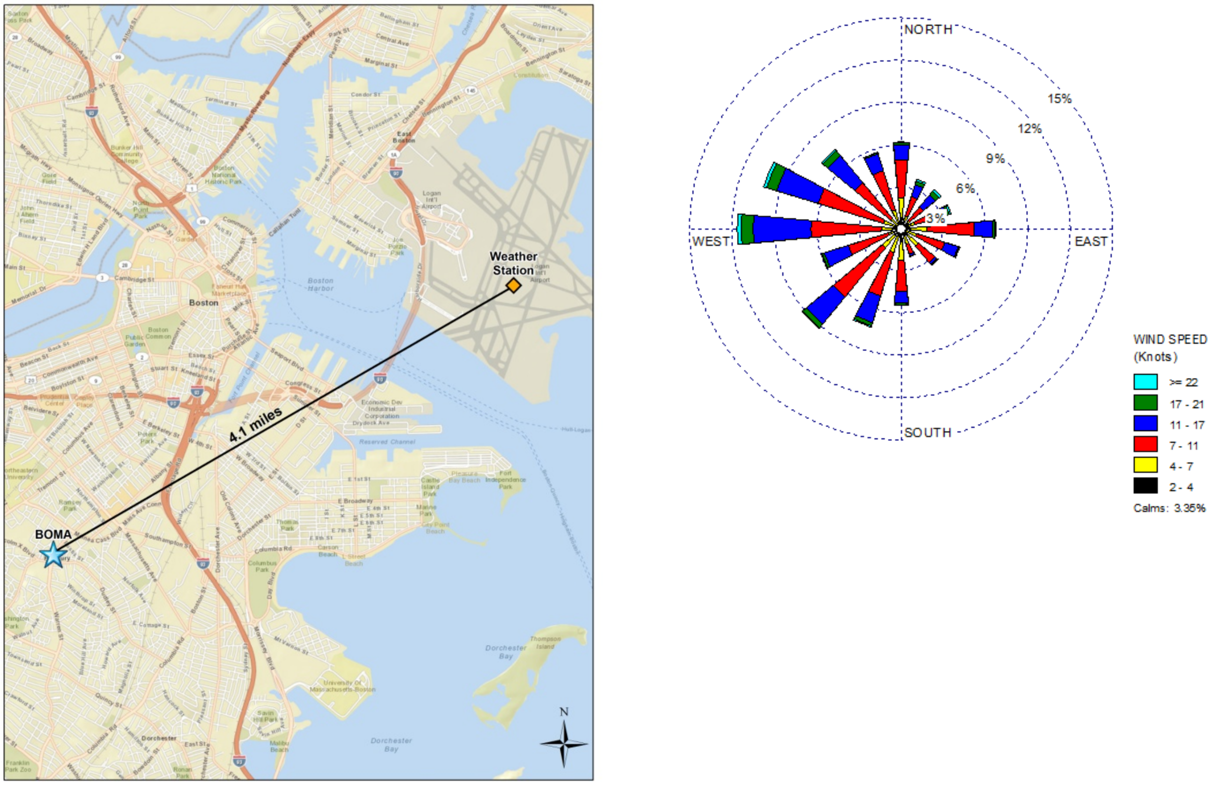


14.2.4 Wind Rose Comparison

Hourly surface wind data from the weather station at Logan International Airport near BOMA were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

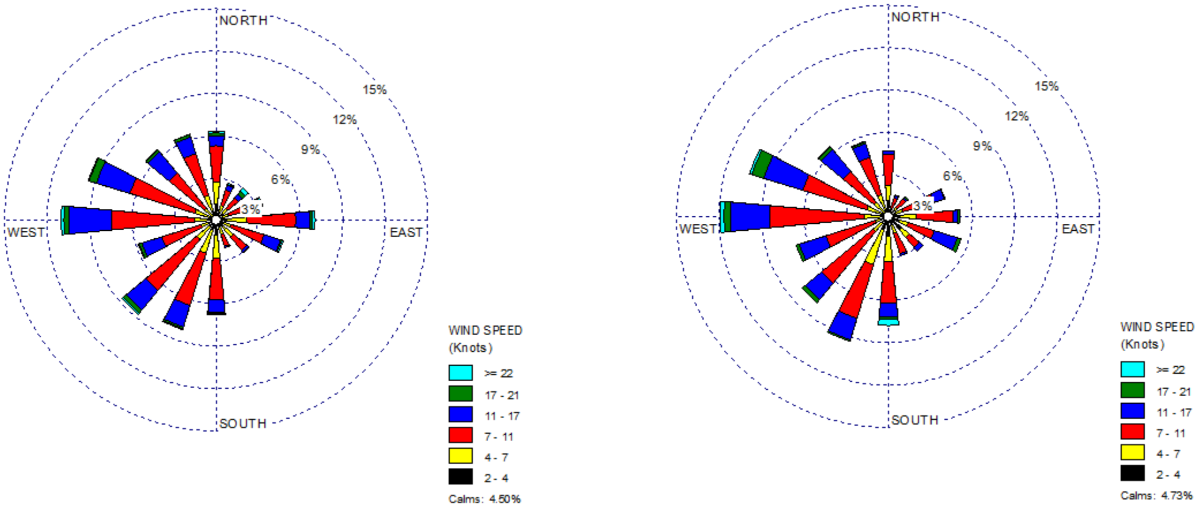
Figure 14-5 presents a map showing the distance between the weather station and BOMA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 14-5 also presents three different wind roses for the BOMA monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 14-5. Wind Roses for the Logan International Airport Weather Station near BOMA



Location of BOMA and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Observations from Figure 14-5 for BOMA include the following:

- The Logan International Airport weather station is located approximately 4 miles northeast of BOMA. Note that the airport is located on a peninsula in Boston Harbor with downtown Boston to the west, Chelsea to the north, and Winthrop to the east, while the BOMA monitoring site is located west of South Boston and farther inland (less than 2 miles from the nearest coastline).

- The historical wind rose shows that calm winds (≤ 2 knots) account for only 3 percent of wind observations. Winds with a westerly component (south-southwest to north-northwest) make up the majority (nearly 60 percent) of winds greater than 2 knots.

- The wind patterns shown on the 2012 wind rose resemble the historical wind patterns, indicating that wind conditions during 2012 were typical of conditions experienced historically near BOMA.

- The sample day wind patterns resemble the full-year and historical wind patterns, indicating that wind conditions on sample days were representative of those experienced over the entire year and historically.

14.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Massachusetts monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 14-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 14-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. BOMA sampled for PM_{10} metals, PAHs, and hexavalent chromium.

Table 14-4. Risk-Based Screening Results for the Massachusetts Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Boston, Massachusetts - BOMA						
Arsenic (PM$_{10}$)	0.00023	57	61	93.44	40.71	40.71
Naphthalene	0.029	54	59	91.53	38.57	79.29
Manganese (PM$_{10}$)	0.005	14	61	22.95	10.00	89.29
Hexavalent Chromium	0.000083	6	50	12.00	4.29	93.57
Nickel (PM$_{10}$)	0.0021	5	61	8.20	3.57	97.14
Acenaphthene	0.011	1	59	1.69	0.71	97.86
Cadmium (PM$_{10}$)	0.00056	1	61	1.64	0.71	98.57
Fluoranthene	0.011	1	59	1.69	0.71	99.29
Fluorene	0.011	1	59	1.69	0.71	100.00
Total		140	530	26.42		

Observations from Table 14-4 include the following:

- Nine pollutants failed at least one screen for BOMA; 26 percent of concentrations for these nine pollutants were greater than their associated risk screening value (or failed screens).

- Five pollutants contributed to 95 percent of failed screens for BOMA and therefore were identified as pollutants of interest for this site. These include three PM$_{10}$ metals, one PAH (naphthalene), and hexavalent chromium.

- Arsenic and naphthalene each account for roughly 40 percent of the total failed screens for BOMA.

14.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Massachusetts monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for the monitoring site.

- Annual concentration averages are presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for BOMA are provided in Appendices M through O.

14.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for BOMA, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for BOMA are presented in Table 14-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 14-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Massachusetts Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Boston, Massachusetts - BOMA						
Arsenic (PM$_{10}$)	61/61	0.56 ± 0.18	0.43 ± 0.14	0.51 ± 0.07	0.54 ± 0.17	0.51 ± 0.07
Hexavalent Chromium	50/61	0.01 ± 0.01	0.06 ± 0.04	0.03 ± 0.01	0.04 ± 0.04	0.03 ± 0.02
Manganese (PM$_{10}$)	61/61	3.73 ± 0.94	3.63 ± 0.76	4.33 ± 0.97	4.52 ± 1.49	4.06 ± 0.51
Naphthalene	59/59	56.23 ± 12.80	45.63 ± 9.63	65.47 ± 11.59	84.48 ± 25.40	63.55 ± 9.09
Nickel (PM$_{10}$)	61/61	1.60 ± 0.38	1.65 ± 1.02	1.19 ± 0.35	1.21 ± 0.41	1.41 ± 0.29

Observations for BOMA from Table 14-5 include the following:

- Naphthalene is the pollutant with the highest annual average concentration (63.55 ± 9.09 ng/m^3). The annual average concentrations for the remaining pollutants of interest are at least an order of magnitude lower. Of the PM$_{10}$ metals, manganese is the pollutant with the highest annual average concentration (4.06 ± 0.51 ng/m^3).

- The fourth quarter concentration of naphthalene is higher than the other quarterly averages and has a higher confidence interval associated with it than the others. A review of the data shows that the maximum concentration of naphthalene was measured at BOMA on November 17, 2012 (235 ng/m^3). The second and third highest measurements are lower but were also measured during the fourth quarter (152 ng/m^3 and 130 ng/m^3). Of the 13 concentrations greater than 75 ng/m^3 measured at BOMA, nine were measured during the fourth quarter.

- The concentrations of manganese measured at BOMA span an order of magnitude, ranging from 1.44 ng/m^3 to 10.8 ng/m^3. The fourth quarter average manganese concentration is higher than the other quarterly averages and has a larger confidence interval than the others. A review of the data shows that the maximum concentration of manganese was measured at BOMA on November 29, 2012. Of the 10 highest manganese concentrations measured at BOMA, six were measured during the fourth quarter.

- The second quarter average concentration of nickel has a relatively large confidence interval associated with it. The maximum nickel concentration was measured at BOMA on May 21, 2012 (8.43 ng/m^3). The next highest concentration measured during the second quarter is much less (2.10 ng/m^3). Nickel concentrations measured during the second quarter range from 0.599 ng/m^3 to 8.43 ng/m^3, with a median concentration of 1.23 ng/m^3. The maximum nickel concentration measured at BOMA is the sixth highest nickel concentrations measured across the program (PM$_{10}$ only). Further, BOMA has the fifth highest annual average concentration among NMP sites sampling PM$_{10}$ metals, as shown in Table 4-12.

- The confidence intervals calculated for the quarterly average concentrations of hexavalent chromium for BOMA indicate that the concentrations are highly variable. Measured detections of hexavalent chromium span two orders of magnitude, ranging from 0.0033 ng/m^3 to 0.314 ng/m^3, although several non-detects were also reported. The median concentration for BOMA is 0.018 ng/m^3. Note that all but one of the 11 non-detects were reported for the colder months of the year (January through March or November and December).

14.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 14-4 for BOMA. Figures 14-6 through 14-10 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 14-6. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

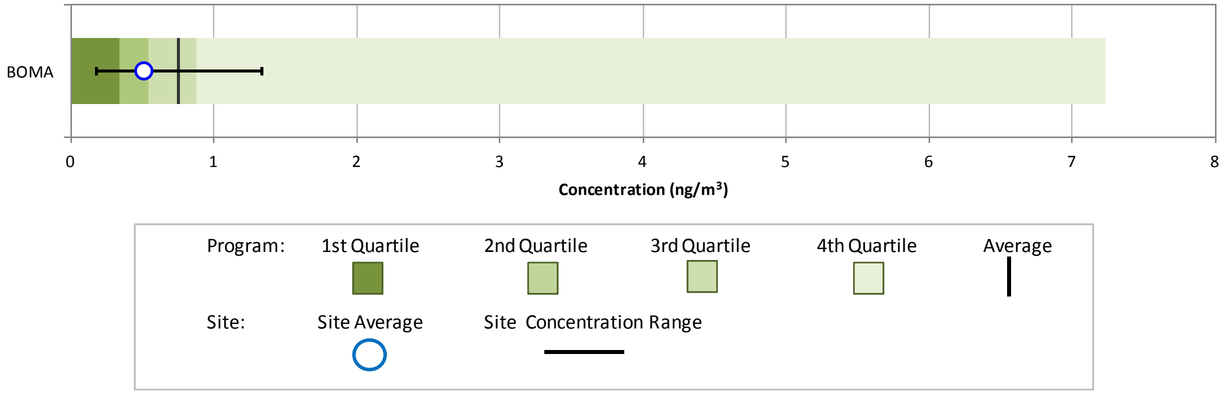


Figure 14-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

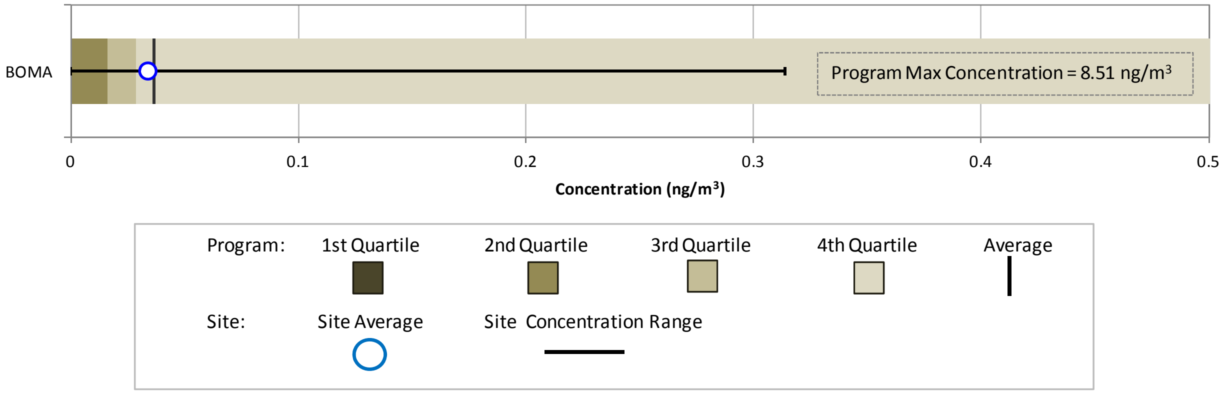


Figure 14-8. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

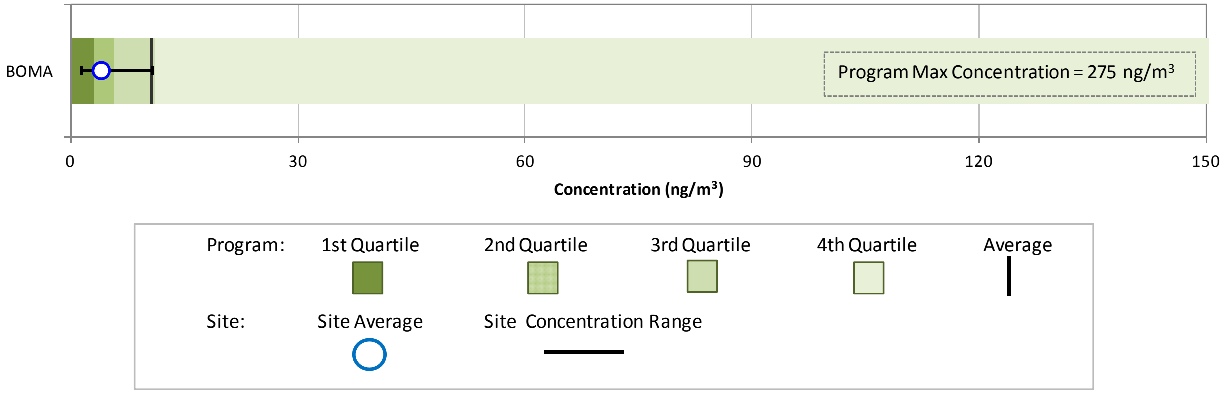


Figure 14-9. Program vs. Site-Specific Average Naphthalene Concentration

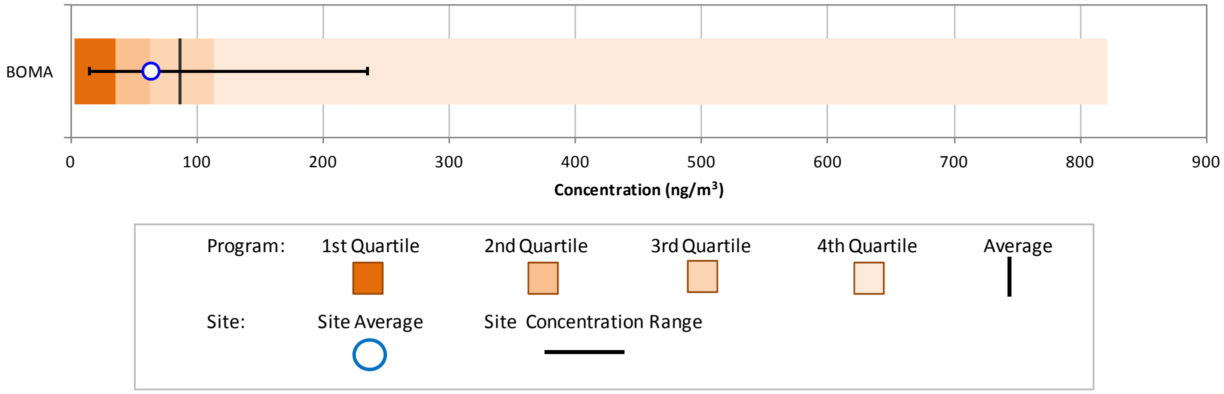
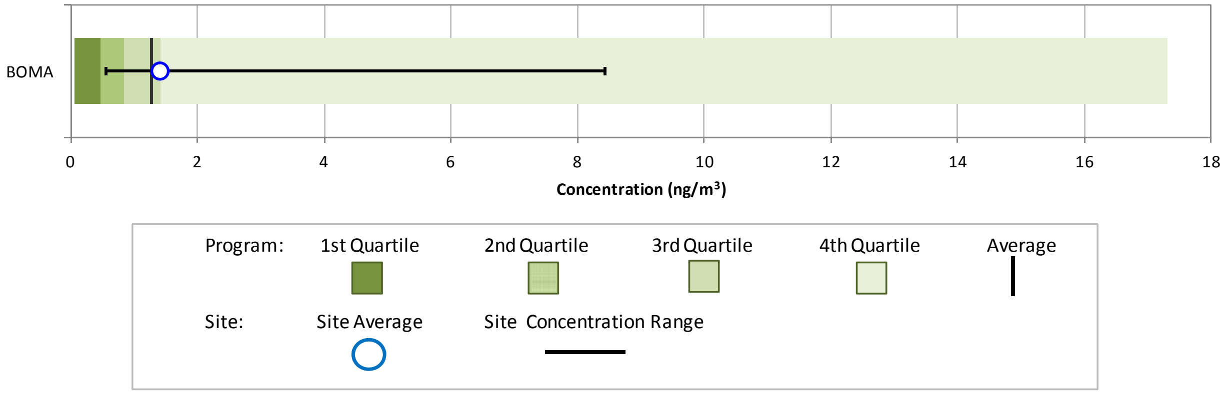


Figure 14-10. Program vs. Site-Specific Average Nickel (PM_{10}) Concentration



Observations from Figures 14-6 through 14-10 include the following:

- Figure 14-6 is the box plot for arsenic and shows that BOMA's annual average arsenic (PM_{10}) concentration is less than the program-level average concentration but similar to the program-level median concentration. The maximum concentration measured at BOMA is considerably less than the maximum concentration measured at the program level. There were no non-detects of arsenic measured at BOMA.

- Figure 14-7 is the box plot for hexavalent chromium. Note that the program-level maximum concentration (8.51 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 0.5 ng/m^3. In addition, the first quartile for hexavalent chromium is zero and thus, not visible in Figure 14-7. This box plot shows that the annual average concentration of hexavalent chromium for BOMA is just less than the program-level average concentration. The maximum concentration measured at BOMA is significantly less than the maximum concentration measured at the program level. As discussed in the previous section, several non-detects of hexavalent chromium were measured at BOMA.

- Figure 14-8 is the box plot for manganese (PM_{10}). Similar to hexavalent chromium, the program-level maximum concentration (275 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range. Thus, the scale has been reduced to 150 ng/m^3. Figure 14-8 shows that the range of manganese concentrations measured at BOMA is relatively small compared to the range of manganese concentrations measured across the program. The maximum manganese concentration measured at BOMA is similar to the program-level average concentration. The annual average manganese concentration for BOMA falls between the program-level first quarter and median concentration.

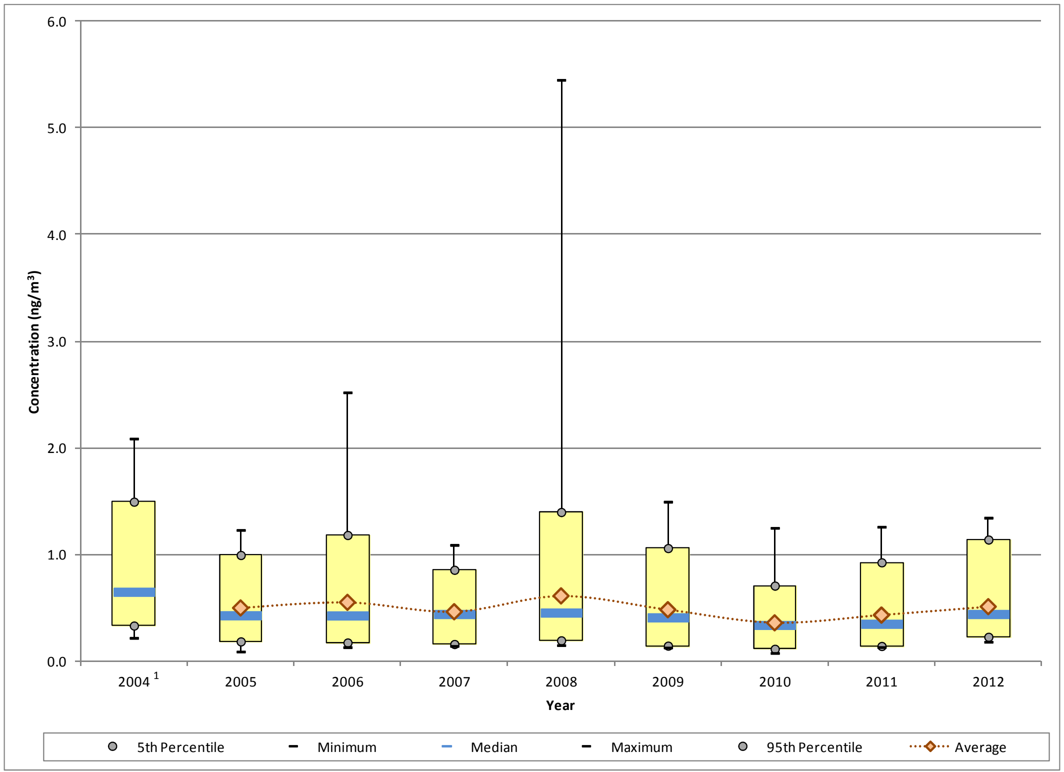
- Figure 14-9 is the box plot for naphthalene and shows that the annual average naphthalene concentration for BOMA is less than the program-level average and similar to the program-level median concentration. The maximum concentration measured at BOMA is considerably less than the maximum concentration measured at the program level.

- Figure 14-10 is the box plot for nickel (PM_{10}). This box plot shows that BOMA's annual average concentration of nickel is just greater than the program-level average and is similar to the program-level third quartile. The minimum nickel concentration measured at BOMA is greater than the program-level first quartile. The maximum nickel concentration measured at BOMA is among the higher nickel concentrations measured across the program.

14.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. BOMA has sampled PM_{10} metals under the NMP since 2003; hexavalent chromium since 2005; and PAHs since 2008. Thus, Figures 14-11 through 14-15 present the 1-year statistical metrics for each of the pollutants of interest for BOMA. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 14-11. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at BOMA



[1] A 1-year average is not presented because there were breaks in sampling during portions of 2004.

Observations from Figure 14-11 for arsenic measurements collected at BOMA include the following:

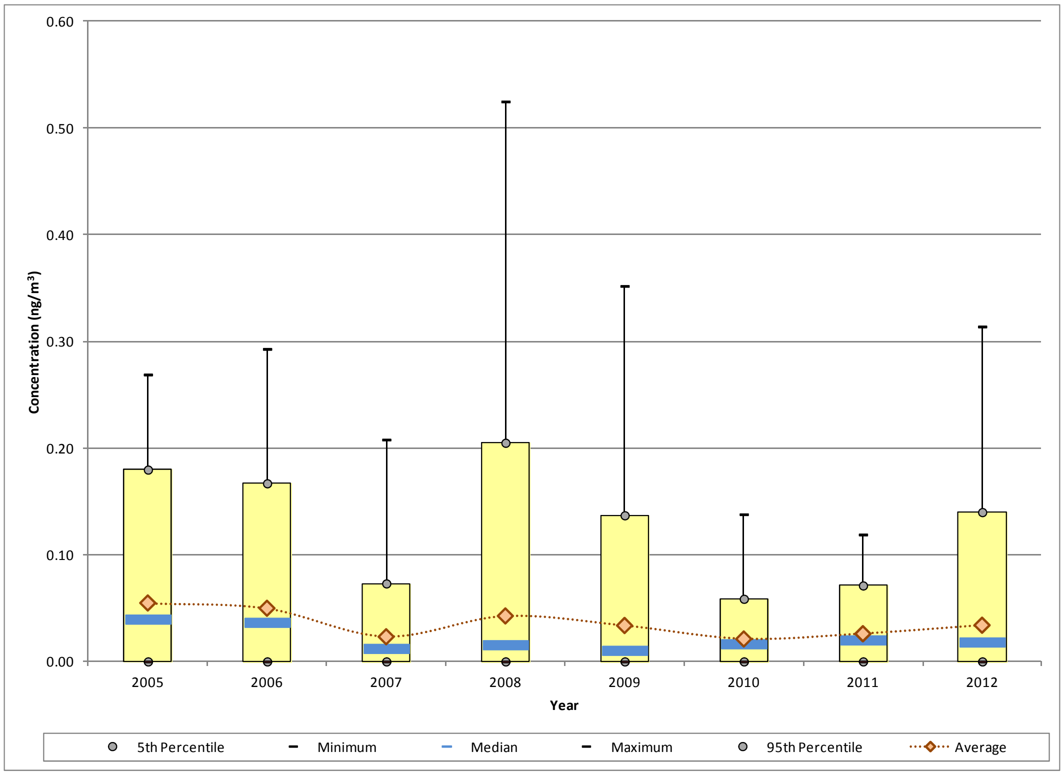
- Although sampling for PM_{10} metals under the NMP began in 2003, data from that year were excluded from this analysis because sampling did not begin until October. In addition, samples were not collected during portions of April, May, September, and October 2004. Because a full year's worth of data is not available for 2004, a 1-year average is not presented, although the range of measurements is provided.

- The maximum arsenic concentration shown was measured on July 5, 2008. The next highest concentration measured is approximately half as high and was measured on July 4, 2006.

- The 1-year average concentrations of arsenic at BOMA have fluctuated over the years, ranging from 0.36 ng/m^3 (2010) to 0.61 ng/m^3 (2008). For 2008, the maximum concentration (5.45 ng/m^3) is driving the 1-year average upward, which is evident from the median concentration, which hardly changed between 2007 and 2008, even though the smallest range of measurements was collected in 2007. If the maximum concentration for 2008 was removed from the dataset, the 1-year average for 2008 would decrease from 0.61 ng/m^3 to 0.53 ng/m^3, making the changes in the 1-year averages between 2007 and 2009 more subtle.

- The 1-year average and median concentrations increased from 2010 to 2011 and again for 2012. Additional years of sampling are needed to determine if this trend continues.

Figure 14-12. Yearly Statistical Metrics for Hexavalent Chromium Concentrations Measured at BOMA



Observations from Figure 14-12 for hexavalent chromium measurements collected at BOMA include the following:

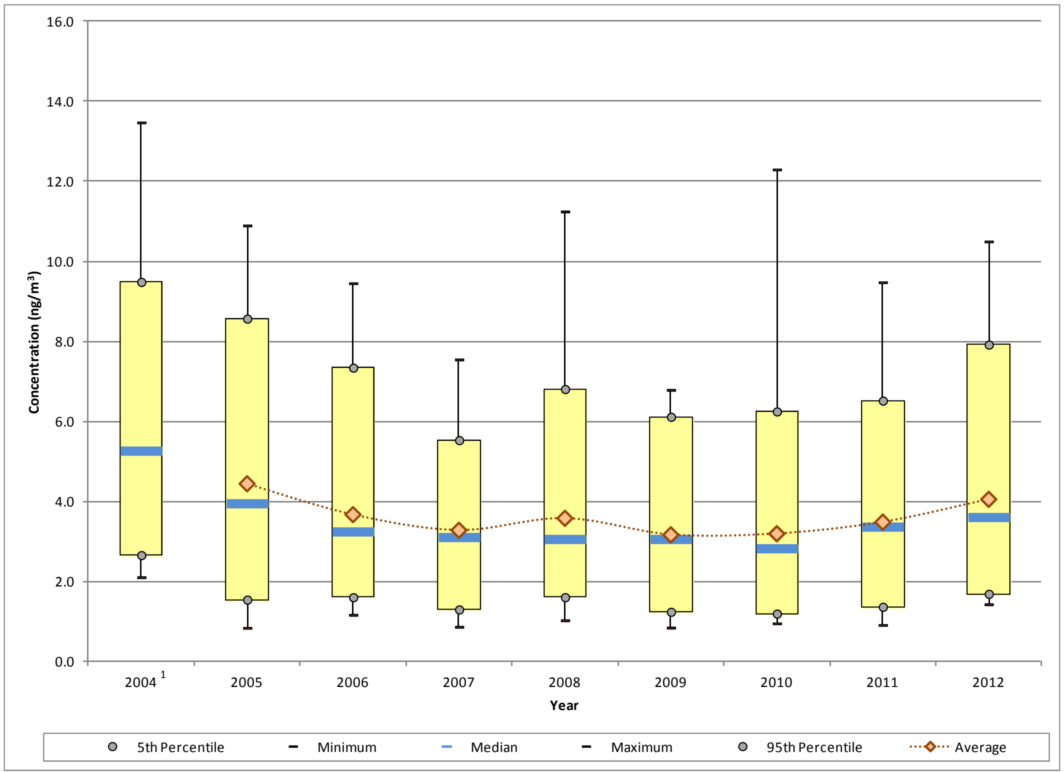
- The maximum hexavalent chromium concentration was measured in 2008 (0.525 ng/m^3). Less than 10 percent of hexavalent chromium concentrations measured at BOMA are greater than 0.1 ng/m^3. At least one concentration greater than 0.1 ng/m^3 has been measured in each year since the onset of sampling, with 2005 having the most (eight) and 2011 having the least (one).

- The range of measurements has varied each year, as indicated by both the maximum concentration and the 95th percentile. The 95th percentile for 2008 is greater than the maximum concentrations for 2010 and 2011.

- The 1-year average concentration decreased significantly from 2006 to 2007, then increased for 2008. A decreasing trend is also shown between 2008 and 2010, followed by a slight increasing trend. However, there is a considerable amount of variability within the measurements collected each year, as indicated by the confidence intervals calculated for the 1-year averages, particularly for 2008.

- The minimum and 5th percentile are both zero for each year of sampling, indicating the presence of non-detects. The percentage of non-detects has varied between 11 percent (2006) to 43 percent (2009).

Figure 14-13. Yearly Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at BOMA



[1] A 1-year average is not presented because there were breaks in sampling during portions of 2004.

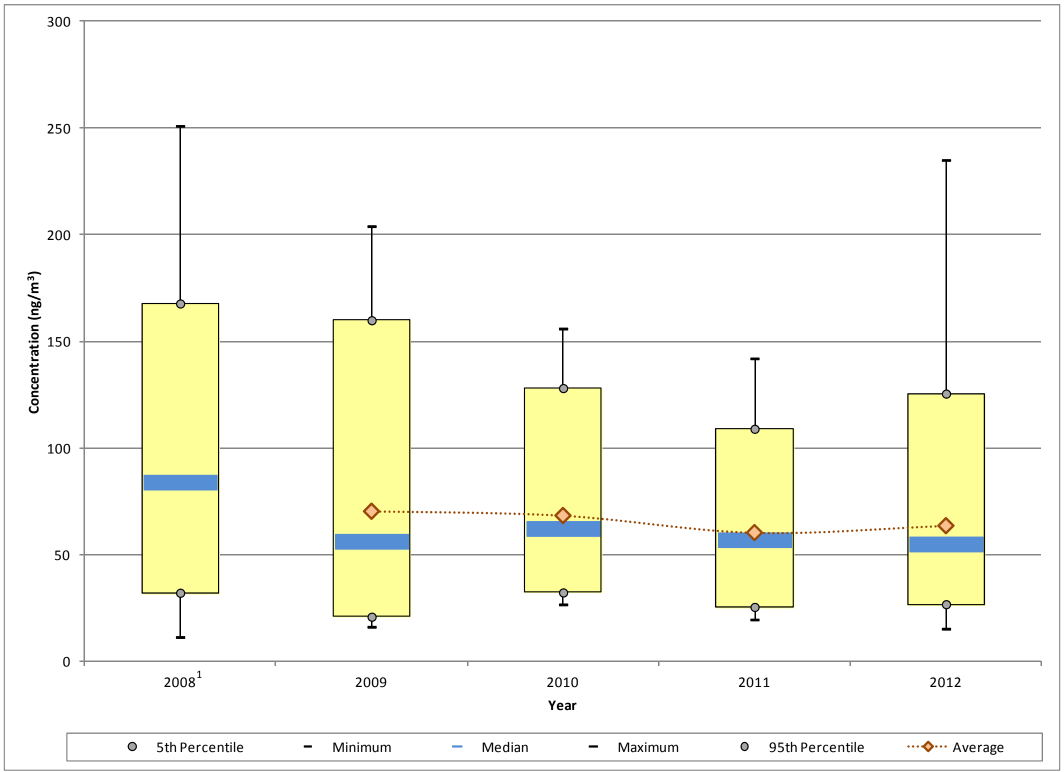
Observations from Figure 14-13 for manganese measurements collected at BOMA include the following:

- The maximum manganese concentration shown was measured on November 11, 2004 (13.5 ng/m^3). Six additional manganese concentrations measured at BOMA are greater than 10 ng/m^3, and were measured in 2004, 2005, 2008, 2010, and 2012.

- A steady decrease in the upper range of concentrations measured, as indicated by the maximum and 95th percentile, is shown between 2004 and 2007. Both the median and 1-year average concentrations of manganese exhibit a decreasing trend as well. With the exception of 2008, when all of the statistical metrics except the median exhibit increases, the 1-year average concentrations of manganese changed relatively little between 2007 and 2010. The 1-year average concentration ranged from 3.16 ng/m^3 (2009) to 3.57 ng/m^3 (2008) between 2007 and 2010.

- Although an increasing trend is shown for 2011 and 2012, additional sampling is required to determine if this trend continues.

Figure 14-14. Yearly Statistical Metrics for Naphthalene Concentrations Measured at BOMA



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2008.

Observations from Figure 14-14 for naphthalene measurements collected at BOMA include the following:

- BOMA began sampling PAHs under the NMP in May 2008. Because a full year's worth of data is not available for 2008, a 1-year average is not presented, although the range of measurements is provided.

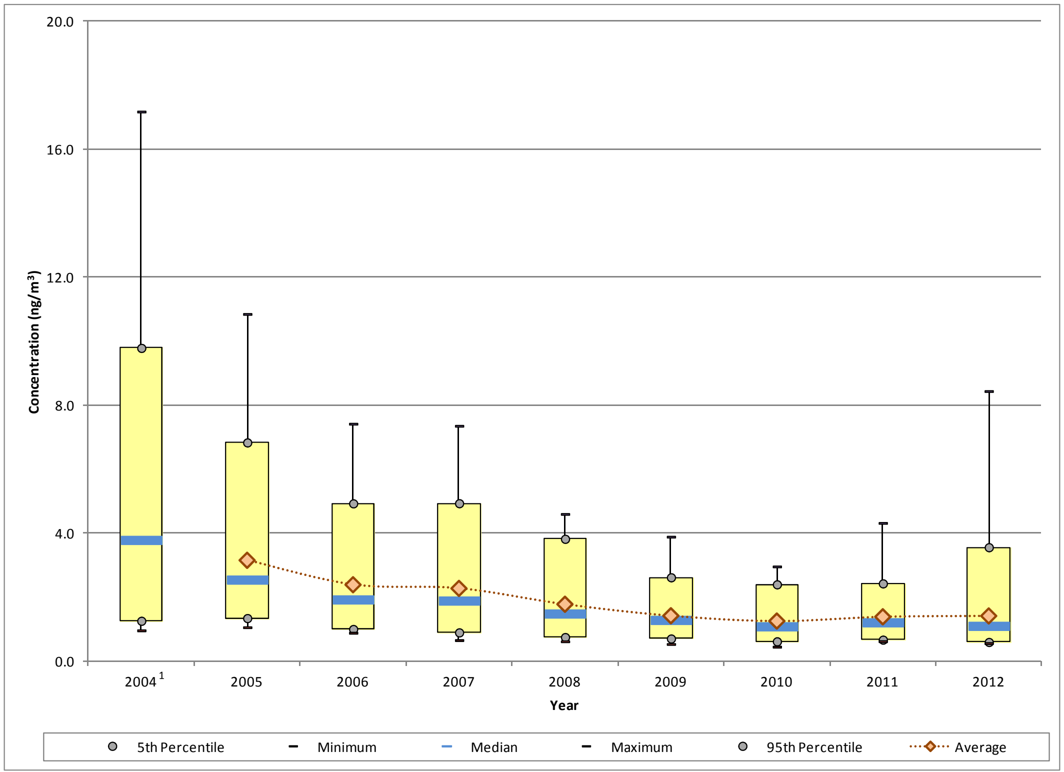
- The maximum naphthalene concentration was measured on the very first sample day (May 6, 2008), although a similar measurement was collected in 2012. Only two additional concentrations greater than 200 ng/m^3 have been measured at BOMA (2008 and 2009).

- The difference between the 5th and 95th percentiles (the range of concentrations within which 90 percent of the measurements lie) decreased each year through 2011. The range increased somewhat for 2012, and is more similar to the range shown for 2010.

- The median concentration decreased significantly from 2008 to 2009, from 84.0 ng/m^3 to 56.3 ng/m^3. Little change is shown after 2008, with the median varying by only 5 ng/m^3 between 2009 and 2012. Similarly, the 1-year average varies by only

10 ng/m^3 for the years shown, ranging from 60.3 ng/m^3 for 2011 to 70.3 ng/m^3 for 2009.

Figure 14-15. Yearly Statistical Metrics for Nickel (PM_{10}) Concentrations Measured at BOMA



[1] A 1-year average is not presented because there were breaks in sampling during portions of 2004.

Observations from Figure 14-15 for nickel measurements collected at BOMA include the following:

- The maximum concentration was measured at BOMA in 2004 (17.2 ng/m^3). All but one of the nickel concentrations greater than 7.50 ng/m^3 were measured in 2004 or 2005 (with the other was measured in 2012).

- A steady decreasing trend in the nickel measurements collected at BOMA is shown through 2010. Little change is shown between 2010 and 2011 with the exception of the maximum concentration. Even with the higher concentrations measured in 2012, the 1-year average concentration did not change significantly from the previous year (from 1.38 ng/m^3 for 2011 to 1.41 ng/m^3 for 2012).

14.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the BOMA monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

14.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Massachusetts monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

14.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for BOMA and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 14-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations for BOMA from Table 14-6 include the following:

- Naphthalene has the highest annual average concentration for BOMA. Manganese and nickel also have annual average concentrations greater than 1.0 ng/m^3.
- Although the annual average concentration for naphthalene is two orders of magnitude greater than the annual average concentration of arsenic, the cancer risk approximations for these two pollutants are fairly similar (2.16 in-a-million for naphthalene and 2.20 in-a-million for arsenic). This speaks to the relative toxicity of one pollutant compared to the other.

- None of the pollutants of interest for BOMA have noncancer hazard approximations greater than 1.0; in fact, none of the pollutants of interest have noncancer hazard approximations greater than 0.1. This indicates that no adverse health effects are expected due to these individual pollutants.

Table 14-6. Risk Approximations for the Massachusetts Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Boston, Massachusetts - BOMA						
Arsenic (PM_{10})	0.0043	0.000015	61/61	0.51 ± 0.07	2.20	0.03
Hexavalent Chromium	0.012	0.0001	50/61	0.03 ± 0.02	0.41	<0.01
Manganese (PM_{10})	--	0.00005	61/61	4.06 ± 0.51	--	0.08
Naphthalene	0.000034	0.003	59/59	63.55 ± 9.09	2.16	0.02
Nickel (PM_{10})	0.00048	0.00009	61/61	1.41 ± 0.29	0.68	0.02

-- = A Cancer URE or Noncancer RfC is not available.

14.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 14-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 14-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 14-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for BOMA, as presented in Table 14-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 14-7. Table 14-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 14-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Massachusetts Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Boston, Massachusetts (Suffolk County) - BOMA					
Formaldehyde	158.03	Formaldehyde	2.05E-03	Arsenic	2.20
Benzene	146.66	Benzene	1.14E-03	Naphthalene	2.16
Acetaldehyde	72.50	1,3-Butadiene	7.78E-04	Nickel	0.68
Ethylbenzene	68.14	POM, Group 3	5.81E-04	Hexavalent Chromium	0.41
1,3-Butadiene	25.92	Naphthalene	4.51E-04		
Tetrachloroethylene	14.49	Nickel, PM	4.47E-04		
Naphthalene	13.28	POM, Group 2b	3.23E-04		
POM, Group 2b	3.67	Arsenic, PM	2.53E-04		
POM, Group 2d	1.81	Hexavalent Chromium, PM	2.17E-04		
Propylene oxide	0.98	Ethylbenzene	1.70E-04		

Table 14-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Massachusetts Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Boston, Massachusetts (Suffolk County) - BOMA					
Toluene	534.20	Acrolein	515,526.17	Manganese	0.08
Hexane	403.19	Formaldehyde	16,125.78	Arsenic	0.03
Xylenes	289.61	1,3-Butadiene	12,959.09	Naphthalene	0.02
Formaldehyde	158.03	Nickel, PM	10,345.15	Nickel	0.02
Benzene	146.66	Acetaldehyde	8,055.15	Hexavalent Chromium	<0.01
Acetaldehyde	72.50	Benzene	4,888.74		
Ethylbenzene	68.14	Naphthalene	4,425.71		
Methyl isobutyl ketone	56.12	Arsenic, PM	3,914.83		
1,3-Butadiene	25.92	Cadmium, PM	2,970.00		
Glycol ethers, gas	16.16	Xylenes	2,896.12		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 14.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 14-7 include the following:

- Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs in Suffolk County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, and 1,3-butadiene.
- Six of the highest emitted pollutants also have the highest toxicity-weighted emissions.
- Four out of five of BOMA's pollutants of interest have cancer UREs and thus, have cancer risk approximations presented in Table 14-7. All four of these pollutants are among those with the highest toxicity-weighted emissions. Conversely, only one of them (naphthalene) appears among the highest emitted.
- POM, Group 2b ranks eighth for quantity emitted and seventh for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at BOMA including acenaphthene, fluoranthene, and fluorene. Although all three of these pollutants failed at least one screen for BOMA, none of them were identified as pollutants of interest for BOMA.

Observations from Table 14-8 include the following:

- Toluene, hexane, and xylenes are the highest emitted pollutants with noncancer RfCs in Suffolk County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene.
- Five of the highest emitted pollutants also have the highest toxicity-weighted emissions.

- Manganese, which has the highest (albeit low) noncancer hazard approximation for BOMA, appears on neither emissions-based list.

- Although arsenic, naphthalene, and nickel are among the pollutants with the highest toxicity-weighted emissions, none of these appear among the highest emitted pollutants.

14.6 Summary of the 2012 Monitoring Data for BOMA

Results from several of the data treatments described in this section include the following:

- ❖ *Nine pollutants failed screens for BOMA, with arsenic and naphthalene accounting for a majority of the failed screens.*

- ❖ *Naphthalene had the highest annual average concentration among the pollutants of interest for BOMA.*

- ❖ *Even though concentrations of nickel have a decreasing trend over the years of sampling, BOMA has the fifth highest annual average concentration for 2012 among NMP sites sampling PM_{10} metals.*

15.0 Sites in Michigan

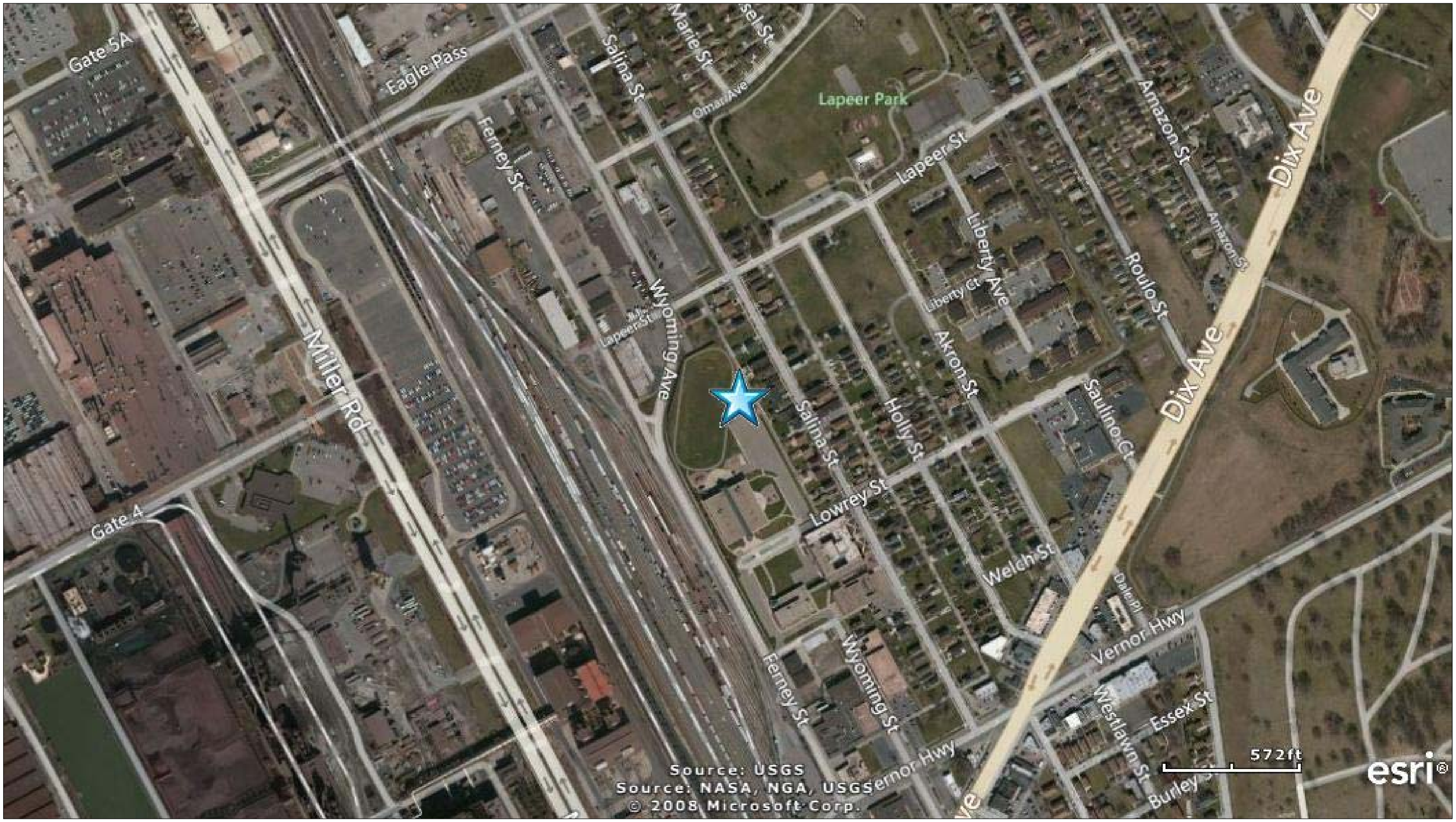
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Michigan, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

15.1 Site Characterization

This section characterizes the monitoring sites by providing geographical and physical information about the locations of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

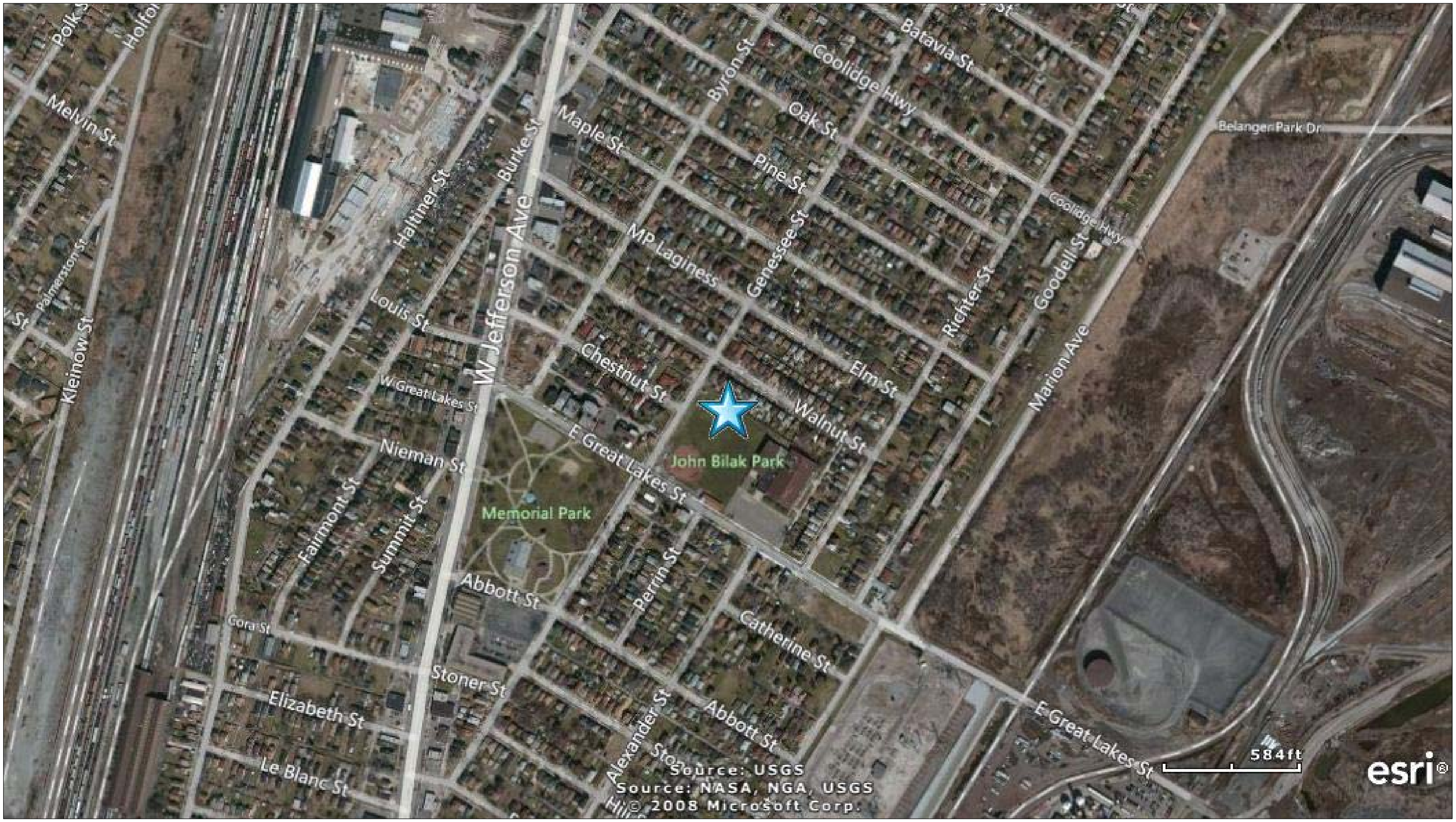
The DEMI, RRMI, and SWMI monitoring sites are located in the Detroit-Warren-Dearborn, MI MSA. Figures 15-1 through 15-3 are the composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites and their immediate surroundings. Figure 15-4 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 15-4. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radii are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary.
Table 15-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 15-1. Dearborn, Michigan (DEMI) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 15-2. River Rouge, Michigan (RRMI) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 15-3. Detroit, Michigan (SWMI) Monitoring Site

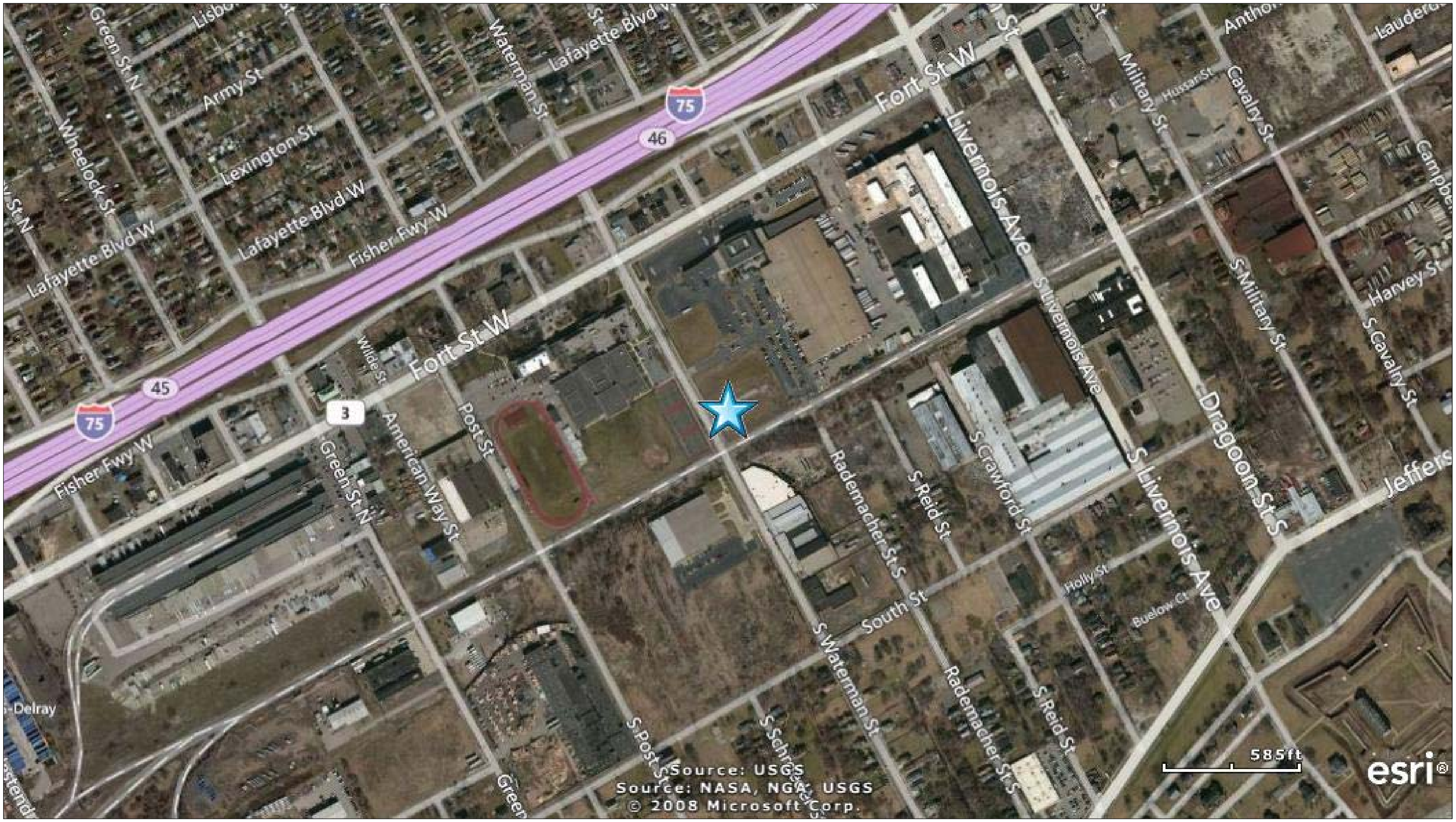


Figure 15-4. NEI Point Sources Located Within 10 Miles of DEMI, RRMI, and SWMI

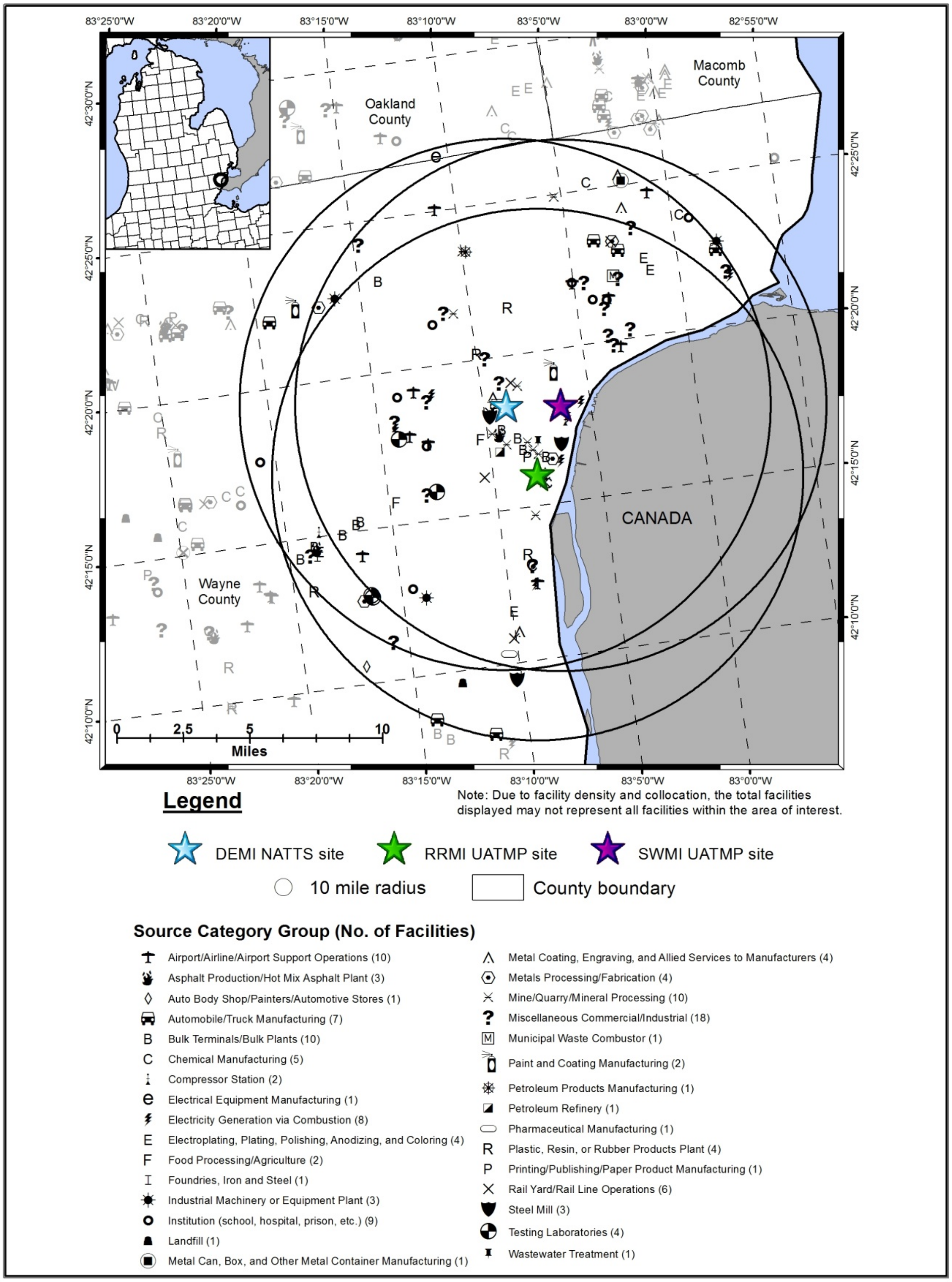


Table 15-1. Geographical Information for the Michigan Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
DEMI	26-163-0033	Dearborn	Wayne	Detroit-Warren-Dearborn, MI MSA	42.306666, -83.148889	Industrial	Suburban	TSP Metals, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, $PM_{2.5}$ Speciation, and IMPROVE Speciation.
RRMI	26-163-0005	River Rouge	Wayne	Detroit-Warren-Dearborn, MI MSA	42.267222, -83.132222	Industrial	Suburban	TSP Metals, Meteorological parameters, PM_{10}, PM_{10} Manganese.
SWMI	26-163-0015	Detroit	Wayne	Detroit-Warren-Dearborn, MI MSA	42.302778, -83.106667	Commercial	Urban/City Center	Soil Index, SO_2, TSP Metals, VOCs, Meteorological parameters, PM_{10}, PM_{10} Manganese, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.
BOLD ITALICS = EPA-designated NATTS Site

DEMI is located in the parking lot of Salinas Elementary School in Dearborn, just southwest of Detroit, and is the Detroit NATTS site. The surrounding area is both suburban and industrial in nature. Figure 15-1 shows that a freight yard is located just west of the site and a residential neighborhood is located to the east. Industrial sources such as automobile and steel manufacturing facilities are also located in the vicinity. The monitoring site lies between two heavily traveled roadways, I-75 (1.4 miles to the east) and I-94 (1.2 miles to the west).

RRMI is located at John Bilak Park in River Rouge, a southwestern suburb of Detroit, less than 1 mile from the Detroit River and the U.S./Canadian border. The surrounding area is of mixed usage, with residential properties surrounded by highly industrial ones. A freight yard is located to the west of the site past Haltiner Street while the Port of Detroit is located just to the east and southeast, just beyond the bottom right-hand side of Figure 15-2. This site is also downwind of a steel manufacturing facility.

SWMI is located on the property of Southwestern High School in the city of Detroit. The high school’s track can be seen just west of the site marker in Figure 15-3. Interstate-75 runs northeast-southwest less than 0.3 miles north of SWMI. The surrounding area is considered commercial, although the site lies approximately 1 mile north of Zug Island, a small, highly industrialized area where the Rouge River empties into the Detroit River. This site is also less than 1 mile west of the Detroit River and U.S./Canadian border.

Figure 15-4 shows that DEMI, RRMI, and SWMI are located within a few miles of each other. Numerous point sources surround these sites. A cluster of sources is located just west of DEMI. Another cluster of sources is located just north of RRMI. The source categories with the most point sources within 10 miles of these sites include the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; bulk terminals and bulk plants; mines, quarries, and mineral processing facilities; and institutional facilities (schools, prisons, and/or hospitals). Although difficult to discern in Figure 15-4, the closest source to DEMI is involved in automobile/truck manufacturing; the closest source to SWMI is involved in electricity generation via combustion; and the closest source to RRMI is involved in asphalt/hot mix asphalt production.

Table 15-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Michigan monitoring sites. Table 15-2 includes both county-level population and vehicle registration information. Table 15-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 15-2 presents the county-level daily VMT for Wayne County.

Table 15-2. Population, Motor Vehicle, and Traffic Information for the Michigan Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
DEMI	1,792,365	1,337,797	87,500	I-94 between Ford Road and Rotunda Drive	40,951,779
RRMI			97,300	I-75 between Outer Drive & M-85	
SWMI			94,400	I-75 between Springwells Street and Livernois Avenue	

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (MDS, 2013)
[3] AADT reflects 2012 data (MI DOT, 2012)
[4] County-level VMT reflects 2011 data (MI DOT, 2013)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 15-2 include the following:

- Wayne County's population and vehicle registration both rank eighth highest among counties with NMP sites.

- The traffic volumes near the Michigan sites are similar to each other and rank 17th, 18th, and 21st among NMP sites. Traffic for DEMI is provided for I-94, between Ford Road and Rotunda Drive; traffic data for RRMI is for I-75 between Outer Drive and South Fort Street/M-85; and traffic data for SWMI is for I-75 between Springwells Street and Livernois Avenue.

- The Wayne County daily VMT is the seventh highest VMT compared to other counties with NMP sites (where VMT data were available).

15.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Michigan on sample days, as well as over the course of the year.

15.2.1 Climate Summary

Detroit is located in a region of active weather. Winters tend to be cold and wet, with snowfall averages between 35 inches and 40 inches per year. Summers are generally mild, although temperatures exceeding 90°F are not uncommon. Precipitation is fairly well distributed throughout the year, with summer precipitation coming primarily in the form of showers and thunderstorms. The urbanization of the area and Lake St. Clair to the east are major influences on the city's weather. The lake tends to keep the Detroit area warmer in the winter and cooler in the summer than more inland areas. The urban heat island also keeps the city warmer than outlying areas. Winds are often breezy and flow from the southwest on average (Wood, 2004; MSU, 2014).

15.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Michigan monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather station to all three sites is located at Detroit City Airport (WBAN 14822). Additional information about this weather station, such as the distance between the sites and the weather station, is provided in Table 15-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 15-3. Average Meteorological Conditions near the Michigan Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Dearborn, Michigan - DEMI									
Detroit City Airport 14822 (42.41, -83.01)	9.7 miles 35° (NE)	Sample Day (72)	61.6 ± 4.4	53.2 ± 4.0	41.1 ± 3.5	47.1 ± 3.4	66.6 ± 2.8	1016.1 ± 1.6	6.8 ± 0.7
		2012	61.6 ± 2.0	53.6 ± 1.8	41.4 ± 1.6	47.4 ± 1.6	66.4 ± 1.3	1016.1 ± 0.7	6.5 ± 0.3
River Rouge, Michigan - RRMI									
Detroit City Airport 14822 (42.41, -83.01)	11.4 miles 23° (NNE)	Sample Day (60)	62.4 ± 4.9	53.8 ± 4.5	40.9 ± 3.9	47.3 ± 3.8	64.8 ± 3.0	1016.2 ± 1.8	6.9 ± 0.8
		2012	61.6 ± 2.0	53.6 ± 1.8	41.4 ± 1.6	47.4 ± 1.6	66.4 ± 1.3	1016.1 ± 0.7	6.5 ± 0.3
Detroit, Michigan - SWMI									
Detroit City Airport 14822 (42.41, -83.01)	8.7 miles 24° (NNE)	Sample Day (30)	61.9 ± 6.6	52.9 ± 6.2	40.7 ± 5.6	46.8 ± 5.4	65.8 ± 3.9	1018.2 ± 2.7	5.8 ± 0.9
		2012	61.6 ± 2.0	53.6 ± 1.8	41.4 ± 1.6	47.4 ± 1.6	66.4 ± 1.3	1016.1 ± 0.7	6.5 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 15-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 15-3 is the 95 percent confidence interval for each parameter. Average meteorological conditions on sample days near the sites were generally representative of average weather conditions experienced throughout the year. Note that the number of sample days for SWMI is roughly half the number for DEMI and RRMI. This is because SWMI sampled on a 1-in-12 day schedule compared to DEMI and RRMI, which sampled on a 1-in-6 day schedule. The biggest difference in Table 15-3 in the meteorological parameters is for sea level pressure for SWMI. This is because SWMI did not sample on some of the days with the lowest sea level pressures. For example, SWMI did not sample on October 30, 2012, the day that Hurricane Sandy came ashore over New Jersey.

15.2.3 Back Trajectory Analysis

Figure 15-5 is the composite back trajectory map for days on which samples were collected at the DEMI monitoring site. Included in Figure 15-5 are four back trajectories per sample day. Figure 15-6 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 15-5 and 15-6 represents 100 miles. Figures 15-7 through15-10 are the composite back trajectory maps and corresponding cluster analyses for RRMI and SWMI.

Figure 15-5. Composite Back Trajectory Map for DEMI

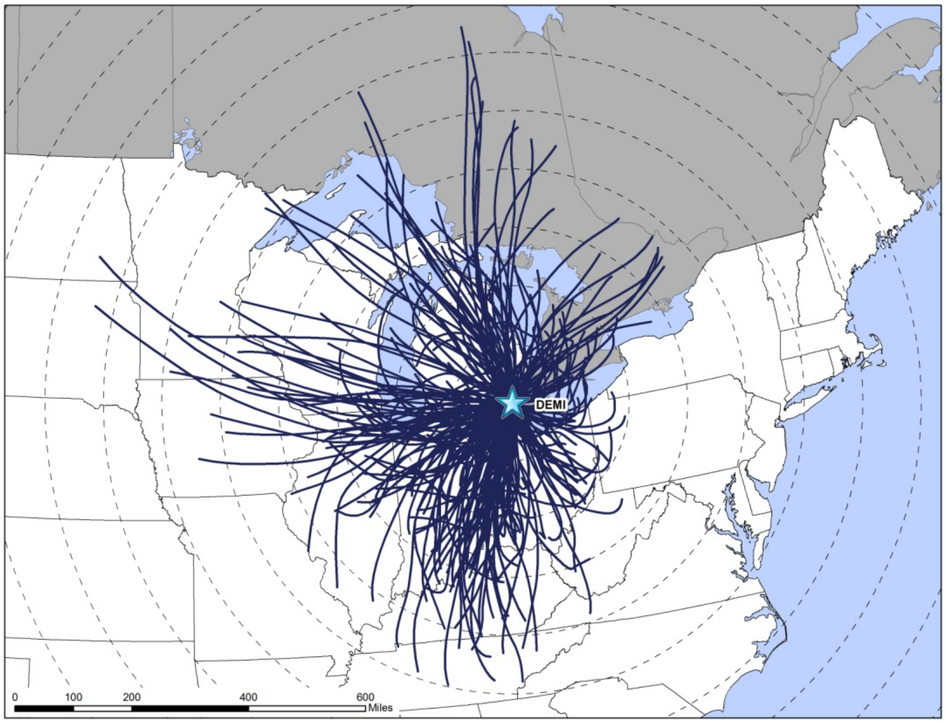


Figure 15-6. Back Trajectory Cluster Map for DEMI

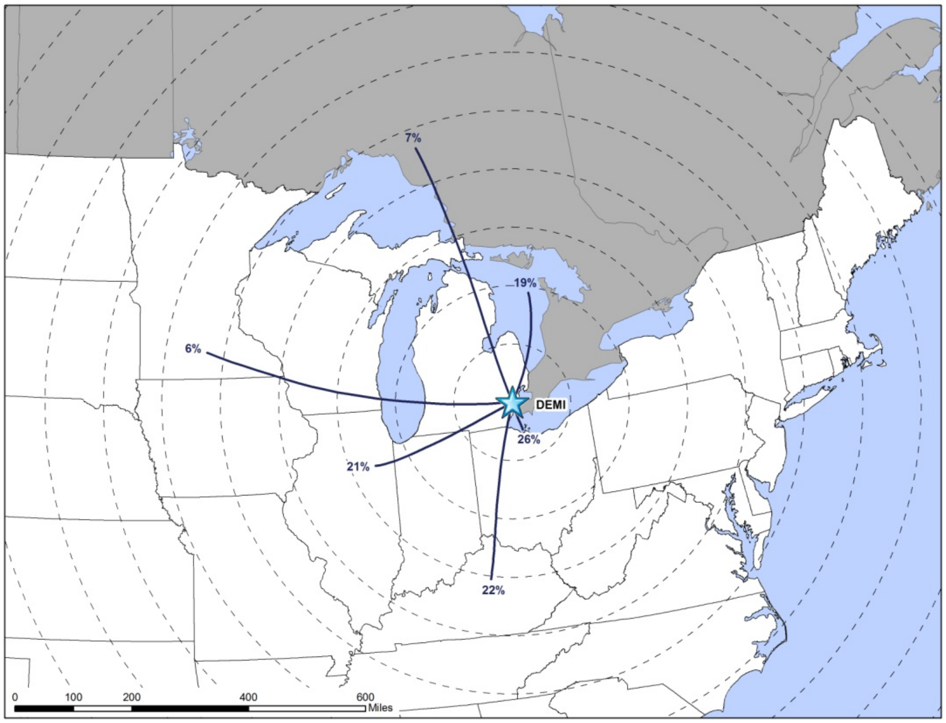


Figure 15-7. Composite Back Trajectory Map for RRMI

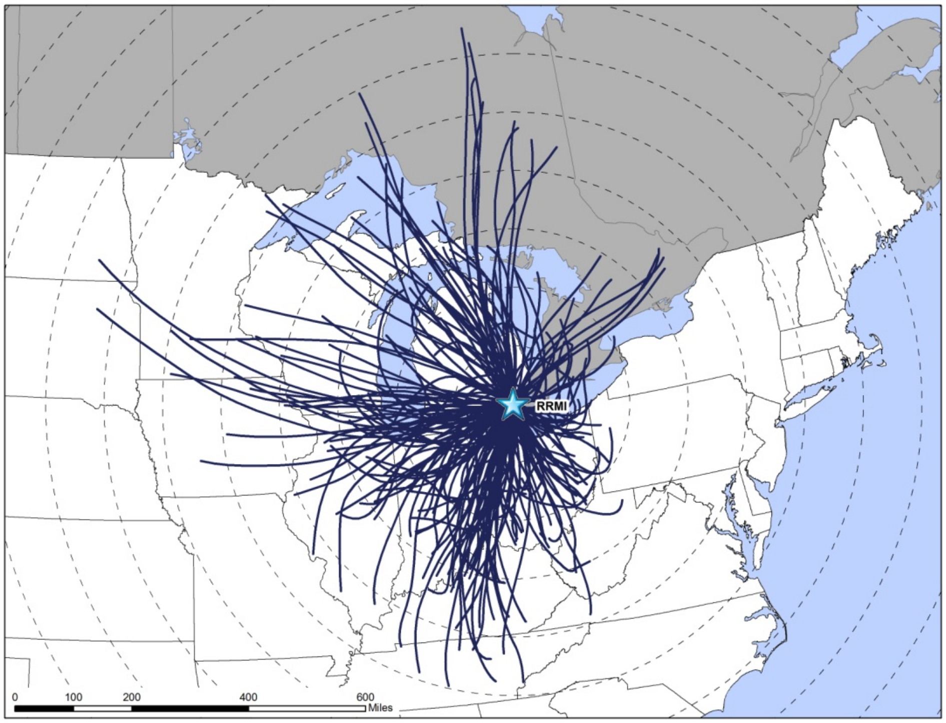


Figure 15-8. Back Trajectory Cluster Map for RRMI

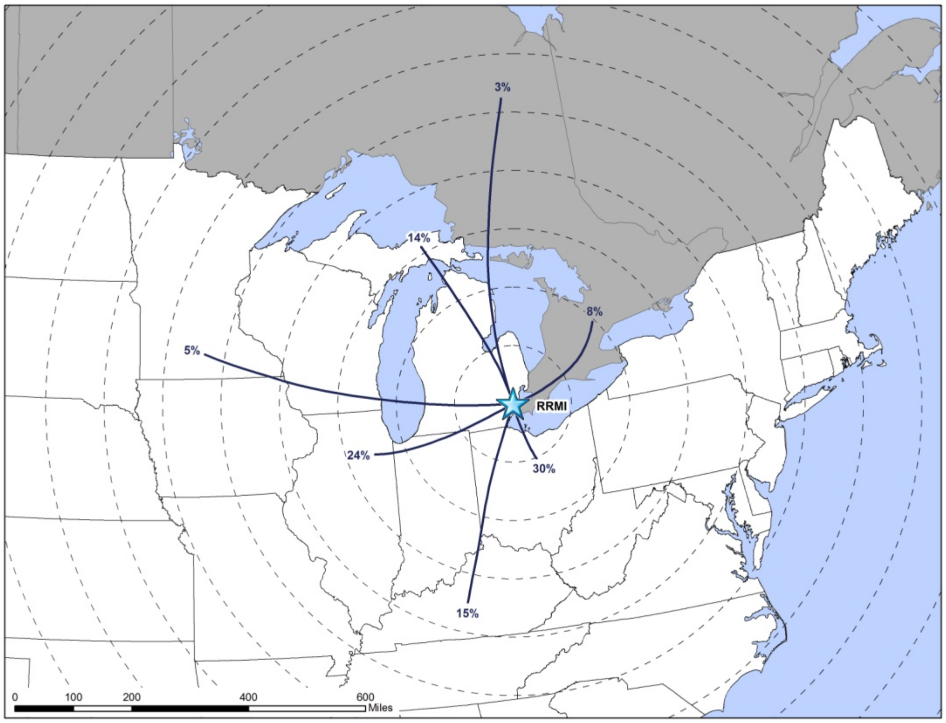


Figure 15-9. Composite Back Trajectory Map for SWMI

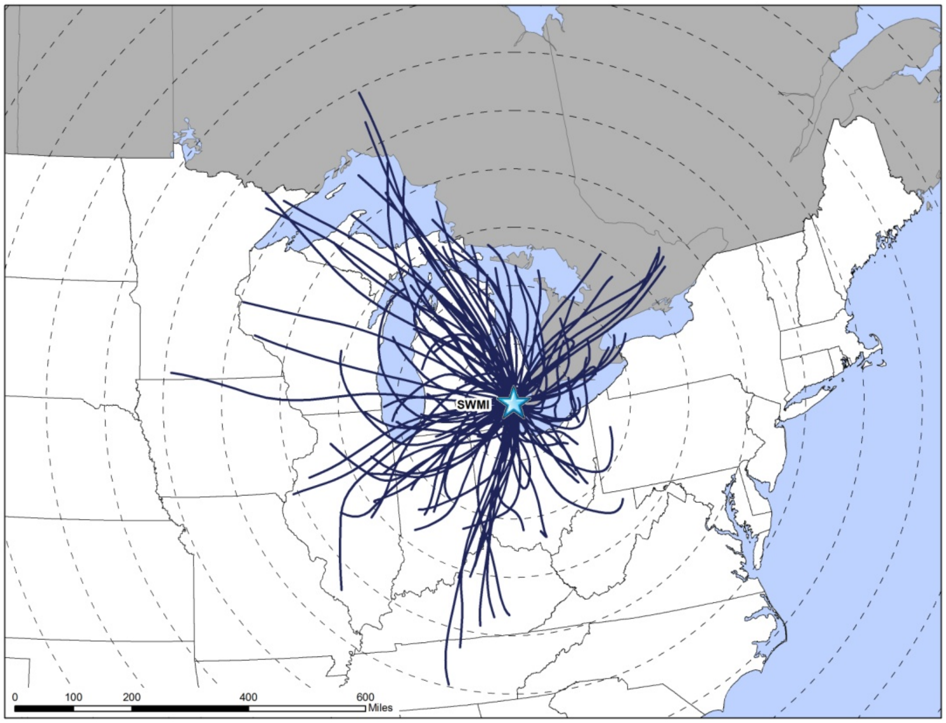
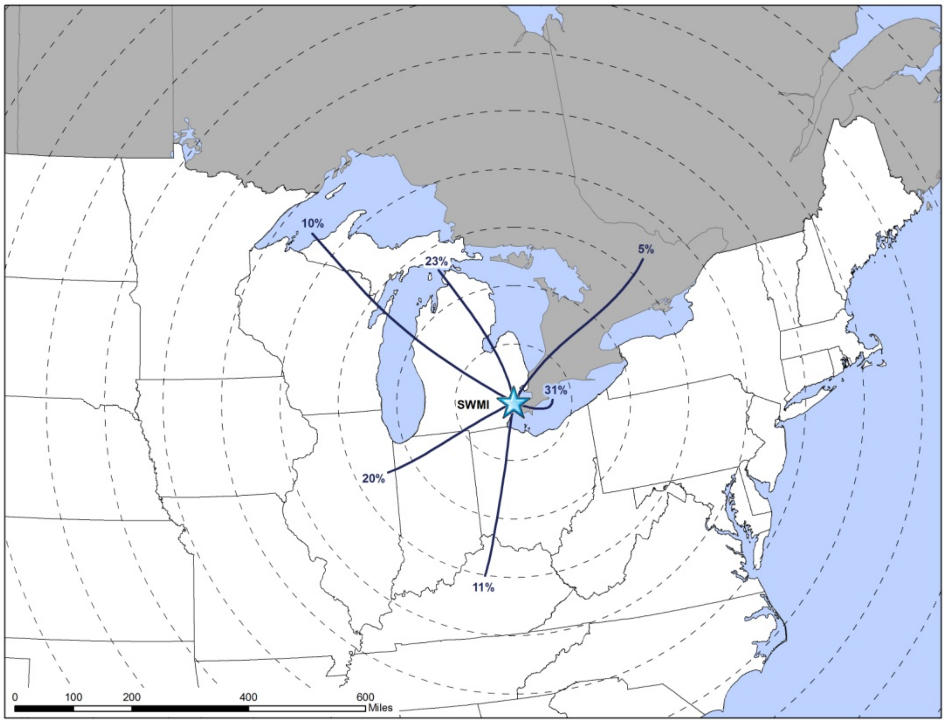


Figure 15-10. Back Trajectory Cluster Map for SWMI



Observations from Figures 15-5 through 15-10 for the Michigan sites include the following:

- The composite back trajectory maps for DEMI and RRMI are similar to each other in trajectory distribution. This is expected given the close proximity to each other and the similarities in sample days. The composite map for SWMI has roughly half the back trajectories because this site sampled on a 1-in-12 day sampling schedule rather than a 1-in-6 day schedule.

- Back trajectories originated from a variety of directions near the monitoring sites. Back trajectories originating to the east of the sites tended to be shorter in length than back trajectories from other directions.

- The 24-hour air shed domain for DEMI was similar in size to RRMI. The farthest away a back trajectory originated from these sites was over North Dakota, or 750 miles away. The average back trajectory lengths for these two sites were just less than 270 miles. Approximately 88 percent of trajectories originated within 450 miles of the sites.

- For SWMI, the air shed domain was slightly smaller than those for DEMI and RRMI, with an average back trajectory length of 251 miles, with greater than 90 percent of back trajectories originating within 450 miles of the site. The longest back trajectories were approximately 590 miles in length (one over southern Minnesota and one over central Ontario, Canada).

- The cluster analysis for DEMI shows that nearly 20 percent of back trajectories originated from a direction with a northerly component, over Michigan and Lake Huron, and are generally less than 300 miles in length. Another 7 percent of back trajectories originated to the northwest to north but were longer in length. Twenty-one percent of back trajectories originated to the southwest, west, and northwest of DEMI. Another 6 percent of back trajectories originated farther west over Iowa and Minnesota. Twenty-two percent of back trajectories originated to the south of the site. The short cluster trajectory originating over Lake Erie represents back trajectories originating over the eastern half of Ohio and Lake Erie as well as shorter back trajectories (generally less than 150 miles) originating from other directions.

- The cluster analysis for RRMI is similar to the cluster analysis for DEMI. The primary difference is how the HYSPLIT model grouped the back trajectories with a northerly component. For RRMI, they are split into three cluster trajectories rather than two.

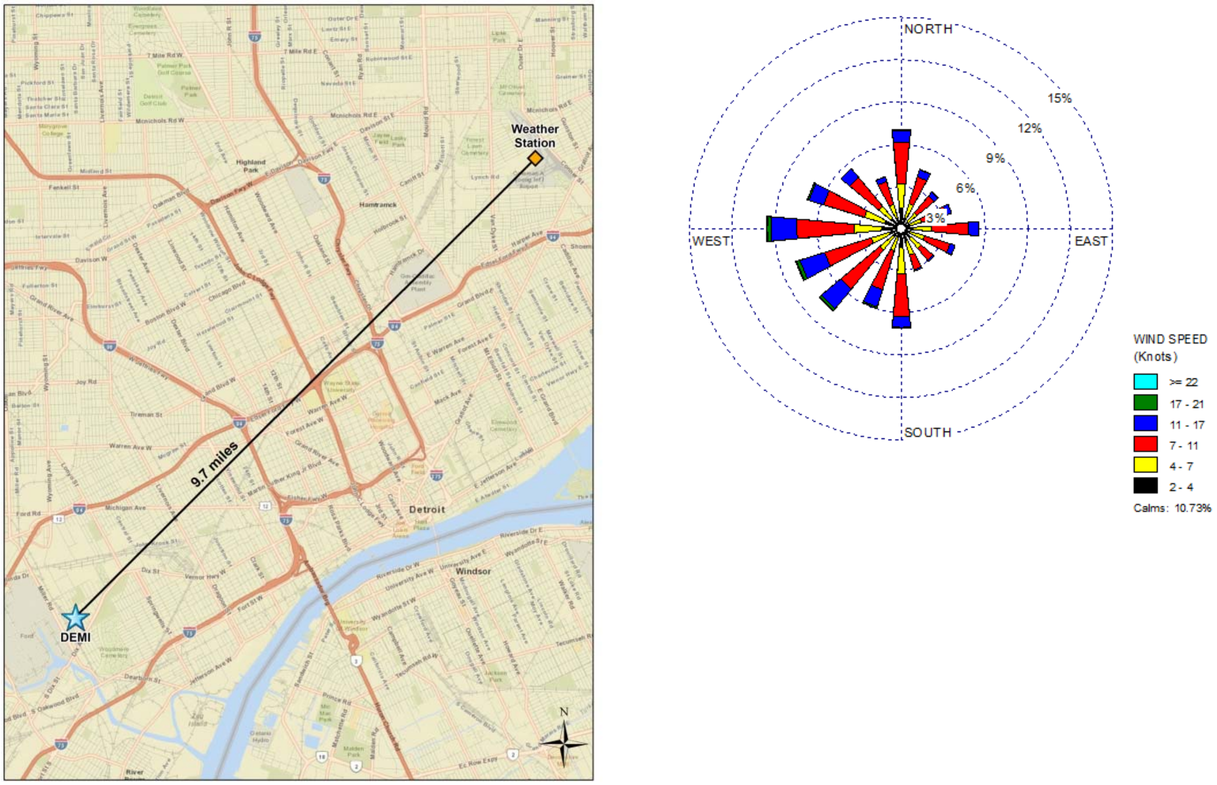
- The cluster analysis for SWMI shows that one-third of back trajectories originated to the northwest of the site but are split into two cluster trajectories based on length. Another 20 percent originated to the southwest of SWMI over Illinois and Indiana. Eleven percent of back trajectories originated to the south of the site, mostly over Ohio and Kentucky. Nearly one third of back trajectories are represented by the short cluster trajectory originating over Lake Erie. This cluster trajectory includes back trajectories originating to the northeast, east, and southeast of SWMI as well as a few shorter back trajectories spiraling in toward SWMI from other directions. The final 5 percent of back trajectories originated over southeast Ontario, Canada.

15.2.4 Wind Rose Comparison

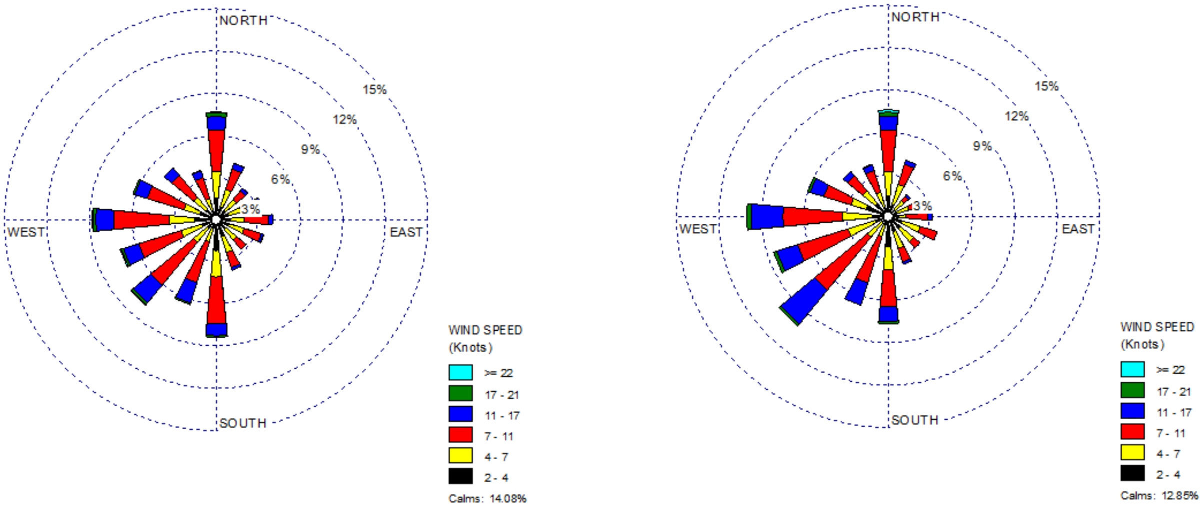
Hourly surface wind data from the weather station at the Detroit City Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 15-11 presents a map showing the distance between the weather station and DEMI, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 15-11 also presents three different wind roses for the DEMI monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 15-12 and 15-13 present the distance maps and wind roses for RRMI and SWMI.

Figure 15-11. Wind Roses for the Detroit City Airport Weather Station near DEMI

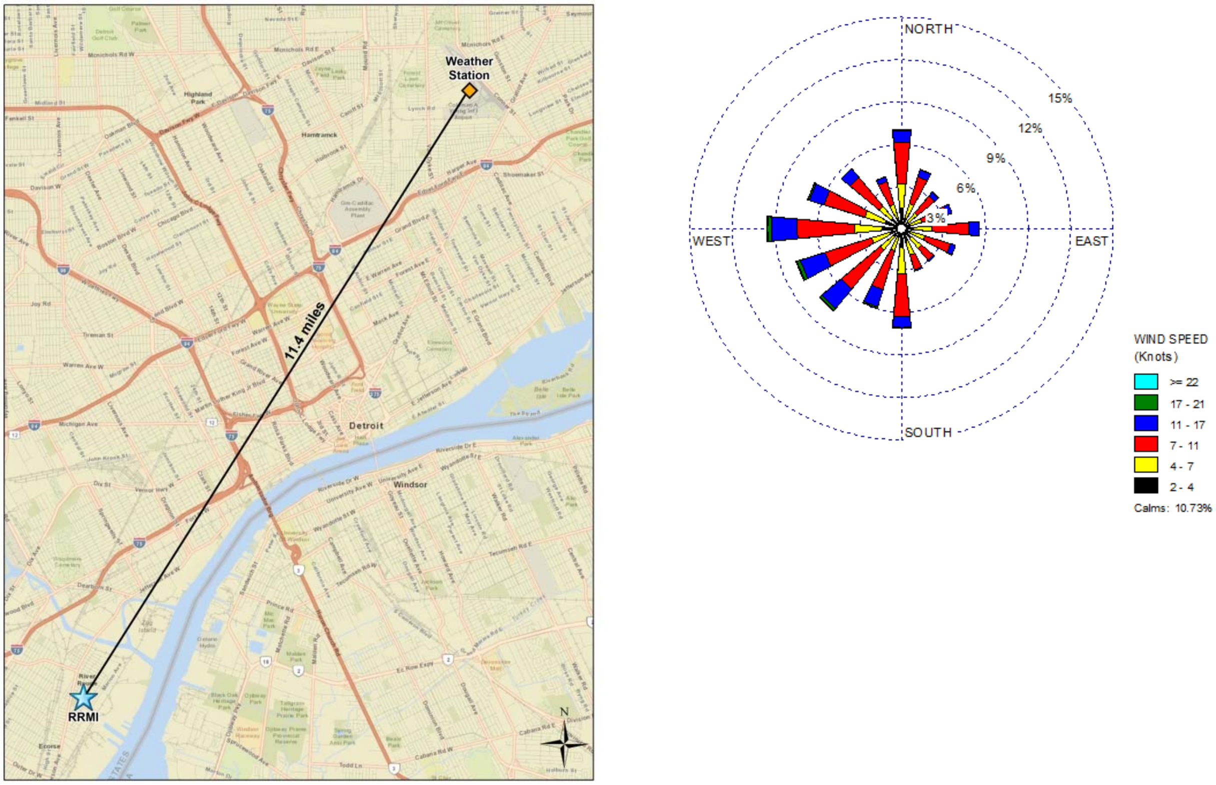

Location of DEMI and Weather Station

2002-2011 Historical Wind Rose


2012 Wind Rose

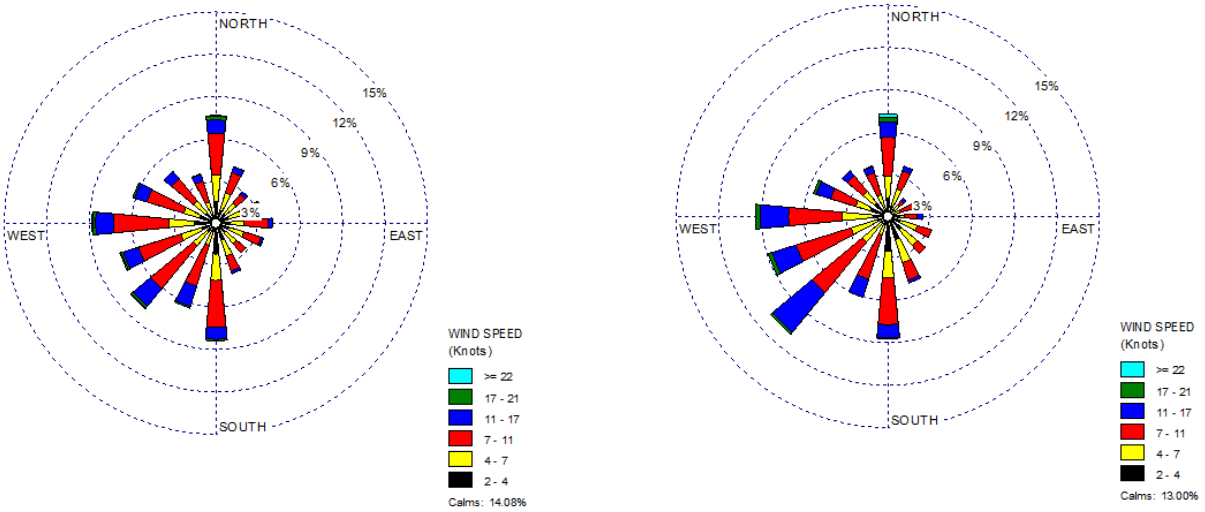
Sample Day Wind Rose

Figure 15-12. Wind Roses for the Detroit City Airport Weather Station near RRMI



Location of RRMI and Weather Station

2002-2011 Historical Wind Rose



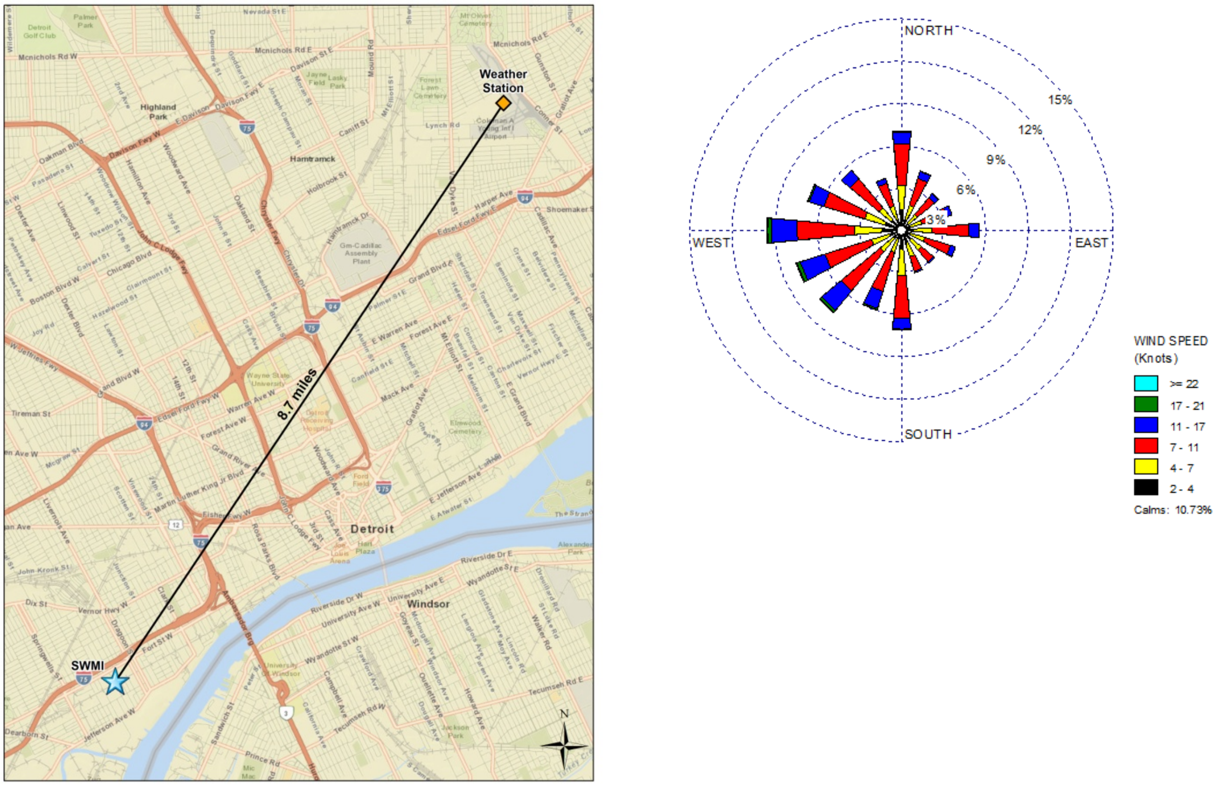
2012 Wind Rose

Sample Day Wind Rose

Figure 15-13. Wind Roses for the Detroit City Airport Weather Station near SWMI

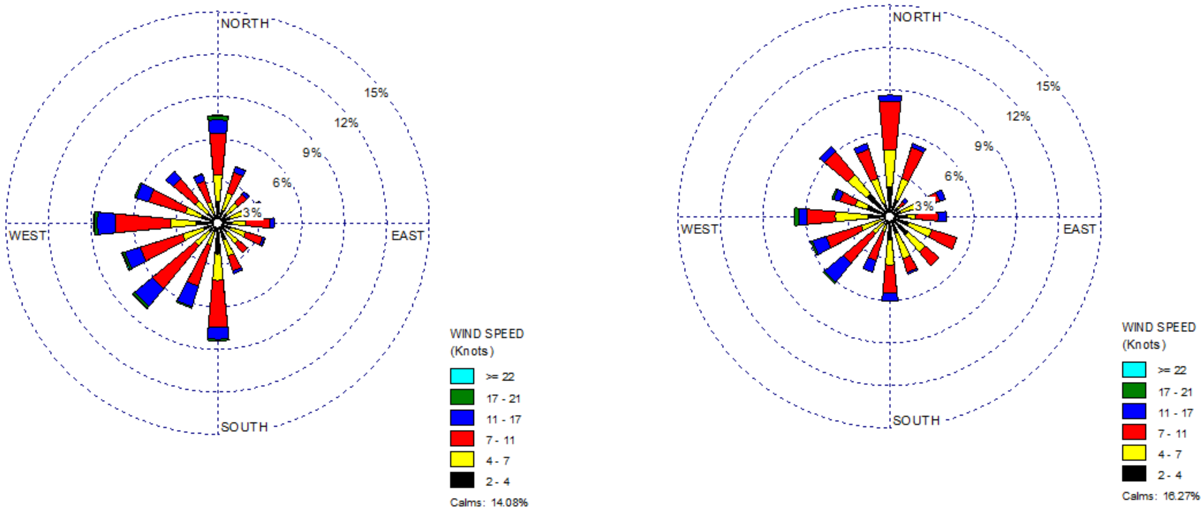
Location of SWMI and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose



Observations from Figures 15-11 through 15-13 include the following:

- The weather station at Detroit City Airport is the closest weather station to all three monitoring sites. This weather station is located to the northeast of all three sites and ranges from 8.7 miles (SWMI) to 11.4 miles (RRMI) away from the sites. Most of the city of Detroit lies between the weather station and the monitoring sites.

- Because the Detroit City Airport weather station is the closest weather station to all three sites, the historical and 2012 wind roses for DEMI are the same as those for RRMI and SWMI.

- The historical wind roses show that winds from a variety of directions were observed near these sites, although winds from the southwest to west were the most frequently observed while winds from the northeast and southeast quadrants were observed the least. Calm winds (≤ 2 knots) were observed for roughly 10 percent of the hourly measurements.

- The wind patterns on the 2012 wind roses resemble the historical wind patterns, although there were slightly fewer south-southwesterly to westerly winds and slightly more winds from due north and due south. The percentage of calm winds is also higher (14 percent).

- The sample day wind rose for DEMI generally resembles the full-year wind rose, although there was a higher percentage of winds from the southwest to west and slightly fewer winds from the south on sample days.

- The sample day wind patterns for RRMI resemble the full-year wind patterns, although there was an even higher percentage of winds from the southwest to west as well as south on sample days near RRMI.

- The wind patterns on the sample day wind rose for SWMI differ from those on the sample day wind roses for DEMI and RRMI. The calm rate (16 percent) is higher for SWMI and winds from the north account for the highest percentage of wind observations. Winds from the northwest, north-northwest, and north-northeast account for nearly as many wind observations as winds from the southwest to west. Recall that the sample day wind rose for SWMI has half the wind observations compared to the sample day wind roses for DEMI and RRMI due to the sampling frequency.

15.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Michigan monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 15-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 15-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. All three Michigan monitoring sites sampled for carbonyl compounds; in addition, DEMI sampled for VOCs, PAHs, and hexavalent chromium.

Table 15-4. Risk-Based Screening Results for the Michigan Monitoring Sites

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Dearborn, Michigan - DEMI						
Benzene	0.13	63	63	100.00	12.12	12.12
Carbon Tetrachloride	0.17	63	63	100.00	12.12	24.23
1,3-Butadiene	0.03	61	61	100.00	11.73	35.96
Acetaldehyde	0.45	60	60	100.00	11.54	47.50
Formaldehyde	0.077	60	60	100.00	11.54	59.04
Naphthalene	0.029	59	60	98.33	11.35	70.38
1,2-Dichloroethane	0.038	53	53	100.00	10.19	80.58
Ethylbenzene	0.4	26	62	41.94	5.00	85.58
Fluorene	0.011	20	60	33.33	3.85	89.42
Acenaphthene	0.011	19	60	31.67	3.65	93.08
Hexavalent Chromium	0.000083	11	58	18.97	2.12	95.19
Fluoranthene	0.011	8	60	13.33	1.54	96.73
p-Dichlorobenzene	0.091	5	26	19.23	0.96	97.69
1,2-Dibromoethane	0.0017	2	2	100.00	0.38	98.08
Hexachloro-1,3-butadiene	0.045	2	3	66.67	0.38	98.46
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.38	98.85
Benzo(a)pyrene	0.00057	1	58	1.72	0.19	99.04
Chloroprene	0.0021	1	1	100.00	0.19	99.23
Tetrachloroethylene	3.8	1	61	1.64	0.19	99.42
Trichloroethylene	0.2	1	16	6.25	0.19	99.62
Vinyl chloride	0.11	1	16	6.25	0.19	99.81
Xylenes	10	1	63	1.59	0.19	100.00
Total		520	968	53.72		
River Rouge, Michigan - RRMI						
Formaldehyde	0.077	49	49	100	50.00	50.00
Acetaldehyde	0.45	49	49	100	50.00	100.00
Total		98	98	100.00		
Detroit, Michigan - SWMI						
Acetaldehyde	0.45	29	30	96.67	50.00	50.00
Formaldehyde	0.077	29	30	96.67	50.00	100.00
Total		58	60	96.67		

Observations from Table 15-4 for DEMI include the following:

- Twenty-two pollutants failed at least one screen for DEMI; nearly 54 percent of concentrations for these 22 pollutants were greater than their associated risk screening value (or failed screens).

- Eleven pollutants contributed to 95 percent of failed screens for DEMI and therefore were identified as pollutants of interest for DEMI. These 11 include two carbonyl compounds, five VOCs, three PAHs, and hexavalent chromium.

- Benzene, carbon tetrachloride, 1,3-butadiene, acetaldehyde, and formaldehyde each failed 100 percent of screens, with each contributing to roughly 12 percent to the total number of failed screens; thus, these five pollutants together account for nearly 60 percent of the total failed screens.

Observations from Table 15-4 for RRMI and SWMI include the following:

- Acetaldehyde, formaldehyde, and propionaldehyde are the only carbonyl compounds with risk screening values.

- Acetaldehyde and formaldehyde each failed 100 percent of screens for RRMI.

- Acetaldehyde and formaldehyde also failed screens for SWMI. These pollutants contributed equally to the total number of failed screens.

- Acetaldehyde and formaldehyde were identified as pollutants of interest for both sites.

15.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Michigan monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.

- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each data analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for DEMI, RRMI, and SWMI are provided in Appendices J, L, M, and O.

15.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Michigan sites, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Michigan monitoring sites are presented in Table 15-5, where applicable. Note that concentrations of the PAHs and hexavalent chromium are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 15-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Michigan Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Dearborn, Michigan - DEMI						
Acetaldehyde	60/60	1.59 ± 0.33	1.75 ± 0.30	1.98 ± 0.29	1.68 ± 0.49	1.75 ± 0.17
Benzene	63/63	1.02 ± 0.32	0.84 ± 0.31	0.89 ± 0.20	0.93 ± 0.41	0.92 ± 0.15
1,3-Butadiene	61/63	0.08 ± 0.03	0.08 ± 0.03	0.11 ± 0.03	0.18 ± 0.08	0.11 ± 0.03
Carbon Tetrachloride	63/63	0.67 ± 0.07	0.74 ± 0.03	0.68 ± 0.03	0.74 ± 0.03	0.71 ± 0.02
1,2-Dichloroethane	53/63	0.08 ± 0.02	0.08 ± 0.01	0.05 ± 0.01	0.05 ± 0.02	0.07 ± 0.01
Ethylbenzene	62/63	0.46 ± 0.21	0.55 ± 0.21	0.56 ± 0.21	0.54 ± 0.43	0.53 ± 0.14
Formaldehyde	60/60	2.15 ± 0.48	4.42 ± 0.93	4.65 ± 0.79	2.41 ± 0.45	3.45 ± 0.44
Acenaphthene[a]	60/60	5.23 ± 2.29	25.03 ± 14.73	16.74 ± 5.90	3.40 ± 1.13	12.60 ± 4.40
Fluorene[a]	60/60	5.68 ± 2.22	20.44 ± 11.46	15.88 ± 5.38	3.40 ± 0.92	11.35 ± 3.53
Hexavalent Chromium[a]	58/62	0.04 ± 0.01	0.05 ± 0.02	0.06 ± 0.03	0.04 ± 0.02	0.05 ± 0.01
Naphthalene[a]	60/60	135.38 ± 51.33	155.61 ± 48.26	165.71 ± 41.92	110.08 ± 55.09	141.70 ± 23.82
River Rouge, Michigan - RRMI						
Acetaldehyde	49/49	1.29 ± 0.27	NA	2.05 ± 0.25	1.63 ± 0.54	NA
Formaldehyde	49/49	2.97 ± 0.46	NA	4.90 ± 0.66	4.01 ± 0.91	NA
Detroit, Michigan - SWMI						
Acetaldehyde	30/30	1.35 ± 0.30	1.63 ± 0.31	2.22 ± 0.76	1.21 ± 0.59	1.62 ± 0.28
Formaldehyde	30/30	2.08 ± 0.41	3.32 ± 0.79	4.91 ± 1.06	1.86 ± 0.92	3.11 ± 0.59

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.
NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for DEMI from Table 15-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde and acetaldehyde; all other annual average concentrations are less than 1.0 µg/m^3.

- The second and third quarter average concentrations of formaldehyde are roughly twice the other quarterly averages, supporting the seasonal trend discussed in Section 4.4.2. A review of the data shows that the maximum concentration of formaldehyde was measured on June 20, 2012 (8.39 µg/m^3) and that the 12 highest concentrations measured at DEMI were measured during the second and third quarters of 2012. Conversely, all but one of the 11 formaldehyde concentrations less than 2 µg/m^3 were measured during the first or fourth quarters of 2012.

- Although the first quarter average concentration of benzene is higher than the other quarterly averages, the fourth quarter average concentration has the largest confidence interval. A review of the data shows that the maximum concentration of benzene was measured on November 17, 2012 (4.00 µg/m^3). This measurement is among the highest benzene measurements among NMP sites sampling this pollutant. The next highest concentrations of benzene were measured at DEMI in April (2.81 µg/m^3) and March (2.46 µg/m^3) and are the only concentrations greater than 2 µg/m^3 measured at this site.

- The maximum 1,3-butadiene concentration measured at DEMI was also measured on November 17, 2012 (0.703 µg/m^3) and is more than twice the next highest concentration (0.266 µg/m^3, also measured in November). The five highest concentrations of 1,3-butadiene (ranging from 0.213 µg/m^3 to 0.703 µg/m^3) were measured at DEMI during the fourth quarter of 2012. Yet, the minimum measured detection was also measured during the fourth quarter of 2012 (0.031 µg/m^3). This explains why the fourth quarter average is higher than the other quarterly averages and also has a relatively large confidence interval associated with it.

- The fourth quarter average concentration of ethylbenzene has a relatively large confidence interval associated with it. A review of the data shows that the maximum concentration of this pollutant was measured on October 6, 2012 (3.63 µg/m^3) and is nearly twice the next highest concentration (1.81 µg/m^3, measured in June). The maximum ethylbenzene concentration measured at DEMI is also the highest ethylbenzene concentration measured among NMP sites sampling this pollutant. Only two sites (DEMI and GPCO) have ethylbenzene measurements greater than 3 µg/m^3.

- The second and third quarter average concentrations of acenaphthene and fluorene are significantly higher than the other quarterly averages and have relatively large confidence intervals associated with them. The maximum concentrations of these pollutants were measured on the same day, June 20, 2012. The highest concentrations of these pollutants were measured in June, July, and August, generally on the same days, although the order varied. A similar observation was made in the 2011 NMP report.

- The quarterly average concentrations of naphthalene all have relatively large confidence intervals associated with them, indicating that the measurements are highly variable. The maximum concentration of naphthalene (455 ng/m^3) was measured on November 17, 2012, the same day as the maximum benzene and 1,3-butadiene concentrations. This was the sixth highest concentration of naphthalene measured across the program. Four concentrations of naphthalene greater than 300 ng/m^3 were measured at DEMI, one in the first quarter, one in the second quarter and two in the third quarter. At least one concentration greater than 200 ng/m^3 was measured each quarter of 2012: three during the first quarter, four during the second, five during the third, and one (the maximum) during the fourth.

Observations for RRMI and SWMI from Table 15-5 include the following:

- A collection error at RRMI resulted in the invalidation of carbonyl compound samples between May 15, 2012 and July 8, 2012. As a result, second quarter and annual average concentrations could not be calculated. However, Appendix L provides the pollutant-specific average concentrations for all valid samples collected over the entire sample period for this site.

- Concentrations of formaldehyde measured at RRMI range from 1.93 μg/m^3 to 7.70 μg/m^3; acetaldehyde concentrations range from 0.54 μg/m^3 to 4.42 μg/m$^{3.}$

- The maximum formaldehyde concentration was measured at SWMI on the same day as the maximum acetaldehyde concentration (September 18, 2012). Concentrations of formaldehyde for SWMI are highly variable, ranging from 0.0246 μg/m^3 to 7.70 μg/m^3; acetaldehyde concentrations exhibit similar variability, ranging from 0.0343 μg/m^3 to 4.35 μg/m$^{3.}$

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Michigan sites from those tables include the following:

- DEMI appears in Tables 4-9 through 4-12 a total of seven times.

- DEMI has the highest annual average concentration of carbon tetrachloride, as shown in Table 4-9. However, the difference between highest and 10th highest annual average concentration of this pollutant is only 0.03 μg/m^3. DEMI also has the sixth highest annual average concentration of ethylbenzene and 10th highest annual average concentration of 1,3-butadiene among NMP sites sampling these pollutants.

- The annual average concentration of formaldehyde for DEMI ranks eighth highest among sites sampling carbonyl compounds.

- The annual average concentration of acenaphthene for DEMI is the second highest among NMP sites sampling PAHs. DEMI's annual average concentrations of fluorene and naphthalene each rank third among sites sampling PAHs, as shown in Table 4-11.

15.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 15-4. Figures 15-14 through 15-24 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 15-14. Program vs. Site-Specific Average Acenaphthene Concentration

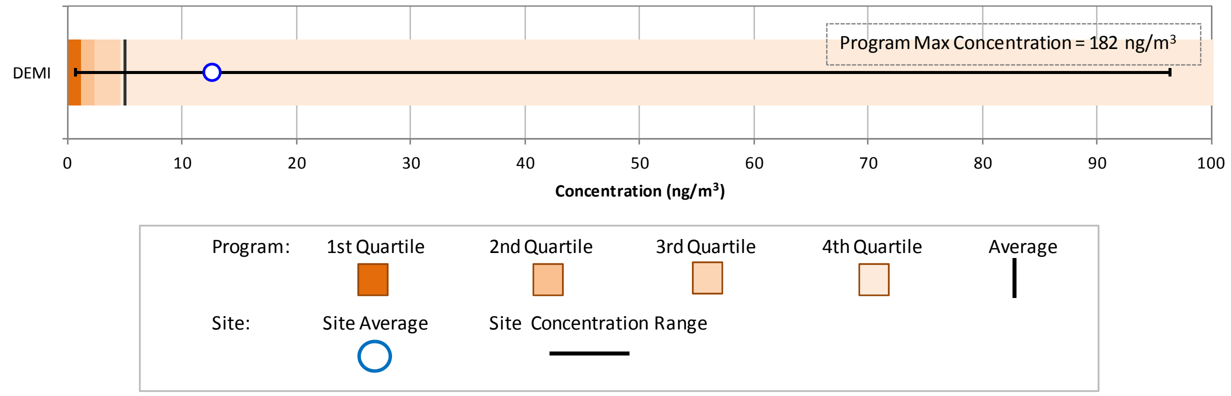


Figure 15-15. Program vs. Site-Specific Average Acetaldehyde Concentrations

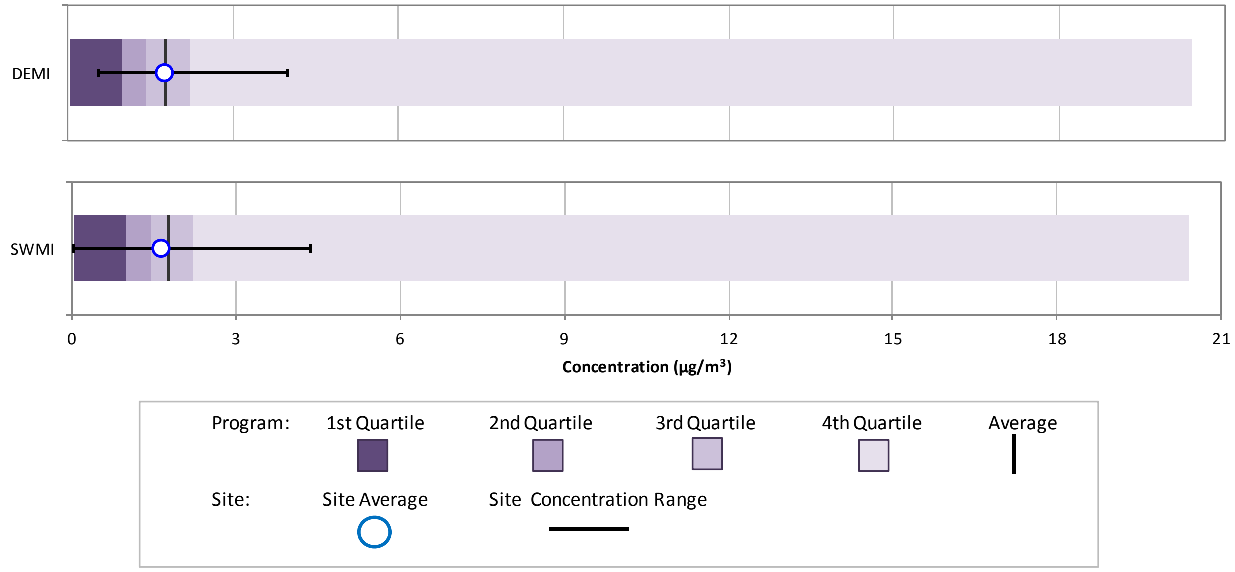


Figure 15-16. Program vs. Site-Specific Average Benzene Concentration

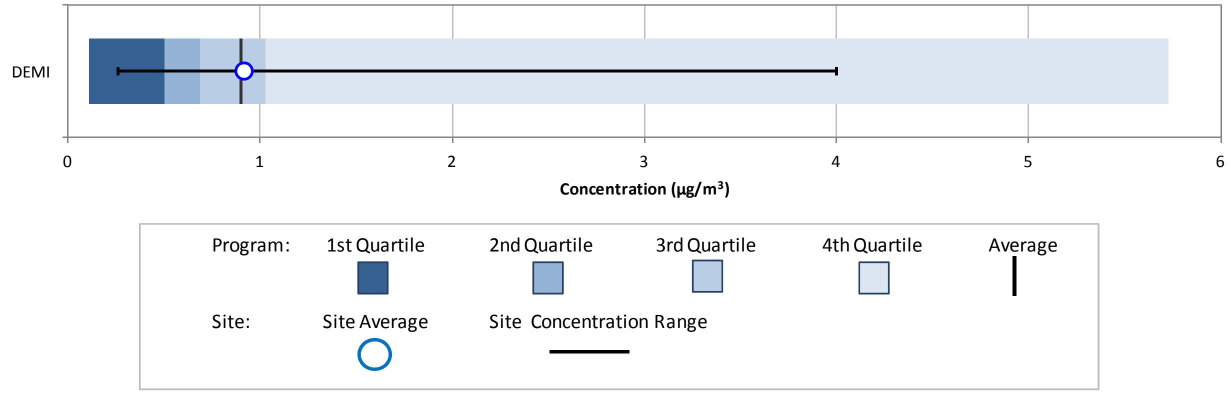


Figure 15-17. Program vs. Site-Specific Average 1,3-Butadiene Concentration

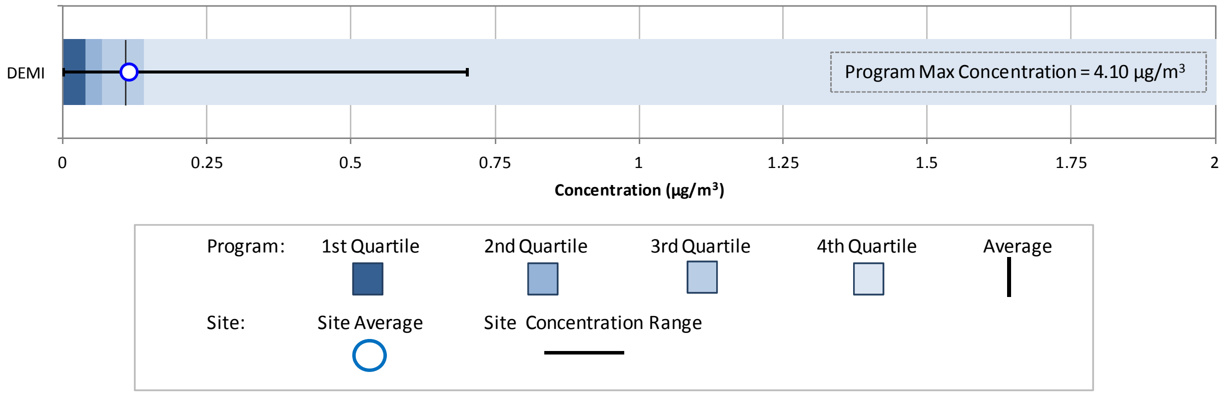


Figure 15-18. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

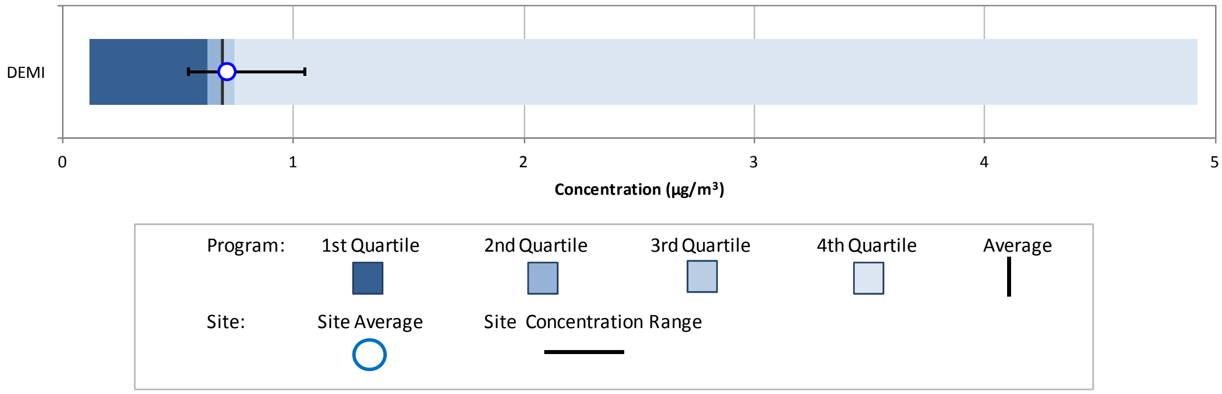


Figure 15-19. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

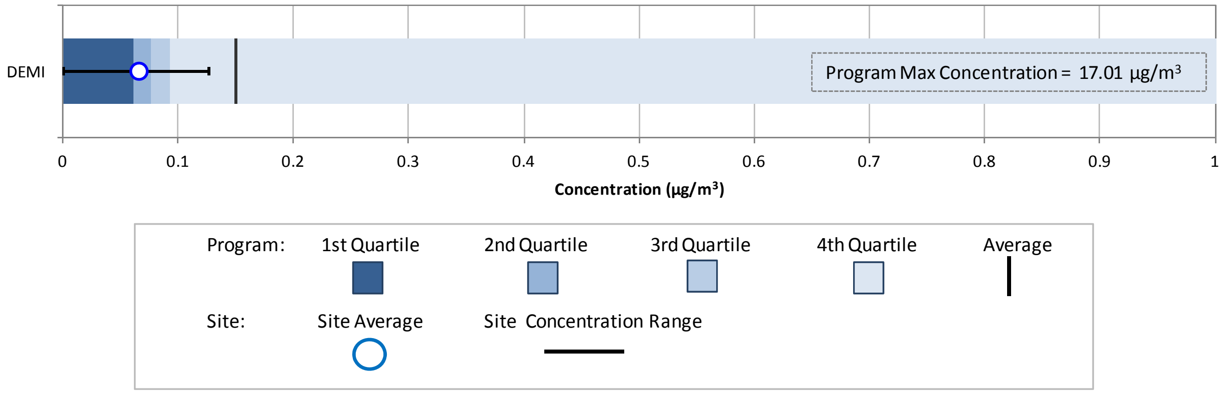


Figure 15-20. Program vs. Site-Specific Average Ethylbenzene Concentration

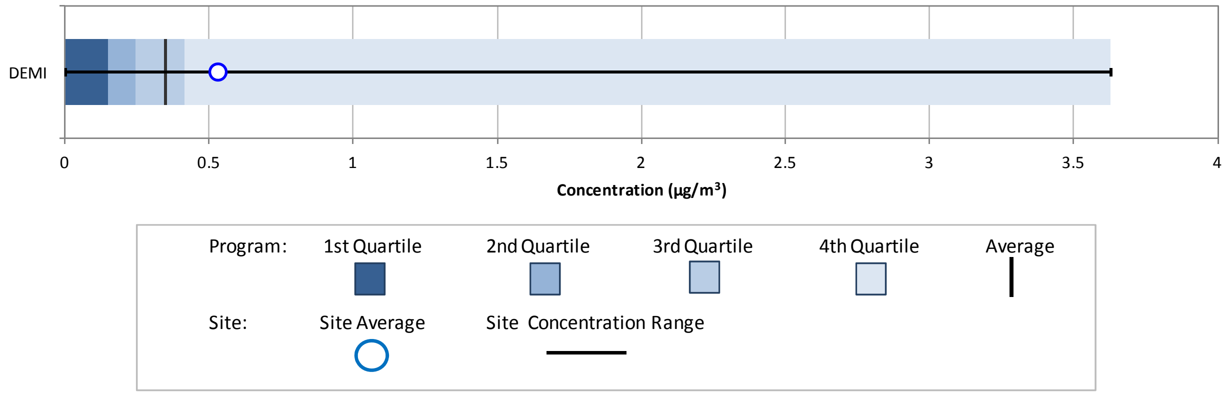


Figure 15-21. Program vs. Site-Specific Average Fluorene Concentration

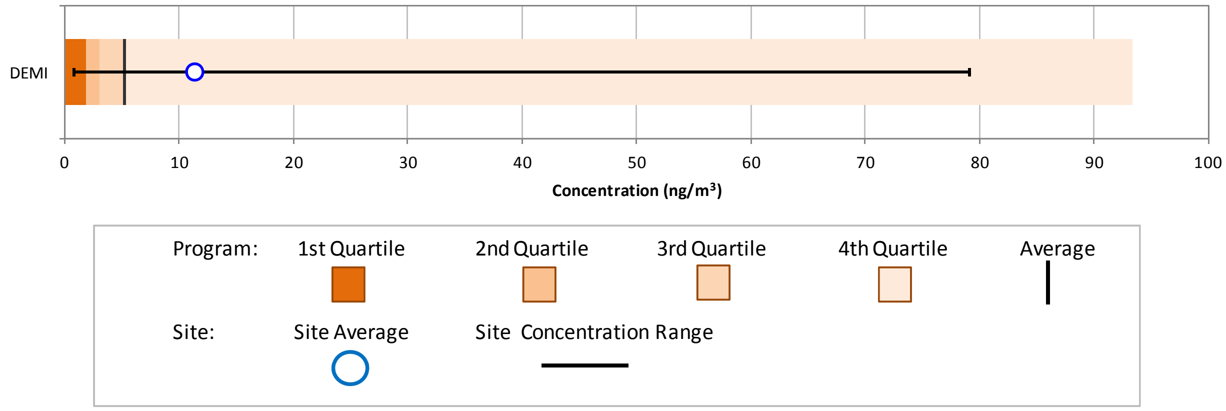


Figure 15-22. Program vs. Site-Specific Average Formaldehyde Concentrations

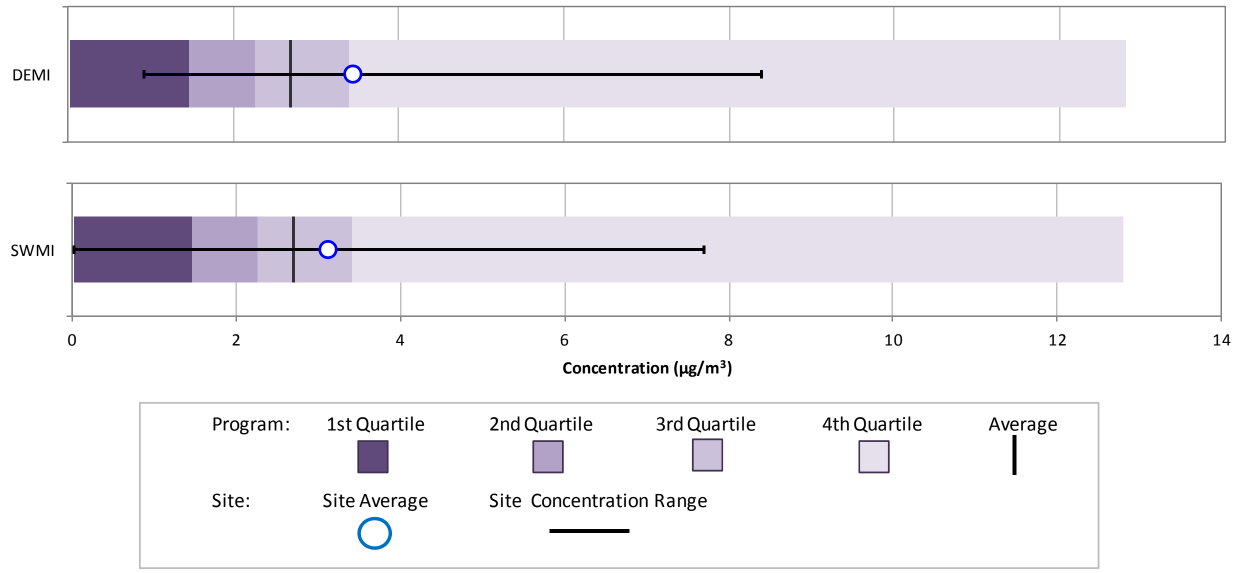


Figure 15-23. Program vs. Site-Specific Average Hexavalent Chromium Concentration

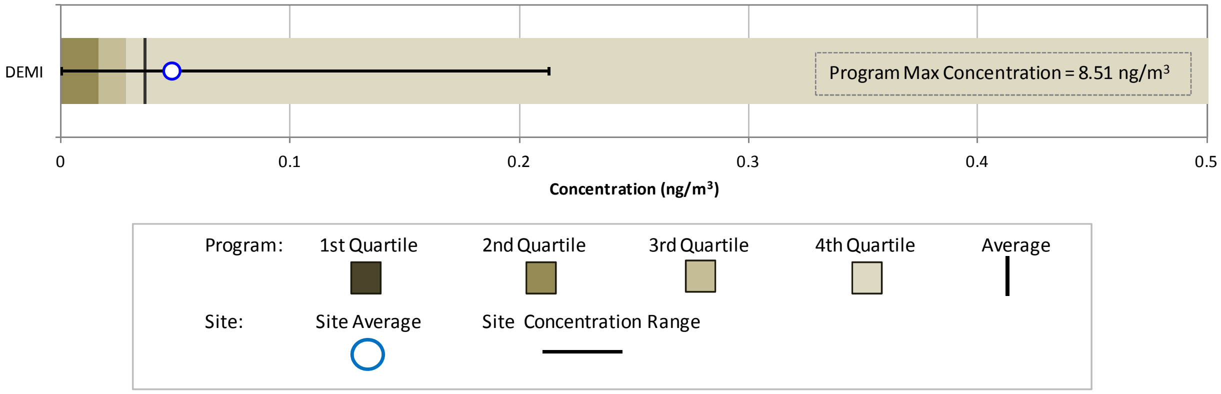
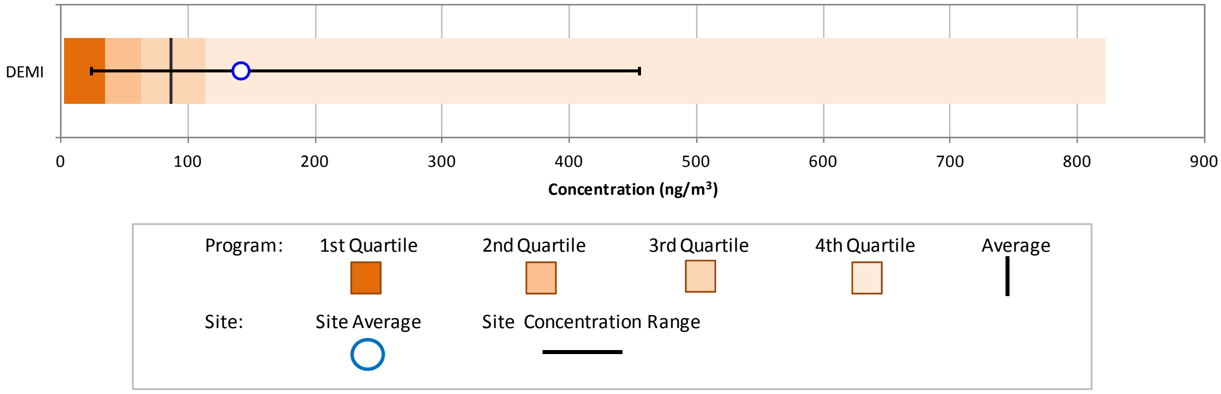


Figure 15-24. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 15-14 through 15-24 include the following:

- Figure 15-14 is the box plot for acenaphthene for DEMI. Note that the program-level maximum concentration (182 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 100 ng/m^3. This box plot shows that although the maximum acenaphthene concentration measured at DEMI is not the maximum concentration across the program, it is among the higher measurements. The maximum acenaphthene concentration measured at DEMI is the third highest acenaphthene measurement program-wide. The annual average acenaphthene concentration for DEMI (12.60 ng/m^3) is more than twice the program-level average concentration (5.00 ng/m^3).

- Figure 15-15 includes the box plots for acetaldehyde for DEMI and SWMI. The box plots show that the maximum acetaldehyde concentrations measured at DEMI and SWMI are significantly less than the program-level maximum concentration. The annual average concentration for DEMI is roughly the same as the program-level average concentration while the annual average for SWMI is just less than the program-level average concentration (but greater than the program-level median). Although no non-detects of acetaldehyde were measured at the Michigan sites or across the program, the minimum concentration of acetaldehyde measured at SWMI is the lowest concentration program-wide (although a concentration of the same magnitude was also measured at BMCO).

- Figure 15-16 is the box plot for benzene, which shows that DEMI's annual average benzene concentration is similar to the program-level average concentration (0.90 μg/m^3). The maximum concentration of benzene measured at DEMI is less than the maximum concentration measured at the program level, but still among the higher measurements program-wide.

- Figure 15-17 is the box plot for 1,3-butadiene. Similar to the acenaphthene box plot, the program-level maximum concentration (4.10 μg/m^3) is not shown directly on the box plot as the scale has been reduced to 2 μg/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 15-17 shows that the annual average concentration of 1,3-butadiene for DEMI is also similar to the program-level average concentration. The maximum 1,3-butadiene concentration measured at DEMI is considerably less than the maximum concentration measured across the program. Two non-detects of 1,3-butadiene were measured at DEMI.

- Figure 15-18 is the box plot for carbon tetrachloride. The annual average concentration of carbon tetrachloride for DEMI is similar to the program-level average concentration (0.69 μg/m^3). The range of measurements collected at DEMI is relatively small, spanning approximately 0.5 μg/m^3. The maximum concentration measured at DEMI is significantly less than the maximum concentration measured across the program.

- Figure 15-19 is the box plot for 1,2-dichloroethane. Note that the program-level maximum concentration (17.01 μg/m^3) is not shown directly on the box plot as the scale has been reduced to 1 μg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. The entire range of measurements collected at DEMI is less than the program-level average concentration. This is because the program-level average is being driven by the higher measurements collected at a few monitoring sites. The annual average for DEMI is less than the median concentration measured at the program level. Ten non-detects of 1,2-dichloroethane were measured at DEMI.

- Figure 15-20 is the box plot for ethylbenzene. Even though the maximum ethylbenzene concentration program-wide was measured at DEMI, this site does not have the highest annual average concentration of this pollutant. The annual average ethylbenzene concentration for DEMI is greater than the program-level median, average, and third quartile.

- The box plot for fluorene presented in Figure 15-21 is similar to the box plot for acenaphthene in that the maximum fluorene concentration measured at DEMI is among highest measurements of fluorene program-wide. The annual average concentration for DEMI is more than twice the program-level average concentration of fluorene.

- Figure 15-22 includes the box plots for formaldehyde for DEMI and SWMI. The box plots show that the annual average concentration for DEMI is slightly greater than the annual average concentration for SWMI. The annual average for DEMI is similar to the program-level third quartile while the annual average for SWMI less than the program-level third quartile, although both are greater than the program-level average concentration. Although no non-detects of formaldehyde were measured at the Michigan sites or across the program, the minimum concentration of formaldehyde measured at SWMI is the minimum concentration program-wide.

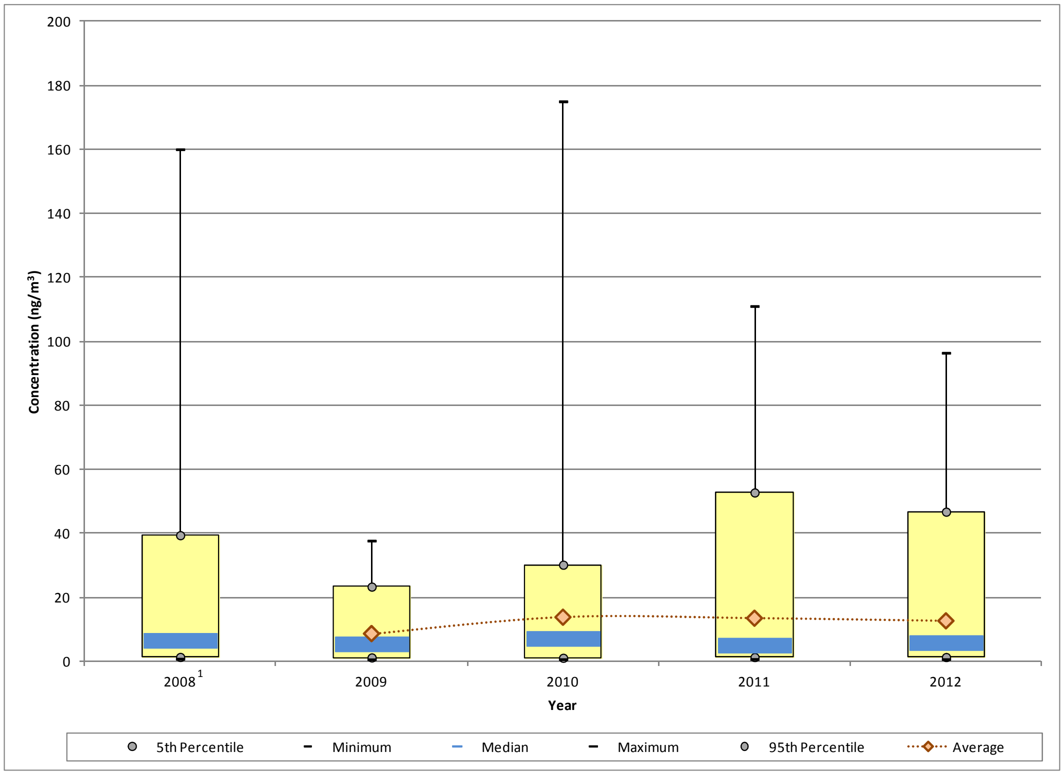
- Figure 15-23 is the box plot for hexavalent chromium. Note that the program-level maximum concentration (8.51 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 0.5 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. In addition, the program-level first quartile is zero and therefore not visible on the box plot. The box plot shows that annual average concentration for DEMI is greater than the program-level average concentration, even though the maximum concentration measured across the program is substantially higher than the maximum concentration measured at DEMI.

- Figure 15-24 is the box plot for naphthalene. The annual average concentration of naphthalene for DEMI is greater than the program-level average concentration. The maximum naphthalene concentration measured at DEMI is less than the maximum concentration measured across program, although it was the sixth highest naphthalene concentration measured across the program.

15.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. DEMI has sampled VOCs and carbonyl compounds under the NMP since 2003, hexavalent chromium since 2005, and PAHs since 2008. Thus, Figures 15-25 through 15-35 present the 1-year statistical metrics for each of the pollutants of interest for DEMI. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented. Although RRMI and SWMI have sampled under the NMP previously, they have not sampled continuously for 5 consecutive years; thus, a trends analysis was not performed for these sites.

Figure 15-25. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at DEMI



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 15-25 for acenaphthene measurements collected at DEMI include the following:

- DEMI began sampling PAHs under the NMP in April 2008. Because a full year's worth of data is not available for 2008, a 1-year average is not presented, although the range of measurements is provided.

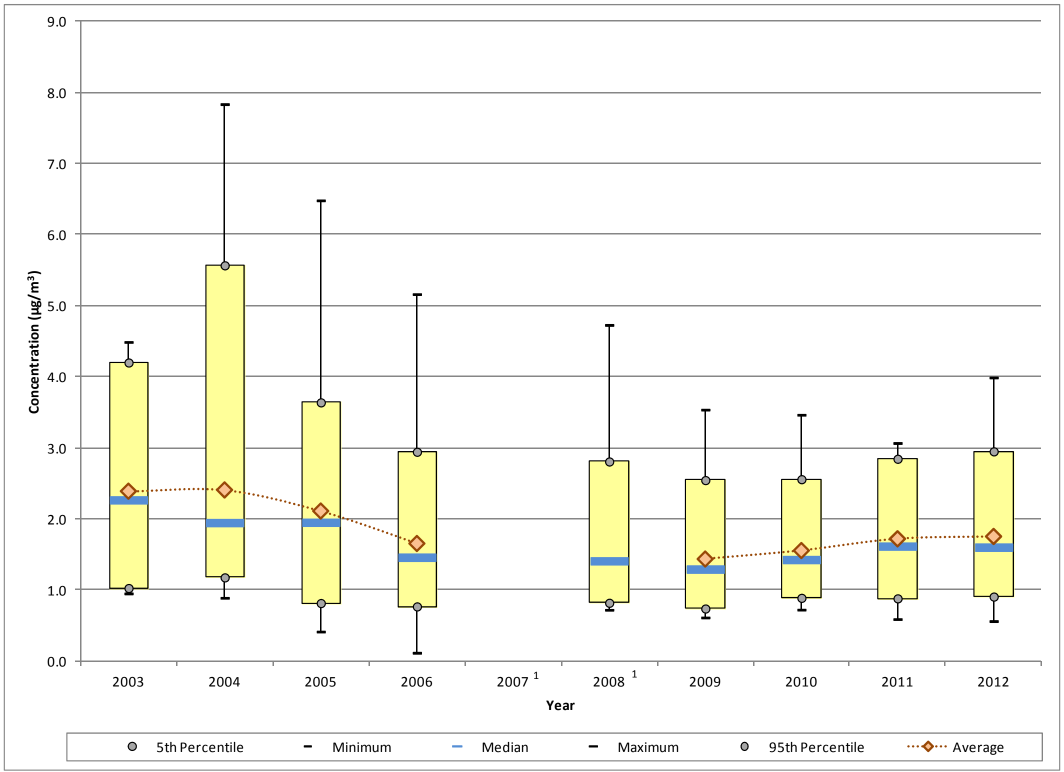
- The maximum acenaphthene concentration measured at DEMI was measured in August 2010 (175 ng/m^3). All five of the concentrations greater than 100 ng/m^3 were measured in either July or August; further, all 30 measurements greater than 25 ng/m^3 were measured during the second or third quarters of the year (the warmer months of the year).

- The range of concentrations measured decreased from 2008 to 2009 as the maximum concentration for 2009 is less than the 95th percentile for 2008.

- Nearly all of the statistical metrics increased from 2009 to 2010, including the median, which is influenced less by a few concentrations at the upper end of the concentration range than the 1-year average, such as the two concentrations greater than 100 ng/m^3 that were measured in 2010; the next highest concentration was considerably less (55.1 ng/m^3).

- Although the 95th percentile increased from 2010 to 2011, the 1-year average exhibits a slight decrease, which continues into 2012. However, confidence intervals calculated for these averages indicate that the measurements are highly variable.

Figure 15-26. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at DEMI



[1] A 1-year average is not presented because data from March 2007 to March 2008 was invalidated.

Observations from Figure 15-26 for acetaldehyde measurements collected at DEMI include the following:

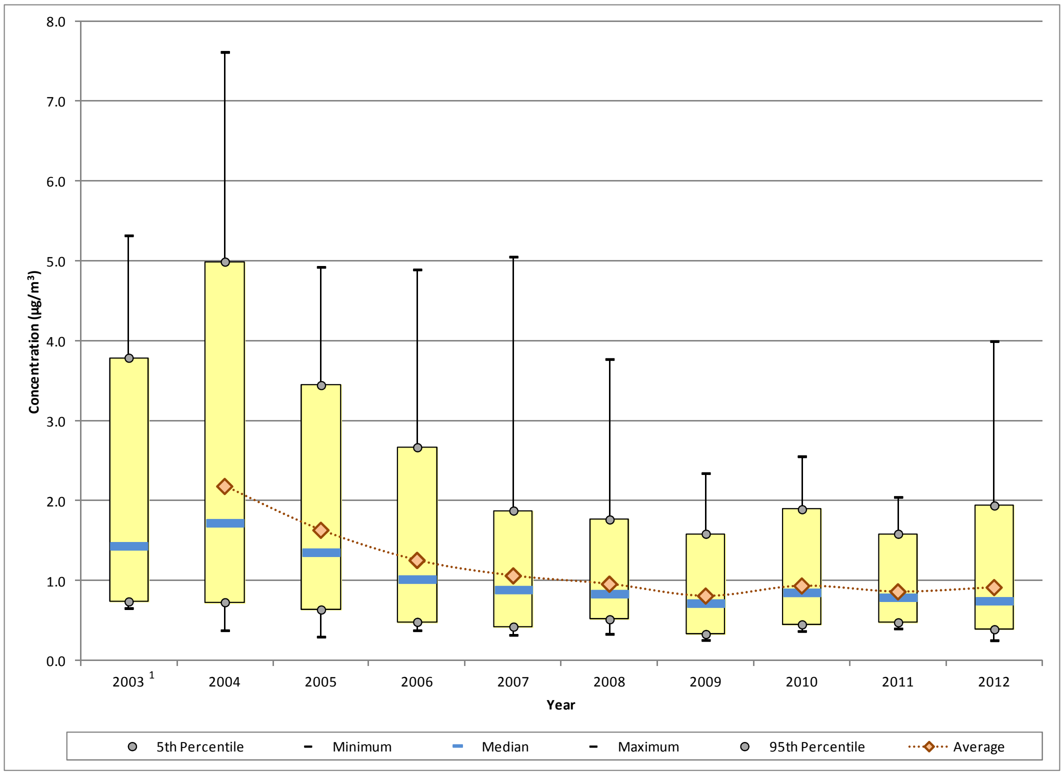
- Carbonyl compounds have been sampled continuously at DEMI under the NMP since 2003, beginning with a 1-in-12 day schedule in 2003 then changing to a 1-in-6 day schedule in the spring of 2004.

- Carbonyl compound samples from the primary sampler were invalidated from March 13, 2007 through March 25, 2008 by the state of Michigan due to a leak in the sample line. With only 12 valid samples in 2007, no statistical metrics are provided. Because less than 75 percent of the samples were valid in 2008, a 1-year average is not presented for 2008, although the range of measurements is provided.

- The maximum acetaldehyde concentration was measured in 2004 (7.84 µg/m^3). Of the six concentrations greater than 5 µg/m^3 measured at DEMI, three were measured in 2004, two were measured in 2005, and one was measured in 2006.

- The 1-year average concentration exhibits a decreasing trend after 2004 that continues through 2006. The median concentration, which is available for 2008, changed little from 2006 to 2008, but decreased slightly for 2009. Both the 1-year average and median concentrations exhibit an increasing trend after 2009 that levels off for 2012, although these changes are not statistically significant.

Figure 15-27. Yearly Statistical Metrics for Benzene Concentrations Measured at DEMI



[1] A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 15-27 for benzene measurements collected at DEMI include the following:

- VOCs have been sampled continuously at DEMI under the NMP since 2003. However, the 1-in-12 day schedule in 2003 combined with a number of invalids resulted in low completeness; as a result, a 1-year average is not presented for 2003.

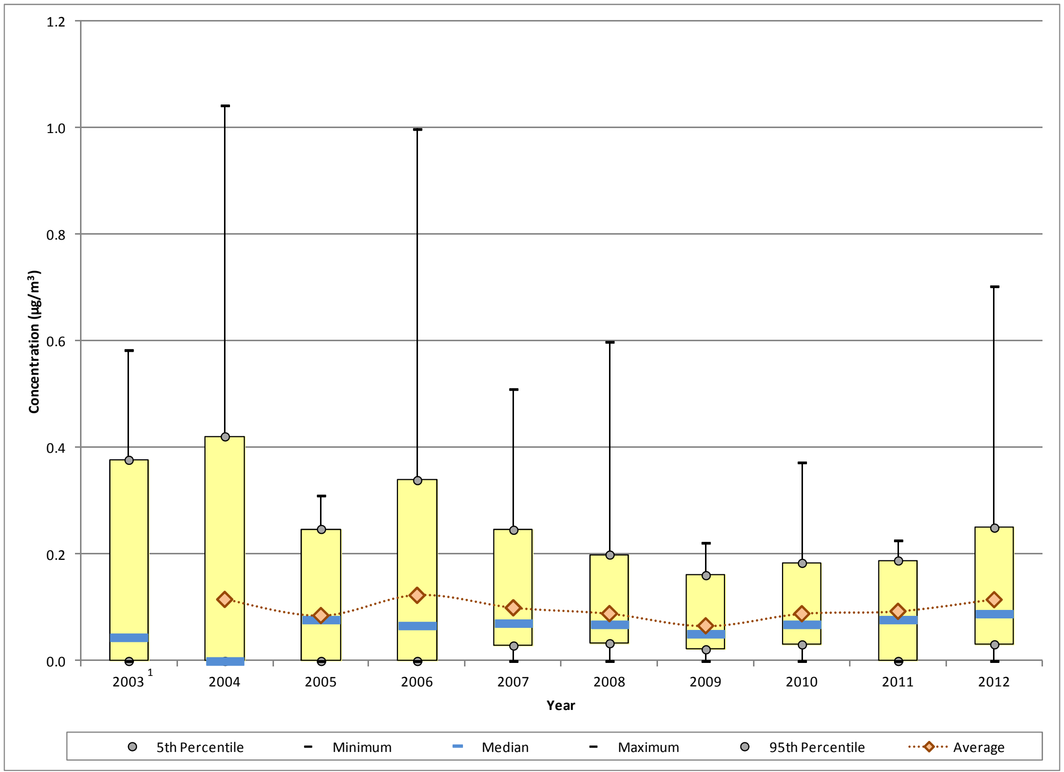
- The three highest benzene concentrations were all measured in 2004 and ranged from 5.44 µg/m^3 to 7.62 µg/m^3. Only two other concentrations greater than 5 µg/m^3 have been measured at DEMI, one in 2003 and one in 2007.

- Both the 1-year average and median concentrations exhibit a steady decreasing trend over the period shown, reaching a minimum in 2009. Between 2009 and 2012, the 1-year average fluctuated between 0.81 µg/m^3 (2009) and 0.94 µg/m^3 (2010).

- The difference between the 1-year average and median concentrations has decreased over the years, indicating less variability in the measurements. Between 2009 and 2011, less than 0.1 µg/m^3 separates these two statistical parameters.

- The minimum, 5th percentile and median concentration decreased from 2011 to 2012 while the 1-year average, 95th percentile, and maximum increased. Thus, the measurements at the lower end of the concentration range decreased while the measurements at the upper end of the concentration range increased.

Figure 15-28. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at DEMI



[1] A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 15-28 for 1,3-butadiene measurements collected at DEMI include the following:

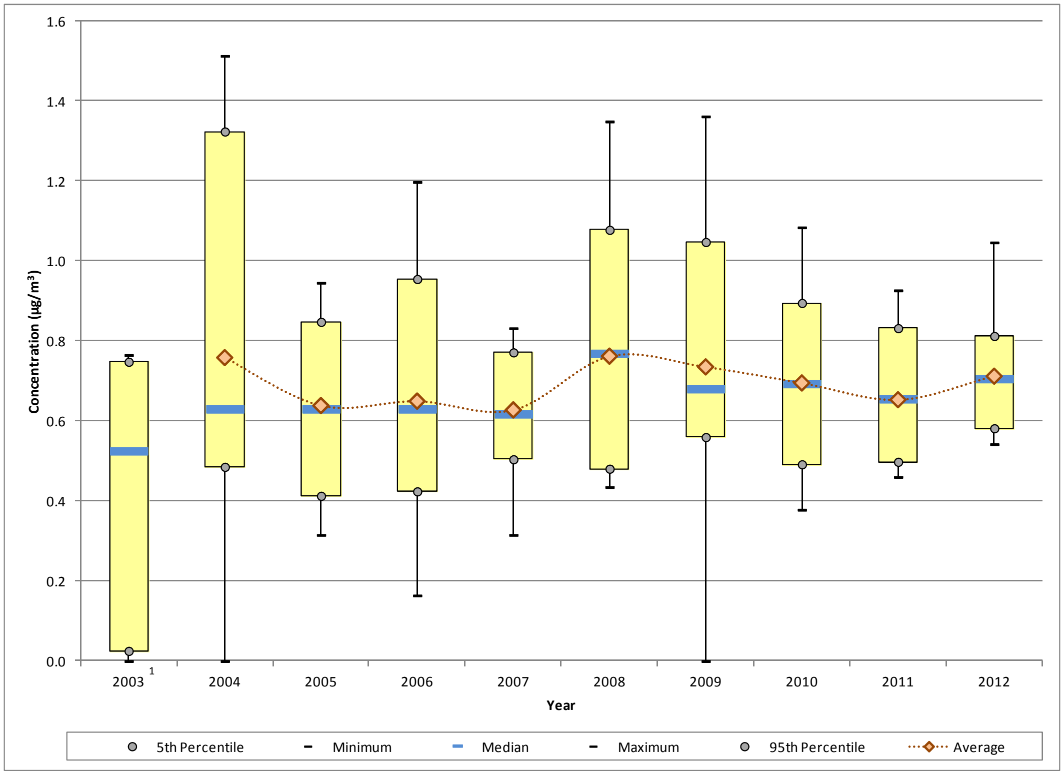
- The maximum 1,3-butadiene concentration was measured on October 18, 2004. This is the only 1,3-butadiene concentration greater than 1 µg/m^3 measured at DEMI, although concentrations greater than 0.90 µg/m^3 were measured in 2004 and 2006.

- For 2004, the minimum, 5th percentile, and median concentrations are all zero, indicating that at least half of the measurements were non-detects. Yet, two of the three highest concentrations were also measured at this site in 2004; in addition, the maximum 95th percentile was calculated for 2004. This indicates there is a high level of variability within the measurements.

- There were fewer non-detects in 2005 and 2006, as indicated by the increase in the median concentration, and even fewer in the years that follow, as indicated by the increase in the 5th percentile. The percentage of non-detects decreased from a high of 60 percent in 2004 down to 2 percent in 2008, then fluctuated between 2 percent and 7 percent for the years that follow.

- Even as the number of non-detects decreased (and thus, the number of zeros factored into the calculated decrease), the 1-year average concentration decreased between 2006 and 2009. An increasing trend is shown for the years after 2009.

Figure 15-29. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at DEMI



[1] A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 15-29 for carbon tetrachloride measurements collected at DEMI include the following:

- In 2003, the measured detections ranged from 0.25 µg/m^3 to 0.76 µg/m^3, plus two non-detects. This is the only year of sampling for which half the measurements were less than 0.5 µg/m^3.

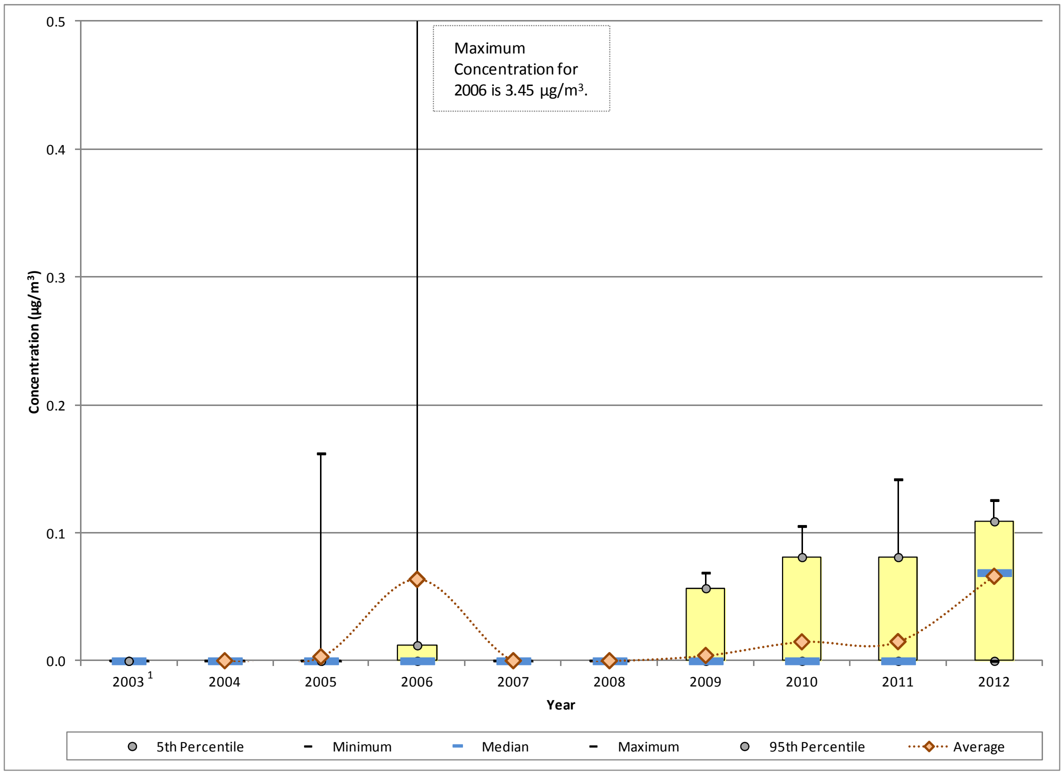
- The range of concentrations in 2004 doubled from 2003 levels. The number of measurements greater than 1 µg/m^3 increased from none in 2003 to 12 for 2004.

- The 1-year average decreased by more than 1 µg/m^3 from 2004 to 2005, as the range of measurements decreased substantially, with little change in the 1-year average from 2005 to 2007.

- With the exception of the 5th percentile, all of the statistical metrics increased significantly for 2008, with the 1-year average and median concentrations for 2008 similar to the 95th percentile for 2007.

- A steady decreasing trend is shown between 2008 and 2011. Between these years, the majority of concentrations are falling within a tighter concentration range. For 2012, the difference between the 5th and 95th percentiles is less than 0.25 µg/m^3, even though an increase in the 1-year average and median concentrations is shown.

Figure 15-30. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at DEMI



[1] A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 15-30 for 1,2-dichloroethane measurements collected at DEMI include the following:

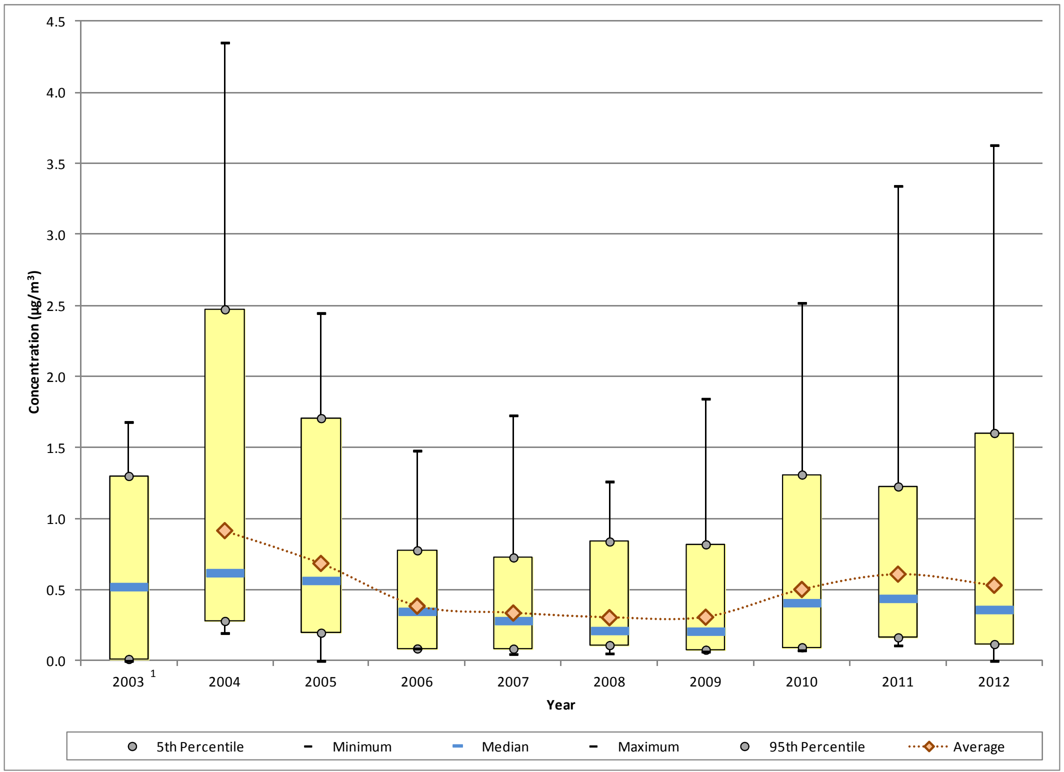
- There were no measured detections of 1,2-dichloroethane in 2003, 2004, 2007, or 2008; there was one measured detection in 2005, three in 2006, four in 2009, 12 in 2010, 11 in 2011, and 53 in 2012. With the exception of 2012, the median concentration is zero for all years, indicating that at least half of the measurements are non-detects.

- As the number of measured detections increase, so do each of the corresponding statistical metrics shown in Figure 15-30.

- As the number of measured detections increased dramatically for 2012, the 1-year average and median concentrations increased correspondingly. The median concentration is actually greater than the annual average for 2012. This is because there were still 10 non-detects (or zeros) factoring into the 1-year average concentration for the year.

- The maximum 1,2-dichloroethane concentration measured at DEMI was measured on July 16, 2006 (3.45 µg/m^3). The next highest concentration was also measured in 2006 but was considerably less (0.16 µg/m^3). A similar measurement was also collected in 2005. All of the 10 remaining concentrations greater than 0.1 µg/m^3 were measured in 2011 or 2012.

Figure 15-31. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at DEMI



[1] A 1-year average is not presented due to low completeness for 2003.

Observations from Figure 15-31 for ethylbenzene measurements collected at DEMI include the following:

- The maximum ethylbenzene concentration was measured in September 2004 (4.35 µg/m^3). The next highest concentration was measured in 2012 (3.63 µg/m^3). The only other ethylbenzene measurement greater than 3 µg/m^3 was measured in 2011. Only 10 concentrations greater than 2 µg/m^3 have been measured at DEMI.

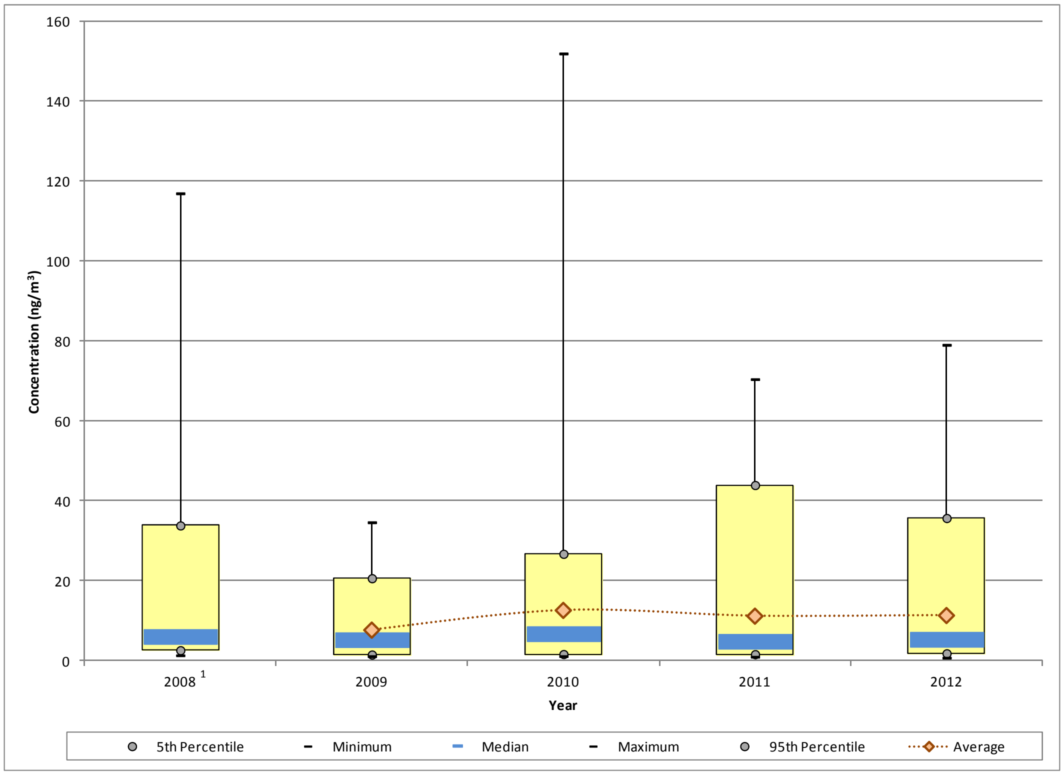
- A steady decreasing trend in the 1-year average concentration is shown after 2004, although the rate of decrease levels out after 2006, with the 1-year average reaching a minimum for 2008 (0.30 µg/m^3). Little change is shown for 2009.

- All of the statistical parameters exhibit increases for 2010, with most continuing this increase for 2011.

- The maximum concentration measured exhibits a steady increasing trend between 2008 and 2012.

- For 2012, the magnitude of the measurements at the lower end of the concentration range decreased (including one non-detect) while the measurements at the upper end of the concentration range increased. However, the number of concentrations at the lower end of the concentration range (those less than 0.25 µg/m^3) nearly doubled from 2011 to 2012, resulting in the slight decreases shown in the central tendency statistics.

Figure 15-32. Yearly Statistical Metrics for Fluorene Concentrations Measured at DEMI



[1] A 1-year average is not presented because sampling under did not begin until April 2008.

Observations from Figure 15-32 for fluorene measurements collected at DEMI include the following:

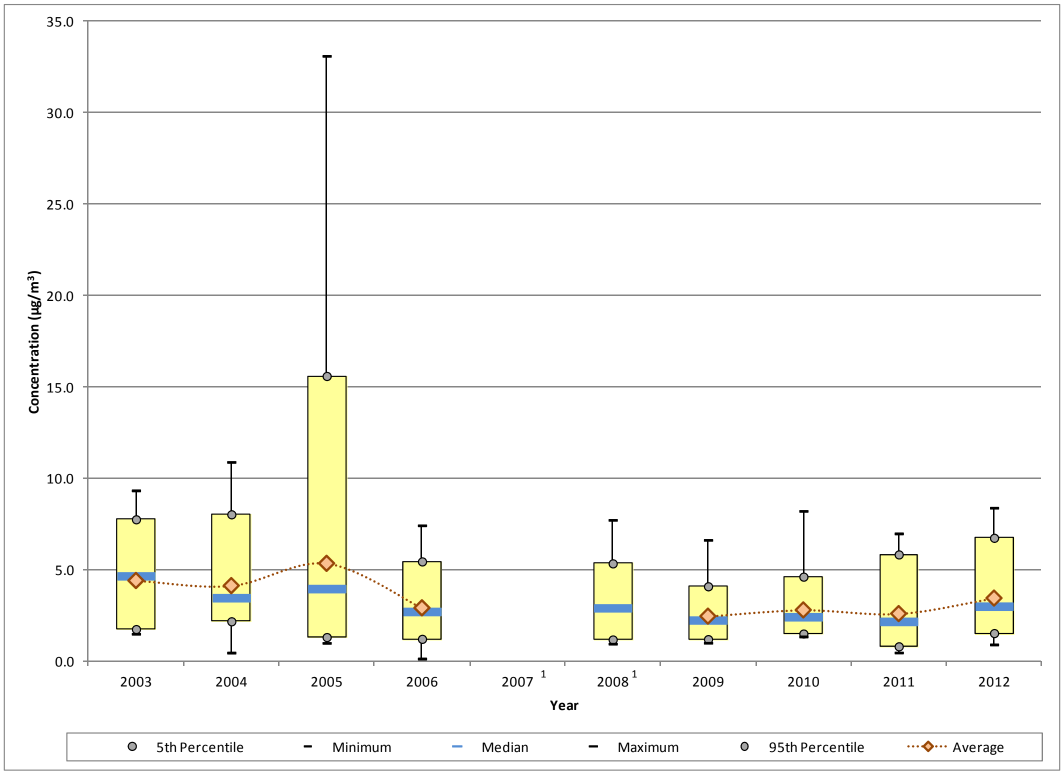
- The maximum fluorene concentration was measured at DEMI in August 2010; only two other measurements greater than 100 ng/m^3 have been measured at DEMI (one in August 2008 and one in August 2010). All eight concentrations greater than 50 ng/m^3 have been measured in June, July, or August and all 32 concentrations greater than 20 ng/m^3 were measured at DEMI during the second or third quarters of the year (the warmer months of the year), similar to acenaphthene and fluoranthene.

- The median concentrations have varied less than 2 ng/m^3 over the years, ranging from 4.92 ng/m^3 (2011) to 6.82 ng/m^3 (2010). The 1-year average concentrations exhibit more variability, although little change is shown from 2011 to 2012.

- All of the statistical metrics increased (at least slightly) from 2009 to 2010. The 1-year average is being driven by the two highest concentrations measured in 2010 (both greater than 100 ng/m^3). The next highest concentration measured in 2010 is considerably less (44.8 ng/m^3). If the two highest concentrations were excluded from the calculation, the 1-year average would decrease from 12.62 ng/m^3 to 8.40 ng/m^3.

- The 95th percentile increased steadily between 2009 and 2011. The number of concentrations greater than 25 ng/m^3 increased from one to three to six during this period. There were seven concentrations greater than 25 ng/m^3 measured in 2012, even though the 95th percentile exhibits a slight decrease.

Figure 15-33. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at DEMI



[1] A 1-year average is not presented because data from March 2007 to March 2008 was invalidated.

Observations from Figure 15-33 for formaldehyde measurements collected at DEMI include the following:

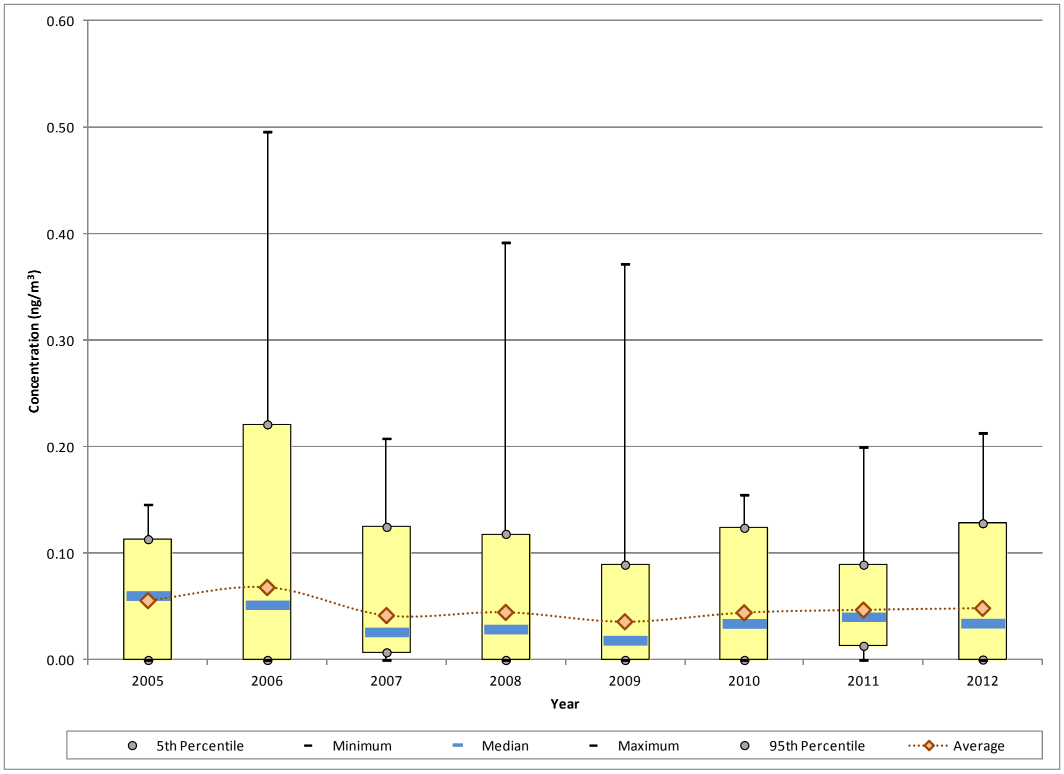
- Recall that carbonyl compounds have been sampled continuously at DEMI under the NMP since 2003 but due to a leak in the sample line, samples collected between March 13, 2007 through March 25, 2008 were invalidated. With only 12 valid samples in 2007, no statistical metrics are provided. Because less than 75 percent of the samples were valid in 2008, a 1-year average is not presented for 2008, although the range of measurements is provided.

- The maximum formaldehyde concentration shown was measured in 2005 (33.1 μg/m^3). The next four highest concentrations measured at DEMI were also measured in 2005 and ranged from 13.3 μg/m^3 to 20.9 μg/m^3. The only other formaldehyde concentrations greater than 10 μg/m^3 were measured in 2004.

- The decrease in the 1-year average concentration shown between 2005 and 2006 is significant (from 5.35 μg/m^3 to 2.92 μg/m^3). The 1-year average concentrations for the years following 2006 (where they could be calculated) did not vary significantly through 2011.

- All of the statistical parameters exhibit increases for 2012. A review of the data shows that the measurements collected in 2012 were higher in general compared to 2011. For instance, there were seven measurements less than 1 μg/m^3 in 2011 and only one in 2012. On the higher end of the range, there were nine concentrations greater than 4 μg/m^3 in 2011 compared to 21 in 2012.

Figure 15-34. Yearly Statistical Metrics for Hexavalent Chromium Concentrations Measured at DEMI



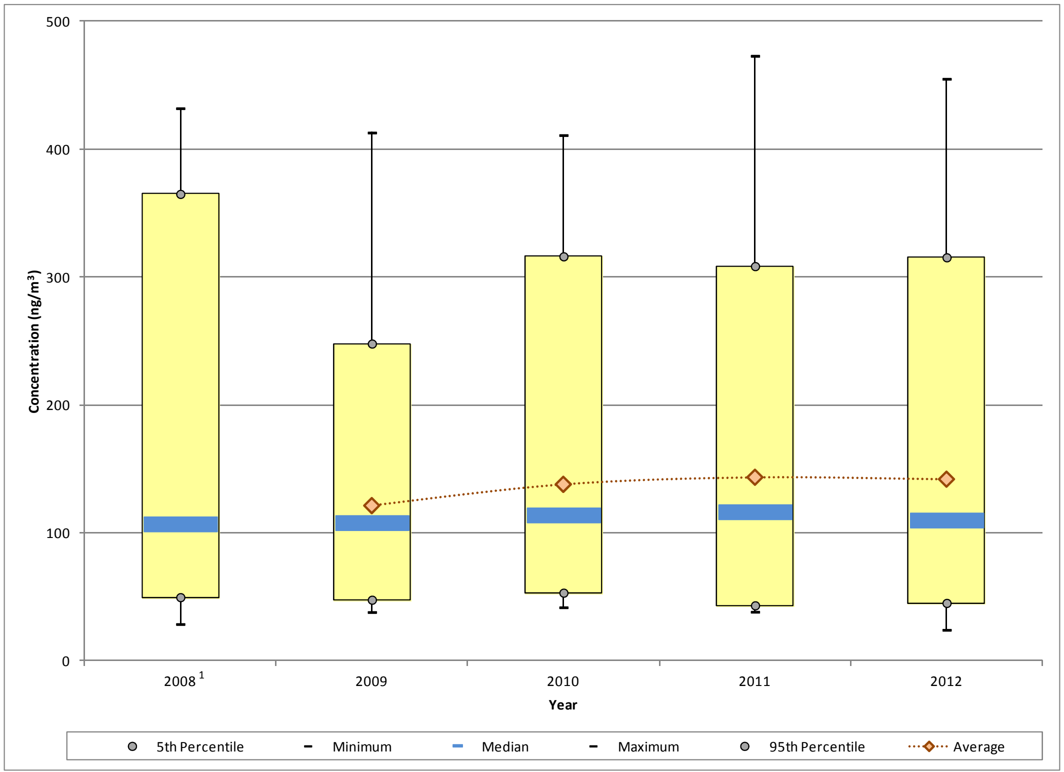
Observations from Figure 15-34 for hexavalent chromium measurements collected at DEMI include the following:

- The minimum concentrations and 5th percentiles for several years are both zero, indicating the presence of non-detects. The percentage of non-detects has ranged from 27 percent (2009) to less than 2 percent (2007 and 2011).

- The maximum hexavalent chromium concentration was measured in 2006. The two highest hexavalent chromium concentrations for this site were measured on July 4, 2006 (0.496 ng/m^3) and on July 5, 2008 (0.392 ng/m^3), although a similar concentration was also measured on January 1, 2009 (0.372 ng/m^3).

- Although a decrease in the 1-year average concentration is shown from 2006 (0.068 ng/m^3) to 2007 (0.042 ng/m^3), the confidence intervals calculated are relatively large as a result of the highest concentrations and indicate that these changes are not statistically significant. The 1-year average concentration changed little after 2006, ranging from 0.036 ng/m^3 (2009) to 0.048 ng/m^3 (2012). The median concentration exhibits a little more variability, ranging from 0.019 ng/m^3 (2009) to 0.041 ng/m^3 (2011).

Figure 15-35. Yearly Statistical Metrics for Naphthalene Concentrations Measured at DEMI



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 15-35 for naphthalene measurements collected at DEMI include the following:

- The maximum naphthalene concentration was measured at DEMI in July 2011 (473 ng/m^3); five additional measurements greater than 400 ng/m^3 have been measured at DEMI (at least one in each year since the onset of sampling).

- The median concentrations exhibit a slight increasing trend through 2011, as do the 1-year average concentrations, although the confidence intervals calculated are relatively large as a result of the wide range of concentrations measured and indicate that these changes are not statistically significant. The range of concentrations measured each year at DEMI spans more than 350 ng/m^3 each year.

- The difference between the 1-year average and median concentrations exhibits an increase for each year, reaching a maximum for 2012.

15.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the Michigan monitoring sites. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

15.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Michigan monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

15.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Michigan sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 15-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 15-6. Risk Approximations for the Michigan Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Dearborn, Michigan - DEMI						
Acenaphthene[a]	0.000088	--	60/60	0.01 ± <0.01	1.11	--
Acetaldehyde	0.0000022	0.009	60/60	1.75 ± 0.17	3.86	0.19
Benzene	0.0000078	0.03	63/63	0.92 ± 0.15	7.15	0.03
1,3-Butadiene	0.00003	0.002	61/63	0.11 ± 0.03	3.44	0.06
Carbon Tetrachloride	0.000006	0.1	63/63	0.71 ± 0.02	4.27	0.01
1,2-Dichloroethane	0.000026	2.4	53/63	0.07 ± 0.01	1.72	<0.01
Ethylbenzene	0.0000025	1	62/63	0.53 ± 0.14	1.33	<0.01
Fluorene[a]	0.000088	--	60/60	0.01 ± <0.01	1.00	--
Formaldehyde	0.000013	0.0098	60/60	3.45 ± 0.44	44.80	0.35
Hexavalent Chromium[a]	0.012	0.0001	58/62	<0.01 ± <0.01	0.58	<0.01
Naphthalene[a]	0.000034	0.003	60/60	0.14 ± 0.02	4.82	0.05
River Rouge, Michigan - RRMI						
Acetaldehyde	0.0000022	0.009	49/49	NA	NA	NA
Formaldehyde	0.000013	0.0098	49/49	NA	NA	NA
Detroit, Michigan - SWMI						
Acetaldehyde	0.0000022	0.009	30/30	1.62 ± 0.28	3.57	0.18
Formaldehyde	0.000013	0.0098	30/30	3.11 ± 0.59	40.48	0.32

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 15-5.

Observations from Table 15-6 include the following:

- Formaldehyde has the highest annual average concentration for DEMI and SWMI. This pollutant also has the highest cancer risk approximation for these sites, ranging from 40.48 in-a-million for SWMI to 44.80 in-a-million for DEMI.

- The range of cancer risk approximations for acetaldehyde was even tighter, ranging from 3.57 in-a-million for SWMI to 3.86 in-a-million for DEMI.

- Aside from formaldehyde and acetaldehyde, the pollutants with the highest cancer risk approximations for DEMI were benzene, naphthalene, and carbon tetrachloride.

- None of the pollutants of interest for DEMI or SWMI have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation for DEMI and SWMI is formaldehyde (which ranged from 0.32 to 0.35).

15.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 15-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 15-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 15-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 15-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 15-7. Table 15-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 15.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 15-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Michigan Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Dearborn, Michigan (Wayne County) - DEMI					
Benzene	516.86	Coke Oven Emissions, PM	8.62E-03	Formaldehyde	44.80
Formaldehyde	422.71	Formaldehyde	5.50E-03	Benzene	7.15
Ethylbenzene	350.07	Benzene	4.03E-03	Naphthalene	4.82
Acetaldehyde	251.15	POM, Group 5a	3.00E-03	Carbon Tetrachloride	4.27
1,3-Butadiene	81.46	Hexavalent Chromium, PM	2.72E-03	Acetaldehyde	3.86
Naphthalene	46.49	1,3-Butadiene	2.44E-03	1,3-Butadiene	3.44
Tetrachloroethylene	30.63	Arsenic, PM	2.15E-03	1,2-Dichloroethane	1.72
Trichloroethylene	17.05	Nickel, PM	1.59E-03	Ethylbenzene	1.33
Dichloromethane	10.96	Naphthalene	1.58E-03	Acenaphthene	1.11
Coke Oven Emissions, PM	8.71	Ethylbenzene	8.75E-04	Fluorene	1.00
River Rouge, Michigan (Wayne County) - RRMI					
Benzene	516.86	Coke Oven Emissions, PM	8.62E-03		
Formaldehyde	422.71	Formaldehyde	5.50E-03		
Ethylbenzene	350.07	Benzene	4.03E-03		
Acetaldehyde	251.15	POM, Group 5a	3.00E-03		
1,3-Butadiene	81.46	Hexavalent Chromium, PM	2.72E-03		
Naphthalene	46.49	1,3-Butadiene	2.44E-03		
Tetrachloroethylene	30.63	Arsenic, PM	2.15E-03		
Trichloroethylene	17.05	Nickel, PM	1.59E-03		
Dichloromethane	10.96	Naphthalene	1.58E-03		
Coke Oven Emissions, PM	8.71	Ethylbenzene	8.75E-04		

Table 15-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Michigan Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Detroit, Michigan (Wayne County) - SWMI					
Benzene	516.86	Coke Oven Emissions, PM	8.62E-03	Formaldehyde	40.48
Formaldehyde	422.71	Formaldehyde	5.50E-03	Acetaldehyde	3.57
Ethylbenzene	350.07	Benzene	4.03E-03		
Acetaldehyde	251.15	POM, Group 5a	3.00E-03		
1,3-Butadiene	81.46	Hexavalent Chromium, PM	2.72E-03		
Naphthalene	46.49	1,3-Butadiene	2.44E-03		
Tetrachloroethylene	30.63	Arsenic, PM	2.15E-03		
Trichloroethylene	17.05	Nickel, PM	1.59E-03		
Dichloromethane	10.96	Naphthalene	1.58E-03		
Coke Oven Emissions, PM	8.71	Ethylbenzene	8.75E-04		

Table 15-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Michigan Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Dearborn, Michigan (Wayne County) - DEMI					
Toluene	4,113.77	Acrolein	1,292,303.40	Formaldehyde	0.35
Hydrochloric acid	3,022.42	Hydrochloric acid	151,120.80	Acetaldehyde	0.19
Ethylene glycol	2,244.10	Manganese, PM	127,044.59	1,3-Butadiene	0.06
Xylenes	1,299.49	Formaldehyde	43,133.35	Naphthalene	0.05
Hexane	1,288.67	1,3-Butadiene	40,728.90	Benzene	0.03
Methanol	1,113.11	Nickel, PM	36,772.89	Carbon Tetrachloride	0.01
Benzene	516.86	Arsenic, PM	33,262.46	Ethylbenzene	<0.01
Formaldehyde	422.71	Acetaldehyde	27,905.70	Hexavalent Chromium	<0.01
Ethylbenzene	350.07	Benzene	17,228.71	1,2-Dichloroethane	<0.01
Acetaldehyde	251.15	Naphthalene	15,496.90		
River Rouge, Michigan (Wayne County) - RRMI					
Toluene	4,113.77	Acrolein	1,292,303.40		
Hydrochloric acid	3,022.42	Hydrochloric acid	151,120.80		
Ethylene glycol	2,244.10	Manganese, PM	127,044.59		
Xylenes	1,299.49	Formaldehyde	43,133.35		
Hexane	1,288.67	1,3-Butadiene	40,728.90		
Methanol	1,113.11	Nickel, PM	36,772.89		
Benzene	516.86	Arsenic, PM	33,262.46		
Formaldehyde	422.71	Acetaldehyde	27,905.70		
Ethylbenzene	350.07	Benzene	17,228.71		
Acetaldehyde	251.15	Naphthalene	15,496.90		

Table 15-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Michigan Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Detroit, Michigan (Wayne County) - SWMI					
Toluene	4,113.77	Acrolein	1,292,303.40	Formaldehyde	0.32
Hydrochloric acid	3,022.42	Hydrochloric acid	151,120.80	Acetaldehyde	0.18
Ethylene glycol	2,244.10	Manganese, PM	127,044.59		
Xylenes	1,299.49	Formaldehyde	43,133.35		
Hexane	1,288.67	1,3-Butadiene	40,728.90		
Methanol	1,113.11	Nickel, PM	36,772.89		
Benzene	516.86	Arsenic, PM	33,262.46		
Formaldehyde	422.71	Acetaldehyde	27,905.70		
Ethylbenzene	350.07	Benzene	17,228.71		
Acetaldehyde	251.15	Naphthalene	15,496.90		

Observations from Table 15-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Wayne County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Wayne County are coke oven emissions, formaldehyde, and benzene.

- Six of the highest emitted pollutants in Wayne County also have the highest toxicity-weighted emissions.

- Formaldehyde has the highest cancer risk approximation for DEMI and SWMI. This pollutant also appears on both emissions-based lists. Acetaldehyde is one of the highest emitted pollutants but does not appear among those with the highest toxicity-weighted emissions.

- In addition to formaldehyde, benzene, naphthalene, ethylbenzene, and 1,3-butadiene are among the pollutants with the highest cancer risk approximations for DEMI and appear on both emissions-based lists. Hexavalent chromium has the fifth highest toxicity-weighted emissions but does not appear among the highest emitted pollutants. Carbon tetrachloride does not appear on either emissions-based list.

Observations from Table 15-8 include the following:

- Toluene, hydrochloric acid, and ethylene glycol are the highest emitted pollutants with noncancer RfCs in Wayne County. The quantity of emissions for highest ranking the pollutants in Table 15-8 is an order of magnitude higher than the quantity of emissions for the highest ranking pollutants in Table 15-7.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for Wayne County are acrolein, hydrochloric acid, and manganese. Although acrolein was sampled for at DEMI, this pollutant was excluded from the pollutants of interest designation and thus subsequent risk-based screening evaluations due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Four of the highest emitted pollutants in Wayne County also have the highest toxicity-weighted emissions.

- Formaldehyde and acetaldehyde have the highest noncancer hazard approximations for both DEMI and SWMI, although none of the pollutants of interest have associated noncancer hazard approximations greater than 1.0. Formaldehyde emissions rank eighth highest for Wayne County while the toxicity-weighted emissions (of the pollutants with noncancer RfCs) rank fourth.

- Acetaldehyde also appears on both emissions-based lists for DEMI and SWMI. Acetaldehyde ranks tenth for quantity emitted and eighth for its toxicity-weighted emissions.

- Benzene is the only other pollutant that appears on all three lists for DEMI.

15.6 Summary of the 2012 Monitoring Data for DEMI, RRMI, and SWMI

Results from several of the data treatments described in this section include the following:

- *Twenty-two pollutants failed screens for DEMI. Acetaldehyde and formaldehyde both failed screens for RRMI and SWMI.*

- *Of the site-specific pollutants of interest, formaldehyde had the highest annual average concentration for DEMI and SWMI. Annual average concentrations could not be calculated for RRMI.*

- *DEMI has the highest annual average concentration of carbon tetrachloride among NMP sites sampling VOCs. DEMI also has some of the highest annual average concentrations of acenaphthene, fluorene, and naphthalene among NMP sites sampling PAHs. The highest concentration of ethylbenzene program-wide was measured at DEMI.*

- *Concentrations of acenaphthene and fluorene measured at DEMI tended to be highest during the summer months. A significant decrease in benzene concentrations occurred at DEMI for many years, although concentrations have leveled off in recent years. The detection rate of 1,2-dichloroethane has been increasing steadily at DEMI over the last few years of sampling.*

16.0 Site in Minnesota

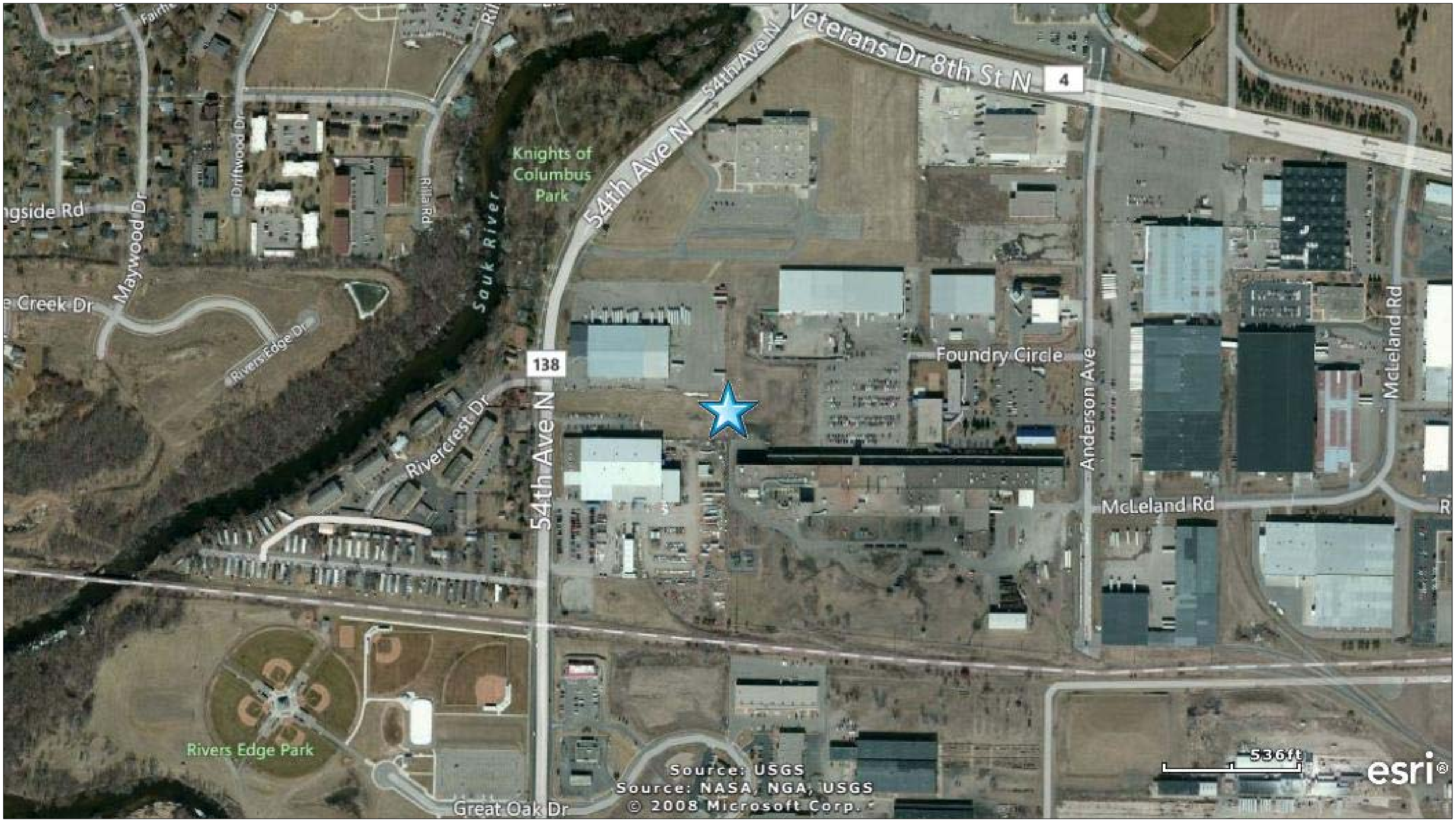
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP site in Minnesota, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

16.1 Site Characterization

This section characterizes the monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The STMN site is located in St. Cloud, Minnesota. Figure 16-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 16-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 16-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 16-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 16-1. St. Cloud, Minnesota (STMN) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 16-2. NEI Point Sources Located Within 10 Miles of STMN

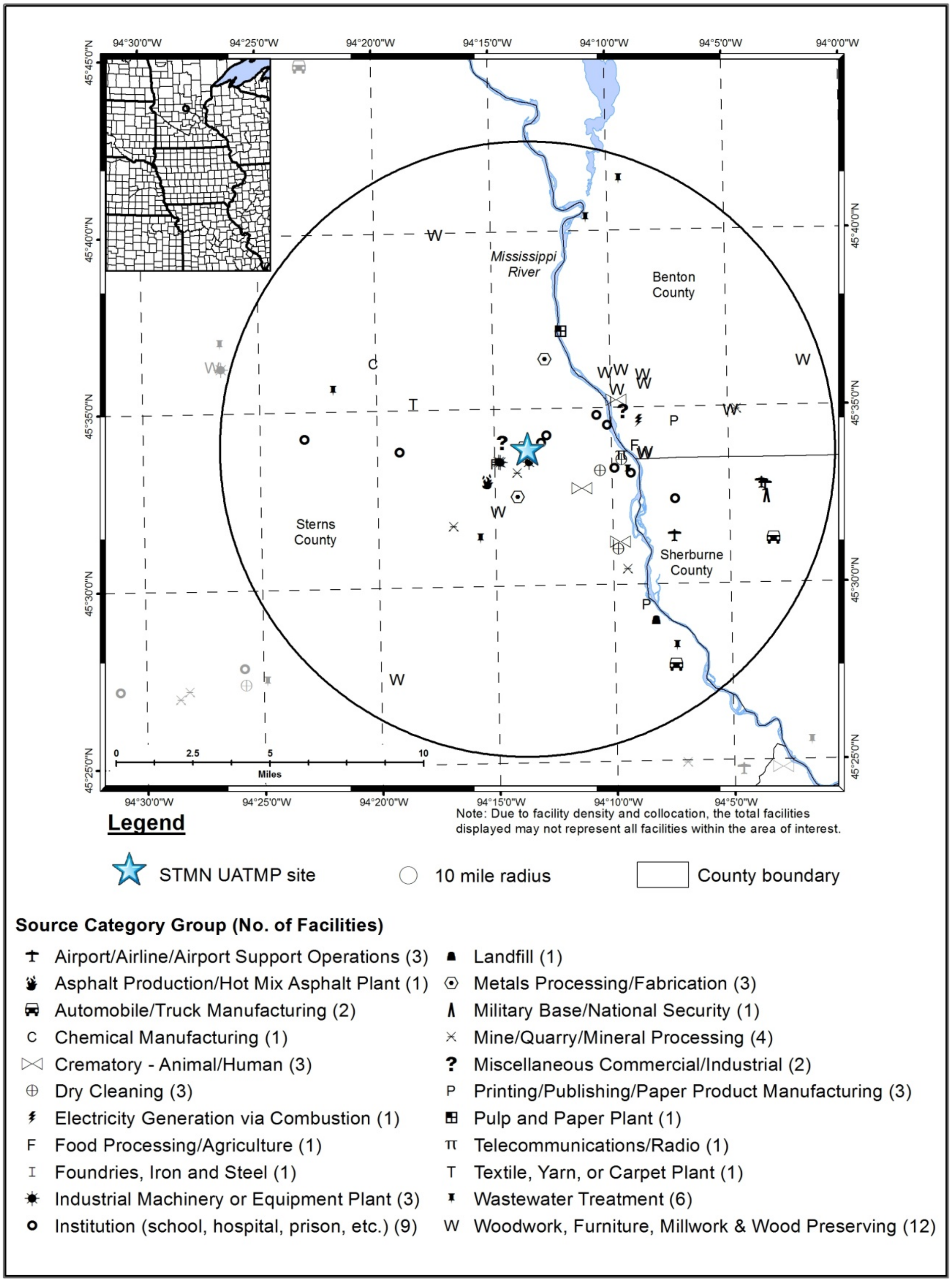


Table 16-1. Geographical Information for the Minnesota Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
STMN	27-145-3053	St. Cloud	Stearns	St. Cloud, MN MSA	45.564637, -94.226345	Industrial	Suburban	TSP, TSP Metals.

[1] Data for additional pollutants are reported to AQS for STMN (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

The STMN monitoring site is located on the property of Grede Foundries, St. Cloud, Inc., on the west side of St. Cloud, Minnesota, just north of the Waite Park town limits. Monitoring at this site is source-oriented and part of a special assessment initiated based on elevated total chromium levels (MPCA, 2013). An apartment complex and mobile home park are separated from additional industrial properties, including a stainless steel tank manufacturing facility, by 54th Avenue North just west of the site. Farther west, the Sauk River runs northeast-southwest through the area and is adjacent to additional residential properties to the north and northwest of the site. A railway runs east-west to the south of the site with commercial properties immediately adjacent.

Figure 16-2 shows that the monitoring site is located in close proximity to many emissions sources. The source categories with the greatest number of emissions sources near STMN include woodworking, institutions (which include schools, prisons, and hospitals), wastewater treatment, and mine/quarry/mineral processing. The sources located to the east and along the county boundary are located near the banks of the Mississippi River. The STMN site is located in a highly industrial area, which includes a major hospital to the northeast, a metals processing and fabrication facility, and foundry, iron, and steel facility, and an industrial machinery/equipment plant. Additional facilities are located to the southwest of STMN.

Table 16-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Minnesota monitoring site. Table 16-2 includes both county-level population and vehicle registration information. Table 16-2 also contains traffic volume information for STMN as well as the location for which the traffic volume was obtained. Additionally, Table 16-2 presents the county-level daily VMT for Stearns County.

Table 16-2. Population, Motor Vehicle, and Traffic Information for the Minnesota Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
STMN	151,606	218,196	24,100	8th Street N, east of Anderson Ave	4,983,115

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (MN DPS, 2013)
[3] AADT reflects 2009 data (MN DOT, 2009)
[4] County-level VMT reflects 2012 data (MN DOT, 2013)

Observations from Table 16-2 include the following:

- The Stearns County population is in the bottom-third compared to other counties with NMP sites. The county-level vehicle registration has a similar ranking compared to other counties with NMP sites.

- The traffic volume near STMN is in the middle of the range compared to other NMP sites. The traffic estimate provided is for 8th Street North (Veterans Drive), east of Anderson Avenue.

- The daily VMT for Stearns County is nearly 5 million miles and ranks 30th compared to other counties with NMP sites (where VMT data were available).

16.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Minnesota on sample days, as well as over the course of the year.

16.2.1 Climate Summary

The city of St. Cloud is located roughly in the center of the state of Minnesota. The area experiences a continental climate, with summers characterized by warm days and cool nights and winters that are long and cold. Annual precipitation is around 30 inches with more than half of the precipitation concentrated between May and September and in the form of thunderstorms. Nearly 50 inches of snow falls on average during the winter months. A northwest wind is predominant in St. Cloud most of the year, although a southerly wind occurs during the summer months (NCDC, 2014; MCWG, 2013).

16.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Minnesota monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station is located at St. Cloud Regional Airport (WBAN 14926). Additional information about the St. Cloud Regional Airport weather station, such as the distance between the site and the weather station, is provided in Table 16-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 16-3. Average Meteorological Conditions near the Minnesota Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
St. Cloud, Minnesota - STMN									
St. Cloud Regional Airport 14926 (45.54, -94.05)	8.1 miles 99° (ESE)	Sample Days (55)	60.1 ± 6.0	49.8 ± 5.5	38.0 ± 5.1	44.1 ± 4.9	68.0 ± 3.5	1015.3 ± 1.9	6.5 ± 0.8
		2012	57.6 ± 2.3	47.6 ± 2.1	36.0 ± 1.9	42.1 ± 1.9	68.1 ± 1.3	1015.6 ± 0.7	6.6 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 16-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 16-3 is the 95 percent confidence interval for each parameter. As shown in Table 16-3, average meteorological conditions on sample days appear warmer than conditions experienced throughout 2012, although the differences are not statistically significant. Sampling at STMN under the NMP did not begin until February 2012, thereby missing the coldest month of the year.

16.2.3 Back Trajectory Analysis

Figure 16-3 is the composite back trajectory map for days on which samples were collected at the STMN monitoring site. Included in Figure 16-3 are four back trajectories per sample day. Figure 16-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 16-3 and 16-4 represents 100 miles.

Figure 16-3. Composite Back Trajectory Map for STMN

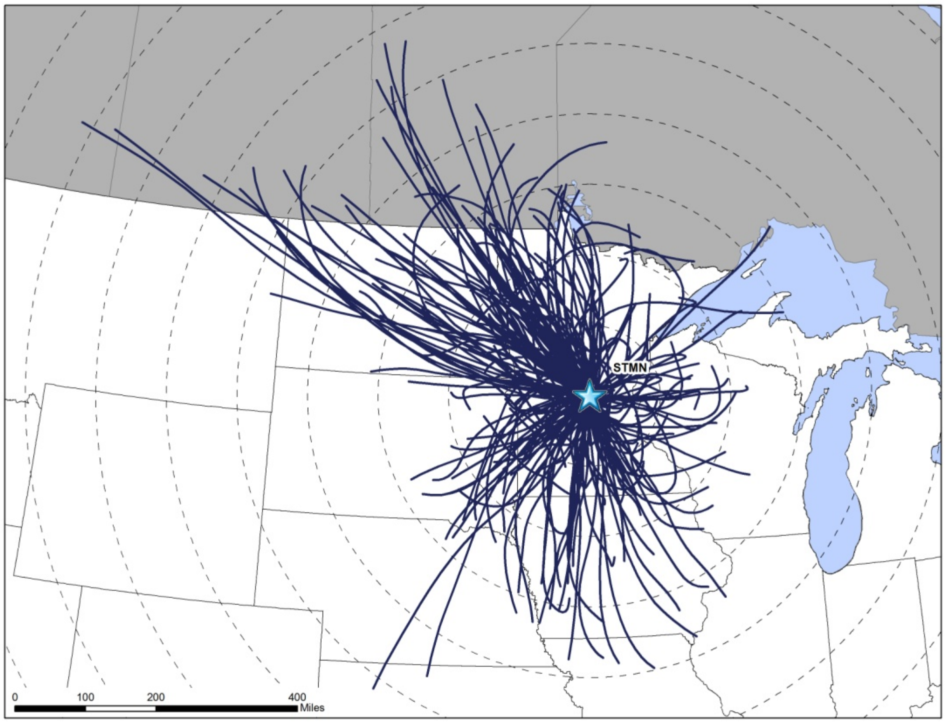


Figure 16-4. Back Trajectory Cluster Map for STMN

Observations from Figures 16-3 and 16-4 for STMN include the following:

- Back trajectories originated from a variety of directions at STMN, although many of the back trajectories originate from the northwest. The longest back trajectories originated to the northwest of STMN.

- The 24-hour air shed domain for STMN is similar in size to other NMP monitoring sites. The farthest away a back trajectory originated was Alberta, Canada, or greater than 800 miles away. However, the average back trajectory length was 245 miles and most back trajectories (90 percent) originated within 400 miles of the site.

- The cluster analysis shows that nearly 50 percent of the back trajectories originated from the northwest of STMN, although the HYSPLIT model split them into two clusters based length (43 percent originated over North Dakota, Manitoba, Canada, and the northwest portion of Minnesota; the remaining 5 percent originated farther west, over Montana or Saskatchewan and Alberta, Canada. Seventeen percent of back trajectories originated to the southeast, south, or southwest of STMN, primarily over Iowa, Nebraska, and South Dakota. The short cluster trajectory originating toward Minneapolis represents relatively short back trajectories (generally less than 200 miles) originating from all quadrants except the northwest. These back trajectories originated over northeast Iowa, the western half of Wisconsin, and Minnesota.

16.2.4 Wind Rose Comparison

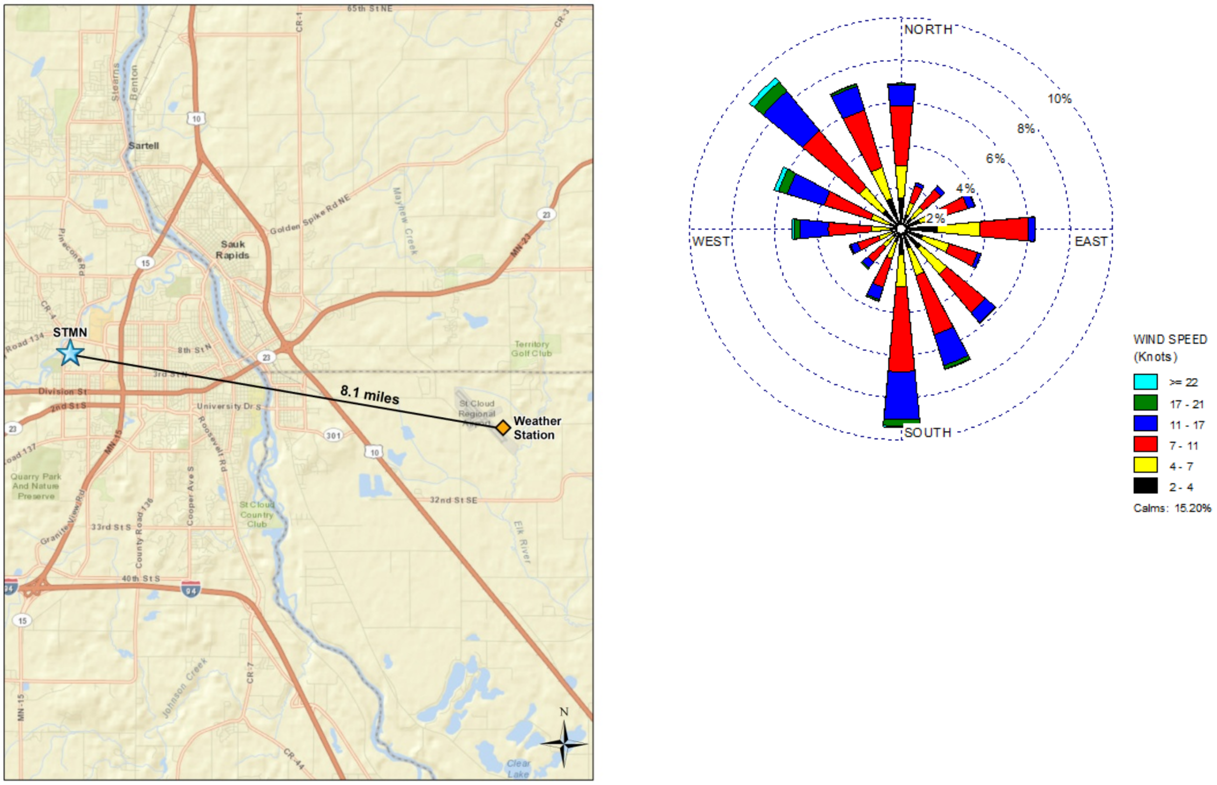
Hourly surface wind data from the weather station at St. Cloud Regional Airport near STMN were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 16-5 presents a map showing the distance between the weather station and STMN, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 16-5 also presents three different wind roses for the STMN monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 16-5. Wind Roses for the St. Cloud Regional Airport Weather Station near STMN

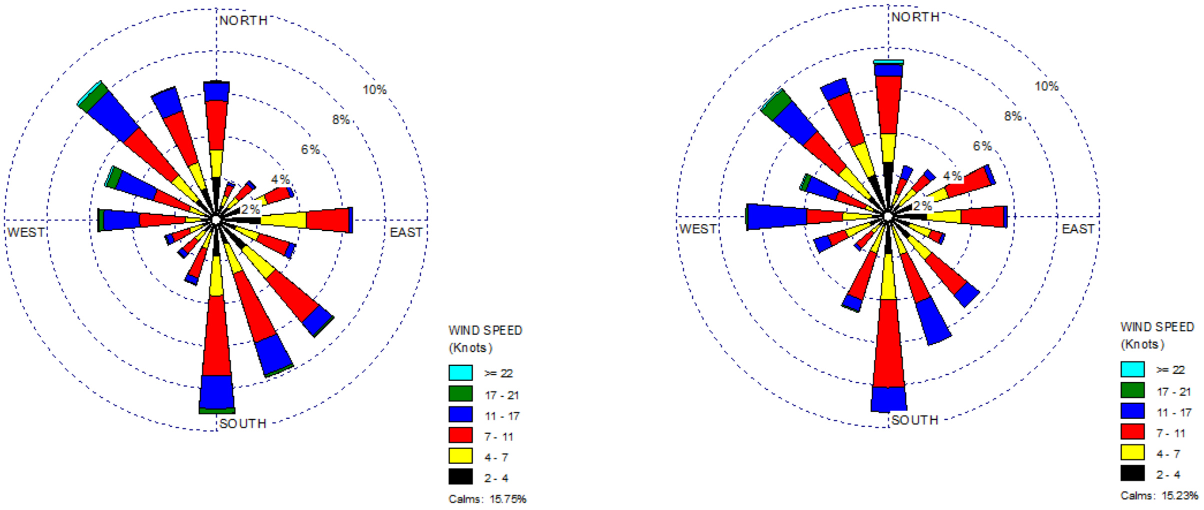
Location of STMN and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose



Observations from Figure 16-5 for STMN include the following:

- The St. Cloud Regional Airport weather station is located approximately 8 miles east of STMN. Most of the city of St. Cloud and the Mississippi River lie between the site and the weather station. The area surrounding the airport is more rural in nature than the more urbanized area surrounding STMN.

- The historical wind rose shows that winds from the northwest quadrant (including west and north) and southeast quadrant (including east and south) were observed more frequently than winds from the northeast or southwest. Winds from these quadrants account for approximately one-third of observations. The strongest wind speeds were most often associated with westerly to northwesterly winds. Calm winds (≤2 knots) were observed for 15 percent of the hourly measurements.

- The wind patterns shown on the 2012 wind rose resemble the historical wind patterns.

- The sample day wind rose exhibits some of the characteristics of the other wind roses, with winds from the northwest and southeast quadrants accounting for the majority of observations, but the individual direction percentages are more variable. There were more wind observations from the east-northeast and south-southwest on sample days and fewer wind observations from the east-southeast and west-northwest.

- The percentage of calm winds, however, is similar across all three wind roses.

16.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for STMN in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 16-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 16-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. STMN sampled only hexavalent chromium.

Table 16-4. Risk-Based Screening Results for the Minnesota Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
St. Cloud, Minnesota - STMN						
Hexavalent Chromium	0.000083	6	39	15.38	100.00	100.00
Total		6	39	15.38		

Table 16-4 presents the results of the preliminary risk-based screening process for STMN. Observations from Table 16-4 include the following:

- Hexavalent chromium was detected in 39 of the 54 valid samples collected at STMN.
- Hexavalent chromium failed six screens for STMN, which represents a roughly 15 percent failure rate.

16.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Minnesota monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for the site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for STMN are provided in Appendix O.

16.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Minnesota site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for STMN are presented in Table 16-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 16-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Minnesota Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
St. Cloud, Minnesota - STMN						
Hexavalent Chromium	39/54	NA	0.757 ± 1.177	0.026 ± 0.011	0.022 ± 0.017	0.283 ± 0.337

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for STMN from Table 16-5 include the following:

- Measured detections of hexavalent chromium span three orders of magnitude, ranging from 0.0044 ng/m^3 to 8.51 ng/m^3. This dataset also includes 15 non-detects.

- The maximum concentration measured at STMN is the single highest hexavalent chromium concentration measured under the NMP since this method was added to the program in 2005. This measurement was collected on May 9, 2012. Two additional measurements greater than 1 ng/m^3 were measured at STMN, one on February 27, 2012 (3.07 ng/m^3) and one on May 15, 2012 (2.15 ng/m^3). These too are among the highest measurements of hexavalent chromium collected program-wide. In total, five hexavalent chromium measurements greater than 1 ng/m^3 have been collected under the NMP between 2005 and 2012.

- The fourth highest hexavalent chromium concentration measured at STMN is an order of magnitude less than the others (0.331 ng/m^3). Only three measurements collected at STMN fall between 0.1 ng/m^3 and 1 ng/m^3.

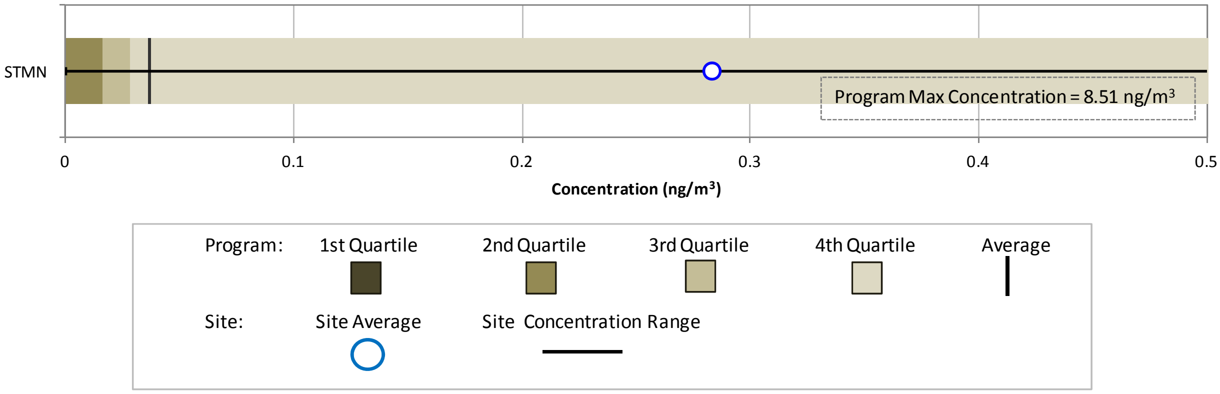
- The second quarter average concentration is significantly higher than the other quarter quarterly averages and the associated confidence interval is greater than the average itself. The second quarter data set includes the two May concentrations discussed above, two of the three measurements between 0.1 ng/m^3 and 1 ng/m^3, as well as four non-detects (zeros). This explains the variability associated with the second quarter average concentration as well as the annual average.

- Because sampling did not begin until February 9, 2012, a first quarter average concentration could not be calculated.

16.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, a hexavalent chromium box plot was created for STMN. Figure 16-6 overlays the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 16-6. Program vs. Site-Specific Average Hexavalent Chromium Concentration



Observations from Figure 16-6 include the following:

- The program-level maximum concentration (8.51 ng/m^3) is not shown directly on the box plot in Figure 16-6 because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to 0.5 ng/m^3. In addition, the program-level first quartile is zero and therefore not visible on the box plot.

- The maximum hexavalent chromium concentration measured at STMN is the maximum concentration measured across the program.

- The annual average for STMN is greater than the program-level first, second, and third quartiles and is an order of magnitude greater than the program-level average concentration.

- The annual average concentration of hexavalent chromium for STMN is the highest annual average concentration of this pollutant calculated among all NMP sites sampling hexavalent chromium. STMN is one of only two sites with an annual average concentration greater than 0.1 ng/m^3.

16.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. Because sampling under the NMP did not begin until February 2012 at STMN, a trends analysis was not conducted for this site.

16.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the Minnesota monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

16.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from STMN to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual average was compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012. Note that hexavalent chromium has an intermediate MRL (0.3 µg/m^3) only.

16.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Minnesota site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutant of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 16-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 16-6. Risk Approximations for the Minnesota Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
St. Cloud, Minnesota - STMN						
Hexavalent Chromium	0.012	0.0001	39/54	0.28 ± 0.34	3.40	<0.01

Observations for STMN from Table 16-6 include the following:

- The annual average concentration of hexavalent chromium for STMN is the highest annual average concentration of this pollutant program-wide.
- The cancer risk approximation for STMN for hexavalent chromium is 3.40 in-a-million, the highest cancer risk approximation calculated for this pollutant across the program.
- The noncancer hazard approximation for hexavalent chromium is less than 0.01, indicating that no adverse noncancer health effects are expected from this individual pollutant.

16.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 16-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 16-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 16-7 provides the pollutants with the highest cancer risk approximations (in-a-million) for the site, as presented in Table 16-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 16-7. Table 16-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 16.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 16-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Minnesota Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
St. Cloud, Minnesota (Stearns County) - STMN					
Bis(2-ethylhexyl)phthalate (DEHP), gas[1]	699.98	Formaldehyde	2.57E-03	Hexavalent Chromium	3.40
Formaldehyde	197.54	Bis(2-ethylhexyl)phthalate (DEHP), gas[1]	1.68E-03		
Benzene	179.92	Benzene	1.40E-03		
Acetaldehyde	109.50	1,3-Butadiene	8.41E-04		
Ethylbenzene	61.53	Naphthalene	5.50E-04		
1,3-Butadiene	28.02	Acetaldehyde	2.41E-04		
Naphthalene	16.18	POM, Group 2b	2.38E-04		
1,3-Dichloropropene	12.08	POM, Group 5a	2.18E-04		
Tetrachloroethylene	4.76	POM, Group 2d	1.79E-04		
Dichloromethane	4.43	POM, Group 3	1.66E-04		

[1] EPA has reviewed the reported emissions of this pollutant and has revised these emissions in version 2 of the 2011 NEI; however, version 1, which is the version cited in this report, is the only version of the 2011 NEI publically available at the time of publication.

Table 16-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Minnesota Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
St. Cloud, Minnesota (Stearns County) - STMN					
Toluene	796.08	Acrolein	390,174.17	Hexavalent Chromium	<0.01
Bis(2-ethylhexyl)phthalate (DEHP), gas[1]	699.98	Bis(2-ethylhexyl)phthalate (DEHP), gas[1]	69,998.10		
Xylenes	304.31	Manganese, PM	21,950.40		
Hexane	206.81	Formaldehyde	20,156.75		
Ethylene glycol	199.63	1,3-Butadiene	14,010.08		
Formaldehyde	197.54	Acetaldehyde	12,166.99		
Benzene	179.92	Lead, PM	6,189.57		
Acetaldehyde	109.50	Benzene	5,997.44		
Methanol	93.71	Naphthalene	5,391.85		
Ethylbenzene	61.53	Chlorine	5,240.71		

[1] EPA has reviewed the reported emissions of this pollutant and has revised these emissions in version 2 of the 2011 NEI; however, version 1, which is the version cited in this report, is the only version of the 2011 NEI publically available at the time of publication.

Observations from Table 16-7 include the following:

- Bis(2-ethylhexyl)phthalate (DEHP) gas, formaldehyde, and benzene are the highest emitted pollutants with cancer UREs in Stearns County. The emissions of bis(2-ethylhexyl)phthalate (DEHP) gas in Stearns County are two orders of magnitude higher than the emissions of this pollutant for any other county with an NMP site.

- Formaldehyde, bis(2-ethylhexyl)phthalate (DEHP) gas, and benzene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Stearns County.

- Six of the highest emitted pollutants in Stearns County also have the highest toxicity-weighted emissions.

- Hexavalent chromium, which is the only pollutant sampled for at STMN, is not among the highest emitted pollutants or those with the highest toxicity-weighted emissions. Hexavalent chromium ranks 29th for total emissions and 12th for toxicity-weighted emissions.

- Naphthalene and several POM Groups rank among Stearns County's highest toxicity-weighted emissions. PAHs were not sampled for at STMN.

Observations from Table 16-8 include the following:

- Toluene, bis(2-ethylhexyl)phthalate (DEHP) gas, and xylenes are the highest emitted pollutants with noncancer RfCs in Stearns County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, bis(2-ethylhexyl)phthalate (DEHP) gas, and manganese.

- Four of the highest emitted pollutants in Stearns County also have the highest toxicity-weighted emissions.
- Again, hexavalent chromium does not appear among the pollutants with the highest emissions or toxicity-weighted emissions. This pollutant's emissions rank 58th and its toxicity-weighted emissions rank 31st (among the pollutants with noncancer RfCs).

16.6 Summary of the 2012 Monitoring Data for STMN

Results from several of the data treatments described in this section include the following:

- ❖ *Hexavalent chromium was the only pollutant sampled for at STMN.*

- ❖ *Concentrations of hexavalent chromium measured at STMN range from 0.0044 ng/m*^{3} *to 8.51 ng/m*^{3}*.*

- *The maximum concentration measured at STMN is the single highest hexavalent chromium concentration measured under the NMP since this method was added to the program in 2005.*

17.0 Site in Missouri

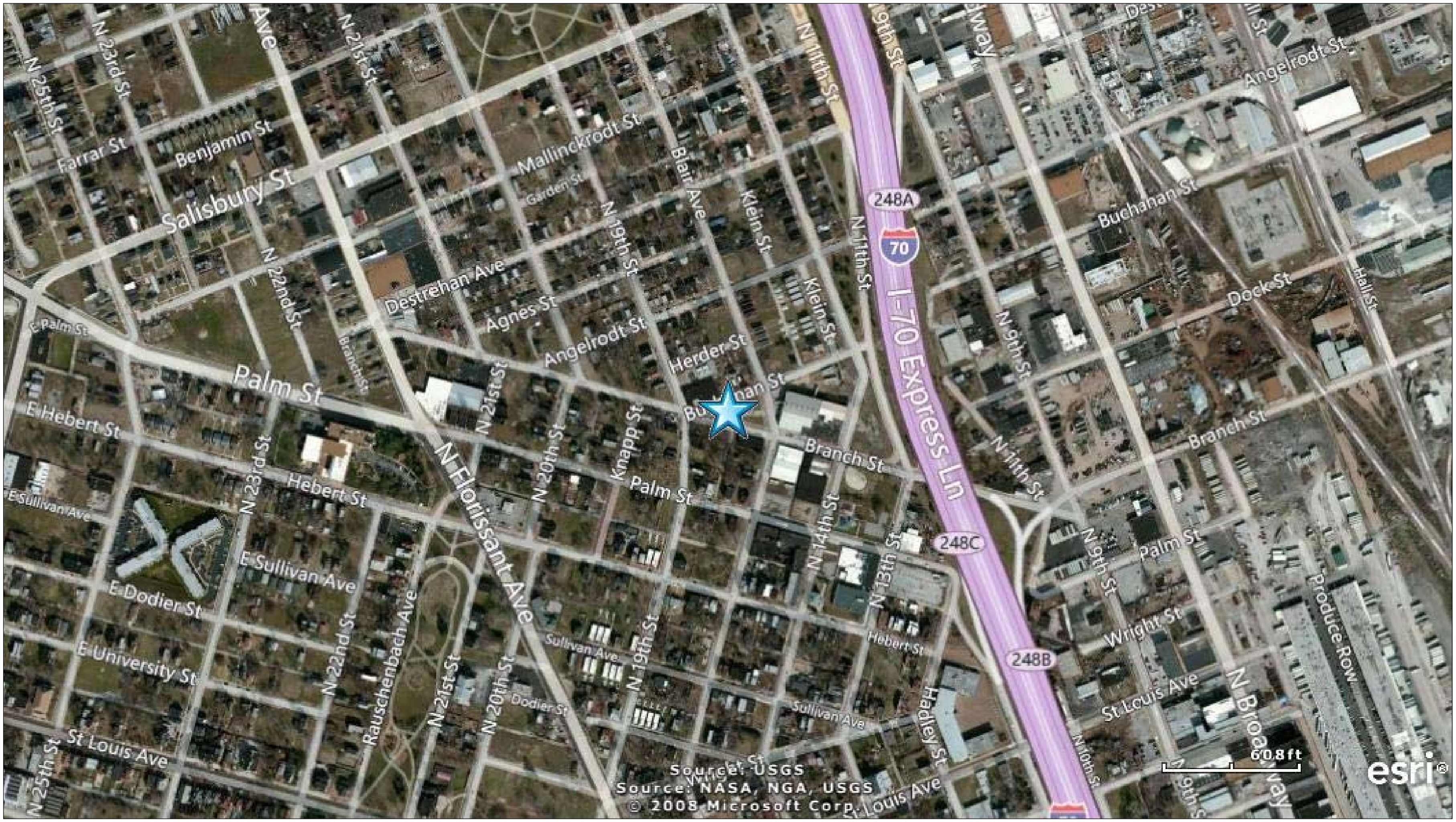
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Missouri, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

17.1 Site Characterization

This section characterizes the S4MO monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

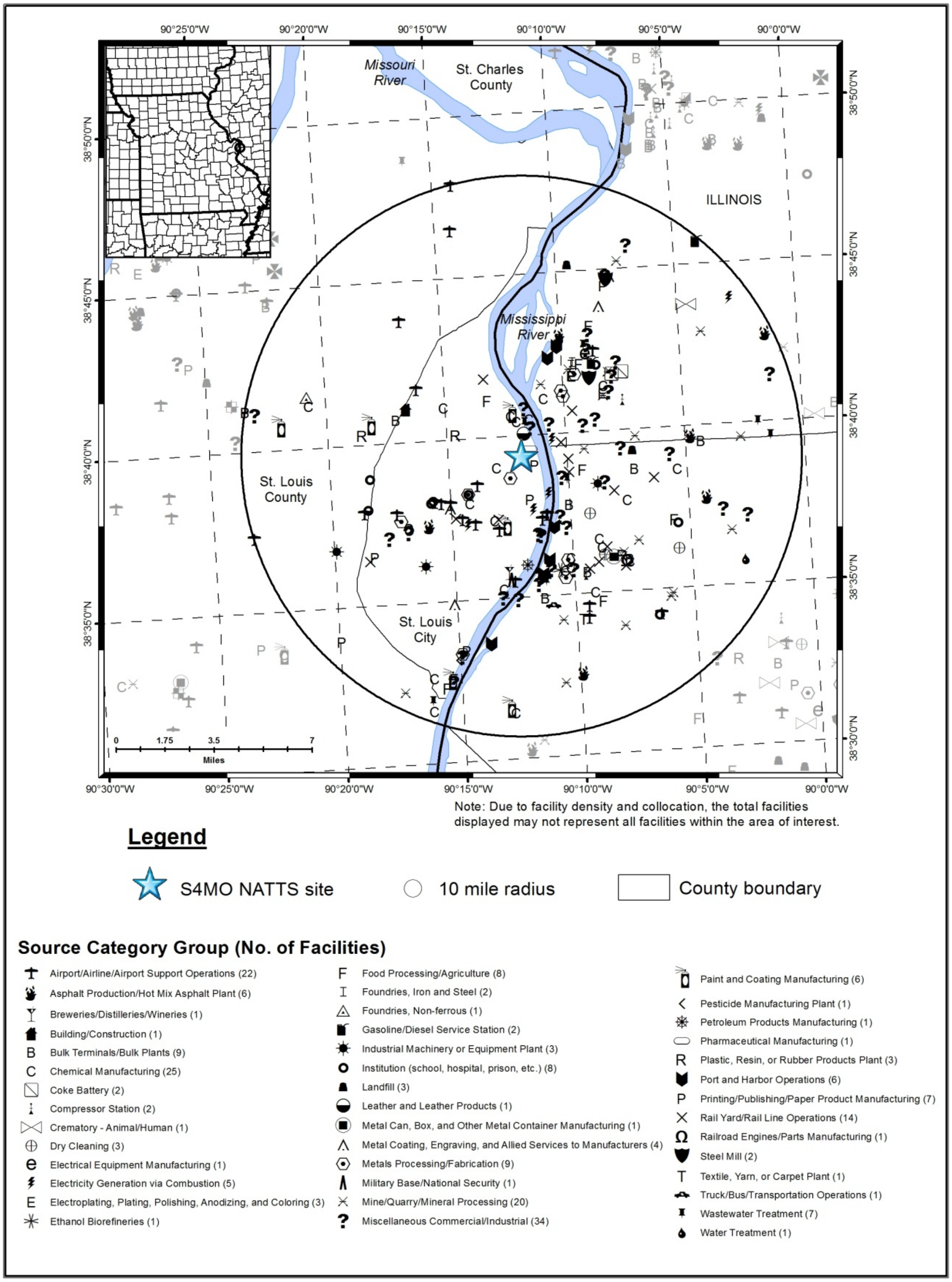
The S4MO monitoring site is located in the St. Louis, MO-IL MSA. Figure 17-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 17-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 17-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 17-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 17-1. St. Louis, Missouri (S4MO) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 17-2. NEI Point Sources Located Within 10 Miles of S4MO



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 17-1. Geographical Information for the Missouri Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
S4MO	29-510-0085	St. Louis	St. Louis City	St. Louis, MO-IL MSA	38.656449, -90.198548	Residential	Urban/City Center	TSP Lead, CO, SO_2, NO_y, NO, O_3, Meteorological parameters, PM_{10}, PM Coarse, Black carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOL D ITALICS = EPA-designated NATTS Site

S4MO is located in central St. Louis. Figure 17-1 shows that the S4MO monitoring site is located less than 1/4 mile west of I-70. The Mississippi River, which separates Missouri and Illinois, is less than 1 mile east of the site. Although the area directly around the monitoring site is primarily residential, industrial facilities are located just on the other side of I-70. Figure 17-2 shows that a large number of point sources are located within 10 miles of S4MO, particularly east of the Missouri/Illinois border. The source categories with the greatest number of point sources surrounding S4MO include mines, quarries, and mineral processing facilities; chemical manufacturing facilities; airport and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; and rail yard/rail line operations. Within 1 mile of S4MO are a pharmaceutical manufacturing facility, a printing and publishing facility, a leather products facility, a metals processing/fabrication facility, and a chemical manufacturing facility.

Table 17-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Missouri monitoring site. Table 17-2 includes both county-level population and vehicle registration information. Table 17-2 also contains traffic volume information for S4MO as well as the location for which the traffic volume was obtained. Additionally, Table 17-2 presents the county-level daily VMT for S4MO. Note that because the state of Missouri provides data within the city of St. Louis separately from St. Louis County, Table 17-2 includes the combination of the city and county data for county-level statistics in order to compare these statistics with other sites' county-level data.

Table 17-2. Population, Motor Vehicle, and Traffic Information for the Missouri Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
S4MO	1,318,610	1,112,866	79,558	I-70 near Exit 249	23,994,911

[1] County-level population estimate reflects county and city data for 2012 (Census Bureau, 2013c)
[2] Vehicle registration reflects county and city data for 2012 (MO DOR, 2013)
[3] AADT reflects 2011 data (MO DOT, 2012)
[4] VMT reflects county and city data for 2012 (MO DOT, 2013)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 17-2 include the following:

- S4MO's county-level population and vehicle registration both rank 10th compared to other counties with NMP sites.
- The traffic volume experienced near S4MO is in the middle of the range compared to other NMP sites. The traffic estimate provided is for I-70 near Exit 249.
- The VMT for S4MO ranks 12th among counties with NMP sites (where VMT data were available).

17.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Missouri on sample days, as well as over the course of the year.

17.2.1 Climate Summary

The city of St. Louis is located along the Mississippi River, which acts as Missouri's eastern border. St. Louis has a climate that is continental in nature, with cold, dry winters; warm, muggy summers; and significant seasonal variability. Warm, moist air flowing northward from the Gulf of Mexico alternates with cold, dry air marching southward from Canada and the northern U.S., resulting in weather patterns that do not persist for very long. Southerly winds prevail during the warmer months of the year, while west-northwesterly winds prevail the rest of the year. Thunderstorms are common, particularly in the spring, summer, and fall, and annual snowfall totals average around 20 inches. The city of St. Louis experiences the urban heat island effect, retaining more heat within the city than outlying areas (Wood, 2004 and MCC, 2014).

17.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the station closest to the Missouri monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station to S4MO is located at St. Louis Downtown Airport (WBAN 03960). Additional information about this weather station, such as the distance between the site and the weather station, is provided in Table 17-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 17-3. Average Meteorological Conditions near the Missouri Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction From Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
St. Louis, Missouri - S4MO									
St. Louis Downtown Airport 03960 (38.57, -90.16)	6.2 miles 157° (SSE)	Sample Days (65)	68.4 ± 4.5	58.1 ± 4.1	44.8 ± 3.9	51.2 ± 3.6	64.8 ± 3.0	1016.8 ± 1.5	5.5 ± 0.7
		2012	70.2 ± 2.0	59.4 ± 1.8	45.9 ± 1.6	52.2 ± 1.5	64.6 ± 1.2	1016.4 ± 0.6	5.5 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 17-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 17-3 is the 95 percent confidence interval for each parameter. Although average meteorological conditions on sample days are not statistically different than the average meteorological conditions experienced throughout 2012, the temperatures do appear slightly cooler on sample days, as shown in Table 17-3. This is likely the result of the inclusion of dates for make-up samples, which were collected during the colder months of the year (one in February and three in December 2012).

17.2.3 Back Trajectory Analysis

Figure 17-3 is the composite back trajectory map for days on which samples were collected at the S4MO monitoring site. Included in Figure 17-3 are four back trajectories per sample day. Figure 17-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 17-3 and 17-4 represents 100 miles.

Figure 17-3. Composite Back Trajectory Map for S4MO

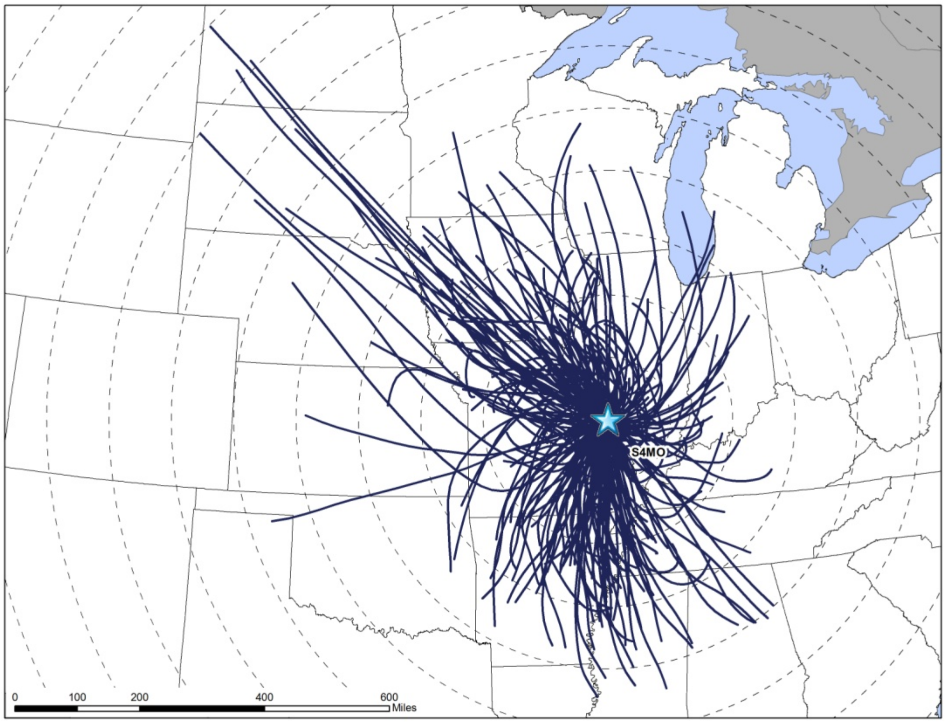
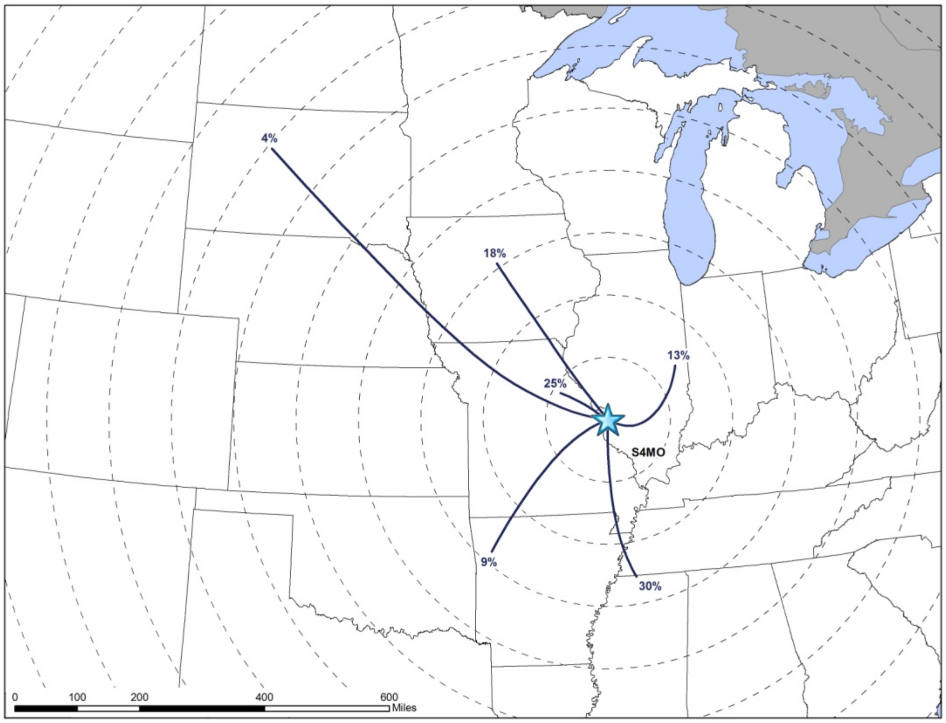


Figure 17-4. Back Trajectory Cluster Map for S4MO



Observations from Figures 17-3 and 17-4 for S4MO include the following:

- Back trajectories originated from a variety of directions at S4MO, although few back trajectories originated from due east or west. The longest back trajectories originated from the northwest.

- The farthest away a back trajectory originated was nearly 900 miles away from S4MO, over western North Dakota. This was the third longest back trajectory constructed for the 2012 NMP report (the other two were constructed for SSSD). However, the 24-hour air shed domain for S4MO is similar in size to other NMP sites, as the average back trajectory length was 251 miles and most back trajectories (88 percent) originated within 400 miles of the monitoring site.

- The cluster analysis shows that nearly 50 percent back trajectories originated to the northwest and north of S4MO, although the model split these into three different clusters. Twenty-five percent originated less than 200 miles away from the site, over the northern half Missouri and central Illinois. Another 18 percent of back trajectories originated farther away, primarily over Iowa. The longest back trajectories originated to the northwest over the Dakotas and Nebraska and account for another 4 percent of back trajectories.

- Nine percent of back trajectories originated to the southwest and west of S4MO, primarily over the western half of Arkansas, but includes the two longer back trajectories that originated over Kansas and the panhandle of Oklahoma. Nearly one third of back trajectories originated to the southeast and south of the site, over eastern Arkansas, Mississippi, Alabama, Tennessee, and Kentucky. The cluster trajectory originating to the northeast of S4MO (13 percent) represents relatively short back trajectories originating over the southernmost portion of Indiana and Illinois, longer back trajectories originating to the northeast of S4MO as far away as Lake Michigan, and all back trajectories in between.

17.2.4 Wind Rose Comparison

Hourly surface wind data from the weather station at St. Louis Downtown Airport near S4MO were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

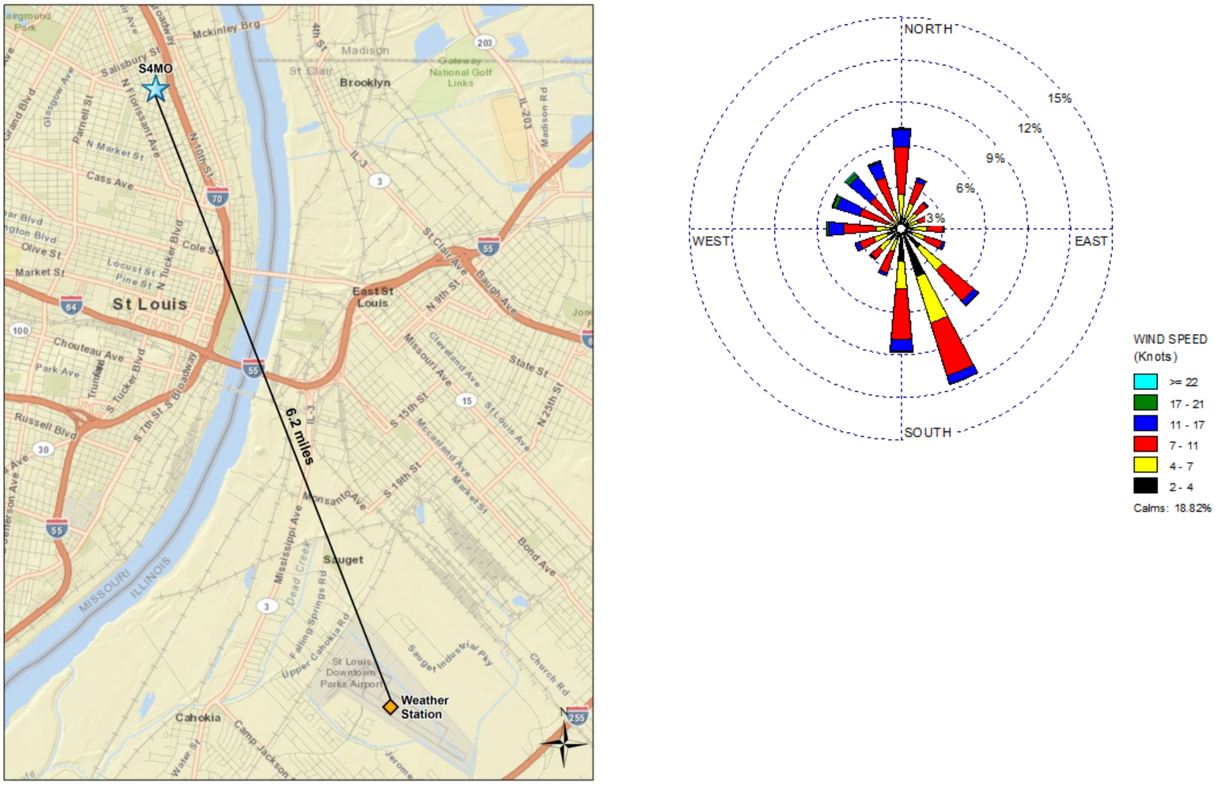
Figure 17-5 presents a map showing the distance between the weather station and S4MO, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 17-5 also presents three different wind roses for the S4MO monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented.

Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 17-5 for S4MO include the following:

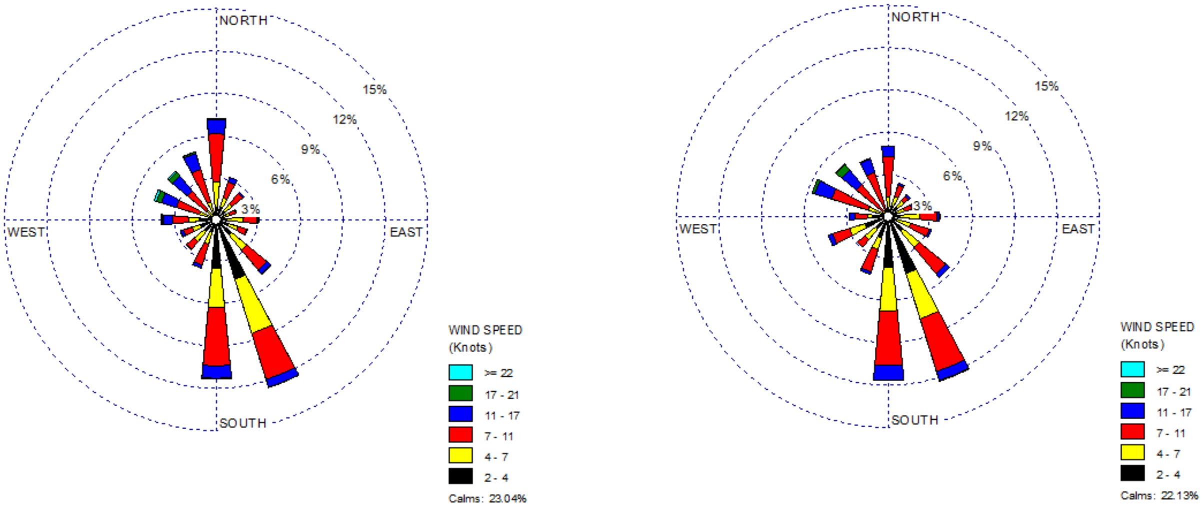
- The St. Louis Downtown Airport weather station is located approximately 6 miles south-southeast of S4MO. The weather station location is across the Mississippi River and state border in Illinois.
- The historical wind rose shows that winds from the southeast, south-southeast, and south were frequently observed near S4MO. Winds from these directions account for approximately 28 percent of observations. Calm winds (≤2 knots) were observed for approximately 19 percent of the hourly wind measurements. Winds from the west to northwest to north account for the majority of the remaining wind observations. The strongest winds were from the west to northwest.
- The wind patterns shown on the 2012 wind rose generally resemble those shown on the historical wind rose, although there were fewer southeasterly winds and more south-southeasterly and southerly winds in 2012. The percentage of calm winds was also higher (23 percent) in 2012.
- The primary wind directions on the sample day wind rose resemble the primary wind directions on the historical and full-year wind roses, while the percentages for the secondary wind directions are more variable.

Figure 17-5. Wind Roses for the St. Louis Downtown Airport Weather Station near S4MO



Location of S4MO and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

17.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the S4MO monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 17-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 17-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. S4MO sampled for VOCs, PAHs, carbonyl compounds, metals (PM_{10}), and hexavalent chromium.

Observations from Table 17-4 include the following:

- Twenty-four pollutants failed at least one screen for S4MO; 56 percent of concentrations for these 24 pollutants were greater than their associated risk screening value (or failed screens).

- Seventeen pollutants contributed to 95 percent of failed screens for S4MO and therefore were identified as pollutants of interest for this site. These 17 include two carbonyl compounds, seven VOCs, five PM_{10} metals, and three PAHs.

- S4MO failed the highest number of screens (692) among all NMP sites (refer to Table 4-8 of Section 4.2). However, the failure rate for S4MO, when incorporating all pollutants with screening values, is approximately 25 percent. This is due primarily to the relatively high number of pollutants sampled for at this site, as discussed in Section 4.2.

- Acetaldehyde, formaldehyde, benzene, carbon tetrachloride, and 1,2-dichloroethane failed 100 percent of screens for S4MO and were detected in all or most of the samples collected. 1,2-Dibromoethane and 1,1,2,2-tetrachloroethane also failed 100 percent of screens but were detected less frequently.

Table 17-4. Risk-Based Screening Results for the Missouri Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
St. Louis, Missouri - S4MO						
Acetaldehyde	0.45	61	61	100.00	8.82	8.82
Formaldehyde	0.077	61	61	100.00	8.82	17.63
Arsenic (PM_{10})	0.00023	60	61	98.36	8.67	26.30
Benzene	0.13	58	58	100.00	8.38	34.68
Carbon Tetrachloride	0.17	58	58	100.00	8.38	43.06
1,3-Butadiene	0.03	57	58	98.28	8.24	51.30
Naphthalene	0.029	57	60	95.00	8.24	59.54
1,2-Dichloroethane	0.038	56	56	100.00	8.09	67.63
Manganese (PM_{10})	0.005	55	61	90.16	7.95	75.58
p-Dichlorobenzene	0.091	30	52	57.69	4.34	79.91
Cadmium (PM_{10})	0.00056	20	61	32.79	2.89	82.80
Ethylbenzene	0.4	17	58	29.31	2.46	85.26
Lead (PM_{10})	0.015	17	61	27.87	2.46	87.72
Fluorene	0.011	16	60	26.67	2.31	90.03
Acenaphthene	0.011	15	60	25.00	2.17	92.20
Hexachloro-1,3-butadiene	0.045	11	14	78.57	1.59	93.79
Nickel (PM_{10})	0.0021	10	61	16.39	1.45	95.23
1,2-Dibromoethane	0.0017	8	8	100.00	1.16	96.39
Hexavalent Chromium	0.000083	7	55	12.73	1.01	97.40
1,1,2,2-Tetrachloroethane	0.017	7	7	100.00	1.01	98.41
Benzo(a)pyrene	0.00057	4	60	6.67	0.58	98.99
Fluoranthene	0.011	3	60	5.00	0.43	99.42
Trichloroethylene	0.2	3	29	10.34	0.43	99.86
Propionaldehyde	0.8	1	61	1.64	0.14	100.00
Total		692	1,241	55.76		

17.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Missouri monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for S4MO.
- Annual average concentrations are presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for S4MO are provided in Appendices J, L, M, N, and O.

17.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Missouri site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where at least three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for S4MO are presented in Table 17-5, where applicable. Note that concentrations of the PAHs and metals are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 17-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Missouri Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
St. Louis, Missouri - S4MO						
Acetaldehyde	61/61	1.30 ± 0.28	1.88 ± 0.41	2.57 ± 0.44	1.62 ± 0.35	1.86 ± 0.21
Benzene	58/58	0.85 ± 0.14	0.64 ± 0.13	0.87 ± 0.40	0.84 ± 0.21	0.80 ± 0.12
1,3-Butadiene	58/58	0.11 ± 0.03	0.09 ± 0.04	0.11 ± 0.04	0.13 ± 0.05	0.11 ± 0.02
Carbon Tetrachloride	58/58	0.64 ± 0.07	0.72 ± 0.05	0.67 ± 0.03	0.68 ± 0.03	0.68 ± 0.02
p-Dichlorobenzene	52/58	0.13 ± 0.08	0.20 ± 0.14	0.21 ± 0.17	0.18 ± 0.11	0.18 ± 0.06
1,2-Dichloroethane	56/58	0.10 ± 0.01	0.09 ± 0.01	0.06 ± 0.01	0.08 ± 0.01	0.08 ± 0.01
Ethylbenzene	58/58	0.35 ± 0.10	0.38 ± 0.13	0.33 ± 0.06	0.37 ± 0.13	0.35 ± 0.05
Formaldehyde	61/61	1.84 ± 0.37	3.71 ± 0.94	5.17 ± 1.20	2.17 ± 0.39	3.26 ± 0.52
Hexachloro-1,3-butadiene	14/58	0.04 ± 0.03	0.02 ± 0.02	0.02 ± 0.02	0	0.02 ± 0.01
Acenaphthene[a]	60/60	4.27 ± 2.01	9.11 ± 3.07	12.23 ± 3.71	3.87 ± 1.99	7.37 ± 1.59
Arsenic (PM$_{10}$)[a]	61/61	0.99 ± 0.37	1.01 ± 0.33	1.02 ± 0.24	1.34 ± 0.90	1.09 ± 0.25
Cadmium (PM$_{10}$)[a]	61/61	0.38 ± 0.17	0.37 ± 0.20	0.97 ± 0.45	0.53 ± 0.33	0.57 ± 0.16
Fluorene[a]	60/60	4.82 ± 1.74	10.58 ± 2.99	13.86 ± 4.10	4.01 ± 1.30	8.32 ± 1.67
Lead (PM$_{10}$)[a]	61/61	12.89 ± 8.01	11.44 ± 7.45	12.59 ± 4.17	16.45 ± 14.32	13.33 ± 4.31
Manganese (PM$_{10}$)[a]	61/61	18.94 ± 10.91	19.63 ± 7.24	21.64 ± 13.25	30.51 ± 36.51	22.66 ± 9.60
Naphthalene[a]	60/60	112.42 ± 42.88	103.15 ± 38.87	116.58 ± 30.37	109.63 ± 52.51	110.45 ± 19.71
Nickel (PM$_{10}$)[a]	61/61	1.31 ± 0.49	1.46 ± 0.59	1.50 ± 0.46	1.40 ± 1.25	1.42 ± 0.36

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for S4MO from Table 17-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde (3.26 ± 0.52 µg/m^3) and acetaldehyde (1.86 ± 0.21 µg/m^3). These are the only pollutants of interest with annual averages greater than 1 µg/m^3.

- The second and third quarter average concentrations of formaldehyde are significantly higher than the first and fourth quarter averages and have larger confidence intervals. Concentrations of formaldehyde measured at S4MO ranged from 1.01 µg/m^3 to 11.8 µg/m^3. The 20 highest concentrations were measured between May and September, or the warmest months of the year. Conversely, the four lowest measurements of formaldehyde were all measured in January and February and all but three of the 22 measurements less than 2 µg/m^3 were measured during the first or fourth quarters of 2012. A similar observation can be made for acetaldehyde but the seasonality is less pronounced.

- The confidence intervals associated with the quarterly averages of *p*-dichlorobenzene are relatively large compared to the averages themselves. A review of the data shows that concentrations of *p*-dichlorobenzene span two orders of magnitude, ranging from 0.0241 µg/m^3 to 1.37 µg/m^3, as well as six non-detects. The maximum *p*-dichlorobenzene concentration was measured in September and is the only *p*-dichlorobenzene concentration greater than 1 µg/m^3 measured across the program. Six of the 13 *p*-dichlorobenzene measurements greater than 0.5 µg/m^3 were measured at S4MO, with the others being measured at ADOK (3) and SPAZ (4).

- The fourth quarter average concentration of hexachlor-1,3-butadiene is zero, indicating that there were no measured detections this quarter. This pollutant was detected in less than one-quarter of the samples collected. Half of the measured detections were measured during the first quarter of 2012, with three measured during the second quarter and four during the third quarter.

- Manganese has the highest annual average concentration (22.66 ± 9.60 ng/m^3) among the PM_{10} metals measured at S4MO. The confidence intervals associated with the quarterly averages for manganese are relatively large, indicating that there is a high level of variability in the measurements. This is particularly true for the fourth quarter, where the confidence interval is greater than the average itself, indicating the likely presence of outliers. Concentrations of manganese measured at S4MO range from 2.09 ng/m^3 to 275 ng/m^3, with a median concentration of 12.70 ng/m^3. The maximum concentration of manganese was measured at S4MO on October 12, 2012 and is the maximum concentration measured across the program, although similar measurements were also collected at the two Tulsa, Oklahoma sites (which are sampling TSP metals rather than PM_{10} metals). The next highest concentration measured at S4MO is still greater than 100 ng/m^3 and was measured in August. Three additional measurements greater than 50 ng/m^3 were measured in January, March, and December.

- The fourth quarter averages of lead, arsenic, and nickel also reflect a high level of variability, based on the associated confidence intervals. Although the maximum concentration of each of these metals was measured during the fourth quarter, they were not measured on the same day. The maximum lead concentration (111 ng/m^3) was measured at S4MO on December 23, 2012 and is more than twice the next highest concentration measured at this site. This is the second highest lead concentration measured across the program. The maximum arsenic concentration was measured on November 17, 2012 (7.23 ng/m^3) and is two and a half times greater than the next highest concentration measured at this site. This too is the highest arsenic concentration measured across the program. The maximum nickel concentration (9.74 ng/m^3) was measured at S4MO on December 5, 2012 and is more than twice the next highest concentration measured at this site. While not the highest nickel concentration measured across the program, it does rank in the top five.

- Naphthalene has the highest annual average concentration among the PAHs measured at S4MO. The confidence intervals calculated for the quarterly averages of naphthalene indicate that there is a high level of variability in the measurements. Concentrations of naphthalene measured at S4MO range from 21.3 ng/m^3 to 360 ng/m^3 with a median concentration of 80.5 ng/m^3.

- Concentrations of acenaphthene and fluorene appear to be highest during the warmer months of the year, particularly the third quarter of 2012. The averages for these quarters have relatively large confidence intervals associated with them. A review of the data shows that the maximum concentration of each pollutant was measured on July 2, 2012 (27.9 ng/m^3 and 31.3 ng/m^3, respectively). The July 2nd sample day is also the same sample day the highest concentrations were measured in 2011. Of the concentrations of each pollutant greater than 10 ng/m^3, the majority were measured during the third quarter, followed by the second quarter. The nine highest concentrations of these pollutants were measured on the same nine sample days, although the exact order varies. For fluorene, eight of the nine measurements greater than 15 ng/m^3 were measured between June and August, while all 10 of the measurements less than 2.50 ng/m^3 were measured in either the first or fourth quarter of the year. Similarly, eight of the nine highest acenaphthene measurements were measured at S4MO between June and August, while all 12 measurements less than 2.0 ng/m^3 were measured in either the first or fourth quarter of the year.

- At the beginning of 2013, the Missouri Department of Natural Resources discovered that a sampler contamination issue resulted in artificially elevated concentrations of acrylonitrile from September 2010 through October 2012. Thus, the acrylonitrile results from this time period were invalidated, which includes all of the results for 2012 through October 30, 2012. All acrylonitrile measurements for November and December were non-detects.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for S4MO from those tables include the following:

- S4MO appears in Tables 4-9 through 4-12 a total of 13 times, the most of any NMP site.

- S4MO has the highest annual average concentration of 1,2-dichloroethane, the second highest annual average concentration of hexachloro-1,3-butadiene, and the third highest annual average concentration of *p*-dichlorobenzene. This site also has the 10th highest annual average concentration of carbon tetrachloride and ethylbenzene.

- S4MO has the 10th highest annual average concentration of both acetaldehyde and formaldehyde among NMP sites sampling carbonyl compounds.

- S4MO's annual average concentration of naphthalene ranks fourth highest among NMP sites sampling PAHs, while this site's annual average concentrations of acenaphthene and fluorene each rank fifth among NMP sites sampling PAHs.

- S4MO has the second highest annual average concentration of arsenic, second only to ASKY-M, among NMP sites sampling PM_{10} metals (and those sampling TSP metals). This site's annual average concentration of manganese ranked third among NMP sites sampling PM_{10} metals, while its annual average concentration of nickel ranked fourth.

17.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 17-4 for S4MO. Figures 17-6 through 17-22 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 17-6. Program vs. Site-Specific Average Acenaphthene Concentration

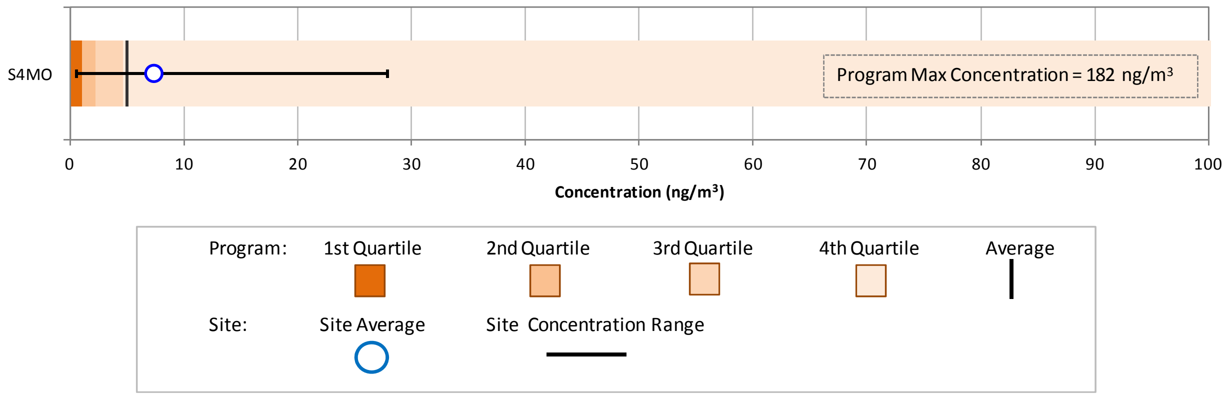


Figure 17-7. Program vs. Site-Specific Average Acetaldehyde Concentration

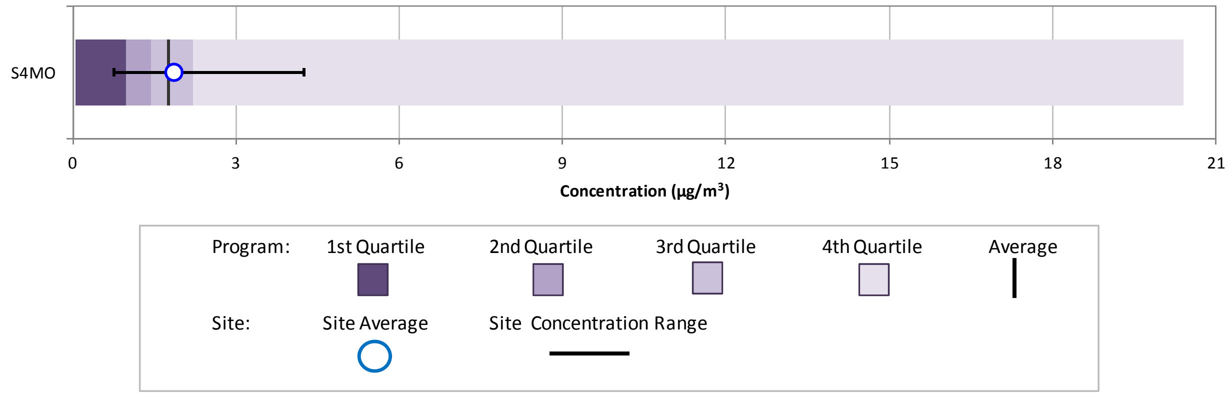


Figure 17-8. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

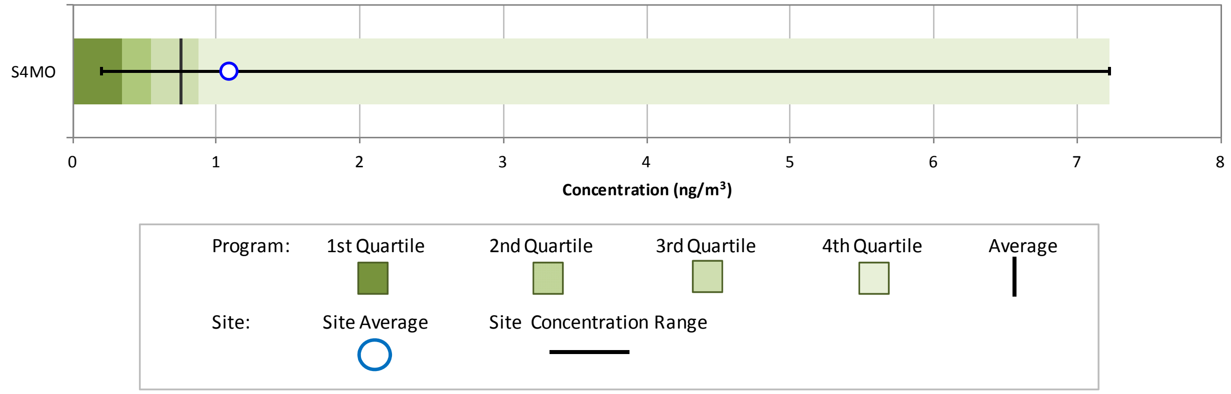


Figure 17-9. Program vs. Site-Specific Average Benzene Concentration

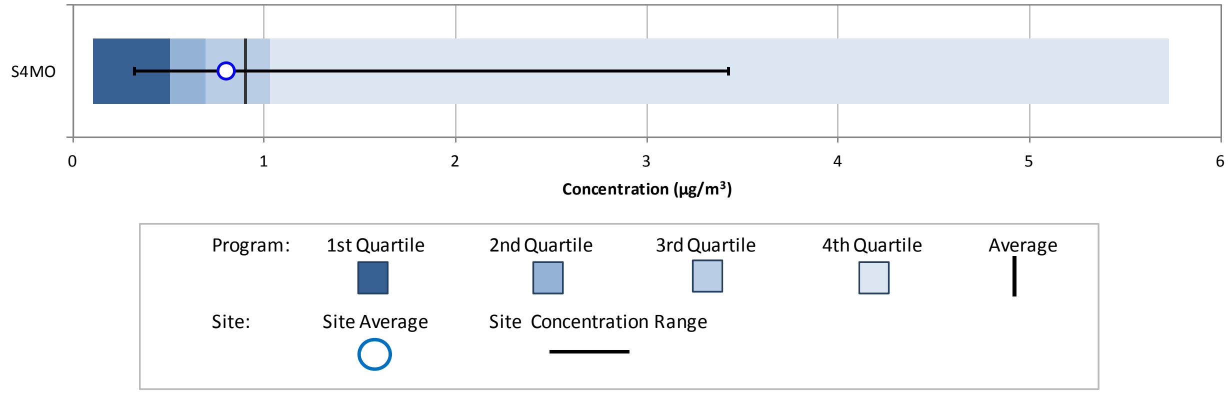


Figure 17-10. Program vs. Site-Specific Average 1,3-Butadiene Concentration

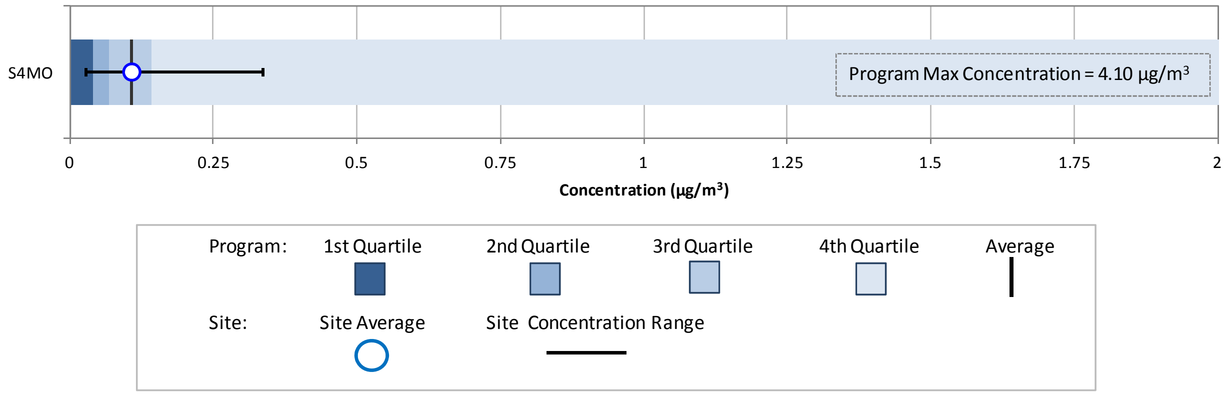


Figure 17-11. Program vs. Site-Specific Average Cadmium (PM_{10}) Concentration

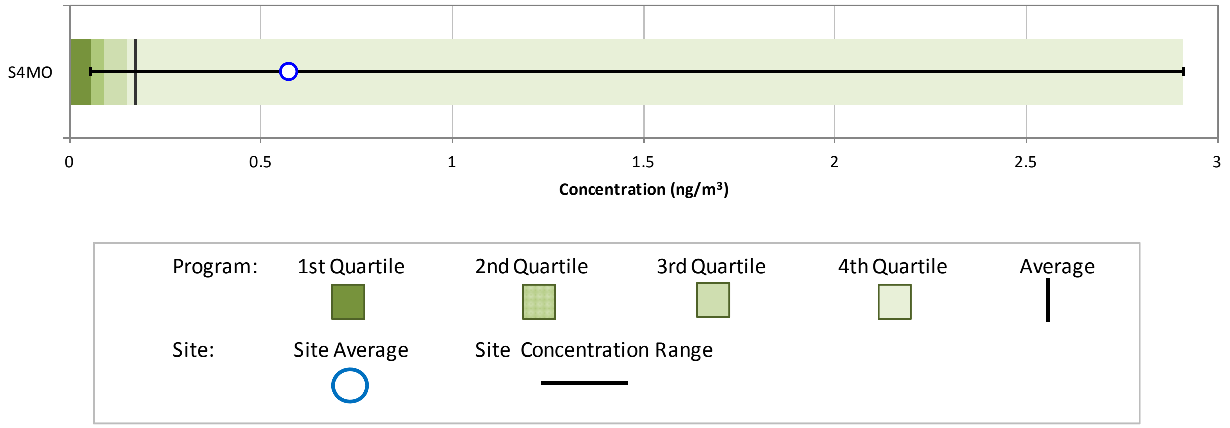


Figure 17-12. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

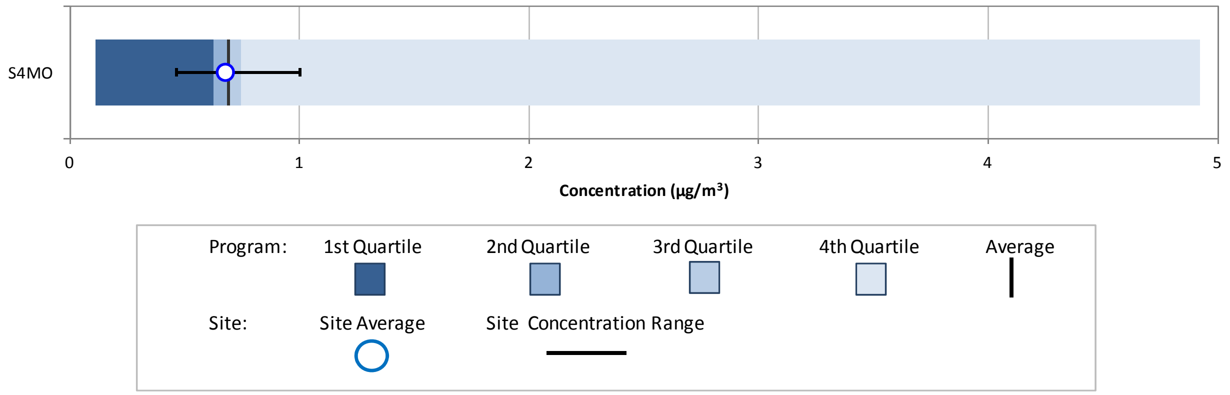


Figure 17-13. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentration

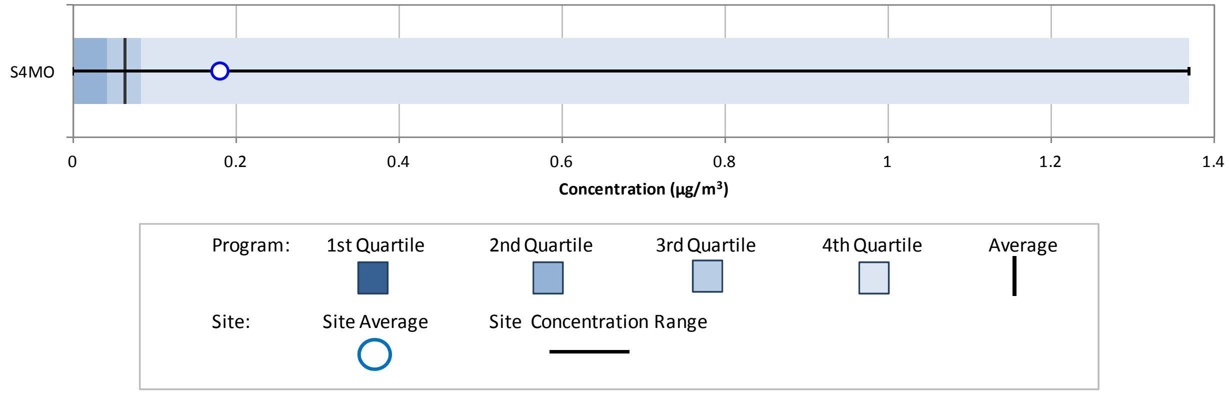


Figure 17-14. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

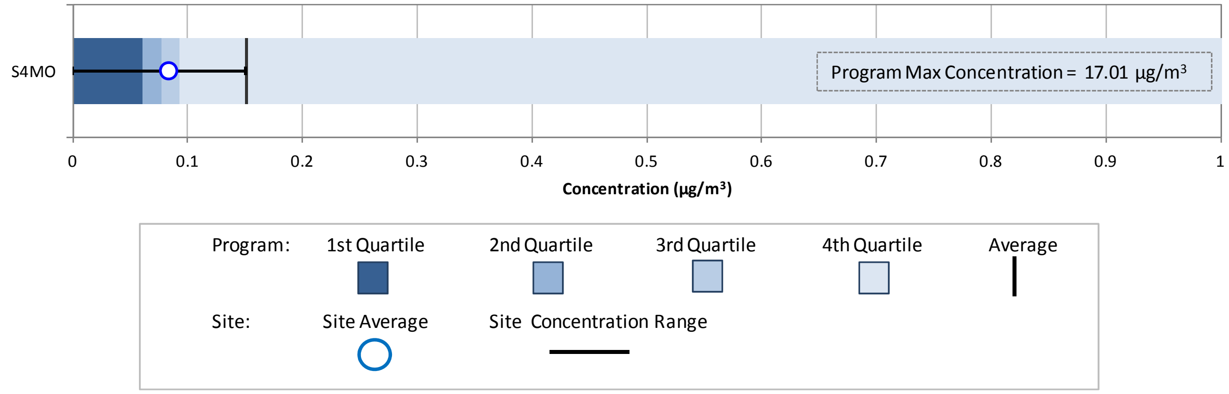
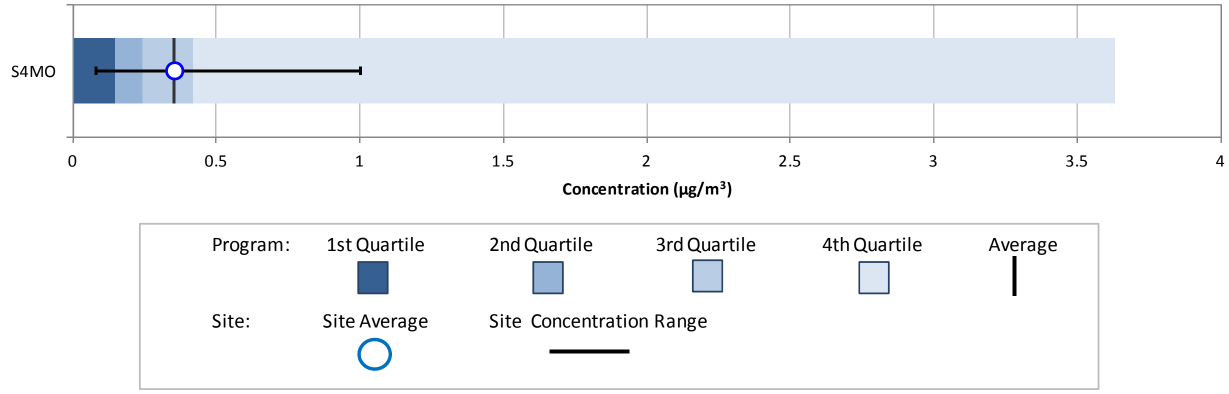


Figure 17-15. Program vs. Site-Specific Average Ethylbenzene Concentration



17-16. Program vs. Site-Specific Average Fluorene Concentration

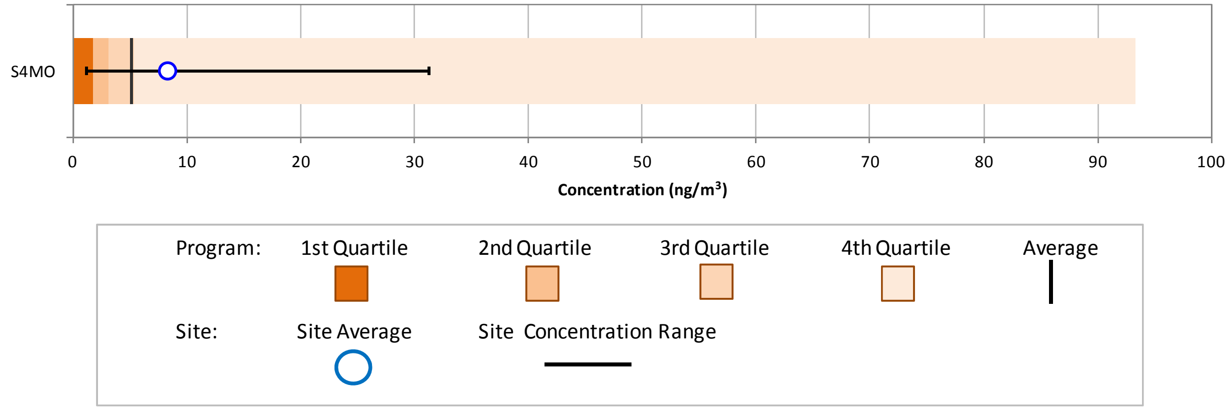


Figure 17-17. Program vs. Site-Specific Average Formaldehyde Concentration

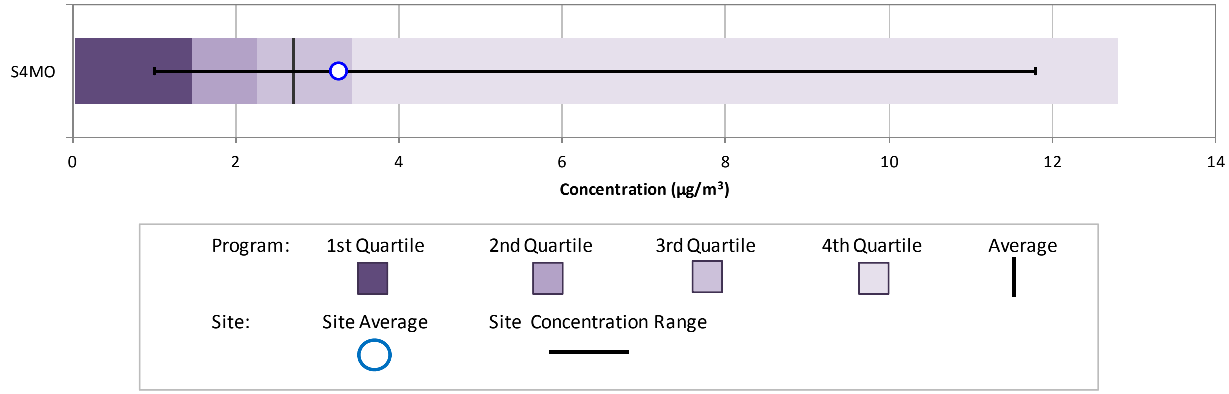


Figure 17-18. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentration

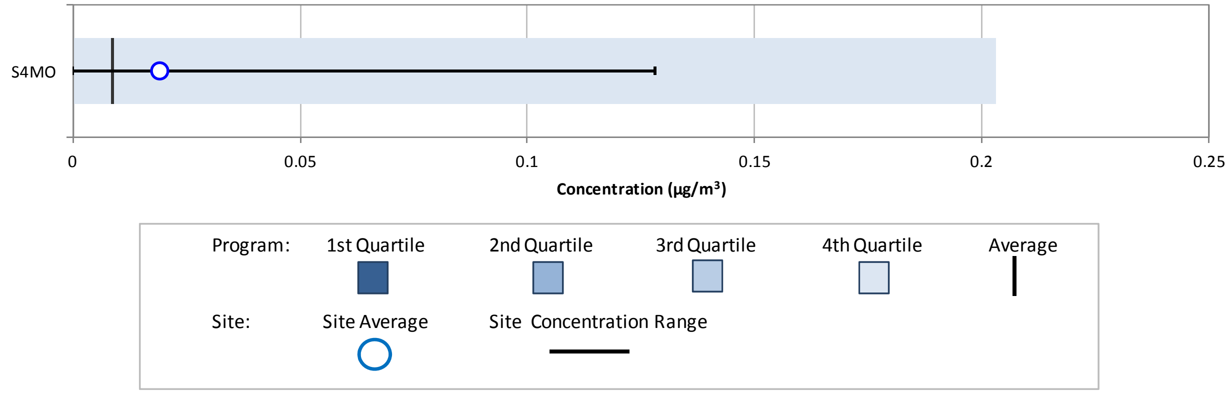


Figure 17-19. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

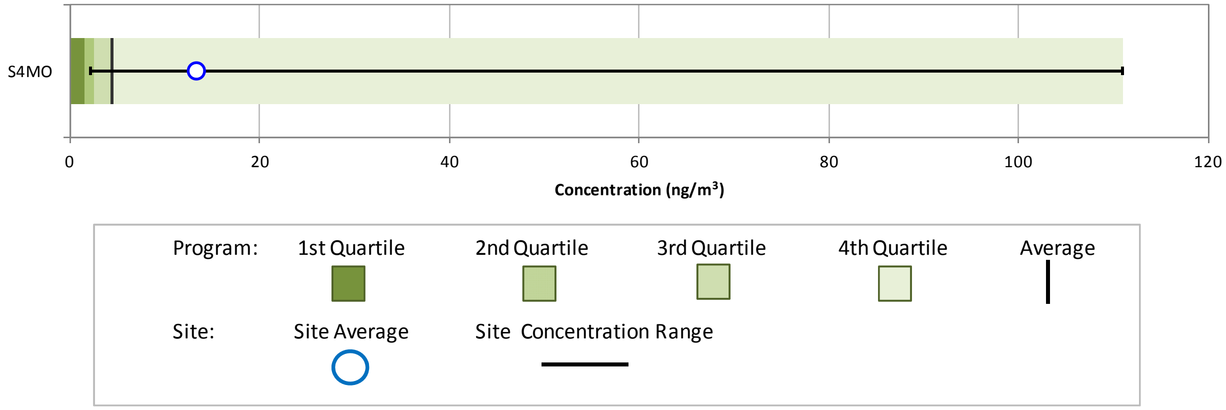


Figure 17-20. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

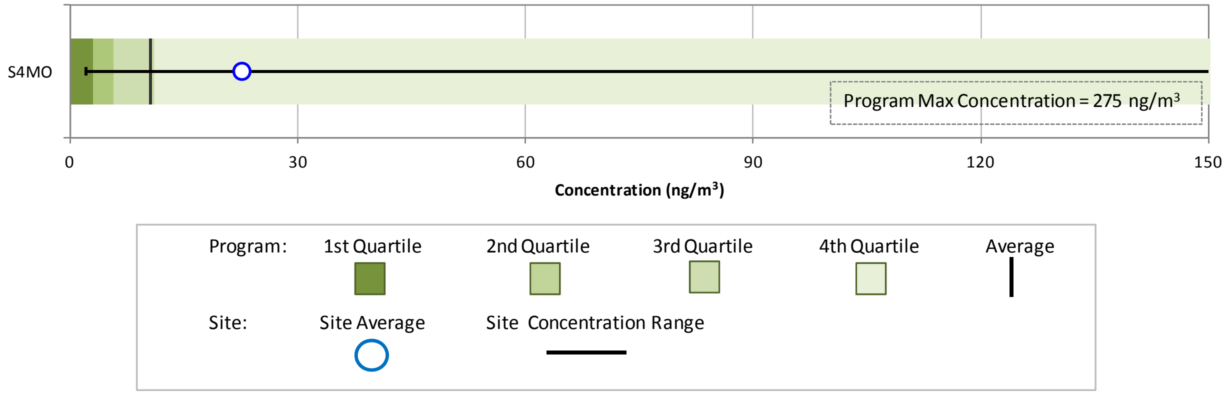


Figure 17-21. Program vs. Site-Specific Average Naphthalene Concentration

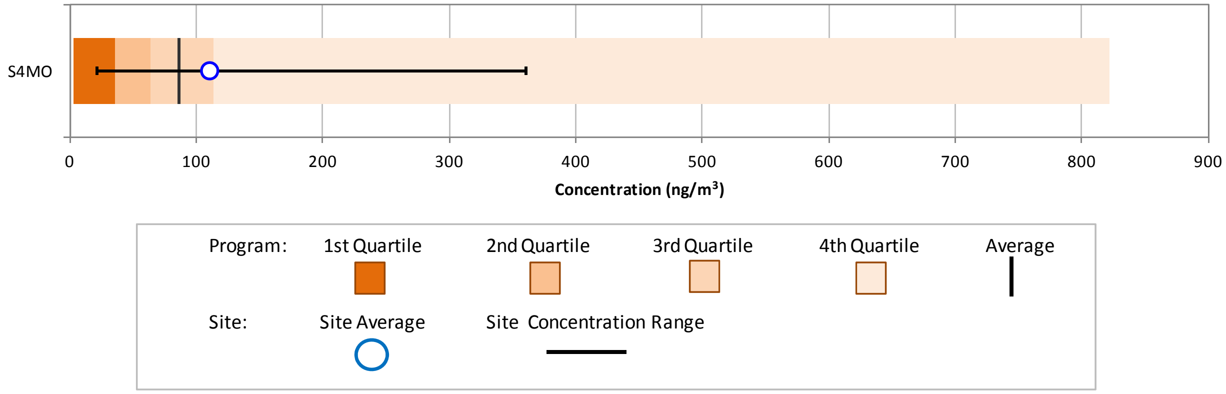
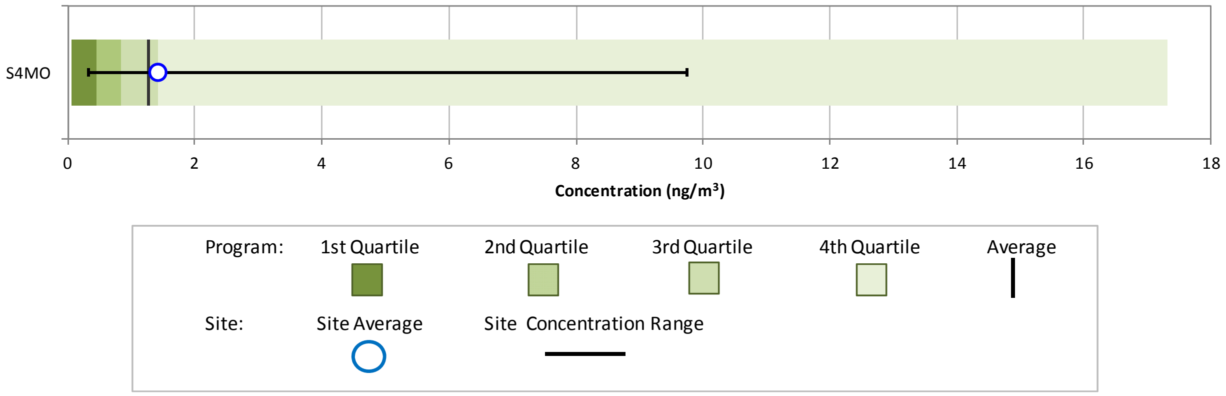


Figure 17-22. Program vs. Site-Specific Average Nickel (PM_{10}) Concentration



Observations from Figures 17-6 through 17-22 include the following:

- Figure 17-6 is the box plot for acenaphthene. Note that the program-level maximum concentration (182 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 100 ng/m^3. Figure 17-6 shows that the maximum acenaphthene concentration measured at S4MO is considerably less than the maximum concentration measured at the program-level. Yet, the annual average concentration of acenaphthene for S4MO is greater than the program-level average concentration.

- Figure 17-7 shows that the annual average acetaldehyde concentration for S4MO is just greater than the program-level average concentration. The maximum acetaldehyde concentration measured at S4MO is considerably less than the maximum concentration measured across the program. The minimum concentration measured at S4MO is among the higher minimum concentrations among NMP sites sampling this pollutant.

- Figure 17-8 shows that the maximum arsenic (PM_{10}) concentration measured at S4MO is the maximum concentration measured across the program. S4MO's annual average arsenic (PM_{10}) concentration is greater than the program-level average and third quartile. Recall from the previous section that this site has the second highest annual average arsenic concentration among NMP sites sampling metals.

- Figure 17-9 is the box plot for benzene and shows that the annual average benzene concentration for S4MO is just less than the program-level average concentration but greater than the program-level median concentration. The maximum benzene concentration measured at S4MO is less than the maximum concentration measured at the program level. There were no non-detects of benzene measured at S4MO or across the program.

- Similar to the acenaphthene graph, the program-level maximum 1,3-butadiene concentration (4.10 µg/m^3) is not shown directly on the box plot as the scale has been reduced to 2 µg/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 17-10 for 1,3-butadiene shows that the maximum concentration measured at S4MO is considerably less than the maximum concentration measured across the program. The annual average 1,3-butadiene concentration for S4MO is roughly equivalent to the program-level average concentration. While there were non-detects of 1,3-butadiene measured across the program, there were none measured at S4MO.

- Figure 17-11 shows that the maximum cadmium (PM_{10}) concentration measured at S4MO is the maximum concentration measured across the program. Of the 25 concentrations greater than 1 ng/m^3 measured across the program, 12 were measured at S4MO. S4MO's annual average cadmium concentration is more than three times higher than the program-level average concentration. The minimum concentration measured at S4MO is just less than the program-level first quartile.

- Figure 17-12 for carbon tetrachloride shows that the range of measurements collected at S4MO is relatively small compared to those measured at the program-level. The annual average concentration for S4MO is similar to the program-level average concentration, which is also similar to the program-level median concentration (less than 0.015 µg/m^3 separates these three parameters).

- Figure 17-13 is the box plot for *p*-dichloromethane. Note that the first quartile is zero and therefore not visible on the graph. This box plot shows that the maximum *p*-dichloromethane concentration across the program was measured at S4MO. The annual average concentration of this pollutant for S4MO is nearly three times greater the program-level average concentration. Even though the maximum *p*-dichlorobenzene concentration was measured at S4MO, this site does not have the highest annual average concentration among sites sampling this pollutant (although it does rank third highest).

- Figure 17-14 is the box plot for 1,2-dichloroethane. Note that the program-level maximum concentration (17.01 µg/m^3) is not shown directly on the box plot as the scale has been reduced to 1 µg/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 17-14 shows that all of the 1,2-dichloromethane measurements collected at S4MO are less than the program-level average concentration. The program-level average concentration is greater than the program third quartile for this pollutant and is greater than or similar to the maximum concentration measured at most sites sampling 1,2-dichloroethane. This is because the program-level average is being driven by the higher measurements collected at a handful of monitoring sites. The annual average concentration for S4MO is just greater than the median concentration at the program level. Recall from the previous section that S4MO has the highest annual average concentration among NMP sites sampling this pollutant.

- Figure 17-15 is the box plot for ethylbenzene and shows that the annual average concentration for S4MO is similar to the program-level average concentration. The maximum concentration of ethylbenzene measured at S4MO is considerably less than the maximum concentration measured across the program. There were no non-detects of ethylbenzene measured at S4MO.

- Figure 17-16 is the box plot for fluorene. The box plot shows that the majority of the fluorene measurements program-wide are within a relatively small concentration range as indicated by the first, second (median), and third quartiles, which are relatively close together. Seventy-five percent of the fluorene measurements program-wide are less than 5.35 ng/m3. But, the maximum concentration measured across the program is significantly higher (93.4 ng/m3). The annual average concentration of fluorene for S4MO is greater than the program-level average, although the maximum fluorene concentration measured at S4MO is considerably less than the program-level maximum concentration.

- Figure 17-17 for formaldehyde shows that the annual average concentration for S4MO is greater than the program-level average concentration but just less than the program-level third quartile. The maximum formaldehyde concentration measured at S4MO is less than the maximum concentration measured across the program but ranks sixth highest among sites sampling formaldehyde. The minimum concentration measured at S4MO is greater than 1 $\mu g/m^3$.

- Figure 17-18 is the box plot for hexachloro-1,3-butadiene. Note that the first, second, and third quartiles for this pollutant are zero and thus, not visible on the box plot. The box plot shows that the annual average concentration of hexachloro-1,3-butadiene for S4MO is greater than the program-level average concentration. The maximum concentration measured at S4MO is one of the higher measurements across the program and S4MO is in a three-way tie for the most measured detections of this pollutant (14). Recall from the previous section that S4MO has the second highest annual average concentration among sites sampling this pollutant.

- Figure 17-19 shows that the majority of the lead measurements program-wide are within a relatively small concentration range as indicated by the first, second (median), and third quartiles, which are relatively close together. The annual average lead (PM_{10}) concentration for S4MO is nearly three times the program-level average concentration. This site has the second highest annual average lead concentration (behind ASKY-M) among sites sampling metals. In addition, the maximum lead concentration measured at S4MO is the maximum concentration measured across the program. The minimum lead concentration measured at S4MO is greater than the program-level first quartile.

- Figure 17-20 is the box plot for manganese (PM_{10}). Note that the program-level maximum concentration (275 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 150 ng/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 17-20 shows that S4MO's annual average manganese (PM_{10}) concentration is roughly twice the program-level average concentration and is also greater than the program-level third quartile. Recall from the previous section that the maximum concentration of manganese measured at S4MO is the maximum concentration measured across the program; in addition, this site has the third highest annual average manganese concentration among sites sampling PM_{10} metals.

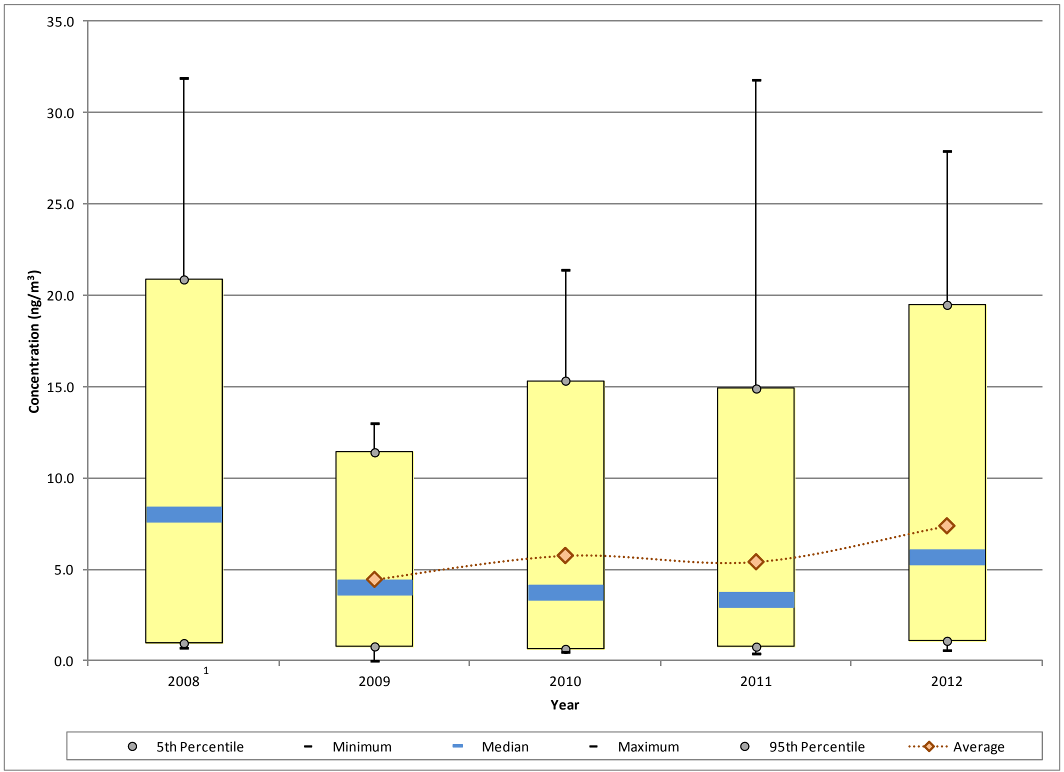
- Figure 17-21 is the box plot for naphthalene and shows that the annual average naphthalene concentration for S4MO is greater than the program-level average concentration and just less than the program-level third quartile. The maximum naphthalene concentration measured at S4MO is considerably less than the program-level maximum concentration.

- Figure 17-22 is the box plot for nickel. The maximum nickel concentration measured at S4MO is among the higher nickel concentrations measured across the program. S4MO's annual average nickel concentration is just greater than the program-level average concentration and similar to the program-level third quartile.

17.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. S4MO has sampled VOCs and carbonyl compounds under the NMP since 2002, PM_{10} metals since 2003, and PAHs since 2008. Thus, Figures 17-23 through 17-39 present the 1-year statistical metrics for each of the pollutants of interest for S4MO. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 17-23. Yearly Statistical Metrics for Acenaphthene Concentrations Measured at S4MO



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 17-23 for acenaphthene measurements collected at S4MO include the following:

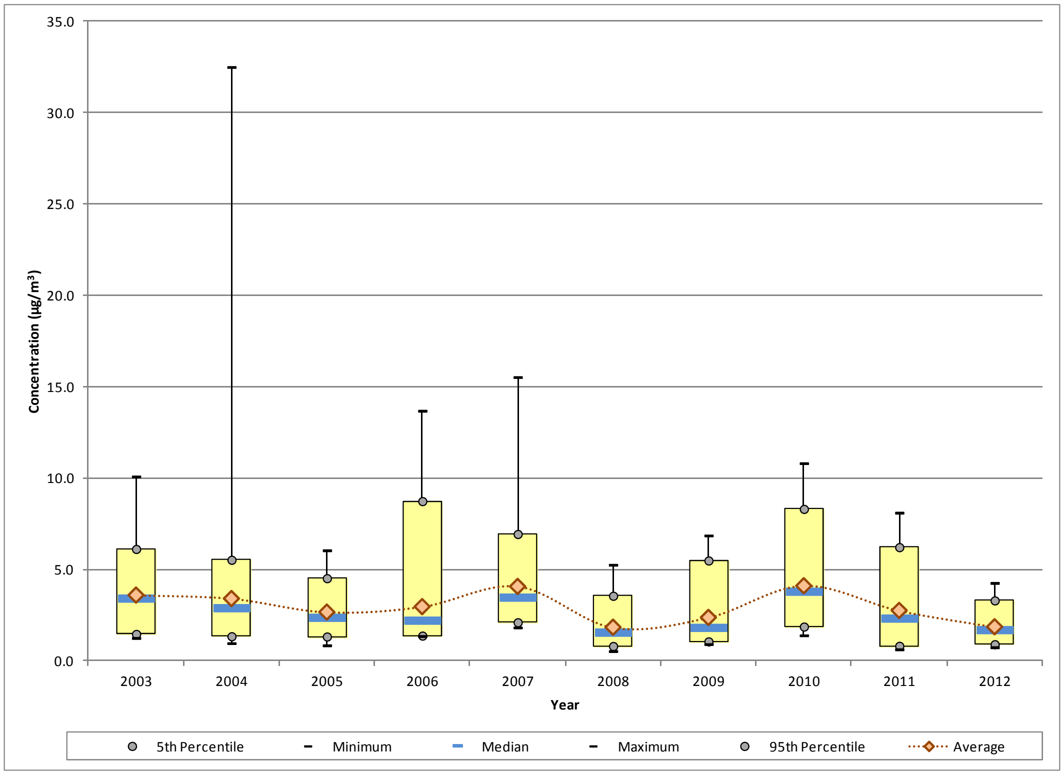
- S4MO began sampling PAHs under the NMP in April 2008. Because a full year's worth of data is not available, a 1-year average for 2008 is not presented, although the range of measurements is provided.

- Two measurements greater than 30 ng/m^3 were measured at S4MO in September 2008. Another measurement greater than 30 ng/m^3 was also measured in July 2011.

- All of the statistical parameters shown exhibit decreases from 2008 to 2009. Although the range of concentrations measured increased from 2009 to 2010, but the median concentration decreased slightly, a trend that continued into 2011.

- With the exception of the maximum concentration, the statistical parameters exhibit increases from 2011 to 2012. This is because the number of measurements at the upper end of the concentration range increased while the number of measurements at the lower end of the concentration decreased. The number of concentrations greater than 10 ng/m^3 increased from 12 to 17 from 2011 to 2012 and the number of concentrations between 5 ng/m^3 and 10 ng/m^3 increased from eight to 15. Conversely, the number of concentrations between 1 ng/m^3 and 5 ng/m^3 decreased from 31 to 25 and the number of concentrations less than 1 ng/m^3 decreased from 10 to three from 2011 to 2012.

Figure 17-24. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at S4MO



Observations from Figure 17-24 for acetaldehyde measurements collected at S4MO include the following:

- Because carbonyl compound sampling under the NMP did not begin at S4MO until December 2002, data from 2002 were excluded from this analysis.

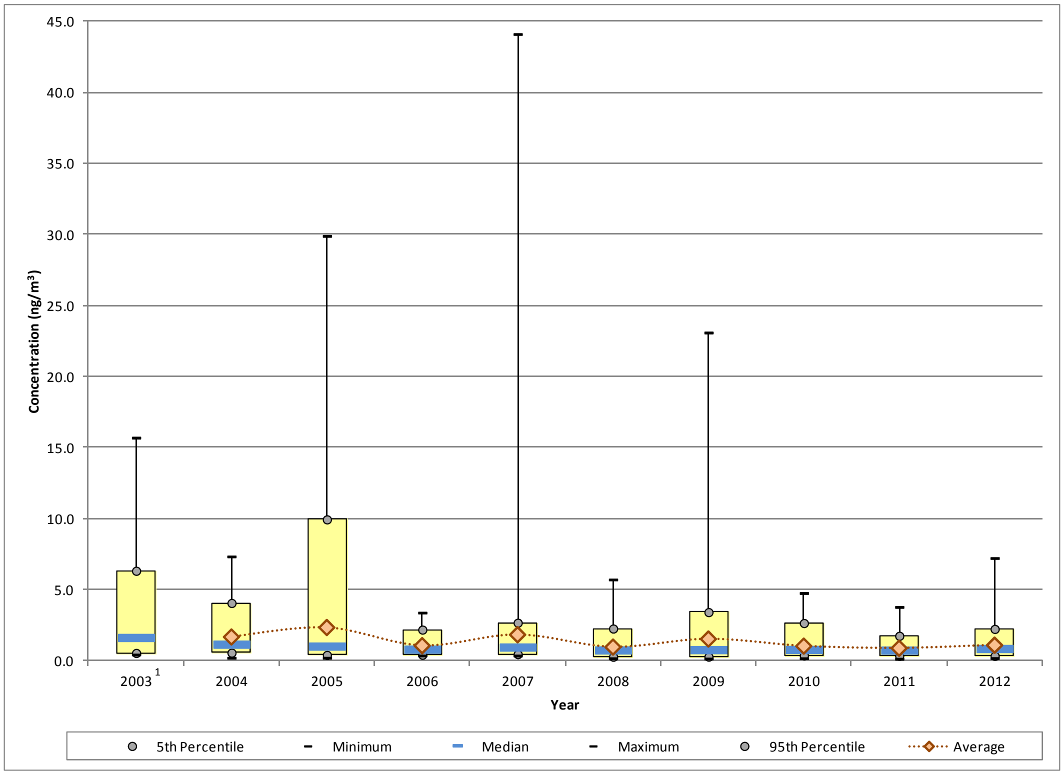
- The maximum acetaldehyde concentration was measured in 2004 (32.5 µg/m^3) and is more than twice the next highest concentration (15.5 µg/m^3, measured in 2007).

- Even with the maximum concentration measured in 2004, nearly all of the statistical metrics decreased from 2003 to 2004. The maximum concentration measured in 2004 is nearly six times higher than the next highest concentration measured that year (5.72 µg/m^3).

- The 1-year average concentrations have an undulating pattern in Figure 17-24, with a few years of a decreasing trend followed by a few years of an increasing trend. The 1-year average concentrations have ranged from 1.83 µg/m^3 (2008) and 4.10 µg/m^3 (2010).

- A significant decrease in the 1-year average concentration is shown from 2010 to 2011 and again for 2012. The range of measurements is at a minimum for 2012; the difference between the 5th and 95th percentiles, or the range within which 90 percent of the measurements fall, is also at a minimum for 2012.

Figure 17-25. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at S4MO



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

Observations from Figure 17-25 for arsenic measurements collected at S4MO include the following:

- S4MO began sampling metals under the NMP in July 2003. Because a full year's worth of data is not available, a 1-year average is not presented, although the range of measurements is provided.

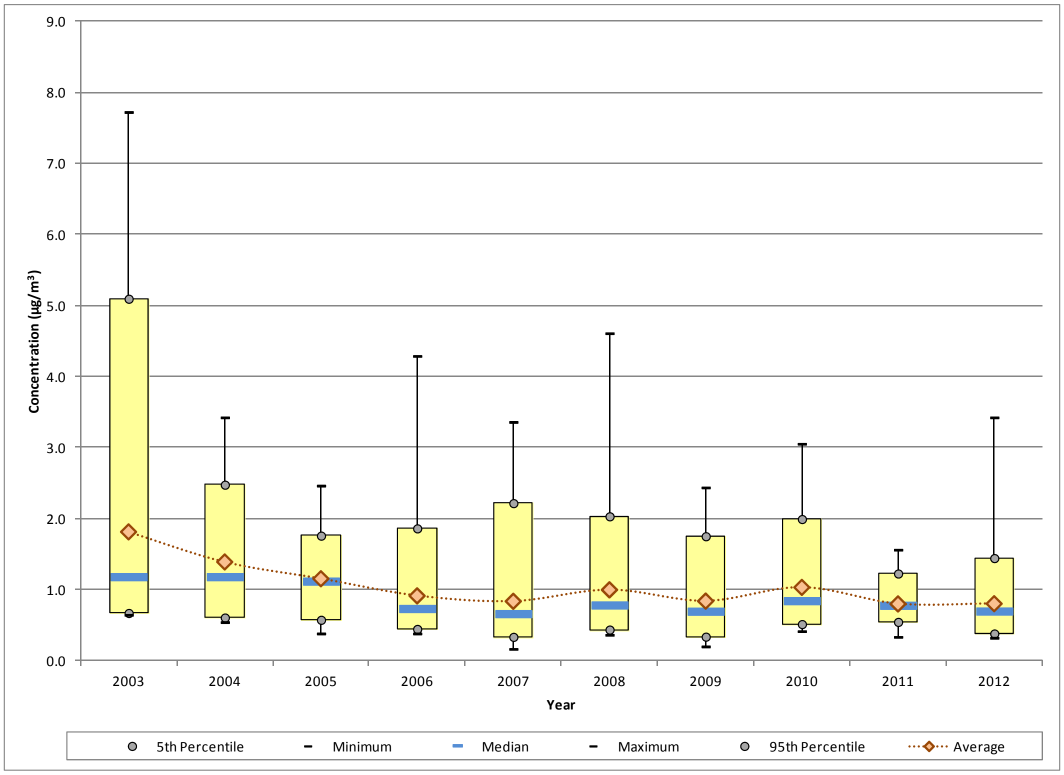
- The maximum arsenic concentration was measured at S4MO on December 26, 2007 (44.1 ng/m^3). Only five additional arsenic concentrations greater than 10 ng/m^3 have been measured at S4MO (three in 2005 and one each in 2003, 2007, and 2009).

- This figure shows that years with little variability in the measurements seem to alternate with years with significant variability, particularly between 2004 and 2010.

- Many of the statistical parameters are at a minimum for 2011. The difference between the 5th and 95th percentiles is at a minimum for 2011, as is the difference between the median and 1-year average concentrations (less than 0.12 ng/m^3 separates these two parameters for 2011).

- Many of the statistical parameters exhibit increases for 2012, although difficult to discern in Figure 17-25. The maximum concentration nearly doubled and the number of measurements greater than 2 ng/m^3 increased from one in 2011 to five in 2012.

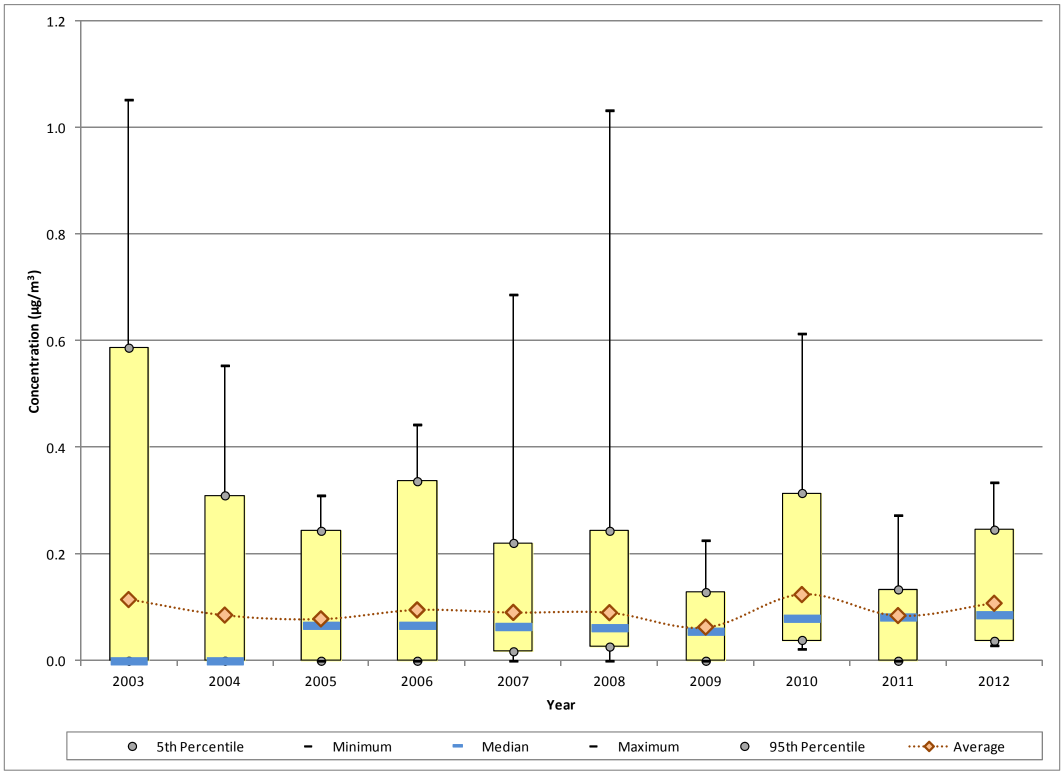
Figure 17-26. Yearly Statistical Metrics for Benzene Concentrations Measured at S4MO



Observations from Figure 17-26 for benzene measurements collected at S4MO include the following:

- Because VOC sampling under the NMP did not begin at S4MO until December 2002, 2002 data was excluded from this analysis.
- All four benzene concentrations greater than 5 µg/m^3 were measured in 2003.
- The 1-year average concentrations exhibit a steady decreasing trend through 2007, representing a roughly 1 µg/m^3 decrease, although the most significant changes occurred in the early years of sampling. In the years following 2007, the 1-year average concentration has varied between 0.80 µg/m^3 (2011) and 1.03 µg/m^3 (2010).
- The range of benzene measurements is smallest for 2011, with a difference of approximately 1 µg/m^3 between the minimum and maximum concentration measured.
- From 2011 to 2012, the statistical parameters representing the upper end of the concentration range (the maximum and 95th percentile) increased while the statistical parameters representing the lower end of the concentration range (the minimum and 5th percentile) decreased, indicating a widening of concentrations measured. Yet, the 1-year average did not change and the median decreased. Even though the maximum concentration measured doubled from 2011 to 2012, it's the concentrations at the lower end of the concentration range most affecting the calculations. The number of concentrations less than 0.5 µg/m^3 increased from two to 11 from 2011 to 2012.

Figure 17-27. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at S4MO



Observations from Figure 17-27 for 1,3-butadiene measurements collected at S4MO include the following:

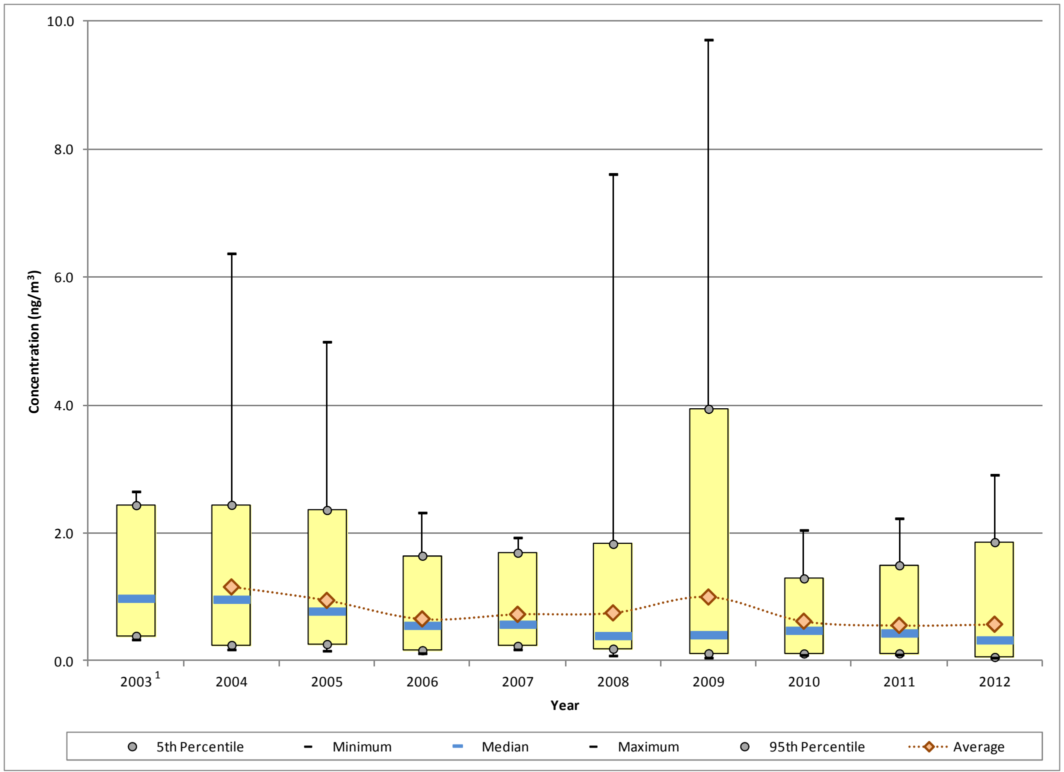
- The maximum 1,3-butadiene concentration was measured at S4MO in 2003, although a similar concentration was also measured in 2008. These are the only two 1,3-butadiene concentrations greater than 1.0 µg/m^3 that have been measured at S4MO.

- The minimum, 5th percentile, and median concentrations are all zero for 2003 and 2004, indicating that at least 50 percent of the measurements were non-detects. The number of non-detects decreased after 2004, from a maximum of 66 percent in 2004 to a minimum of zero percent in 2010 and 2012.

- Between 2004 and 2008, the 1-year average concentration changed very little, ranging from 0.078 µg/m^3 (2005) to 0.095 µg/m^3 (2006). Greater fluctuations are shown in the years that follow. Years with a higher number of non-detects, as indicated by the minimum and 5th percentile, such as 2009 and 2011, alternate with years without any non-detects and concentrations that are higher in magnitude, as indicated by the 95th percentile and maximum concentration.

- Even with the variable range of measurements, the median concentration shown for the period from 2010 to 2012 varies by less than 0.01 µg/m^3.

Figure 17-28. Yearly Statistical Metrics for Cadmium (PM_{10}) Concentrations Measured at S4MO



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

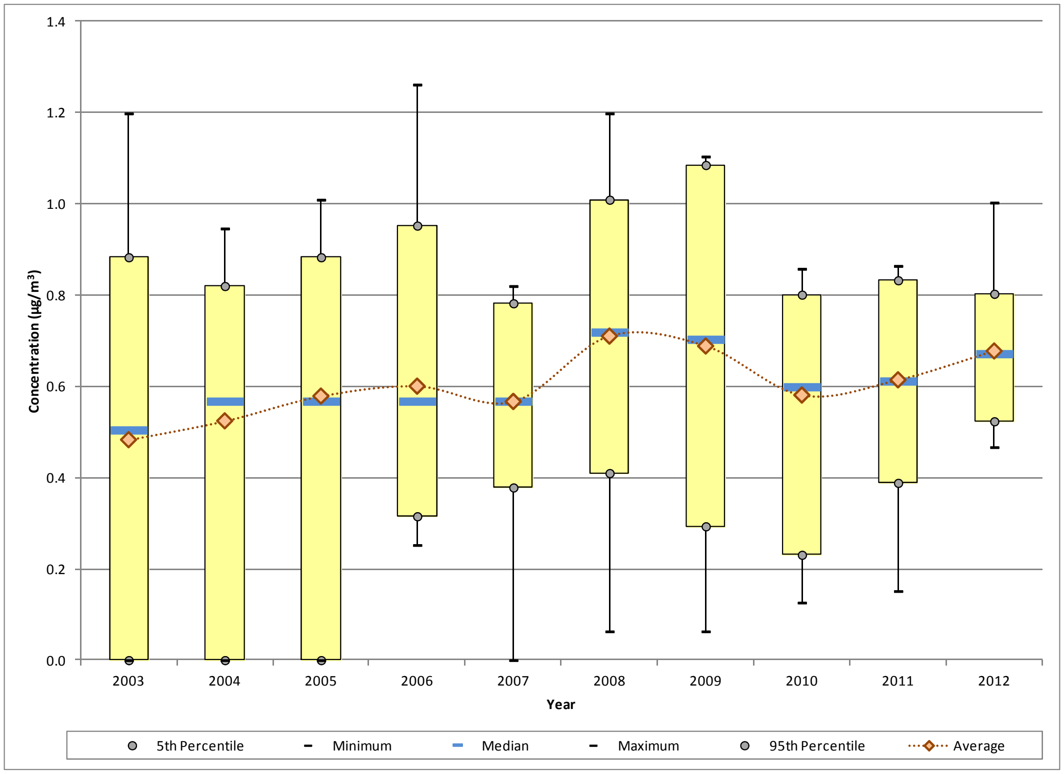
Observations from Figure 17-28 for cadmium measurements collected at S4MO include the following:

- The maximum concentration for most years of sampling is less than 3 ng/m^3; the 12 measurements greater than 3 ng/m^3 were measured at S4MO in 2004 (three), 2005 (two), 2008 (two), and 2009 (five).

- A steady decreasing trend is shown in the 1-year average and median concentrations between 2004 and 2006. Even though the 1-year average exhibits an increasing trend between 2006 and 2009, the median concentration does not, indicating that concentrations at the upper end of the concentration range are driving the 1-year average, particularly for 2009. The difference between the 1-year average and median concentrations is at a maximum for 2009, indicating an increasing level of variability in the measurements. The range of concentrations measured decreased significantly from 2009 to 2010.

- A slight increasing trend in the maximum and 95th percentile is shown from 2010 to 2011 and 2012, yet the median cadmium concentration is at a minimum for 2012. This is a result of the increasing number of concentrations at the lower end of the concentration range. The minimum concentration measured in 2012 decreased by half and the number of concentrations less than 0.25 ng/m^3 increased from 10 in both 2010 and 2011 to 24 in 2012.

Figure 17-29. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at S4MO



Observations from Figure 17-29 for carbon tetrachloride measurements collected at S4MO include the following:

- Twenty of the 21 non-detects of carbon tetrachloride were measured in 2003, 2004, or 2005, with the final non-detect measured in 2007.

- A steady increasing trend in the 1-year average in shown through 2006. Although the maximum concentration decreased substantially from 2006 to 2007, the change in the 1-year average is slight and the median concentration did not change at all. In fact, the median concentration is the same for 2005, 2006, and 2007.

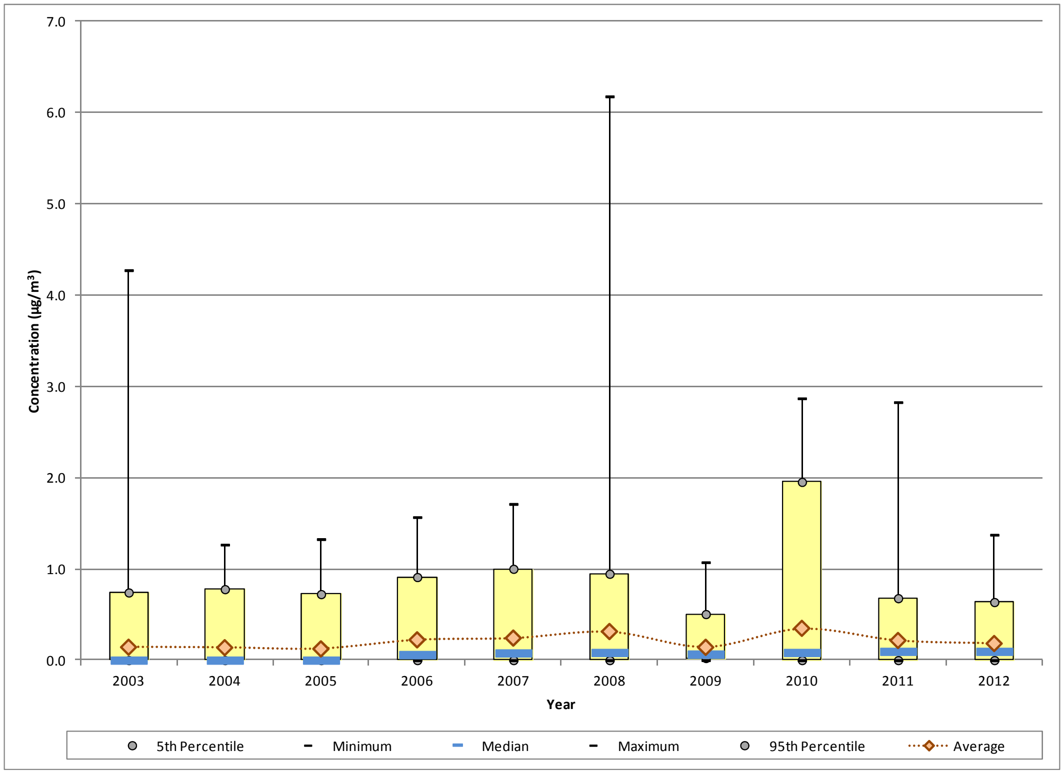
- All of the statistical parameters exhibit increases from 2007 to 2008. Both the median and 1-year average concentrations have a decreasing trend from 2008 through 2010, after which these parameters begin increasing again.

- Although there appears to be significant variability in these measurements, the changes shown in the 1-year averages vary by less than 0.25 µg/m^3.

- The box and whisker plots for this pollutant appear “inverted,” with the minimum concentration extending farther away from the majority of measurements than the maximum concentration (which is more common, see benzene as an example) for the period between 2007 and 2011.

- The range of concentrations measured is at a minimum for 2012. The difference between the 5th and 95th percentiles is also at a minimum for 2012, indicating that the majority of measurements are falling within a tighter range.

Figure 17-30. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at S4MO



Observations from Figure 17-30 for *p*-dichlorobenzene measurements collected at S4MO include the following:

- The minimum, 5th percentile, and median concentrations are all zero for 2003, 2004, and 2005, indicating that at least 50 percent of the measurements were non-detects. The number of non-detects was at a maximum in 2003 (90 percent), after which the percentage decreased, reaching a minimum of 5 percent for 2009. The percentage of non-detects has varied between 10 percent and 20 percent since 2009.

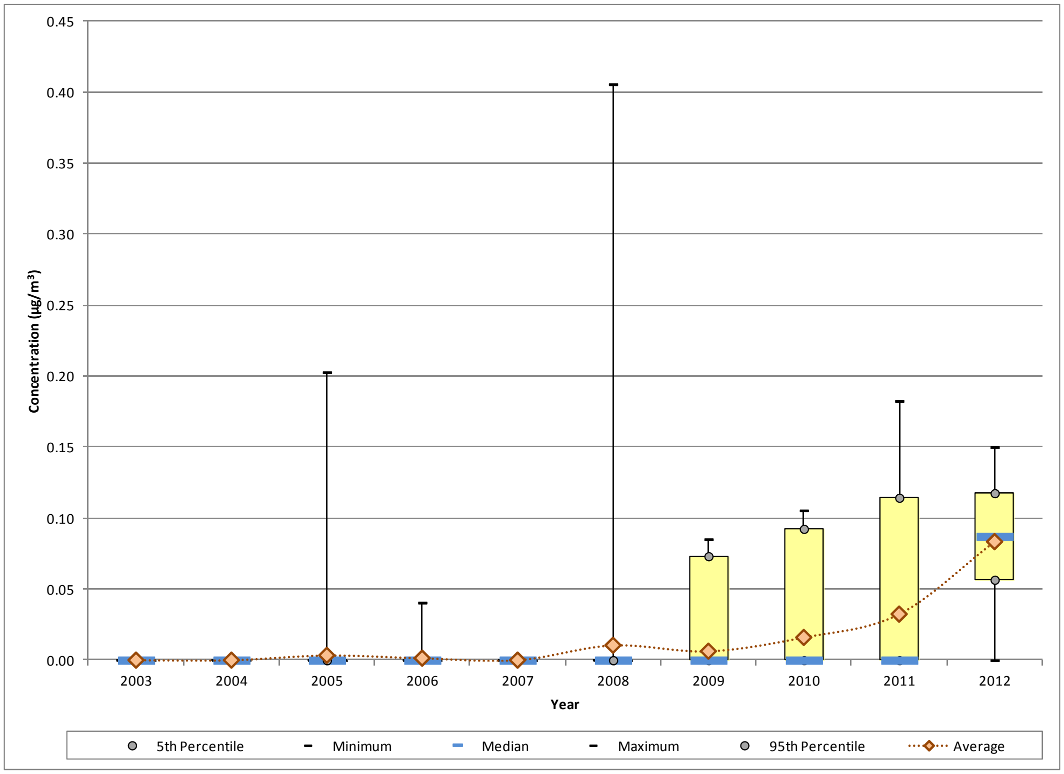
- The 1-year average and median concentrations exhibit a steady increasing trend between 2005 and 2008. However, the relatively large number of non-detects (zeros) combined with the range of measured detections result in a relatively high level of variability, based on the confidence intervals calculated for the 1-year averages. This is particularly true for 2008, when the maximum *p*-dichlorobenzene concentration was measured. The difference between the median and 1-year average concentration is also an indicator of this. During this period, the 1-year average was at least three times greater than the median.

- The concentrations measured decreased considerably from 2008 to 2009 then increased again in 2010. The increase in most of the statistical parameters for 2010, particularly the 95th percentile, indicates that concentrations measured were higher in general that year. The number of measurements greater than 0.75 μg/m^3 increased from two in 2009 to eight for 2010.

- Although the maximum concentration measured in 2011 is similar to the maximum concentration measured in 2010, the 95th percentile and 1-year average decreased while the median concentration increased. This is because there were fewer measurements at the upper end of the concentration range and a greater number of non-detects from the previous year.

- The concentrations measured in 2012 exhibit less variability than the previous two years. The difference between the 1-year average and median concentration is at a minimum over the 3-year period.

Figure 17-31. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at S4MO



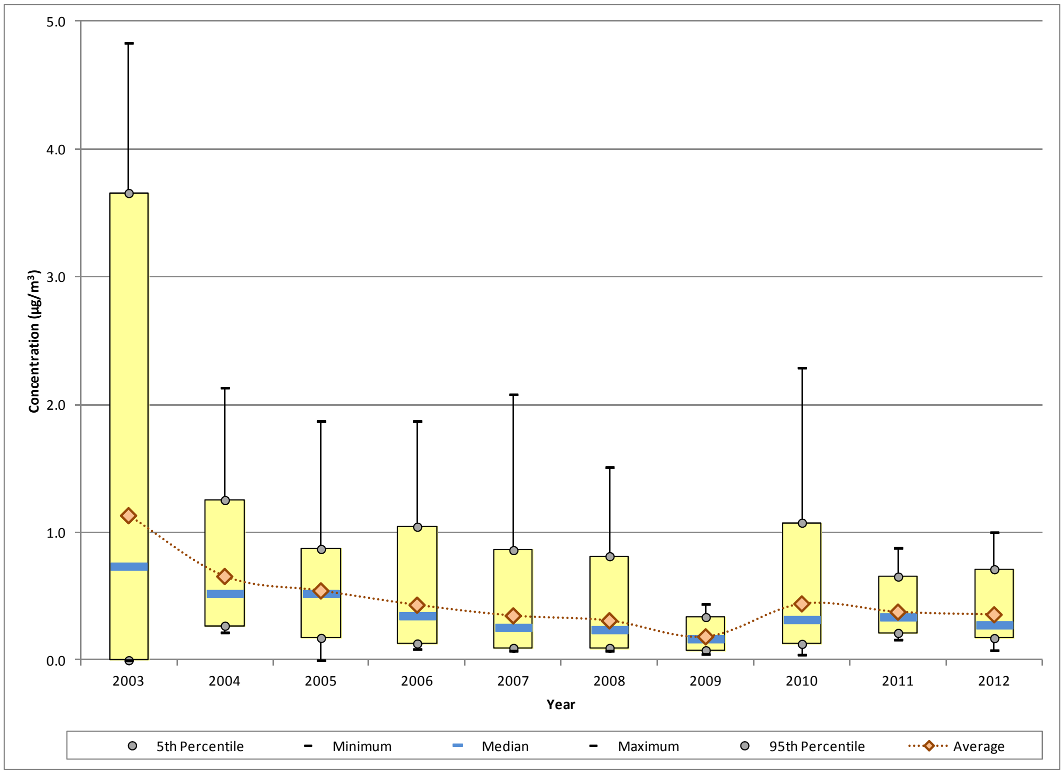
Observations from Figure 17-31 for 1,2-dichloroethane measurements collected at S4MO include the following:

- With the exception of 2012, the median concentration is zero for all years, indicating that at least 50 percent of the measurements were non-detects. There were no measured detections of 1,2-dichloroethane in 2003, 2004, or 2007, one measured detection in 2005, two in 2006 and 2008, five in 2009, 10 in 2010, 18 in 2011, and 56 in 2012.

- As the number of measured detections increased in the later years of sampling, each of the corresponding statistical metrics shown in Figure 17-31 also increased.

- As the number of measured detections increased dramatically for 2012, the median and 1-year average concentrations increased correspondingly. The median concentration is actually greater than the 1-year average for 2012, although the difference is less than 0.005 µg/m^3. The majority of measurements fall within a relatively small range (roughly 0.06 µg/m^3) as indicated by the 5th and 95th percentiles.

Figure 17-32. Yearly Statistical Metrics for Ethylbenzne Concentrations Measured at S4MO



Observations from Figure 17-32 for ethylbenzene measurements collected at S4MO include the following:

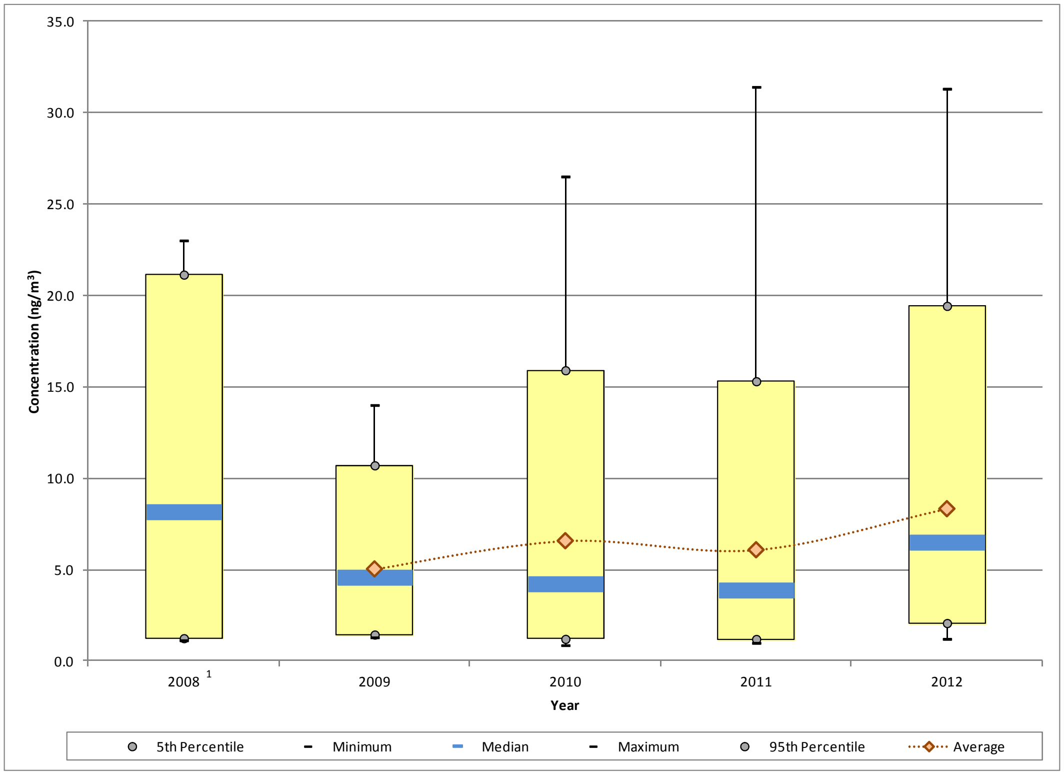
- The maximum concentration of ethylbenzene was measured at S4MO in 2003. In fact, the eight highest concentrations (those greater than 2.50 µg/m^3) were all measured in 2003. Nearly half of the ethylbenzene concentrations greater than 1 µg/m^3 were measured in 2003 (21 out of 44).

- The 1-year average concentration has a steady decreasing trend through 2009, when nearly all of the statistical parameters were at a minimum. The maximum concentration for 2009 (0.44 µg/m^3) is less than the 1-year average for some of the earlier years of sampling.

- Nearly all of the statistical parameters exhibit considerable increases from 2009 to 2010, with the median and 1-year average concentrations doubling, the 95th percentile tripling, and the maximum increasing by a factor of five.

- The range of measurements collected in 2011 and 2012 decreased by more than half compared to 2010. A decrease in the 1-year average is shown from 2010 to 2011 and again for 2012, although the changes are not statistically significant.

Figure 17-33. Yearly Statistical Metrics for Fluorene Concentrations Measured at S4MO



[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 17-33 for fluorene measurements collected at S4MO include the following:

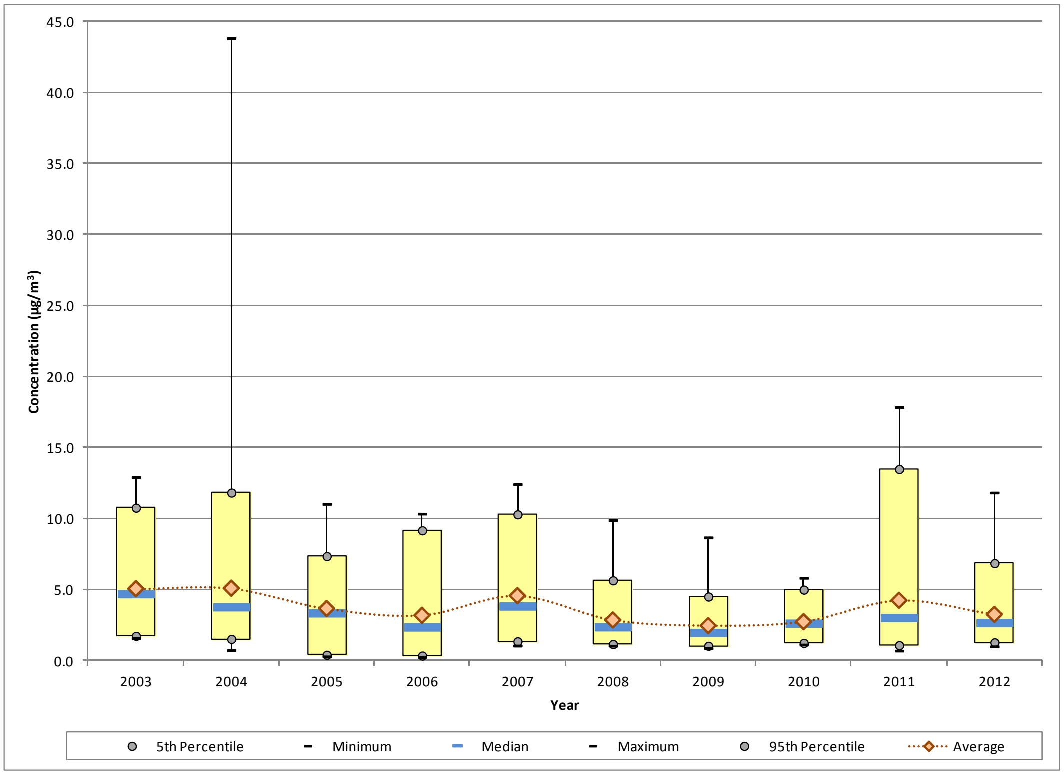
- The box and whisker plots for fluorene measurements resemble the plots for acenaphthalene presented in Figure 17-23.

- Two measurements greater than 30 ng/m^3 have been measured at S4MO, one on July 2, 2011 (31.4 ng/m^3) and one on July 2, 2012 (31.3 ng/m^3).

- All of the statistical parameters shown exhibit decreases from 2008 to 2009. From 2009 to 2010, the range of concentrations measured increased but the median concentration decreased, a trend that continued into 2011. A similar observation was made for acenaphthene.

- With the exception of the maximum concentration, the statistical parameters exhibit increases from 2011 to 2012. This is because the number of measurements at the upper end of the range increased while the number of measurements at the lower end of the concentration range decreased. The number of concentrations greater than 10 ng/m^3 increased from 13 to 22 from 2011 to 2012; conversely, the number of concentrations less than 1 ng/m^3 decreased from 11 to three from 2011 to 2012.

Figure 17-34. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at S4MO



Observations from Figure 17-34 for formaldehyde measurements collected at S4MO include the following:

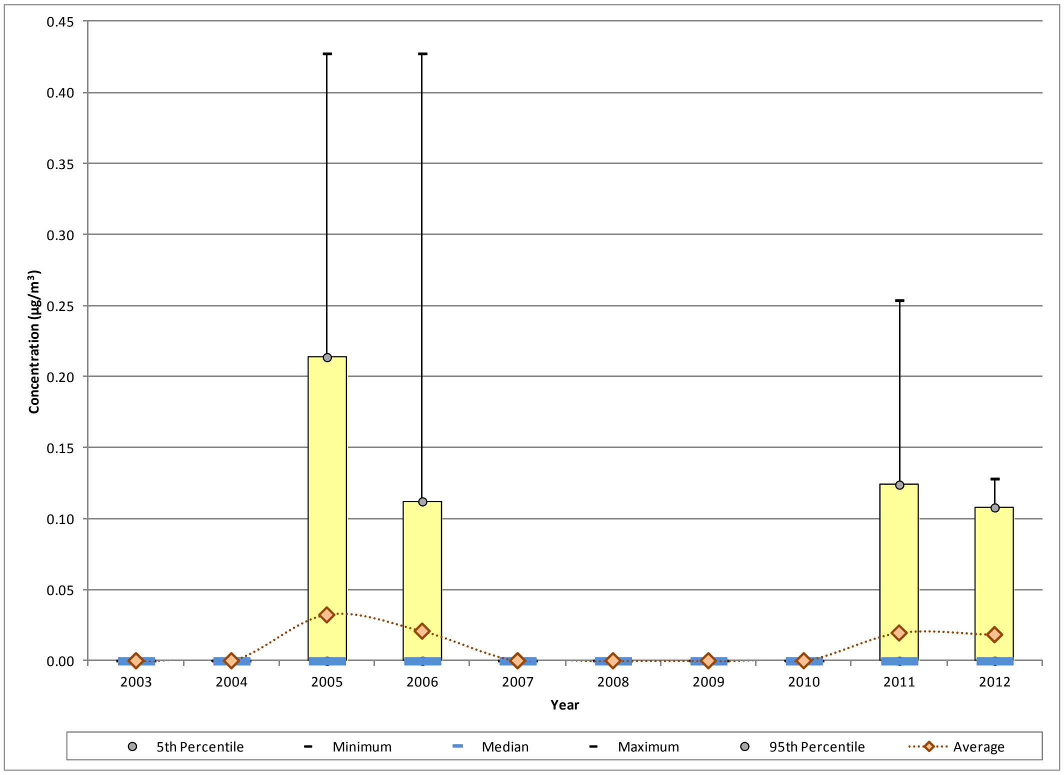
- The maximum formaldehyde concentration (43.8 µg/m^3) was measured in 2004 on the same day that the maximum acetaldehyde concentration was measured (August 31, 2004). This concentration is more than twice the next highest concentration (17.8 µg/m^3), which was measured in 2011. The six highest concentrations of formaldehyde were all measured in 2004 (2) or 2011 (4).

- The 1-year average concentration has a decreasing trend between 2003 and 2006. After the increase shown for 2007, the decreasing trend resumed through 2009, when the 1-year average was at a minimum (2.46 µg/m^3). The 1-year average concentration did not change significantly between 2009 and 2010, even though the smallest range of concentrations was measured in 2010.

- Most of the statistical parameters exhibit considerably increases from 2010 to 2011. There were 11 concentrations of formaldehyde measured in 2011 that were greater than the maximum concentration measured in 2010.

- Most of the statistical parameters exhibit decreases from 2011 to 2012.

Figure 17-35. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at S4MO

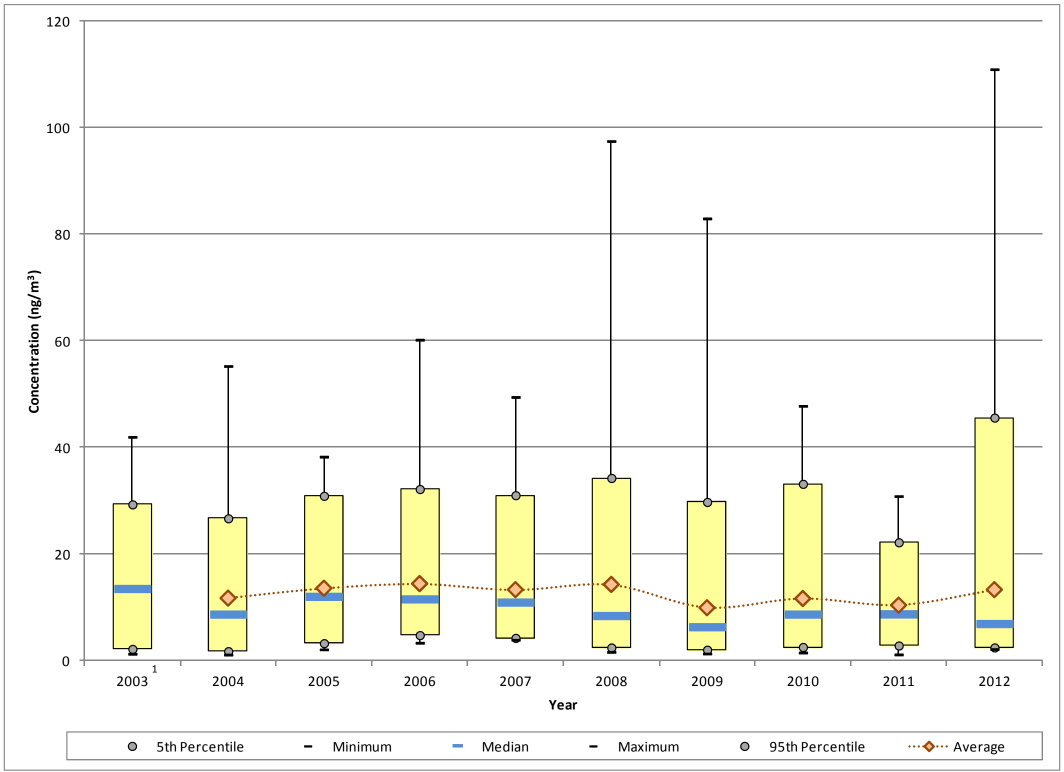


Observations from Figure 17-35 for hexachloro-1,3-butadiene measurements collected at S4MO include the following:

- The median concentration for hexachloro-1,3-butadiene for each year of sampling is zero, indicating that at least 50 percent of the measurements were non-detects. For 2003, 2004, and 2007 through 2010, 100 percent of the measurements were non-detects.

- For 2005 and 2006, the number of measured detections was less than 15 percent. For 2011, measured detections accounted for 16 percent of the measurements. For 2012, that number increased to 22 percent. Additional years of sampling are needed to determine if the number of measured detections will continue to increase.

Figure 17-36. Yearly Statistical Metrics for Lead (PM_{10}) Concentrations Measured at S4MO



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

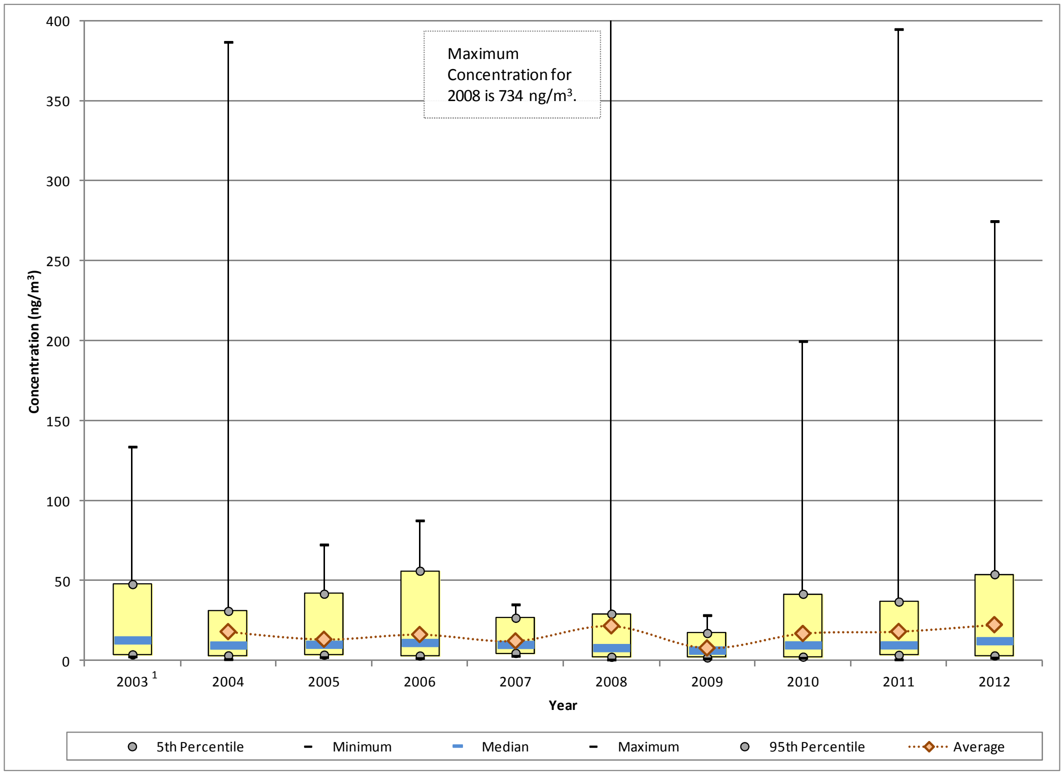
Observations from Figure 17-36 for lead measurements collected at S4MO include the following:

- The maximum lead concentration was measured at S4MO in 2012 (111 ng/m^3). This is the only measurement greater than 100 ng/m^3 measured at S4MO.

- The 95th percentile for 2012 is greater than the 95th percentiles for all other years as well as the maximum concentration for some years. Even though the maximum, 95th percentile, and 1-year average concentration increased from to 2011 to 2012, the median concentration actually decreased. Concentrations less than 7 ng/m^3 account for more than half of the concentrations measured in 2012, up from 31 percent in 2011.

- The 1-year average concentration of lead at S4MO has fluctuated over the years and exhibits no real trend. The 1-year averages have ranged from 9.94 ng/m^3 (2009) to 14.46 ng/m^3 (2006). The confidence intervals calculated for these averages are relatively large and indicate a considerable amount of variability in the measurements. This site has the second highest annual average concentration of lead for 2012 and has had the highest annual average for the last several years compared to other NMP sites sampling PM_{10} metals under the NMP.

Figure 17-37. Yearly Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at S4MO



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

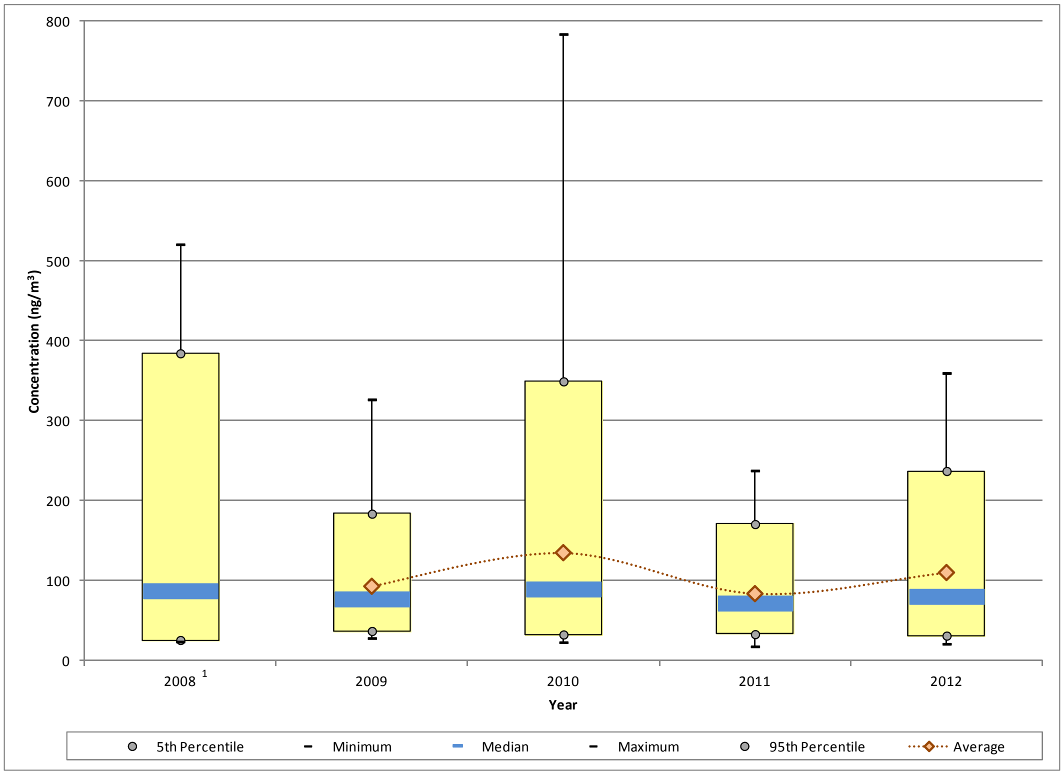
Observations from Figure 17-37 for manganese measurements collected at S4MO include the following:

- The maximum manganese concentration was measured on November 26, 2008 (734 ng/m^3) and is nearly twice the next highest concentration (395 ng/m^3, measured in 2011). A similar concentration was also measured in 2004 (387 ng/m^3). The maximum manganese concentration measured in 2012 ranks fourth highest since metals sampling began at S4MO.

- Seven manganese concentrations greater than 100 ng/m^3 have been measured at S4MO since 2003, with only 2012 having more than one. For each of these years, the second highest concentration of manganese was at least half as high as the highest concentration. For example, for 2010, the two highest concentrations are 200 ng/m^3 and 84.5 ng/m^3.

- The 1-year average concentration of manganese has ranged from 8.08 ng/m^3 (2009) to 22.66 ng/m^3 (2012). The median concentration, which is influenced less by outliers, has varied less, ranging from 6.82 ng/m^3 (2009) to 13.15 ng/m^3 (2003). The median concentration actually has a decreasing trend from 2006 to 2009, despite the outlier measured in 2008 (the two highest concentrations measured in 2008 were 734 ng/m^3 and 31.2 ng/m^3).

Figure 17-38. Yearly Statistical Metrics for Naphthalene Concentrations Measured at S4MO

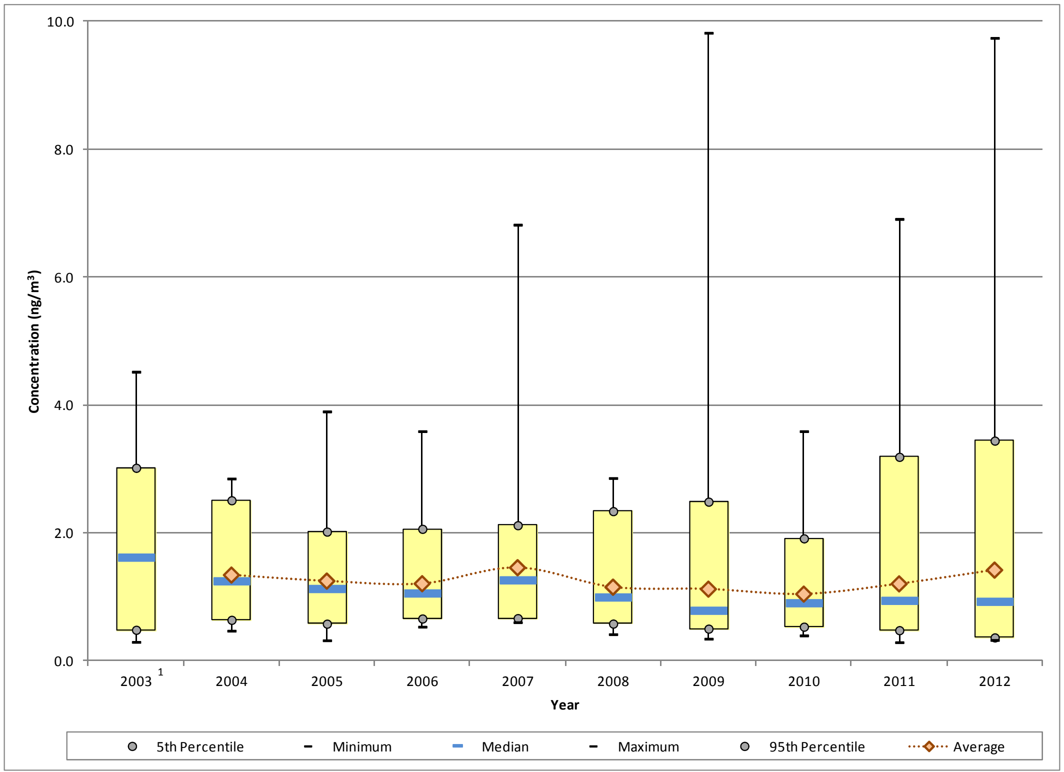


[1] A 1-year average is not presented because sampling under the NMP did not begin until April 2008.

Observations from Figure 17-38 for naphthalene measurements collected at S4MO include the following:

- Naphthalene concentrations measured at S4MO exhibit considerable variability, ranging from 18 ng/m^3 (2011) to 784 ng/m^3 (2010).
- The 1-year average concentration has ranged from 83.82 ng/m^3 (2011) to 135 ng/m^3 (2010). The median varies less, ranging from 72.20 ng/m^3 (2011) to 89.85 ng/m^3 (2010).
- The years when rather high concentrations were measured alternate with years when the maximum concentration is considerably less, resulting in the 1-year average (and median) concentrations having an undulating pattern.

Figure 17-39. Yearly Statistical Metrics for Nickel (PM_{10}) Concentrations Measured at S4MO



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2003.

Observations from Figure 17-39 for nickel measurements collected at S4MO include the following:

- The two highest nickel concentration were measured in 2009 (9.82 ng/m^3) and 2012 (9.74 ng/m^3). No other concentrations greater than 7 ng/m^3 have been measured at S4MO.

- The 1-year average concentration has ranged from 1.04 ng/m^3 (2010) to 1.45 ng/m^3 (2007). The slight decreasing trend shown between 2004 and 2010 was interrupted by the increase shown for 2007. This year has the highest minimum concentration, the second fewest measurements less than 1 ng/m^3, and the fourth highest concentration measured at S4MO.

- The 1-year average, 95th percentile, and maximum concentrations exhibit an increasing trend between 2010 and 2012. However, the wide range of concentrations measured results in relatively large confidence intervals that indicate that the change is not statistically significant.

17.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the S4MO monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

17.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Missouri monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

17.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for S4MO and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 17-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 17-6. Risk Approximations for the Missouri Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
St. Louis, Missouri - S4MO						
Acenaphthene[a]	0.000088	--	60/60	0.01 ± <0.01	0.65	--
Acetaldehyde	0.0000022	0.009	61/61	1.86 ± 0.21	4.08	0.21
Arsenic (PM_{10})[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	4.67	0.07
Benzene	0.0000078	0.03	58/58	0.80 ± 0.12	6.25	0.03
1,3-Butadiene	0.00003	0.002	58/58	0.11 ± 0.02	3.24	0.05
Cadmium (PM_{10})[a]	0.0018	0.00001	61/61	<0.01 ± <0.01	1.03	0.06
Carbon Tetrachloride	0.000006	0.1	58/58	0.68 ± 0.02	4.06	0.01
p-Dichlorobenzene	0.000011	0.8	52/58	0.18 ± 0.06	1.98	<0.01
1,2-Dichloroethane	0.000026	2.4	56/58	0.08 ± 0.01	2.17	<0.01
Ethylbenzene	0.0000025	1	58/58	0.35 ± 0.05	0.89	<0.01
Fluorene[a]	0.000088	--	60/60	0.01 ± <0.01	0.73	--
Formaldehyde	0.000013	0.0098	61/61	3.26 ± 0.52	42.33	0.33
Hexachloro-1,3-butadiene	0.000022	0.09	14/58	0.02 ± 0.01	0.42	<0.01
Lead (PM_{10})[a]	--	0.00015	61/61	0.01 ± <0.01	--	0.09
Manganese (PM_{10})[a]	--	0.00005	61/61	0.02 ± 0.01	--	0.45
Naphthalene[a]	0.000034	0.003	60/60	0.11 ± 0.02	3.76	0.04
Nickel (PM_{10})[a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.68	0.02

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 17-5.

Observations for S4MO from Table 17-6 include the following:

- The pollutants with the highest annual average concentrations for S4MO are formaldehyde, acetaldehyde, and benzene.

- Formaldehyde has the highest cancer risk approximations for S4MO (42.33 in-a-million), The cancer risk approximation for formaldehyde is among the higher cancer risk approximations calculated among the site-specific pollutants of interest across the program.

- Benzene has the highest cancer risk approximation for S4MO among the VOCs (6.25 in-a-million); arsenic has the highest cancer risk approximation for S4MO among the metals (4.67 in-a-million); and naphthalene has the highest cancer risk approximation for S4MO among the PAHs (3.76 in-a-million).

- None of the pollutants of interest for S4MO have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. The pollutant with the highest noncancer hazard approximation is manganese (0.45), which is the fifth highest noncancer hazard approximation calculated for a site-specific pollutant interest among NMP sites.

17.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 17-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 17-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 17-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for S4MO, as presented in Table 17-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 17-7. Table 17-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 17.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 17-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Missouri Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		**Top 10 Cancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
St. Louis, Missouri (St. Louis City) - S4MO					
Formaldehyde	283.51	Formaldehyde	3.69E-03	Formaldehyde	42.33
Acetaldehyde	125.56	Naphthalene	9.90E-04	Benzene	6.25
Benzene	114.51	Benzene	8.93E-04	Arsenic	4.67
Ethylbenzene	54.99	Hexavalent Chromium, PM	8.16E-04	Acetaldehyde	4.08
Naphthalene	29.11	1,3-Butadiene	5.86E-04	Carbon Tetrachloride	4.06
1,3-Butadiene	19.55	POM, Group 2d	5.04E-04	Naphthalene	3.76
Trichloroethylene	15.45	POM, Group 3	5.02E-04	1,3-Butadiene	3.24
POM, Group 2d	5.73	POM, Group 2b	4.49E-04	1,2-Dichloroethane	2.17
POM, Group 2b	5.10	Acetaldehyde	2.76E-04	*p*-Dichlorobenzene	1.98
Dichloromethane	3.65	Arsenic, PM	2.48E-04	Cadmium	1.03

Table 17-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Missouri Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		**Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
St. Louis, Missouri (St. Louis City) - S4MO					
Toluene	703.90	Acrolein	888,399.09	Manganese	0.45
Ethylene glycol	393.90	Formaldehyde	28,929.21	Formaldehyde	0.33
Formaldehyde	283.51	Manganese, PM	18,321.76	Acetaldehyde	0.21
Hexane	232.58	Acetaldehyde	13,951.64	Lead	0.09
Xylenes	221.77	1,3-Butadiene	9,774.06	Arsenic	0.07
Methanol	208.08	Naphthalene	9,702.37	Cadmium	0.06
Acetaldehyde	125.56	Trichloroethylene	7,726.86	1,3-Butadiene	0.05
Benzene	114.51	Arsenic, PM	3,850.67	Naphthalene	0.04
Hydrochloric acid	70.78	Benzene	3,816.95	Benzene	0.03
Ethylbenzene	54.99	Hydrochloric acid	3,539.11	Nickel	0.02

Observations from Table 17-7 include the following:

- Formaldehyde, acetaldehyde, and benzene are the highest emitted pollutants with cancer UREs in the city of St. Louis.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, naphthalene, and benzene.

- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions.

- Formaldehyde tops all three lists, with the highest quantity emitted, the highest toxicity-weighted emissions, and the highest cancer risk approximation. Benzene, acetaldehyde, naphthalene, and 1,3-butadiene also appear on all three lists.

- Arsenic has the third highest cancer risk approximation for S4MO. While arsenic is not one of the highest emitted pollutants, it ranks 10th for its toxicity-weighted emissions. Carbon tetrachloride has the fifth highest cancer risk approximation for S4MO but appears on neither emissions-based list.

- POM, Group 2b is the ninth highest emitted “pollutant” in St. Louis and ranks eighth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at S4MO including acenaphthene and fluorene, which are pollutants of interest for S4MO. These pollutants are not among those with the highest cancer risk approximations for S4MO.

Observations from Table 17-8 include the following:

- Toluene, ethylene glycol, and formaldehyde are the highest emitted pollutants with noncancer RfCs in the city of St. Louis.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and manganese. Although acrolein was sampled for at S4MO, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Four of the highest emitted pollutants in the city of St. Louis also have the highest toxicity-weighted emissions.

- Manganese, the pollutant with highest noncancer hazard approximation, has the third highest toxicity-weighted emissions but is not one of the highest emitted (it ranks 30th). Arsenic, naphthalene, and 1,3-butadiene are also among the pollutants with the highest toxicity-weighted emissions, but are not among the highest emitted.

- Formaldehyde and acetaldehyde are the pollutants with the second and third highest noncancer hazard approximations for S4MO, respectively; these two pollutants of interest appear on both emissions-based lists. Benzene also appears on all three lists.

17.6 Summary of the 2012 Monitoring Data for S4MO

Results from several of the data treatments described in this section include the following:

- *Twenty-four pollutants failed screens for S4MO. S4MO failed the highest number of screens among all NMP sites.*

- *Formaldehyde and acetaldehyde have the highest annual average concentrations for S4MO. These are the only pollutants of interest with annual averages greater than 1 µg/m*^{3}*.*

- *S4MO has the highest annual average concentration of 1,2-dichloroethane, the second highest annual average concentration of hexachloro-1,3-butadiene, and the third highest annual average concentration of p-dichlorobenzene. S4MO also has the second highest annual average concentration of arsenic and the third highest annual average concentration of manganese.*

- *Concentrations of acetaldehyde measured at S4MO since 2010 have a decreasing trend. In addition, the detection rate of 1,2-dichloroethane has been increasing steadily at S4MO over the last few years of sampling.*

18.0 Sites in New Jersey

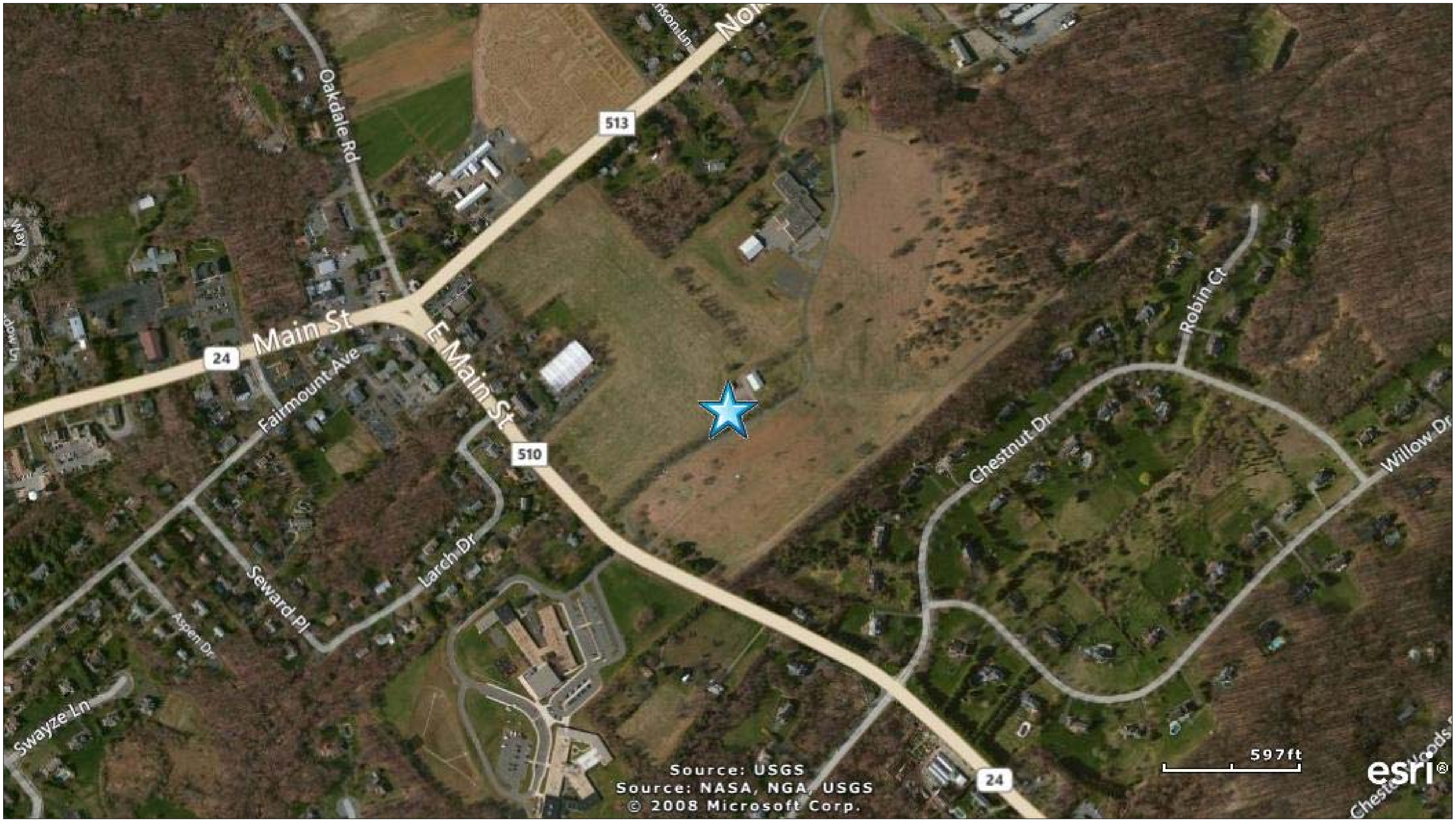
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at UATMP sites in New Jersey, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

18.1 Site Characterization

This section characterizes the New Jersey monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring data.

The New Jersey sites are all located within the New York-Newark-Jersey City, NY-NJ-PA MSA. Figure 18-1 is a composite satellite image retrieved from ArcGIS Explorer showing the CHNJ monitoring site and its immediate surroundings. Figure 18-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 18-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 18-3 through 18-5 are the composite satellite maps and emissions source map for ELNJ and NBNJ. Table 18-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 18-1. Chester, New Jersey (CHNJ) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 18-2. NEI Point Sources Located Within 10 Miles of CHNJ

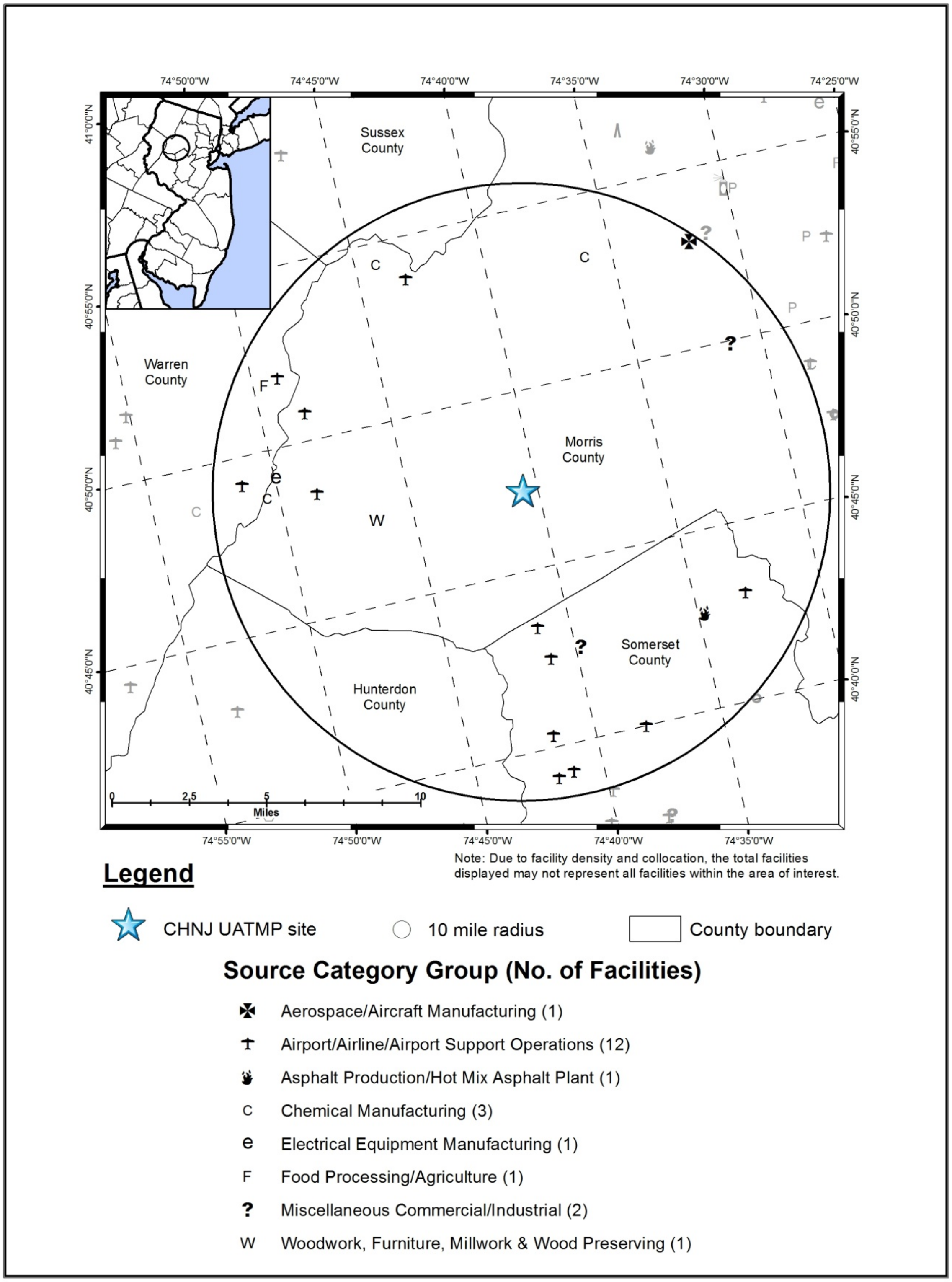
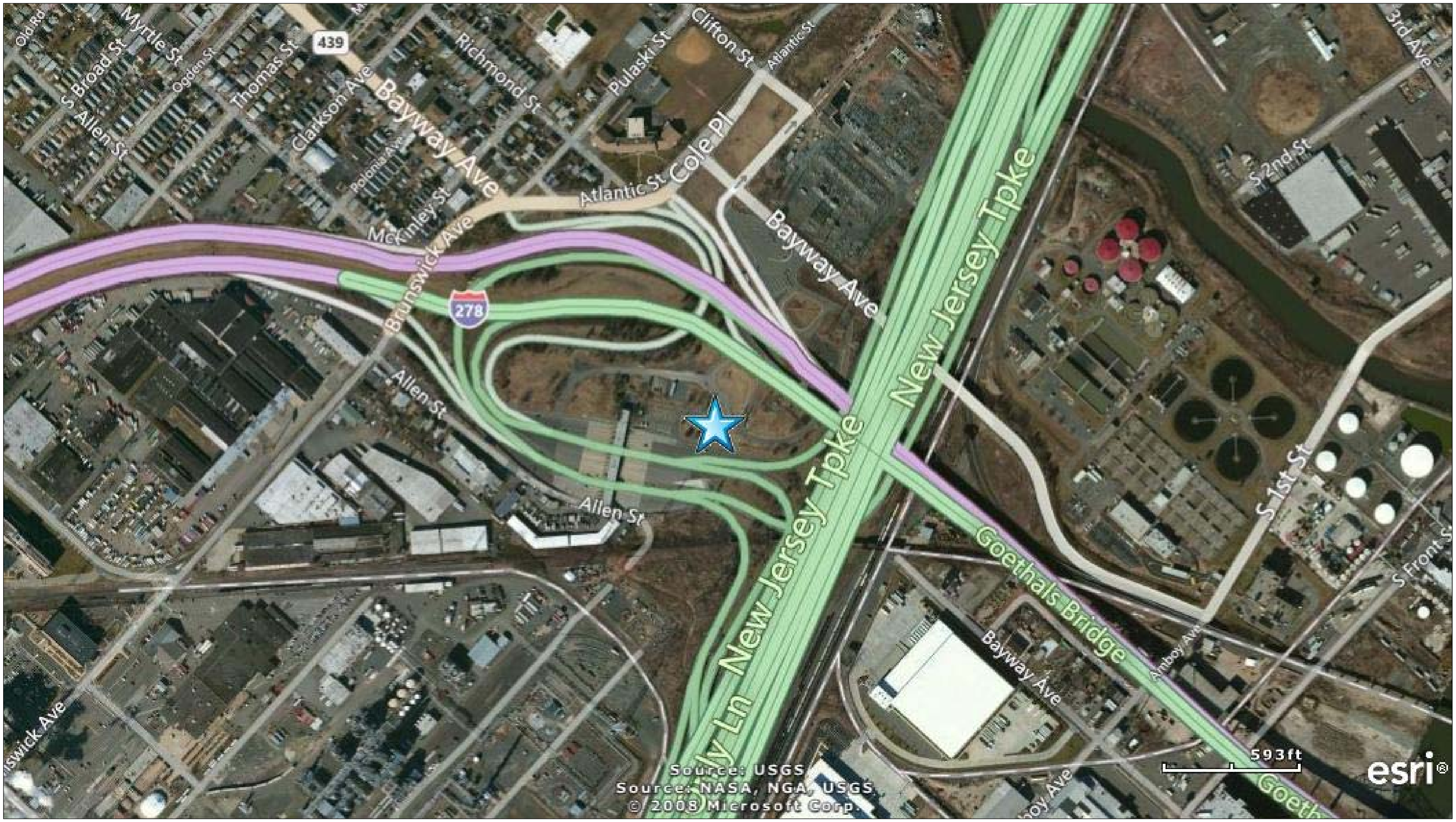
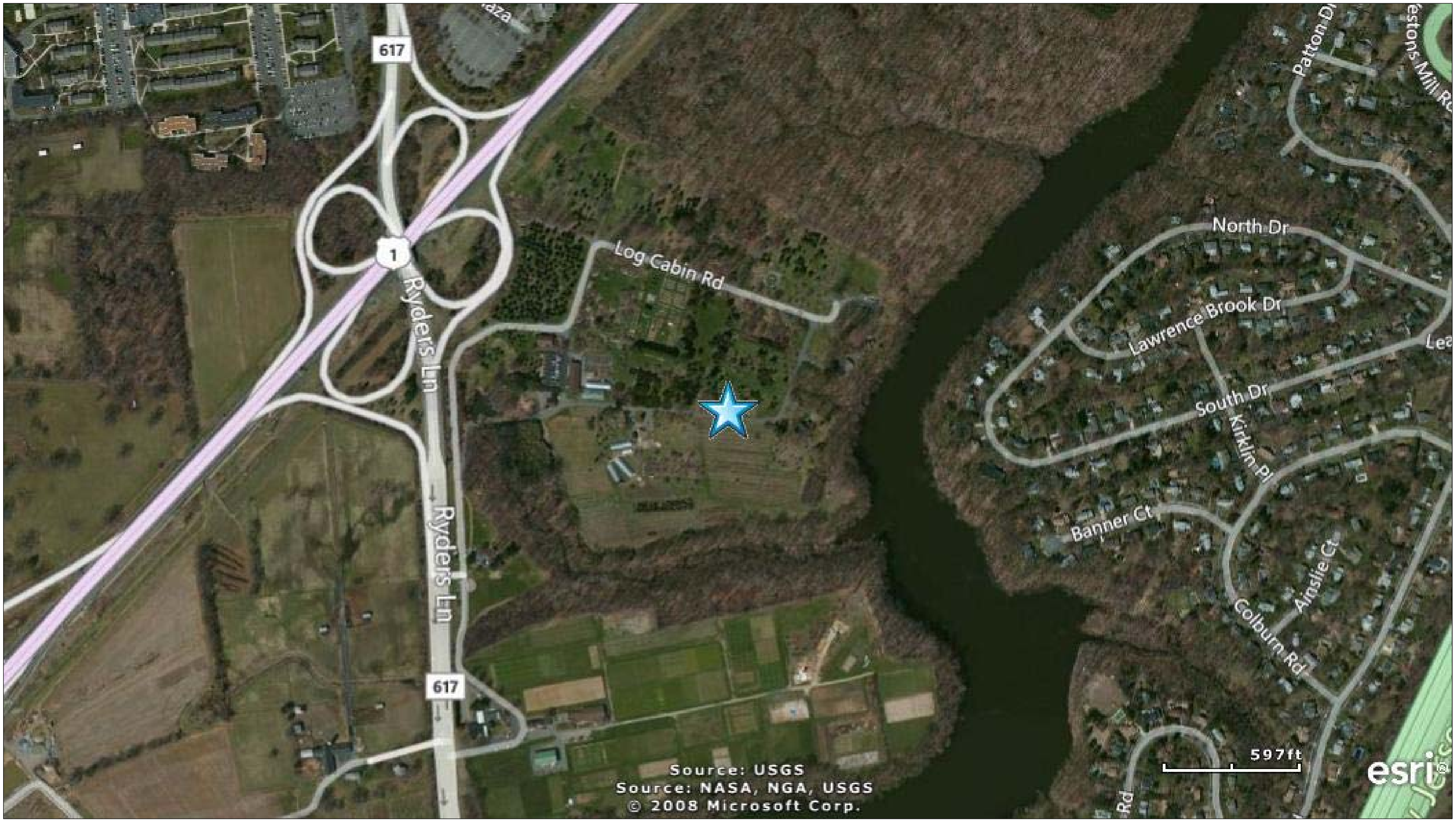


Figure 18-3. Elizabeth, New Jersey (ELNJ) Monitoring Site



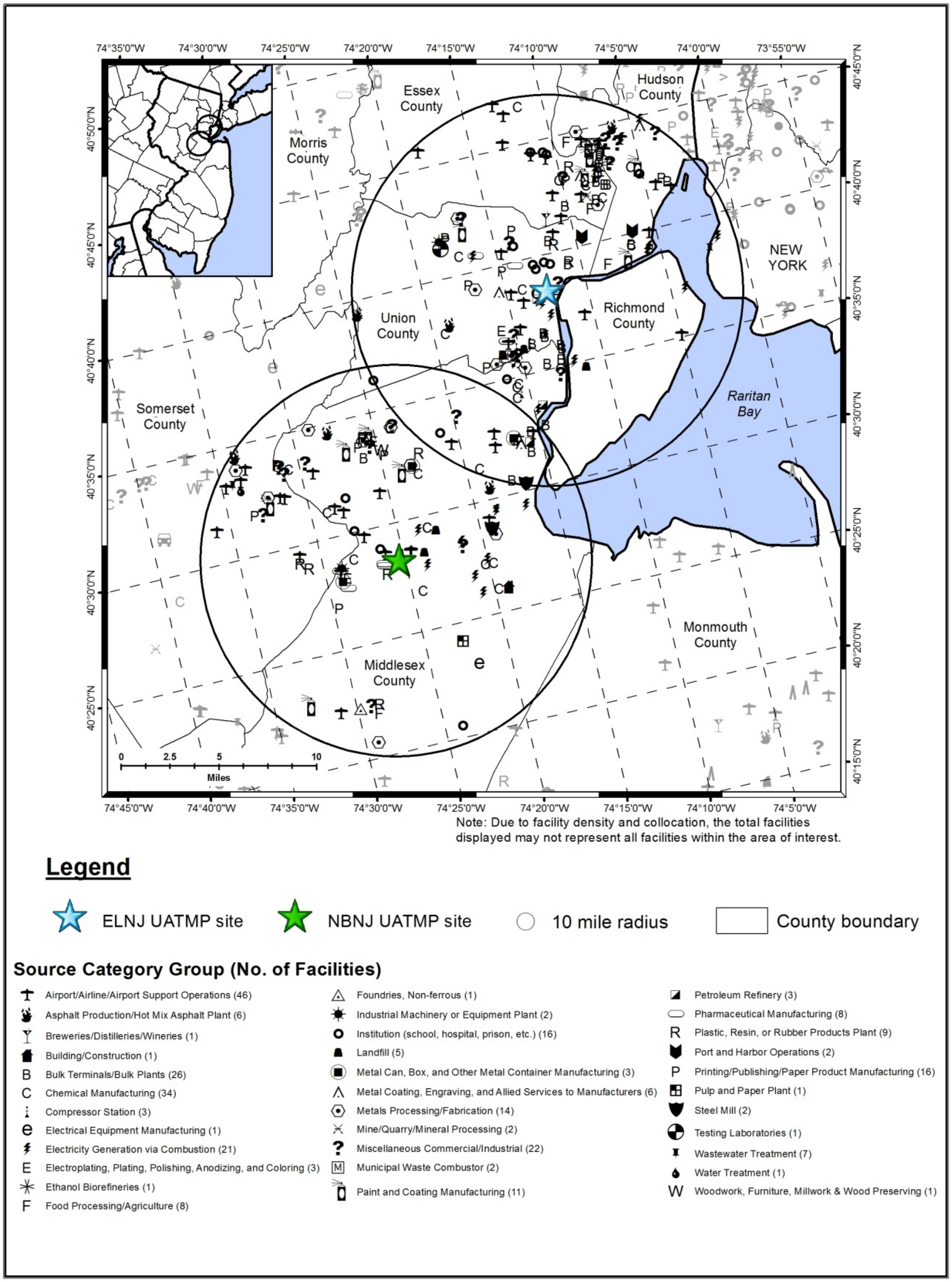
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 18-4. North Brunswick, New Jersey (NBNJ) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 18-5. NEI Point Sources Located Within 10 Miles of ELNJ and NBNJ



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 18-1. Geographical Information for the New Jersey Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
CHNJ	34-027-3001	Chester	Morris	New York-Newark-Jersey City, NY-NJ-PA MSA	40.787628, -74.676301	Agricultural	Rural	SO_2, NO, NO_2, O_3, Meteorological parameters, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
ELNJ	34-039-0004	Elizabeth	Union	New York-Newark-Jersey City, NY-NJ-PA MSA	40.64144, -74.208365	Industrial	Suburban	CO, SO_2, NO_2, NO_x, Meteorological parameters, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
NBNJ	34-023-0006	North Brunswick	Middlesex	New York-Newark-Jersey City, NY-NJ-PA MSA	40.472825, -74.422403	Agricultural	Rural	Meteorological parameters, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

CHNJ is located in northern New Jersey, in the town of Chester, west of the New York City metropolitan area. Figure 18-1 shows that CHNJ is located in an open area near Building 1 of the Department of Public Works off Route 513. The surrounding area is rural and agricultural with a rolling topography, but surrounded by small neighborhoods. Although the location is considered part of the New York City MSA, the site's location is outside most of the urbanized areas. Figure 18-2 shows that few sources are within a few miles of CHNJ. The source category with the greatest number of emissions sources surrounding CHNJ is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. The sources closest to CHNJ include a privately owned heliport and a wood work, furniture, millwork, and wood preserving facility.

ELNJ is located in the city of Elizabeth, which lies just south of Newark and west of Newark Bay and Staten Island, New York. As Figure 18-3 shows, the monitoring site is located just off Exit 13 of the New Jersey Turnpike (I-95), near the toll plaza. Interstate-278 intersects the Turnpike here as well. The surrounding area is highly industrialized, with an oil refinery located just southwest of the site. Additional industry is located to the southwest, west, and east, while residential neighborhoods are located to the northwest and north of the site.

NBNJ is located in North Brunswick, approximately 16 miles southwest of Elizabeth. The monitoring site is located on the property of Rutgers University's Cook-Douglass campus, on a horticultural farm. The surrounding area is agricultural and rural, although residential neighborhoods are located to the east, across a branch of the Raritan River, as shown in Figure 18-4. County Road 617 (Ryders Lane) and US-1 intersect just west of the site and I-95 runs northeast-southwest about 1 mile east of the site, part of which can be seen in the lower right hand corner of Figure 18-4.

Figure 18-5 shows that the outer portions of the 10-mile radii for ELNJ and NBNJ intersect and that many emissions sources surround these two sites. The majority of the emissions sources are located in northern Middlesex County and northeastward toward New York City and northern New Jersey. The source categories with the greatest number of emissions sources in the vicinity of these sites include airport operations, chemical manufacturing, bulk terminals and bulk plants, and electricity generation via combustion. The emissions sources in closest proximity to the ELNJ monitoring site are in the wastewater treatment, chemical manufacturing, bulk terminals/bulk plant, and petroleum refining source categories. The emissions sources in closest proximity to the NBNJ monitoring site are involved in airport and airport support operations and pharmaceutical manufacturing.

Table 18-2 presents additional site-characterizing information, including indicators of mobile source activity, for the New Jersey monitoring sites. Table 18-2 includes a county-level population for each site. County-level vehicle registration data for Union, Morris, and Middlesex Counties were not available from the State of New Jersey. Thus, state-level vehicle registration, which was obtained from the Federal Highway Administration (FHWA), was allocated to the county level using the county-level proportion of the state population from the U.S. Census Bureau. Table 18-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 18-2 presents the county-level daily VMT for Middlesex, Morris, and Union Counties.

Table 18-2. Population, Motor Vehicle, and Traffic Information for the New Jersey Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
CHNJ	497,999	445,710	11,215	Route 510, east of Fox Chase Rd	14,844,444
ELNJ	543,976	485,449	250,000	I-95 between Exits 13 & 13A	12,264,174
NBNJ	823,041	733,908	110,653	US-1, west of Route 617	20,644,392

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects ratios based on 2011 state-level vehicle registration data from the FHWA and the 2011 county-level proportion of the state population data (FHWA, 2013a and Census Bureau, 2012)
[3] AADT for ELNJ reflects 2006 data from NJ Department of Treasury and 2009 data for NBNJ and 2012 data for CHNJ from the New Jersey DOT (NJ DOTr, 2008 and NJ DOT, 2013)
[4] County-level VMT reflects 2011 data (NJ DOT, 2011)

Observations from Table 18-2 include the following:

- Middlesex County, where NBNJ is located, has the highest county-level population for the New Jersey sites while Morris County, where CHNJ is located, has the least. Compared to NMP monitoring sites in other locations, the county-level populations are in the middle of the range, ranking 16th, 24th, and 25th.

- The estimated county-level vehicle registration is also highest for NBNJ and least for CHNJ. The county-level registration estimates for the sites have similar rankings as the county-level populations among NMP sites.

- ELNJ and NBNJ experience a significantly higher average traffic volume than CHNJ. Traffic data for ELNJ are provided for I-95, between Exit 13 and 13A; this is the second highest traffic volume among all NMP sites. Traffic data for CHNJ are provided for Route 510, east of Fox Chase Road; traffic data for NBNJ are provided for US-1, west of State Road 617 (Ryders Lane).

- The daily VMT is highest for Middlesex County (NBNJ) and lowest for Union County (ELNJ). However, VMT for the New Jersey counties are in the middle of the range compared to other counties with NMP sites (where VMT data were available).

18.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in New Jersey on sample days, as well as over the course of the year.

18.2.1 Climate Summary

Frontal systems push across the state of New Jersey regularly, producing variable weather conditions. The state's proximity to the Atlantic Ocean has a moderating effect on temperatures. Summers along the coast tend to be cooler than areas farther inland, while winters tend to be warmer. Large urban areas within the state experience the urban heat island effect, in which urban areas retain more heat than outlying areas. New Jersey's Mid-Atlantic location also allows for ample annual precipitation and relatively high humidity. Greater than 3 inches of precipitation can be expected each month in the northeastern portion of the state. A southwesterly wind is most common in the summer and a northwesterly wind is typical in the winter. Winds from the west and northwest result in air masses that dry out, stabilize, and warm as they move eastward from higher elevations to sea level (Wood, 2004; Rutgers, 2014).

18.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the New Jersey monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather stations are located at Somerville-Somerset Airport (near CHNJ and NBNJ) and Newark International Airport (near ELNJ), WBAN 54785 and 14734, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 18-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 18-3. Average Meteorological Conditions near the New Jersey Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Chester, New Jersey - CHNJ									
Somerville, New Jersey/Somerset Airport 54785 (40.62, -74.67)	11.3 miles 165° (SSE)	Sample Days (65)	64.2 ± 4.3	53.7 ± 4.0	43.2 ± 4.4	48.6 ± 3.8	71.4 ± 3.3	1017.4 ± 1.8	2.5 ± 0.4
		2012	65.2 ± 1.8	54.6 ± 1.6	43.4 ± 1.8	49.3 ± 1.6	70.1 ± 1.5	1015.9 ± 0.8	2.9 ± 0.2
Elizabeth, New Jersey - ELNJ									
Newark International Airport 14734 (40.68, -74.17)	3.4 miles 20° (NNE)	Sample Days (65)	63.7 ± 4.2	56.4 ± 4.0	42.2 ± 4.4	49.6 ± 3.6	62.8 ± 4.2	1016.6 ± 2.1	7.9 ± 0.7
		2012	65.4 ± 1.8	57.8 ± 1.7	43.1 ± 1.8	50.7 ± 1.5	61.8 ± 1.7	1015.9 ± 0.8	7.8 ± 0.4
North Brunswick, New Jersey - NBNJ									
Somerville, New Jersey/Somerset Airport 54785 (40.62, -74.67)	16.1 miles 297° (WNW)	Sample Days (67)	64.5 ± 4.3	54.1 ± 4.0	43.7 ± 4.3	49.0 ± 3.8	71.9 ± 3.5	1017.2 ± 1.8	2.6 ± 0.4
		2012	65.2 ± 1.8	54.6 ± 1.6	43.4 ± 1.8	49.3 ± 1.6	70.1 ± 1.5	1015.9 ± 0.8	2.9 ± 0.2

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 18-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 18-3 is the 95 percent confidence interval for each parameter. As shown in Table 18-3, average meteorological conditions on sample days were generally representative of average weather conditions experienced throughout the year near CHNJ, ELNJ, and NBNJ. The largest difference between a sample day and a full-year average is for relative humidity at NBNJ, although the difference is not statistically significant.

18.2.3 Back Trajectory Analysis

Figure 18-6 is the composite back trajectory map for days on which samples were collected at the CHNJ monitoring site. Included in Figure 18-6 are four back trajectories per sample day. Figure 18-7 is the corresponding cluster analysis. Similarly, Figures 18-8 through 18-11 are the composite back trajectory maps and corresponding cluster analyses for ELNJ and NBNJ. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 18-6 through 18-11 represents 100 miles.

Figure 18-6. Composite Back Trajectory Map for CHNJ

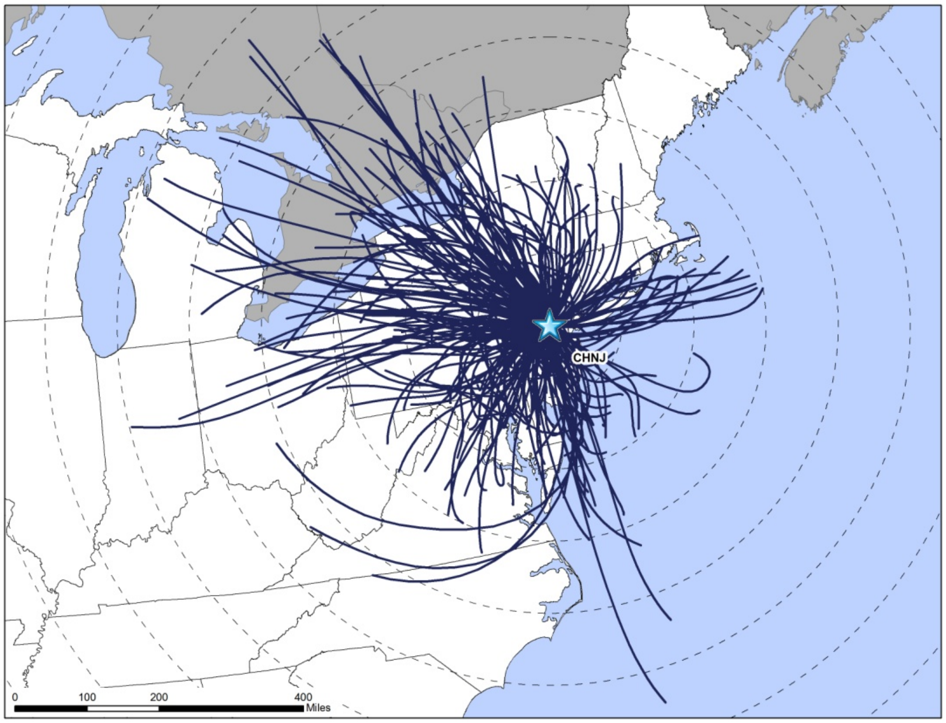


Figure 18-7. Back Trajectory Cluster Map for CHNJ

Figure 18-8. Composite Back Trajectory Map for ELNJ

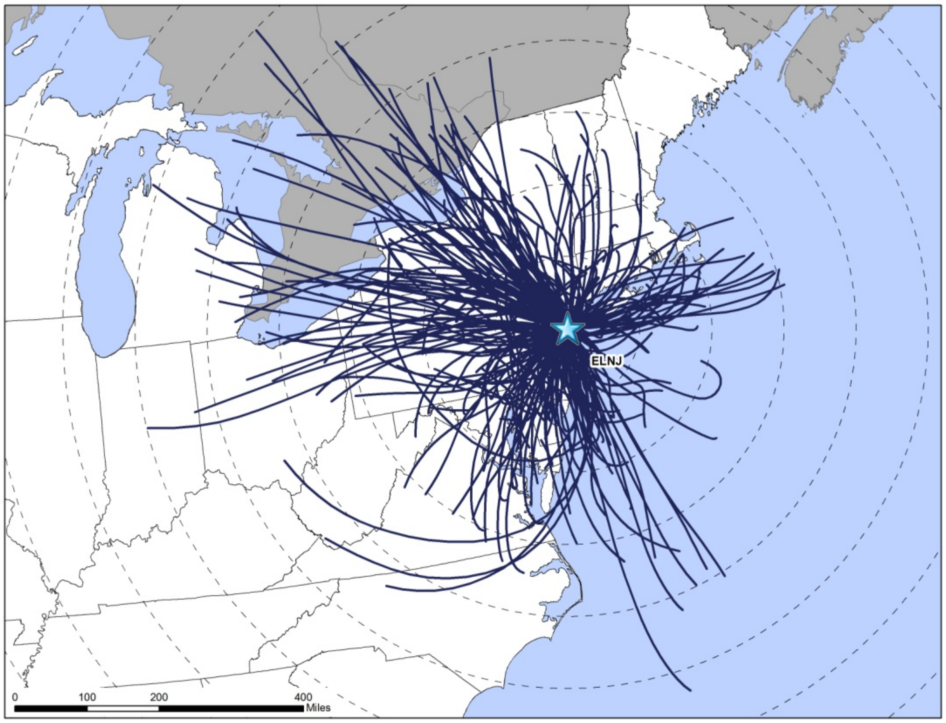


Figure 18-9. Back Trajectory Cluster Map for ELNJ

Figure 18-10. Composite Back Trajectory Map for NBNJ

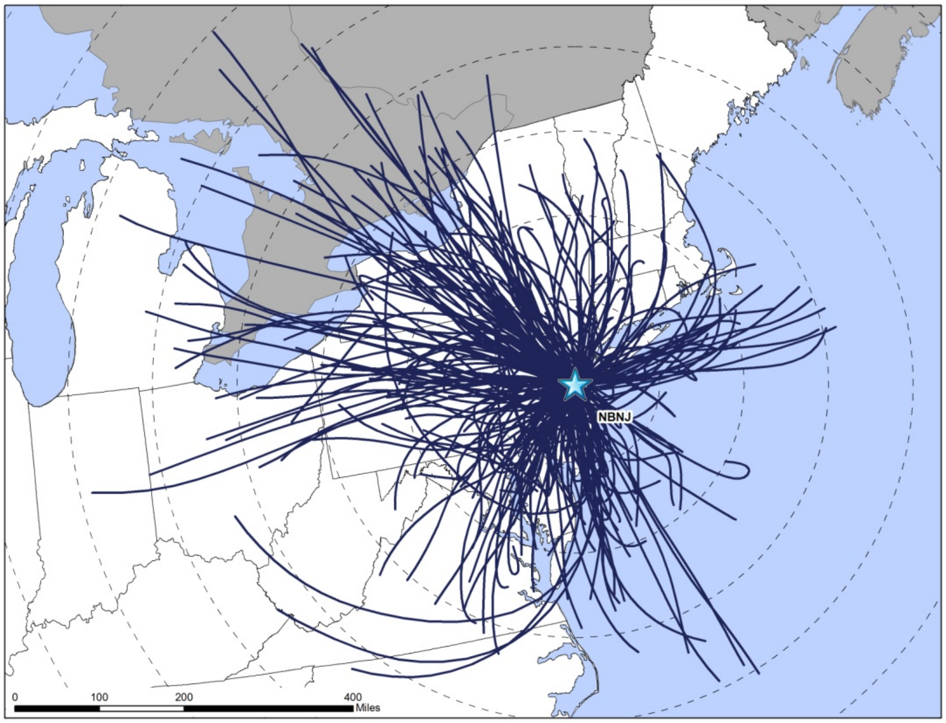


Figure 18-11. Back Trajectory Cluster Map for NBNJ

Observations from Figures 18-6 through 18-11 include the following:

- Due to their relatively close proximity to each other and the standardization of sample days, the back trajectories shown on each composite back trajectory map for the New Jersey sites are similar to each other. The composite map for NBNJ is on a slightly smaller scale because the relatively long back trajectory originating off the North Carolina/South Carolina coast corresponds to a sample day in which a sample was not collected at NBNJ.

- Back trajectories originated from a variety of directions at the sites. In general, the longest back trajectories originated from west or northwest of the monitoring sites.

- The 24-hour air shed domains for the New Jersey sites were similar in size to each other. Back trajectories greater than or approaching 600 miles in length were constructed for each site. These back trajectories originated over Ontario, Canada, Michigan, and Indiana. The average back trajectory length for these sites ranged from 223 miles (CHNJ) to 236 miles (ELNJ).

- The cluster trajectories for the New Jersey sites are similar to each other in geographical distribution, although the percentages vary. Each of the cluster maps has a long cluster trajectory originating over Lake Erie; another longer cluster trajectory originating over southeast Ontario; a relatively short cluster trajectory originating over central or southeast New York; a cluster trajectory originating to the south of Nantucket; and a cluster trajectory originating off the Delmarva Peninsula. The cluster trajectory originating over northern Virginia and the eastern panhandle of West Virginia for CHNJ and NBNJ is split into two cluster trajectories for ELNJ.

18.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations nearest the New Jersey sites, as presented in Section 18.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 18-12 presents a map showing the distance between the weather station and CHNJ, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 18-12 also presents three different wind roses for the CHNJ monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in

2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 18-13 and 18-14 present the distance maps and wind roses for ELNJ and NBNJ, respectively.

Observations from Figures 18-12 and 18-14 for CHNJ and NBNJ include the following:

- The weather station at Somerville/Somerset Airport is the closest weather station to both CHNJ and NBNJ. The Somerville/Somerset Airport weather station is located 11.3 miles south-southeast of CHNJ and 16.1 miles west-northwest of NBNJ.

- The historical and full-year wind roses for CHNJ are identical to the historical and full-year wind roses for NBNJ because the data are from the same weather station.

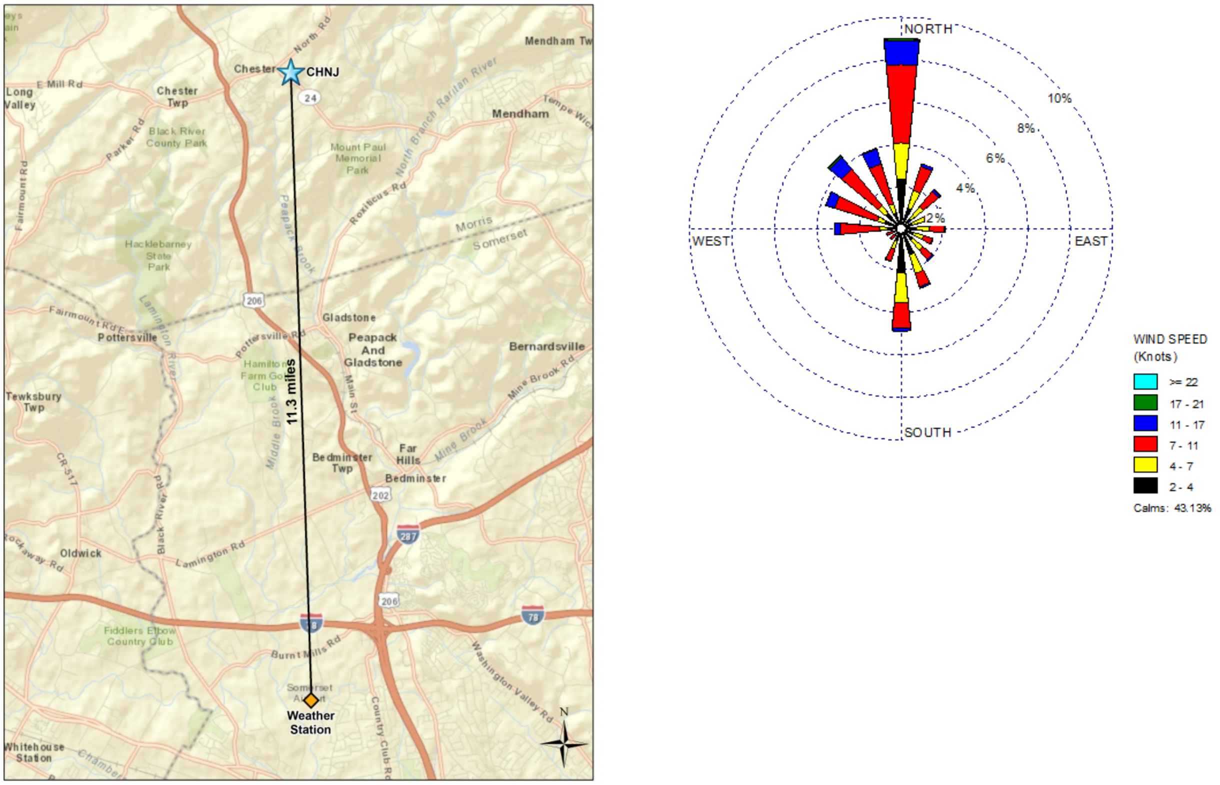
- The historical wind roses for these sites show that calm winds (≤ 2 knots) accounted for greater than 40 percent of observations. For wind speeds greater than 2 knots, northerly winds were observed most frequently, accounting for 9 percent of the observations, while winds from the southwest quadrant were rarely observed.

- Calm winds account 50 percent of the wind observations throughout 2012. Winds from the west-northwest to north account for another one-quarter of wind observations throughout 2012.

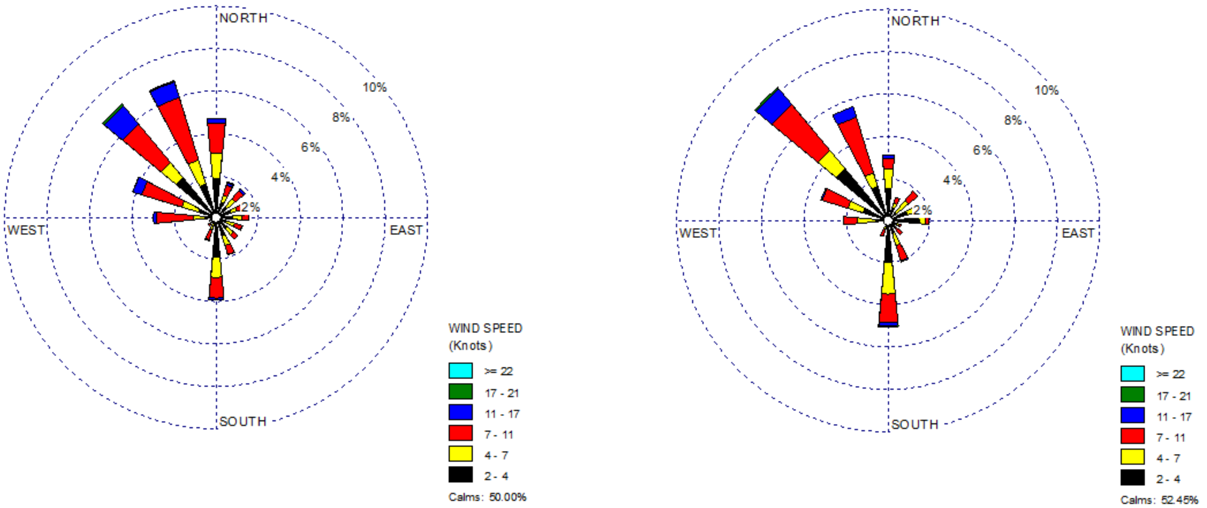
- Wind patterns on the sample day wind roses share many of the characteristics of the full year wind roses, even if at first glance it does not appear that way. Calm winds were still prevalent on sample days, accounting for more than half of wind observations. Although northwesterly and north-northwesterly winds still account for the majority of wind observations on sample days (for winds greater than 2 knots), the percentages are more varied. There were fewer observations from the west-northwest and north on sample days and a higher percentage of winds from the northeast.

- While the 2012 wind roses do exhibit the same prevalence for calm winds as the historical wind rose, they do not exhibit the same northerly predominance for wind speeds greater than 2 knots. Instead, there was an increase in wind observations from the northwest quadrant. A similar observation was made for 2009, 2010, and 2011 in previous NMP reports.

Figure 18-12. Wind Roses for the Somerville-Somerset Airport Weather Station near CHNJ


Location of CHNJ and Weather Station

2002-2011 Historical Wind Rose

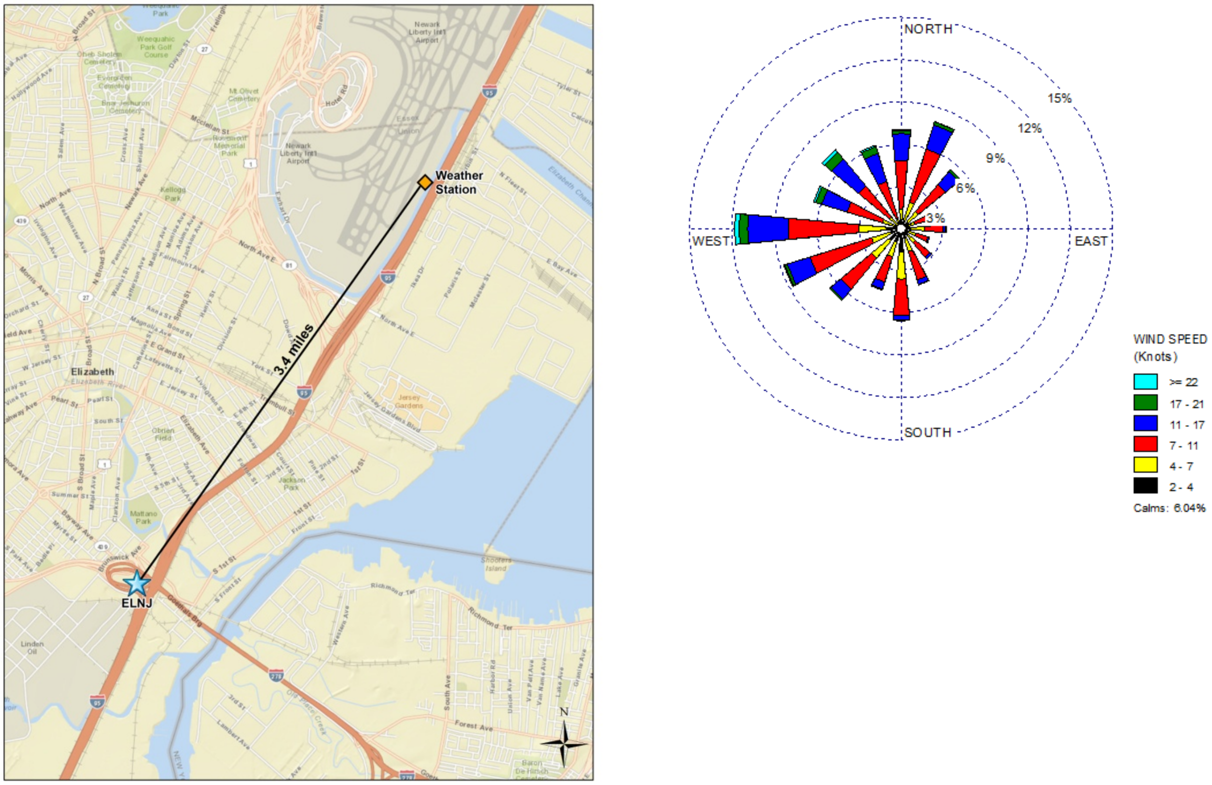

2012 Wind Rose

Sample Day Wind Rose

Figure 18-13. Wind Roses for the Newark International Airport Weather Station near ELNJ

Location of ELNJ and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

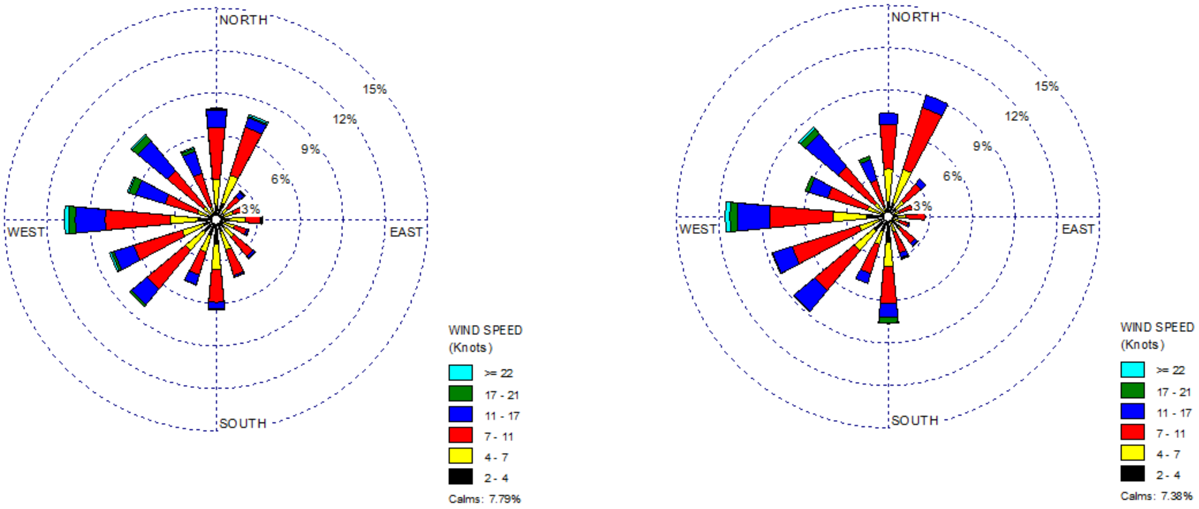
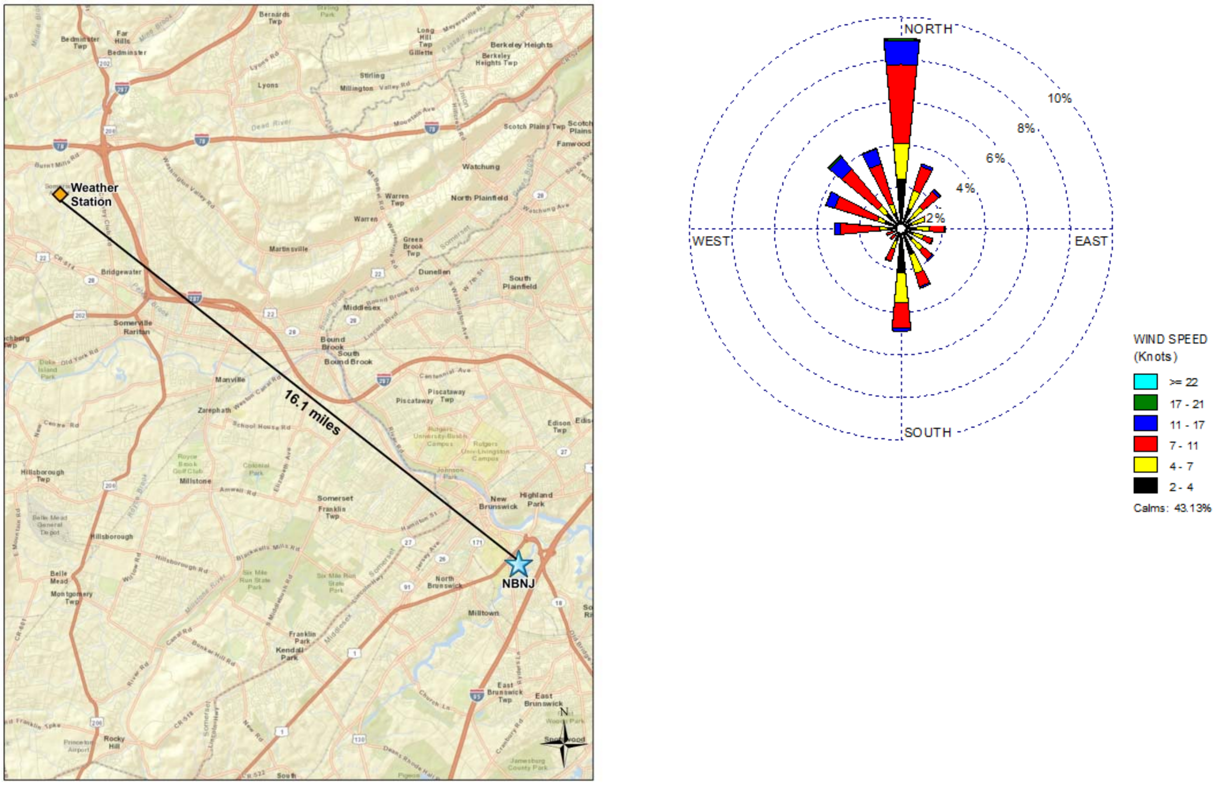
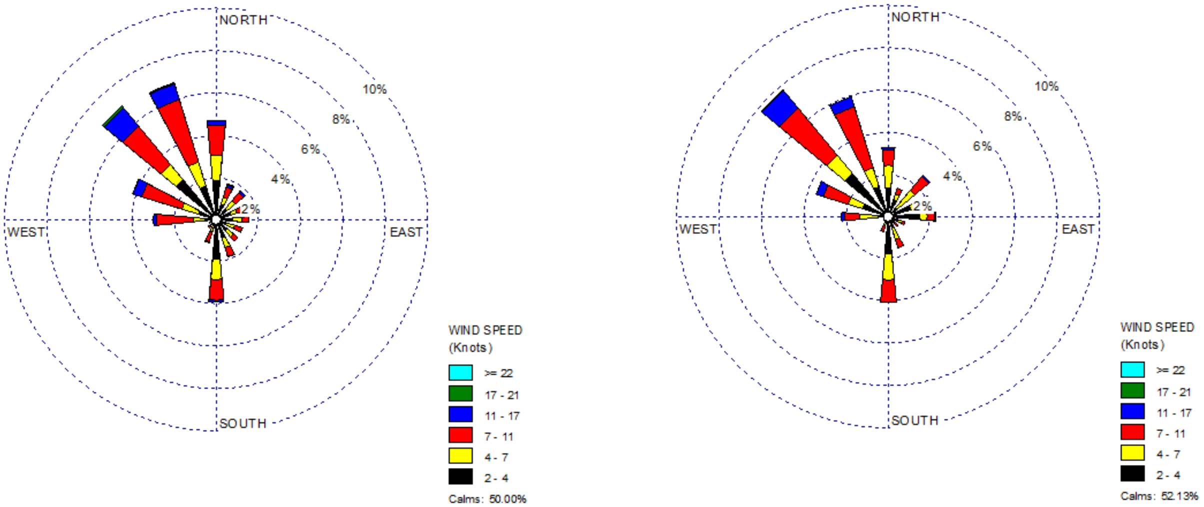


Figure 18-14. Wind Roses for the Somerville-Somerset Airport Weather Station near NBNJ


Location of NBNJ and Weather Station

2002-2011 Historical Wind Rose


2012 Wind Rose

Sample Day Wind Rose

Observations from Figure 18-13 for ELNJ include the following:

- The Newark International Airport weather station is located 3.4 miles north-northeast of ELNJ.
- The historical wind rose shows that winds from a variety of directions were observed near ELNJ, although winds from the east-northeast to southeast were observed infrequently. Calm winds account for 6 percent of observations. The strongest winds were associated with westerly to northwesterly winds.
- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns, indicating that wind conditions observed throughout 2012 were similar to those observed historically. This is also true for the sample day wind rose.

18.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each New Jersey monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 18-4. Pollutants of interest are those for which the individual pollutant’s total failed screens contribute to the top 95 percent of the site’s total failed screens and are shaded in gray in Table 18-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. All three New Jersey sites sampled for VOCs and carbonyl compounds.

Table 18-4. Risk-Based Screening Results for the New Jersey Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Chester, New Jersey - CHNJ						
Acetaldehyde	0.45	62	62	100.00	16.23	16.23
Formaldehyde	0.077	62	62	100.00	16.23	32.46
Benzene	0.13	61	61	100.00	15.97	48.43
Carbon Tetrachloride	0.17	61	61	100.00	15.97	64.40
1,2-Dichloroethane	0.038	58	58	100.00	15.18	79.58
1,3-Butadiene	0.03	43	51	84.31	11.26	90.84
Hexachloro-1,3-butadiene	0.045	12	14	85.71	3.14	93.98
1,1,2,2-Tetrachloroethane	0.017	9	9	100.00	2.36	96.34
1,2-Dibromoethane	0.0017	7	7	100.00	1.83	98.17
p-Dichlorobenzene	0.091	4	36	11.11	1.05	99.21
Chloroprene	0.0021	1	1	100.00	0.26	99.48
Ethylbenzene	0.4	1	61	1.64	0.26	99.74
Propionaldehyde	0.8	1	62	1.61	0.26	100.00
Total		382	545	70.09		
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	0.45	61	61	100.00	14.12	14.12
Benzene	0.13	61	61	100.00	14.12	28.24
1,3-Butadiene	0.03	61	61	100.00	14.12	42.36
Carbon Tetrachloride	0.17	61	61	100.00	14.12	56.48
Formaldehyde	0.077	61	61	100.00	14.12	70.60
1,2-Dichloroethane	0.038	55	55	100.00	12.73	83.33
Ethylbenzene	0.4	27	60	45.00	6.25	89.58
p-Dichlorobenzene	0.091	19	51	37.25	4.40	93.98
Propionaldehyde	0.8	11	61	18.03	2.55	96.53
Hexachloro-1,3-butadiene	0.045	6	7	85.71	1.39	97.92
1,1,2,2-Tetrachloroethane	0.017	5	5	100.00	1.16	99.07
1,2-Dibromoethane	0.0017	2	2	100.00	0.46	99.54
Chloroprene	0.0021	1	1	100.00	0.23	99.77
Trichloroethylene	0.2	1	30	3.33	0.23	100.00
Total		432	577	74.87		
North Brunswick, New Jersey - NBNJ						
Benzene	0.13	60	60	100.00	15.04	15.04
Carbon Tetrachloride	0.17	60	60	100.00	15.04	30.08
Formaldehyde	0.077	60	60	100.00	15.04	45.11
Acetaldehyde	0.45	59	60	98.33	14.79	59.90
1,3-Butadiene	0.03	58	60	96.67	14.54	74.44
1,2-Dichloroethane	0.038	58	58	100.00	14.54	88.97
Hexachloro-1,3-butadiene	0.045	12	14	85.71	3.01	91.98
1,1,2,2-Tetrachloroethane	0.017	10	10	100.00	2.51	94.49
p-Dichlorobenzene	0.091	9	41	21.95	2.26	96.74
1,2-Dibromoethane	0.0017	7	7	100.00	1.75	98.50
Ethylbenzene	0.4	5	60	8.33	1.25	99.75
Trichloroethylene	0.2	1	25	4.00	0.25	100.00
Total		399	515	77.48		

Observations from Table 18-4 include the following:

- Thirteen pollutants failed at least one screen for CHNJ; 70 percent of concentrations for these 13 pollutants were greater than their associated risk screening value (or failed screens).
- Eight pollutants contributed to 95 percent of failed screens for CHNJ and therefore were identified as pollutants of interest for this site. These eight include two carbonyl compounds and six VOCs.
- Fourteen pollutants failed at least one screen for ELNJ, with nearly 75 percent of concentrations for these 14 pollutants greater than their associated risk screening value.
- Nine pollutants contributed to 95 percent of failed screens for ELNJ and therefore were identified as pollutants of interest for this site. These nine include three carbonyl compounds and six VOCs.
- Twelve pollutants failed at least one screen for NBNJ, with 77 percent of concentrations for these 12 pollutants greater than their associated risk screening value.
- Nine pollutants contributed to 95 percent of failed screens for NBNJ and therefore were identified as pollutants of interest for this site. These nine include two carbonyl compounds and seven VOCs.
- CHNJ, ELNJ, and NBNJ have six pollutants of interest in common: acetaldehyde, formaldehyde, benzene, carbon tetrachloride, 1,3-butadiene, and 1,2-dichloroethane. Of these, benzene, carbon tetrachloride, formaldehyde, and 1,2-dichloroethane failed 100 percent of screens for each site.

18.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the New Jersey monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.
- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for the three New Jersey monitoring sites are provided in Appendices J and L.

18.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each New Jersey site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the New Jersey monitoring sites are presented in Table 18-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 18-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the New Jersey Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Chester, New Jersey - CHNJ						
Acetaldehyde	62/62	1.61 ± 0.59	1.45 ± 0.28	1.32 ± 0.24	1.67 ± 0.33	1.51 ± 0.18
Benzene	61/61	0.61 ± 0.08	0.67 ± 0.11	0.60 ± 0.24	0.67 ± 0.09	0.64 ± 0.07
1,3-Butadiene	51/61	0.03 ± 0.01	0.02 ± 0.01	0.05 ± 0.02	0.06 ± 0.02	0.04 ± 0.01
Carbon Tetrachloride	61/61	0.61 ± 0.09	0.71 ± 0.05	0.66 ± 0.03	0.70 ± 0.04	0.67 ± 0.03
1,2-Dichloroethane	58/61	0.08 ± 0.01	0.09 ± 0.01	0.06 ± 0.01	0.06 ± 0.01	0.07 ± 0.01
Formaldehyde	62/62	2.23 ± 0.39	2.55 ± 0.83	3.44 ± 0.80	1.46 ± 0.31	2.46 ± 0.35
1,1,2,2-Tetrachloroethane	9/61	0.01 ± 0.01	0.01 ± 0.02	0.01 ± 0.01	<0.01 ± <0.01	0.01 ± 0.01
Hexachloro-1,3-butadiene	14/61	0.02 ± 0.02	0.02 ± 0.02	0.02 ± 0.02	0.01 ± 0.01	0.02 ± 0.01
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	61/61	2.31 ± 0.46	2.20 ± 0.62	3.36 ± 0.69	2.71 ± 0.89	2.66 ± 0.34
Benzene	61/61	1.02 ± 0.15	0.91 ± 0.33	0.97 ± 0.15	1.28 ± 0.44	1.04 ± 0.14
1,3-Butadiene	61/61	0.14 ± 0.03	0.08 ± 0.02	0.14 ± 0.04	0.20 ± 0.05	0.14 ± 0.02
Carbon Tetrachloride	61/61	0.57 ± 0.10	0.74 ± 0.03	0.68 ± 0.03	0.70 ± 0.02	0.67 ± 0.03
p-Dichlorobenzene	51/61	0.06 ± 0.02	0.07 ± 0.03	0.09 ± 0.03	0.07 ± 0.05	0.07 ± 0.02
1,2-Dichloroethane	55/61	0.09 ± 0.02	0.09 ± 0.01	0.07 ± 0.01	0.06 ± 0.02	0.08 ± 0.01
Ethylbenzene	60/61	0.34 ± 0.07	0.34 ± 0.08	0.46 ± 0.07	0.50 ± 0.17	0.41 ± 0.05
Formaldehyde	61/61	2.98 ± 0.46	3.50 ± 1.01	5.51 ± 1.08	3.47 ± 0.63	3.89 ± 0.47
Propionaldehyde	61/61	0.35 ± 0.09	0.48 ± 0.14	0.74 ± 0.16	0.49 ± 0.17	0.52 ± 0.08

Table 18-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the New Jersey Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
North Brunswick, New Jersey - NBNJ						
Acetaldehyde	60/60	1.97 ± 0.43	1.20 ± 0.33	1.37 ± 0.22	1.10 ± 0.19	1.41 ± 0.17
Benzene	60/60	0.76 ± 0.11	0.94 ± 0.49	0.68 ± 0.07	1.06 ± 0.15	0.86 ± 0.12
1,3-Butadiene	60/60	0.06 ± 0.02	0.07 ± 0.01	0.09 ± 0.02	0.14 ± 0.03	0.09 ± 0.01
Carbon Tetrachloride	60/60	0.62 ± 0.07	0.70 ± 0.06	0.67 ± 0.04	0.70 ± 0.03	0.67 ± 0.03
p-Dichlorobenzene	41/60	0.03 ± 0.02	0.05 ± 0.03	0.07 ± 0.02	0.06 ± 0.03	0.05 ± 0.01
1,2-Dichloroethane	58/60	0.08 ± 0.01	0.08 ± 0.02	0.08 ± 0.01	0.07 ± 0.01	0.08 ± 0.01
Formaldehyde	60/60	1.53 ± 0.27	1.89 ± 0.73	2.64 ± 0.62	1.26 ± 0.15	1.82 ± 0.26
Hexachloro-1,3-butadiene	14/60	0.02 ± 0.02	0.02 ± 0.03	0.03 ± 0.03	<0.01 ± 0.01	0.02 ± 0.01
1,1,2,2-Tetrachloroethane	10/60	0.01 ± 0.01	0.02 ± 0.02	0.01 ± 0.01	0	0.01 ± 0.01

Observations for CHNJ from Table 18-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde and acetaldehyde. These are the two pollutants with annual average concentrations greater than 1 $\mu g/m^3$.

- Concentrations of formaldehyde were lowest during the fourth quarter of 2012. Three of the four concentrations less than 1 $\mu g/m^3$ were measured in December. Further, seven of the 13 concentrations less than 1.5 $\mu g/m^3$ were measured at CHNJ during the fourth quarter of the year (with none measured during the first quarter and three each measured in the second and third quarters). Conversely, eight of the 10 measurements greater than 4 $\mu g/m^3$ were measured in July or August, and are reflected in the higher third quarter average.

- The quarterly average concentrations of benzene are fairly similar to each other, but the confidence interval for the third quarter average is two to three times higher than the other confidence intervals. A review of the data shows that the two highest benzene concentrations were both measured in July. Benzene concentrations measured during the third quarter range from 0.371 $\mu g/m^3$ to 2.35 $\mu g/m^3$. This range is more than three times greater than the range of concentrations measured in each of the other quarters.

- The quarterly average concentrations of acetaldehyde are also similar in magnitude to each other, but the confidence interval for the first quarter average is nearly twice the other confidence intervals. A review of the data shows that the maximum acetaldehyde concentration was measured on March 28, 2012 (5.38 µg/m^3) and is more than twice the next highest concentration measured at CHNJ. This is explains the higher variability in the first quarter measurements reflected by the confidence intervals.

Observations for ELNJ from Table 18-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde, acetaldehyde, and benzene. These are the only pollutants with annual average concentrations greater than 1 µg/m^3.

- The concentrations of the carbonyl compound pollutants of interest for ELNJ appear higher during the warmer months of the year, as illustrated by the third quarter average concentrations, particularly for formaldehyde. However, the differences are not statistically significant.

- Concentrations of several of the VOCs appear highest during the fourth quarter. Although not significantly different, the fourth quarter averages of benzene, ethylbenzene, and 1,3-butadiene are higher than the other quarterly averages and have relatively large confidence intervals. A review of the data shows that the maximum concentration of each of these pollutants was measured on the same sample day, November 23, 2012. “Higher” concentrations of these pollutants were also measured on samples collected on November 11, 2012 and October 18, 2012 for each of these pollutants. The maximum concentrations of acetaldehyde and propionaldehyde were also collected on November 11, 2012 at ELNJ.

Observations for NBNJ from Table 18-5 include the following:

- The pollutants of interest with the highest annual average concentrations are formaldehyde and acetaldehyde. These are the only pollutants with annual average concentrations greater than 1 µg/m^3.

- Concentrations of formaldehyde appear higher during the warmer months of the year, although the differences among the quarterly averages are not statistically significant. A review of the data shows that the two highest concentrations of formaldehyde (those greater than 5 µg/m^3) were measured in June and July; further, 16 of the 18 formaldehyde concentrations greater than 2 µg/m^3 were measured during the second and third quarters of the year.

- Even though the highest quarterly average concentration of benzene was calculated for the fourth quarter, the confidence interval for the second quarter average concentration is considerably higher than the confidence intervals for the other quarterly averages. This indicates a relatively high level of variability associated with the second quarter measurements. A review of the data shows that the maximum concentration of benzene was measured on April 3, 2012 (4.00 µg/m^3). The next seven highest concentrations were all measured during the fourth quarter and were all less than 2 µg/m^3. Aside from the maximum concentration, the concentrations measured during the second quarter of 2012 ranged from 0.545 µg/m^3 to 0.938 µg/m^3. Thus, it is the maximum concentration that is driving the large confidence interval for the second quarter average.

- The fourth quarter average 1,3-butadiene concentration is higher than the other quarterly averages (although not significantly so). A review of the data shows that the three highest concentrations were all measured during the fourth quarter of 2012; further, of the 18 concentrations greater than 0.1 µg/m^3, 12 were measured during the fourth quarter (with two in the first quarter, one in the second quarter, and three in the third quarter).

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the New Jersey sites from those tables include the following:

- The New Jersey sites appear in Table 4-9 for VOCs a total of nine times (CHNJ, once; ELNJ, six times; and NBNJ, twice). At least one New Jersey site appears among the rankings for each of the program-level pollutants of interest except carbon tetrachloride. All three New Jersey sites appear for hexachloro-1,3-butadiene, with NBNJ ranking first for this pollutant.

- ELNJ appears in Table 4-10 for both carbonyl compounds. ELNJ has the fourth highest annual average concentration of formaldehyde and the fifth highest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds.

18.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 18-4 for each of the New Jersey sites. Figures 18-15 through 18-25 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 18-15. Program vs. Site-Specific Average Acetaldehyde Concentrations

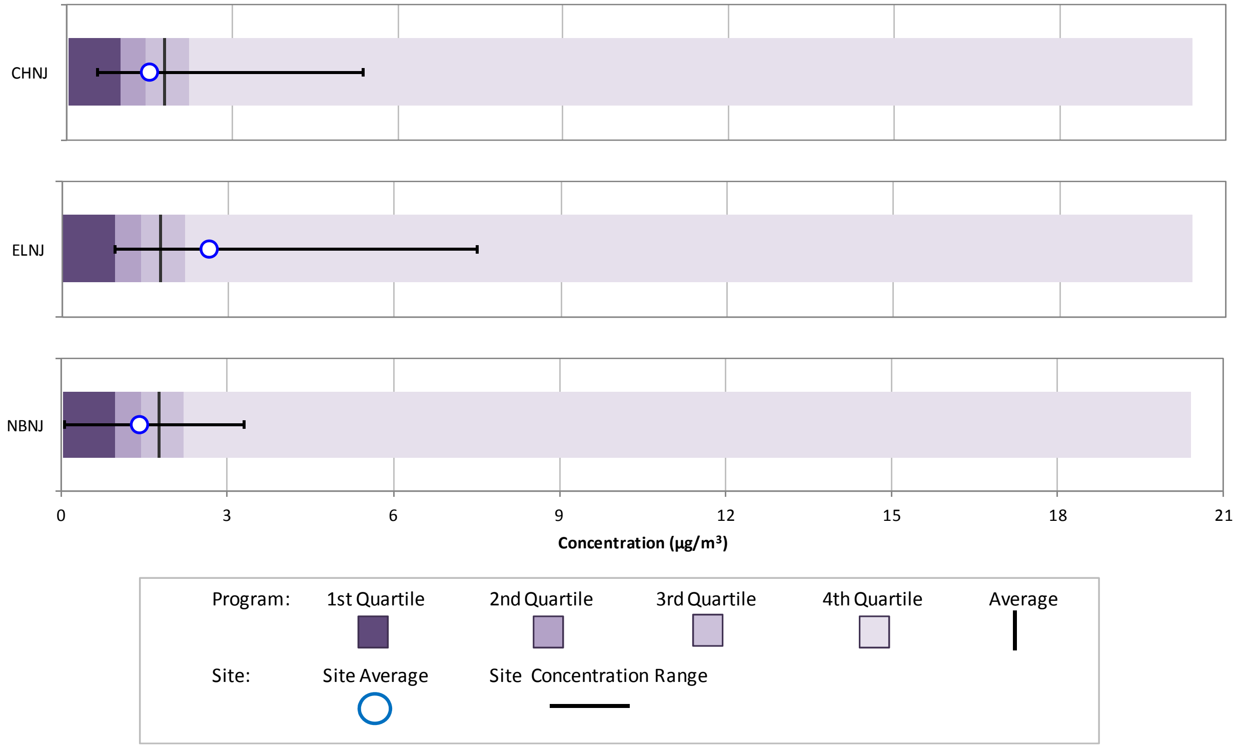


Figure 18-16. Program vs. Site-Specific Average Benzene Concentrations

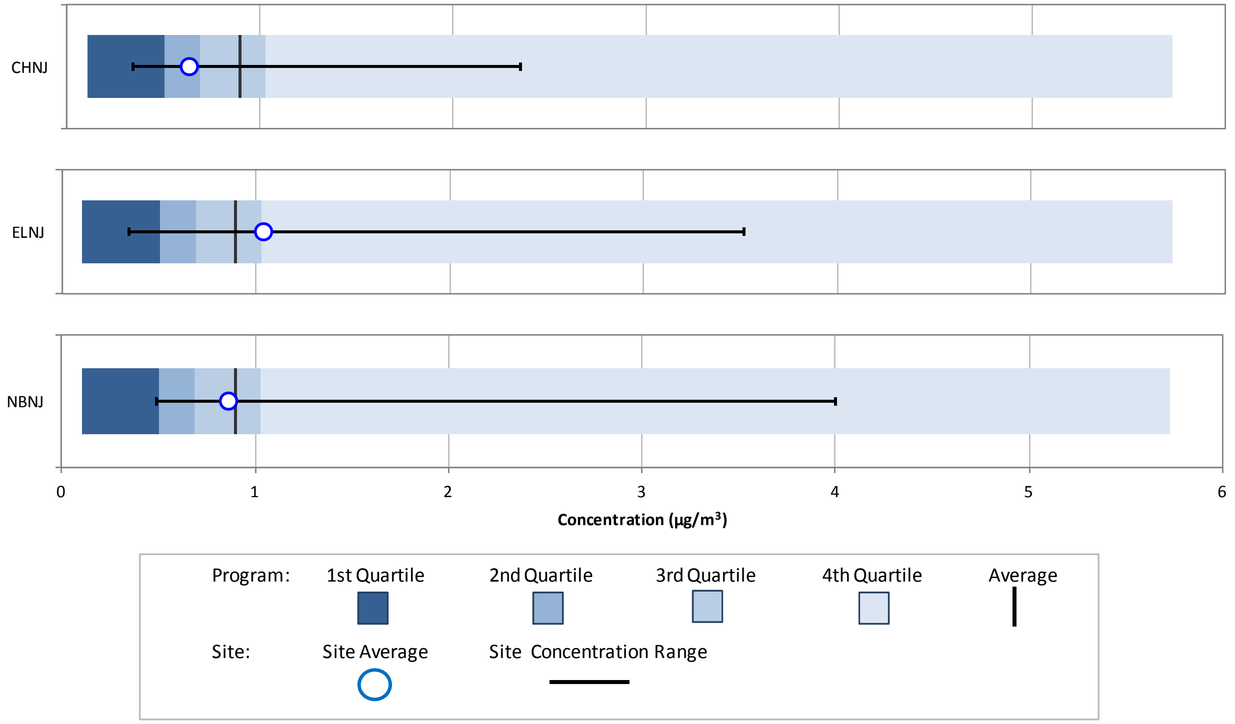


Figure 18-17. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

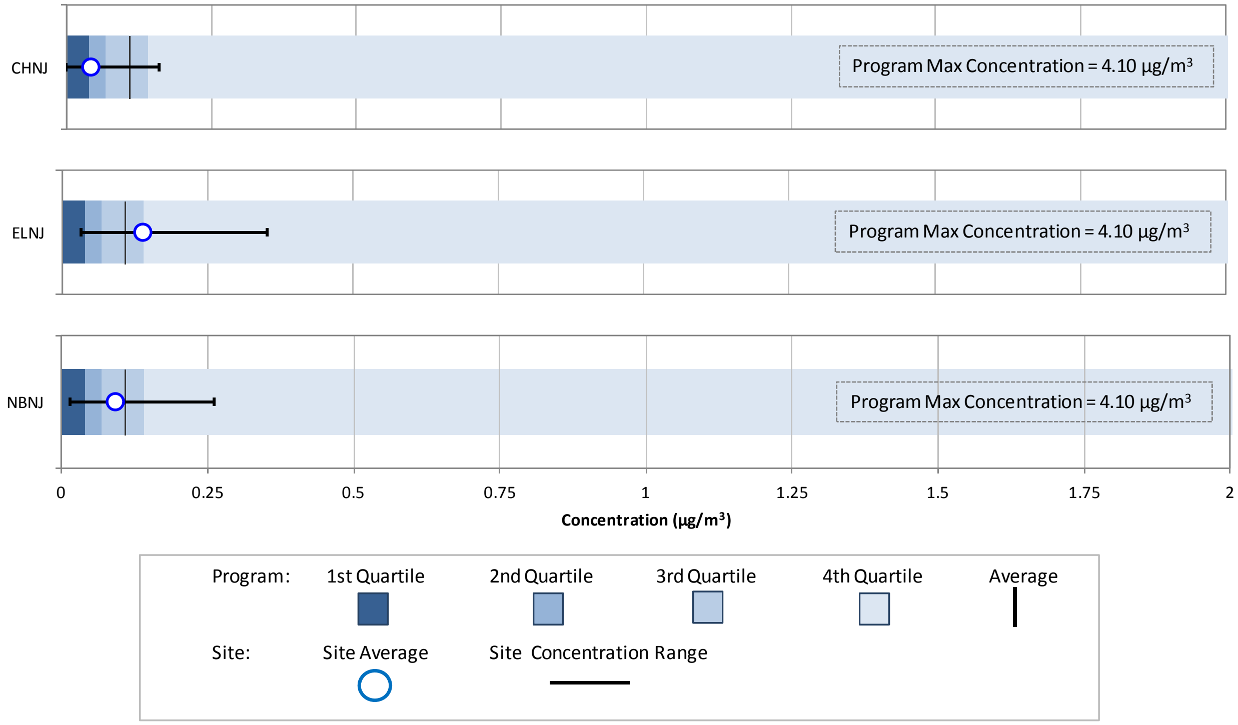


Figure 18-18. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

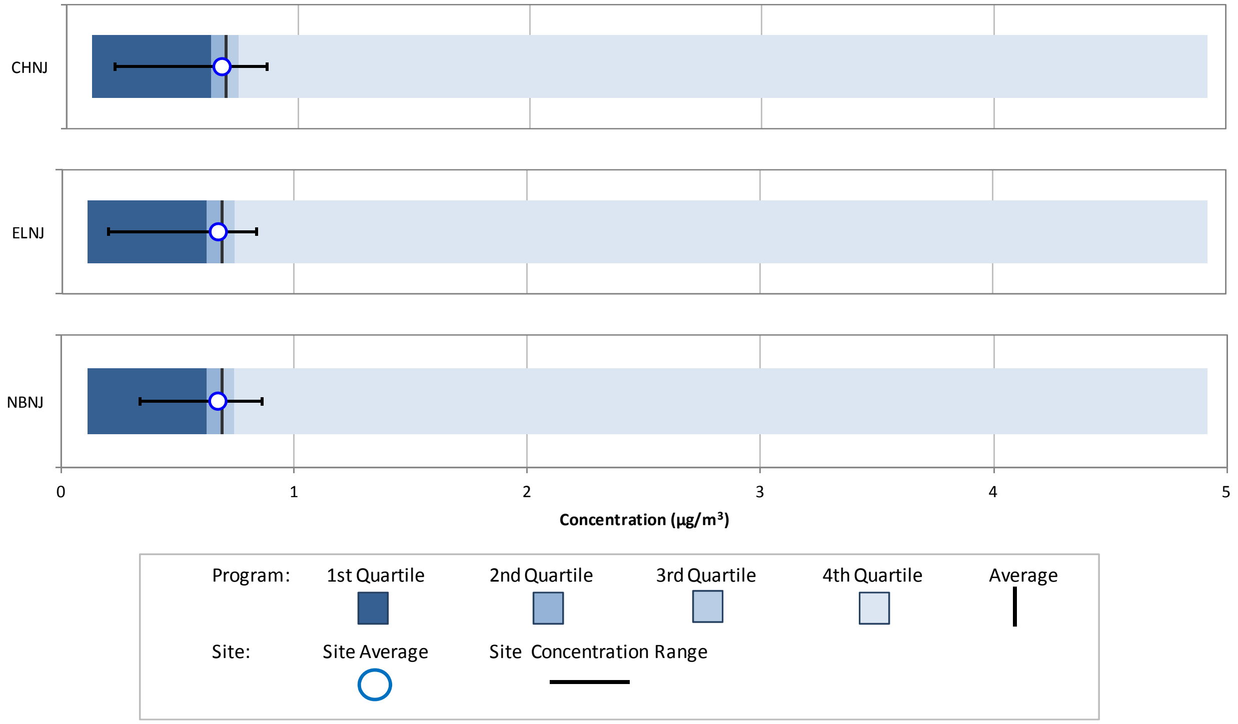


Figure 18-19. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentrations

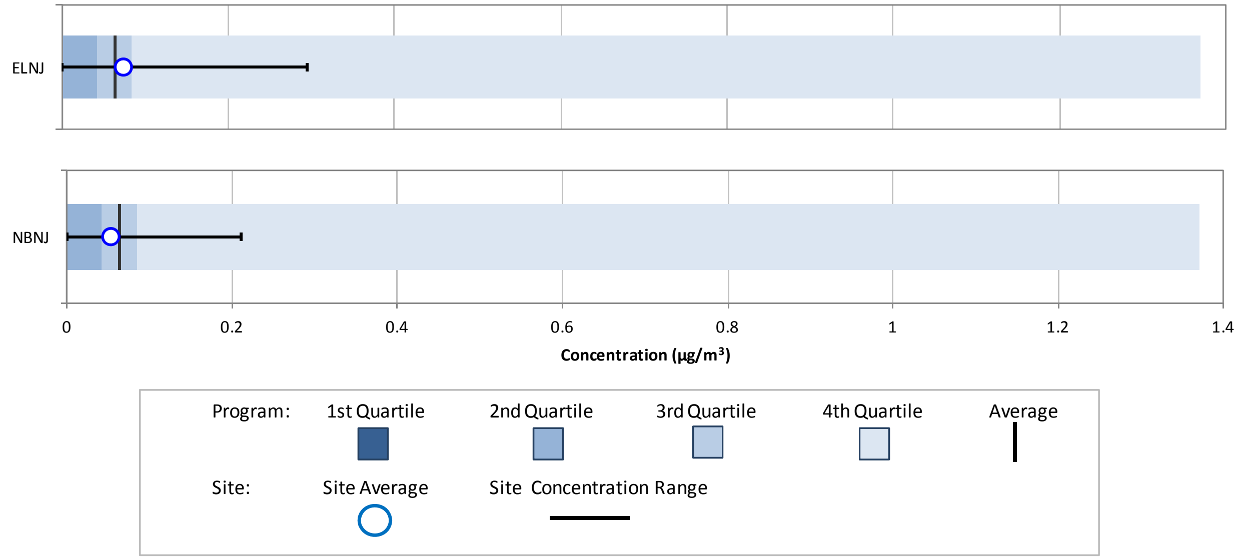


Figure 18-20. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

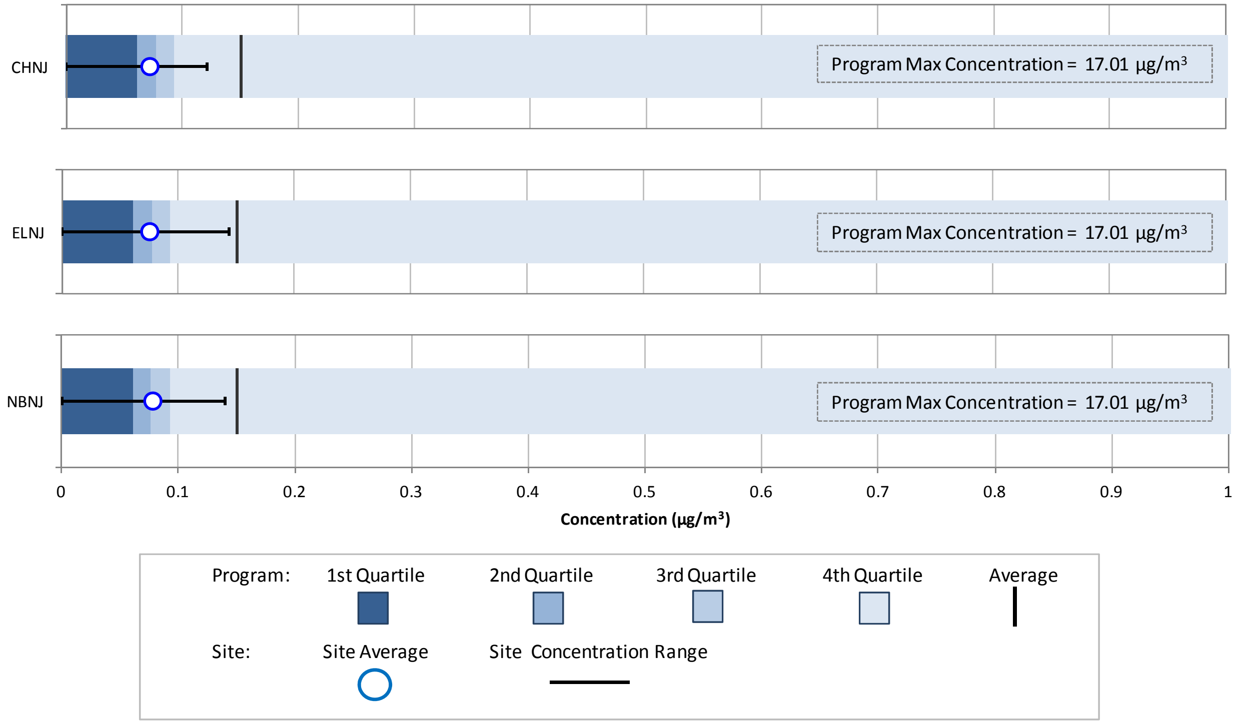


Figure 18-21. Program vs. Site-Specific Average Ethylbenzene Concentration

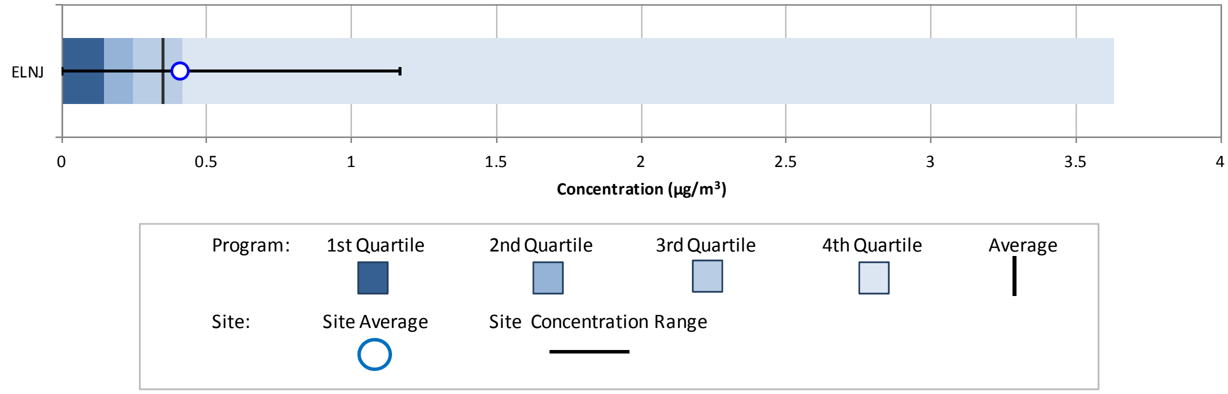


Figure 18-22. Program vs. Site-Specific Average Formaldehyde Concentrations

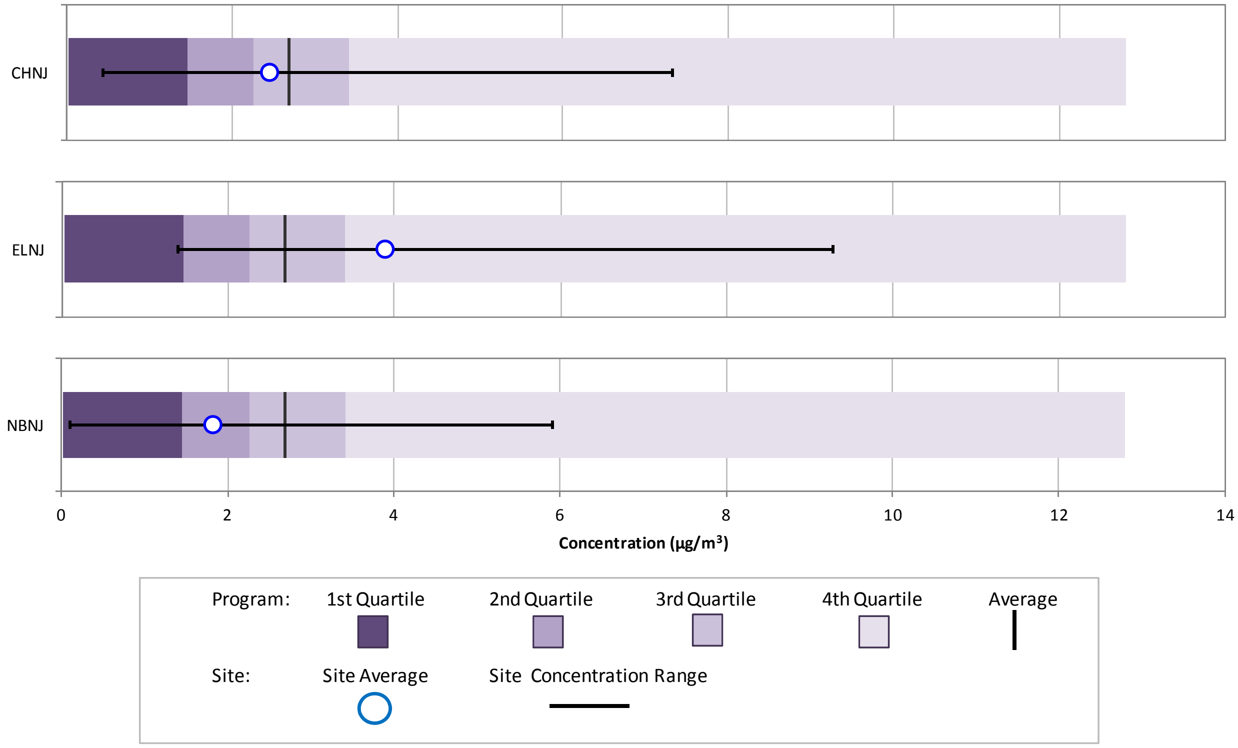


Figure 18-23. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentrations

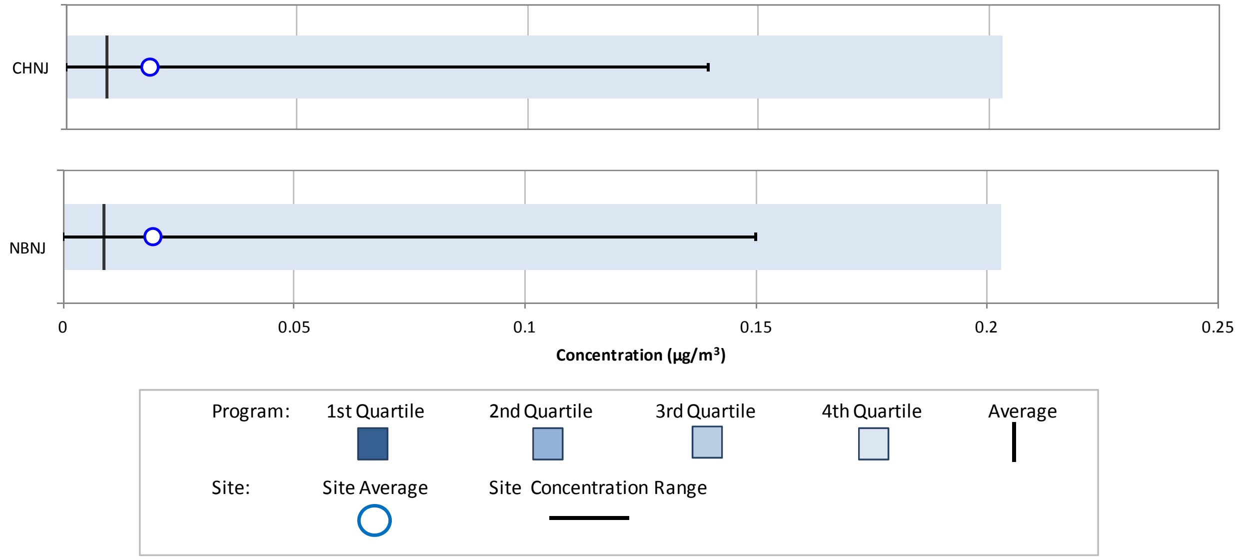


Figure 18-24. Program vs. Site-Specific Average Propionaldehyde Concentration

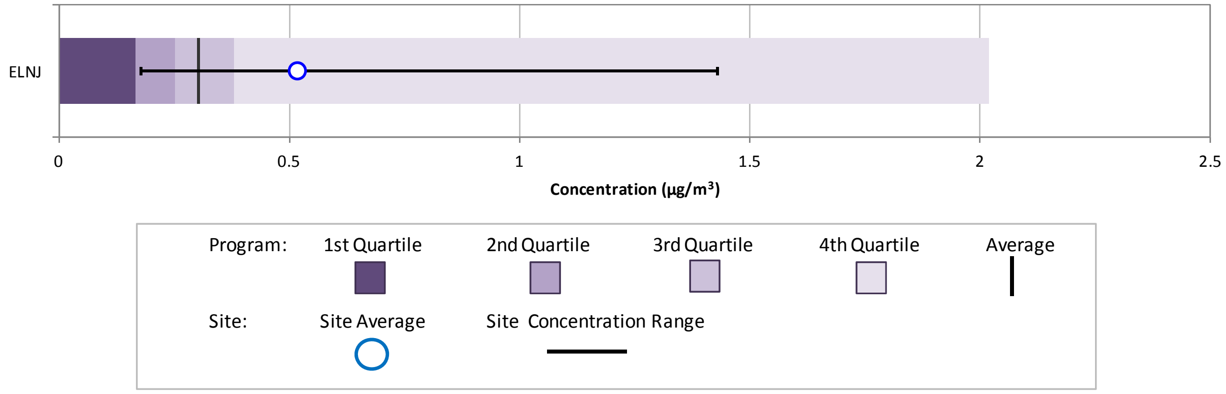
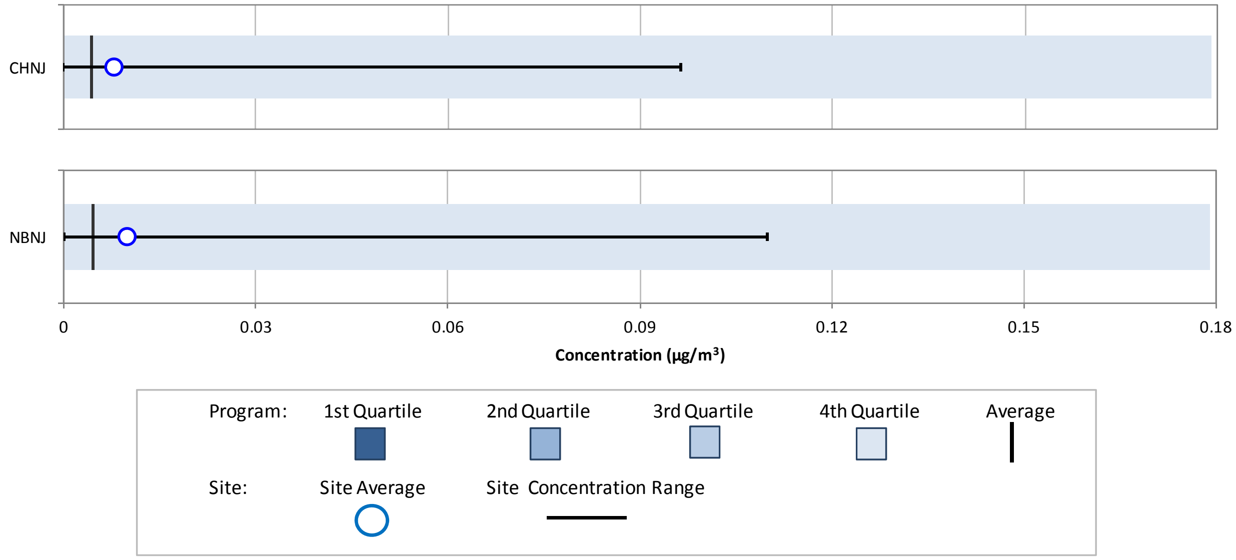


Figure 18-25. Program vs. Site-Specific Average 1,1,2,2-Tetrachloroethane Concentrations



Observations from Figures 18-15 through 18-25 include the following:

- Figure 18-15 for acetaldehyde shows all three sites. The range of acetaldehyde concentrations measured is largest at ELNJ and smallest at NBNJ. The annual average concentration for ELNJ is greater than the program-level average concentration as well as the program-level third quartile. The annual averages for CHNJ and NBNJ are less than the program-level average concentration and similar to the program-level median concentration. The minimum concentration measured at NBNJ is considerably less than the minimum concentration for the other two New Jersey sites. The minimum concentration measured at ELNJ is similar to the program-level first quartile.

- Figure 18-16 presents the box plots for benzene. Among the New Jersey sites, the smallest range of benzene measurements was measured at CHNJ. The annual average benzene concentration for CHNJ is less than the program-level median concentration. The annual average concentration for ELNJ is greater than the program-level average concentration and similar to the program-level third quartile. NBNJ's annual average benzene concentration is just less the program-level average concentration, even though the maximum benzene concentration among the New Jersey sites was measured at NBNJ. The minimum benzene concentration measured at NBNJ is similar to the program-level first quartile.

- Figure 18-17 presents the box plots for 1,3-butadiene. The program-level maximum concentration (4.10 µg/m^3) is not shown directly on the box plots as the scale has been reduced to 2 µg/m^3 to allow for the observation of data points at the lower end of the concentration range. Among the New Jersey sites, the smallest range of 1,3-butadiene concentrations was measured at CHNJ while the largest range was measured at ELNJ. However, the maximum concentration measured at all three sites is considerably less than the program-level maximum concentration. The annual average 1,3-butadiene concentration for CHNJ is greater than the program-level first quartile but less than the program-level median concentration. The annual average concentration for NBNJ is just less than the program-level average concentration but greater than the median concentration. ELNJ's annual average concentration is greater than the program-level average concentration and similar to the program-level third quartile. Ten non-detects were measured at CHNJ while none were measured at ELNJ or NBNJ.

- Figure 18-18 presents the box plots for carbon tetrachloride. The range of measurements collected at CHNJ and ELNJ are similar to each other, while the minimum concentration measured at NBNJ is higher than the other two sites. The annual average concentrations are the same for each of the New Jersey sites (0.67 µg/m^3) and are just less than both the program-level average and median concentrations. Note that the program-level median and average concentrations are very similar to each other (less than 0.005 µg/m^3 separates these two parameters).

- Figure 18-19 presents the box plots for *p*-dichlorobenzene for ELNJ and NBNJ, the two sites for which this is a pollutant of interest. Note that the program-level first quartile is zero and therefore not visible on the box plot. The minimum concentrations for both ELNJ and NBNJ are zero as non-detects were measured at these sites. The range of *p*-dichlorobenzene concentrations is slightly greater for ELNJ than NBNJ. The annual average concentration for NBNJ is just less than the program-level average concentration while the annual average concentration for ELNJ is just greater than the program-level average concentration (roughly 0.02 µg/m^3 separates these two annual averages).

- Figure 18-20 presents the box plots for 1,2-dichloroethane for all three sites. Similar to 1,3-butadiene, the program-level maximum concentration (17.01 µg/m^3) is not shown directly on the box plots as the scale has been reduced to 1 µg/m^3 to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is greater than the program-level third quartile for this pollutant and is greater than or similar to the maximum concentration measured at most sites sampling 1,2-dichloroethane. This is because the program-level average is being driven by the higher measurements collected at a few monitoring sites. Figure 18-20 shows that the maximum 1,2-dichloroethane concentrations measured at the New Jersey sites are two orders of magnitude less than the average concentration across the program. The annual averages for each site are similar to the median concentration measured at the program level. A few non-detects of 1,2-dichloroethane were measured at each New Jersey site.

- Figure 18-21 presents the box plot for ethylbenzene for ELNJ, the only site for which this is a pollutant of interest. The annual average concentration for ELNJ is just greater than the program-level average and similar to the program-level third quartile. A single non-detect of ethylbenzene was measured at ELNJ.

- Figure 18-22 presents the box plots for formaldehyde for all three sites. The annual average concentration of formaldehyde is greatest for ELNJ and lowest for NBNJ. The annual average for ELNJ is greater than both the program-level average concentration and third quartile. The annual average concentration for CHNJ is less than the program-level average but greater than the program-level median. The annual average concentration for NBNJ is less than both the program-level average and median concentrations. Similar to many of the other pollutants of interest for the New Jersey sites, the minimum concentration for ELNJ is just less than the program-level first quartile.

- Figure 18-23 presents the box plots for hexchloro-1,3-butadiene for CHNJ and NBNJ (this pollutant was not a pollutant of interest for ELNJ). Note that the first, second, and third quartiles for hexchloro-1,3-butadiene are zero at the program-level and therefore not visible on the box plots due to the large number of non-detects. The annual average hexchloro-1,3-butadiene concentrations for both sites are greater than the program-level average concentration. There were 14 measured detections collected at each of these sites. The range of hexachloro-1,3-butadiene measurements collected at CHNJ is fairly similar in magnitude to the range of measurements collected at NBNJ.

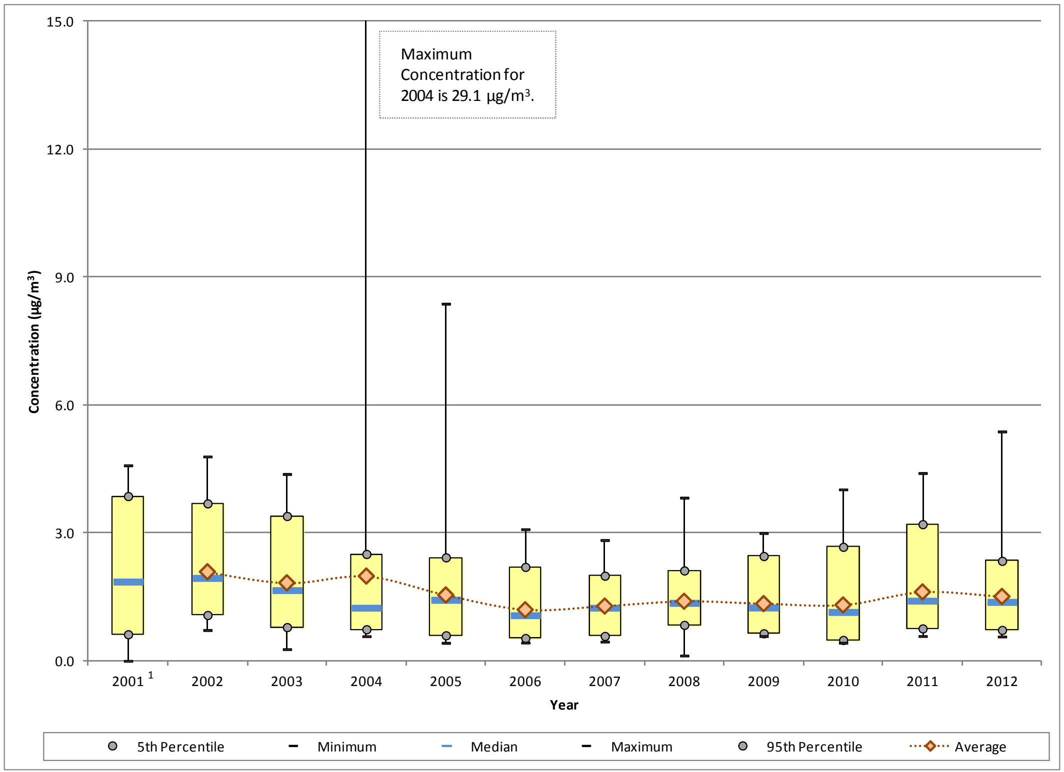
- Figure 18-24 presents the box plot for propionaldehyde for ELNJ. The minimum concentration measured at ELNJ is greater than the program-level first quartile. The annual average concentration for ELNJ is greater than both the program-level average and third quartile. ELNJ has the second highest annual average concentration of propionaldehyde among NMP sites sampling carbonyl compounds (second only to BTUT).

- Figure 18-25 presents the box plots for 1,1,2,2-tetrachloroethane for CHNJ and NBNJ. Note that the first, second, and third quartiles for 1,1,2,2-tetrachloroethane are zero at the program-level and therefore not visible on the box plots due to the large number of non-detects. The annual average 1,1,2,2-tetrachloroethane concentrations for both sites are greater than the program-level average concentration. There were nine measured detections collected at CHNJ and 10 collected at NBNJ.

18.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. CHNJ, ELNJ, and NBNJ have sampled VOCs and carbonyl compounds under the NMP for many years. ELNJ has sampled under the NMP since 2000 and CHNJ and NBNJ since 2001. Thus, Figures 18-26 through 18-51 present the 1-year statistical metrics for each of the pollutants of interest first for CHNJ, then for ELNJ and NBNJ. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 18-26. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at CHNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-26 for acetaldehyde measurements collected at CHNJ include the following:

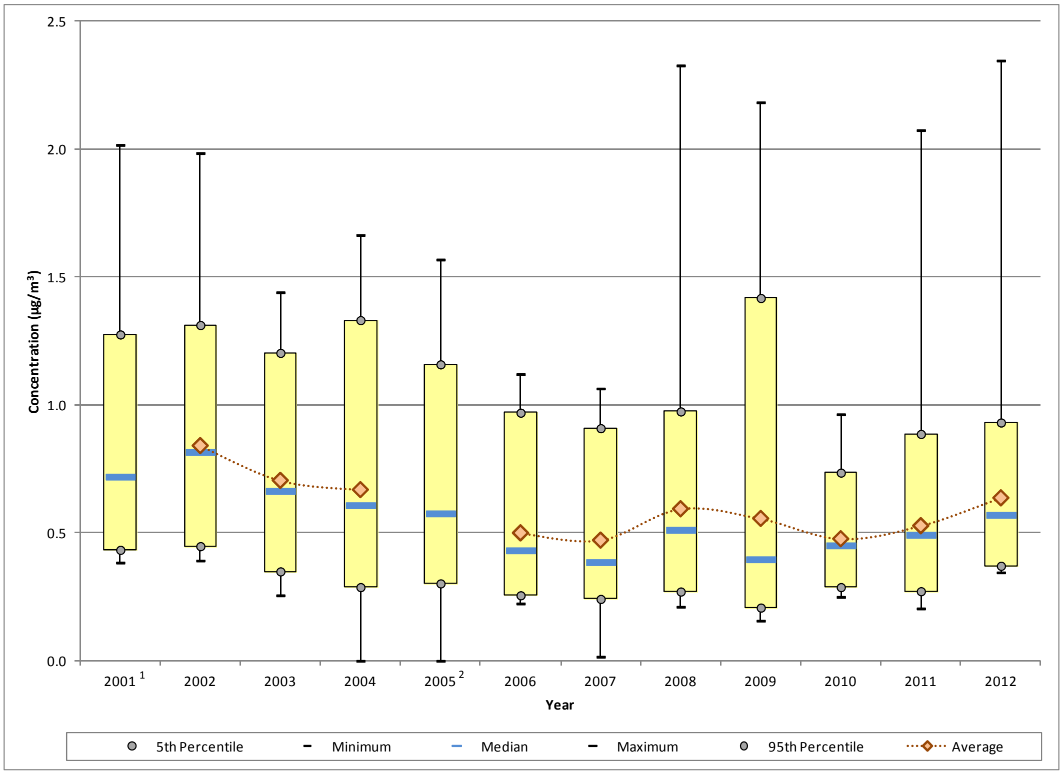
- Sampling for carbonyl compounds under the NMP began at CHNJ in May 2001. Because a full year's worth of data is not available for 2001, a 1-year average is not presented, although the range of measurements is provided.

- The maximum acetaldehyde concentration was measured on June 2, 2004 (29.1 µg/m^3). The second highest concentration was also measured in 2004 (11.5 µg/m^3). Only two additional acetaldehyde concentrations greater than 5 µg/m^3 have been measured at CHNJ, one in 2005 (8.38 µg/m^3) and one in 2012 (5.38 µg/m^3).

- An overall decreasing trend in the 1-year average and median concentrations is shown though 2006, after which the median and average concentrations leveled out through 2010. Note that the high concentrations measured in 2004 and 2005 result in confidence intervals that are relatively large.

- The maximum and 95th percentile increased from 2009 to 2010 and again in 2011. All of the statistical metrics exhibit an increase from 2010 to 2011. Although the maximum concentration increased again for 2012, the 95th percentile decreased nearly 1 µg/m^3, indicating that fewer concentrations at the upper end of the range were measured in 2012. The second highest concentration measured in 2012 is half the magnitude of the maximum concentration for 2012.

Figure 18-27. Yearly Statistical Metrics for Benzene Concentrations Measured at CHNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.
[2] A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 18-27 for benzene measurements collected at CHNJ include the following:

- Similar to carbonyl compounds, sampling for VOCs under the NMP began at CHNJ in May 2001. Because a full year's worth of data is not available, a 1-year average is not presented, although the range of measurements is provided. In addition, a 1-year average for 2005 is not provided due to completeness less than 85 percent.

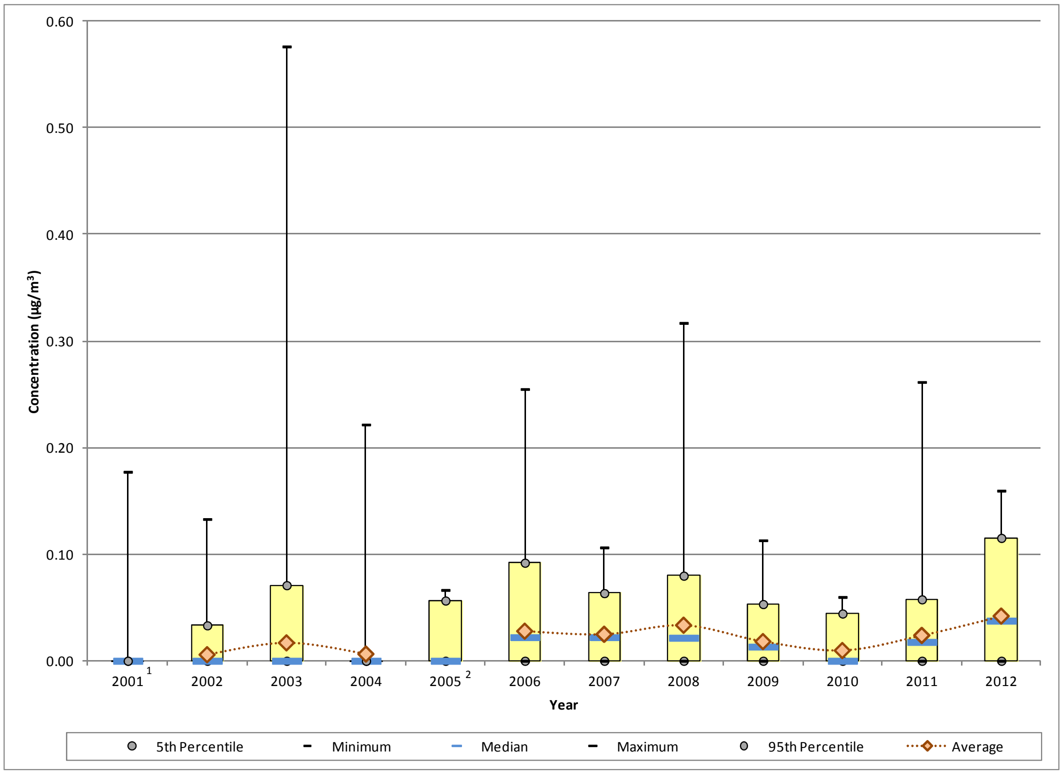
- The maximum benzene concentration measured at CHNJ was measured in 2012 (2.35 µg/m^3), although a similar concentration was also measured in 2008. Only eight benzene concentrations greater than 2 µg/m^3 have been measured at CHNJ since the onset of sampling (one was measured in 2001, two in 2008, three in 2009, and one each in 2011 and 2012).

- The 1-year average and median concentrations exhibit a decreasing trend through 2007, although no 1-year average is shown for 2001 or 2005. Even though an increase in the 1-year average concentration is shown from 2007 to 2008, this increase is being driven not by the three measurements greater than 1 µg/m^3 but by the measurements in the middle of the concentration range. This evident from the increase shown in the median concentration. The number of concentrations between 0.5 µg/m^3 and 0.75 µg/m^3 doubled from 10 to 20 in 2008.

- Even though the 1-year average and median concentrations exhibit decreases from 2008 to 2009, the 95th percentile is at a maximum for 2009. This is also true for the difference between the 5th and 95th percentiles, or the range within which the majority of concentrations fall. Conversely, the difference between the 5th and 95th percentiles is at a minimum for 2010.

- An increase in the 1-year average, median, 95th percentile, and maximum concentration is shown from 2010 to 2011 and again for 2012. Additional years of sampling are needed to determine if this trend continues.

Figure 18-28. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at CHNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.
[2] A 1-year average is not presented due to low completeness in 2005.

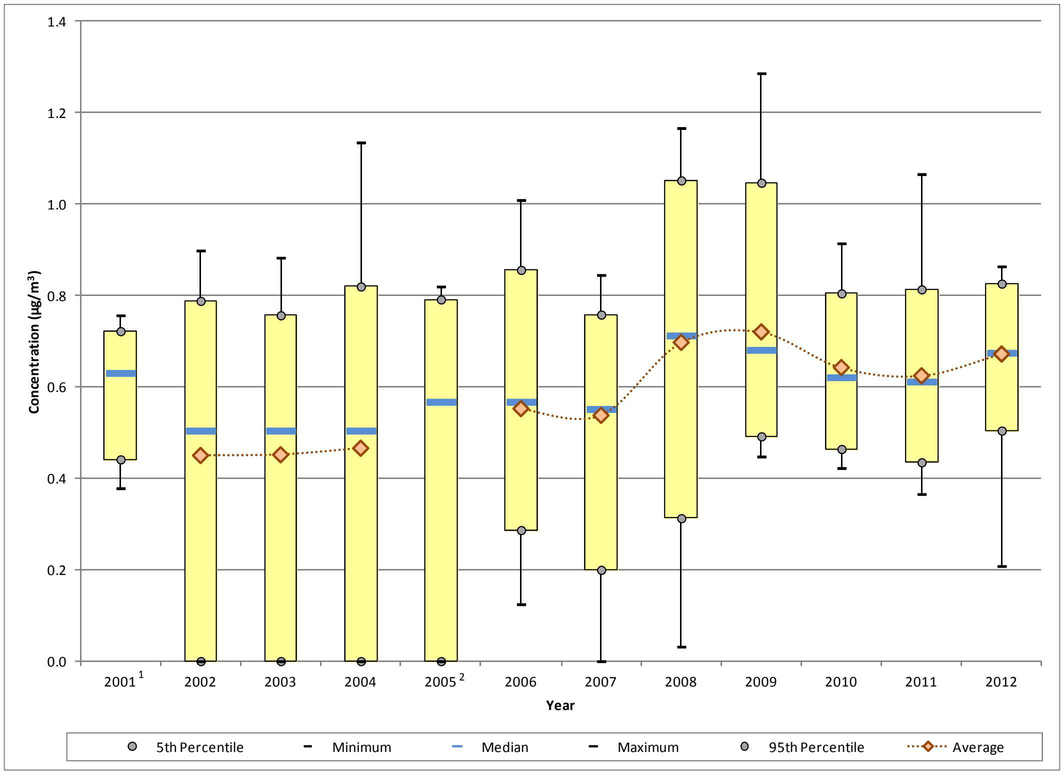
Observations from Figure 18-28 for 1,3-butadiene measurements collected at CHNJ include the following:

- The maximum 1,3-butadiene concentration was measured in 2003 and is nearly twice the next highest concentration, which was measured in 2008. Only five 1,3-butadiene concentrations measured at CHNJ are greater than 0.2 µg/m^3.

- For 2001 and 2004, the minimum, 5th percentile, median, and 95th percentile are all zero. This is because the percentage of non-detects was greater than 95 percent for these years. More than 50 percent of the measurements were non-detects between 2001 and 2005 (as well as 2010), as indicated by the median concentration. The percentage of non-detects decreased steadily between 2004 (96 percent) and 2008, when the percentage of non-detects reached a minimum of 17 percent. After 2008, an increasing number of non-detects was reported. After 2010, the number of non-detects began decreasing again, dropping to 18 percent for 2012.

- The 1-year average and median concentrations have a decreasing trend from 2008 through 2010 and then an increasing trend through 2012. These changes correspond with the changes in the number of non-detects/measured detections discussed above.

Figure 18-29. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at CHNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.
[2] A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 18-29 for carbon tetrachloride measurements collected at CHNJ include the following:

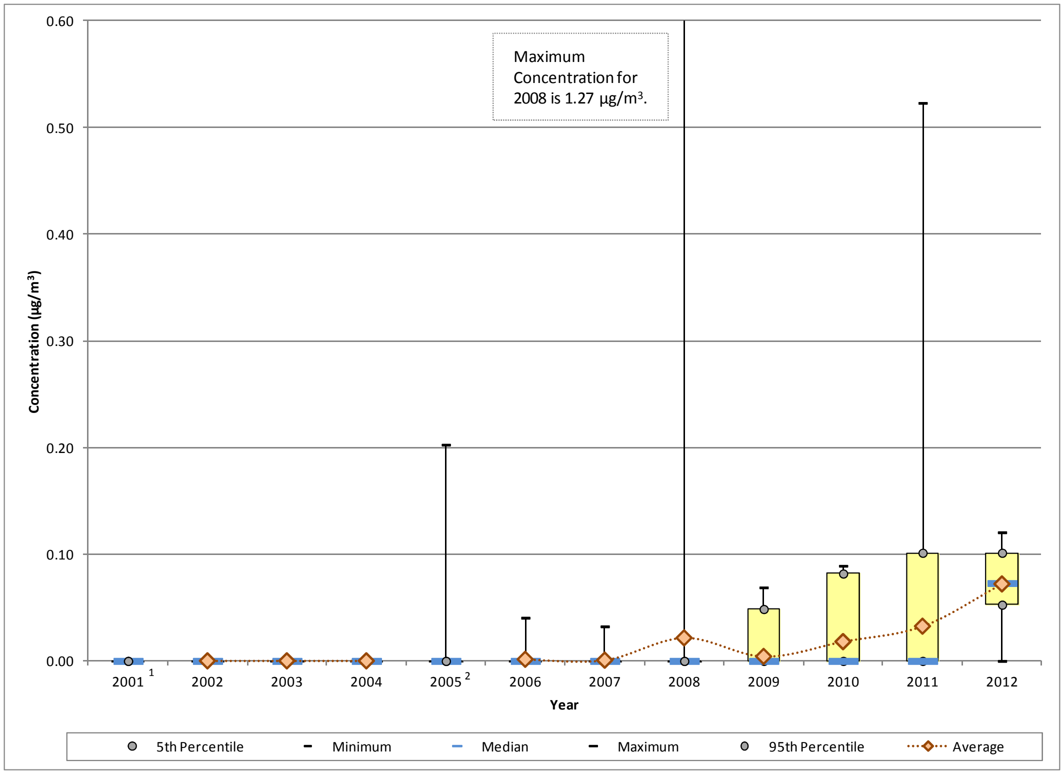
- The range of carbon tetrachloride measurements increased significantly from 2001 to 2002. This is predominantly due to a few non-detects that were measured between 2002 and 2005. After 2005, only one non-detect was reported.

- All of the statistical parameters exhibit an increase from 2007 to 2008. The 95th percentile for 2007 is just greater than the 1-year average and median concentrations for 2008. There were 14 measurements in 2008 that were greater than the maximum concentration measured in 2007. The number of measurements greater than 0.6 µg/m^3 doubled from 2007 to 2008.

- The minimum concentration measured in 2009 increased by an order of magnitude. Although the 1-year average increased slightly from 2008 to 2009, the median concentration decreased slightly. The decreasing trend in the median concentration continues through 2011. The 1-year average exhibits a similar trend.

- Although the minimum concentration decreased from 2011 to 2012, the 5th percentile is at a maximum for 2012.

Figure 18-30. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at CHNJ



Maximum Concentration for 2008 is 1.27 µg/m³.

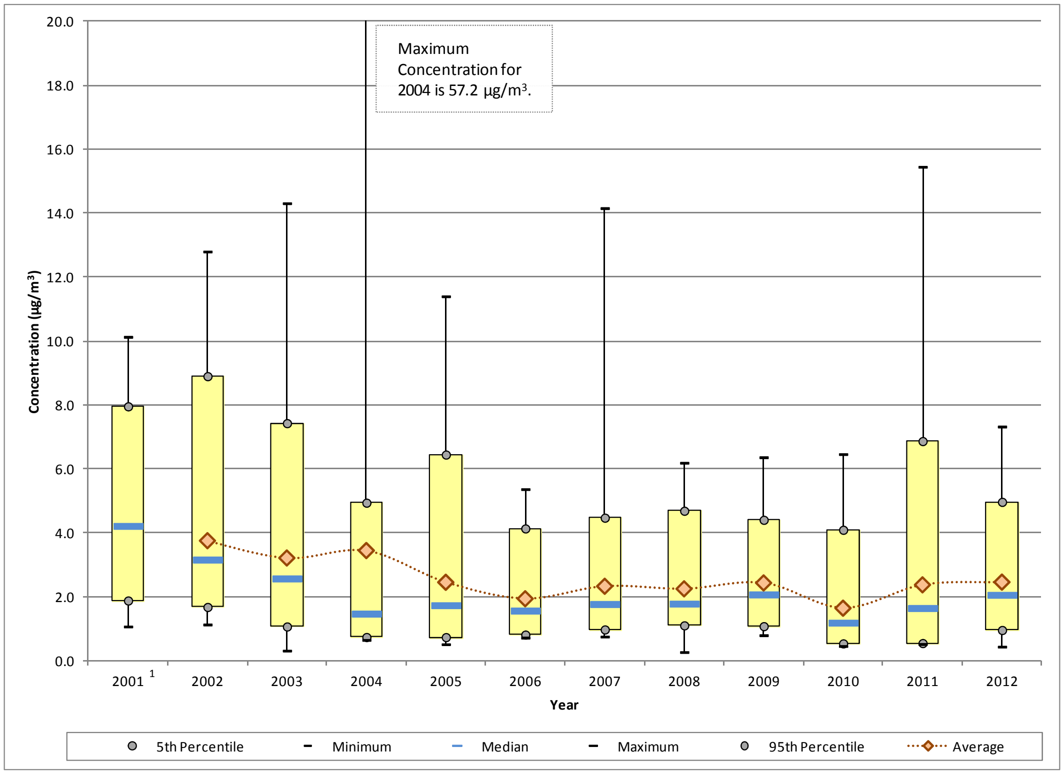
[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.
[2] A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 18-30 for 1,2-dichloroethane measurements collected at CHNJ include the following:

- There were no measured detections of 1,2-dichloroethane between 2001 and 2004. There were one or two measured detections each year between 2005 and 2008. After 2008, the number of measured detections increased significantly, from 7 percent in 2009, to 25 percent for 2010, 30 percent in 2011, and 95 percent for 2012. This explains the significant increase in the 1-year average concentration shown for the later years of sampling.

- 2012 is the first year that the 5th percentile and median concentration are greater than zero. Aside from the three non-detects, the range of measurements collected in 2012 is relatively small, ranging from 0.0527 µg/m^3 to 0.121 µg/m^3. The 1-year average and median concentrations calculated for 2012 are less than 0.001 µg/m^3 apart, indicating little variability associated with the measurements collected in 2012.

Figure 18-31. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at CHNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-31 for formaldehyde measurements collected at CHNJ include the following:

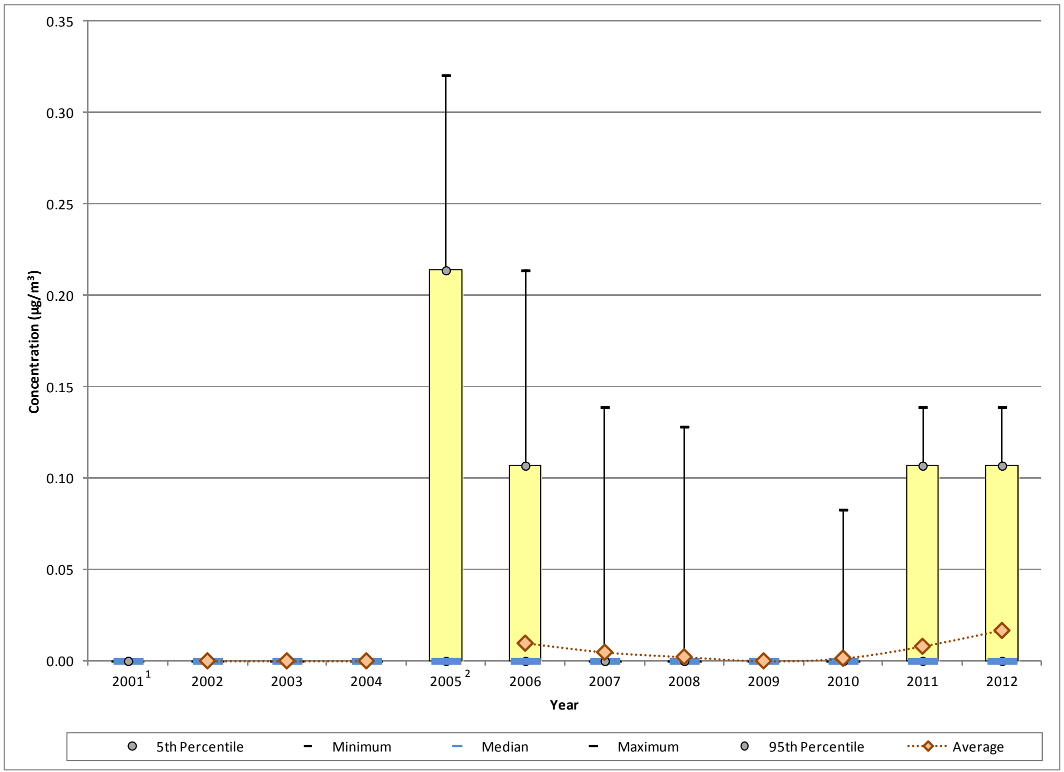
- The two highest formaldehyde concentrations were measured on the same days in 2004 as the two highest concentrations of acetaldehyde. The maximum concentration of formaldehyde (57.2 µg/m^3) is nearly twice the second highest concentration and almost four times the maximum concentrations shown for other years.

- A decreasing trend in the 1-year average and median formaldehyde concentrations is shown though 2006, after which the 1-year average and median concentrations leveled out through 2009. Less than 0.5 µg/m^3 separates the 1-year averages calculated for the period between 2006 and 2009.

- The 1-year and median concentrations decreased significantly for 2010, when the 1-year average concentration reached a minimum. This is due primarily to the measurements at the lower end of the concentration range. The number of concentrations less than 1 µg/m^3 increased from two in 2009 to 21 in 2010.

- Similar to acetaldehyde, all of the statistical metrics calculated for formaldehyde exhibit an increase from 2010 to 2011. The 95th percentile for 2011 is greater than the maximum concentration for 2010. Although the range of measurements decreased for 2012, little change is shown in the 1-year average concentration.

Figure 18-32. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at CHNJ

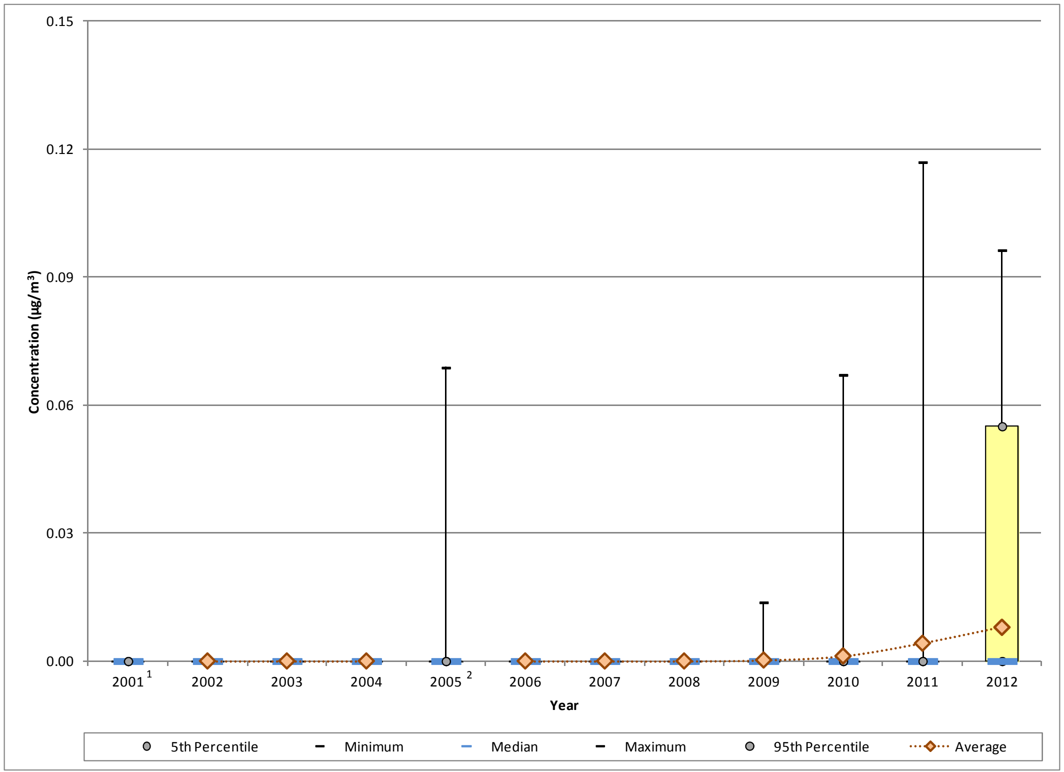


[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.
[2] A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 18-32 for hexachloro-1,3-butadiene measurements collected at CHNJ include the following:

- There were no measured detections of hexachloro-1,3-butadiene measured during the first 4 years of sampling.
- The number of measured detections increased to seven for 2005, representing 14 percent of measurements, then decreased each year through 2009, when again no measured detections were measured. The number of measured detections increased to one for 2010, then four for 2011, then up to 12 for 2012, or nearly 20 percent, the maximum number of measured detections since sampling began.

Figure 18-33. Yearly Statistical Metrics for 1,1,2,2-Tetrachloroethane Concentrations Measured at CHNJ



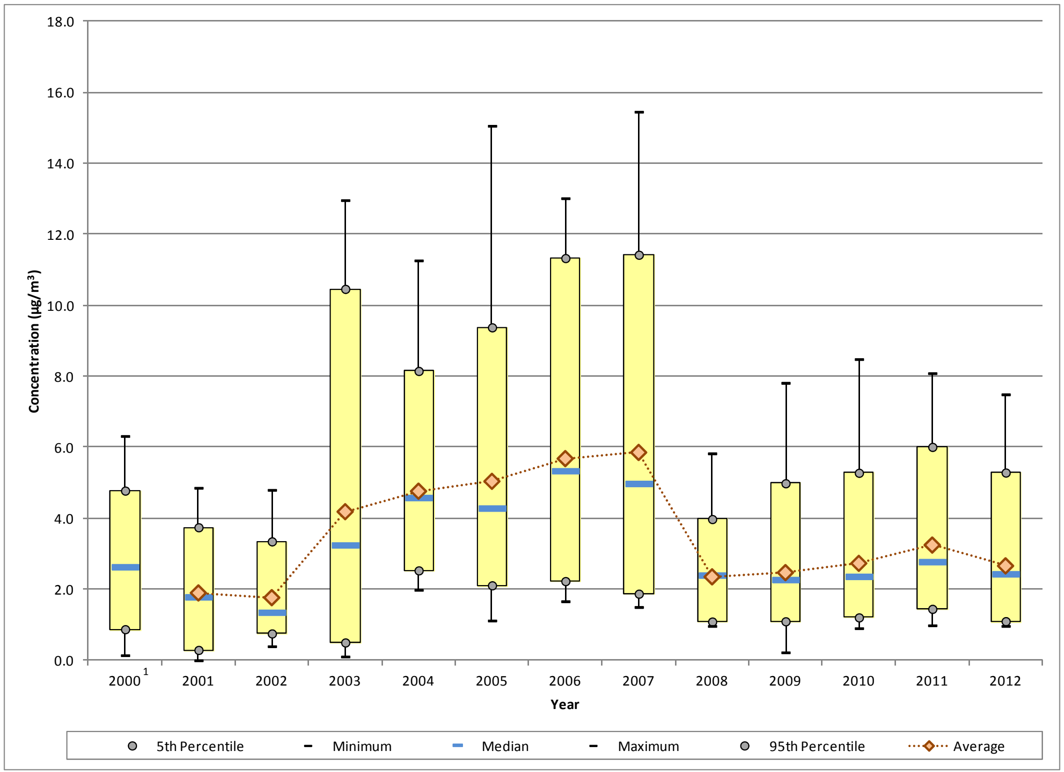
[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.
[2] A 1-year average is not presented due to low completeness in 2005.

Observations from Figure 18-33 for 1,1,2,2-tetrachloroethane measurements collected at CHNJ include the following:

- Between 2001 and 2011, a total of seven measured detections of 1,1,2,2-tetrachloroethane were measured at CHNJ (two in 2005, one each in 2009 and 2010, and three in 2011). The number of measured detections for 2012 is greater than all the previous years combined (9).

- Additional years of sampling are needed to determine if the number of measured detections continues to increase.

Figure 18-34. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at ELNJ



[1] A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 18-34 for acetaldehyde measurements collected at ELNJ include the following:

- ELNJ is the longest running NMP site. Carbonyl compound sampling under the NMP began at ELNJ in January 2000. However, sporadic sampling at the beginning of 2000 combined with a 1-in-12 day sampling schedule led to completeness less than 85 percent. Thus, a 1-year average is not presented for 2000, although the range of measurements is provided.

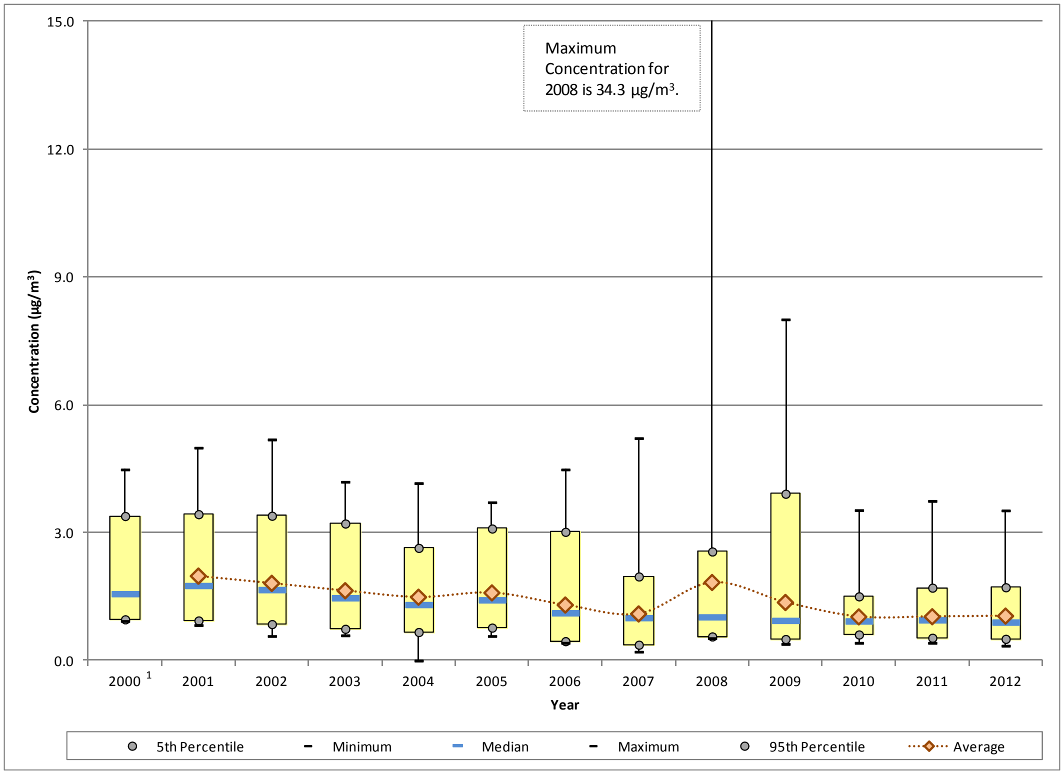
- The maximum acetaldehyde concentration was measured in 2007, although a concentration of similar magnitude was also measured in 2005. In total, 22 concentrations greater than 10 µg/m^3 have been measured at ELNJ, all of which were measured prior to 2008.

- The range of measurements between 2003 and 2007 is considerably higher than those collected during the first 3 years of sampling. The 1-year average concentration increased significantly from 2002 to 2003. This increasing trend continued through 2007, although the rate of change slowed over the years. A significant decrease in the 1-year average concentration is shown from 2007 to 2008, where the 1-year average decreased by more than half. The range of measurements collected in 2008 is more similar to the range shown before 2003.

- Although an increasing trend is also shown between 2008 and 2011, the 1-year averages are roughly half the magnitude of those shown before 2008.

- All of the statistical parameters exhibit decreases from 2011 to 2012.

Figure 18-35. Yearly Statistical Metrics for Benzene Concentrations Measured at ELNJ



[1] A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 18-35 for benzene measurements collected at ELNJ include the following:

- The maximum benzene concentration (34.3 µg/m^3) was measured in 2008 and is more than four times higher than the next highest concentration (measured in 2009). The third highest concentration was also measured in 2009. In all, only five benzene concentrations greater than 5 µg/m^3 have been measured at ELNJ.

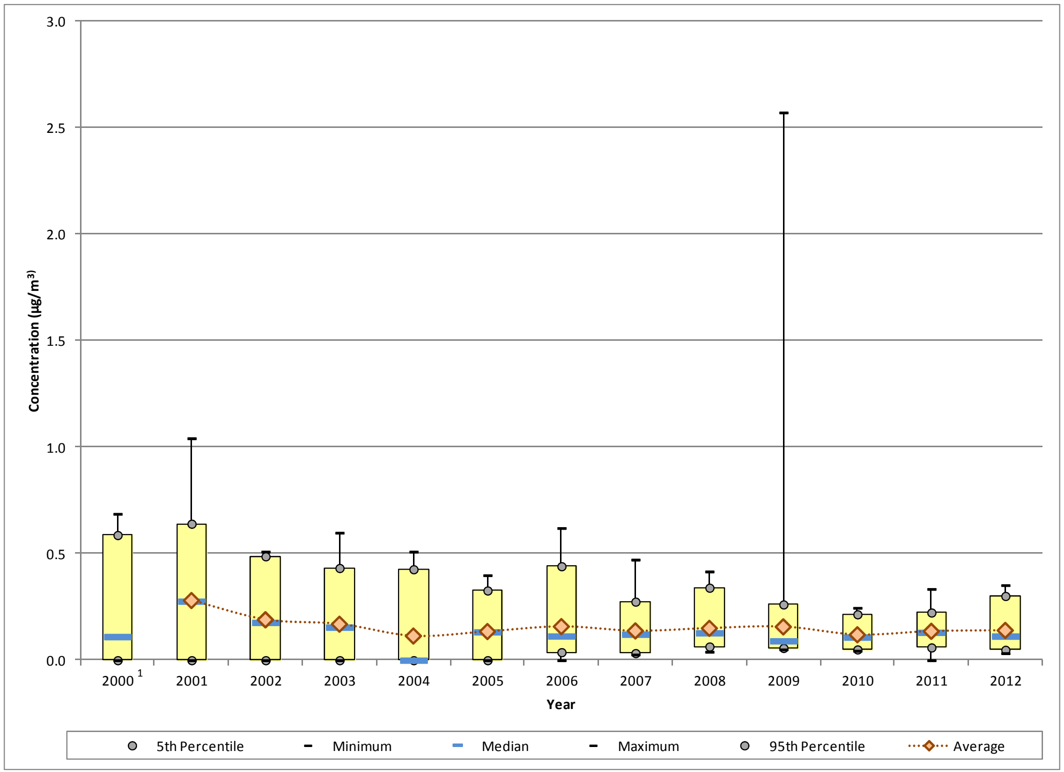
- A decreasing trend in the 1-year average and median concentrations is shown through 2007.

- All of the statistical parameters exhibit at least a slight increase for 2008. If the maximum concentration for 2008 was removed from the data set, the 1-year average concentration would exhibit a negligible increase for 2008. Thus, it is this single concentration that is primarily driving the change in the 1-year average concentration. The median concentration is influenced less by outliers, as this statistical parameter represents the midpoint of a data set. That the median increased by less than 0.02 µg/m^3 between 2007 and 2008 further indicates that this outlier is the primary driver pushing the 1-year average concentration upward. However, the minimum concentration doubled from 2007 to 2008, indicating that the outlier may not be the only factor.

- Even though two of the three highest concentrations were measured in 2009, the 1-year average concentration decreased from 2008 to 2009, likely a result of the magnitude of the outlier affecting the 2008 calculations.

- Figure 18-35 shows that benzene concentrations measured in 2010, 2011, and 2012 were fairly constant. The difference in the 1-year average concentrations for these years is less than 0.02 µg/m^3.

Figure 18-36. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at ELNJ



[1] A 1-year average is not presented due to low completeness in 2000.

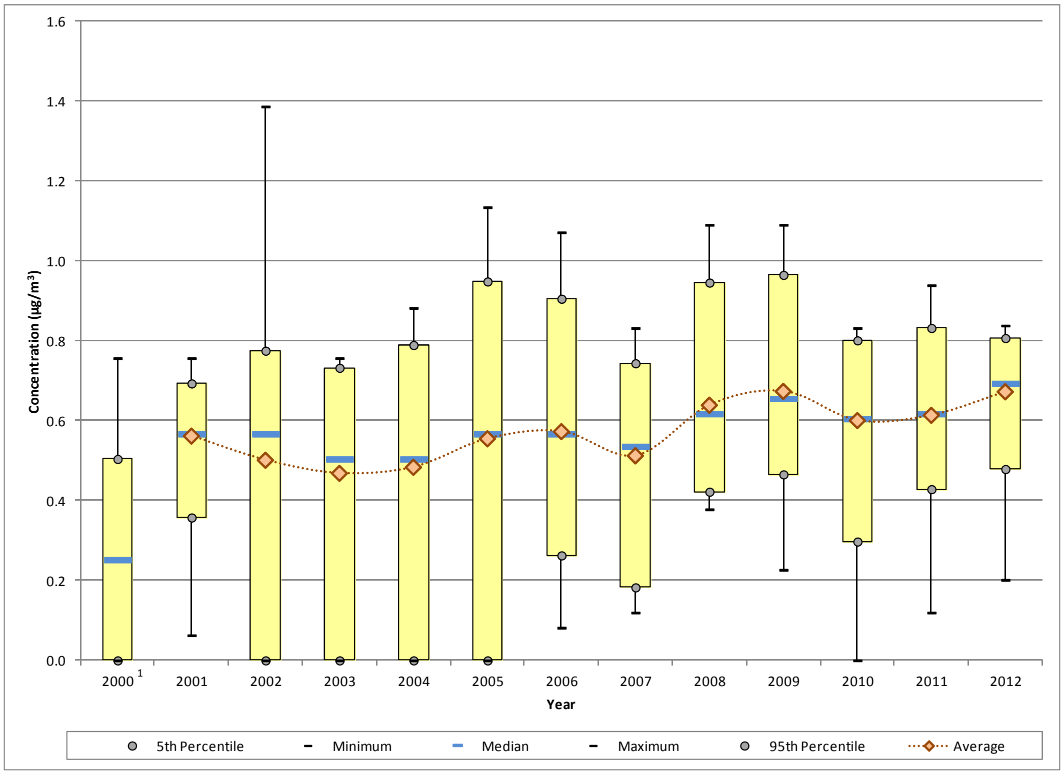
Observations from Figure 18-36 for 1,3-butadiene measurements collected at ELNJ include the following:

- The maximum concentration of 1,3-butadiene was measured in 2009 and is nearly two and a half times the next highest concentration (measured in 2001). These are the only concentrations of 1,3-butadiene measured at ELNJ that are greater than 1 µg/m^3.

- The minimum and 5th percentile are zero for the first 6 years of sampling, indicating that at least 5 percent of the measurements were non-detects. For 2004, even the median is zero, indicating that at least half of the measurements were non-detects. Between 2000 and 2006, the percentage has ranged from 5 percent (2006) to 57 percent (2004). After 2006, only two non-detects have been measured (both in 2011).

- Figure 18-36 shows a decreasing trend in the 1-year average concentration through 2004, after which the 1-year average concentration remain fairly constant. Even with the higher concentration measured in 2009, the 1-year average concentration for 2009 is similar to the 1-year average concentration for 2008. Between 2005 and 2012, the 1-year average concentration has ranged from 0.12 µg/m^3 (2010) to 0.16 µg/m^3 (2006 and 2009).

Figure 18-37. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at ELNJ



[1] A 1-year average is not presented due to low completeness in 2000.

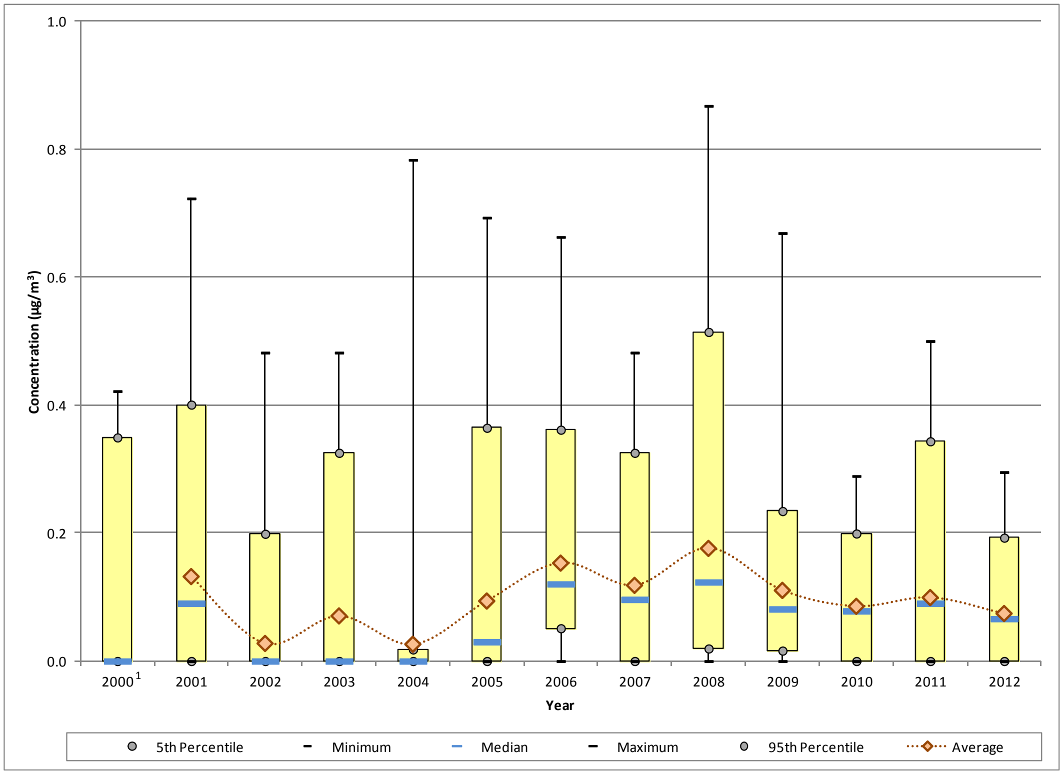
Observations from Figure 18-37 for carbon tetrachloride measurements collected at ELNJ include the following:

- The minimum and 5th percentile are zero for five of the first 6 years of sampling, indicating that at least 5 percent of the measurements were non-detects (2001 being the exception). After 2005, only one non-detect has been reported (2010).

- The 1-year average carbon tetrachloride concentrations vary by no more than 0.1 µg/m^3 during the period from 2001 to 2007, even though the range of measurements varies. All of the statistical parameters exhibit an increase in magnitude from 2007 to 2008. 2008 is the first year that the 1-year average concentration is greater than 0.6 µg/m^3; all of the 1-year averages between 2008 and 2012 are greater than 0.6 µg/m^3.

- The difference between the 5th percentile and 95th percentile, or the range within which the majority of measurements fall, has been decreasing since 2005 and reaches a minimum for 2012. Less than 0.35 µg/m^3 separates these parameters for 2012.

Figure 18-38. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at ELNJ



[1] A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 18-38 for *p*-dichlorobenzene measurements collected at ELNJ include the following:

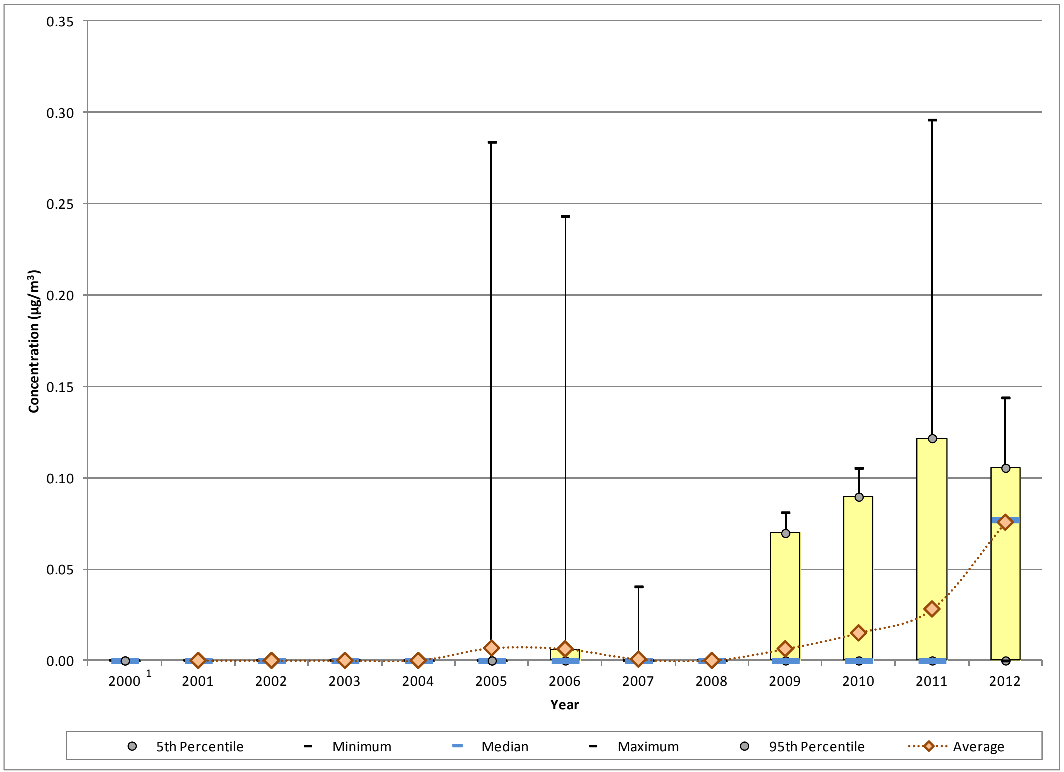
- At least one non-detect has been measured at this site each year since the onset of sampling. For many years, this number is higher as indicated by the 5th percentile and/or median concentration. The percentage of non-detects has ranged from 5 percent (2006 and 2009) to 95 percent (2004).

- Most of the increases or decreases shown in the 1-year average concentrations correspond with a substantial increase or decrease in the number of non-detects for a particular year. This is not true is for 2008 and 2009. For both years, the number of non-detects is three, representing 5 percent of the measurements. The change in the 1-year average (and median) is a result in the concentrations measured, both at the upper and lower end of the concentration range. The number of measurements greater than 0.3 µg/m^3 is three times higher for 2008 than 2009; the number of measurements less than 0.1 µg/m^3 increased from 22 in 2008 to 35 in 2009.

- For 2010, the number of non-detects increased to 25 percent of the measurements (up from 5 percent for 2009), yet only a small decrease in the 1-year average is shown (compared to other years) and the median itself did not change.

- The data collected between 2010 and 2012 seem to exhibit less variability than the previous years. The 1-year average concentration for each year between 2010 and 2012 is less than 0.1 µg/m^3 and non-detects account for between 15 percent and 25 percent of the measurements collected.

Figure 18-39. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at ELNJ



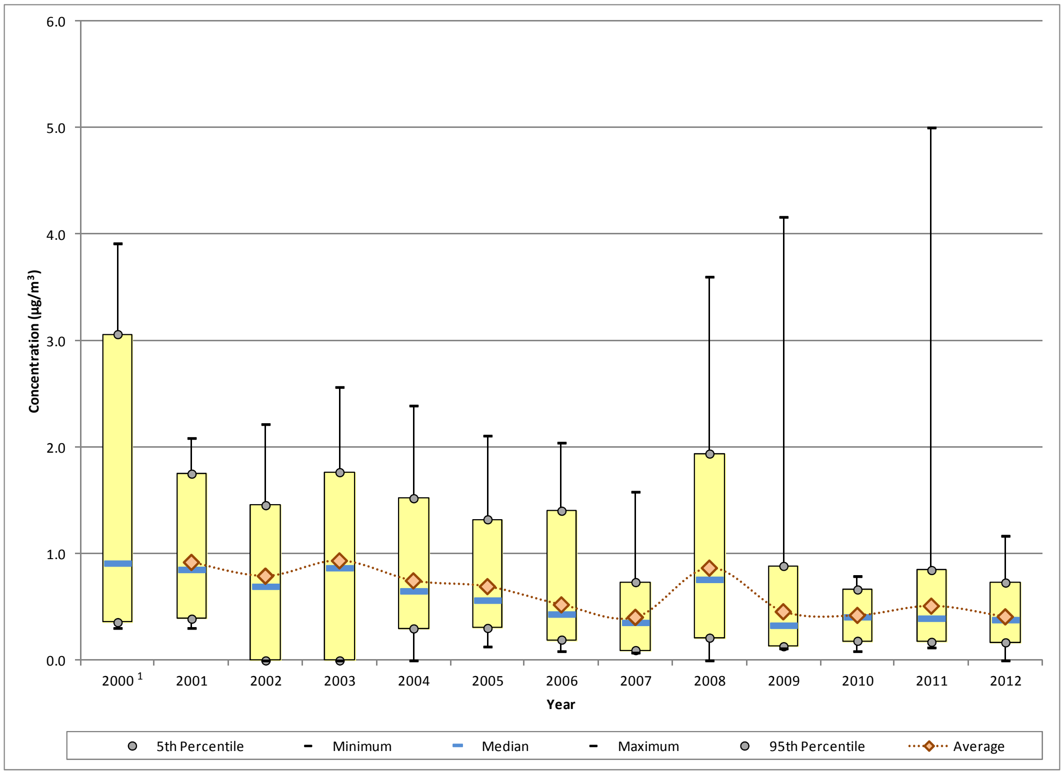
[1] A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 18-39 for 1,2-dichloroethane measurements collected at ELNJ include the following:

- There were no measured detections of 1,2-dichloroethane between 2000 and 2004. Between one and three measured detections were measured between 2005 and 2007, after which no measured detections were measured in 2008. After 2008, the number of measured detections increased significantly, from five in 2009, to 11 for 2010, 16 in 2011, and 55 for 2012. This explains the significant increase in the 1-year average concentrations shown for the later years of sampling.

- 2012 is the first year that the median concentration is greater than zero. Aside from the six non-detects, the range of measurements collected in 2012 is relatively small, ranging from 0.061 µg/m^3 to 0.144 µg/m^3. The 1-year average and median concentrations calculated for 2012 are approximately 0.0015 µg/m^3 apart, indicating relatively little variability associated with the measurements collected in 2012.

Figure 18-40. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at ELNJ

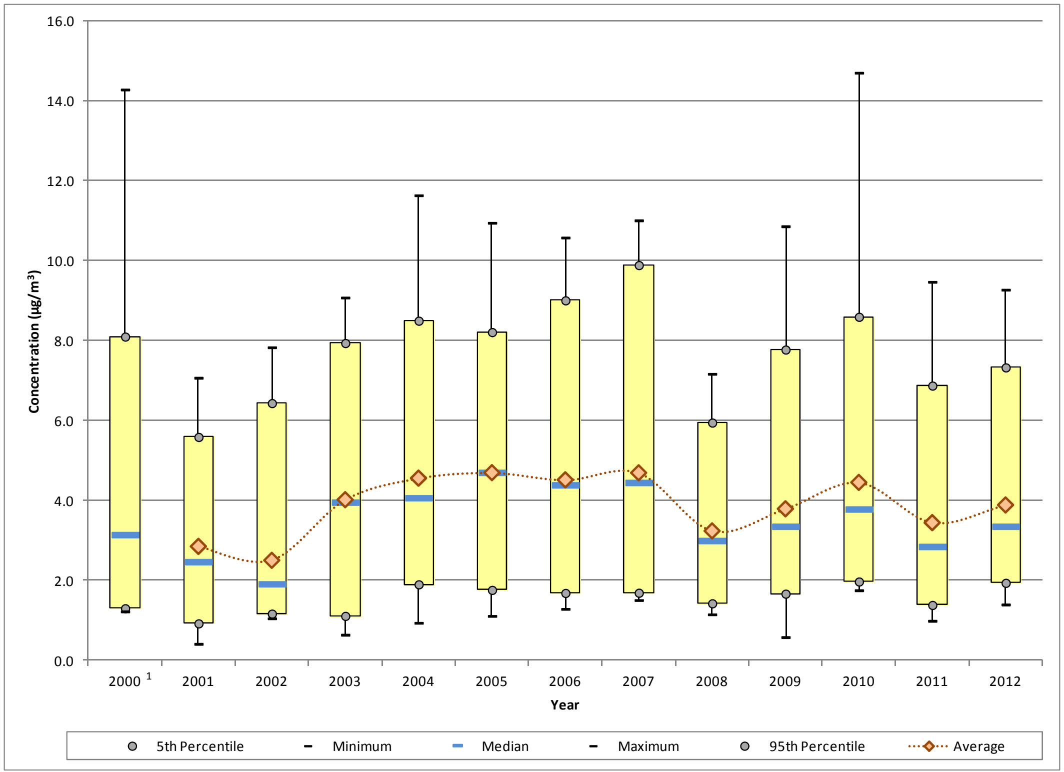


[1] A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 18-40 for ethylbenzene measurements collected at ELNJ include the following:

- There is a steady decreasing trend in the 1-year average and median concentrations between 2001 and 2007.
- A significant increase in these parameters is shown for 2008. The median concentration for 2008 is greater than the 95th percentile for 2007. The number of measurements greater than 1 µg/m^3 increased from one in 2007 to 16 in 2008.
- The measurements collected in 2009 more resemble those collected in 2007 than 2008, with the exception of the maximum concentration measured.
- The smallest range of ethylbenzene measurements was collected in 2010, with all measurements spanning less than 1 µg/m^3.
- Between 2009 and 2012, the majority of concentrations fell within a fairly similar range and the 1-year average concentration did not change significantly, ranging from 0.41 µg/m^3 (2012) to 0.51 µg/m^3 (2011).

Figure 18-41. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at ELNJ



[1] A 1-year average is not presented due to low completeness in 2000.

Observations from Figure 18-41 for formaldehyde measurements collected at ELNJ include the following:

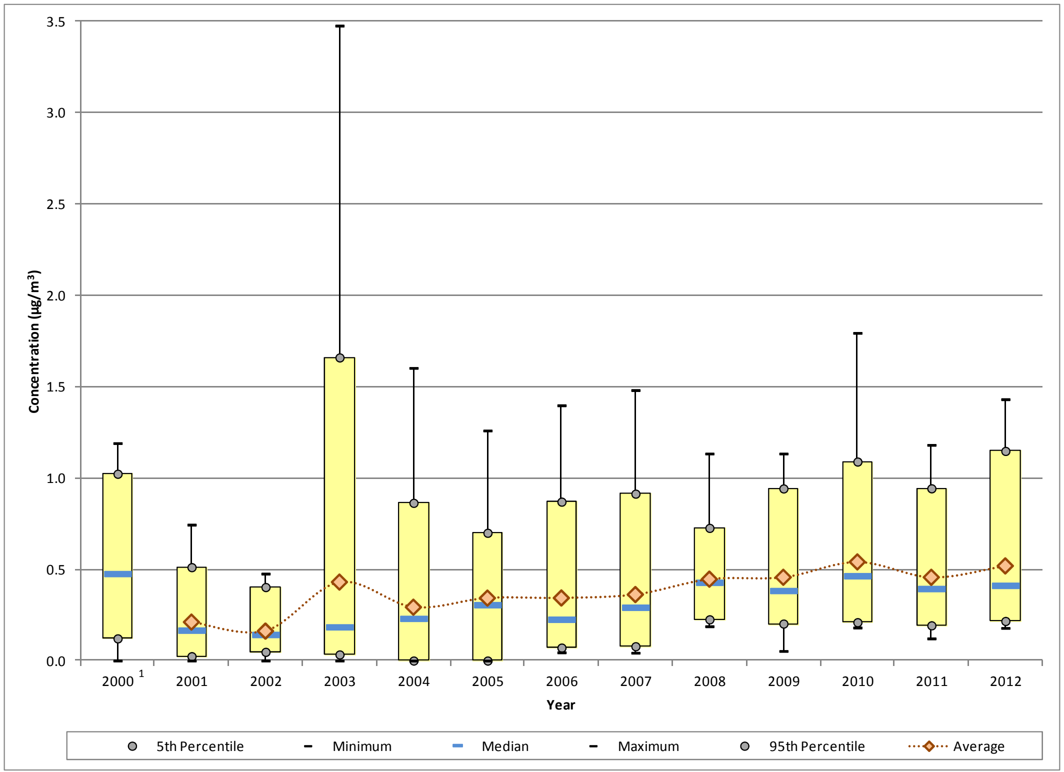
- The maximum formaldehyde concentration was measured at ELNJ in 2010, although a similar measurement was also collected in 2000. A total of 12 concentrations greater than 10 µg/m^3 have been measured at ELNJ.

- After a decreasing trend through 2002, there was a significant increase in formaldehyde concentrations from 2002 to 2003, as shown by the median, which more than doubled, and the 1-year average concentration, which increased by roughly 60 percent. The number of formaldehyde concentrations greater than 4 µg/m^3 nearly tripled from 2002 to 2003 (from 9 to 25) while the number of measurements less than 2 µg/m^3 decreased by half (from 29 to 15).

- Between 2004 and 2007, there was relatively little change in the 1-year average formaldehyde concentrations, which ranged from 4.52 µg/m^3 (2006) to 4.70 µg/m^3 (2005) during this time.

- Similar to acetaldehyde, the 1-year average concentration of formaldehyde decreased significantly between 2007 and 2008, after which an increasing trend is shown through 2010. While the trends graph for acetaldehyde shows a continued increase for 2011 followed by a decrease for 2012, formaldehyde concentrations decrease for 2011 then increase slightly for 2012.

Figure 18-42. Yearly Statistical Metrics for Propionaldehyde Concentrations Measured at ELNJ



[1] A 1-year average is not presented due to low completeness in 2000.

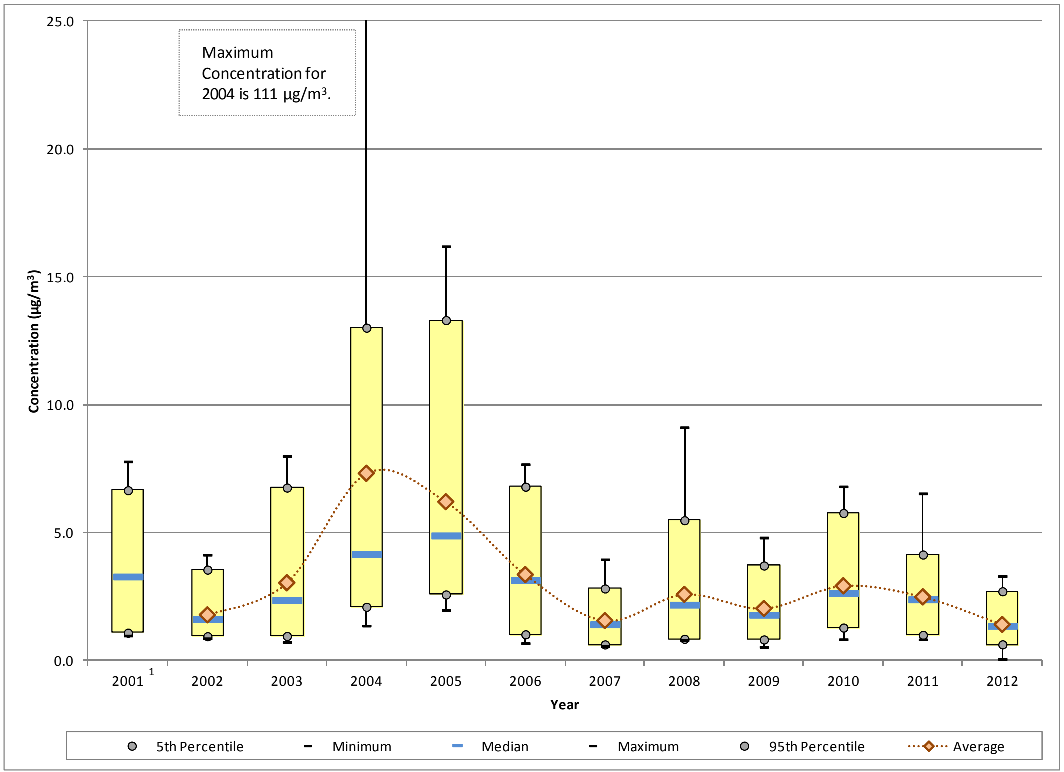
Observations from Figure 18-42 for propionaldehyde measurements collected at ELNJ include the following:

- A decrease in the concentrations is shown between 2000 and 2002, as the maximum concentration measured in 2002 is the same as the median concentration calculated for 2000 and is less than the 95th percentile for 2001.

- The maximum propionaldehyde concentration was measured at ELNJ in 2003 (3.48 µg/m^3). The next two highest concentrations were also measured in 2003 and together these three measurements are the only concentrations greater than 2 µg/m^3 measured at ELNJ since the onset of sampling. In addition, there were 12 measurements collected in 2003 greater in magnitude than the maximum concentration measured in 2002. This explains the significant increase in the 1-year average concentration.

- A steady increasing trend in the 1-year average concentration of propionaldehyde is shown between 2002 and 2010 (with the exception of 2003 to 2004). The 1-year average concentration more than tripled over the period (from 0.16 µg/m^3 in 2002 to 0.54 µg/m^3 in 2010), after which some fluctuation is shown.

Figure 18-43. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at NBNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-43 for acetaldehyde measurements collected at NBNJ include the following:

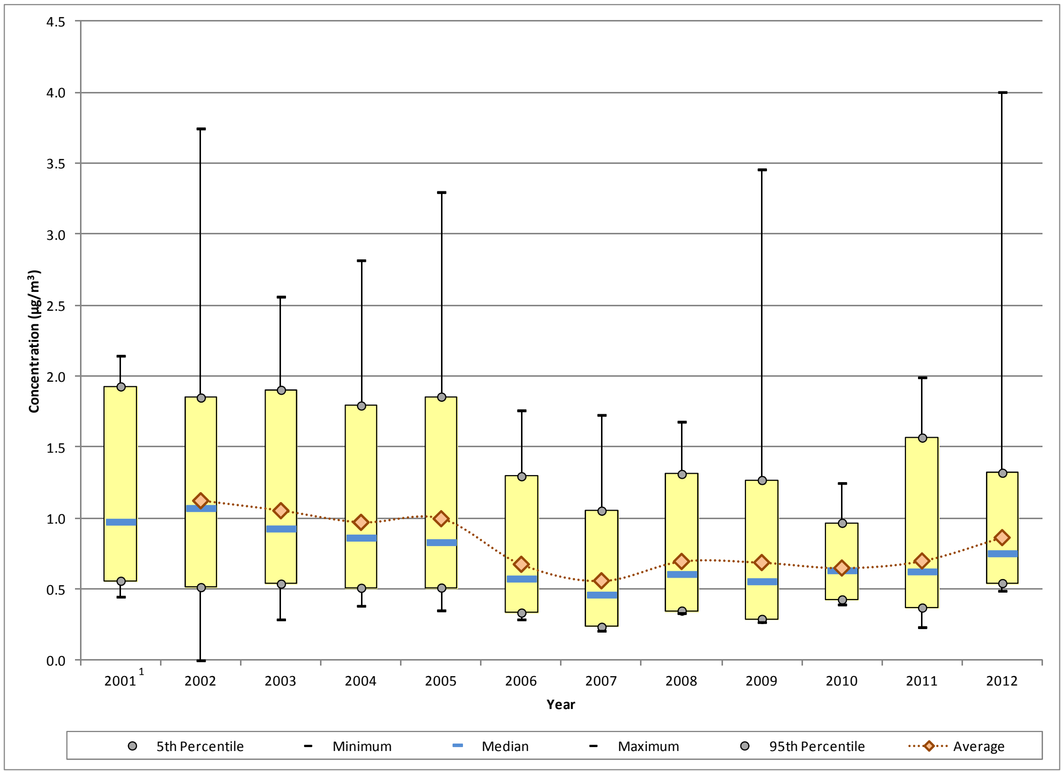
- Sampling for carbonyl compounds under the NMP began at NBNJ in May 2001. Because a full year's worth of data is not available for 2001, a 1-year average is not presented, although the range of measurements is provided.

- The maximum acetaldehyde concentration was measured in 2004. This concentration (111 µg/m^3) is nearly seven times higher, and an order of magnitude higher, than the next highest concentration (16.2 µg/m^3, measured in 2005).

- Of the 29 concentrations greater than 8 µg/m^3, 28 were measured at NBNJ in 2004 or 2005 (the one other was measured in 2008). This, along with the outlier concentration measured in 2004, explains the significant increase in the statistical metrics shown from 2003 to 2004. Even without an outlier for 2005, most of the statistical metrics for 2005 exhibit slight increases from 2004 levels. The 1-year average, however, does not. If the outlier was removed from the data set for 2004, the 1-year average concentration for 2004 would be less than the 1-year average concentration for 2005.

- The 1-year average concentration decreases significantly from 2005 through 2007, as do all of the other statistical parameters. Between 2008 and 2011, the 1-year average concentration fluctuates between 2 µg/m^3 and 3 µg/m^3. The 1-year average, as well as most of the other statistical parameters, is at a minimum for 2012 (1.41 µg/m^3).

Figure 18-44. Yearly Statistical Metrics for Benzene Concentrations Measured at NBNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-44 for benzene measurements collected at NBNJ include the following:

- Sampling for VOCs under the NMP began at NBNJ in May 2001. Because a full year's worth of data is not available for 2001, a 1-year average is not presented, although the range of measurements is provided.

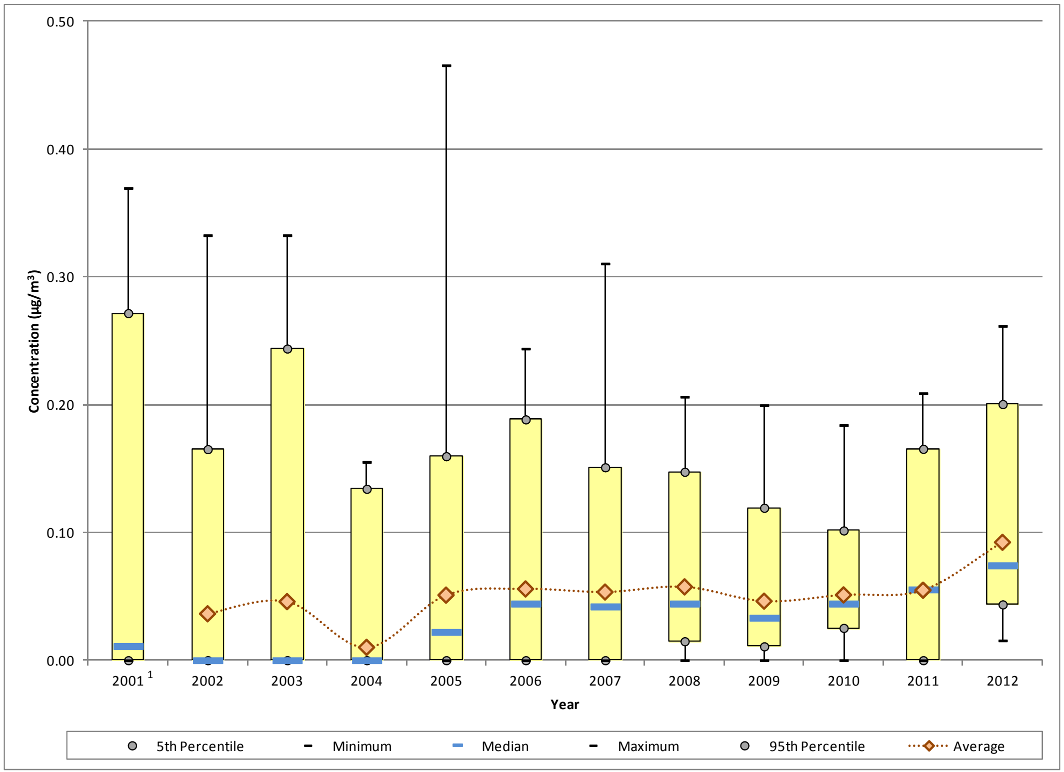
- The maximum benzene concentration was measured in 2012 (4.00 µg/m^3); aside from this measurement, only three concentrations of benzene greater than 3 µg/m^3 have been measured at NBNJ.

- Although a slight decreasing trend in the 1-year average concentration is shown between 2002 and 2004, a significant decrease is shown between 2005 and 2007, when both the median and 1-year average concentrations were at a minimum.

- Between 2008 and 2011, the 1-year average concentration is fairly static, ranging from 0.65 µg/m^3 (2010) to 0.70 µg/m^3 (2011), even though there is some fluctuation in the range of concentrations measured.

- The 1-year average benzene concentration increased from 2011 to 2012, as did many of the statistical parameters, even though the majority of the measurements fell into a smaller range for 2012 than 2011. The minimum and 5th percentile increased considerably for 2012; there were 17 measurements in 2011 that are less than the minimum concentration measured in 2012 (0.49 µg/m^3). In addition, the number of measurements in the mid- to upper-end of the concentration increased substantially for 2012. While the number of measurements between 0.5 µg/m^3 and 0.75 µg/m^3 was the same for both years, the number of benzene measurements between 0.75 µg/m^3 and 1 µg/m^3 increased from two in 2011 to 20 in 2012.

Figure 18-45. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at NBNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-45 for 1,3-butadiene measurements collected at NBNJ include the following:

- The maximum 1,3-butadiene concentration was measured in 2005 and is the only measurement greater than 0.40 µg/m^3 measured at NBNJ.

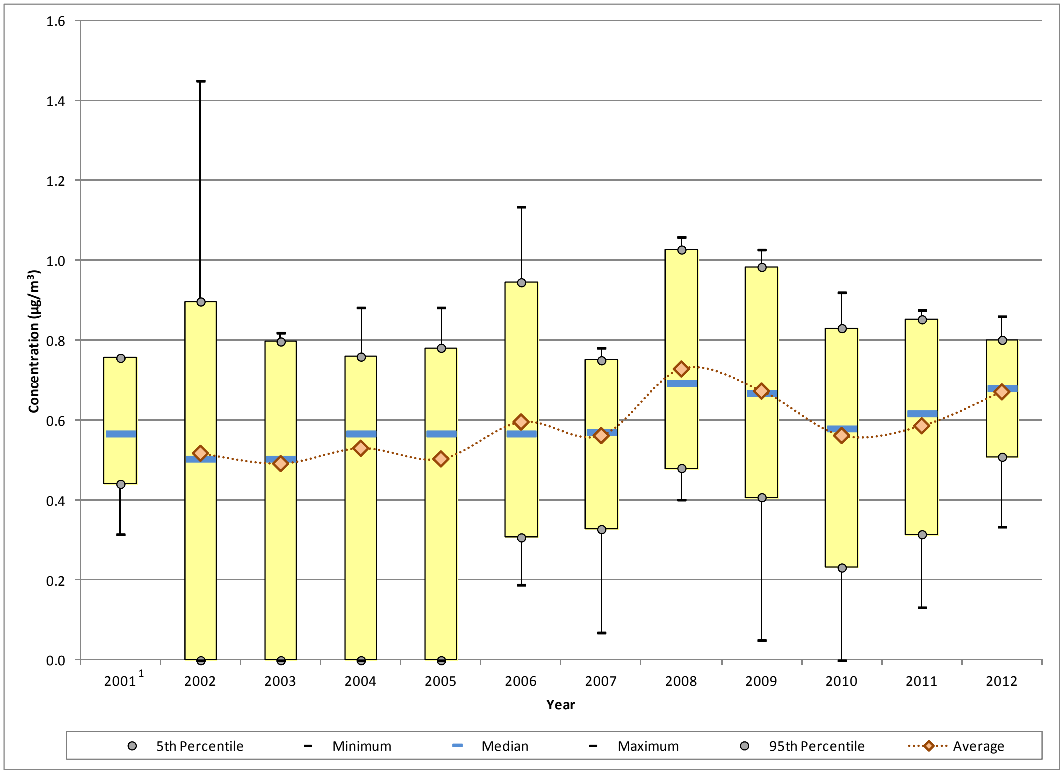
- The minimum, 5th percentile, and median concentrations are zero for 2002 through 2004. This indicates that at least half of the measurements were non-detects for these years. The median concentration increased from 2004 to 2005, indicating that the number of non-detects decreased, although the minimum and 5th percentile are still zero for 2005 through 2007. Further decreases in the number of non-detects are indicated by the 5th percentile increasing for 2008 through 2010. The number of non-detects increased considerably for 2011, from 4 percent in 2010 to 29 percent for 2011, an increase that is evident from the return of the 5th percentile to zero for 2011. There were no non-detects measured in 2012, as indicating by the minimum concentration, which is greater than zero for the first time.

- The 1-year average concentration of 1,3-butadiene decreased significantly from 2003 to 2004. This is likely a result of the change in the number of non-detects as well as a reduction in the range of measurements. The number of non-detects increased from 69 percent to 93 percent from 2003 to 2004. Thus, many zeros were substituted into this average. The increase in the 1-year average concentration shown from 2004 to 2005 results from a combination of fewer non-detects and a larger range of measurements. The number of non-detects decreased to 47 percent for 2005.

- The 1-year average concentration exhibits little change between 2005 and 2011, ranging from 0.046 µg/m^3 (2009) to 0.057 µg/m^3 (2008).

- The 1-year average concentration increases significantly from 2011 to 2012. Increases are also exhibited by each of the other statistical parameters. This is partially due to the decrease in non-detects (and thus, zeroes substituted for non-detects in the calculations) from 29 percent to 0 percent from 2011 to 2012. The number of concentrations at the upper end of the concentration range increased as well; the number of measurements greater than 0.1 µg/m^3 increased from eight in 2011 to 18 in 2012.

Figure 18-46. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at NBNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-46 for carbon tetrachloride measurements collected at NBNJ include the following:

- The range of carbon tetrachloride measurements collected in 2001 was considerably smaller than those collected in the years immediately following. The considerable decrease in the minimum concentration shown for 2002 to 2005 is due to non-detects, which account for at least 5 percent of the measurements collected each year.

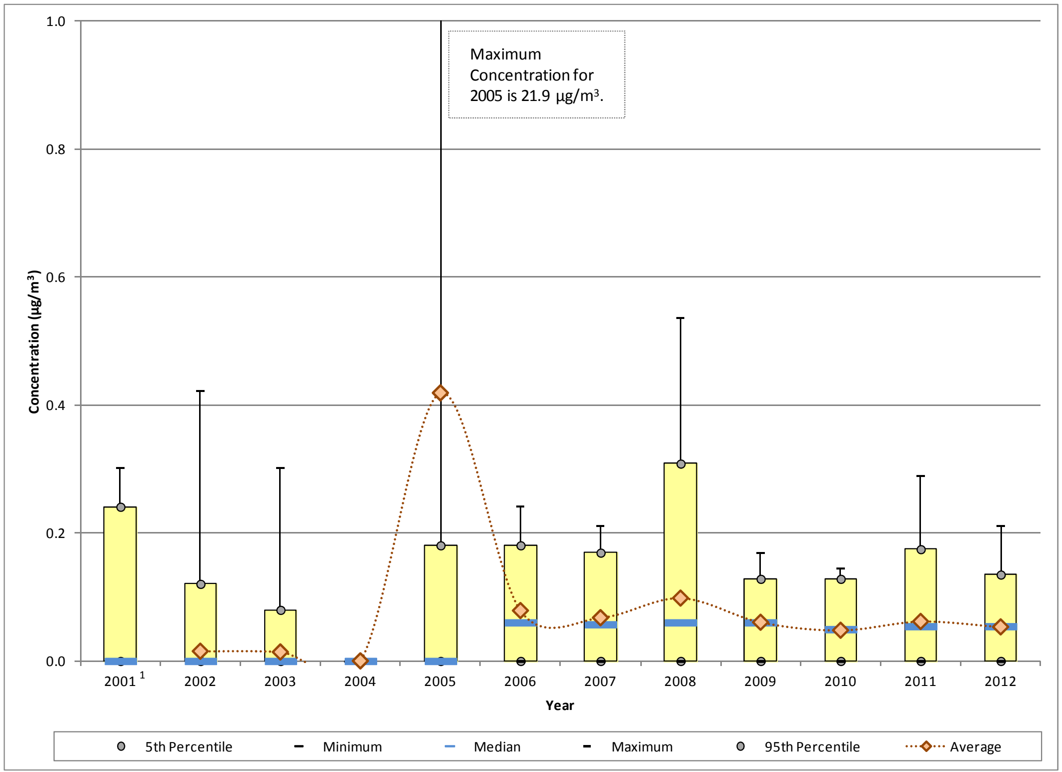
- The 1-year average concentration changed little between 2002 and 2005, ranging from 0.49 µg/m^3 to 0.60 µg/m^3. A slight increase in the 1-year average concentration is shown from 2005 to 2006, a result of higher concentrations at both the lower and upper end of the concentration range. Note that between 2004 and 2007, the median concentration varied by 0.003 µg/m^3.

- All of the statistical parameters exhibit increases for 2008. The minimum concentration increased six-fold from 2007 to 2008. In addition, there were 19 measurements collected in 2008 that were greater than the maximum concentration for 2007.

- A decreasing trend in the measurements is shown after 2008 and continues through 2010. Even though the maximum concentrations continue to decrease for 2011 and 2012 and the difference between the 5th percentile and 95th percentile decreases each year, the 1-year average and median concentrations exhibit an increasing trend for the final 2 years shown.

- The box and whisker plots for this pollutant appear “inverted” for the second half of the sampling period, with the minimum concentration extending farther away from the majority of the measurements rather than the maximum (see benzene or 1,3-butadiene as examples). This is a common feature of the trends graphs for carbon tetrachloride across many NMP sites.

Figure 18-47. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at NBNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-47 for *p*-dichlorobenzene measurements collected at NBNJ include the following:

- The maximum *p*-dichlorobenzene concentration measured at NBNJ was measured on July 27, 2005 (21.9 µg/m^3) and is significantly greater than all other concentrations of this pollutant for this site. All other *p*-dichlorobenzene concentrations measured at NBNJ are less than 0.60 µg/m^3.

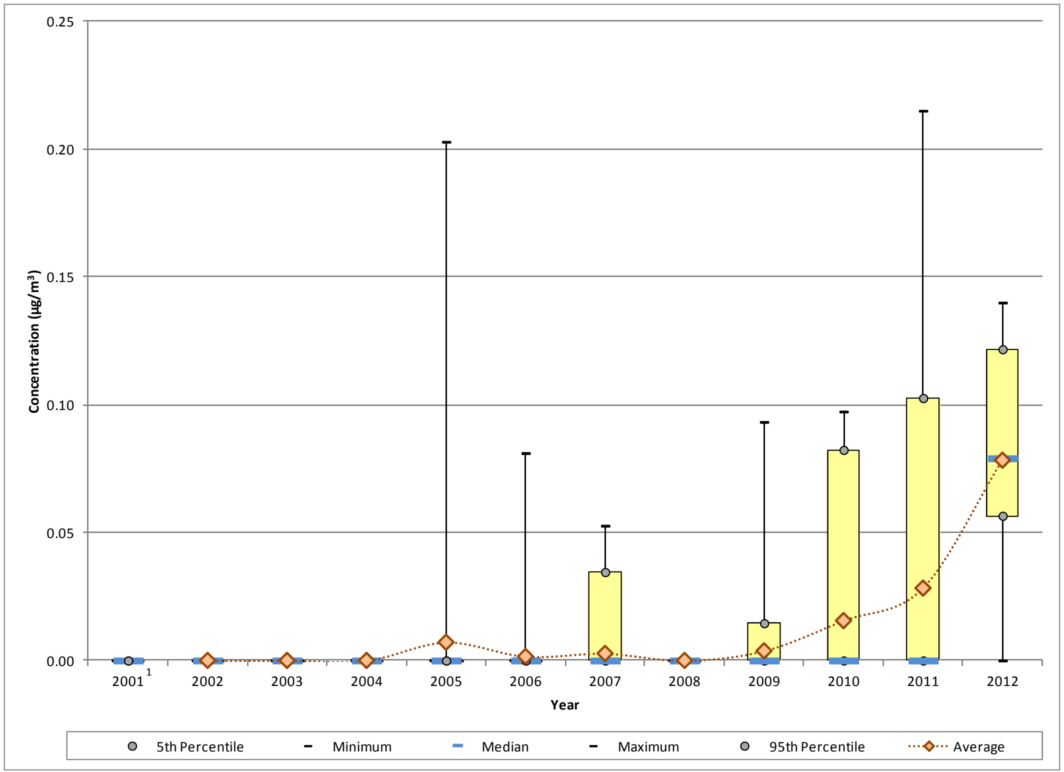
- The median concentration of *p*-dichlorobenzene is zero for the first 5 years of sampling, indicating that at least half of the measurements were non-detects (or zeros substituted for non-detects). There were no measured detections of this pollutant measured at NBNJ in 2004. Between 2001 and 2005, the number of non-detects ranged from 68 percent (2005) to 100 percent (2004).

- The number of non-detects decreased significantly after 2005. Between 2006 and 2009, the number of non-detects varied between 13 percent (2009) and 17 percent (2007). The number of non-detects increased to 40 percent for 2010, after which it hovered around 30 percent for the last 2 years shown in Figure 18-47.

- The 1-year average concentration is close to zero for the first few years of sampling due to the low number of measured detections. For 2005, the 1-year average increased significantly, but is driven solely by the outlying concentration measured that year. If the maximum concentration for 2005 is removed from the data set, the 1-year average concentration decreases by an order of magnitude.

- Between 2006 and 2012, the 1-year average concentration of *p*-dichlorobenzene ranges from 0.048 µg/m^3 (2010) and 0.098 µg/m^3 (2008). The maximum concentration measured in 2008 is considerably higher than the maximum concentrations measured for the other years between 2006 and 2012. Even the 95th percentile for 2008 is greater than the maximum concentrations for each year during this time frame. 2008 has the greatest number of *p*-dichlorobenzene measurements greater than 0.1µg/m^3 (18).

Figure 18-48. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at NBNJ



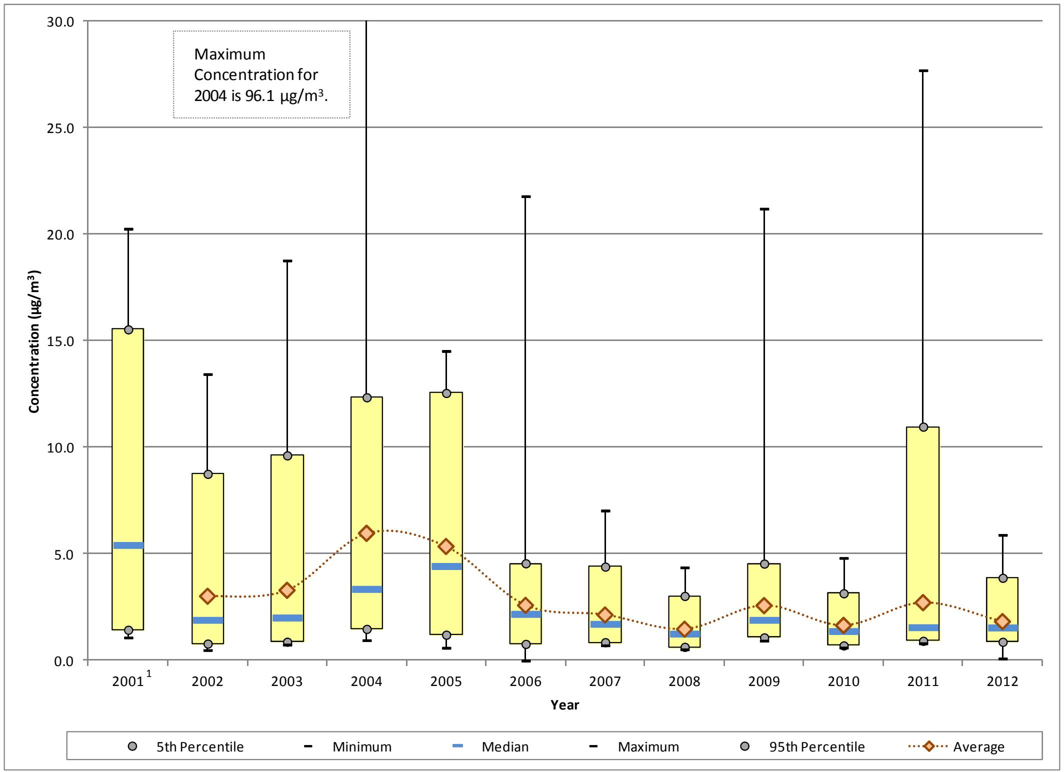
[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-48 for 1,2-dichloroethane measurements collected at NBNJ include the following:

- There were no measured detections of 1,2-dichloroethane between 2001and 2004. Between one and four measured detections were measured between 2005 and 2007, after which no measured detections were measured in 2008. After 2008, the number of measured detections increased significantly, from three in 2009, to 11 for 2010, 18 in 2011, and 58 for 2012. This increase in the number of measured detections is very similar to what was exhibited by the measurements collected at ELNJ. This also explains the significant increase in the 1-year average concentrations shown for the later years of sampling.

- 2012 is the first year that the median concentration is greater than zero. Aside from the two non-detects, the range of measurements collected in 2012 is relatively small, ranging from 0.053 µg/m^3 to 0.140 µg/m^3. The 1-year average and median concentrations calculated for 2012 are less than 0.001 µg/m^3 apart, indicating relatively little variability associated with the measurements collected in 2012.

Figure 18-49. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at NBNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-49 for formaldehyde measurements collected at NBNJ include the following:

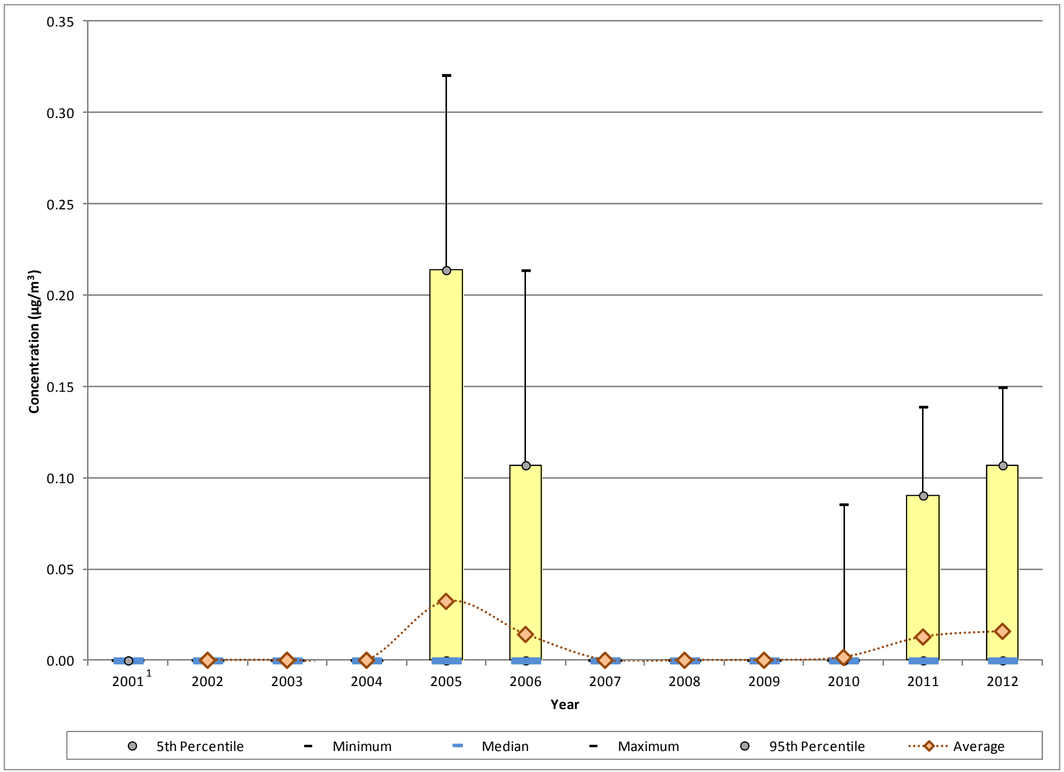
- The maximum formaldehyde concentration (96.1 µg/m^3) was measured at NBNJ on the same day in 2004 that the highest acetaldehyde concentration was measured (August 31, 2004). This concentration of formaldehyde is more than three times the next highest concentration (27.7 µg/m^3, measured in 2011). Concentrations greater than 20 µg/m^3 have been measured during five of the 12 years shown.

- After little change between 2002 and 2003, each of the statistical metrics exhibit increases from 2003 to 2004. This is due in part to the outlying measurement collected in 2004. If the maximum concentration was excluded from the calculations for 2004, the statistical parameters shown for 2004 would fall between those of 2003 and 2005, exhibiting lesser increases.

- After 2005, concentrations of formaldehyde decreased steadily, reaching a minimum in 2008. This year also has the smallest range of formaldehyde measurements, although a similar range was measured in 2010.

- Between 2008 and 2012, a year with more variability in the measurements alternates with a year with less variability. The measurements for 2011 exhibit a considerable amount of variability compared to the rest of the years within this period. The 95th percentile for 2011 is more than double the 95th percentile for the other years within this period. That said, the median concentrations are nearly the same for 2011 and 2012 and vary by less than 0.20 µg/m^3 between 2010 and 2012.

Figure 18-50. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at NBNJ



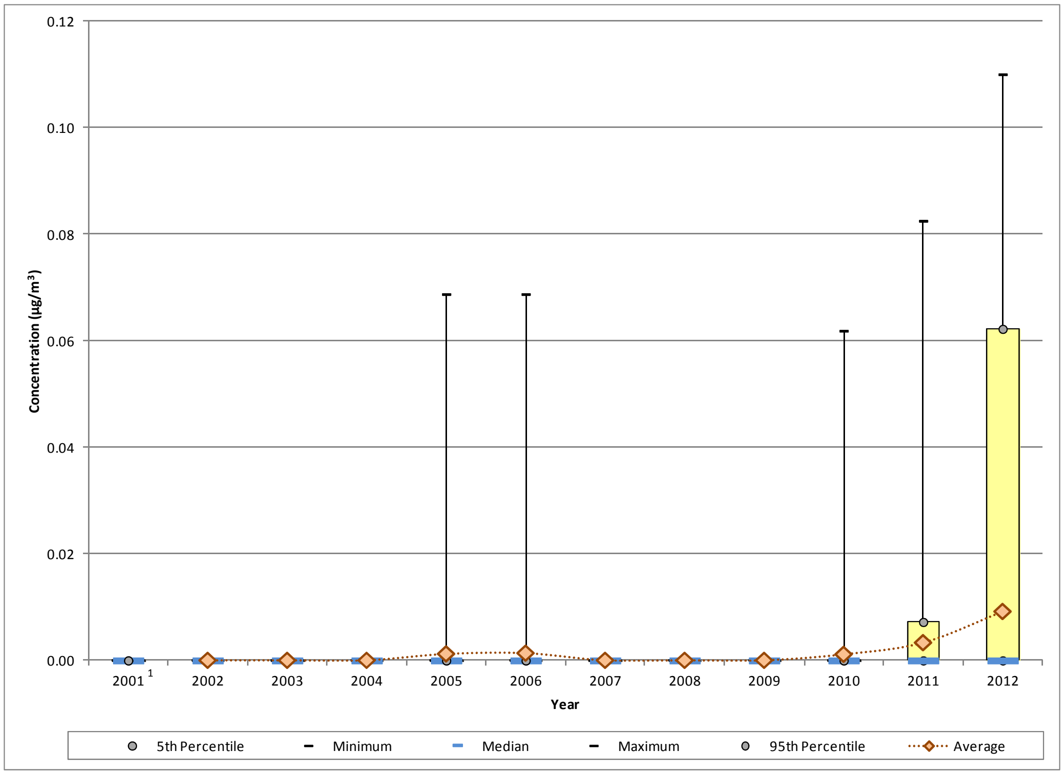
[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-50 for hexachloro-1,3-butadiene measurements collected at NBNJ include the following:

- There were no measured detections of hexachloro-1,3-butadiene measured during the first 4 years of sampling at NBNJ.

- The number of measured detections increased to nine for 2005, representing 16 percent of measurements, then decreased to five for 2006. The number of measured detections returned to zero for 2007 through 2009. A single measured detection was reported for 2010. The number of measured detections increased to eight for 2011 and to 11 for 2012, representing 18 percent of the measurements, the maximum number of measured detections since sampling began at NBNJ.

Figure 18-51. Yearly Statistical Metrics for 1,1,2,2-Tetrachloroethane Concentrations Measured at NBNJ



[1] A 1-year average is not presented because sampling under the NMP did not begin until May 2001.

Observations from Figure 18-51 for 1,1,2,2-tetrachloroethane measurements collected at NBNJ include the following:

- Between 2001 and 2011, a total of six measured detections of 1,1,2,2-tetrachloroethane were measured at NBNJ (one each in 2005, 2006, and 2010, and three in 2011). The number of measured detections for 2012 is greater than all the previous years combined (9).
- Additional sampling is needed to determine if the increase in the number of measured detections continues.

18.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each New Jersey monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

18.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the New Jersey monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

18.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the New Jersey sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 18-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 18-6. Risk Approximations for the New Jersey Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Chester, New Jersey - CHNJ						
Acetaldehyde	0.0000022	0.009	62/62	1.51 ± 0.18	3.31	0.17
Benzene	0.0000078	0.03	61/61	0.64 ± 0.07	4.97	0.02
1,3-Butadiene	0.00003	0.002	51/61	0.04 ± 0.01	1.27	0.02
Carbon Tetrachloride	0.000006	0.1	61/61	0.67 ± 0.03	4.03	0.01
1,2-Dichloroethane	0.000026	2.4	58/61	0.07 ± 0.01	1.87	<0.01
Formaldehyde	0.000013	0.0098	62/62	2.46 ± 0.35	31.92	0.25
Hexachloro-1,3-butadiene	0.000022	0.09	14/61	0.02 ± 0.01	0.40	<0.01
1,1,2,2-Tetrachloroethane	0.000058	--	9/61	0.01 ± 0.01	0.46	--
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	0.0000022	0.009	61/61	2.66 ± 0.34	5.85	0.30
Benzene	0.0000078	0.03	61/61	1.04 ± 0.14	8.12	0.03
1,3-Butadiene	0.00003	0.002	61/61	0.14 ± 0.02	4.18	0.07
Carbon Tetrachloride	0.000006	0.1	61/61	0.67 ± 0.03	4.03	0.01
p-Dichlorobenzene	0.000011	0.8	51/61	0.07 ± 0.02	0.81	<0.01
1,2-Dichloroethane	0.000026	2.4	55/61	0.08 ± 0.01	1.97	<0.01
Ethylbenzene	0.0000025	1	60/61	0.41 ± 0.05	1.02	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.89 ± 0.47	50.57	0.40
Propionaldehyde	--	0.008	61/61	0.52 ± 0.08	--	0.06

-- = A Cancer URE or Noncancer RfC is not available.

Table 18-6. Risk Approximations for the New Jersey Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
North Brunswick, New Jersey - NBNJ						
Acetaldehyde	0.0000022	0.009	60/60	1.41 ± 0.17	3.10	0.16
Benzene	0.0000078	0.03	60/60	0.86 ± 0.12	6.74	0.03
1,3-Butadiene	0.00003	0.002	60/60	0.09 ± 0.01	2.76	0.05
Carbon Tetrachloride	0.000006	0.1	60/60	0.67 ± 0.03	4.03	0.01
p-Dichlorobenzene	0.000011	0.8	41/60	0.05 ± 0.01	0.58	<0.01
1,2-Dichloroethane	0.000026	2.4	58/60	0.08 ± 0.01	2.04	<0.01
Formaldehyde	0.000013	0.0098	60/60	1.82 ± 0.26	23.68	0.19
Hexachloro-1,3-butadiene	0.000022	0.09	14/60	0.02 ± 0.01	0.43	<0.01
1,1,2,2-Tetrachloroethane	0.000058	--	10/60	0.01 ± 0.01	0.57	--

-- = A Cancer URE or Noncancer RfC is not available.

Observations from Table 18-6 include the following:

- For CHNJ, the pollutants with the highest annual averages are formaldehyde, acetaldehyde, and carbon tetrachloride. Formaldehyde has the highest cancer risk approximation for this site (31.92 in-a-million), followed by benzene and carbon tetrachloride. The cancer risk approximation for formaldehyde is at least an order of magnitude higher than the approximations for the other pollutants of interest. None of the pollutants of interest for CHNJ have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. Formaldehyde is the pollutant with the highest noncancer hazard approximation (0.25).

- For ELNJ, the pollutants with the highest annual averages are formaldehyde, acetaldehyde, and benzene. These three pollutants also have the highest cancer risk approximations for this site, although the cancer risk approximation for benzene is greater than the cancer risk approximation for acetaldehyde. ELNJ’s cancer risk approximation for formaldehyde (50.57 in-a-million) is the highest cancer risk approximation among the pollutants of interest for the New Jersey sites and the fourth highest among all NMP sites. None of the pollutants of interest for ELNJ have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. Formaldehyde is the pollutant with the highest noncancer hazard approximation (0.40).

- For NBNJ, the pollutants with the highest annual averages are formaldehyde, acetaldehyde, and benzene. Formaldehyde has the highest cancer risk approximation for NBNJ, followed by benzene and carbon tetrachloride. None of the pollutants of interest for NBNJ have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. Formaldehyde is the pollutant with the highest noncancer hazard approximation for NBNJ (0.19), although the noncancer hazard approximation for acetaldehyde is similar (0.16).

18.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 18-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 18-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 18-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 18-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 18-7. Table 18-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site’s annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 18.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 18-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the New Jersey Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Chester, New Jersey (Morris County) - CHNJ					
Tetrachloroethylene	285.46	Benzene	1.21E-03	Formaldehyde	31.92
Benzene	155.47	Formaldehyde	1.20E-03	Benzene	4.97
Formaldehyde	92.49	1,3-Butadiene	7.37E-04	Carbon Tetrachloride	4.03
Ethylbenzene	89.56	Naphthalene	3.48E-04	Acetaldehyde	3.31
Acetaldehyde	55.40	POM, Group 3	2.84E-04	1,2-Dichloroethane	1.87
1,3-Butadiene	24.57	Ethylbenzene	2.24E-04	1,3-Butadiene	1.27
Naphthalene	10.24	Nickel, PM	2.03E-04	1,1,2,2-Tetrachloroethane	0.46
Dichloromethane	5.27	POM, Group 2b	1.72E-04	Hexachloro-1,3-butadiene	0.40
POM, Group 2b	1.95	Hexavalent Chromium, PM	1.52E-04		
Trichloroethylene	1.54	Arsenic, PM	1.30E-04		
Elizabeth, New Jersey (Union County) - ELNJ					
Tetrachloroethylene	1,432.00	Formaldehyde	1.31E-03	Formaldehyde	50.57
Benzene	134.93	Benzene	1.05E-03	Benzene	8.12
Formaldehyde	101.13	1,3-Butadiene	6.14E-04	Acetaldehyde	5.85
Ethylbenzene	76.77	Naphthalene	3.92E-04	1,3-Butadiene	4.18
Acetaldehyde	58.90	Tetrachloroethylene	3.72E-04	Carbon Tetrachloride	4.03
1,3-Butadiene	20.46	POM, Group 3	2.71E-04	1,2-Dichloroethane	1.97
Naphthalene	11.54	Hexavalent Chromium, PM	2.65E-04	Ethylbenzene	1.02
Dichloromethane	2.95	Ethylbenzene	1.92E-04	*p*-Dichlorobenzene	0.81
Trichloroethylene	1.77	POM, Group 2b	1.55E-04		
POM, Group 2b	1.76	Acetaldehyde	1.30E-04		

Table 18-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the New Jersey Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		**Top 10 Cancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
North Brunswick, New Jersey (Middlesex County) - NBNJ					
Tetrachloroethylene	1,352.40	Formaldehyde	1.86E-03	Formaldehyde	23.68
Benzene	205.10	Benzene	1.60E-03	Benzene	6.74
Formaldehyde	142.95	1,3-Butadiene	9.29E-04	Carbon Tetrachloride	4.03
Ethylbenzene	115.00	Naphthalene	5.50E-04	Acetaldehyde	3.10
Acetaldehyde	79.40	Hydrazine	4.38E-04	1,3-Butadiene	2.76
1,3-Butadiene	30.98	POM, Group 3	4.08E-04	1,2-Dichloroethane	2.04
Naphthalene	16.17	Tetrachloroethylene	3.52E-04	*p*-Dichlorobenzene	0.58
Trichloroethylene	3.19	Ethylbenzene	2.87E-04	1,1,2,2-Tetrachloroethane	0.57
Dichloromethane	2.77	POM, Group 2b	2.32E-04	Hexachloro-1,3-butadiene	0.43
POM, Group 2b	2.64	Hexavalent Chromium, PM	2.12E-04		

Table 18-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the New Jersey Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Chester, New Jersey (Morris County) - CHNJ					
Toluene	628.36	Acrolein	210,793.55	Formaldehyde	0.25
Xylenes	355.29	1,3-Butadiene	12,287.45	Acetaldehyde	0.17
Hexane	319.95	Formaldehyde	9,437.51	Benzene	0.02
Tetrachloroethylene	285.46	Tetrachloroethylene	7,136.42	1,3-Butadiene	0.02
Benzene	155.47	Acetaldehyde	6,155.06	Carbon Tetrachloride	0.01
Formaldehyde	92.49	Benzene	5,182.23	Hexachloro-1,3-butadiene	<0.01
Ethylbenzene	89.56	Nickel, PM	4,696.47	1,2-Dichloroethane	<0.01
Ethylene glycol	81.35	Xylenes	3,552.87		
Acetaldehyde	55.40	Naphthalene	3,412.38		
Methyl isobutyl ketone	44.30	Lead, PM	2,413.62		
Elizabeth, New Jersey (Union County) - ELNJ					
Tetrachloroethylene	1,432.00	Acrolein	279,707.82	Formaldehyde	0.40
Toluene	541.43	Cyanide Compounds, PM	37,500.01	Acetaldehyde	0.30
Hexane	355.77	Tetrachloroethylene	35,799.91	1,3-Butadiene	0.07
Xylenes	289.97	Formaldehyde	10,319.26	Propionaldehyde	0.06
Benzene	134.93	1,3-Butadiene	10,228.03	Benzene	0.03
Formaldehyde	101.13	Acetaldehyde	6,544.54	Carbon Tetrachloride	0.01
Ethylbenzene	76.77	Manganese, PM	4,514.27	Ethylbenzene	<0.01
Acetaldehyde	58.90	Benzene	4,497.65	*p*-Dichlorobenzene	<0.01
Ethylene glycol	45.15	Chlorine	4,370.00	1,2-Dichloroethane	<0.01
Methyl isobutyl ketone	44.91	Naphthalene	3,848.04		

Table 18-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the New Jersey Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
North Brunswick, New Jersey (Middlesex County) - NBNJ					
Tetrachloroethylene	1,352.40	Acrolein	367,039.29	Formaldehyde	0.19
Toluene	786.36	Tetrachloroethylene	33,810.00	Acetaldehyde	0.16
Hexane	506.75	1,3-Butadiene	15,490.94	1,3-Butadiene	0.05
Xylenes	448.83	Formaldehyde	14,586.38	Benzene	0.03
Benzene	205.10	Acetaldehyde	8,822.64	Carbon Tetrachloride	0.01
Formaldehyde	142.95	Benzene	6,836.50	Hexachloro-1,3-butadiene	<0.01
Ethylbenzene	115.00	Manganese, PM	5,831.26	*p*-Dichlorobenzene	<0.01
Acetaldehyde	79.40	Naphthalene	5,389.62	1,2-Dichloroethane	<0.01
Methyl isobutyl ketone	58.71	Lead, PM	5,101.39		
Ethylene glycol	35.26	Titanium tetrachloride	4,535.00		

Observations from Table 18-7 include the following:

- Tetrachloroethylene is the highest emitted pollutant with a cancer URE in all three New Jersey counties, followed by benzene, formaldehyde, and ethylbenzene. The tetrachloroethylene emissions in Union and Middlesex Counties are an order of magnitude greater than the emissions in Morris County.

- Benzene, formaldehyde, 1,3-butadiene, and naphthalene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for all three New Jersey counties, although not necessarily in that order.

- Six of the 10 highest emitted pollutants in Morris County also have the highest toxicity-weighted emissions. Eight of the highest emitted pollutants in Union County also have the highest toxicity-weighted emissions. Seven of the highest emitted pollutants in Middlesex County also have the highest toxicity-weighted emissions.

- Formaldehyde, benzene, and 1,3-butadiene are among the pollutants with the highest cancer risk approximations for CHNJ and also appear on both emissions-based lists. Acetaldehyde is also among the pollutants with the highest cancer risk approximations for CHNJ; this pollutant also appears among the highest emitted pollutants in Morris County but does not appear among those with the highest toxicity-weighted emissions.

- Five of the 10 pollutants of interest listed in Table 18-7 for ELNJ also appear on both emissions-based lists: formaldehyde, benzene, acetaldehyde, ethylbenzene, and 1,3-butadiene.

- Formaldehyde, benzene, and 1,3-butadiene are among those with the highest cancer risk approximations for NBNJ, and each of these appear on both emissions-based lists for Middlesex County. Acetaldehyde has one of the higher cancer risk approximations for NBNJ; although acetaldehyde is one of the highest emitted pollutants in Middlesex County, it is not among those with the highest toxicity-weighted emissions.

- Carbon tetrachloride is among the pollutants with the highest cancer risk approximations for each of the three New Jersey counties, ranking third, fifth, and third for CHNJ, ELNJ, and NBNJ, respectively. This pollutant’s total emissions rank greater than 20th for each county and its toxicity-weighted emissions rank greater than 30th for each county; thus, carbon tetrachloride does not appear on either emissions-based list in Table 18-7.

Observations from Table 18-8 include the following:

- Tetrachloroethylene is also the highest emitted pollutant with a noncancer RfC in Union and Middlesex Counties, but ranks fourth in Morris County. Toluene, xylenes, and hexane are the highest emitted pollutants with noncancer RfCs in Morris County. These pollutants are among the highest emitted (behind tetrachloroethylene) in Union and Middlesex Counties.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for all three counties but is not among the highest emitted pollutants for any of the New Jersey counties (acrolein ranks between 16th and 17th for these counties). Although acrolein was sampled for at all three sites, this pollutant was excluded from the pollutant of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Formaldehyde, benzene, acetaldehyde, and tetrachloroethylene appear on both emissions-based lists for Morris, Union, and Middlesex Counties. Xylenes also appear on both lists for Morris County.

- Formaldehyde, acetaldehyde, and benzene are among the pollutants with the highest noncancer hazard approximations for CHNJ, ELNJ, and NBNJ (although all were less than an HQ of 1.0). These pollutants also appear on both emissions-based lists for all three New Jersey counties. 1,3-Butadiene ranks among the pollutants with the highest noncancer hazard approximations and is among the pollutants with the highest toxicity-weighted emissions but is not among the pollutants with the highest emissions (of the pollutants with noncancer RfCs).

18.6 Summary of the 2012 Monitoring Data for the New Jersey Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Thirteen pollutants failed at least one screen for CHNJ; 14 failed screens for ELNJ; 12 failed screens for NBNJ.*

- ❖ *Formaldehyde and acetaldehyde had the highest annual average concentrations for each of the New Jersey sites.*

- ❖ *NBNJ has the highest annual average concentration of hexachloro-1,3-butadiene among all NMP sites sampling VOCs, with the annual average for CHNJ ranking third and ELNJ ranking ninth.*

- ❖ *ELNJ is the longest running NMP site still participating in the program. Concentrations of propionaldehyde measured at ELNJ have a fairly steady increasing trend. In addition, the detection rate of 1,2-dichloroethane at all three New Jersey sites has been increasing steadily over the last few years of sampling.*

19.0 Sites in New York

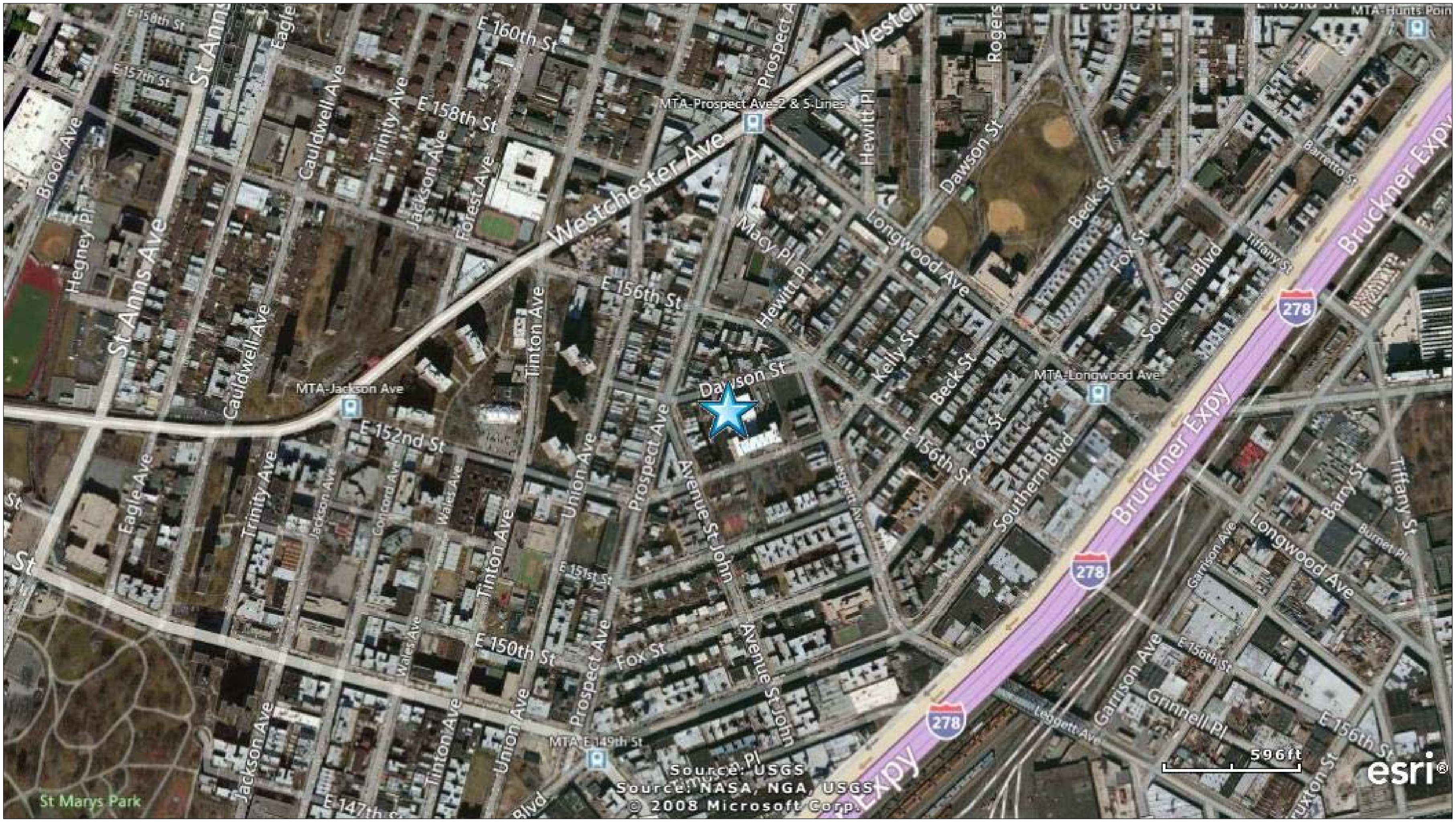
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS sites in New York, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

19.1 Site Characterization

This section characterizes the New York monitoring sites by providing geographical and physical information about the locations of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

Two New York monitoring sites are located in New York City (BXNY and MONY) and one is located in Rochester (ROCH). Figures 19-1 and 19-2 are composite satellite images retrieved from ArcGIS Explorer showing the New York City monitoring sites and their immediate surroundings. Figure 19-3 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 19-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 19-4 and 19-5 are the composite satellite image and point emissions sources map for ROCH. Table 19-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 19-1. New York City, New York (BXNY) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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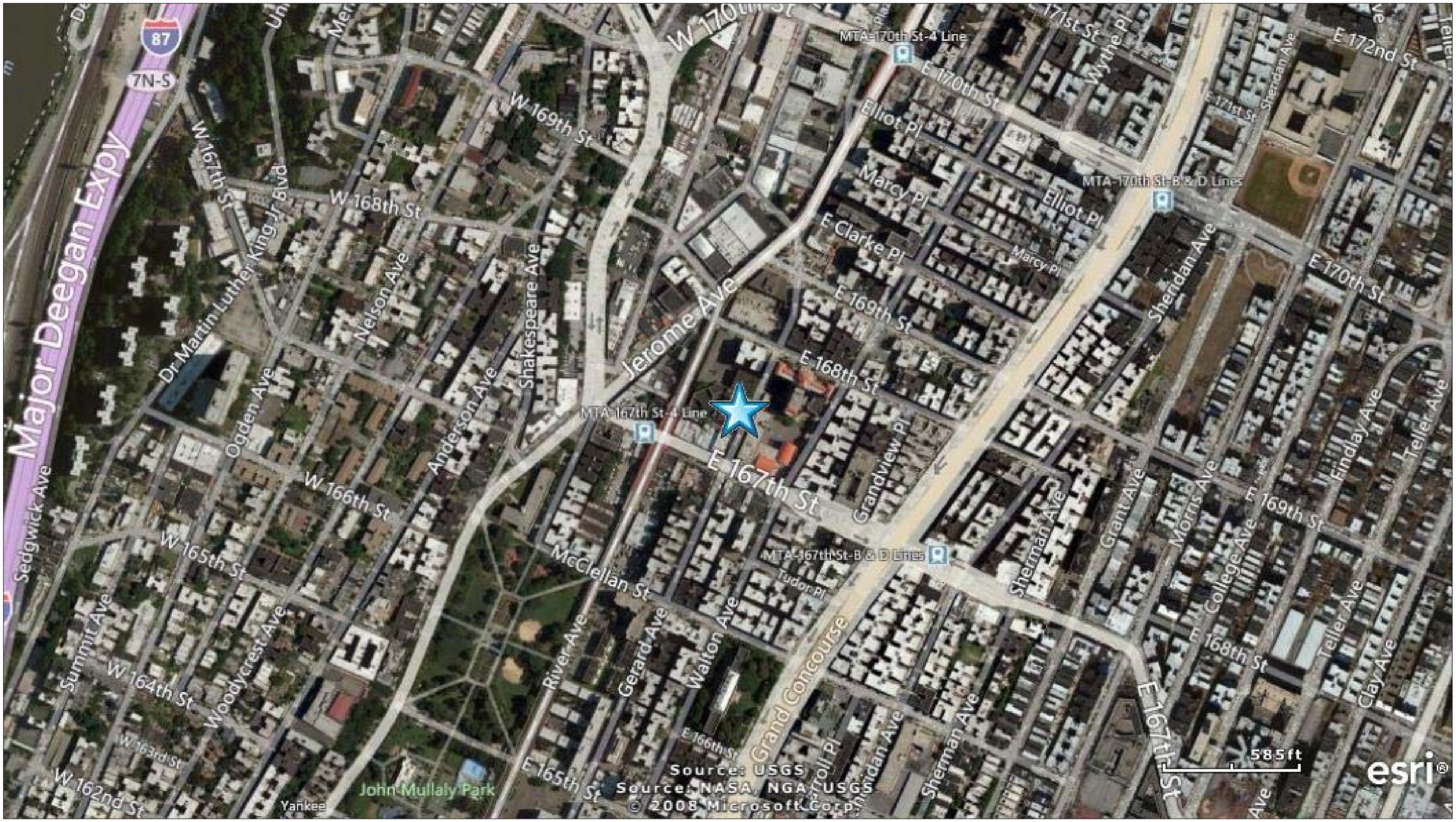
Figure 19-2. New York City, New York (MONY) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 19-3. NEI Point Sources Located Within 10 Miles of BXNY and MONY

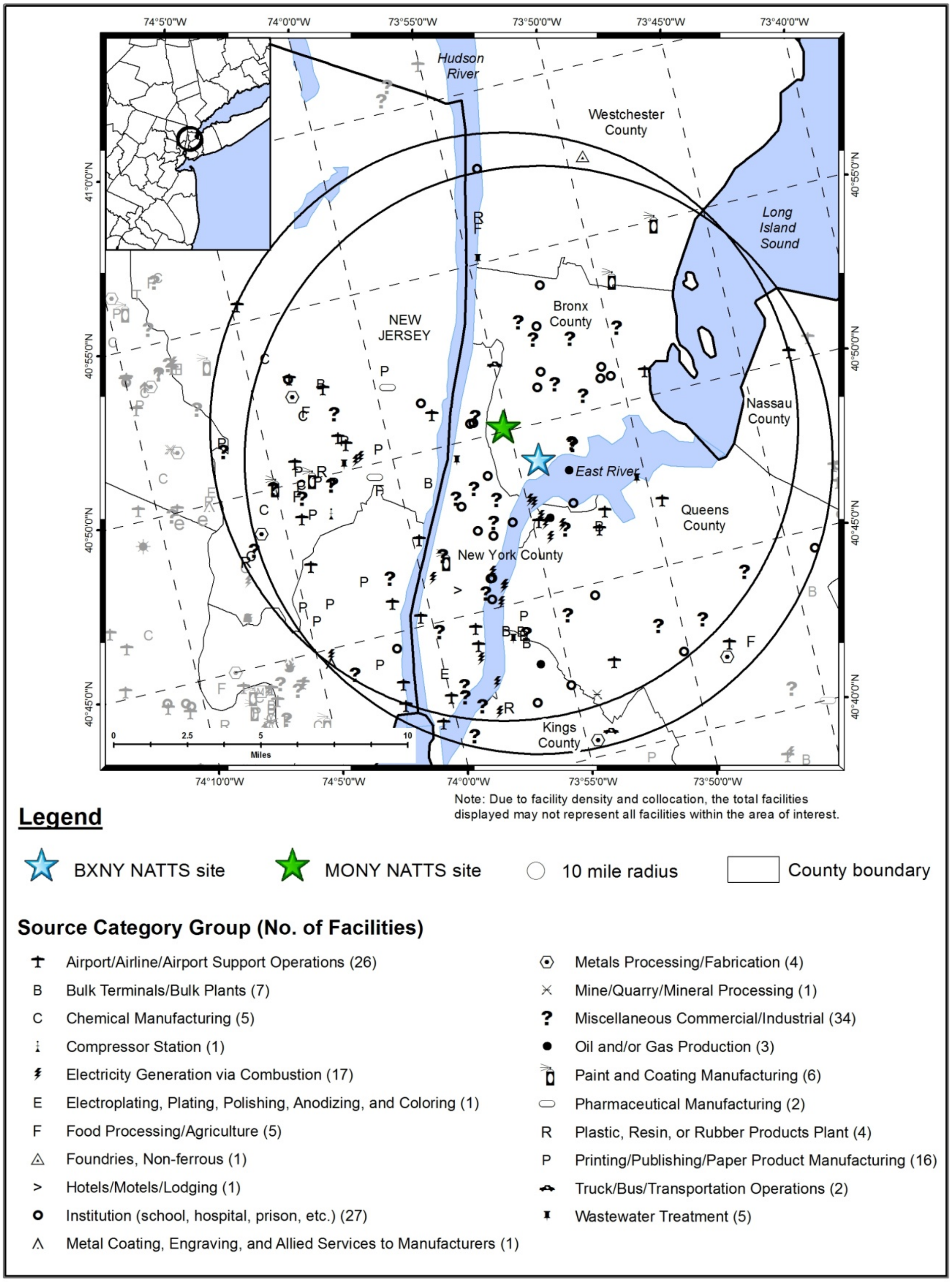
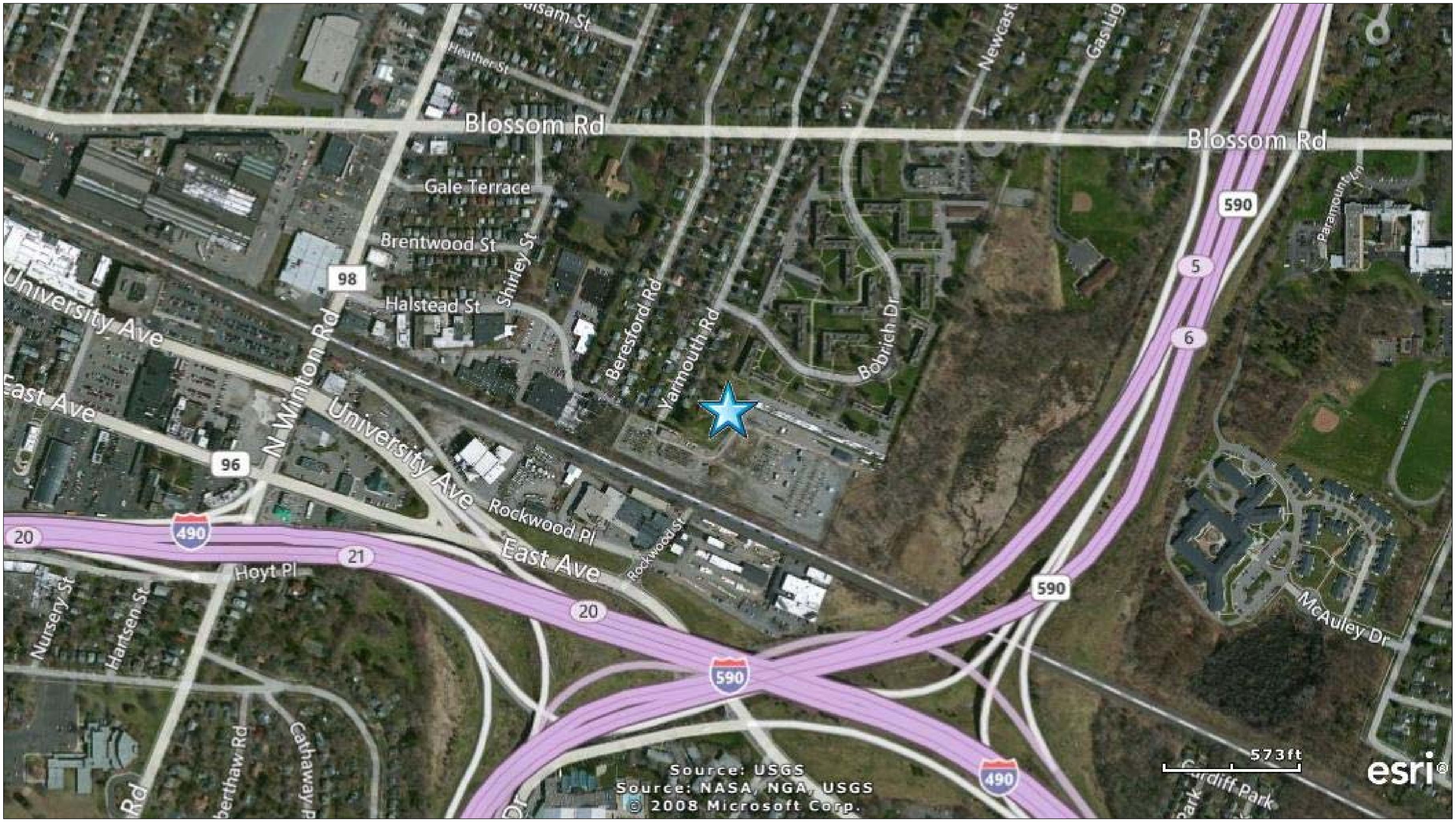


Figure 19-4. Rochester, New York (ROCH) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 19-5. NEI Point Sources Located Within 10 Miles of ROCH

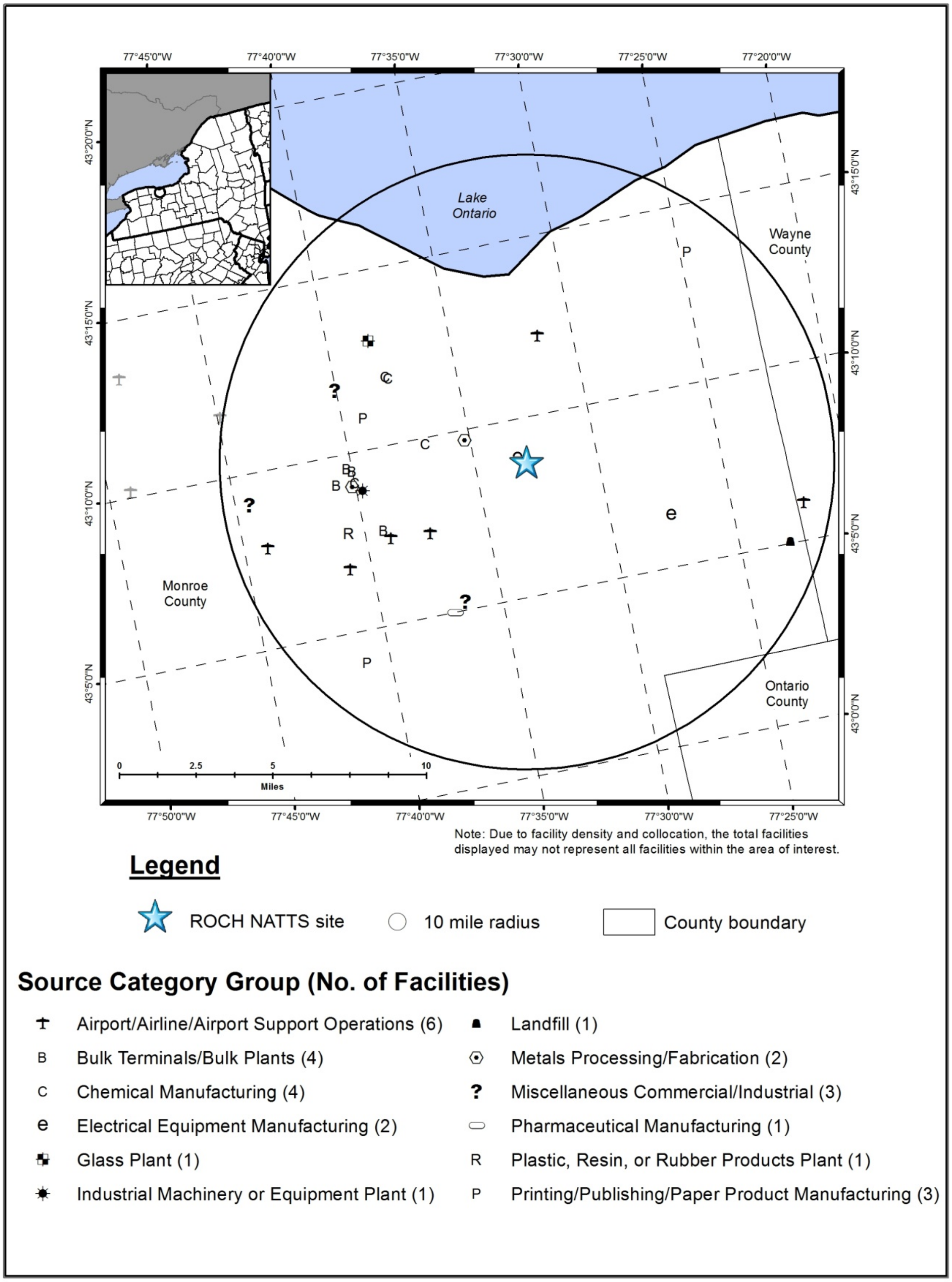


Table 19-1. Geographical Information for the New York Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
BXNY	36-005-0110	New York	Bronx	New York-Newark-Jersey City, NY-NJ-PA MSA	40.81618, -73.902	Residential	Urban/City Center	Haze, SO_2, NO, NO_2, NO_x, VOCs, Carbonyl compounds, O_3, Meteorological Parameters, PM coarse, Black Carbon, PM_{10}, PM_{10} Metals, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
MONY	36-005-0080	New York	Bronx	New York-Newark-Jersey City, NY-NJ-PA MSA	40.83606, -73.92009	Residential	Urban/City Center	Carbonyl Compounds, VOCs, Meteorological Parameters, Black carbon, PM_{10}, PM_{10} Speciation, $PM_{2.5}$.
ROCH	36-055-1007	Rochester	Monroe	Rochester, NY MSA	43.14618, -77.54817	Residential	Urban/City Center	CO, SO_2, NO, NO_y, VOCs, Carbonyl compounds, O_3, Meteorological parameters, Black Carbon, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

BXNY is located on the property of Public School 52 (PS 52) in the Bronx Borough of New York City, northeast of Manhattan. The site was established in 1999 and is considered one of the premier particulate sampling sites in New York City and is the Bronx (#1) NATTS site. The surrounding area is urban and residential, as shown in Figure 19-1. The Bruckner Expressway (I-278) is located a few blocks east of the monitoring site and other heavily traveled roadways are also located within a few miles of the site. A freight yard and other industries lie on the southeast and south side of I-278, part of which can be seen in the lower right-hand side of Figure 19-1. BXNY is less than one-half mile from the East River.

The MONY site is located at the Morrisania Neighborhood Family Care center. This site is considered the Bronx (#2) NATTS site and is a relocation of the BXNY site. MONY is located less than three-quarters of a mile south of I-95, one-half mile east of I-87 and the Harlem River, which separates the island of Manhattan from the Bronx. Part of the Harlem River can be seen in the upper left-hand corner of Figure 19-2. The Hudson River is just a few blocks farther west. The area surrounding MONY is primarily residential, although commercial areas are located along Jerome Avenue and East 167th Street.

The BXNY site is 1.65 miles southeast of the MONY site. Figure 19-3 shows the numerous point sources that are located within 10 miles of the sites. The majority of the emissions sources are located to the south and west of the sites. The source categories with the greatest number of emissions sources surrounding these sites include institutions such as hospitals, schools, and prisons; airport and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; electricity generation via combustion; and printing, publishing, and paper product manufacturing. The point source closest to BXNY is involved in oil and gas production. Two point sources are located within 1 mile of MONY: one is a hospital/medical school and the other falls into the miscellaneous commercial/industrial source category.

In June 2010, the monitoring instruments at BXNY were moved to MONY due to roofing construction. At the end of June 2012, the instrumentation was returned to the BXNY site and sampling resumed at this location in July 2012. Thus, this report includes the final 6 months of sampling at MONY and the initial 6 months of sampling after the relocation back to BXNY.

ROCH is located at a power substation on the east side of Rochester, in western New York. Rochester is approximately halfway between Syracuse and Buffalo, with Lake Ontario situated to the north. Although the area north and west of the site is primarily residential, as shown in Figure 19-4, a railroad transverses the area just south of the site, and I-590 and I-490 intersect farther south with commercial areas adjacent to this corridor. The site is used by researchers from several universities for short-term air monitoring studies and is the Rochester NATTS site. As Figure 19-5 shows, the relatively few point sources within 10 miles of ROCH are located primarily on the west side of the 10-mile radius. The airport and airport support operations source category is the source category with the greatest number of emissions sources surrounding ROCH, although there are also bulk plants/bulk terminals, chemical manufacturers, metals processors/fabricators, and electrical equipment manufacturers nearby, to name a few. The closest source to ROCH is an electrical equipment manufacturer

Table 19-2 presents additional site-characterizing information, including indicators of mobile source activity, for the New York monitoring sites. Table 19-2 includes both county-level population and vehicle registration information. Table 19-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 19-2 presents the county-level daily VMT for Bronx and Monroe Counties.

Table 19-2. Population, Motor Vehicle, and Traffic Information for the New York Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
BXNY	1,408,473	251,398	99,201	I-278 between I-87 and I-895	8,178,210
MONY			91,213	I-87 between Bronx Expressway & Macombs Bridge	
ROCH	747,813	556,055	88,348	I-490 at I-590	15,980,952

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (NYS DMV, 2012)
[3] AADT reflects 2011 data (NYS DOT, 2011)
[4] County-level VMT reflects 2011 data (NYS DOT, 2013)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 19-2 include the following:

- Bronx County has the ninth highest county-level population among counties with NMP sites. The population of Rochester County is less than the Bronx County population and ranks 17th among NMP sites.

- County-level vehicle ownership for Bronx County ranks 29th among counties with NMP sites, which is in the middle of the range among NMP sites. The county-level vehicle registration for Rochester County is more than twice the vehicle registration for Bronx County and ranks 18th compared to other NMP sites.

- Although the population for Bronx County is twice the population for Rochester County, the vehicle registration for Bronx County is roughly half the vehicle registration for Rochester County The difference in county-level population and vehicle registration ranking for Bronx County may be explained by mass transportation systems.

- Of the New York monitoring sites, traffic is highest near BXNY, which ranks 16th among NMP sites. The traffic volumes near MONY and ROCH are not that different from each other and, compared to other NMP sites, the traffic volumes near MONY and ROCH rank 19th and 20th, respectively. The traffic data for BXNY is for I-278 between I-87 and I-895; the traffic data for MONY are provided for I-87 between the Bronx Expressway and Macombs Bridge; and the traffic data for ROCH are provided for I-490 at I-590.

- County-level daily VMT for Monroe County is nearly twice the VMT for Bronx County. These VMT are in the middle of the range compared to other counties with NMP sites (where VMT data are available).

19.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in New York on sample days, as well as over the course of the year.

19.2.1 Climate Summary

Weather conditions are somewhat variable in New York City as frontal systems frequently affect the area. Precipitation is spread fairly evenly throughout the year, with thunderstorms in the summer and fall and more significant rain or snow events in the winter and spring. Wintertime snow accumulations generally range from 3 inches to 10 inches. The proximity to the Atlantic Ocean offers a moderating influence from cold outbreaks as well as the summertime heat. The urban heat island effect tends to keep the city warmer than outlying areas. Both influences result in a relatively small diurnal range of temperatures. In addition, air sinking down from the mountains to the west can help drive temperatures higher during warm spells. Northwesterly winds prevail during the winter months while southwesterly winds are common during the warmer months (Wood, 2004; Cornell, 2014).

Rochester is located in western New York and borders Lake Ontario’s south side. Elevation increases significantly from the shore to the southern-most parts of the city, rising over 800 feet. The lake acts as a moderating influence on the city’s temperatures, both in the summer and the winter, as Lake Ontario does not freeze most winters. It also plays a major factor in the city’s precipitation patterns. Lake effect snow enhances the area’s snowfall totals, although snowfall rates tend to be higher near Lake Ontario and points east rather than farther inland. The average winter sees 90 inches of snowfall in the city. Spring and summer tend to be sunny due to the stabilizing effect of the lake, while cloudy conditions are prevalent in the fall and winter. Prevailing winds are from the southwest year-round (Bair 1992; Wood, 2004).

19.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the stations closest to the New York monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather station to both MONY and BXNY is located at La Guardia Airport, WBAN 14732. The closest weather station to ROCH is located at Greater Rochester International Airport, WBAN 14768. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 19-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 19-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for the entire year. Also included in Table 19-3 is the 95 percent confidence interval for each parameter. As expected, Table 19-3 shows that conditions were cooler in western New York than in New York City. Temperatures near BXNY appear warmer on sample days than they were the rest of the year. Recall, though, that sampling at this site began in July 2012, thereby missing the coldest months of the year. The reverse is true for MONY. Temperatures near MONY appear cooler on sample days than they were the rest of the year; this site completed sampling June 2012, thereby missing the warmest months of the year. Average meteorological conditions on sample days near ROCH were representative of average weather conditions experienced throughout the year.

Table 19-3. Average Meteorological Conditions near the New York Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
New York City, New York - BXNY									
La Guardia Airport 14732 (40.78, -73.88)	2.8 miles 143° (SE)	Sample Days (34)	67.7 ± 5.5	62.2 ± 5.1	49.5 ± 4.9	55.3 ± 4.4	65.7 ± 5.0	1015.6 ± 2.7	8.5 ± 1.1
		2012	64.4 ± 1.7	58.1 ± 1.6	43.3 ± 1.8	50.9 ± 1.5	61.0 ± 1.6	1015.8 ± 0.8	8.9 ± 0.4
New York City, New York - MONY									
La Guardia Airport 14732 (40.78, -73.88)	4.4 miles 139° (SE)	Sample Days (30)	59.2 ± 6.1	52.6 ± 5.8	36.7 ± 6.9	45.7 ± 5.5	58.2 ± 6.5	1016.8 ± 3.0	9.1 ± 1.2
		2012	64.4 ± 1.7	58.1 ± 1.6	43.3 ± 1.8	50.9 ± 1.5	61.0 ± 1.6	1015.8 ± 0.8	8.9 ± 0.4
Rochester, New York - ROCH									
Greater Rochester Intl. Airport 14768 (43.12, -77.68)	6.4 miles 240° (WSW)	Sample Days (61)	61.5 ± 4.7	52.5 ± 4.3	41.5 ± 4.0	47.1 ± 3.8	69.0 ± 2.7	1015.5 ± 2.0	7.5 ± 0.8
		2012	60.3 ± 1.9	51.9 ± 1.7	41.3 ± 1.6	46.6 ± 1.5	70.1 ± 1.1	1015.6 ± 0.7	7.2 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

19.2.3 Back Trajectory Analysis

Figure 19-6 is the composite back trajectory map for days on which samples were collected at the BXNY monitoring site. Included in Figure 19-5 are four back trajectories per sample day. Figure 19-7 is the corresponding cluster analysis. Similarly, Figures 19-8 through 19-11 are the composite back trajectory maps and corresponding cluster analyses for days on which samples were collected at MONY and ROCH. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 19-6 through 19-11 represents 100 miles.

Observations from Figures 19-6 and 19-7 for BXNY include the following:

- The back trajectory maps for BXNY include sample days between July and December 2012 only to match the sampling period for this site.

- Back trajectories originated from a variety of directions at BXNY, with the longest back trajectories originating to the northwest of BXNY.

- The 24-hour air shed domain for BXNY is similar in size to other NMP sites. Although the farthest away a back trajectory originated was over Lake Michigan, or less than 650 miles away, the average back trajectory length was 208 miles and nearly 90 percent of trajectories originated within 350 miles of the site. Recall, however that this map includes only 6 months of sample days and that the map may look different with a full year’s worth of data.

- The cluster analysis shows that one-quarter back trajectories originated to the west and northwest of BXNY, but are split into two cluster trajectories based on length. The short cluster trajectory also originating to the northwest of BXNY and accounting for 29 percent of back trajectories represents relatively short back trajectories (generally less than 150 miles) originating from a variety of directions. Eight percent of back trajectories originated to the north of BXNY over upstate New York and Vermont. Twelve percent originated to the east of the site over the offshore waters of the New England states. Another 15 percent of back trajectories originated to the south of BXNY, primarily over the offshore waters of New Jersey and the Delmarva Peninsula. The final 12 percent of back trajectories originated to the southwest of BXNY, over Virginia, Maryland, and Pennsylvania. This cluster also includes three of the four back trajectories that spiral around from the Appalachian Mountains, along the NC/VA border, and offshore towards the monitoring site. These back trajectories represent October 30, 2012, when Hurricane Sandy came ashore.

Figure 19-6. Composite Back Trajectory Map for BXNY

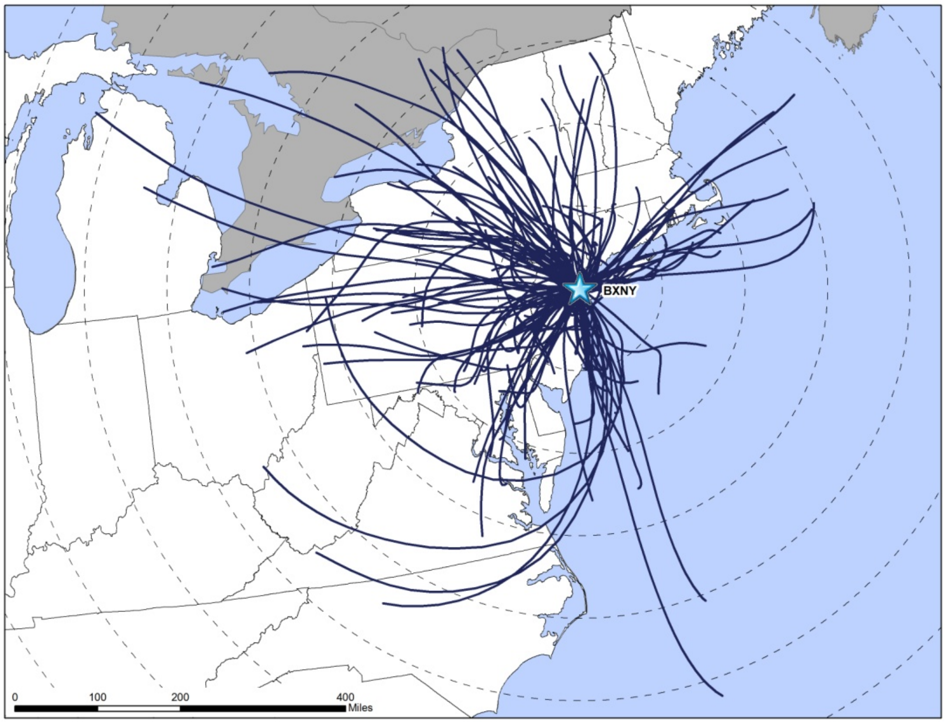


Figure 19-7. Back Trajectory Cluster Map for BXNY

Figure 19-8. Composite Back Trajectory Map for MONY

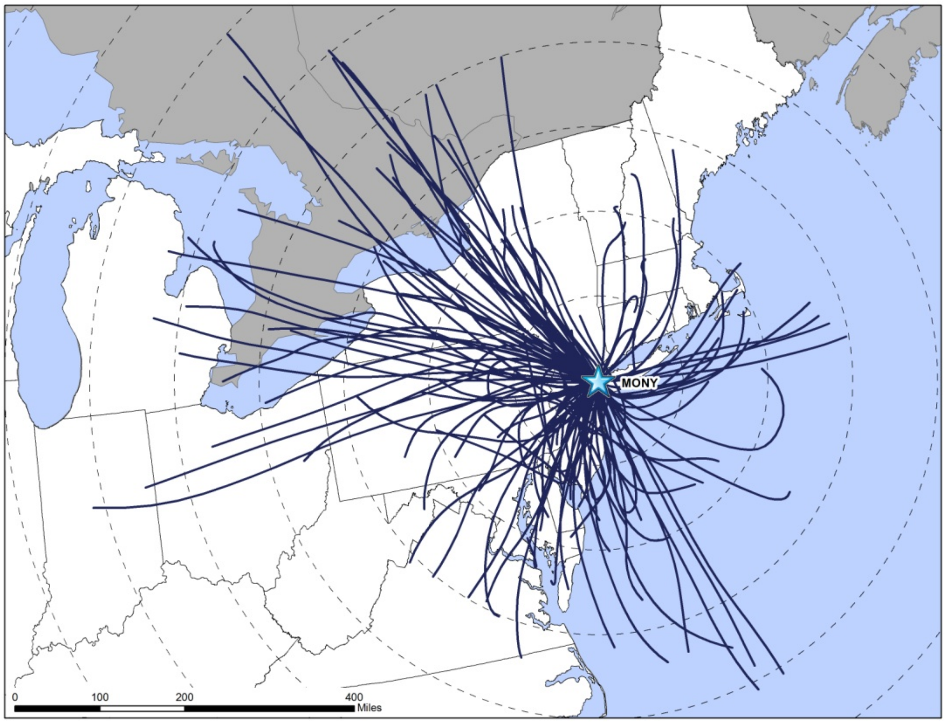


Figure 19-9. Back Trajectory Cluster Map for MONY

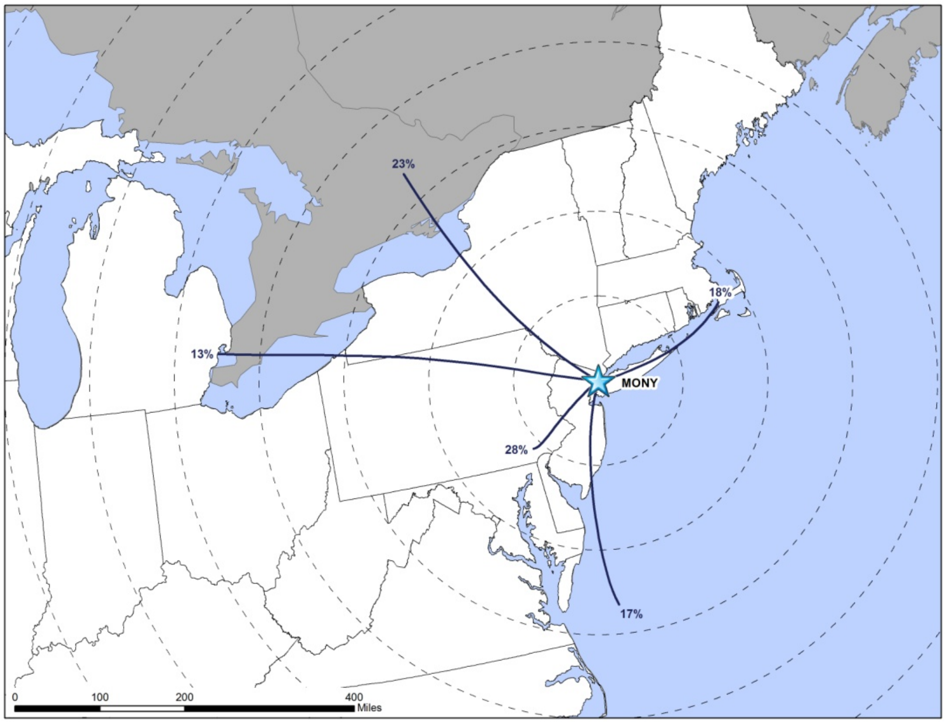


Figure 19-10. Composite Back Trajectory Map for ROCH

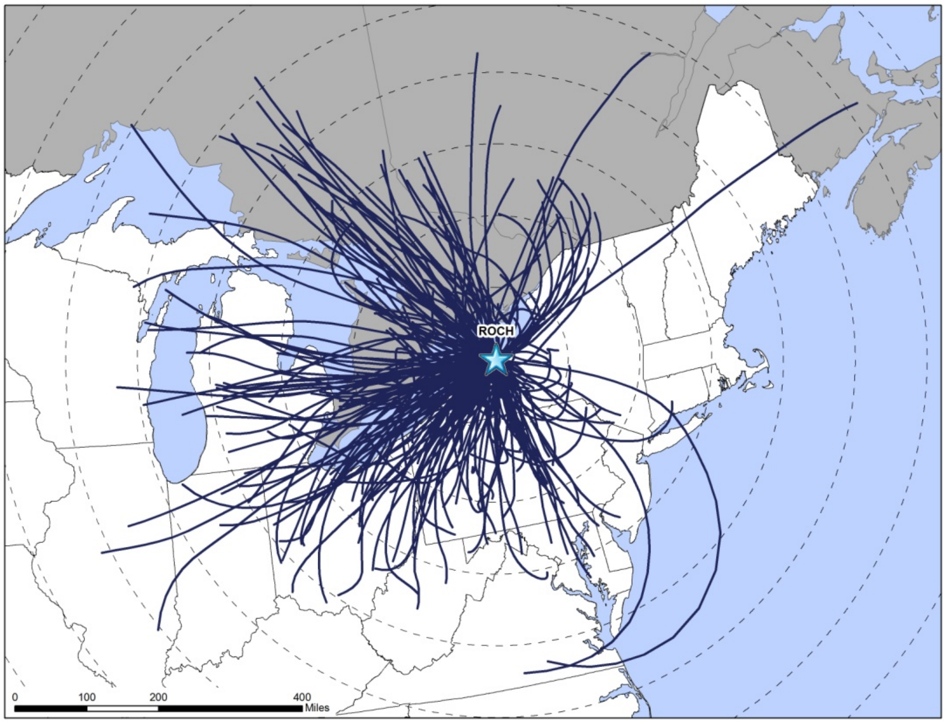
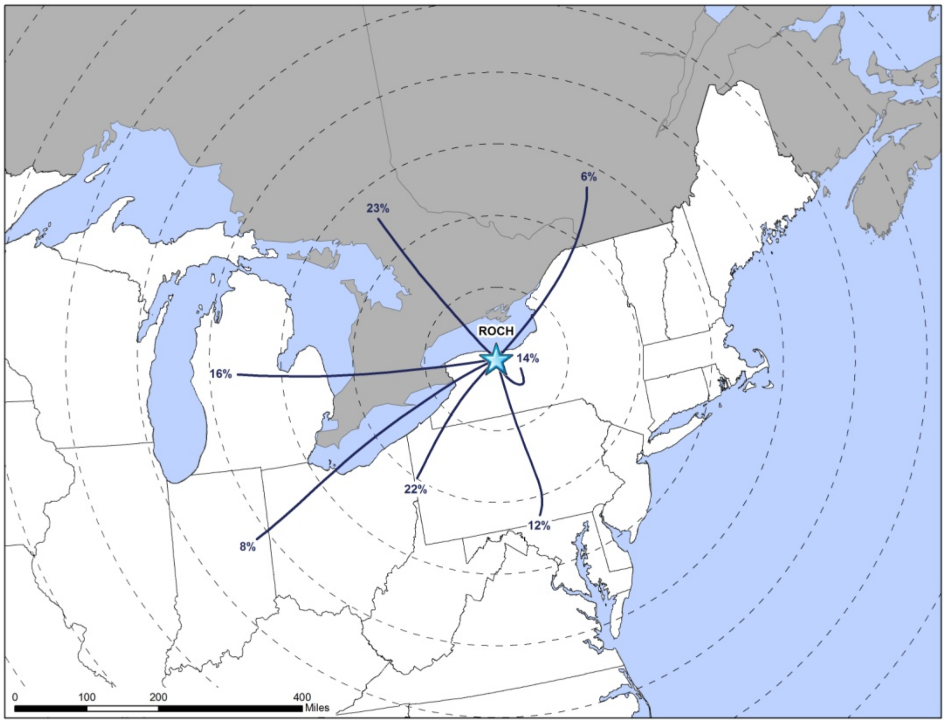


Figure 19-11. Back Trajectory Cluster Map for ROCH



Observations from Figures 19-8 and 19-9 for MONY include the following:

- The back trajectory maps for MONY include sample days between only January and June 2012 to match the sampling period for this site.

- Relatively few back trajectories originated to the north and northeast of the MONY site. The longest back trajectories originated from the west and northwest of MONY.

- The 24-hour air shed domain for MONY is larger in size to BXNY and many NMP sites, with an average back trajectory length of 269 miles. The farthest away a back trajectory originated was over central Indiana or greater than 600 miles away, although 85 percent of trajectories originated within 400 miles of the site. Recall, however, that this map includes only 6 months of sample days and that the map may look different with a full year's worth of data.

- The cluster analysis shows that nearly one-quarter of back trajectories originated to the northwest of MONY, over New York and southeast Ontario, Canada. Another 13 percent of back trajectories originated to the west of MONY, over Lake Huron and southward to Ohio. The relatively short cluster trajectory (28 percent) represents back trajectories originating to the south, southwest, and west of the site but generally less than 200 miles away. Another 17 percent of back trajectories originated over the Mid-Atlantic states and their offshore waters. The cluster trajectory originating toward Cape Cod, Massachusetts represents all of the back trajectories originating to the northeast, east, and southeast of MONY.

Observations from Figures 19-10 and 19-11 for ROCH include the following:

- Back trajectories originated from a variety of directions at ROCH, although relatively few originated from the northeast and east of ROCH.

- The farthest away a back trajectory originated from ROCH was over New Brunswick, Canada, or greater than 600 miles away. This back trajectory is also associated with Hurricane Sandy's path. However, the average back trajectory length was 257 miles and 93 percent of back trajectories originated within 450 miles of the site.

- The cluster analysis shows that nearly 70 percent of back trajectories originated from a direction with a westerly component. These back trajectories are represented by four cluster trajectories in Figure 19-11: 1) back trajectories originating over southeast Ontario, Canada (23 percent); 2) back trajectories originating over Michigan and Lake Michigan (16 percent); 3) longer trajectories originating towards Illinois, Indiana, and western Ohio (8 percent); and 4) shorter back trajectories originating from over western Pennsylvania and eastern Ohio (22 percent).

- Six percent of back trajectories originated to the northeast of ROCH; this cluster includes the two long back trajectories originating farther than 500 miles away and those back trajectories wedged between them. The very short cluster trajectory originating just east of ROCH and then curving back towards the site represents those back trajectories originating within 100 miles of the site and from a variety of directions. This cluster trajectory also represents a few longer back trajectories originating along the NY-PA-NJ borders. The final 12 percent of back trajectories originated to the south-southeast to south-southwest of the site and includes the two curvy back trajectories originating over south-central Virginia associated with Hurricane Sandy.

19.2.4 Wind Rose Comparison

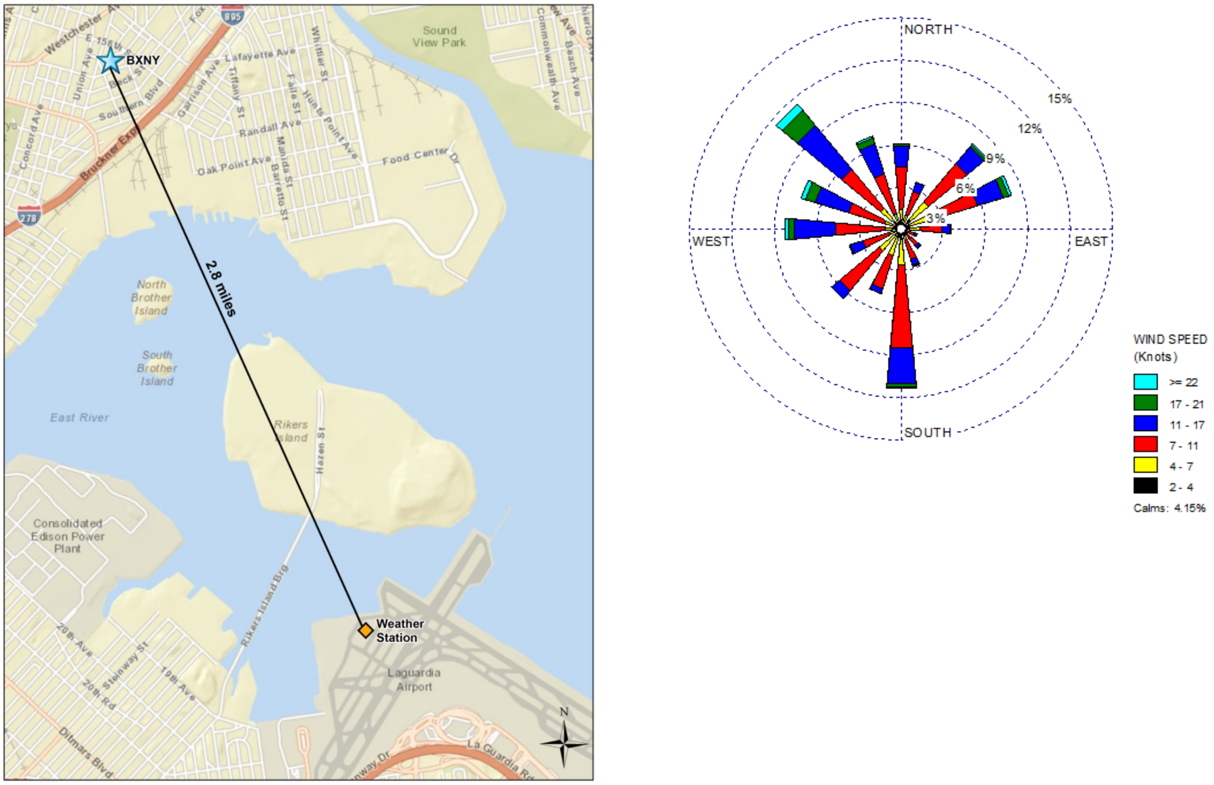
Hourly surface wind data from the weather stations at La Guardia Airport (for BXNY and MONY) and Greater Rochester International Airport (for ROCH) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 19-12 presents a map showing the distance between the weather station and BXNY, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 19-12 also presents three different wind roses for the BXNY monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 19-13 and 19-14 present the distance maps and wind roses for MONY and ROCH.

Figure 19-12. Wind Roses for the La Guardia Airport Weather Station near BXNY

Location of BXNY and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

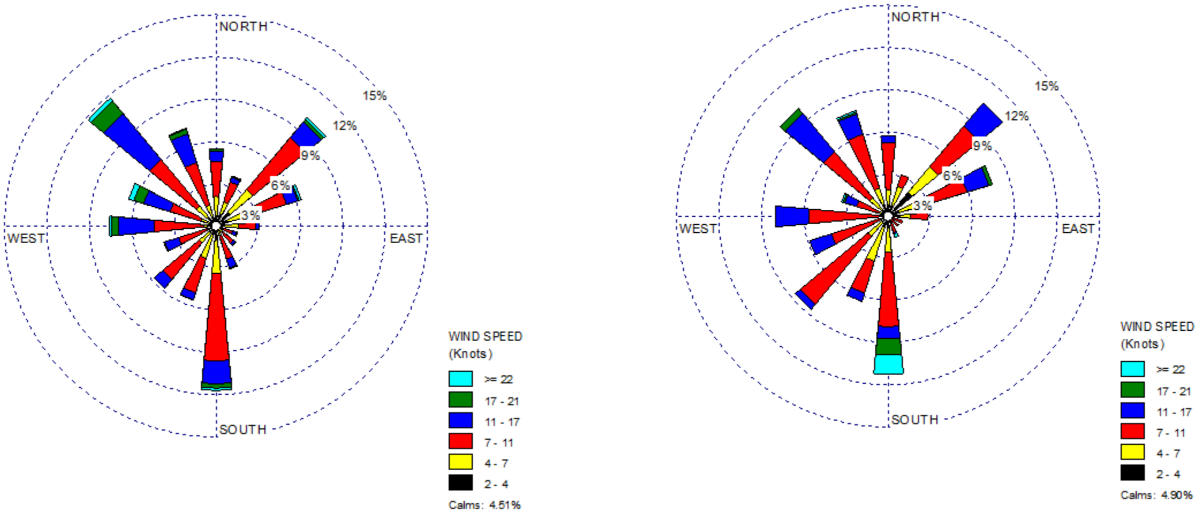
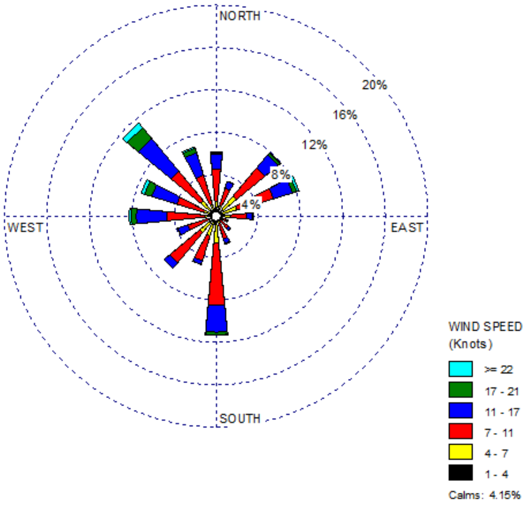


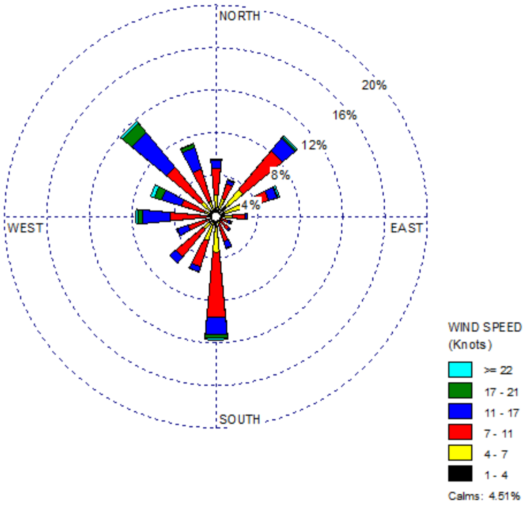
Figure 19-13. Wind Roses for the La Guardia Airport Weather Station near MONY

Location of MONY and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

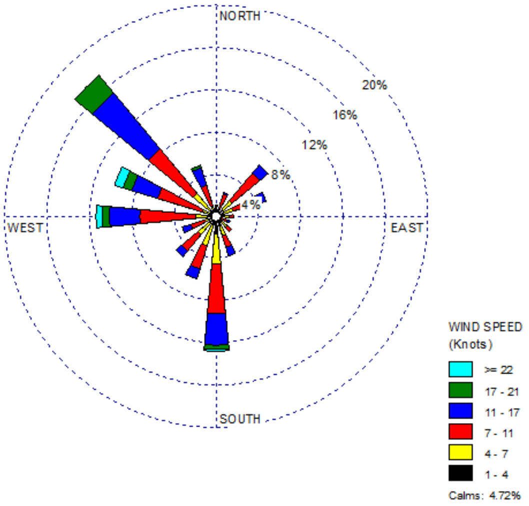
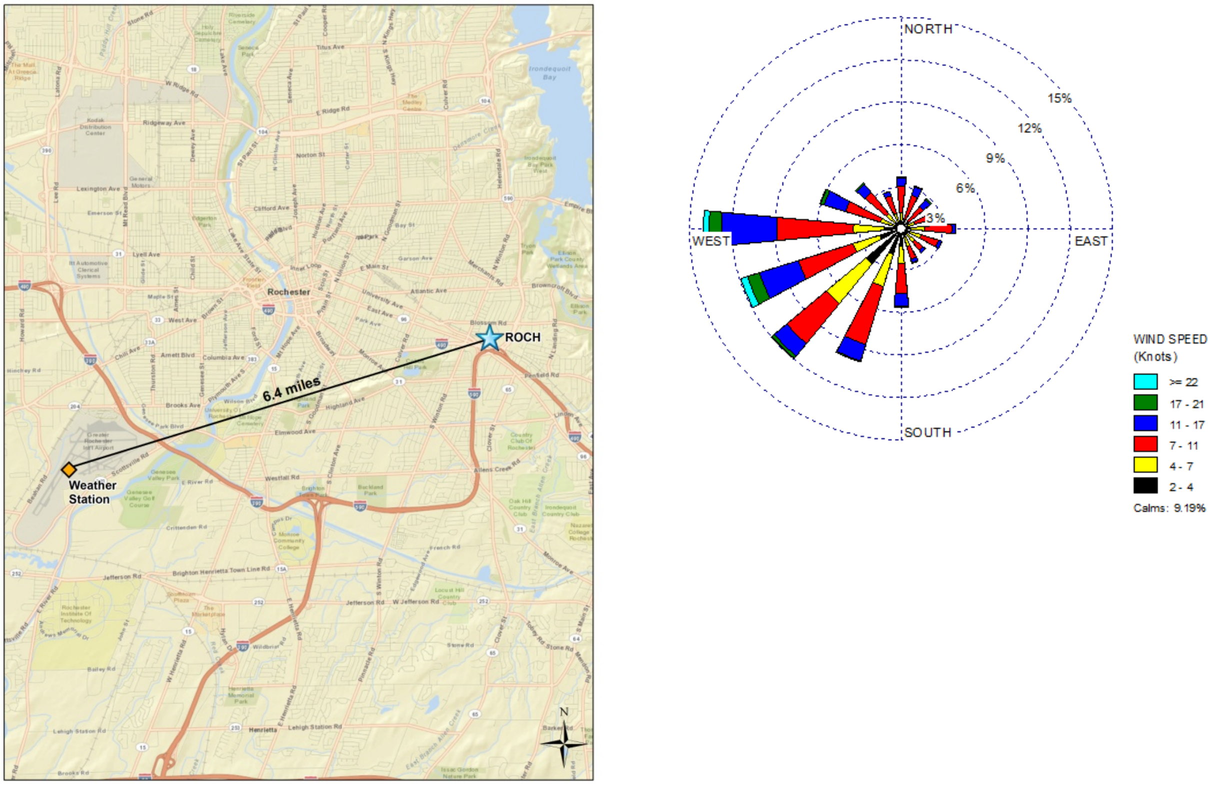
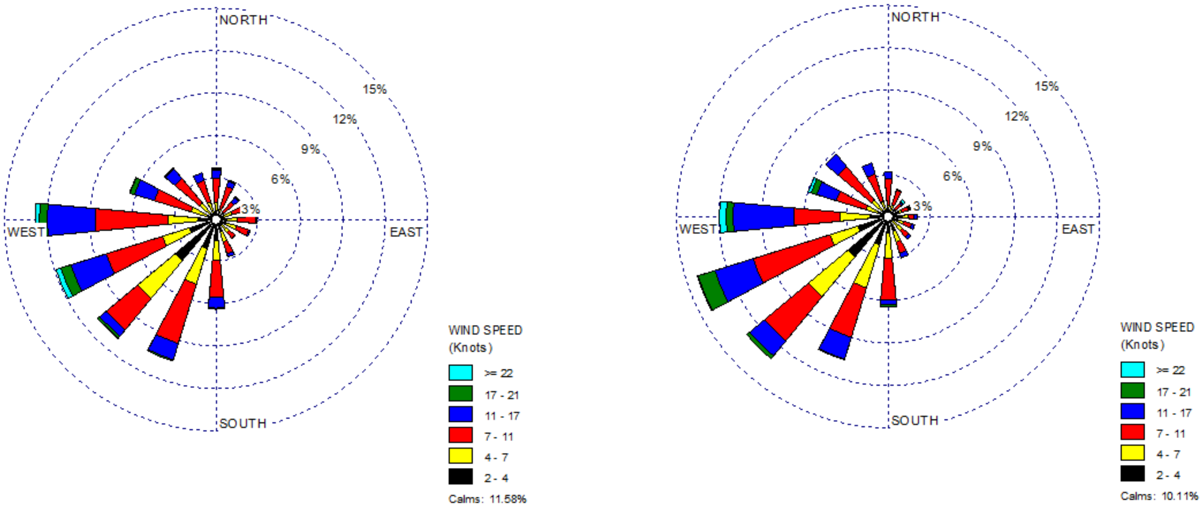


Figure 19-14. Wind Roses for the Greater Rochester International Airport Weather Station near ROCH



Location of ROCH and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Observations from Figures 19-12 and 19-3 for BXNY and MONY include the following:

- The weather station at La Guardia Airport is located 2.8 miles southeast of BXNY and 4.4 miles southeast of MONY. The East River and Rikers Island separate the sites and the weather station.

- Because the La Guardia Airport weather station is the closest weather station to both sites, the historical and 2012 wind roses for BXNY are the same as those for MONY.

- The historical wind rose shows that winds from a variety of directions are observed near BXNY and MONY, although rarely from the southeast quadrant. Winds from the west to northwest to north account for nearly 40 percent of the wind observations. Winds from the northeast and east-northeast account for another 17 percent of observations while winds from the south account for nearly 12 percent. Calm winds (≤2 knots) were observed for less than 5 percent of the hourly measurements near BXNY and MONY.

- The full-year wind rose for 2012 shares many similarities with the historical wind rose, such as the prominence of winds from the northwest and the lack of winds from the southeast quadrant. There are some differences, though. For example, winds from the northeast account for a higher percentage than winds from the east-northeast, whereas the percentages are more similar historically.

- For BXNY, the sample day wind patterns resemble the wind patterns on the other wind roses, particularly the full-year wind rose, although there are fewer strong winds associated with winds from the northwest quadrant and more strong winds associated with southerly winds.

- For MONY, westerly to northwesterly winds account for nearly 40 percent of the wind observations, with southerly winds accounting for another 12 percent of observations. While this is a common attribute of the historical and full-year wind roses, the sample day wind rose lacks winds from the north-northwest to north to northeast.

- The differences between the sample day wind rose for MONY and the wind rose for BXNY likely results from seasonal differences in the wind observations experienced near the sites. Recall that sampling at MONY was discontinued June, the instrumentation moved, and sampling restarted at BXNY in July.

Observations from Figure 19-14 for ROCH include the following:

- The Greater Rochester International Airport weather station is located 6.4 miles west-southwest of ROCH, with much of the southern half of the city of Rochester between them.

- The historical wind rose shows that winds from the south-southwest to west were frequently observed, accounting for nearly 50 percent of the wind observations. Calm winds were observed for less than 10 percent of the hourly measurements near

ROCH, while the strongest winds were most frequently observed with west-southwesterly and westerly winds.

- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns for ROCH, although the percentage of calm winds was slightly higher (nearly 12 percent).

- The sample day wind patterns are similar to those shown on the full-year wind rose, although the percentages differ somewhat.

19.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each New York monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 19-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 19-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. All three New York sites sampled for hexavalent chromium and PAHs.

Table 19-4. Risk-Based Screening Results for the New York Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
PS 52, New York City, New York - BXNY						
Naphthalene	0.029	22	22	100.00	57.89	57.89
Fluorene	0.011	8	22	36.36	21.05	78.95
Acenaphthene	0.011	6	22	27.27	15.79	94.74
Acenaphthylene	0.011	1	17	5.88	2.63	97.37
Fluoranthene	0.011	1	22	4.55	2.63	100.00
Total		38	105	36.19		
Morrisania, New York City, New York - MONY						
Naphthalene	0.029	30	30	100.00	65.22	65.22
Acenaphthene	0.011	6	30	20.00	13.04	78.26
Fluorene	0.011	6	30	20.00	13.04	91.30
Benzo(a)pyrene	0.00057	3	30	10.00	6.52	97.83
Fluoranthene	0.011	1	30	3.33	2.17	100.00
Total		46	150	30.67		
Rochester, New York - ROCH						
Naphthalene	0.029	44	58	75.86	48.35	48.35
Acenaphthene	0.011	22	58	37.93	24.18	72.53
Fluorene	0.011	17	58	29.31	18.68	91.21
Fluoranthene	0.011	8	58	13.79	8.79	100.00
Total		91	232	39.22		

Observations from Table 19-4 include the following:

- Five pollutants failed screens for BXNY; 36 percent of concentrations for these five pollutants were greater than their associated risk screening value (or failed screens). All five of these pollutants were identified as pollutants of interest for BXNY. Although the first four pollutants together account for more than 95 percent of the total failed screens for BXNY, fluoranthene failed the same number of screens as acenaphthylene; thus, fluoranthene was also added as a pollutant of interest for BXNY, per the procedure described in Section 3.2.

- Five pollutants also failed screens for MONY; 31 percent of concentrations for these five pollutants were greater than their associated risk screening value (or failed screens). Four of these five pollutants contributed to 95 percent of failed screens for MONY and therefore were identified as pollutants of interest.

- Four pollutants failed screens for ROCH; 39 percent of concentrations for these four pollutants were greater than their associated risk screening value (or failed screens). All four of these pollutants contributed to 95 percent of failed screens; therefore, all four were identified as pollutants of interest for this site.

- Although hexavalent chromium was sampled for at each of these sites, this pollutant did not fail any screens.

- For all three sites, naphthalene, acenaphthene, and fluorene were identified as pollutants of interest. Naphthalene failed the majority of screens for each site, accounting for between 48 percent (ROCH) and 65 percent (MONY) of failed screens.

- The number of samples collected at ROCH is about twice as many as those collected at MONY or BXNY. Recall that sampling occurred year-round at ROCH, while 6 months of sampling occurred at BXNY and MONY due to sampler relocation.

19.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the New York monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.

- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for BXNY, MONY, and ROCH are provided in Appendices M and O.

19.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each New York site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the

New York monitoring sites are presented in Table 19-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 19-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the New York Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
PS 52, New York City, New York - BXNY						
Acenaphthene	22/22	NA	NA	11.03 ± 2.50	NA	NA
Acenaphthylene	17/22	NA	NA	0.30 ± 0.17	NA	NA
Fluoranthene	22/22	NA	NA	7.25 ± 2.08	NA	NA
Fluorene	22/22	NA	NA	12.43 ± 3.21	NA	NA
Naphthalene	22/22	NA	NA	124.50 ± 16.50	NA	NA
Morrisania, New York City, New York - MONY						
Acenaphthene	30/30	5.51 ± 2.42	11.22 ± 4.31	NA	NA	NA
Benzo(a)pyrene	30/30	0.35 ± 0.10	0.17 ± 0.12	NA	NA	NA
Fluorene	30/30	6.31 ± 1.96	10.85 ± 3.78	NA	NA	NA
Naphthalene	30/30	133.47 ± 30.63	124.30 ± 24.46	NA	NA	NA
Rochester, New York - ROCH						
Acenaphthene	58/58	3.43 ± 1.61	16.47 ± 7.75	22.86 ± 7.02	5.27 ± 3.79	12.27 ± 3.43
Fluoranthene	58/58	2.74 ± 1.17	8.39 ± 4.07	9.41 ± 2.65	1.72 ± 0.46	5.68 ± 1.50
Fluorene	58/58	3.43 ± 1.34	13.80 ± 6.35	18.01 ± 5.43	3.70 ± 1.87	9.95 ± 2.68
Naphthalene	58/58	44.41 ± 9.37	65.41 ± 21.35	74.80 ± 20.11	60.06 ± 27.74	61.48 ± 10.13

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations from Table 19-5 include the following:

- Sampling at BXNY began in July, which explains why there are no first or second quarter averages. In addition, damage to the PAH sampler sustained during the landfall of Hurricane Sandy resulted in no samples collected during the month of November. Thus, there are no fourth quarter averages either. Annual averages were not calculated for BXNY because there are fewer than three quarterly averages available. However, Appendix M and Appendix O provide the pollutant-specific average concentrations for all valid samples collected over the entire sample period for this site.

- Four of the five pollutants of interest for BXNY were detected in all of the valid samples collected at this site. The third quarter average concentration of naphthalene is an order of magnitude greater than the quarterly average concentrations for the other pollutants of interest.

- Sampling at MONY ended in June, which explains why there are no third or fourth quarter averages. Because there are fewer than three quarterly averages available for MONY, annual averages were not calculated. However, the pollutant-specific average concentrations for all valid samples collected over the entire sample period for this site are provided in Appendix M and Appendix O.

- The available quarterly average concentrations of naphthalene for MONY are an order of magnitude greater than the quarterly average concentrations for the other pollutants of interest.

- The second quarter averages for acenaphthene and fluorene for MONY are greater than the corresponding first quarter averages of these pollutants. The reverse is true for benzo(a)pyrene. However, the differences between the first and second quarter averages are not statistically significant and additional quarterly averages would be needed to determine if there is a seasonal trend in the measurements.

- Naphthalene has the highest quarterly averages (and annual average) among the pollutants of interest for ROCH. The quarterly averages of naphthalene for ROCH are roughly half other quarterly averages calculated for BXNY and MONY (where available). In fact, the annual average concentration of naphthalene for ROCH is among the lower annual averages, ranking 15th out of 20 NMP sites (where annual averages could be calculated).

- Quarterly averages of acenaphthene, fluoranthene, and fluorene were considerably higher during the second and third quarters of the year. This supports the seasonal trends discussed in Section 4.4.2.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for ROCH from those tables include the following:

- ROCH has the third highest annual average concentration of acenaphthene and the fourth highest annual average concentration of fluorene among NMP sites sampling PAHs.

- ROCH does not appear in Table 4-11 for naphthalene. As discussed in the previous section, the annual average concentration of naphthalene for ROCH ranks 15th compared to other NMP sites sampling PAHs.

19.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Because ROCH is the only site for which annual averages could be calculated, box plots were created for the four pollutants of interest for ROCH. Figures 19-15 through 19-18 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations for each pollutant, as described in Section 3.5.3.

Figure 19-15. Program vs. Site-Specific Average Acenaphthene Concentration

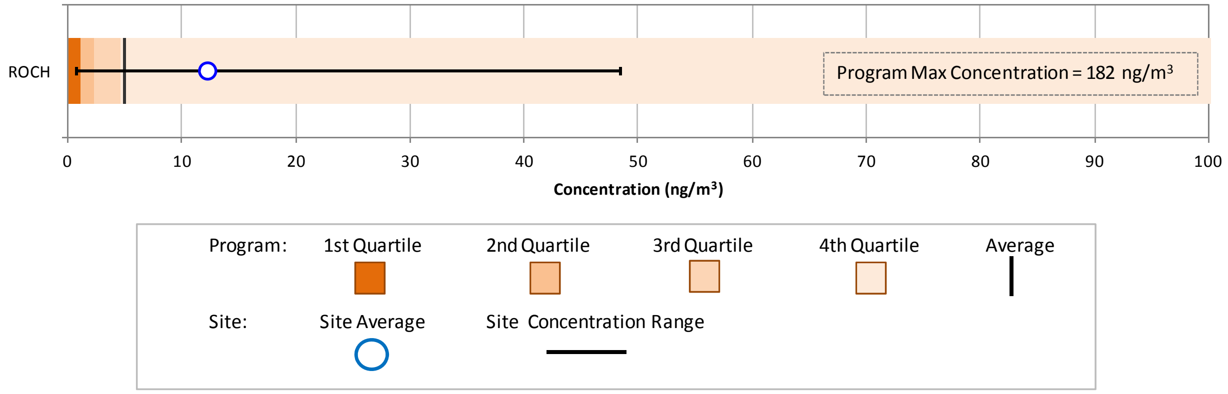


Figure 19-16. Program vs. Site-Specific Average Fluoranthene Concentration

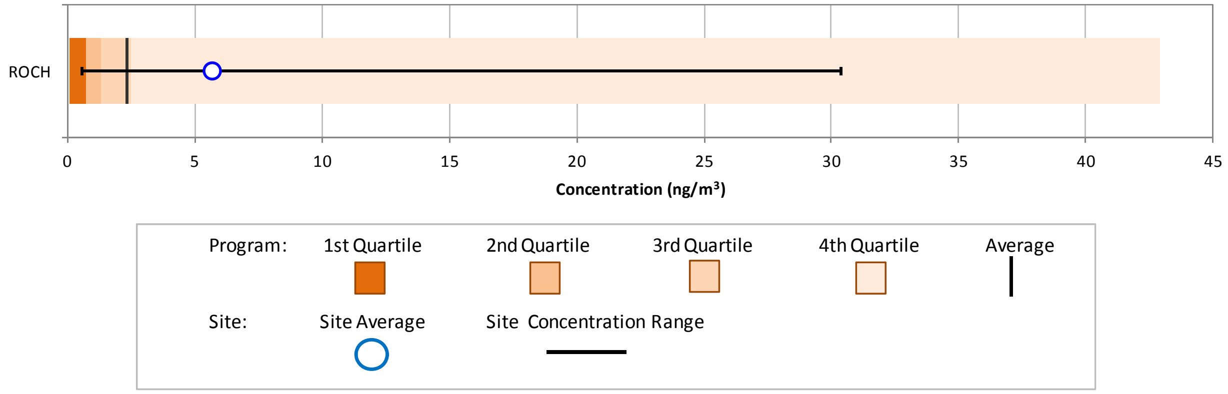


Figure 19-17. Program vs. Site-Specific Average Fluorene Concentration

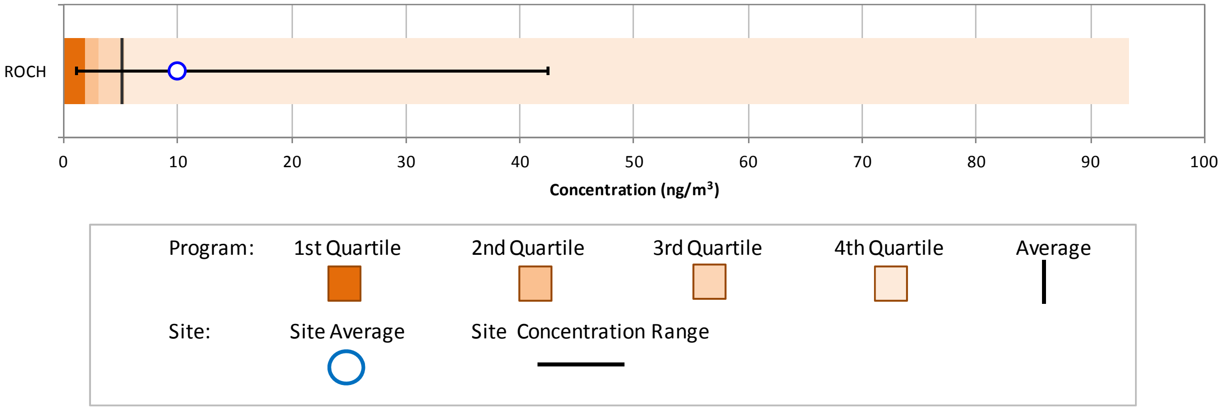
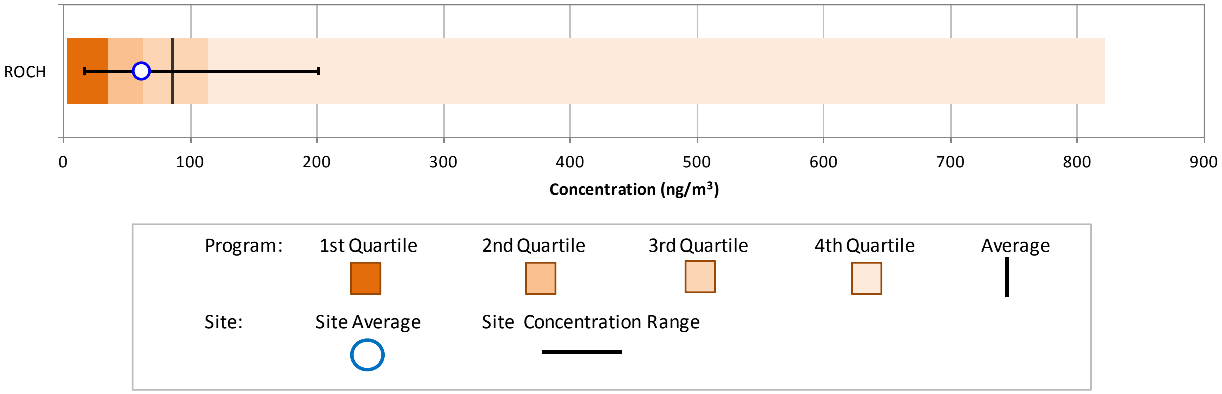


Figure 19-18. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 19-15 through 19-18 include the following:

- Figure 19-15 presents the box plot for acenaphthene. Note that the program-level maximum concentration (182 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 100 ng/m^3. The box plot shows that the annual average concentration for ROCH is nearly two and half times greater the program-level average concentration. The maximum concentration of acenaphthene for ROCH is considerably less than the maximum concentration measured across the program, although the maximum concentration measured at ROCH is among the higher measurements.

- Figure 19-16 presents the box plot for fluoranthene. Similar to acenaphthene, the annual average concentration for ROCH is nearly two and half times greater the program-level average concentration. Although the maximum concentration of fluoranthene measured at ROCH is less than the maximum concentration measured across the program, it is the fourth highest concentration measured among NMP sites sampling PAHs. This site has the second highest annual average concentration of fluoranthene among NMP sites sampling PAHs (behind NBIL).

- Figure 19-17 presents the box plot for fluorene. The annual average concentration for ROCH is just less than twice the program-level average concentration. The maximum concentration of fluorene measured at ROCH is considerably less than the maximum concentration measured across the program, although the maximum concentration measured at ROCH is among the higher measurements.

- Figure 19-18 presents the box plot for naphthalene. In contrast to the box plots for the other pollutants of interest for ROCH, Figure 19-18 shows that the annual average naphthalene concentration is less than the program-level average concentration and is similar to the program-level median. The maximum naphthalene concentration measured at ROCH is considerably less than the program-level maximum concentration.

19.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. A trends analysis was not performed for BXNY or MONY due to the sampler relocation. Although sampling for PAHs at ROCH began in July 2008, a trends analysis was not performed for ROCH. This is because a collection error was discovered at the site, resulting in the invalidation of nearly one and one-half years' worth of samples. As a result, there is not 5 consecutive years of data available for the ROCH monitoring site.

19.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each New York monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

19.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the New York monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

19.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the New York sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 19-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Observations for the New York sites from Table 19-6 include the following:

- ROCH is the only site for which annual averages could be calculated. Naphthalene has the highest annual average concentration among the pollutants of interest for ROCH.

- Naphthalene also has the highest cancer risk approximation for ROCH (2.09 in-a-million). Acenaphthene also has a cancer risk approximation greater than 1 in-a-million (1.08 in-a-million).

- Only naphthalene has a noncancer RfC. The noncancer hazard approximation for naphthalene is 0.02, considerably less than 1.0, indicating that no adverse health effects are expected from this individual pollutant.

Table 19-6. Risk Approximations for the New York Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
PS 52, New York City, New York - BXNY						
Acenaphthene	0.000088	--	22/22	NA	NA	NA
Acenaphthylene	0.000088	--	17/22	NA	NA	NA
Fluoranthene	0.000088	--	22/22	NA	NA	NA
Fluorene	0.000088	--	22/22	NA	NA	NA
Naphthalene	0.000034	0.003	22/22	NA	NA	NA
Morrisania, New York City, New York - MONY						
Acenaphthene	0.000088	--	30/30	NA	NA	NA
Benzo(a)pyrene	0.00176	--	30/30	NA	NA	NA
Fluorene	0.000088	--	30/30	NA	NA	NA
Naphthalene	0.000034	0.003	30/30	NA	NA	NA
Rochester, New York - ROCH						
Acenaphthene	0.000088	--	58/58	12.27 ± 3.43	1.08	--
Fluoranthene	0.000088	--	58/58	5.68 ± 1.50	0.50	--
Fluorene	0.000088	--	58/58	9.95 ± 2.68	0.88	--
Naphthalene	0.000034	0.003	58/58	61.48 ± 10.13	2.09	0.02

-- = A Cancer URE or Noncancer RfC is not available.
NA = Not available due to the criteria for calculating an annual average.

19.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 19-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 19-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 19-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 19-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 19-7. Table 19-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 19-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the New York Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		**Top 10 Cancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
PS 52, New York City, New York (Bronx County) - BXNY					
Benzene	154.89	Formaldehyde	1.36E-03		
Ethylbenzene	112.57	Benzene	1.21E-03		
Formaldehyde	104.34	1,3-Butadiene	5.81E-04		
Tetrachloroethylene	81.66	Naphthalene	3.88E-04		
Acetaldehyde	61.40	Ethylbenzene	2.81E-04		
1,3-Butadiene	19.36	Arsenic, PM	2.64E-04		
Naphthalene	11.42	POM, Group 2d	1.69E-04		
POM, Group 2d	1.92	POM, Group 2b	1.63E-04		
POM, Group 2b	1.85	Hexavalent Chromium, PM	1.57E-04		
POM, Group 1a	1.60	POM, Group 1a	1.41E-04		
New York City, New York (Bronx County) - MONY					
Benzene	154.89	Formaldehyde	1.36E-03		
Ethylbenzene	112.57	Benzene	1.21E-03		
Formaldehyde	104.34	1,3-Butadiene	5.81E-04		
Tetrachloroethylene	81.66	Naphthalene	3.88E-04		
Acetaldehyde	61.40	Ethylbenzene	2.81E-04		
1,3-Butadiene	19.36	Arsenic, PM	2.64E-04		
Naphthalene	11.42	POM, Group 2d	1.69E-04		
POM, Group 2d	1.92	POM, Group 2b	1.63E-04		
POM, Group 2b	1.85	Hexavalent Chromium, PM	1.57E-04		
POM, Group 1a	1.60	POM, Group 1a	1.41E-04		

Table 19-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the New York Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Rochester, New York (Monroe County) - ROCH					
Benzene	263.68	Formaldehyde	2.58E-03	Naphthalene	2.09
Formaldehyde	198.08	Benzene	2.06E-03	Acenaphthene	1.08
Ethylbenzene	146.98	1,3-Butadiene	1.21E-03	Fluorene	0.88
Acetaldehyde	107.77	POM, Group 3	1.19E-03	Fluoranthene	0.50
Dichloromethane	46.10	POM, Group 1a	8.14E-04		
1,3-Butadiene	40.49	Naphthalene	8.05E-04		
Tetrachloroethylene	24.16	POM, Group 2b	5.27E-04		
Naphthalene	23.67	Arsenic, PM	4.74E-04		
POM, Group 1a	9.25	Ethylbenzene	3.67E-04		
Trichloroethylene	6.40	POM, Group 2d	3.64E-04		

Table 19-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the New York Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
PS 52, New York City, New York (Bronx County) - BXNY					
Toluene	2,284.17	Acrolein	251,938.53		
Ethylene glycol	1,704.89	Formaldehyde	10,647.01		
Methanol	793.11	1,3-Butadiene	9,680.02		
Hexane	507.63	Acetaldehyde	6,822.71		
Xylenes	368.69	Benzene	5,162.93		
Benzene	154.89	Ethylene glycol	4,262.23		
Ethylbenzene	112.57	Cadmium, PM	4,115.92		
Formaldehyde	104.34	Arsenic, PM	4,095.60		
Tetrachloroethylene	81.66	Naphthalene	3,805.84		
Methyl isobutyl ketone	63.81	Xylenes	3,686.91		
Morrisania, New York City, New York (Bronx County) - MONY					
Toluene	2,284.17	Acrolein	251,938.53		
Ethylene glycol	1,704.89	Formaldehyde	10,647.01		
Methanol	793.11	1,3-Butadiene	9,680.02		
Hexane	507.63	Acetaldehyde	6,822.71		
Xylenes	368.69	Benzene	5,162.93		
Benzene	154.89	Ethylene glycol	4,262.23		
Ethylbenzene	112.57	Cadmium, PM	4,115.92		
Formaldehyde	104.34	Arsenic, PM	4,095.60		
Tetrachloroethylene	81.66	Naphthalene	3,805.84		
Methyl isobutyl ketone	63.81	Xylenes	3,686.91		

Table 19-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the New York Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Rochester, New York (Monroe County) - ROCH					
Toluene	1,721.15	Acrolein	528,479.46	Naphthalene	0.02
Ethylene glycol	917.86	1,3-Butadiene	20,242.88		
Xylenes	529.64	Formaldehyde	20,212.66		
Methanol	510.18	Hydrochloric acid	12,893.11		
Hexane	504.94	Acetaldehyde	11,974.58		
Benzene	263.68	Cadmium, PM	9,105.49		
Hydrochloric acid	257.86	Benzene	8,789.41		
Formaldehyde	198.08	Naphthalene	7,889.94		
Ethylbenzene	146.98	Arsenic, PM	7,350.08		
Acetaldehyde	107.77	Nickel, PM	6,416.61		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 19.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 19-7 include the following:

- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in Bronx and Monroe Counties (although not necessarily in that order).

- Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for both New York counties.

- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Bronx County; six of the highest emitted pollutants also have the highest toxicity-weighted emissions for Monroe County.

- Naphthalene, which is a pollutant of interest for all three sites and has the highest concentrations measured at each site, appears on both emissions-based lists for Bronx and Monroe Counties.

- Emissions of several POM Groups rank among the highest emitted pollutants as well as the highest toxicity-weighted emissions for Bronx County. POM, Group 2b appears on both emissions-based lists for Bronx County and includes several PAHs sampled for at BXNY and MONY, including acenaphthene, fluoranthene, and fluorene. POM, Group 2d also appears on both emissions-based lists for Bronx County and includes anthracene, phenanthrene, and pyrene. None of these pollutants failed screens for BXNY or MONY. POM, Group 1a also appears on both emissions-based lists for Bronx County but does not include any PAHs sampled for under Method TO-13A.

- POM Group 1a appears on both emissions-based lists for Monroe County while POM, Groups 2b and 2d are among the pollutants with the highest toxicity-weighted emissions for Monroe County. Three of the four pollutants of interest for ROCH are part of POM, Group 2b. POM, Group 3 is among the pollutants with the highest toxicity-weighted emissions for this county.

Observations from Table 19-8 include the following:

- Toluene and ethylene glycol are the highest emitted pollutants with noncancer RfCs in both Bronx and Monroe Counties, although the emissions are higher for Bronx County than Monroe County.

- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) is acrolein for both counties. Formaldehyde and 1,3-butadiene round out the top three for both counties.

- Four of the highest emitted pollutants in Bronx County are also among the pollutants with the highest toxicity-weighted emissions; four of the highest emitted pollutants in Monroe County are also among the pollutants with the highest toxicity-weighted emissions.

- Naphthalene is among the pollutants with the highest toxicity-weighted emissions for each county, but is not among the highest emitted pollutants with a noncancer toxicity factor for either county. None of the other pollutants of interest for the three New York sites have noncancer RfCs.

- Several metals appear among the pollutants with the highest toxicity weighted emissions for Monroe County although none of these appear among the highest emitted. Metals were not sampled at ROCH under the NMP.

19.6 Summary of the 2012 Monitoring Data for BXNY, MONY, and ROCH

Results from several of the data treatments described in this section include the following:

❖ *The instrumentation at the MONY monitoring site was relocated to the BXNY monitoring site at the end of June 2012. This relocation returns the instruments to the original NATTS location that was discontinued due to ongoing roofing construction.*

❖ *Five pollutants failed screens for BXNY, five pollutants failed screens for MONY, and four pollutants failed screens for ROCH. Naphthalene, acenaphthene, and fluorene were identified as pollutants of interest for each New York monitoring site.*

❖ *Naphthalene had the highest annual average concentration among the pollutants of interest for ROCH. Concentrations of acenaphthene, fluoranthene, and fluorene were highest at ROCH during the warmer months of the year.*

❖ *ROCH had the second, third, and fourth highest annual average concentrations of fluoranthene, acenapthalene, and fluorene, respectively, among NMP sites sampling PAHs.*

20.0 Sites in Oklahoma

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP sites in Oklahoma, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

20.1 Site Characterization

This section characterizes the Oklahoma monitoring sites by providing geographical and physical information about the locations of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

Two Oklahoma sites (TOOK and TMOK) are located in the Tulsa, Oklahoma MSA. Another site, PROK, is located east of the Tulsa area in Pryor Creek, Oklahoma. There are also two sites in the Oklahoma City, Oklahoma MSA (ADOK and OCOK).

Figures 20-1 and 20-2 are composite satellite images retrieved from ArcGIS Explorer showing the Tulsa monitoring sites and their immediate surroundings. Figure 20-3 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 20-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radii are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 20-4 through 20-8 are the composite satellite maps and emissions source maps for the Pryor Creek and Oklahoma City sites. Table 20-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 20-1. Tulsa, Oklahoma (TOOK) Monitoring Site

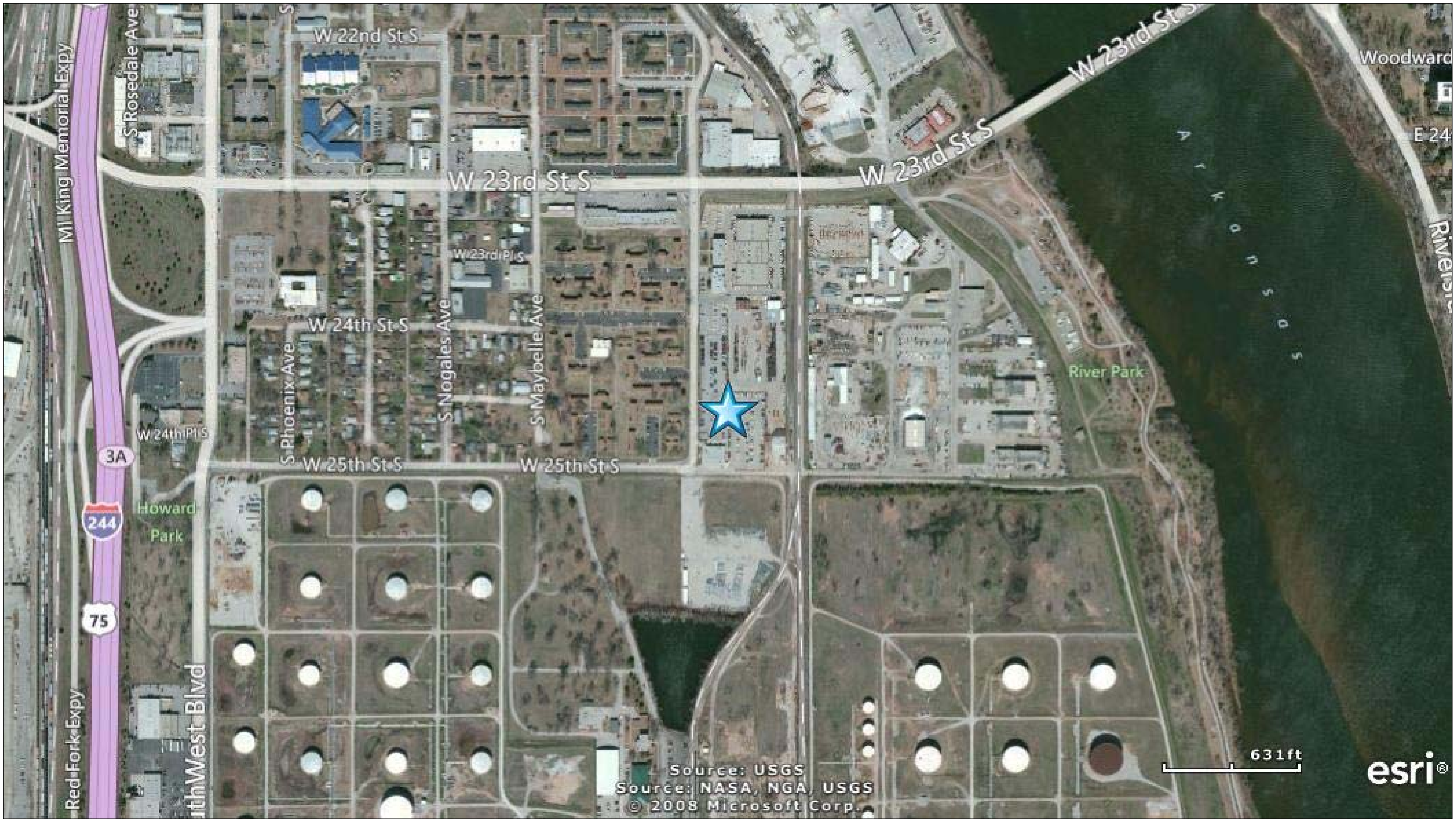
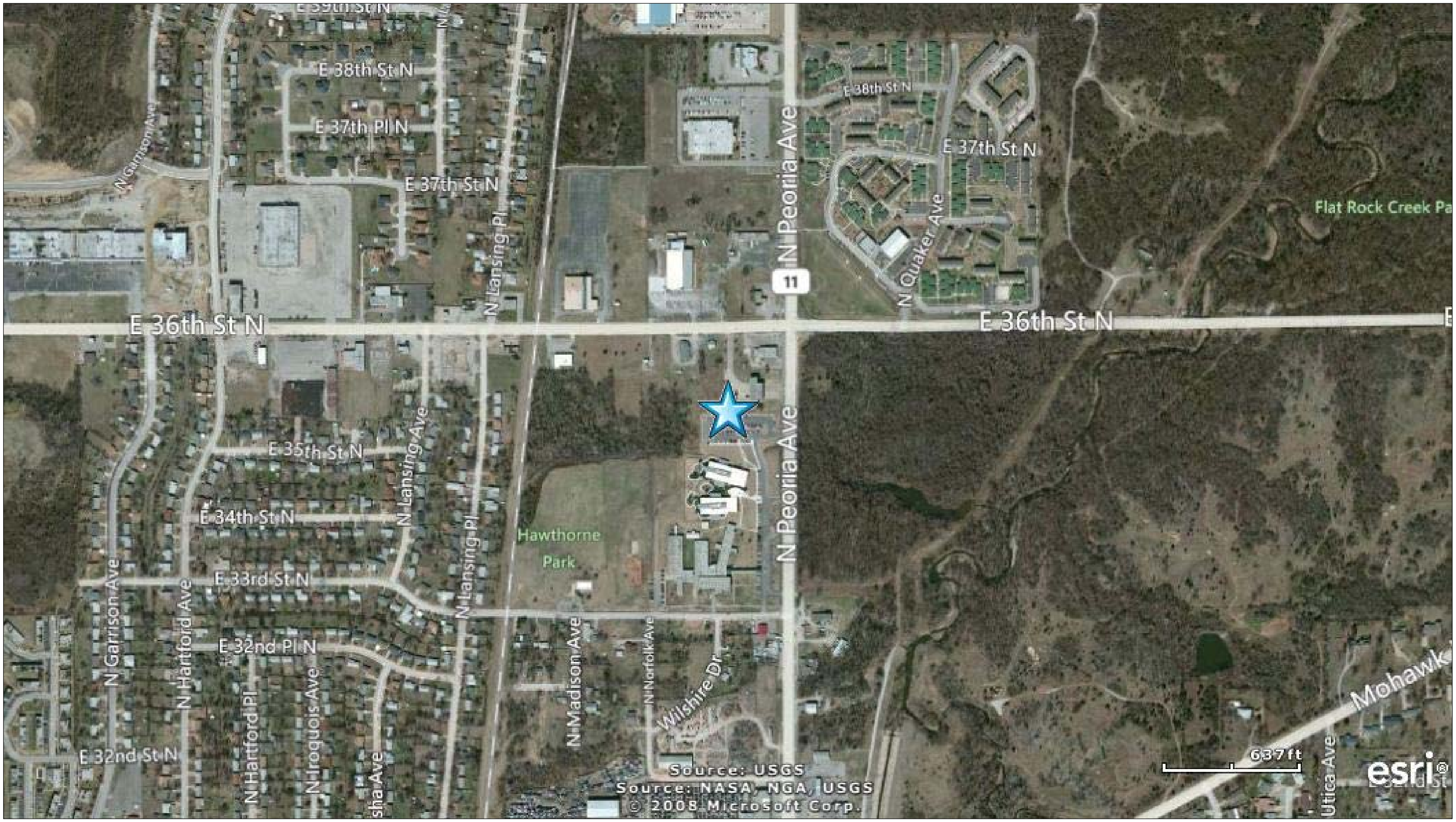


Figure 20-2. Tulsa, Oklahoma (TMOK) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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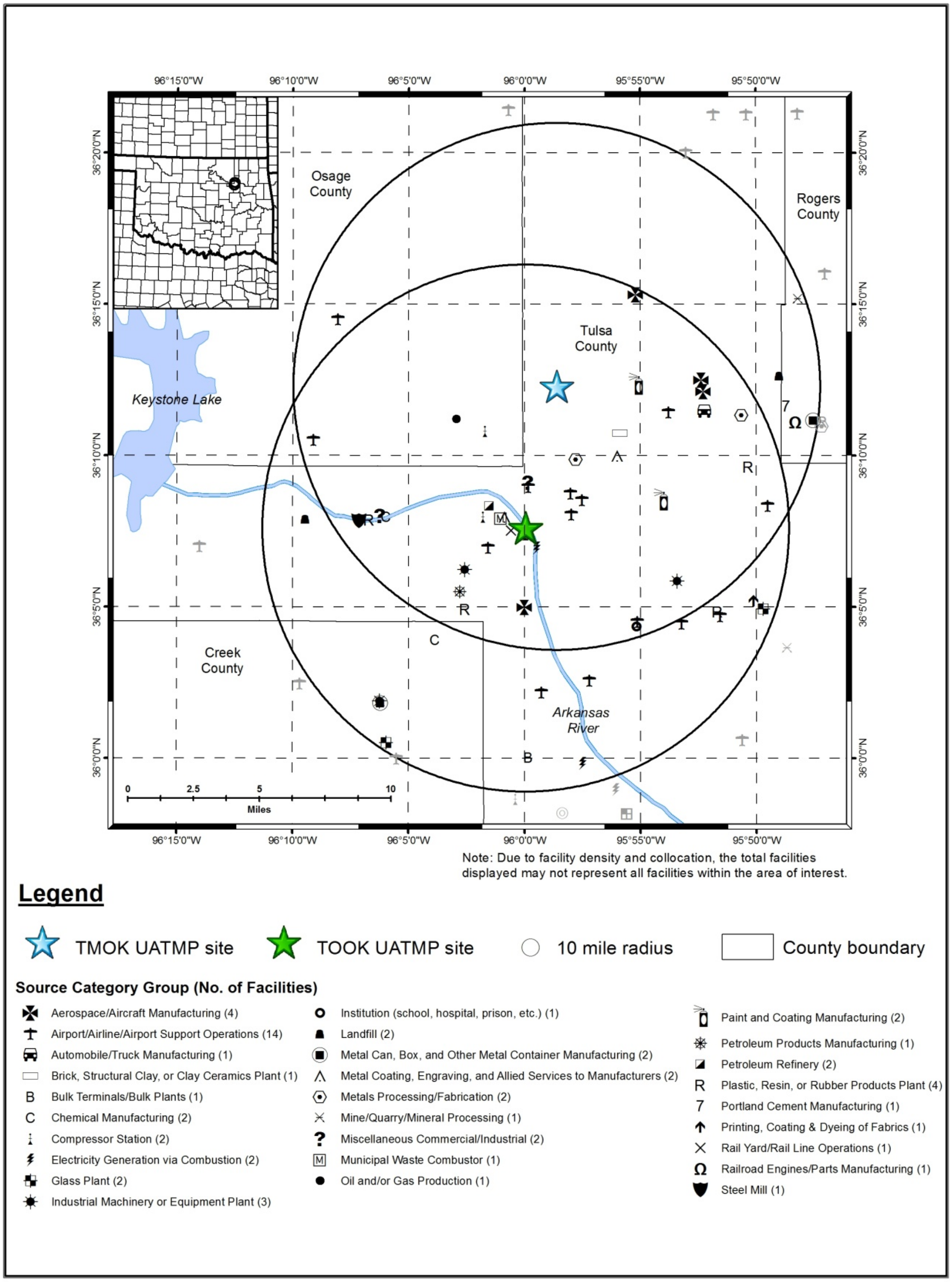
Figure 20-3. NEI Point Sources Located Within 10 Miles of TMOK and TOOK



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 20-4. Pryor Creek, Oklahoma (PROK) Monitoring Site

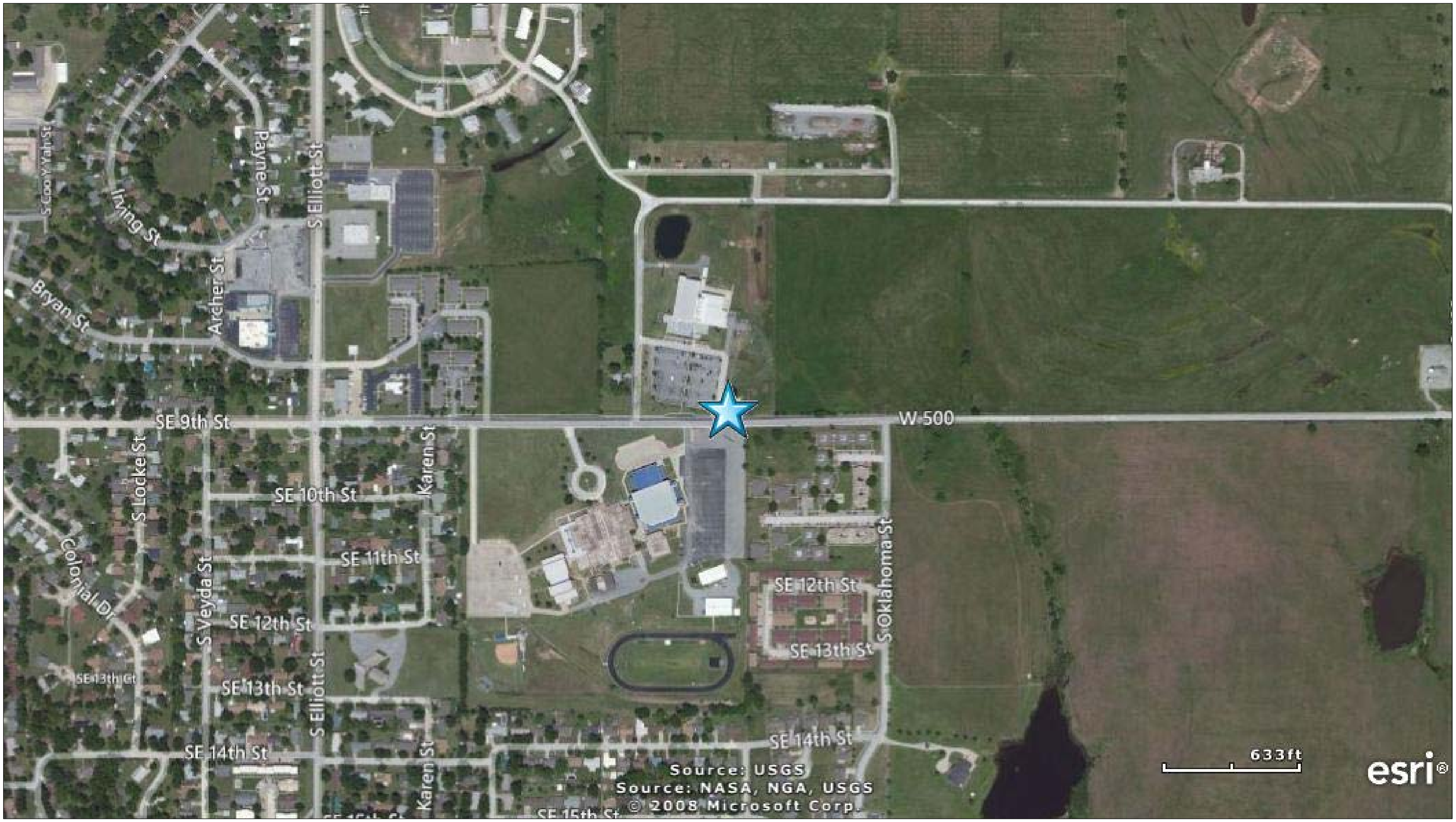
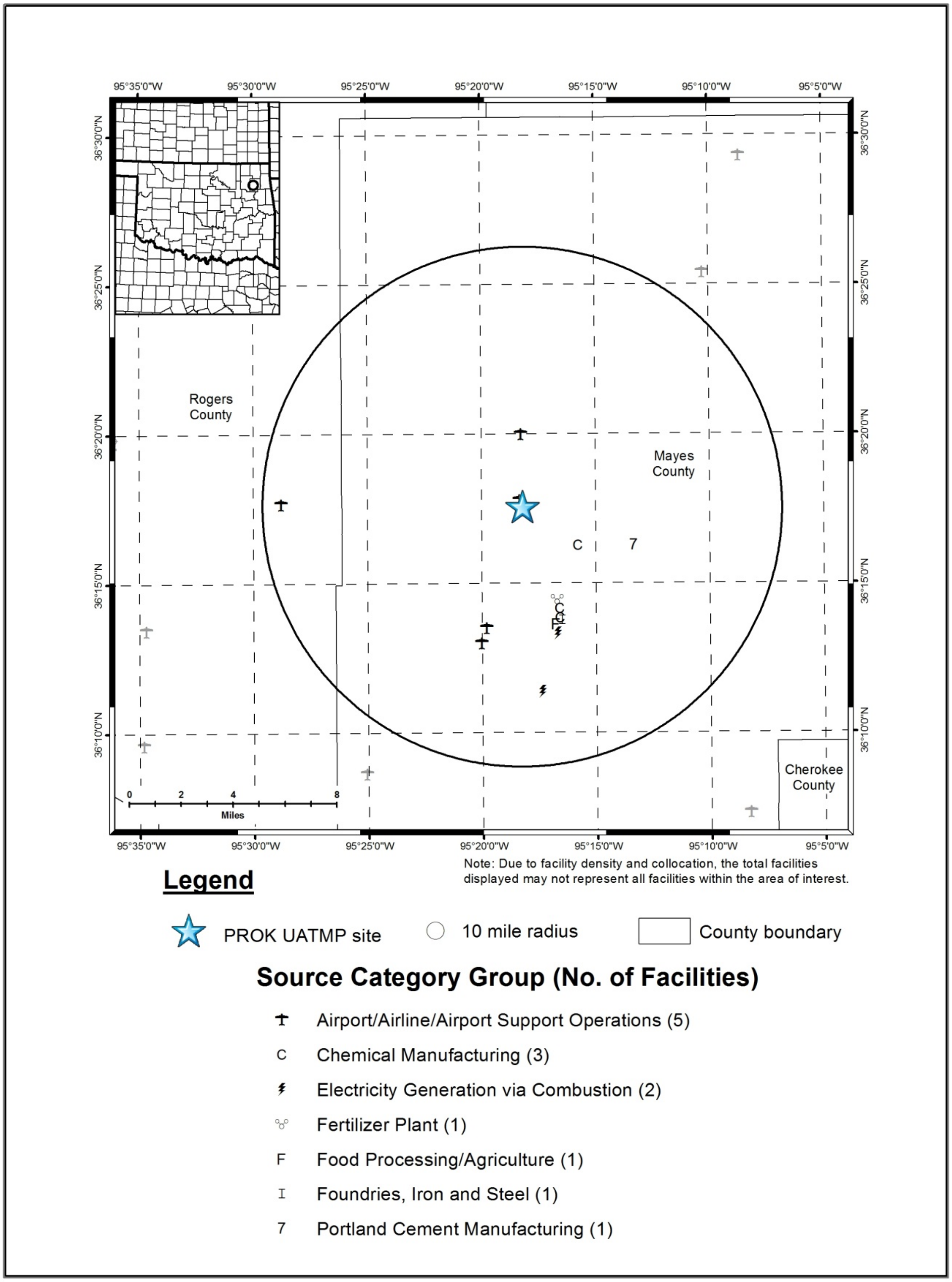
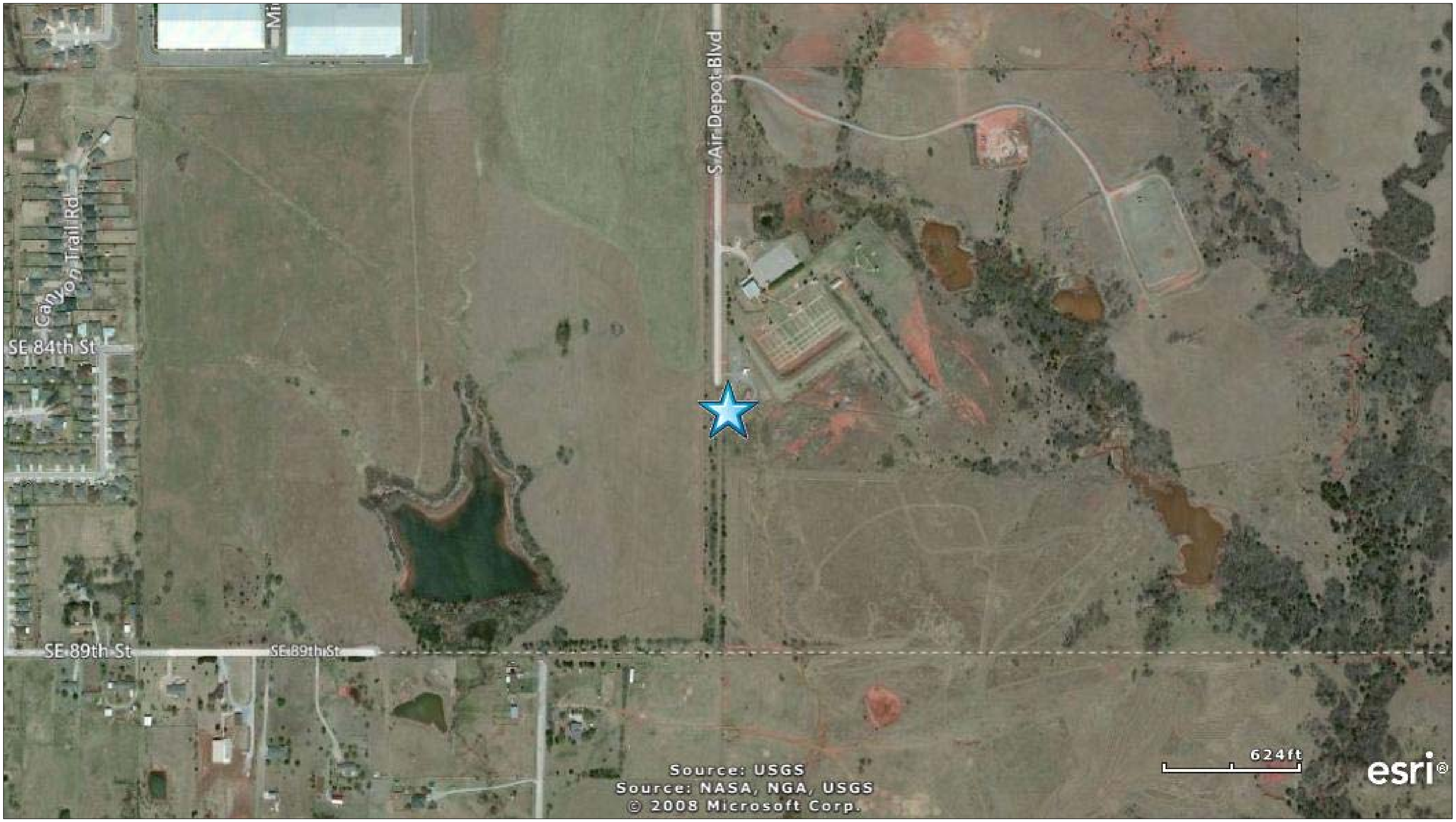


Figure 20-5. NEI Point Sources Located Within 10 Miles of PROK



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 20-6. Oklahoma City, Oklahoma (ADOK) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 20-7. Oklahoma City, Oklahoma (OCOK) Monitoring Site

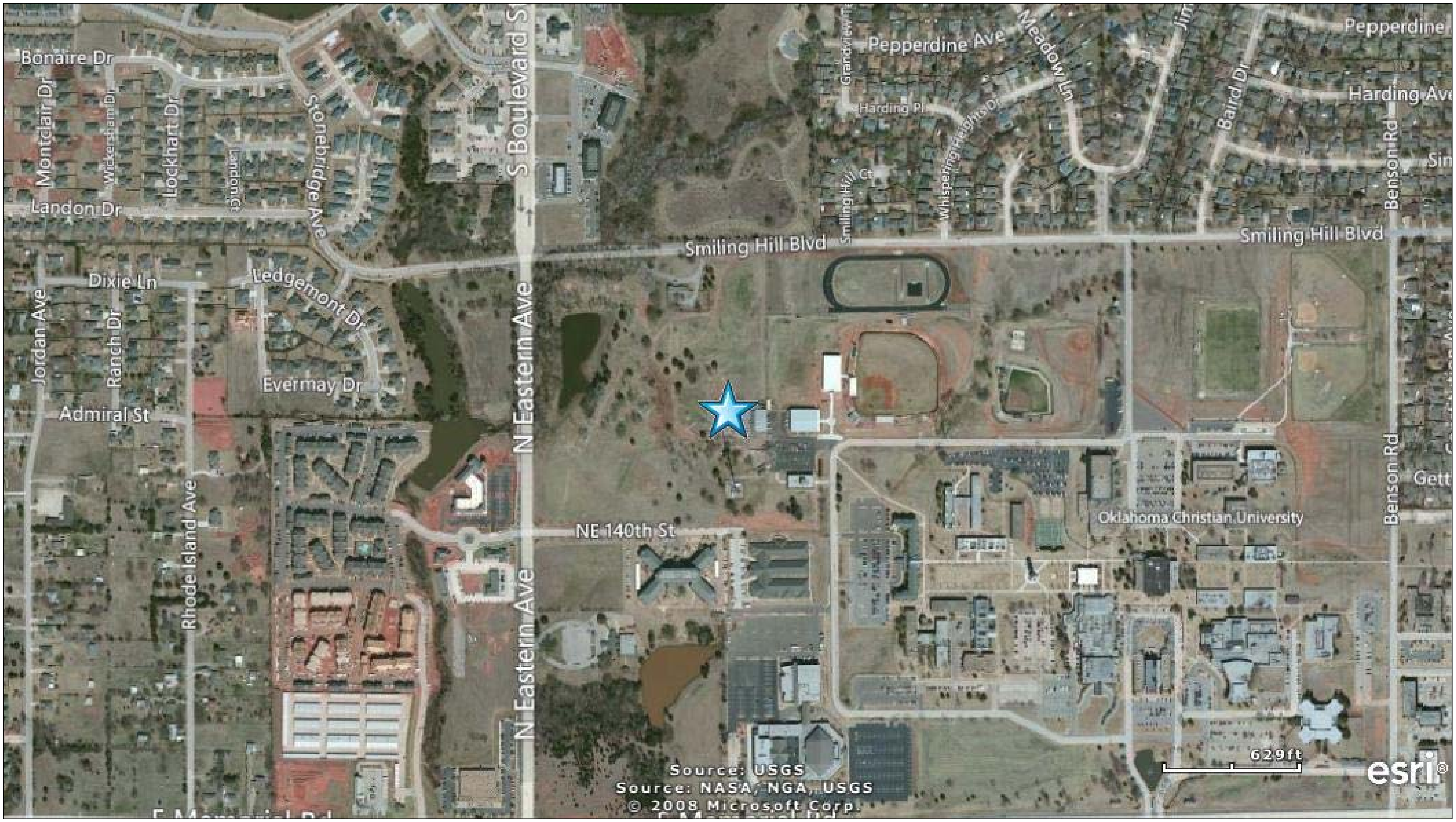
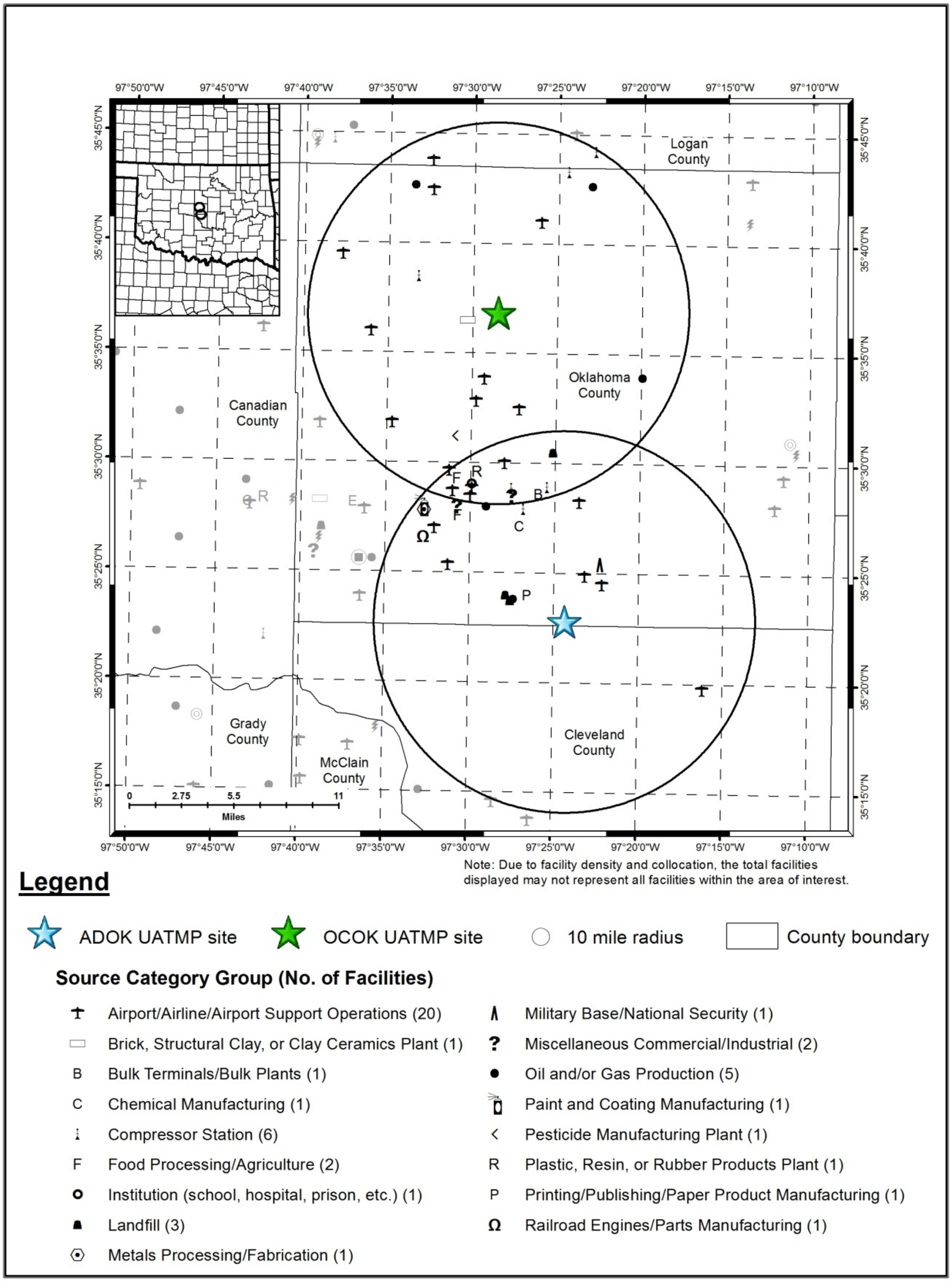


Figure 20-8. NEI Point Sources Located Within 10 Miles of ADOK and OCOK



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 20-1. Geographical Information for the Oklahoma Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
TOOK	40-143-0235	Tulsa	Tulsa	Tulsa, OK MSA	36.126945, -95.998941	Industrial	Urban/City Center	SO_2, H_2S, and Meteorological parameters.
TMOK	40-143-1127	Tulsa	Tulsa	Tulsa, OK MSA	36.204902, -95.976537	Residential	Urban/City Center	CO, SO_2, NO_y, NO, NO_2, NO_x, O_3, Meteorological parameters, PM_{10}, PM Coarse, $PM_{2.5}$, and $PM_{2.5}$ Speciation, IMPROVE Speciation.
PROK	40-097-0187	Pryor Creek	Mayes	Not in an MSA	36.292941, -95.303409	Industrial	Suburban	None.
ADOK	40-109-0042	Oklahoma City	Oklahoma	Oklahoma City, OK MSA	35.3803163, -97.4057199	Commercial	Urban/City Center	None.
OCOK	40-109-1037	Oklahoma City	Oklahoma	Oklahoma City, OK MSA	35.614131, -97.475083	Residential	Suburban	CO, SO_2, NO, NO_2, NO_x, O_3, Meteorological parameters, PM coarse, PM_{10}, $PM_{2.5}$, and $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

TOOK is located in West Tulsa, on the southwest side of the Arkansas River. The site is located in the parking lot of the Public Works building. The monitoring site is positioned between the Arkansas River and I-244, which runs parallel to Southwest Boulevard. The surrounding area is primarily industrial, although residential areas are located immediately west of the site. As shown in Figure 20-1, an oil refinery is located just south of W 25th Street S. Another refinery is located to the northwest of the site, on the other side of I-244. A rail yard is also located on the west side of I-244, the edge of which can be seen on left-hand side of Figure 20-1.

TMOK is located in north Tulsa on the property of Fire Station Number 24. As shown in Figure 20-2, the intersection of North Peoria Avenue (Highway 11) and East 36th Street North lies just to the northeast of the site. The surrounding area is primarily residential, with wooded areas just to the east, an early childhood education facility and an elementary school to the south, and a park to the west.

Figure 20-3 shows that the Tulsa sites are located approximately 5 miles apart, with TMOK to the north and TOOK to the south. Many of the emissions sources are clustered around TOOK, while there are no point sources within 2 miles of TMOK. There are a variety of industries in the area although the source category with the greatest number of sources surrounding the Tulsa sites is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. Point sources close to TOOK include two petroleum refineries; a rail yard; a municipal waste combustor; a compressor station; a metal coating, engraving, and allied services to manufacturers facility; and a facility generating electricity via combustion.

PROK is located on the eastern edge of the town of Pryor Creek, on the property of Pryor Creek High School. Residential areas are located to the northwest, west, and south of the site, while agricultural areas are located to the east, as shown in Figure 20-4. The monitoring site is located due north (and downwind) of an industrial park located a few miles to the south. Figure 20-5 shows that there are relatively few emissions sources surrounding PROK and that the airport source category has the greatest number of emissions sources near the site. An aircraft operations facility is located one-quarter mile north of PROK but is located under the site symbol in Figure 20-5. A chemical manufacturer and a Portland cement plant are located south and east of PROK. The aforementioned industrial park is represented in Figure 20-5 by the six facilities oriented north-south to the south-southeast of PROK. Two chemical manufacturers, a fertilizer plant, a food processing/agricultural facility, a foundry, and a facility generating electricity via combustion are located at this industrial park.

The instrumentation at the Midwest City, Oklahoma monitoring site was relocated from north of Tinker Air Force Base to a location to the south of Tinker Air Force Base in December 2011. The new monitoring site (ADOK) is located on the property of the Oklahoma City Police Department firing range, approximately one-half mile south of I-240. The area is considered commercial although the immediate area surrounding ADOK is open, with a residential subdivision located farther west, as shown in Figure 20-6. This site lies just northwest of Stanley Draper Lake and is surrounded by grasslands, with little activity or traffic. The monitoring site was relocated to this location to capture any influence from Tinker Air Force Base and to collect background data (OK DEQ, 2013).

OCOK is located in northern Oklahoma City, on the property of Oklahoma Christian University of Science and Arts. The site is located in the northwest corner of the University, near the athletic fields. The areas surrounding the university are primarily residential. Heavily traveled roadways such as I-35 and I-44 to the east and John Kilpatrick Turnpike to the south are within a few miles of the site, although outside the boundaries of Figure 20-7.

Figure 20-8 shows that ADOK and OCOK are approximately 13 miles apart and that most of the point sources located within 10 miles of them are located between the sites in the center of Oklahoma City (northwest of ADOK and south of OCOK). The source category with the greatest number of sources surrounding these two sites is the airport source category. The point sources closest to ADOK is a printing and publishing facility, although the southern-most edge of Tinker Air Force Base lies just on the other side of I-240; the source closest to OCOK is involved in brink, structural clay, or clay ceramics.

Table 20-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Oklahoma monitoring sites. Table 20-2 includes both county-level population and vehicle registration information. Table 20-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained.

Additionally, Table 20-2 presents the county-level daily VMT for Tulsa, Mayes, and Oklahoma Counties.

Table 20-2. Population, Motor Vehicle, and Traffic Information for the Oklahoma Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
TOOK	613,816	618,359	63,000	I-244 at Southwest Blvd	20,402,564
TMOK			12,600	Near intersection of E 36th St N. & N. Peoria Ave	
PROK	41,168	41,391	15,100	Highway 69, south of Route 20	1,662,076
ADOK	741,781	847,824	34,100	I-240 between I-35 and I-40	27,411,171
OCOK			40,900	Route 77, north of toll road	

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (OKTC, 2012)
[3] AADT reflects 2011 data (OK DOT, 2011)
[4] County-level VMT reflects 2012 data (OK DOT, 2013)

Observations from Table 20-2 include the following:

- The Mayes County population is significantly less than the populations for Tulsa and Oklahoma Counties. Compared to other NMP monitoring sites, the Tulsa and Oklahoma County populations are in the middle of the range, while Mayes County's population is on the low end.

- The Mayes County vehicle registration is also significantly less than vehicle registrations for Tulsa and Oklahoma Counties. These observations are expected given the relatively rural nature of the area surrounding PROK compared to the urban locations of the Tulsa and Oklahoma City sites. Compared to other NMP sites, the Oklahoma County vehicle ownership is in the top third while the vehicle ownership for Tulsa County is in the middle third.

- The traffic volume passing the TMOK site is the lowest among the Oklahoma monitoring sites and is similar to the traffic passing the PROK site, while the traffic passing by TOOK is the highest of the five sites. The traffic data for all five Oklahoma sites are in the middle third compared to other NMP sites. The following list provides the roadways or intersections from which the traffic data were obtained: TOOK – I-244, near Southwest Boulevard; TMOK – intersection of East 36th Street North and North Peoria Avenue; PROK – Highway 69, south of Graham Avenue (Route 20); ADOK – I-240, between I-35 and I-40; and OCOK – Route 77 north of the toll road.

- County-level VMT is greatest for Oklahoma County and ranks 11th compared to other NMP sites. VMT is the least for Mayes County and is among the lower VMTs compared to other NMP sites.

20.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Oklahoma on sample days, as well as over the course of the year.

20.2.1 Climate Summary

Tulsa is located in northeast Oklahoma, just southeast of the Osage Indian Reservation, and along the Arkansas River. Pryor Creek is also in northeast Oklahoma, approximately 30 miles east of Tulsa. Oklahoma City is located in the center of the state. These areas are characterized by a continental climate, with long, warm summers and relatively mild winters. Precipitation is generally concentrated in the spring and summer months, with maximum precipitation occurring in May, June, and September, although precipitation amounts generally decrease across the state from east to west. Spring and summer precipitation usually results from showers and thunderstorms, while fall and winter precipitation accompanies frontal systems. Annual snowfall in these areas is less than 10 inches per year. A southerly wind prevails for much of the year. Oklahoma is part of "Tornado Alley," where severe thunderstorms capable of producing strong winds, hail, and tornadoes occur more frequently than other areas around the country; tornadoes are more prevalent here than any other region in the U.S. (Wood, 2004; NCDC, 2014; NOAA, 2014a).

20.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the Oklahoma monitoring sites (NCDC, 2011 and 2012), as described in Section 3.5.2. The closest weather stations to the Tulsa sites are located at Richard Lloyd Jones Jr. Airport (near TOOK) and Tulsa International Airport (near TMOK), WBAN 53908 and 13968, respectively. The closest weather station to the Pryor Creek site is located at Claremore Regional Airport, WBAN 53940. The two closest weather stations to the Oklahoma City sites are located at Tinker Air Force Base Airport (near ADOK) and Wiley Post Airport (near OCOK), WBAN 13919 and 03954, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 20-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 20-3. Average Meteorological Conditions near the Oklahoma Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Tulsa, Oklahoma - TOOK									
Richard Lloyd Jones Jr. Airport 53908 (36.04, -95.98)	6.1 miles 173° (S)	Sample Days (65)	78.0 ± 4.1	65.8 ± 4.2	48.4 ± 4.0	56.1 ± 3.5	57.9 ± 3.0	1015.8 ± 1.5	5.4 ± 0.8
		2012	76.5 ± 1.8	64.5 ± 1.8	47.3 ± 1.7	55.1 ± 1.5	58.3 ± 1.3	1016.3 ± 0.6	5.4 ± 0.3
Tulsa, Oklahoma - TMOK									
Tulsa International Airport 13968 (36.20, -95.89)	4.7 miles 95° (E)	Sample Days (61)	75.9 ± 4.3	64.9 ± 4.2	48.6 ± 4.1	55.9 ± 3.6	59.5 ± 3.3	1014.9 ± 1.6	7.8 ± 1.0
		2012	75.7 ± 1.8	65.0 ± 1.8	48.3 ± 1.6	55.7 ± 1.5	58.9 ± 1.4	1015.1 ± 0.7	8.0 ± 0.4
Pryor Creek, Oklahoma - PROK									
Claremore Regional Airport 53940 (36.29, -95.47)	9.3 miles 270° (W)	Sample Days (51)	77.0 ± 4.4	65.6 ± 4.1	51.7 ± 3.8	57.7 ± 3.4	65.0 ± 3.5	NA	7.0 ± 1.2
		2012	73.5 ± 1.8	61.8 ± 1.7	47.9 ± 1.6	54.1 ± 1.5	64.6 ± 1.3	NA	7.0 ± 0.3
Oklahoma City, Oklahoma - ADOK									
Tinker AFB/Airport 13919 (35.42, -97.39)	2.8 miles 26° (NNE)	Sample Days (69)	74.0 ± 4.4	63.0 ± 4.1	47.6 ± 3.9	54.5 ± 3.5	62.1 ± 3.8	1016.1 ± 1.6	9.2 ± 0.9
		December 2011 & 2012	73.2 ± 1.8	62.4 ± 1.7	47.4 ± 1.6	54.2 ± 1.5	62.4 ± 1.6	1015.8 ± 0.7	9.6 ± 0.4

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA = Sea level pressure was not recorded at the Claremore Regional Airport.

Table 20-3. Average Meteorological Conditions near the Oklahoma Monitoring Sites (Continued)

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Oklahoma City, Oklahoma - OCOK									
Wiley Post Airport 03954 (35.53, -97.65)	10.7 miles 240° (WSW)	Sample Days (64)	75.8 ± 4.2	64.3 ± 4.3	47.6 ± 4.0	55.1 ± 3.5	59.0 ± 3.5	1014.8 ± 1.6	9.7 ± 1.1
		2012	74.8 ± 1.8	64.0 ± 1.8	47.2 ± 1.7	54.8 ± 1.5	58.6 ± 1.5	1015.0 ± 0.7	10.2 ± 0.5

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA = Sea level pressure was not recorded at the Claremore Regional Airport.

Table 20-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 20-3 is the 95 percent confidence interval for each parameter. As shown in Table 20-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year for most of the Oklahoma monitoring sites. The differences are greatest for PROK, where sample days appear warmer than conditions experienced throughout the year, but the difference is not statistically significant. Sampling was discontinued at PROK at the end of October 2012, thereby missing two of the cooler months of the year. Note that sampling at ADOK began in December 2011 and data from the five samples collected that month are included in this report. Thus, the meteorological averages provided in Table 20-3 include meteorological observations from December 2011.

20.2.3 Back Trajectory Analysis

Figure 20-9 is the composite back trajectory map for days on which samples were collected at the TOOK monitoring site. Included in Figure 20-9 are four back trajectories per sample day. Figure 20-10 is the corresponding cluster analysis. Similarly, Figures 20-11 through 20-18 are the composite back trajectory maps for days on which samples were collected at the remaining Oklahoma sites and the corresponding cluster analyses. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 20-9 through 20-18 represents 100 miles.

Figure 20-9. Composite Back Trajectory Map for TOOK

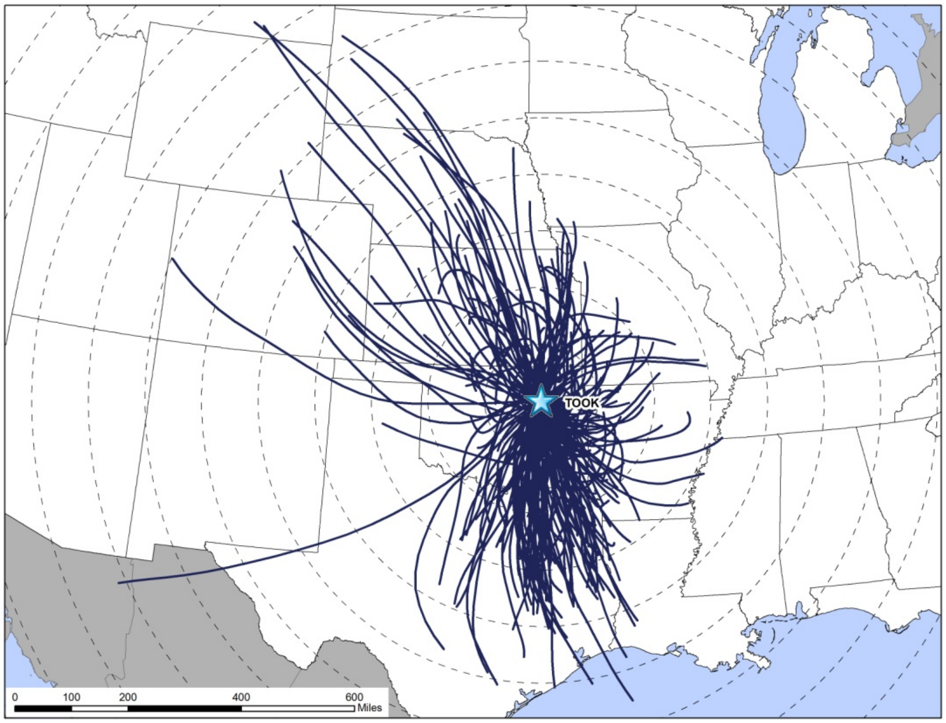


Figure 20-10. Back Trajectory Cluster Map for TOOK

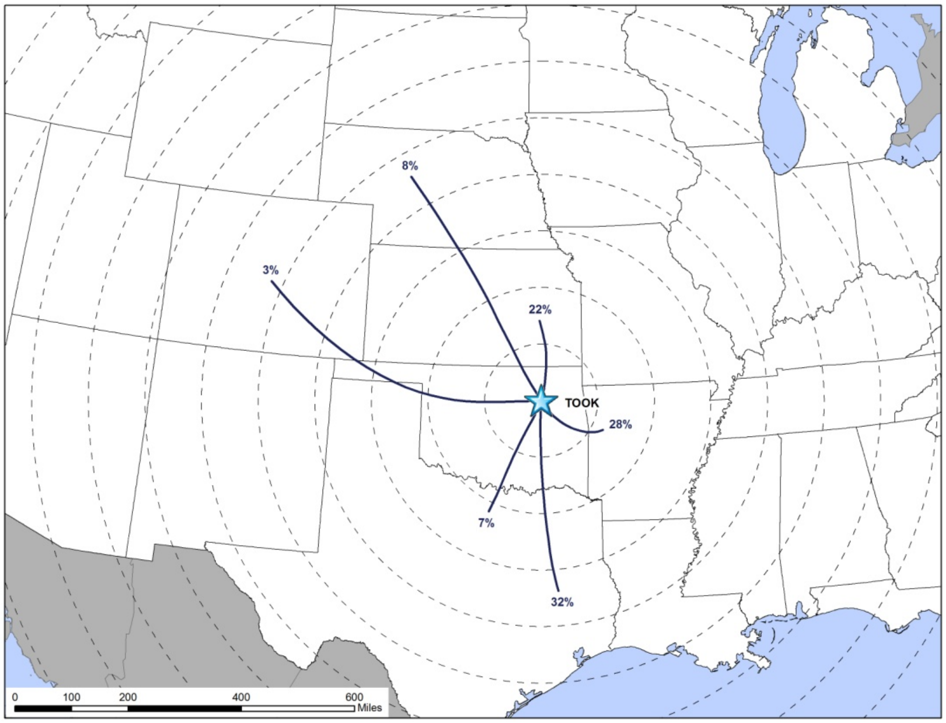


Figure 20-11. Composite Back Trajectory Map for TMOK

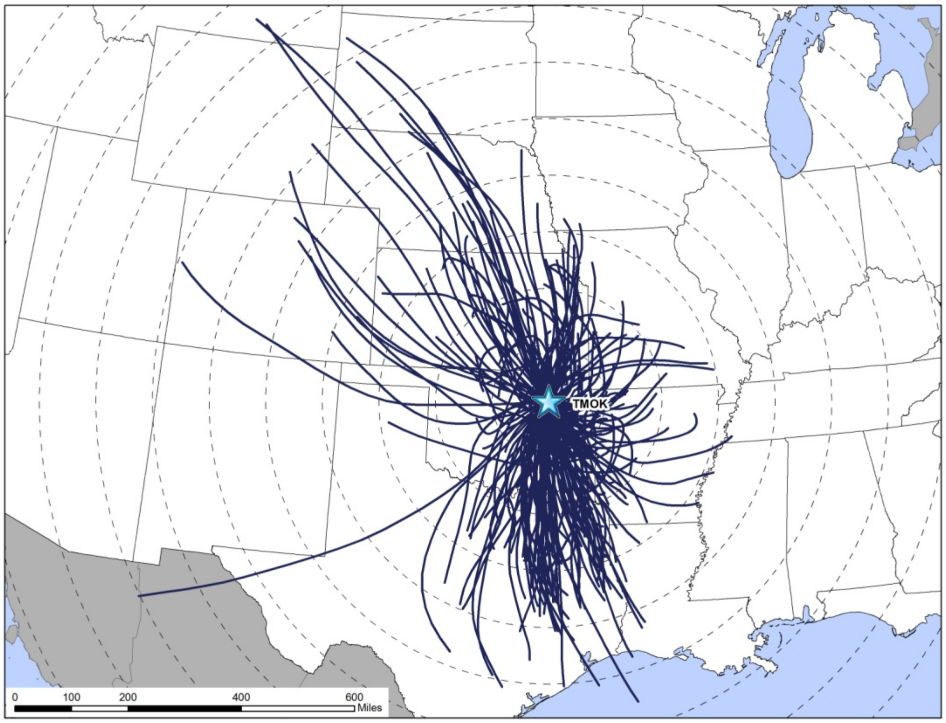


Figure 20-12. Back Trajectory Cluster Map for TMOK

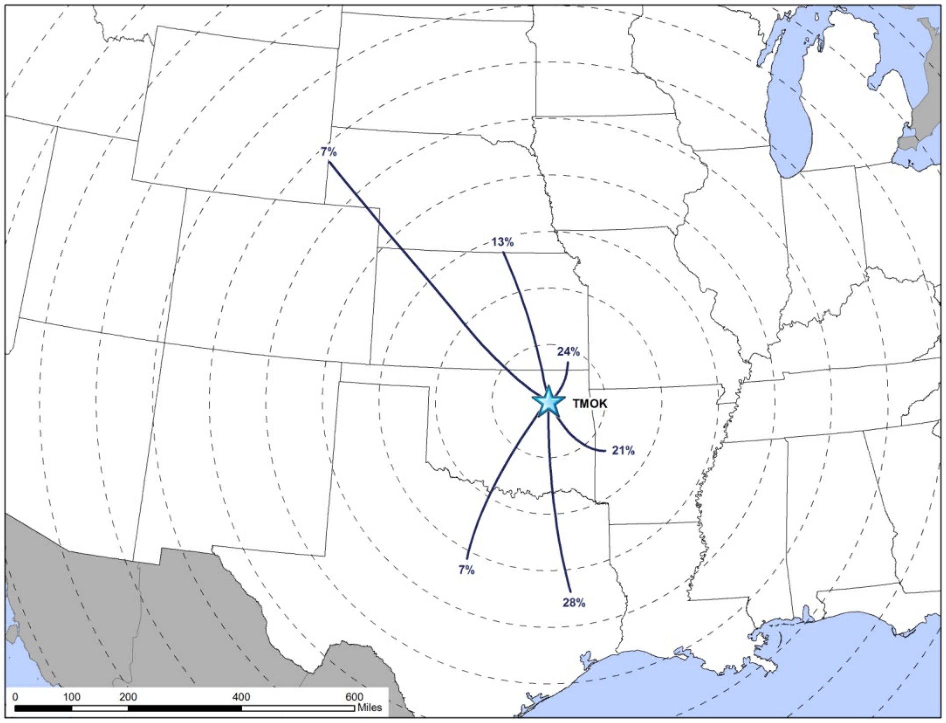


Figure 20-13. Composite Back Trajectory Map for PROK

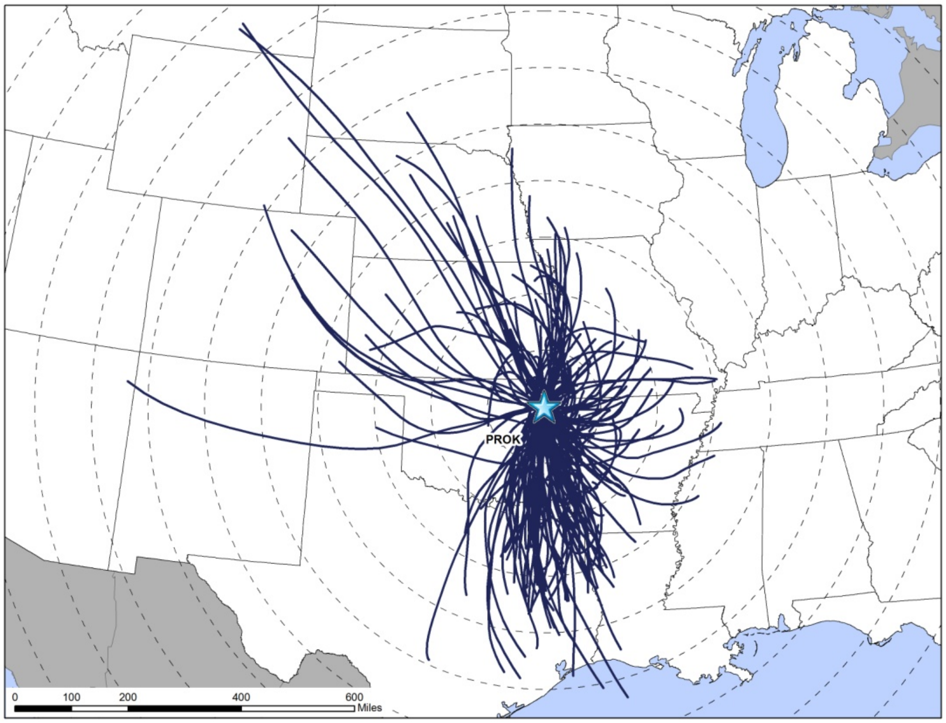


Figure 20-14. Back Trajectory Cluster Map for PROK

Figure 20-15. Composite Back Trajectory Map for ADOK

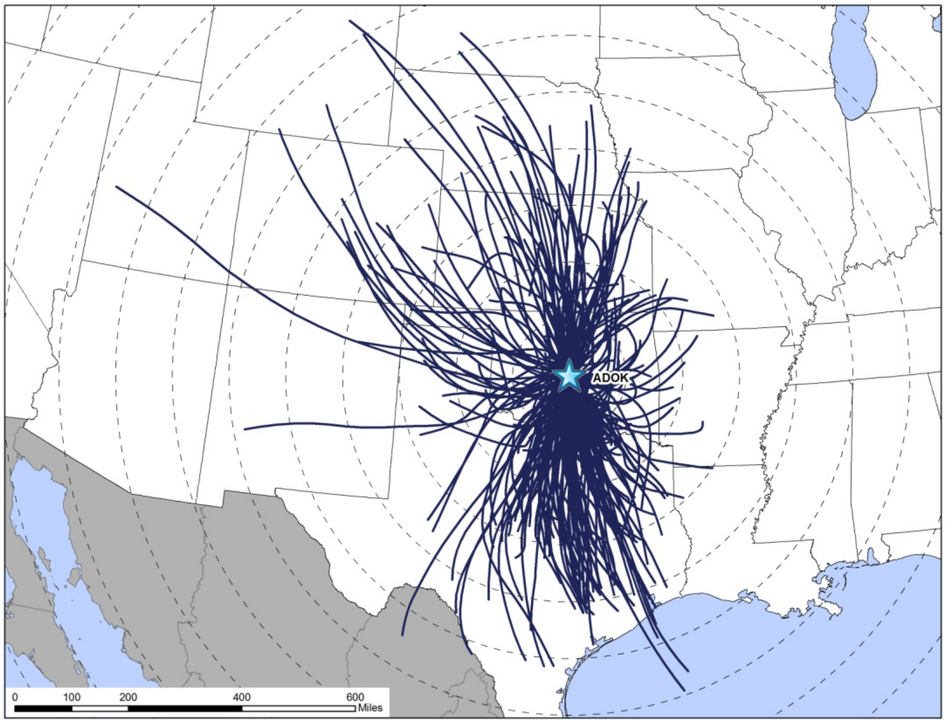


Figure 20-16. Back Trajectory Cluster Map for ADOK

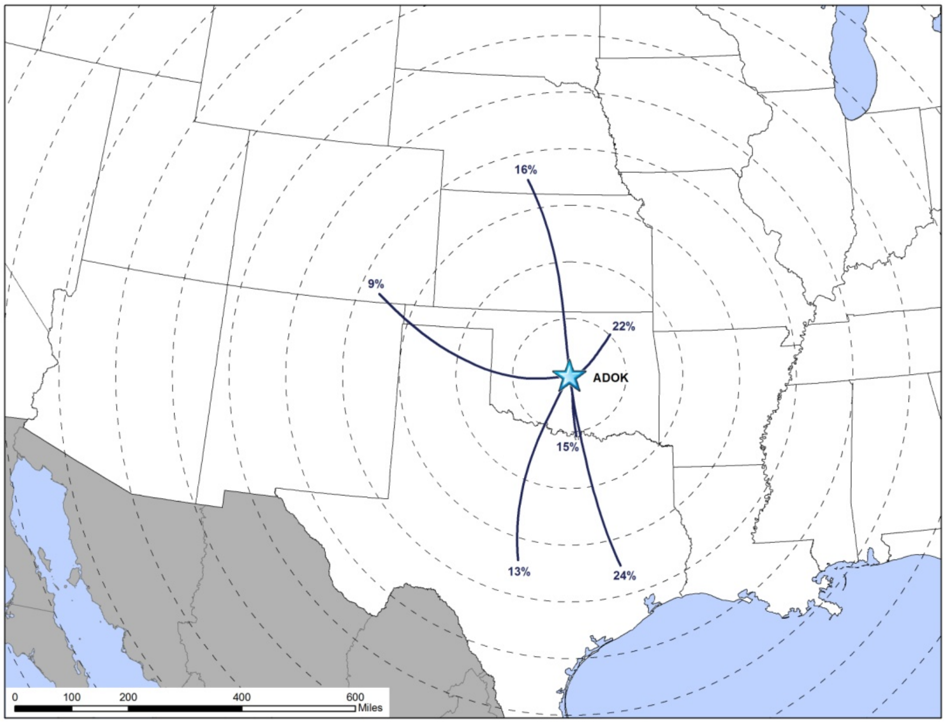


Figure 20-17. Composite Back Trajectory Map for OCOK

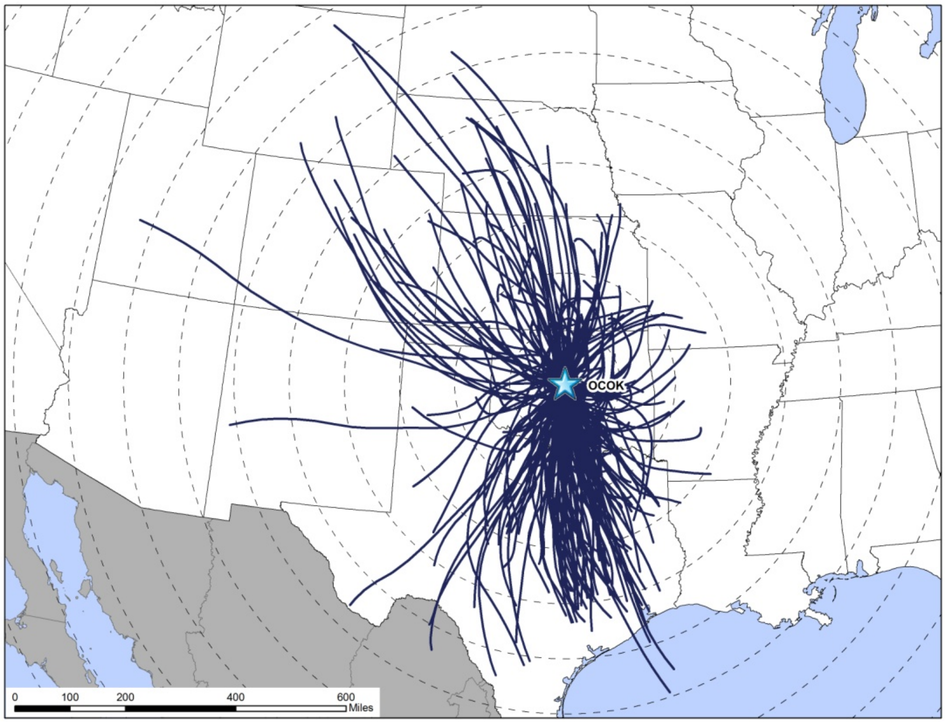
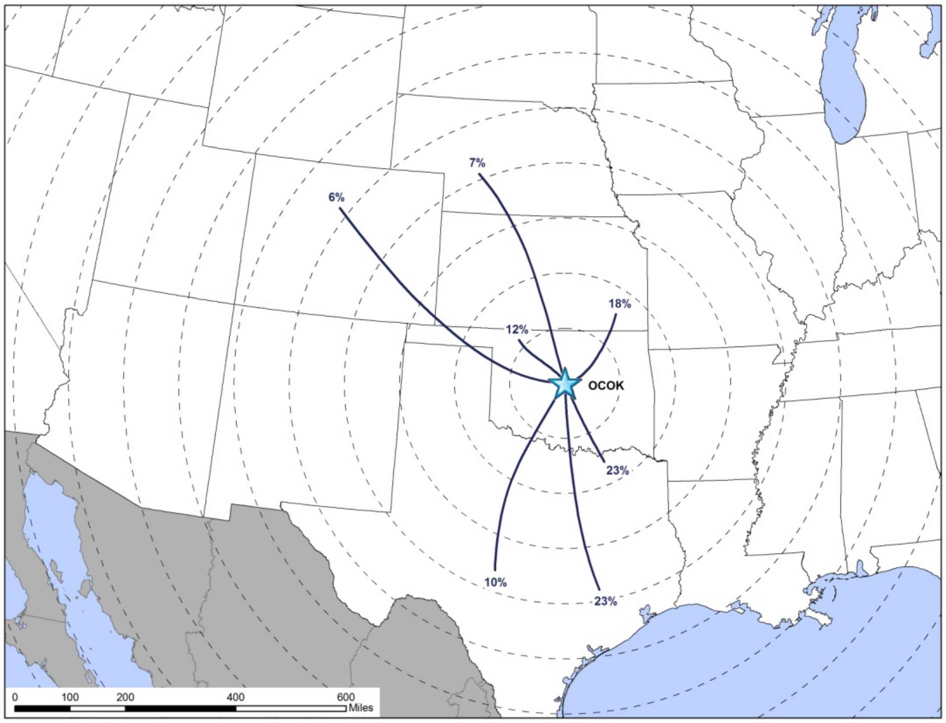


Figure 20-18. Back Trajectory Cluster Map for OCOK



Observations from Figures 20-9 through 20-18 include the following:

- The back trajectory maps for the Tulsa sites, the Pryor Creek site, and the Oklahoma City sites are similar to each other in back trajectory distribution. This is somewhat expected, given their relatively close proximity to each other and the similarity in sample days, although not all sites sampled on the exact same days over the period.

- The air shed domain for the OCOK site was among the largest in size compared to other NMP sites, based on an average back trajectory length of 281 miles. The farthest away a back trajectory originated was over western Utah, or approximately 825 miles away. The air shed domains for the other Oklahoma sites are in the top third compared to other NMP sites, based on the average back trajectory length. The farthest away a back trajectory originated was greater than 800 miles away for all five sites. The average back trajectory length for the Oklahoma sites ranged from 250 miles (PROK) to 281 miles (TOOK).

- Each of the sites exhibits a tendency for back trajectories to originate from the south-southeast to south-southwest of the sites and from the northwest to northeast of the sites, with the longest back trajectories generally originating from the northwest.

- For the Tulsa sites, nearly 40 percent of back trajectories originated from the southeast to southwest, generally over the eastern half of Texas, although these are split into two cluster trajectories. Roughly one-quarter of back trajectories originated to the east of the sites, primarily over Arkansas. The short cluster trajectory originating to the north of the sites includes those back trajectories with a northern component and that originated primarily over eastern Kansas and along the Kansas/Missouri border. The remaining back trajectories originated from the west to northwest to north of the sites, but of varying lengths.

- The cluster analysis for PROK groups together the relatively short back trajectories originating from the north over eastern Kansas and along Kansas/Missouri border with the relatively short back trajectories originating over the southern half of Missouri and Arkansas. These back trajectories together account for greater than 40 percent of back trajectories. Those back trajectories originating to the southeast, south, and southwest account for another 42 percent of back trajectories. Back trajectories originating to the north account for 9 percent of back trajectories while those originating to the west and northwest account for another 6 percent. Recall that sampling was discontinued at PROK at the end of October 2012; thus, this site has fewer sample days included in its back trajectory maps.

- The cluster analysis maps for the Oklahoma City sites are similar to each in cluster distribution patterns, although the percentages vary. Greater than 50 percent of back trajectories originated to the south of the sites, but are split into three different cluster trajectories based on back trajectory length and the location in Texas the back trajectory originated. Approximately 20 percent of back trajectories originated over the eastern half of Oklahoma and southeast Kansas. This cluster trajectory for OCOK includes a few of the longer trajectories originating over northeast Kansas, which explains why this cluster trajectory is longer for OCOK than ADOK. Twenty-five percent of back trajectories originated from the west, northwest, and north of the sites.

These back trajectories are represented by two cluster trajectories for ADOK and three for OCOK.

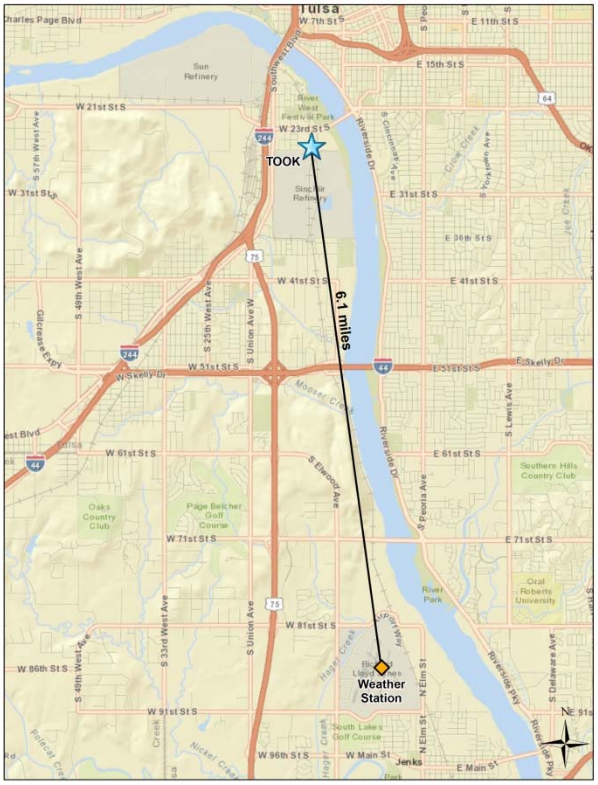
20.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations at Richard Lloyd Jones Junior Airport (for TOOK), Tulsa International Airport (for TMOK), Claremore Regional Airport (for PROK), Tinker Air Force Base (for ADOK), and Wiley Post Airport (for OCOK) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

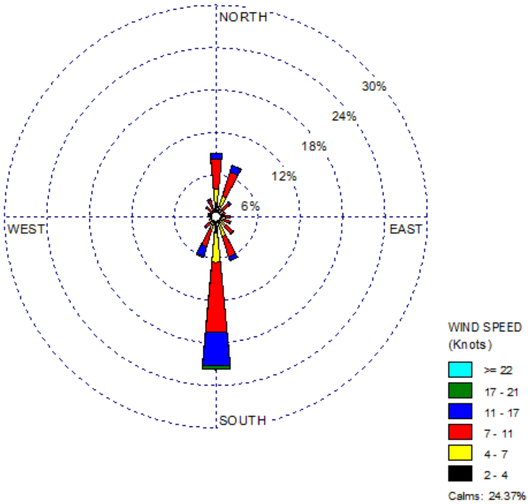
Figure 20-19 presents a map showing the distance between the weather station and TOOK, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 20-19 also presents three different wind roses for the TOOK monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind observations for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 20-20 through 20-23 present the distance maps and wind roses for the remaining Oklahoma sites.

Figure 20-19. Wind Roses for the Richard Lloyd Jones Jr. Airport Weather Station near TOOK

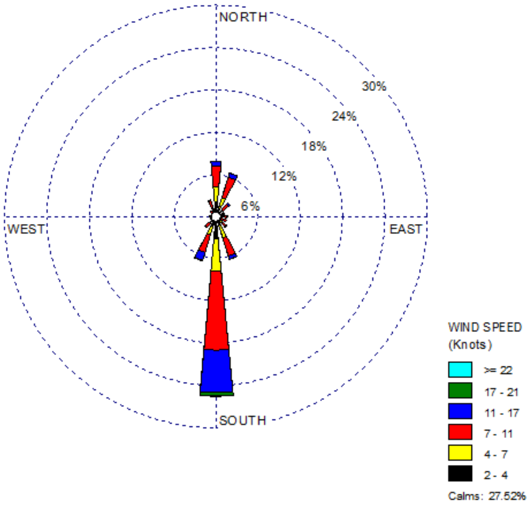
Location of TOOK and Weather Station



2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

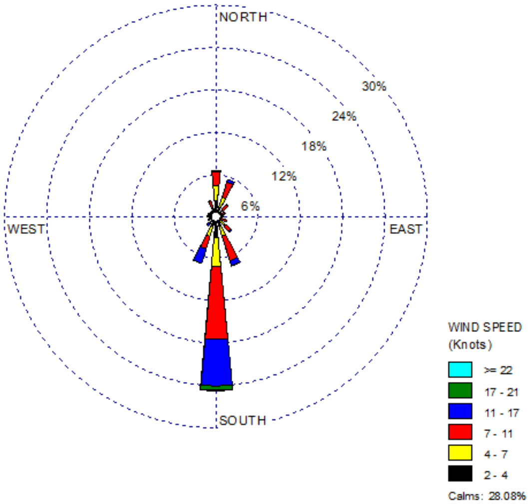
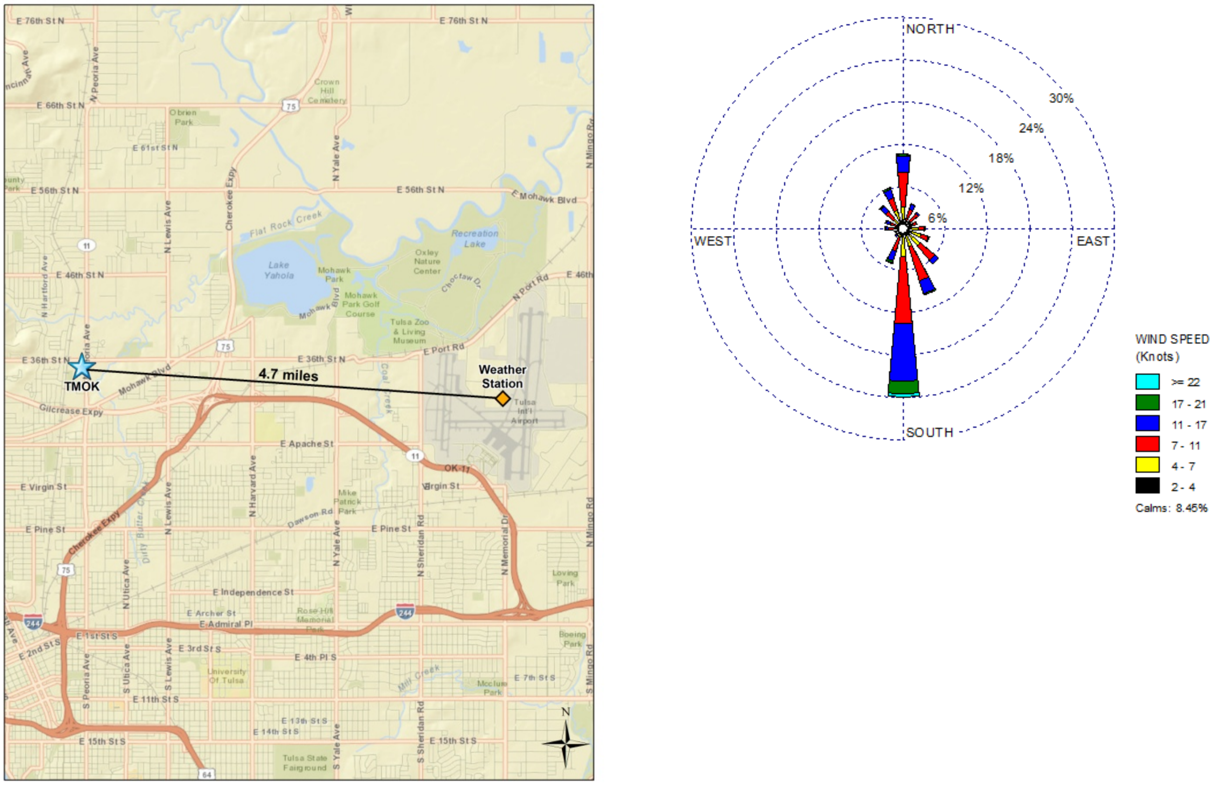
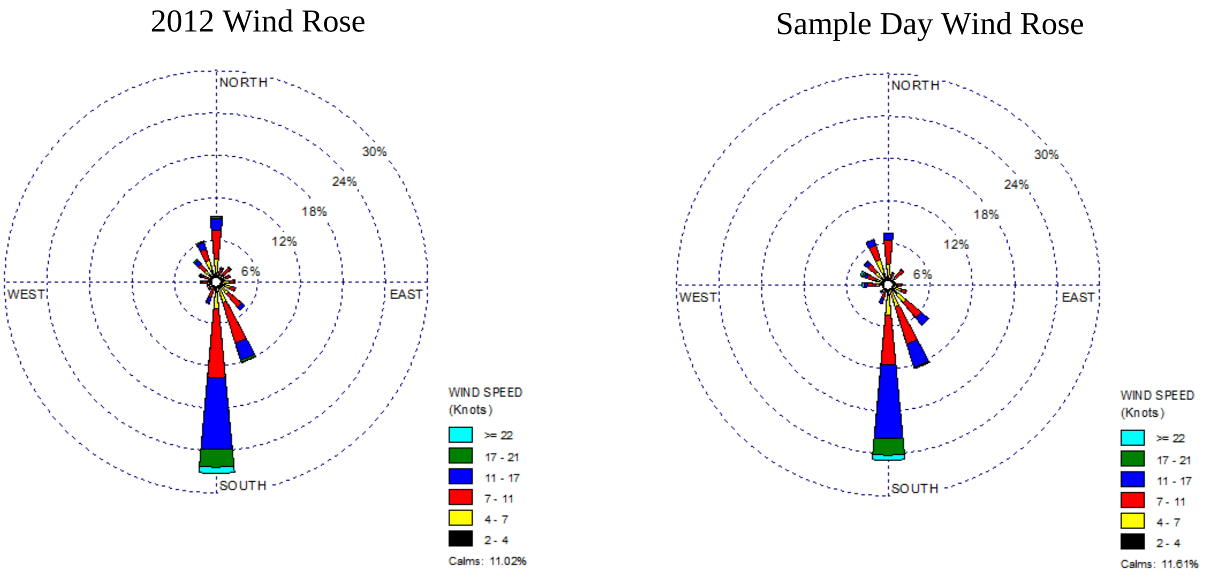


Figure 20-20. Wind Roses for the Tulsa International Airport Weather Station near TMOK



Location of TMOK and Weather Station

2002-2011 Historical Wind Rose



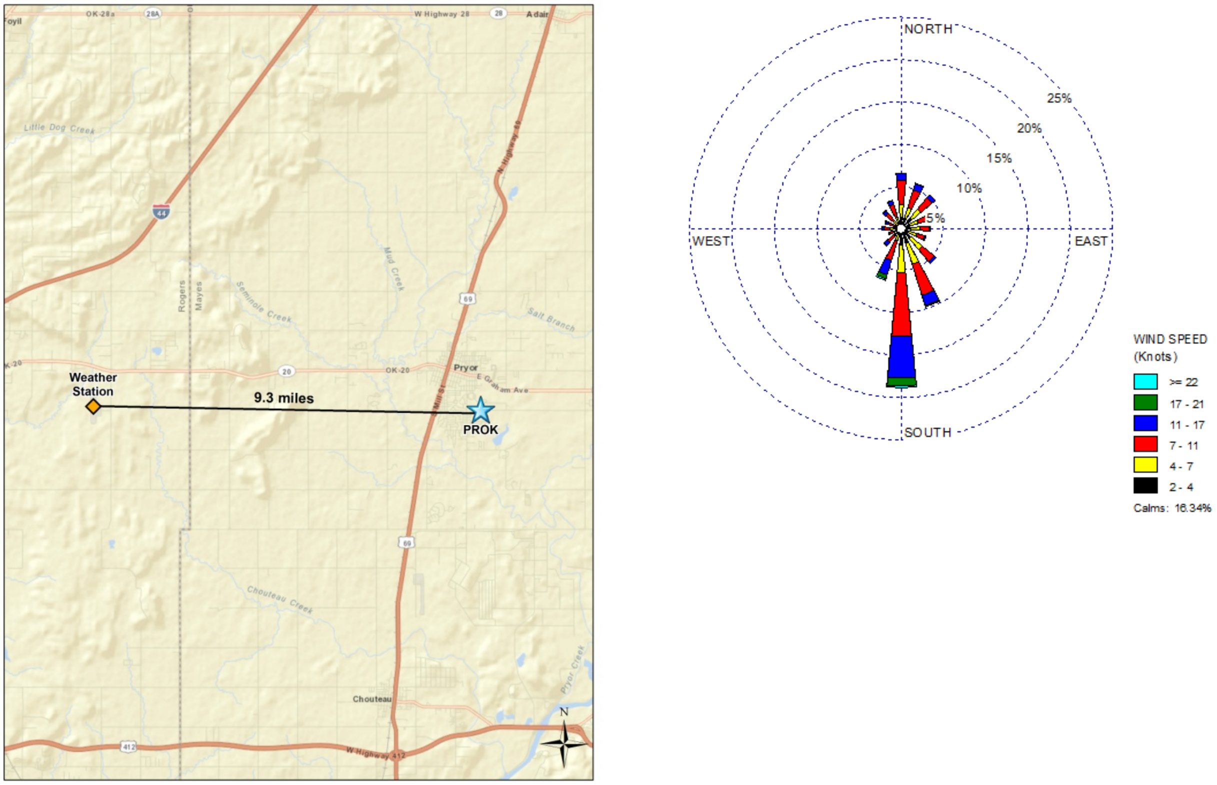
2012 Wind Rose

Sample Day Wind Rose

Figure 20-21. Wind Roses for the Claremore Regional Airport Weather Station near PROK

Location of PROK and Weather Station

2003-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

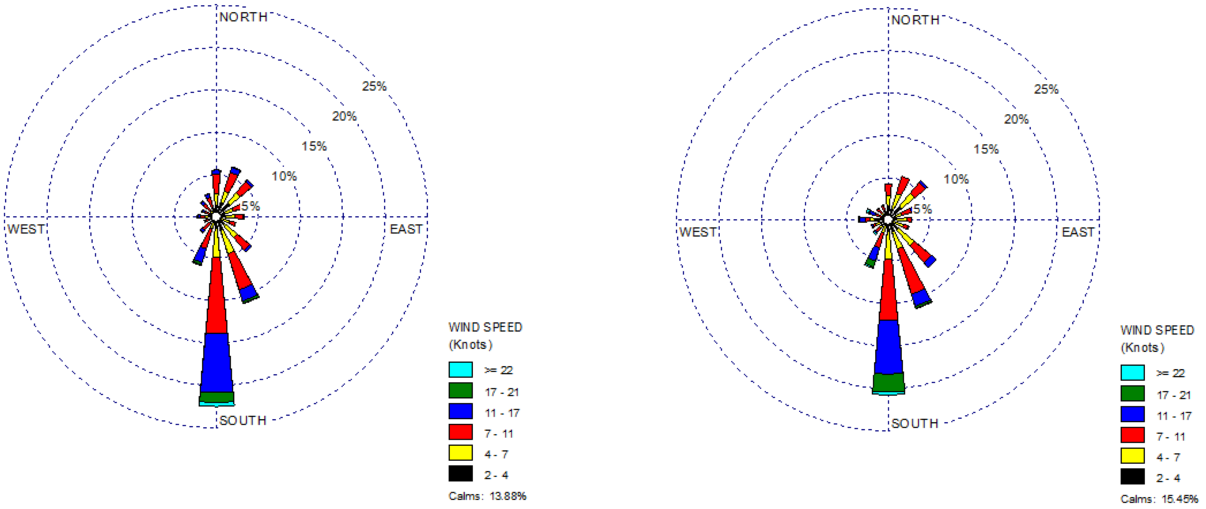
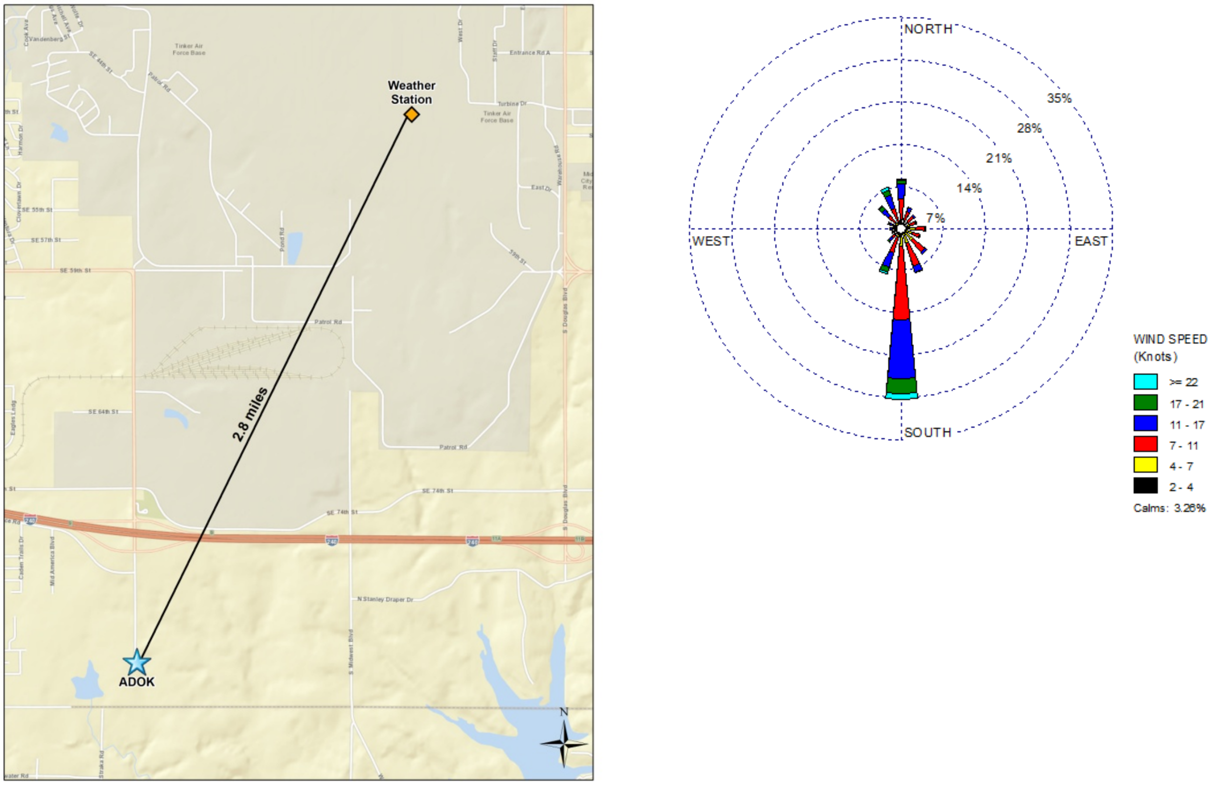
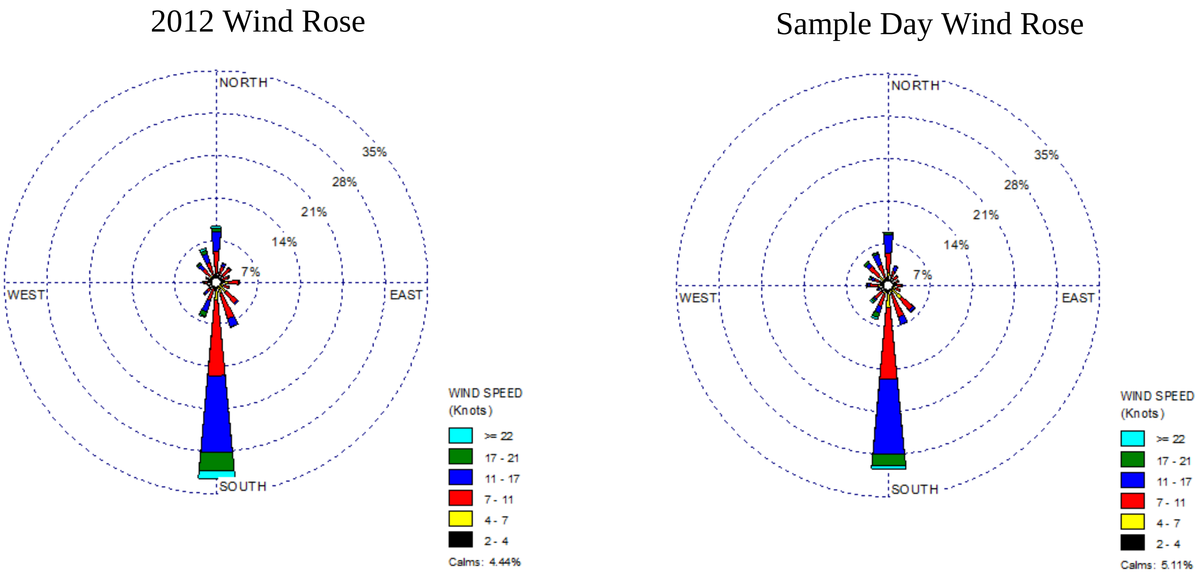


Figure 20-22. Wind Roses for the Tinker Air Force Base Airport Weather Station near ADOK



Location of ADOK and Weather Station

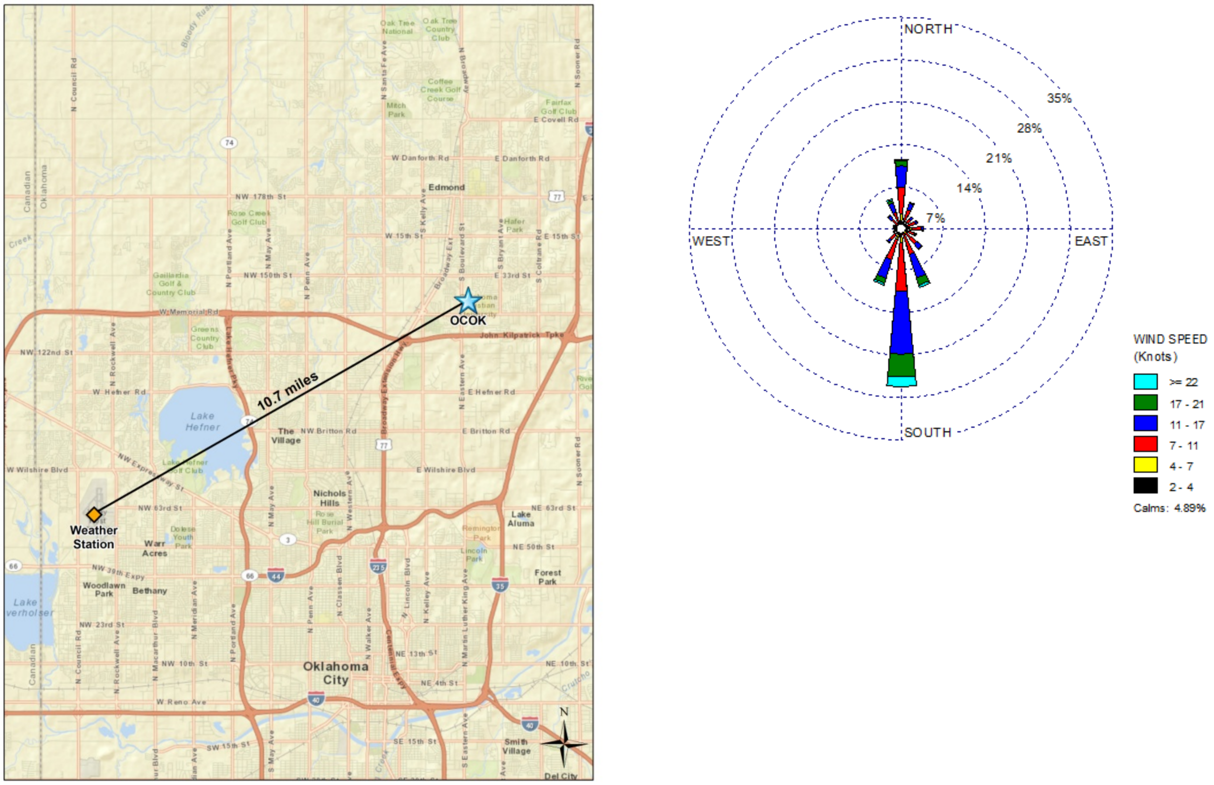
2006-2011 Historical Wind Rose



2012 Wind Rose

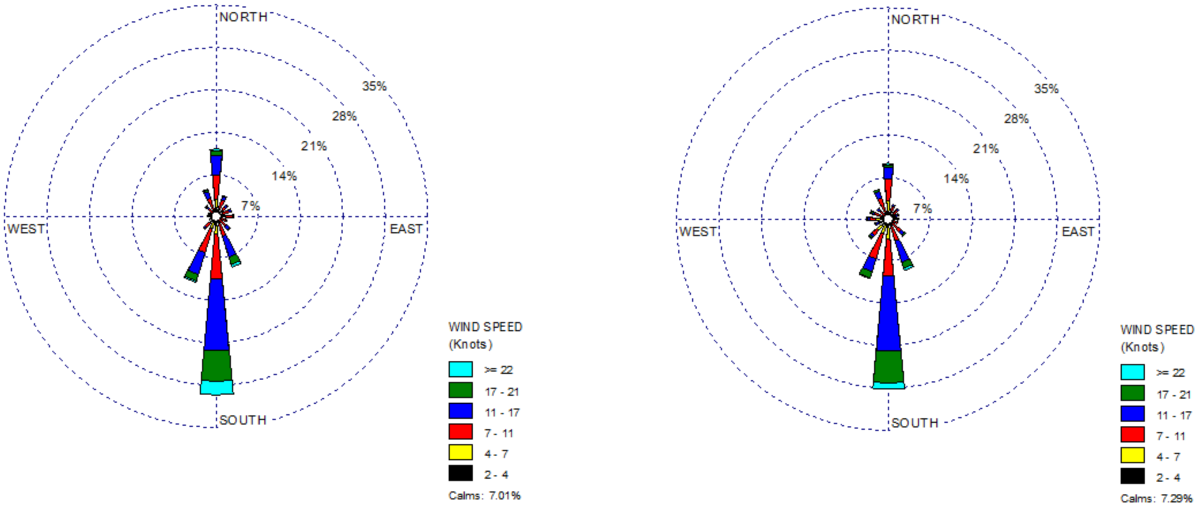
Sample Day Wind Rose

Figure 20-23. Wind Roses for the Wiley Post Airport Weather Station near OCOK



Location of OCOK and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

Observations from Figures 20-19 through 20-23 include the following:

- The distance maps show that the distances between the sites and the weather stations varies from 2.8 miles between Tinker Air Force Base and ADOK to 10.7 miles between OCOK and the Wiley Post Airport.

- Even though the historical data are from five different weather stations, the wind patterns shown on the wind roses for the Oklahoma sites are similar to each other. Each of the historical wind roses shows that southerly winds prevailed near each Oklahoma monitoring site, accounting for roughly 20 percent to 30 percent of observations among the historical time periods. The historical wind roses varied in the percentage of calm winds (≤2 knots) observed, ranging from as little as 3 percent at the Tinker Air Force Base (ADOK) to as high as 24 percent at the Richard Lloyd Jones Jr. Airport (TOOK). Calms winds, winds from the south-southeast to south-southwest, and winds from the north-northwest to north-northeast account for the majority of wind observations at each site while winds from the west or east were rarely observed near each site.

- For TOOK, the 2012 wind patterns are similar to the historical wind patterns, as are the sample day wind patterns, although a slightly higher percentage of calm winds were observed in 2012 and on sample days. These similarities indicate that conditions on sample days were representative of those experienced over the entire year and historically.

- For TMOK, the 2012 wind patterns are similar to the historical wind patterns, as are the sample day wind patterns, although a slightly higher percentage of calm winds were observed in 2012 and on sample days. These similarities indicate that conditions on sample days were representative of those experienced over the entire year and historically.

- For PROK, the historical wind rose includes 9 years of data, starting with 2003. The 2012 wind patterns resemble the historical wind patterns. The sample day wind rose for PROK is similar to the historical and full-year wind roses, indicating that conditions on sample days were representative of conditions experienced throughout the year and historically.

- For ADOK, the historical wind rose includes 6 years of data, starting with 2006. The 2012 wind patterns resemble the historical wind patterns, although there were slightly more southerly wind observations in 2012. This is also true of calm winds. The sample day wind patterns resemble the historical and the full-year wind patterns, although there is an even higher percentage of calm winds on sample days.

- For OCOK, the wind patterns shown on the 2012 wind rose resemble the historical wind patterns, but with a slightly higher percentage of calm winds. The sample day wind rose for OCOK is similar to both the historical and full-year wind roses, but also exhibits a higher percentage of calm winds.

20.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Oklahoma monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 20-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 20-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. The five Oklahoma sites sampled for VOCs, carbonyl compounds, and metals (TSP).

Table 20-4. Risk-Based Screening Results for the Oklahoma Monitoring Sites

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Tulsa, Oklahoma - TOOK						
Acetaldehyde	0.45	61	61	100.00	10.08	10.08
Arsenic (TSP)	0.00023	61	61	100.00	10.08	20.17
Formaldehyde	0.077	61	61	100.00	10.08	30.25
Manganese (TSP)	0.005	61	61	100.00	10.08	40.33
Benzene	0.13	60	60	100.00	9.92	50.25
Carbon Tetrachloride	0.17	60	60	100.00	9.92	60.17
1,3-Butadiene	0.03	58	60	96.67	9.59	69.75
Ethylbenzene	0.4	51	60	85.00	8.43	78.18
1,2-Dichloroethane	0.038	41	41	100.00	6.78	84.96
p-Dichlorobenzene	0.091	29	55	52.73	4.79	89.75
Nickel (TSP)	0.0021	24	61	39.34	3.97	93.72
Hexachloro-1,3-butadiene	0.045	7	10	70.00	1.16	94.88
Propionaldehyde	0.8	7	61	11.48	1.16	96.03
1,1,2,2-Tetrachloroethane	0.017	5	5	100.00	0.83	96.86
Xylenes	10	5	60	8.33	0.83	97.69
Cadmium (TSP)	0.00056	4	61	6.56	0.66	98.35
Lead (TSP)	0.015	4	61	6.56	0.66	99.01
1,2-Dibromoethane	0.0017	3	3	100.00	0.50	99.50
Beryllium (TSP)	0.00042	1	61	1.64	0.17	99.67
Cobalt (TSP)	0.01	1	61	1.64	0.17	99.83
Trichloroethylene	0.2	1	11	9.09	0.17	100.00
Total		605	1,035	58.45		

Table 20-4. Risk-Based Screening Results for the Oklahoma Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Tulsa, Oklahoma - TMOK						
Benzene	0.13	61	61	100.00	10.91	10.91
Carbon Tetrachloride	0.17	61	61	100.00	10.91	21.82
Manganese (TSP)	0.005	61	61	100.00	10.91	32.74
Acetaldehyde	0.45	59	59	100.00	10.55	43.29
Arsenic (TSP)	0.00023	59	61	96.72	10.55	53.85
Formaldehyde	0.077	59	59	100.00	10.55	64.40
1,3-Butadiene	0.03	57	60	95.00	10.20	74.60
1,2-Dichloroethane	0.038	42	42	100.00	7.51	82.11
Ethylbenzene	0.4	40	61	65.57	7.16	89.27
p-Dichlorobenzene	0.091	20	54	37.04	3.58	92.84
Nickel (TSP)	0.0021	15	61	24.59	2.68	95.53
Propionaldehyde	0.8	7	59	11.86	1.25	96.78
Hexachloro-1,3-butadiene	0.045	6	9	66.67	1.07	97.85
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	0.72	98.57
1,2-Dibromoethane	0.0017	3	3	100.00	0.54	99.11
Lead (TSP)	0.015	2	61	3.28	0.36	99.46
Beryllium (TSP)	0.00042	1	61	1.64	0.18	99.64
Cadmium (TSP)	0.00056	1	61	1.64	0.18	99.82
Trichloroethylene	0.2	1	19	5.26	0.18	100.00
Total		559	917	60.96		
Pryor Creek, Oklahoma - PROK						
Acetaldehyde	0.45	51	51	100.00	12.47	12.47
Benzene	0.13	51	51	100.00	12.47	24.94
Carbon Tetrachloride	0.17	51	51	100.00	12.47	37.41
Formaldehyde	0.077	51	51	100.00	12.47	49.88
Arsenic (TSP)	0.00023	47	49	95.92	11.49	61.37
1,2-Dichloroethane	0.038	46	47	97.87	11.25	72.62
Manganese (TSP)	0.005	45	49	91.84	11.00	83.62
1,3-Butadiene	0.03	28	39	71.79	6.85	90.46
p-Dichlorobenzene	0.091	21	45	46.67	5.13	95.60
Hexachloro-1,3-butadiene	0.045	4	6	66.67	0.98	96.58
1,1,2,2-Tetrachloroethane	0.017	3	3	100.00	0.73	97.31
Cadmium (TSP)	0.00056	2	49	4.08	0.49	97.80
1,2-Dibromoethane	0.0017	2	2	100.00	0.49	98.29
Ethylbenzene	0.4	2	51	3.92	0.49	98.78
Nickel (TSP)	0.0021	2	49	4.08	0.49	99.27
Beryllium (TSP)	0.00042	1	49	2.04	0.24	99.51
Propionaldehyde	0.8	1	51	1.96	0.24	99.76
Trichloroethylene	0.2	1	3	33.33	0.24	100.00
Total		409	696	58.76		

Table 20-4. Risk-Based Screening Results for the Oklahoma Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Oklahoma City, Oklahoma - ADOK						
Acetaldehyde	0.45	66	66	100.00	12.84	12.84
Benzene	0.13	66	66	100.00	12.84	25.68
Formaldehyde	0.077	66	66	100.00	12.84	38.52
Carbon Tetrachloride	0.17	65	66	98.48	12.65	51.17
Arsenic (TSP)	0.00023	59	64	92.19	11.48	62.65
Manganese (TSP)	0.005	58	64	90.63	11.28	73.93
1,2-Dichloroethane	0.038	54	54	100.00	10.51	84.44
1,3-Butadiene	0.03	32	44	72.73	6.23	90.66
p-Dichlorobenzene	0.091	24	57	42.11	4.67	95.33
Lead (TSP)	0.015	6	64	9.38	1.17	96.50
1,1,2,2-Tetrachloroethane	0.017	6	6	100.00	1.17	97.67
Ethylbenzene	0.4	3	66	4.55	0.58	98.25
Propionaldehyde	0.8	3	66	4.55	0.58	98.83
1,2-Dibromoethane	0.0017	2	2	100.00	0.39	99.22
Hexachloro-1,3-butadiene	0.045	2	5	40.00	0.39	99.61
Cadmium (TSP)	0.00056	1	64	1.56	0.19	99.81
Nickel (TSP)	0.0021	1	64	1.56	0.19	100.00
Total		514	884	58.14		
Oklahoma City, Oklahoma - OCOK						
Benzene	0.13	61	61	100.00	12.03	12.03
Carbon Tetrachloride	0.17	61	61	100.00	12.03	24.06
Acetaldehyde	0.45	60	60	100.00	11.83	35.90
Arsenic (TSP)	0.00023	60	61	98.36	11.83	47.73
Formaldehyde	0.077	60	60	100.00	11.83	59.57
Manganese (TSP)	0.005	58	61	95.08	11.44	71.01
1,2-Dichloroethane	0.038	52	52	100.00	10.26	81.26
1,3-Butadiene	0.03	47	56	83.93	9.27	90.53
p-Dichlorobenzene	0.091	16	54	29.63	3.16	93.69
Ethylbenzene	0.4	7	61	11.48	1.38	95.07
Propionaldehyde	0.8	7	60	11.67	1.38	96.45
Hexachloro-1,3-butadiene	0.045	4	8	50.00	0.79	97.24
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	0.79	98.03
Trichloroethylene	0.2	4	7	57.14	0.79	98.82
Nickel (TSP)	0.0021	3	61	4.92	0.59	99.41
1,2-Dibromoethane	0.0017	2	2	100.00	0.39	99.80
Cadmium (TSP)	0.00056	1	61	1.64	0.20	100.00
Total		507	790	64.18		

Observations from Table 20-4 include the following:

- Twenty-one pollutants failed at least one screen for TOOK; 58 percent of concentrations for these 21 pollutants were greater than their associated risk screening value (or failed screens).
- Thirteen pollutants contributed to 95 percent of failed screens for TOOK and therefore were identified as pollutants of interest for this site. These 13 include three carbonyl compounds, seven VOCs, and three TSP metals.
- Nineteen pollutants failed at least one screen for TMOK; 61 percent of concentrations for these 19 pollutants were greater than their associated risk screening value (or failed screens).
- Eleven pollutants contributed to 95 percent of failed screens for TMOK and therefore were identified as pollutants of interest for this site. These 11 include two carbonyl compounds, six VOCs, and three TSP metals.
- Eighteen pollutants failed at least one screen for PROK; 59 percent of concentrations for these 18 pollutants were greater than their associated risk screening value (or failed screens).
- Nine pollutants contributed to 95 percent of failed screens for PROK and therefore were identified as pollutants of interest for this site. These nine include two carbonyl compounds, five VOCs, and two TSP metals.
- Seventeen pollutants failed at least one screen for ADOK; 58 percent of concentrations for these 17 pollutants were greater than their associated risk screening value (or failed screens).
- Nine pollutants contributed to 95 percent of failed screens for ADOK and therefore were identified as pollutants of interest for this site. These nine include two carbonyl compounds, five VOCs, and two TSP metals.
- Seventeen pollutants failed at least one screen for OCOK; 64 percent of concentrations for these 17 pollutants were greater than their associated risk screening value (or failed screens).
- Eleven pollutants contributed to 95 percent of failed screens for OCOK and therefore were identified as pollutants of interest for this site. These 11 include three carbonyl compounds, six VOCs, and two TSP metals.
- The number of pollutants identified as pollutants of interest range from nine to 13 among the Oklahoma sites. These sites have nine pollutants of interest in common: acetaldehyde, arsenic, benzene, 1,3-butadiene, carbon tetrachloride, *p*-dichlorobenzene, 1,2-dichloroethane, formaldehyde, and manganese.

- TOOK failed the third highest number of screens among all NMP sites, with the other Oklahoma sites ranking sixth (TMOK), eighth (ADOK), 11th (OCOK), and 14th (PROK), as shown in Table 4-8.

20.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Oklahoma monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.

- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for the five Oklahoma sites are provided in Appendices J, L, and N.

20.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Oklahoma site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Oklahoma monitoring sites are presented in Table 20-5, where applicable. Note that concentrations of the TSP metals are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 20-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Oklahoma Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Tulsa, Oklahoma - TOOK						
Acetaldehyde	61/61	1.71 ± 0.28	3.25 ± 0.96	3.96 ± 0.97	2.11 ± 0.54	2.78 ± 0.42
Benzene	60/60	2.05 ± 0.55	2.48 ± 0.69	2.51 ± 0.76	1.80 ± 0.48	2.21 ± 0.31
1,3-Butadiene	60/60	0.10 ± 0.03	0.07 ± 0.02	0.08 ± 0.03	0.14 ± 0.04	0.10 ± 0.02
Carbon Tetrachloride	60/60	0.64 ± 0.05	0.72 ± 0.04	0.63 ± 0.03	0.64 ± 0.05	0.66 ± 0.02
p-Dichlorobenzene	55/60	0.12 ± 0.02	0.11 ± 0.03	0.08 ± 0.02	0.07 ± 0.02	0.09 ± 0.01
1,2-Dichloroethane	41/60	0.06 ± 0.03	0.11 ± 0.01	0.05 ± 0.02	0.06 ± 0.04	0.07 ± 0.01
Ethylbenzene	60/60	0.93 ± 0.42	1.01 ± 0.31	1.06 ± 0.38	0.66 ± 0.21	0.91 ± 0.17
Formaldehyde	61/61	1.85 ± 0.30	3.96 ± 1.42	5.11 ± 1.04	2.66 ± 0.47	3.42 ± 0.54
Hexachloro-1,3-butadiene	10/60	0.01 ± 0.01	0.02 ± 0.02	0.02 ± 0.02	0	0.01 ± 0.01
Propionaldehyde	61/61	0.29 ± 0.06	0.59 ± 0.22	0.69 ± 0.15	0.42 ± 0.13	0.50 ± 0.08
Arsenic (TSP)[a]	61/61	0.88 ± 0.19	1.08 ± 0.21	0.82 ± 0.19	0.93 ± 0.23	0.92 ± 0.10
Manganese (TSP)[a]	61/61	33.02 ± 11.60	37.59 ± 8.17	32.49 ± 7.97	50.62 ± 33.47	38.33 ± 8.81
Nickel (TSP)[a]	61/61	2.35 ± 0.83	2.34 ± 0.57	1.86 ± 0.38	3.18 ± 1.73	2.42 ± 0.49

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.
NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Table 20-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Oklahoma Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Tulsa, Oklahoma - TMOK						
Acetaldehyde	59/59	1.52 ± 0.23	2.57 ± 0.53	3.41 ± 0.84	1.77 ± 0.40	2.33 ± 0.32
Benzene	61/61	1.23 ± 0.25	1.47 ± 0.44	1.06 ± 0.18	1.27 ± 0.43	1.25 ± 0.16
1,3-Butadiene	60/61	0.11 ± 0.04	0.10 ± 0.03	0.10 ± 0.03	0.18 ± 0.07	0.12 ± 0.02
Carbon Tetrachloride	61/61	0.66 ± 0.06	0.74 ± 0.03	0.65 ± 0.03	0.68 ± 0.04	0.68 ± 0.02
p-Dichlorobenzene	54/61	0.07 ± 0.02	0.11 ± 0.03	0.07 ± 0.02	0.08 ± 0.03	0.08 ± 0.01
1,2-Dichloroethane	42/61	0.04 ± 0.02	0.11 ± 0.02	0.05 ± 0.02	0.07 ± 0.03	0.06 ± 0.01
Ethylbenzene	61/61	0.52 ± 0.17	0.64 ± 0.16	0.52 ± 0.12	0.55 ± 0.22	0.56 ± 0.08
Formaldehyde	59/59	2.56 ± 0.39	4.17 ± 1.04	4.99 ± 1.09	2.71 ± 0.49	3.63 ± 0.47
Arsenic (TSP)[a]	61/61	0.72 ± 0.18	0.99 ± 0.28	0.61 ± 0.16	0.78 ± 0.24	0.77 ± 0.11
Manganese (TSP)[a]	61/61	21.11 ± 9.34	25.96 ± 5.17	19.90 ± 5.11	38.34 ± 33.71	26.22 ± 8.46
Nickel (TSP)[a]	61/61	1.57 ± 0.45	1.85 ± 0.36	1.27 ± 0.34	2.02 ± 0.86	1.67 ± 0.26
Pryor Creek, Oklahoma - PROK						
Acetaldehyde	51/51	1.21 ± 0.19	1.64 ± 0.31	1.94 ± 0.41	NA	1.56 ± 0.19
Benzene	51/51	0.62 ± 0.10	0.77 ± 0.36	0.50 ± 0.06	NA	0.61 ± 0.11
1,3-Butadiene	39/51	0.04 ± 0.02	0.03 ± 0.01	0.05 ± 0.03	NA	0.05 ± 0.01
Carbon Tetrachloride	51/51	0.67 ± 0.08	0.77 ± 0.07	0.65 ± 0.03	NA	0.69 ± 0.03
p-Dichlorobenzene	45/51	0.12 ± 0.03	0.14 ± 0.05	0.04 ± 0.01	NA	0.09 ± 0.02
1,2-Dichloroethane	47/51	0.09 ± 0.01	0.08 ± 0.02	0.05 ± 0.01	NA	0.07 ± 0.01
Formaldehyde	51/51	1.86 ± 0.31	4.27 ± 1.41	5.03 ± 1.10	NA	3.58 ± 0.65
Arsenic (TSP)[a]	49/49	0.58 ± 0.19	0.70 ± 0.12	0.58 ± 0.27	NA	0.63 ± 0.10
Manganese (TSP)[a]	49/49	12.10 ± 6.96	15.16 ± 2.83	16.54 ± 3.67	NA	18.66 ± 8.09

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.
NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Table 20-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Oklahoma Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Oklahoma City, Oklahoma - ADOK						
Acetaldehyde	66/66	1.16 ± 0.16	1.98 ± 0.46	2.84 ± 0.58	1.39 ± 0.30	1.81 ± 0.24
Benzene	66/66	0.65 ± 0.08	0.72 ± 0.26	0.57 ± 0.22	0.58 ± 0.10	0.63 ± 0.08
1,3-Butadiene	44/66	0.04 ± 0.02	0.02 ± 0.01	0.06 ± 0.03	0.05 ± 0.04	0.04 ± 0.01
Carbon Tetrachloride	66/66	0.62 ± 0.07	0.73 ± 0.04	0.67 ± 0.03	0.68 ± 0.05	0.67 ± 0.03
p-Dichlorobenzene	57/66	0.04 ± 0.01	0.05 ± 0.01	0.28 ± 0.13	0.16 ± 0.03	0.13 ± 0.04
1,2-Dichloroethane	54/66	0.07 ± 0.02	0.09 ± 0.01	0.05 ± 0.02	0.05 ± 0.02	0.06 ± 0.01
Formaldehyde	66/66	1.64 ± 0.25	3.81 ± 1.13	4.82 ± 0.92	2.06 ± 0.34	3.00 ± 0.46
Arsenic (TSP)[a]	64/64	0.48 ± 0.10	0.56 ± 0.10	0.49 ± 0.13	0.46 ± 0.10	0.49 ± 0.05
Manganese (TSP)[a]	64/64	11.40 ± 7.40	14.28 ± 5.17	14.26 ± 3.19	12.80 ± 3.43	13.08 ± 2.62
Oklahoma City, Oklahoma - OCOK						
Acetaldehyde	60/60	1.47 ± 0.22	2.55 ± 0.52	3.59 ± 0.70	1.67 ± 0.30	2.34 ± 0.32
Benzene	61/61	0.71 ± 0.08	1.01 ± 0.43	0.61 ± 0.09	0.79 ± 0.16	0.78 ± 0.12
1,3-Butadiene	56/61	0.05 ± 0.01	0.12 ± 0.14	0.07 ± 0.03	0.08 ± 0.05	0.08 ± 0.04
Carbon Tetrachloride	61/61	0.61 ± 0.06	0.73 ± 0.04	0.65 ± 0.03	0.65 ± 0.05	0.66 ± 0.03
p-Dichlorobenzene	54/61	0.04 ± 0.01	0.05 ± 0.02	0.09 ± 0.02	0.08 ± 0.02	0.07 ± 0.01
1,2-Dichloroethane	52/61	0.08 ± 0.01	0.09 ± 0.01	0.06 ± 0.01	0.05 ± 0.02	0.07 ± 0.01
Ethylbenzene	61/61	0.20 ± 0.03	0.48 ± 0.37	0.30 ± 0.04	0.26 ± 0.07	0.31 ± 0.09
Formaldehyde	60/60	1.81 ± 0.28	4.16 ± 1.15	5.46 ± 1.07	2.44 ± 0.43	3.49 ± 0.54
Propionaldehyde	60/60	0.29 ± 0.05	0.57 ± 0.11	0.71 ± 0.13	0.33 ± 0.07	0.48 ± 0.06
Arsenic (TSP)[a]	61/61	0.51 ± 0.17	0.67 ± 0.14	0.58 ± 0.15	0.52 ± 0.10	0.57 ± 0.07
Manganese (TSP)[a]	61/61	15.45 ± 9.33	16.09 ± 4.28	29.68 ± 11.40	22.63 ± 6.71	21.10 ± 4.26

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

Observations for all five Oklahoma sites from Table 20-5 include the following:

- Formaldehyde has the highest annual average concentration for each site, followed by acetaldehyde. With the exception of the Tulsa sites, these were the only two pollutants of interest with annual average concentrations greater than 1 µg/m^3 for each site. For TOOK and TMOK, benzene also has an annual average concentration greater than 1 µg/m^3. However, the annual average for TOOK (2.21 ± 0.31 µg/m^3) is greater than the annual average for TMOK (1.25 ± 0.16 µg/m^3). This observation was also made in the 2011 report, but the difference has decreased for 2012.

- Annual average concentrations of formaldehyde range from 3.00 ± 0.46 µg/m^3 for ADOK to 3.63 ± 0.47 µg/m^3 for TMOK. With the exception of ADOK, the annual averages of formaldehyde span less than 0.25 µg/m^3. The annual average concentration of acetaldehyde are more variable and ranged from 1.56 ± 0.19 µg/m^3 for PROK to 2.78 ± 0.42 µg/m^3 for TOOK.

- Concentrations of the carbonyl compounds, formaldehyde in particular, tended to be highest in the summer months and lowest in the winter months. However, the confidence intervals associated with some of these averages indicate that the differences are not statistically significant for all locations. Three of the five Oklahoma sites measured their maximum formaldehyde concentration on June 26, 2012. The June 26th sample was invalid for OCOK and a make-up sample was collected on June 28, 2012. The maximum formaldehyde concentration for OCOK was measured in the June 28th sample. While the maximum formaldehyde concentration was measured at TMOK on August 1, 2012 (10.1 µg/m^3), a similar concentration was also measured on June 26, 2012 (10.0 µg/m^3). The formaldehyde concentrations measured at the Oklahoma sites on or near June 26, 2012 account for some of the highest concentrations measured program-wide.

- The annual average concentration of manganese is higher than the annual average concentrations of the other TSP metals for each site. The annual average manganese concentrations range from 13.08 ± 2.62 ng/m^3 for ADOK to 38.33 ± 8.81 ng/m^3 for TOOK. Manganese concentrations greater than 70 ng/m^3 were measured at all five Oklahoma sites and concentrations greater than 200 ng/m^3 were measured at TOOK, TMOK, and PROK.

Observations for TOOK from Table 20-5 include the following:

- Although the third quarter average formaldehyde concentration is the highest among the quarterly averages for TOOK, the confidence interval is larger for the second quarter average. As discussed above, the maximum formaldehyde concentration was measured on June 26, 2012 (12.8 µg/m^3). This is the highest concentration of formaldehyde among all NMP sites across the program, although a concentration of the same magnitude was also measured at SPIL. The maximum acetaldehyde concentration was also measured at TOOK on June 26, 2012 and is the fourth highest acetaldehyde concentration measured program-wide.

- Of the 32 benzene concentrations greater than 3 μg/m^3 measured across the program, 13 were measured at TOOK. The site with the next highest number of benzene concentrations greater than 3 μg/m^3 is ROIL, with five. Concentrations of benzene measured at TOOK range from 0.46 μg/m^3 to 5.73 μg/m^3.

- Of the 10 ethylbenzene concentrations greater than 2 μg/m^3 measured across the program, five were measured at TOOK. At least one of these was measured in each quarter except the fourth quarter, explaining the differences in the quarterly averages and the associated confidence intervals shown in Table 20-5 for TOOK. Concentrations of ethylbenzene measured at TOOK range from 0.14 μg/m^3 to 2.89 μg/m^3.

- The fourth quarter average concentration of manganese is greater than the other quarterly averages and has a relatively large confidence interval associated with it. This is also true for nickel. A review of the data shows that the maximum concentration of each of the metal pollutants of interest was measured at TOOK on October 18, 2012. The maximum manganese concentration (273 ng/m^3) is the only manganese concentration measured at TOOK greater than 100 ng/m^3. This concentration is the second highest manganese concentration measured at an NMP site sampling metals (behind only S4MO, 275 ng/m^3). The maximum manganese concentrations measured at TMOK and PROK were also measured on this sample day (266 ng/m^3 and 204 ng/m^3, respectively). These maximum concentrations correlate to the day a large dust storm affected the Tulsa area.

Observations for TMOK from Table 20-5 include the following:

- The fourth quarter average concentration of 1,3-butadiene is greater than the other quarterly averages and has a larger confidence interval associated with it. A review of the data shows that the two highest concentrations of 1,3-butaidene were both measured during the fourth quarter (0.50 μg/m^3 on November 17, 2012 and 0.34 μg/m^3 on October 30, 2012). Further, eight of the 11 concentrations of 1,3-butadiene greater than 0.20 μg/m^3 were measured at TMOK during the fourth quarter of 2012.

- The fourth quarter average concentration of manganese is greater than the other quarterly averages and has a large confidence interval of nearly the same magnitude associated with it. A review of the data shows that the maximum concentration of this pollutant was measured at TMOK on October 18, 2012. The maximum manganese concentration (266 ng/m^3) is the only manganese concentration measured at TMOK greater than 100 ng/m^3. This concentration is the third highest manganese concentration measured at an NMP site sampling metals. This is the same day the maximum manganese concentrations were measured at TOOK and PROK. These relatively high concentrations correlate to a dust storm affecting the Tulsa area. The maximum manganese concentrations measured at TMOK and TOOK were also measured on the same day in 2011 (October 6, 2011) and was discussed in the 2011 NMP report.

- Nickel is also highest during the fourth quarter and has a relatively large confidence interval associated with it. The maximum nickel concentration (7.01 ng/m^3) was also measured at TMOK on October 18th, and is nearly twice the next highest nickel concentration measured at TMOK (3.78 ng/m^3, also measured during the fourth quarter).

Observations for PROK from Table 20-5 include the following:

- The formaldehyde concentration measured at PROK on June 26, 2012 (12.4 µg/m^3) is the fourth highest formaldehyde concentration measured program-wide.

- The maximum benzene concentration was measured at PROK on April 3, 2012 (3.12 µg/m^3). The second highest benzene concentration (1.05 µg/m^3) was measured at PROK on June 26, 2012, the same day the maximum formaldehyde concentration was measured at PROK (and other Oklahoma sites).

- The maximum manganese concentration (204 ng/m^3) was measured at PROK on October 18, 2012, which is the same day the maximum manganese concentrations were measured at TOOK and TMOK, and is the fifth highest manganese concentration measured program-wide. The next highest manganese concentration measured at PROK is considerably less (57.6 ng/m^3) and no other measurements greater than 30 ng/m^3 were measured at PROK.

- Because sampling at PROK was discontinued at the end of October 2012, there are no fourth quarter averages for this site in Table 20-5.

Observations for ADOK from Table 20-5 include the following:.

- The third and fourth quarter average concentrations of *p*-dichlorobenzene are considerably higher than the other quarterly averages, particularly the third quarter. A review of the data shows that the maximum concentration of this pollutant was measured on August 13, 2012 (0.81 µg/m^3). The eight highest concentrations of *p*-dichlorobenzene were all measured at ADOK in August or September and ranged from 0.283 µg/m^3 to 0.807 µg/m^3. Further, all but one of the 22 concentrations greater than 0.1 µg/m^3 measured at ADOK were measured between August and December.

Observations for OCOK from Table 20-5 include the following:

- The second quarter average concentrations of 1,3-butadiene and ethylbenzene are higher than the other quarterly averages and have relatively large confidence intervals, particularly 1,3-butadiene, for which the confidence interval is greater than the average itself. This is also true for benzene. The maximum concentrations of 1,3-butadiene and ethylbenzene were measured at OCOK on June 14, 2012 (and the second highest concentration of benzene was also measured on this date). The ethylbenzene concentration for this date (2.93 µg/m^3) is more than five times higher than the next highest concentration measured at OCOK and is the third highest ethylbenzene concentration measured across the program. The 1,3-butadiene concentration for this date (1.09 µg/m^3) is nearly four times higher than the next highest concentration measured at OCOK and the fourth highest 1,3-butadiene concentration measured across the program. Although the benzene concentration for this date is the second highest benzene concentration measured at OCOK (2.82 µg/m^3), it is just less than the maximum concentration measured at this site (2.97 µg/m^3), which was also measured during the second quarter.

- The quarterly averages of propionaldehyde for OCOK exhibit the same trend as formaldehyde and acetaldehyde in that the quarterly averages for the warmer months are greater than the quarterly averages for the cooler months.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Oklahoma sites include the following:

- The Oklahoma sites appear in Tables 4-9 through 4-12 a total of 37 times. However, because they are the only sites sampling TSP metals, all five sites appear for each metal, accounting for 15 of the appearances.

- TOOK has the highest annual average of concentrations of benzene and ethylbenzene among all NMP sites sampling these pollutants. The annual average concentrations for TMOK rank fifth for both pollutants. Similar findings for benzene were observed in the 2010 and 2011 NMP reports.

- An annual average concentration for at least one Oklahoma site ranked among the highest annual average concentrations for all of the VOC pollutants of interest provided in Table 4-9.

- Four of the five Oklahoma sites appear in Table 4-10 for their annual average concentrations of formaldehyde, ranking between fifth and ninth. Only ADOK does not appear in this table for formaldehyde (it ranked 14th).

- TOOK has the third highest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds. OCOK and TMOK rank seventh and eighth, respectively.

- TOOK has the highest annual average concentration of the three TSP metals shown in Table 4-12, followed by TMOK. TOOK has the highest annual average manganese concentration among all NMP sites sampling manganese.

20.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 20-4. Figures 20-24 through 20-36 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 20-24. Program vs. Site-Specific Average Acetaldehyde Concentrations

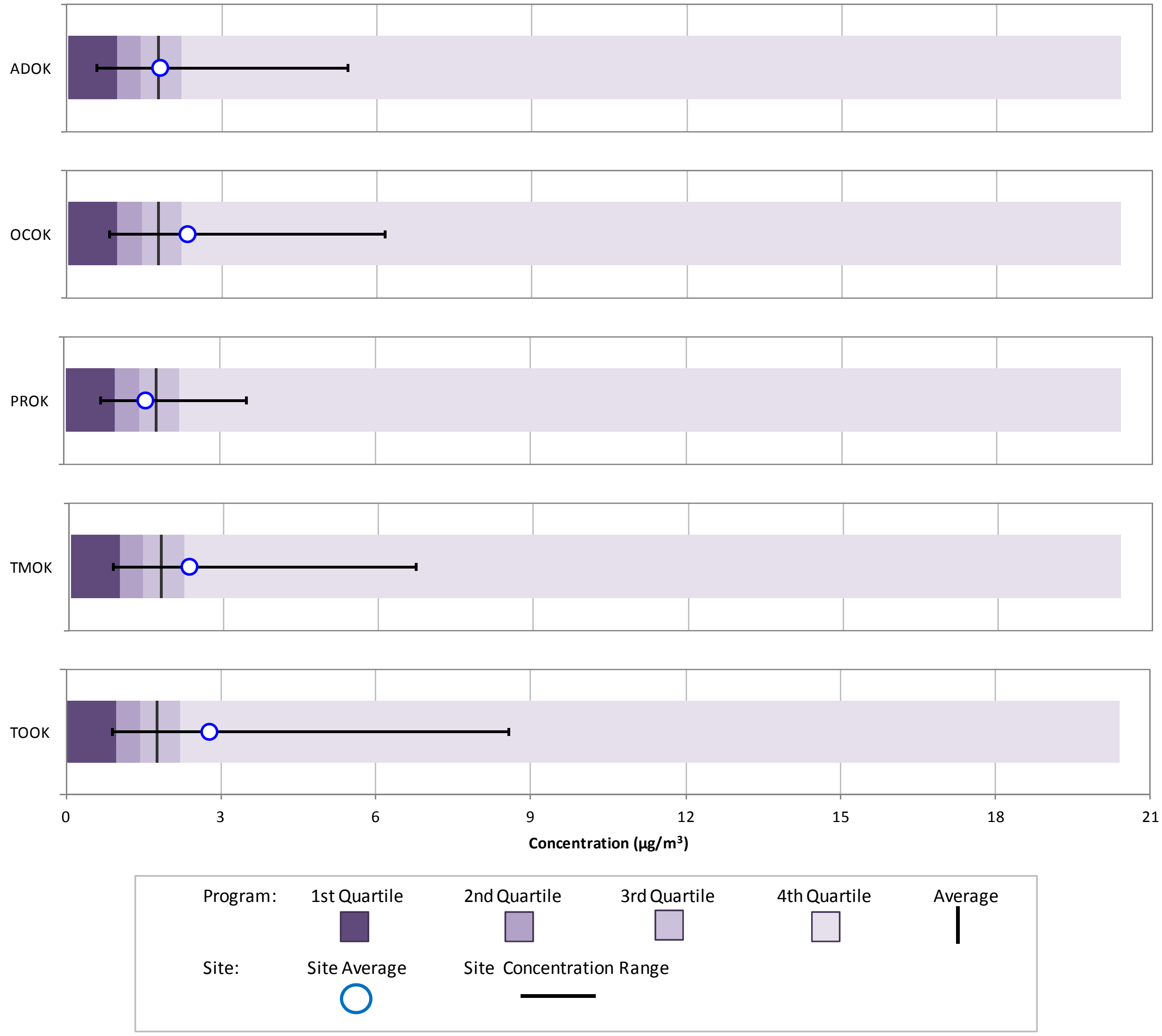


Figure 20-25. Program vs. Site-Specific Average Arsenic (TSP) Concentrations

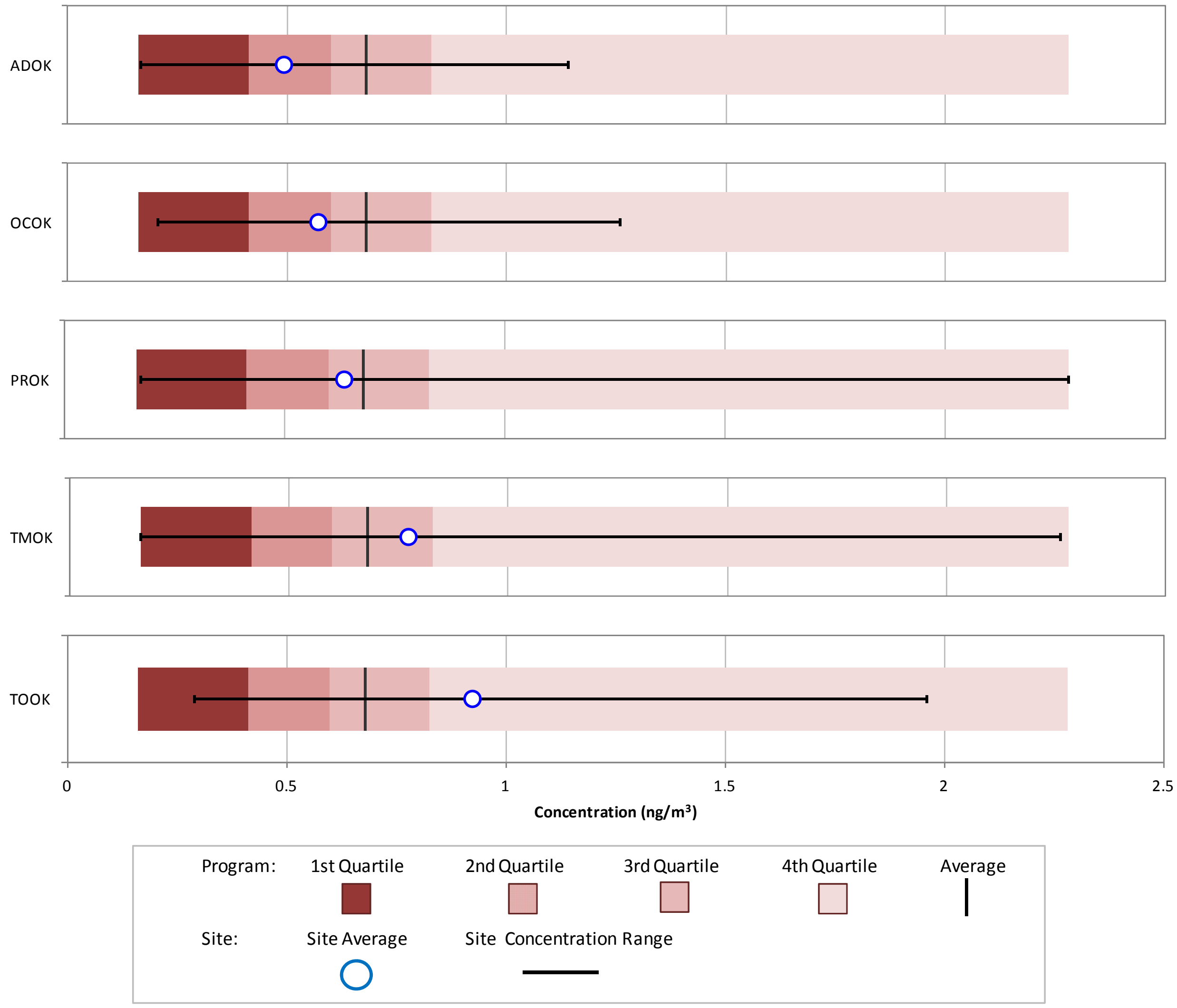


Figure 20-26. Program vs. Site-Specific Average Benzene Concentrations

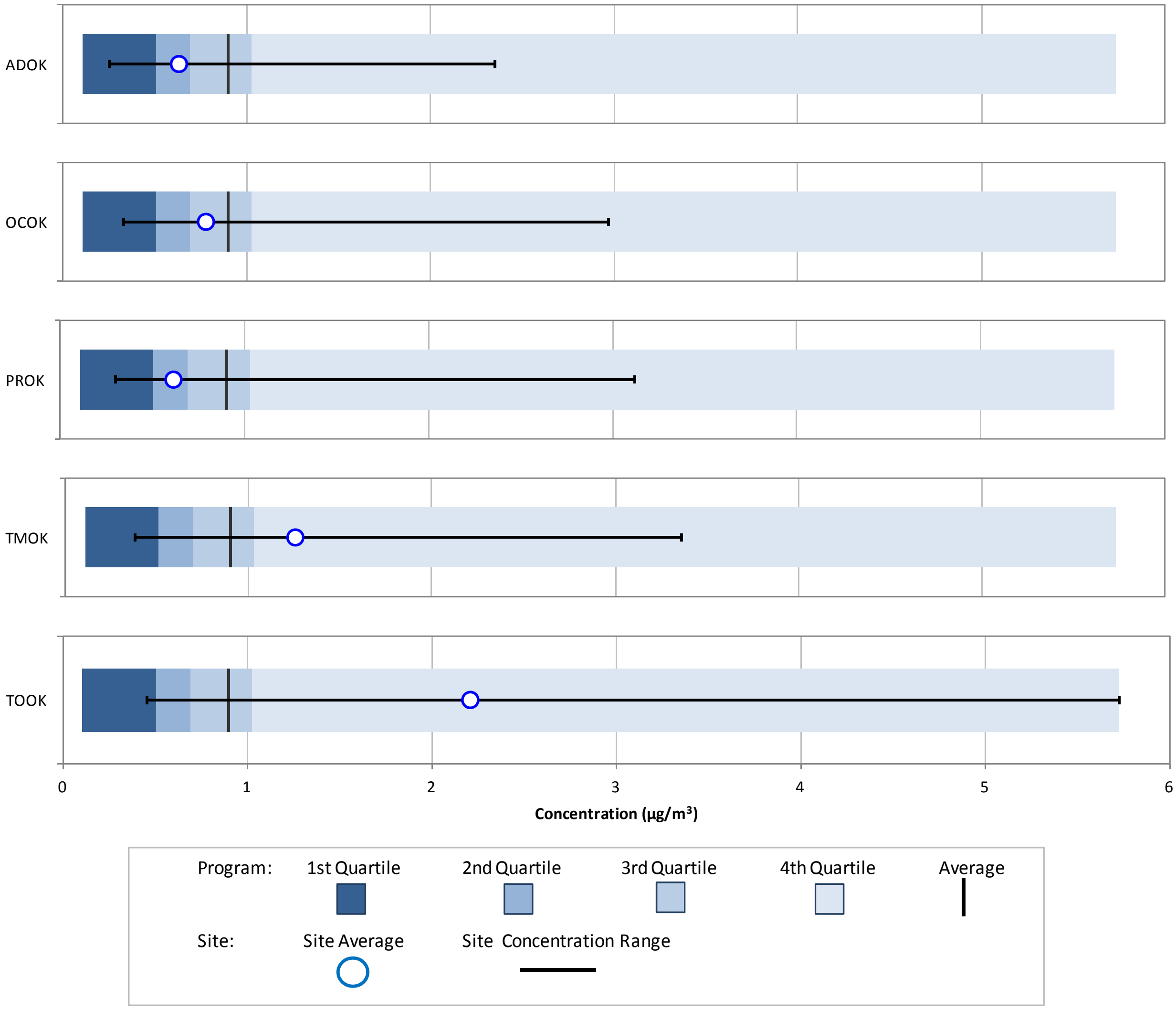


Figure 20-27. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

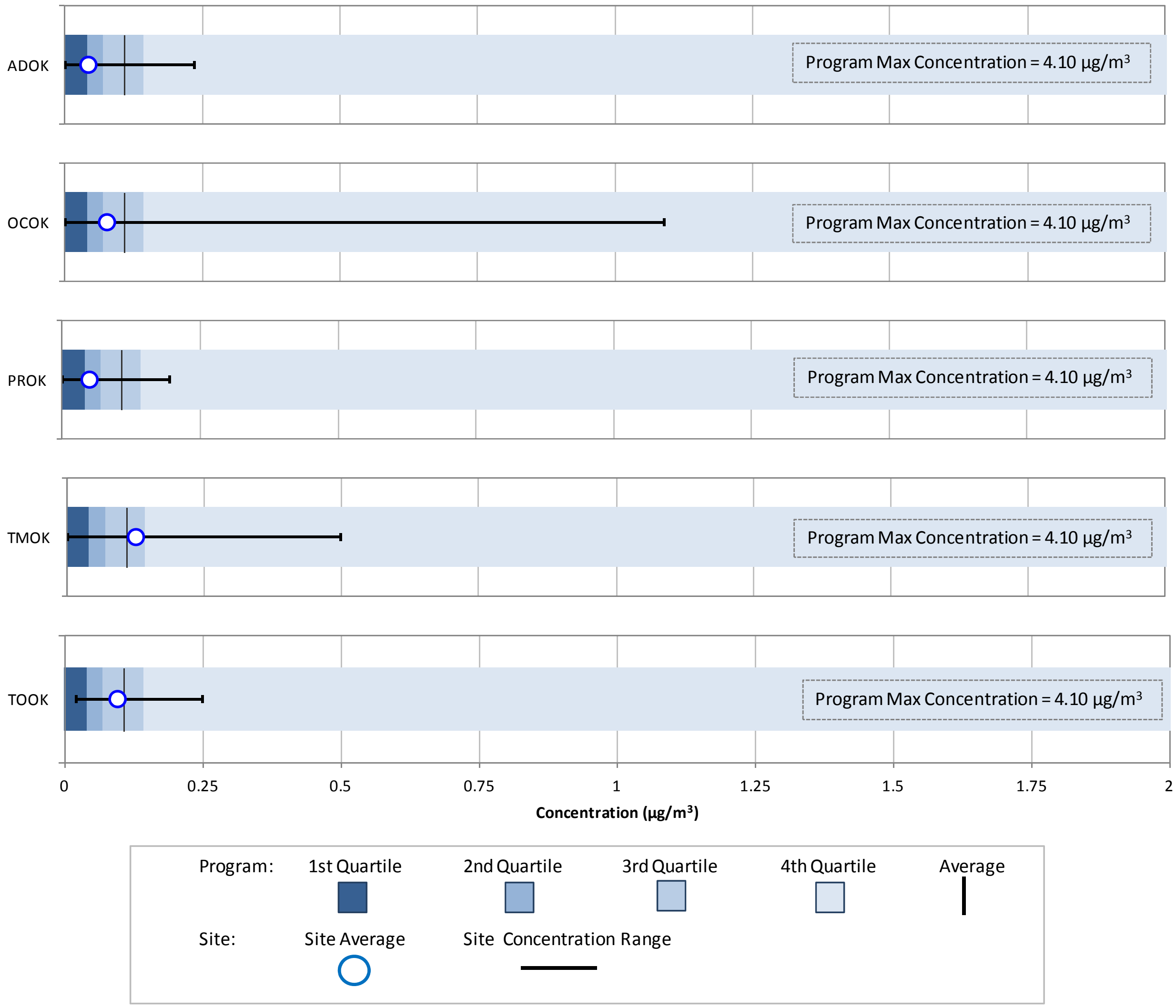


Figure 20-28. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

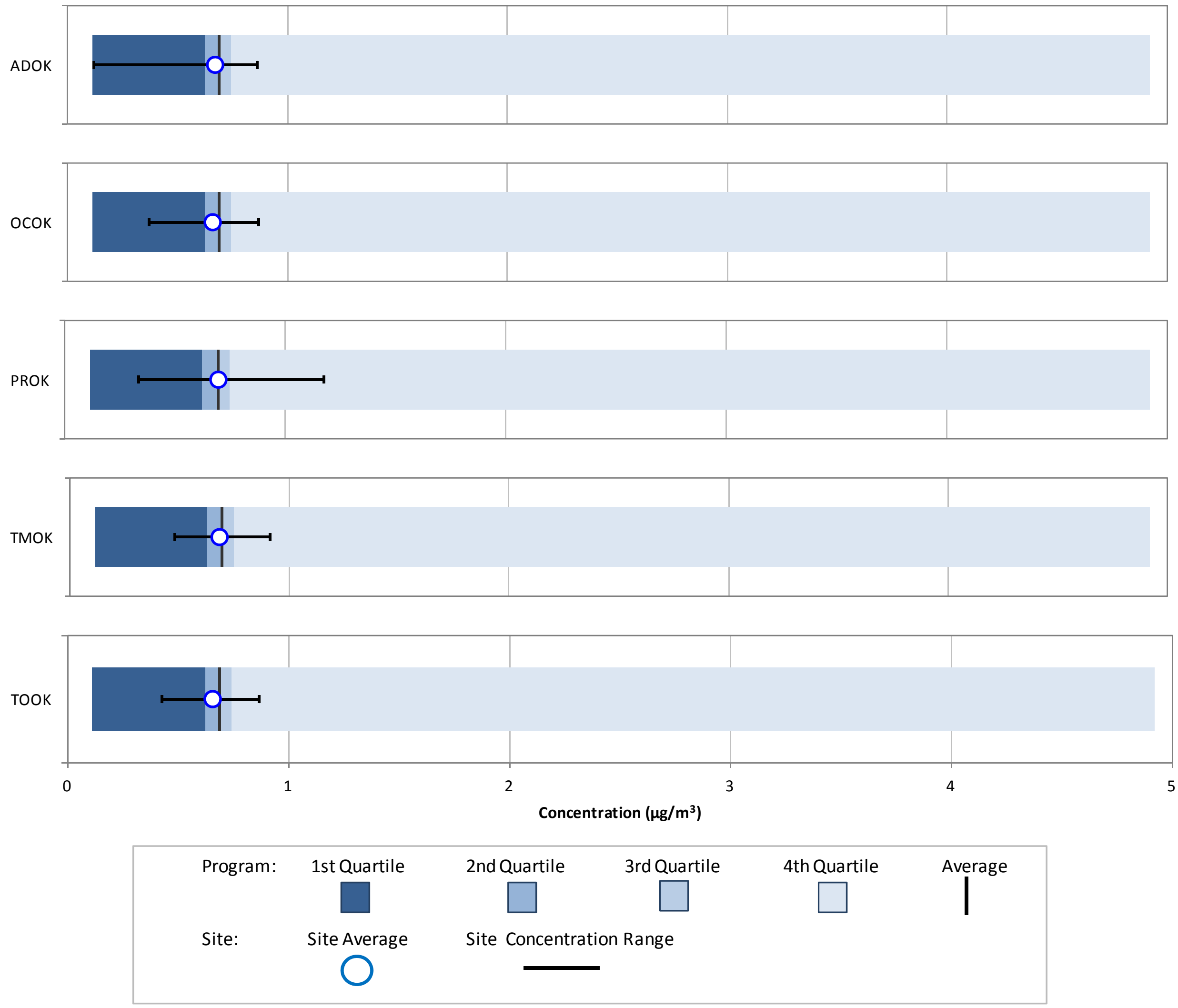


Figure 20-29. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentrations

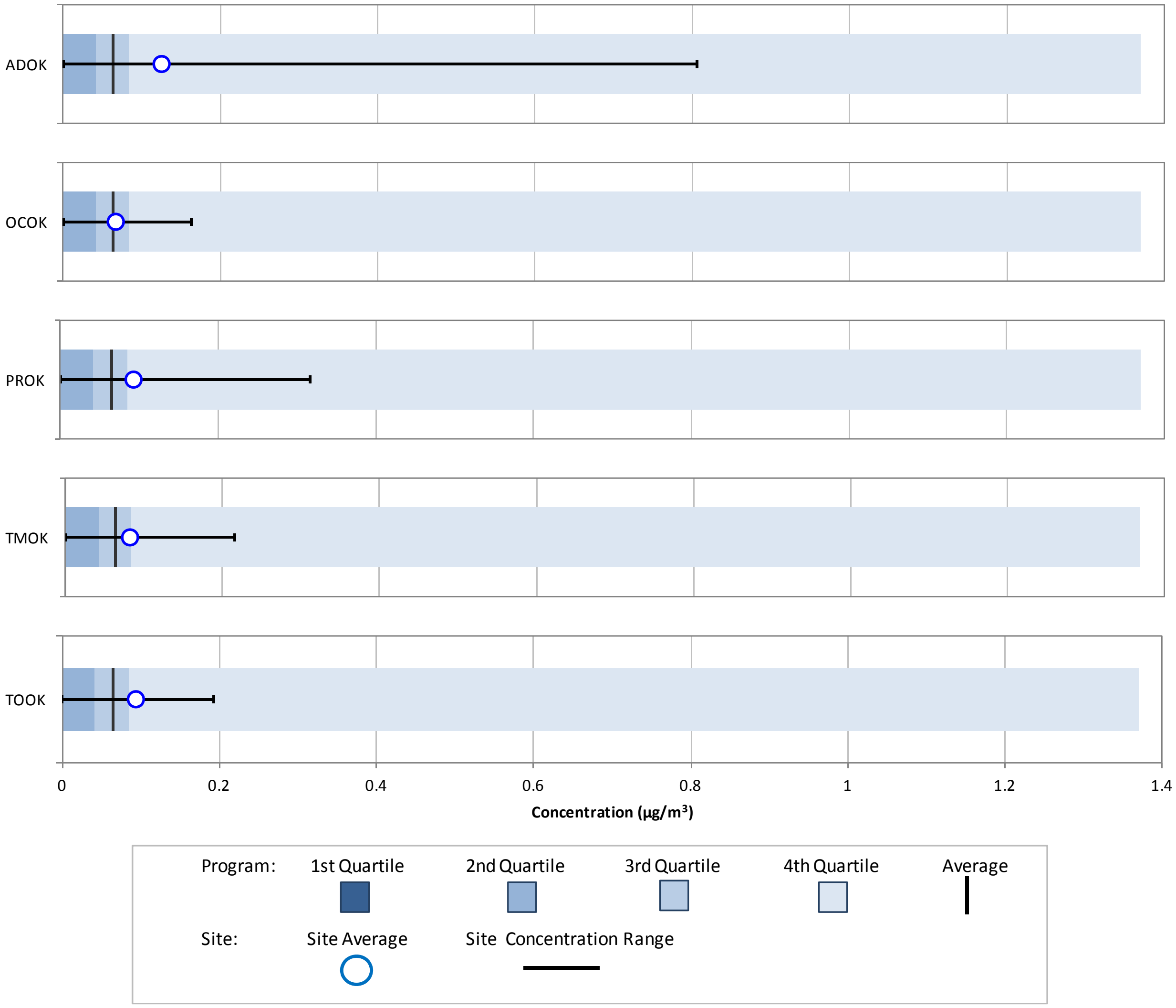


Figure 20-30. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

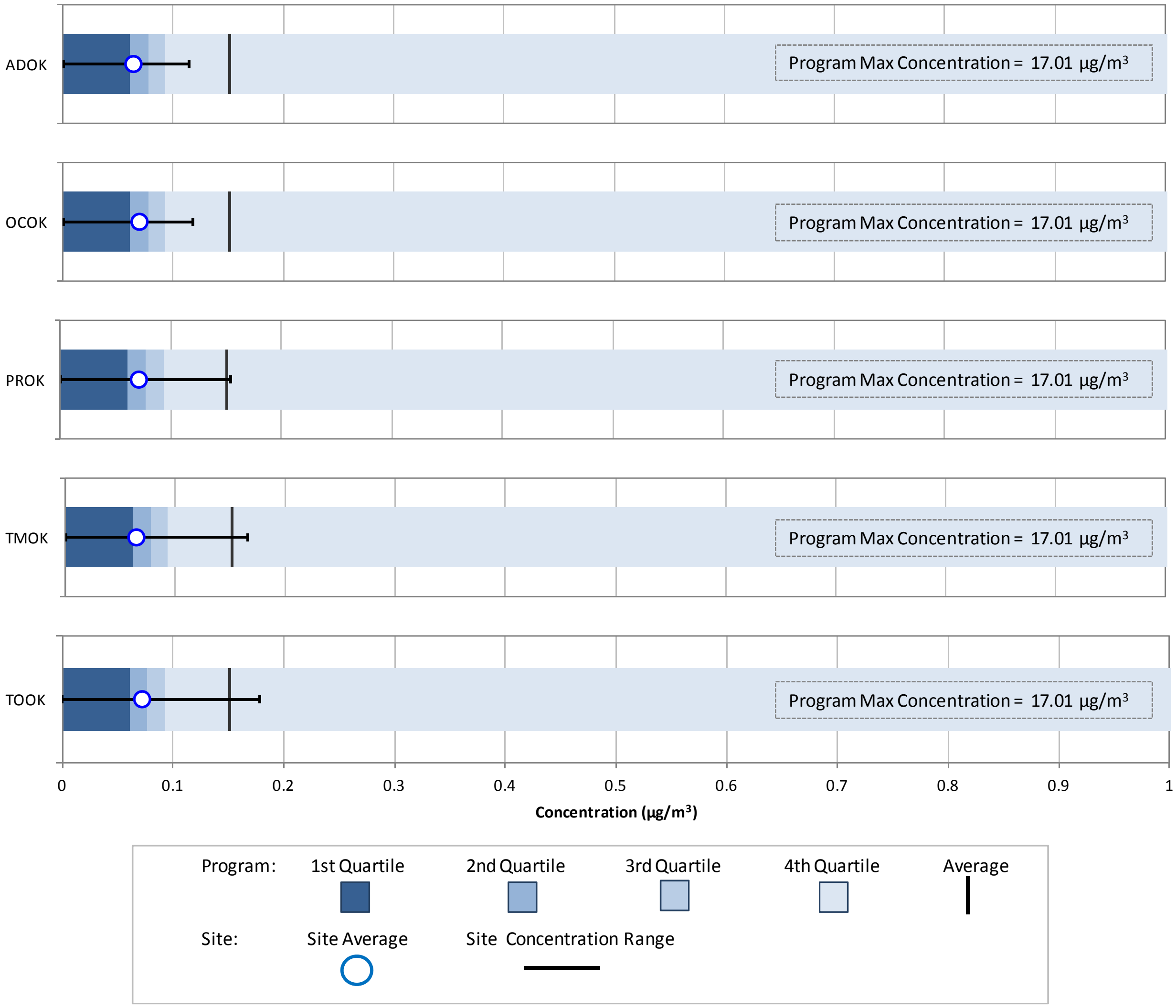


Figure 20-31. Program vs. Site-Specific Average Ethylbenzene Concentrations

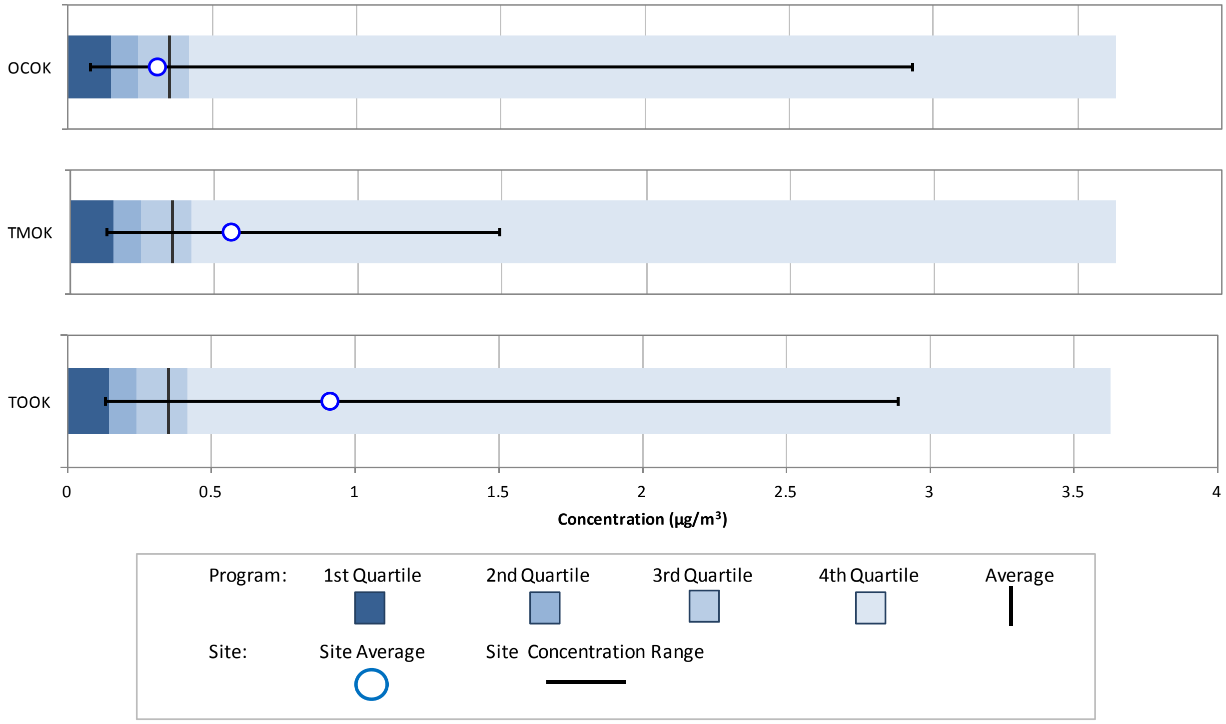


Figure 20-32. Program vs. Site-Specific Average Formaldehyde Concentrations

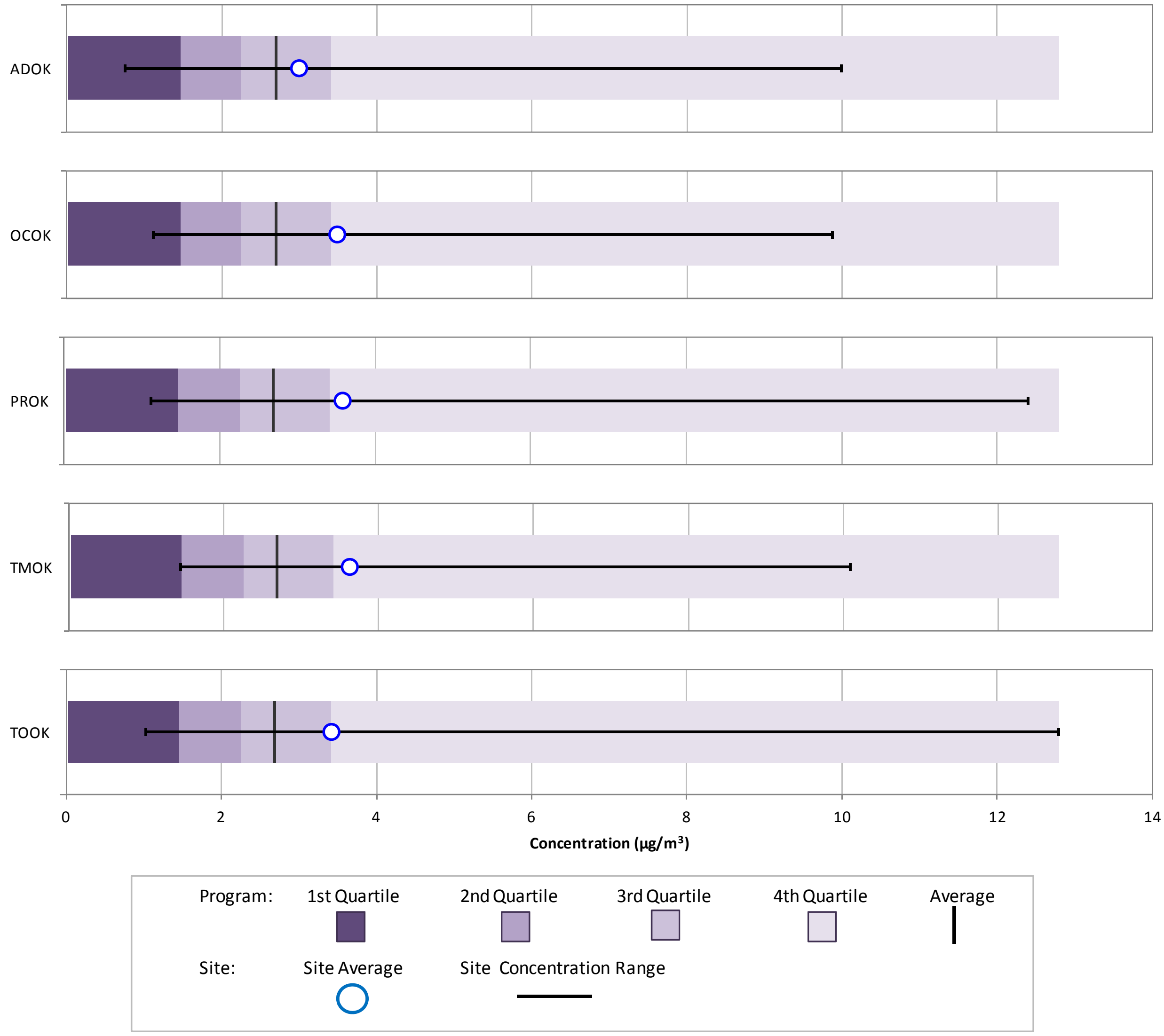


Figure 20-33. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentration

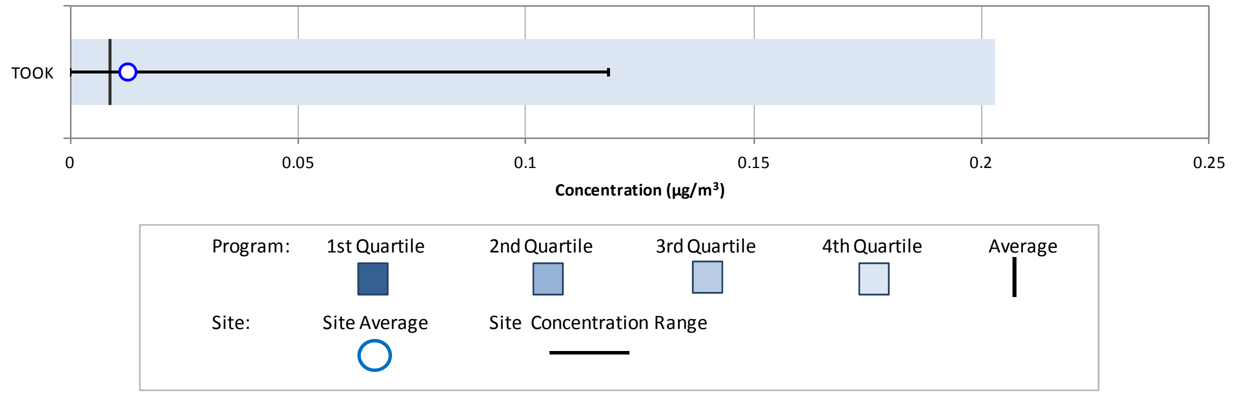


Figure 20-34. Program vs. Site-Specific Average Manganese (TSP) Concentrations

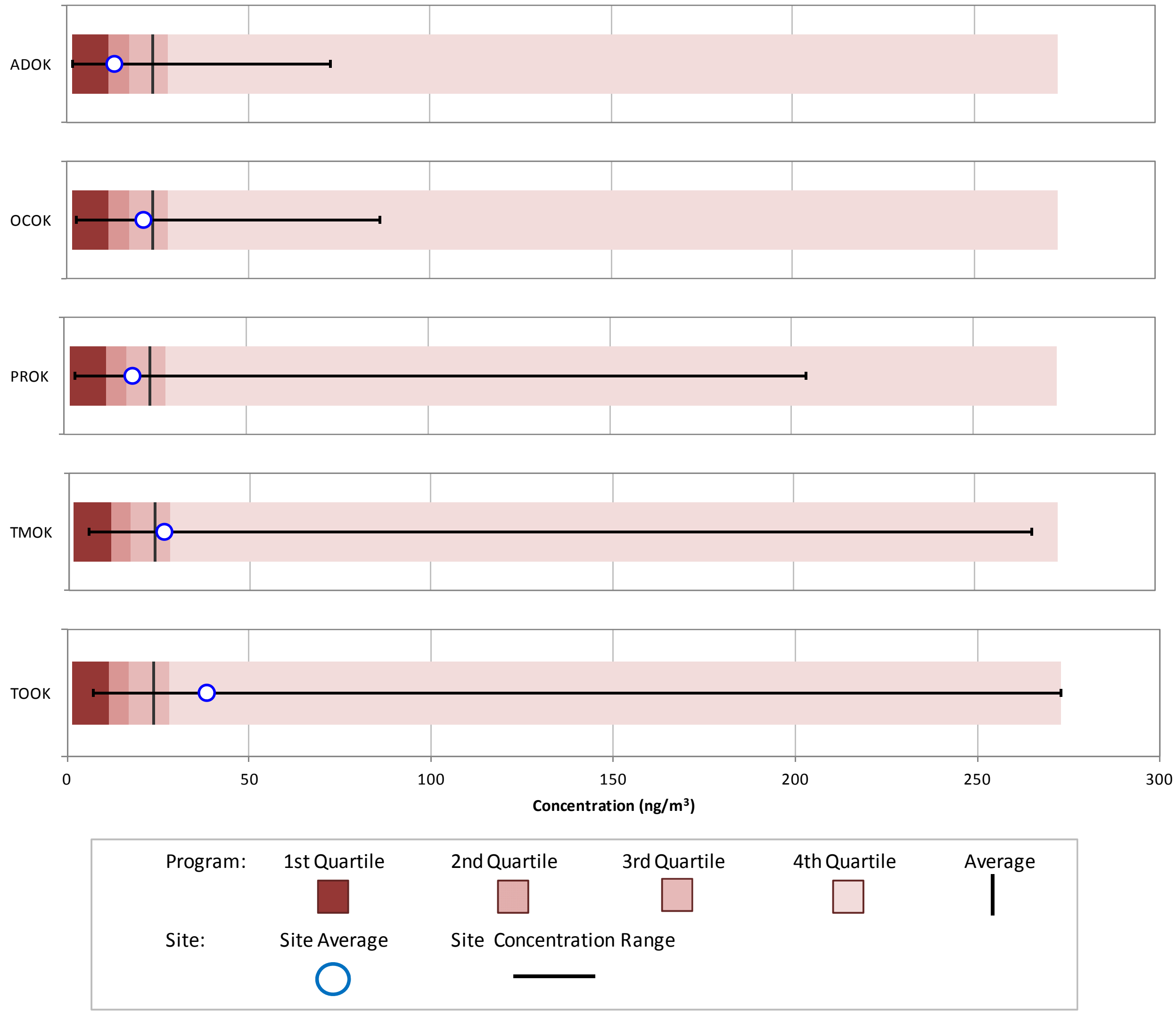


Figure 20-35. Program vs. Site-Specific Average Nickel (TSP) Concentrations

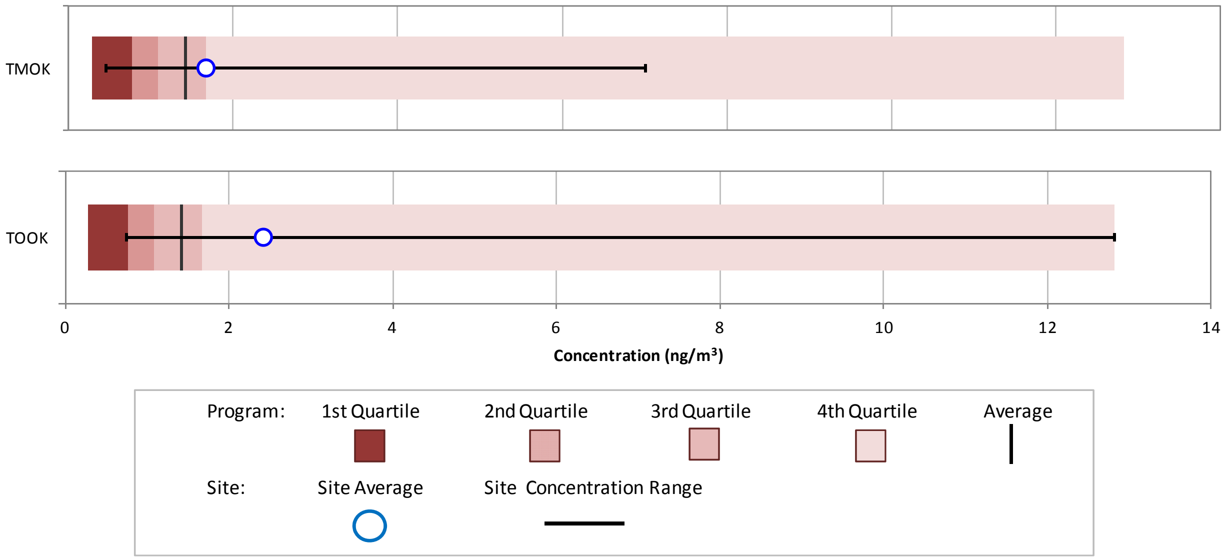
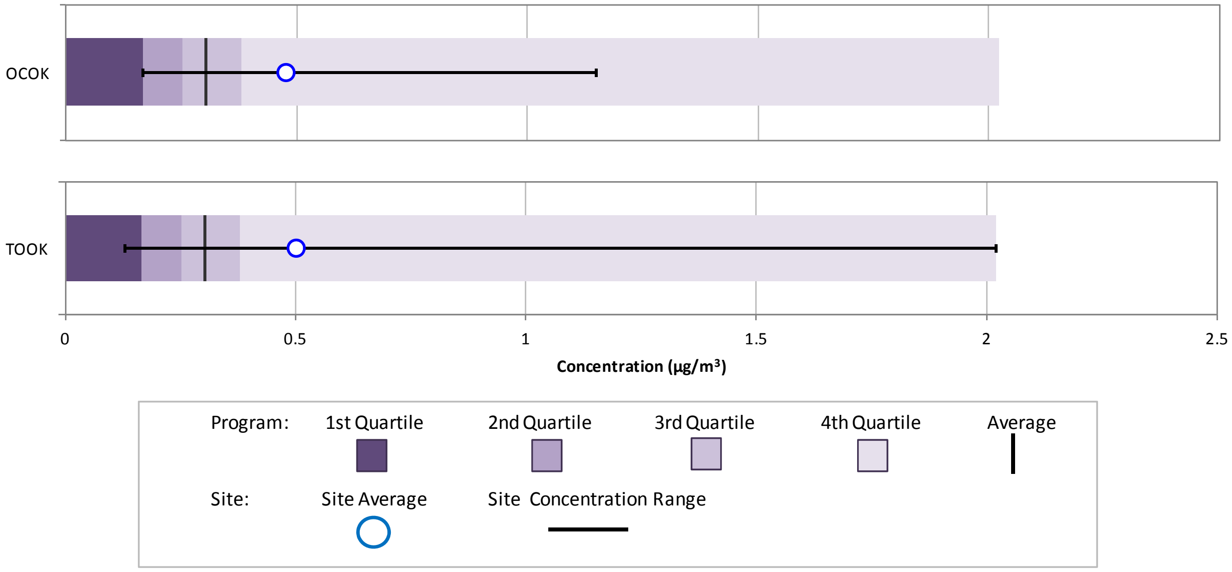


Figure 20-36. Program vs. Site-Specific Average Propionaldehyde Concentrations



Observations from Figures 20-24 through 20-36 include the following:

- Figure 20-24 shows that the range of acetaldehyde concentrations is largest for TOOK and smallest for PROK. The annual average acetaldehyde concentrations for TOOK, TMOK, and OCOK are greater than the program-level average for acetaldehyde. The annual average for TOOK is also greater than the program-level third quartile. The annual average acetaldehyde concentration for ADOK is similar to the program-level average while the annual average for PROK is just less than the program-level average. The minimum acetaldehyde concentrations measured at TOOK, TMOK, and OCOK are just less than the program-level first quartile.

- Because the Oklahoma sites are the only sites sampling TSP metals, Figure 20-25 compares the individual Oklahoma site data against the combined Oklahoma data. Figure 20-25 shows that the annual average arsenic (TSP) concentration is greatest for TOOK and least for ADOK. This figure also shows that the range of measurements of arsenic is largest for PROK, where the maximum arsenic (TSP) concentration was measured, although a similar concentration was also measured at TMOK. The minimum arsenic concentration measured among the five sites sampling TSP metals was measured at TMOK.

- Figure 20-26 presents the box plots for benzene. The maximum benzene concentration measured across the program was measured at TOOK. The annual average concentration of benzene for TOOK and TMOK are greater than the program-level average while the annual average concentrations of benzene for PROK, ADOK, and OCOK are less than the program-level average. The annual average benzene concentration for TOOK is more than twice the program-level average concentration and three to four times greater than the annual average concentrations of the other Oklahoma sites except TMOK.

- Figure 20-27 presents the box plots for 1,3-butadiene. The program-level maximum concentration (4.10 µg/m^3) is not shown directly on the box plots as the scale has been reduced to 2 µg/m^3 to allow for the observation of data points at the lower end of the concentration range. Among the Oklahoma sites, the maximum concentration of 1,3-buadiene was measured at OCOK (1.09 µg/m^3); this measurement is more than twice the next highest concentration (0.50 µg/m^3) measured at one of these five sites. The annual average 1,3-butadiene concentrations for four of the five Oklahoma sites OCOK are less than the program-level average concentration, while the annual average for TMOK is just greater than the program-level average. At least one non-detect of 1,3-butadiene was measured at the Oklahoma sites, with the exception of TOOK.

- Figure 20-28 presents the box plots for carbon tetrachloride. Although the range of carbon tetrachloride measurements varies by site, each of the annual average concentrations of carbon tetrachloride is similar to the program-level average concentration. The maximum carbon tetrachloride concentrations measured at the Oklahoma sites are considerably less than the maximum concentration measured at the program level.

- Figure 20-29 presents the box plots for *p*-dichlorobenzene. Note that the program-level first quartile is zero and therefore not visible on the box plots in Figure 20-29. The range of measurements collected at ADOK is considerably larger than those measured at the other Oklahoma sites. Even so, the annual average concentrations of *p*-dichlorobenzene for all of these sites are greater than the program-level average concentration (although the difference for OCOK is minimal). The annual average concentration for ADOK is twice the program-level average. Several non-detects were measured at each of the Oklahoma sites.

- Figure 20-30 presents the box plots for 1,2-dichloroethane for all five sites. Note that the program-level maximum concentration (17.01 µg/m^3) is not shown directly on the box plots as the scale has been reduced to 1 µg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. Figure 20-30 for 1,2-dichloroethane shows that nearly the entire range of 1,2-dichloroethane measurements collected at the Oklahoma sites was less than the program-level average concentration. This is because the program-level average is being driven by the higher measurements collected at a few monitoring sites. The maximum 1,2-dichloroethane concentrations measured at each Oklahoma site is at least two orders of magnitude less than the maximum concentration measured across the program. The annual average concentrations for the Oklahoma sites are less than or similar to the median concentration for the program.

- Figure 20-31 for ethylbenzene presents the concentration data for only three of the five sites because these are the only sites for which this pollutant is a pollutant of interest. The range of concentrations measured at TMOK is roughly half the range of concentrations measured at OCOK and TOOK. Even though the range of measurements shown in Figure 20-31 is roughly the same for OCOK and TOOK, the annual average concentration for TOOK is twice that of OCOK. This is because the maximum concentration measured at OCOK (2.93 µg/m^3) is so much higher than the next highest measurement, as discussed in the previous section. Aside from the maximum concentration, all ethylbenzene measurements collected at OCOK are less than 0.60 µg/m^3. Conversely, nearly 70 percent of the measurements from TOOK are greater than 0.60 µg/m^3. The annual average ethylbenzene concentration for TMOK lies between the annual averages for TOOK and OCOK. The annual averages for TOOK and TMOK are both greater than the program-level average concentration and third quartile.

- Figure 20-32 shows that the annual average formaldehyde concentration for each Oklahoma site is greater than the program-level average concentration and that four of the five are greater than the program-level third quartile. The annual average concentrations of formaldehyde did not vary significantly among the Oklahoma sites. The maximum concentration measured across the program was measured at TOOK, although a similar concentration was also measured at PROK. The minimum concentration of formaldehyde measured at TMOK is similar to the program-level first quartile.

- Figure 20-33 presents the hexachloro-1,3-butadiene concentration data for only TOOK because TOOK is the only site for which hexachloro-1,3-butadiene is a pollutant of interest. Note that the first, second, and third quartiles are zero due to the large number of non-detects for this pollutant. The annual average concentration of hexachloro-1,3-butadiene for TOOK is just greater than the program-level average concentration. Of the 60 measurements collected at TOOK, 50 were non-detects, or roughly 17 percent, which is slightly higher than the percentage across the program (13 percent).

- Figure 20-34 compares the manganese data for each individual Oklahoma site against the combined Oklahoma data. The range of measurements collected at each site increases in the same order as the sites are presented in Figure 20-34. The minimum manganese (TSP) concentration was measured at ADOK while the maximum manganese (TSP) concentration was measured at TOOK (although a similar measurement was also collected at TMOK). The annual average manganese concentration was greatest for TOOK and least for ADOK, among the Oklahoma sites.

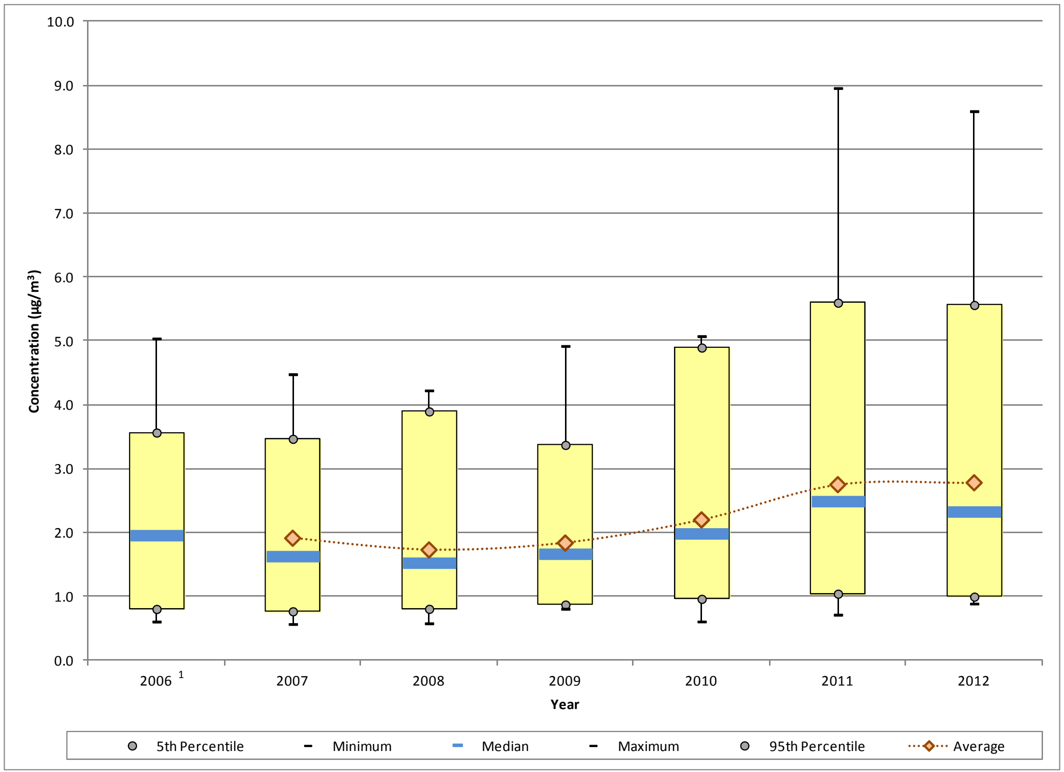
- Figure 20-35 presents the nickel concentration data for two of the five Oklahoma sites because the Tulsa sites are the only ones for which nickel is a pollutant of interest. The range of nickel measurements collected was greater at TOOK than TMOK. The maximum nickel (TSP) concentration was measured at TOOK; this measurement ranked fourth among all nickel (TSP and PM_{10}) measurements collected across the program.

- Propionaldehyde is a pollutant of interest for OCOK and TOOK; thus, box plots for propionaldehyde for these sites are presented in Figure 20-36. The maximum propionaldehyde concentration measured across the program was measured at TOOK. Even though the range of measurements was larger for TOOK than OCOK, the annual average concentrations for these two sites are similar to each other. Both annual averages are greater than the program-level average concentration as well as the third quartile. The minimum propionaldehyde concentration measured at OCOK is just greater than the program-level first quartile.

20.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. TOOK has sampled TSP metals, carbonyl compounds, and VOCs under the NMP since 2006; thus, Figures 20-37 through 20-49 present the 1-year statistical metrics for each of the pollutants of interest for TOOK. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented. Although PROK has technically sampled since 2008, sampling did not begin until late October 2008. Because this is less than 6 months of sampling, 2008 would not be included. This would result in fewer than 5 years of data on the graph; thus, trends graphs were not created for PROK.

Figure 20-37. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at TOOK



[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 20-37 for acetaldehyde measurements collected at TOOK include the following:

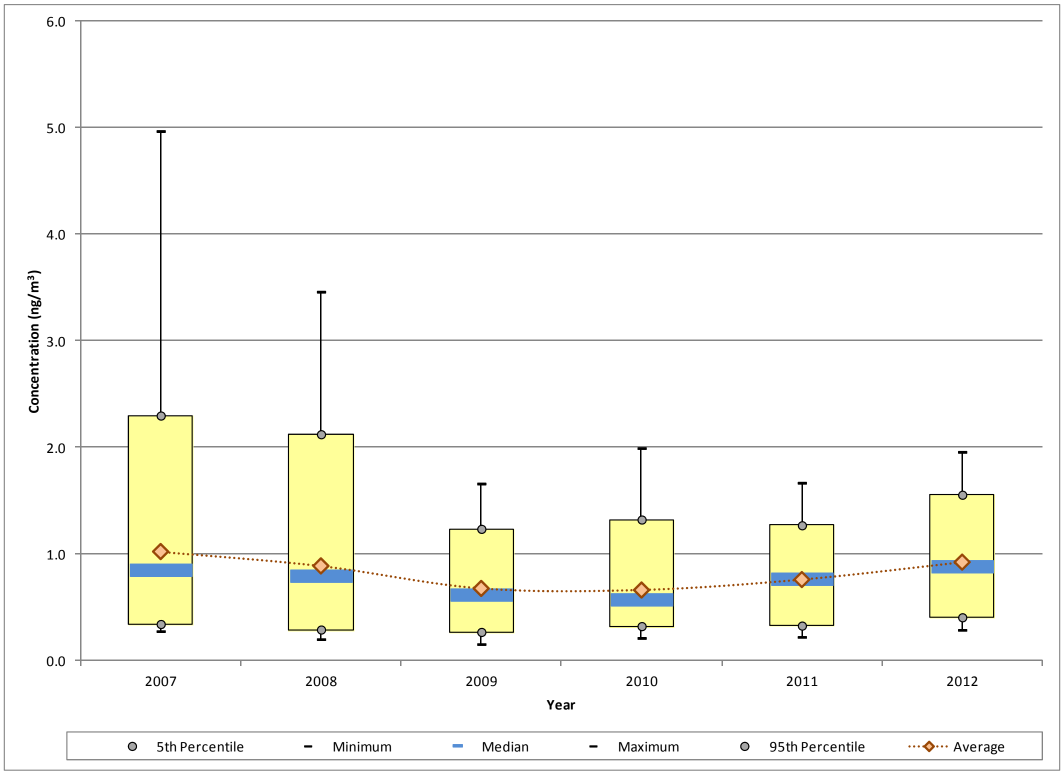
- Although TOOK began sampling carbonyl compounds under the NMP in January 2006, equipment complications at the onset of sampling resulted in a low completeness for 2006; thus, a 1-year average is not presented for 2006, although the range of measurements is provided.

- The maximum concentration of acetaldehyde was measured in 2011 (8.95 µg/m^3), although a similar concentration was also measured in 2012 (8.59 µg/m^3). The 12 highest concentrations were all measured in 2011 or 2012. Of the 30 acetaldehyde concentrations greater than 4 µg/m^3 measured at TOOK, 12 were measured in 2012, eight were measured in 2011, five were measured in 2010, one was measured in each year between 2007 and 2009, and two were measured in 2006.

- The statistical metrics exhibit an increasing trend between 2009 and 2011. The 95th percentile for 2011 and 2012 are greater than the maximum concentrations measured prior to 2011.

- Little change is shown in the acetaldehyde measurements from 2011 to 2012.

Figure 20-38. Yearly Statistical Metrics for Arsenic (TSP) Concentrations Measured at TOOK



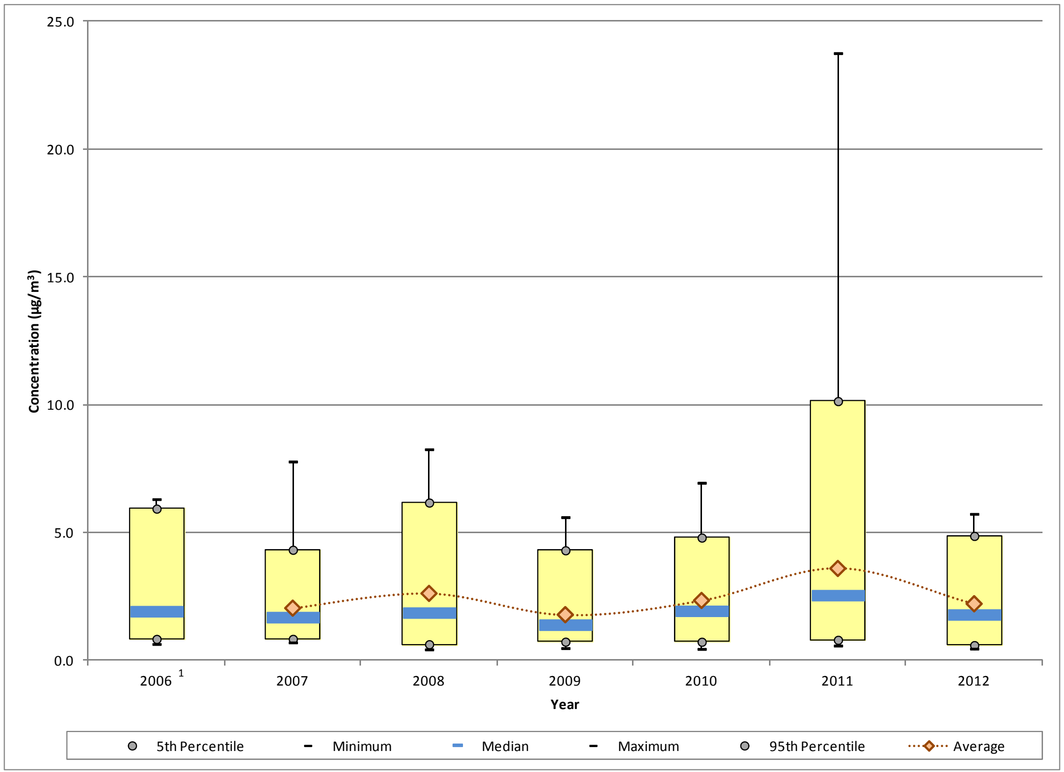
Observations from Figure 20-38 for arsenic (TSP) measurements collected at TOOK include the following:

- Although TOOK began sampling TSP metals in 2006, sampling did not begin until October, which does not yield enough samples for the statistical metrics to be calculated; thus, Figure 20-38 excludes data from 2006 per the criteria specified in Section 3.5.3.2.

- The two highest concentrations of arsenic were measured at TOOK in September 2007. These are the only two concentrations greater than 4 ng/m^3 measured at TOOK.

- The 1-year average and median concentrations exhibit a decreasing trend between 2007 and 2010, although the difference in relatively small between 2009 and 2010. Although the range of measurements decreased slightly for 2011, the 1-year average and median concentrations increased for 2011, an increase that continues into 2012.

Figure 20-39. Yearly Statistical Metrics for Benzene Concentrations Measured at TOOK



[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

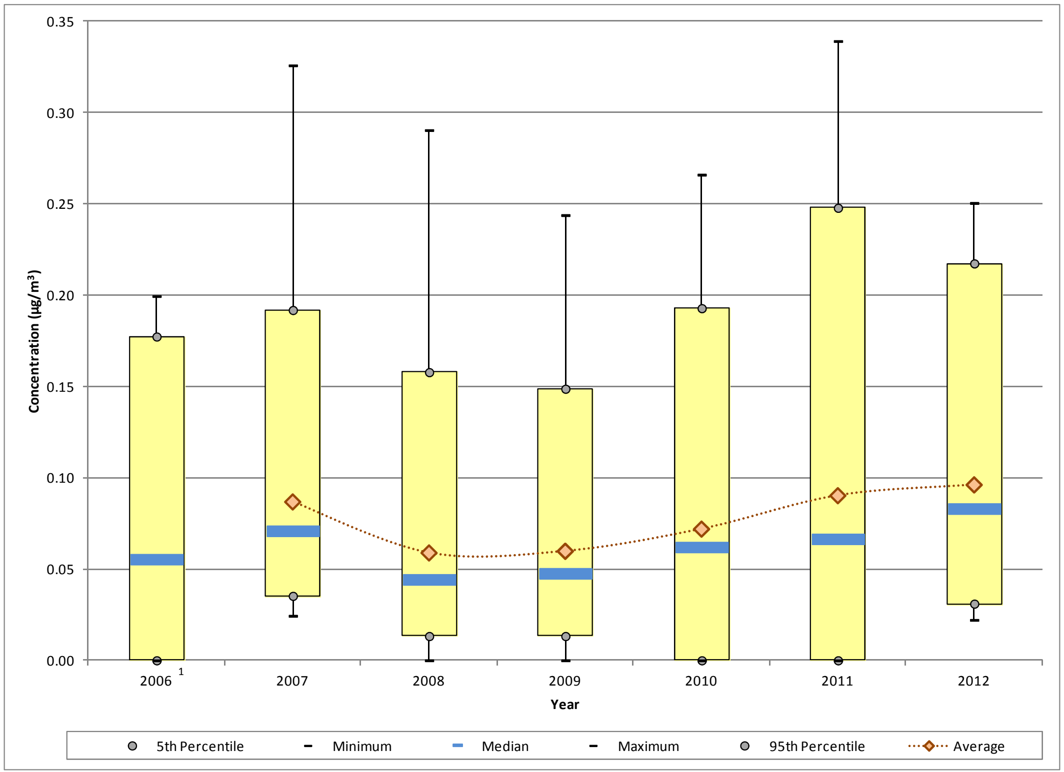
Observations from Figure 20-39 for benzene measurements collected at TOOK include the following:

- Although TOOK began sampling VOCs under the NMP in January 2006, equipment complications at the onset of sampling resulted in a low completeness for 2006; thus, a 1-year average is not presented for 2006, although the range of measurements is provided.

- The maximum concentration of benzene was measured in 2011 (23.8 µg/m^3). The four highest benzene concentrations measured at TOOK were measured in 2011 and are greater than 10 µg/m^3. The 95th percentile for 2011 is greater than the maximum concentration for each of the other years shown.

- The 1-year average benzene concentration has fluctuated over the years. After a substantial decrease from 2008 to 2009, most of the statistical parameters increased for 2010, and again for 2011. All of the statistical parameters decreased for 2012, particularly the maximum concentration and 95th percentile.

Figure 20-40. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at TOOK



[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

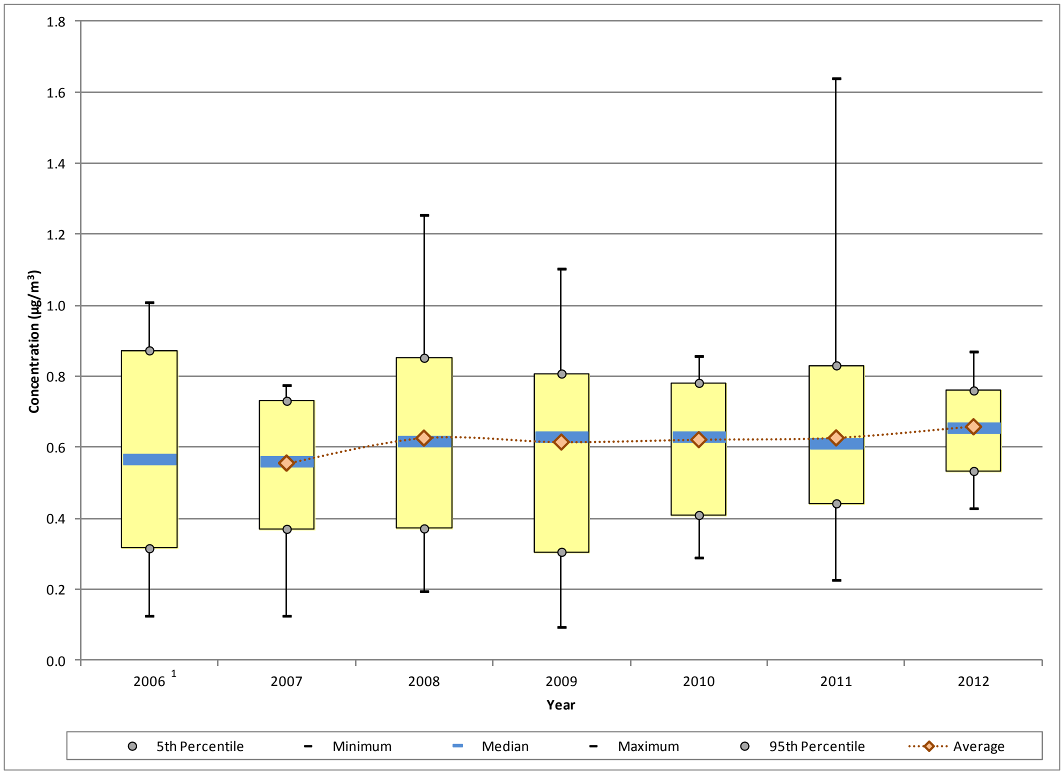
Observations from Figure 20-40 for 1,3-butadiene measurements collected at TOOK include the following:

- The maximum concentration of 1,3-butadiene was measured in December 2011 (0.34 µg/m^3), although a similar concentration was also measured in 2007 (0.33 µg/m^3).

- After an initial decrease from 2007 to 2008 and little change in 2009, the 1-year average concentration began to increase, with the greatest increase occurring from 2010 to 2011. With the exception of the minimum and 5th percentile, all of the statistical metrics increased between 2009 and 2011. Even though the maximum and 95th percentile decreased, additional increases are shown for the 1-year average and median concentrations for 2012.

- The minimum concentration for most years is zero, indicating the presence of non-detects. For 2006, 2010, and 2011, both the minimum concentration and 5th percentile are zero, indicating that more than one non-detect was measured during those years. The percentage of non-detects has ranged from zero (2007 and 2012) to 14 percent (2006).

Figure 20-41. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at TOOK



[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

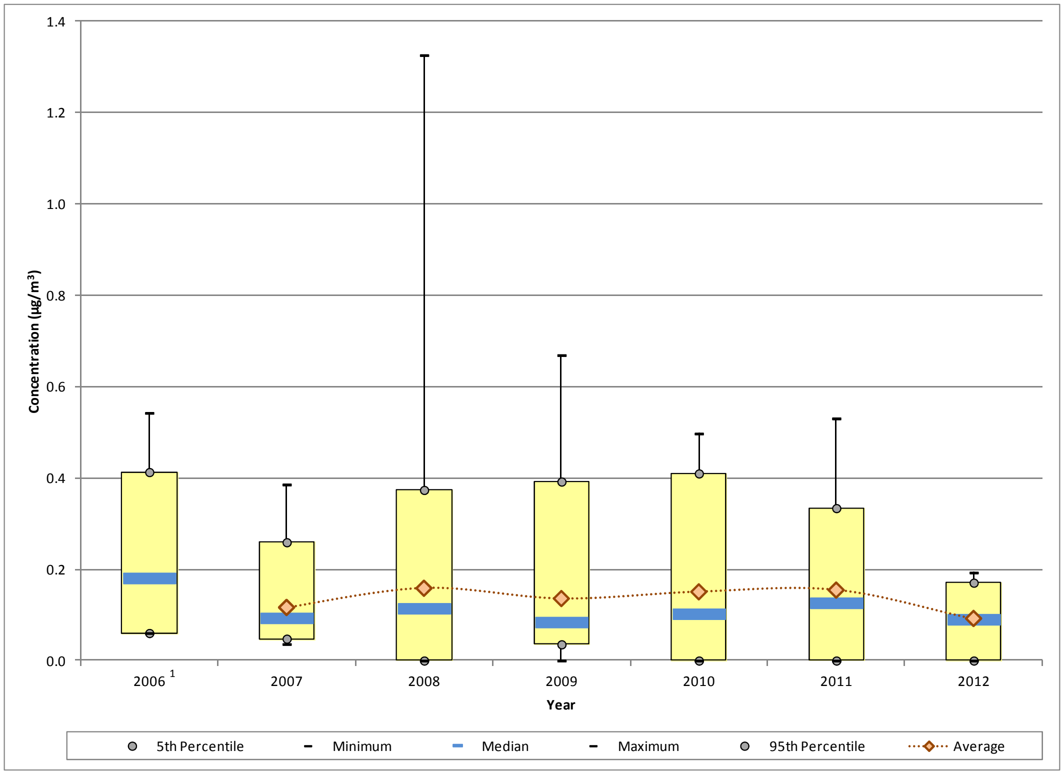
Observations from Figure 20-41 for carbon tetrachloride measurements collected at TOOK include the following:

- Similar to other compounds, the maximum concentration of carbon tetrachloride was measured in 2011 (1.64 µg/m^3). With the exception of 2011, the range of carbon tetrachloride measurements spans 1 µg/m^3 or less. The range of measurements is at a minimum for 2012, when the difference between the minimum and maximum concentration is less than 0.45 µg/m^3.

- The 1-year average concentration increased slightly from 2007 to 2008, after which little change is shown through 2011. Between 2008 and 2011, the 1-year averages range from 0.61 µg/m^3 to 0.63 µg/m^3. A slight increase is shown for 2012 (0.66 µg/m^3), even though the measurements for this year exhibit the least variability.

- For each year shown, the median concentration is very similar to the 1-year average concentration. The difference between these two parameters is greatest for 2009, yet only 0.016 µg/m^3 separates them. This indicates that there is relatively little variability in the central tendency of the measurements.

Figure 20-42. Yearly Statistical Metrics for *p*-Dichlorobenzene Concentrations Measured at TOOK



[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

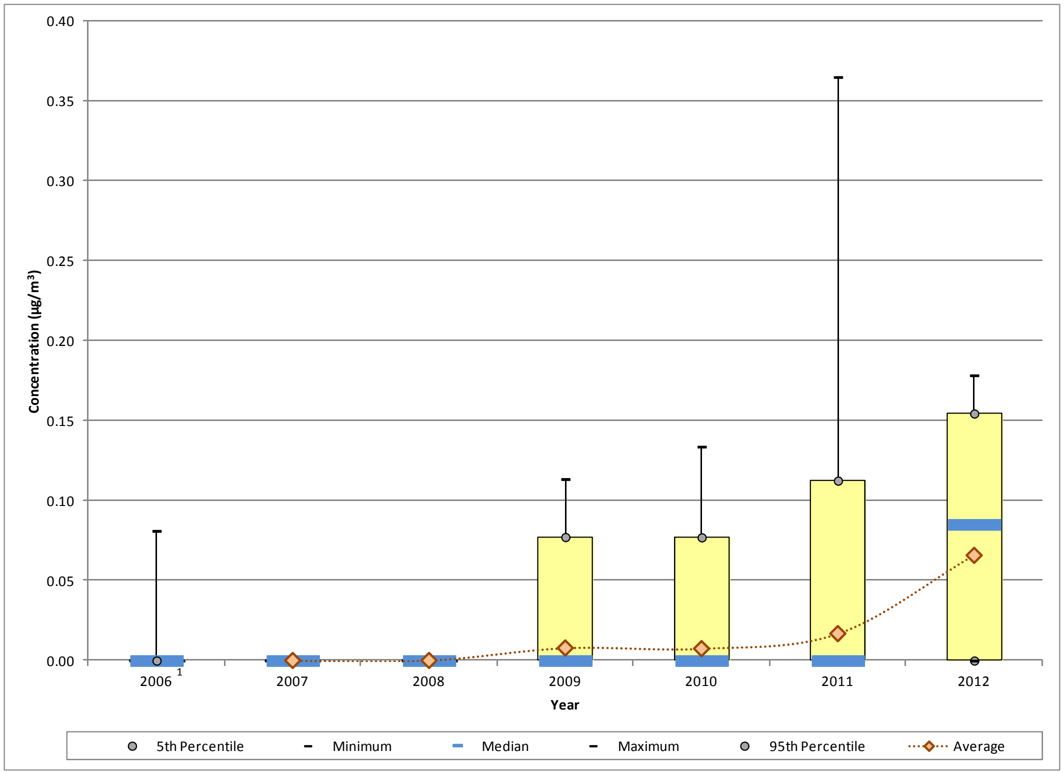
Observations from Figure 20-42 for *p*-dichlorobenzene measurements collected at TOOK include the following:

- The maximum concentration of *p*-dichlorobenzene was measured in 2008 (1.33 µg/m^3) and is the only measurement greater than 0.70 µg/m^3 measured at TOOK.

- There were no non-detects of *p*-dichlorobenzene measured at TOOK in 2006 or 2007. After 2007, at least two non-detects were measured each year. For 2008 and 2010 through 2012, the minimum and 5th percentile are both zero, indicating the presence of additional non-detects. For 2010 through 2012, six non-detects were measured each year.

- The 1-year average concentration fluctuated between 0.12 µg/m^3 and 0.16 µg/m^3 between 2007 and 2011. The 1-year average decreased significantly from 2011 to 2012 (0.09 µg/m^3). 2012 is the first year that a *p*-dichlorobenzene concentration greater than 0.20 µg/m^3 was not measured. By comparison, 15 concentrations greater than 0.20 µg/m^3 were measured in 2011 and at least eight concentrations greater than 0.20 µg/m^3 were measured every other year of sampling. Additional years of sampling are needed to determine if this trend continues.

Figure 20-43. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at TOOK



[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

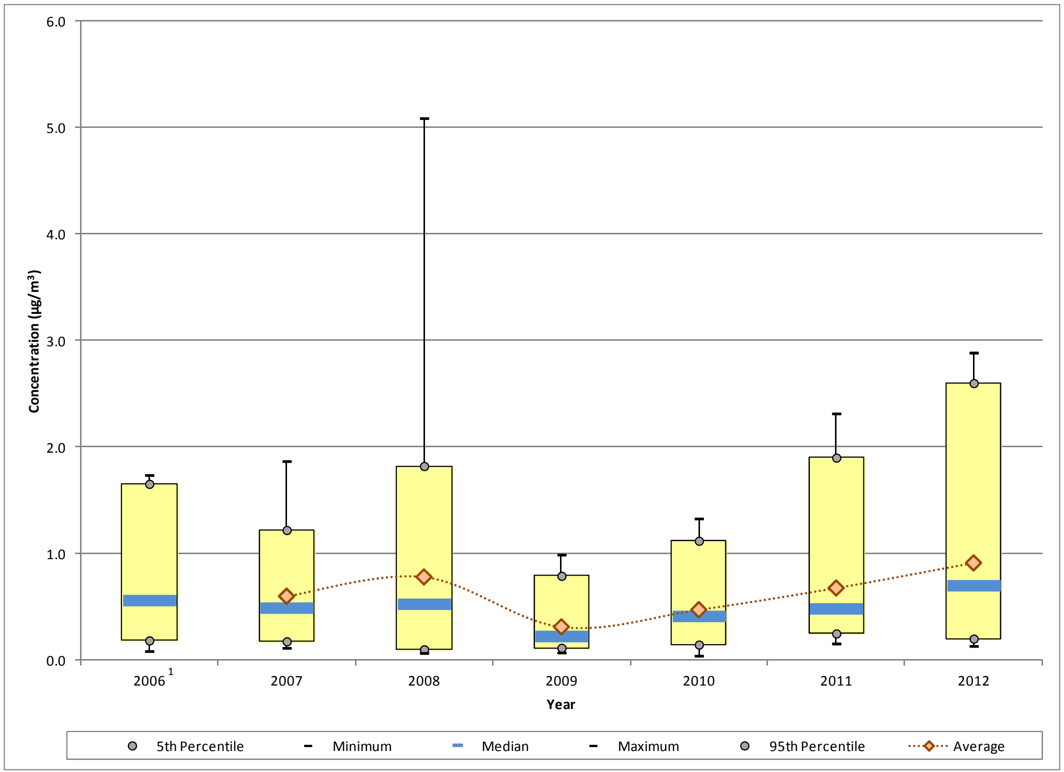
Observations from Figure 20-43 for 1,2-dichloroethane measurements collected at TOOK include the following:

- In 2006 there was one measured detection of 1,2-dichloroethane. In 2007 and 2008 there were none. Between 2009 and 2011, the number of measured detections varied from five to six. The number of measured detections increased significantly for 2012, up from six in 2011 to 38 in 2012.

- The median concentration for all years through 2011 is zero, indicating that at least half of the measurements were non-detects. The number of non-detects decreased to 22 for 2012, accounting for 37 percent of the valid samples collected.

- The 1-year average concentration for 2012 is less than the median concentration, which is a little unusual. The 1-year average is more susceptible to outliers (on either end of the concentration range) than the median concentration, which represents the midpoint of a group of measurements. The 1-year average for 2012 is less than the median, indicating that concentrations on the lower end of the concentration range (the many zeroes representing non-detects) are pulling the average down (just like a maximum or outlier concentration can pull the average up).

Figure 20-44. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at TOOK



[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 20-44 for ethylbenzene measurements collected at TOOK include the following:

- The two highest concentrations of ethylbenzene were both measured during the summer of 2008 (5.09 µg/m^3 and 4.57 µg/m^3). No other ethylbenzene concentrations greater than 3 µg/m^3 have been measured at TOOK since the onset of sampling.

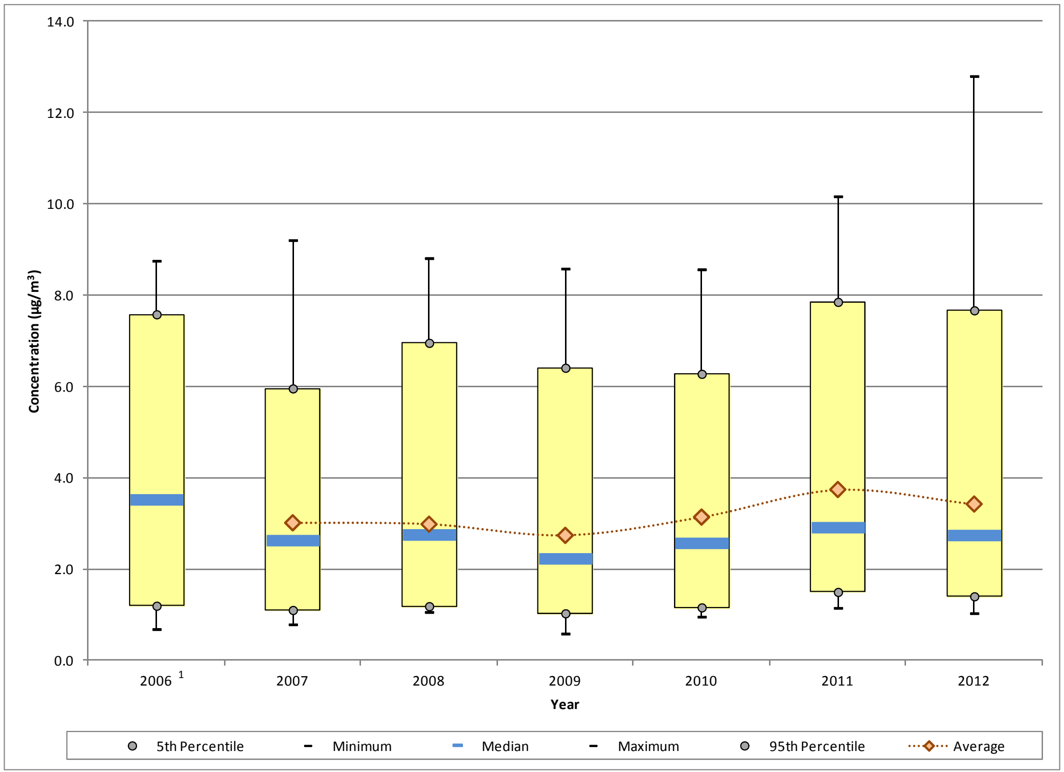
- The next five highest concentrations, those between 2.50 µg/m^3 and 3 µg/m^3, were all measured at TOOK in 2012.

- The maximum, 95th percentile, and 1-year average concentrations exhibit increases from 2007 to 2008. Even the median increased, although slightly. Even if the two highest concentrations measured in 2008 were excluded from the dataset, the 1-year average would still exhibit a slight increase.

- Most of the statistical parameters are at a minimum for 2009. The 1-year average and median concentrations decreased by half from 2008. There were no ethylbenzene concentrations greater than 1 µg/m^3 measured at TOOK in 2009 while at least seven concentrations greater than 1 µg/m^3 were measured during the other years of sampling.

- After 2009, concentrations of ethylbenzene measured at TOOK exhibit a significant increasing trend. Although several of the pollutants of interest for TOOK increased slightly for 2012, the increase shown for ethylbenzene is the most significant.

Figure 20-45. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at TOOK

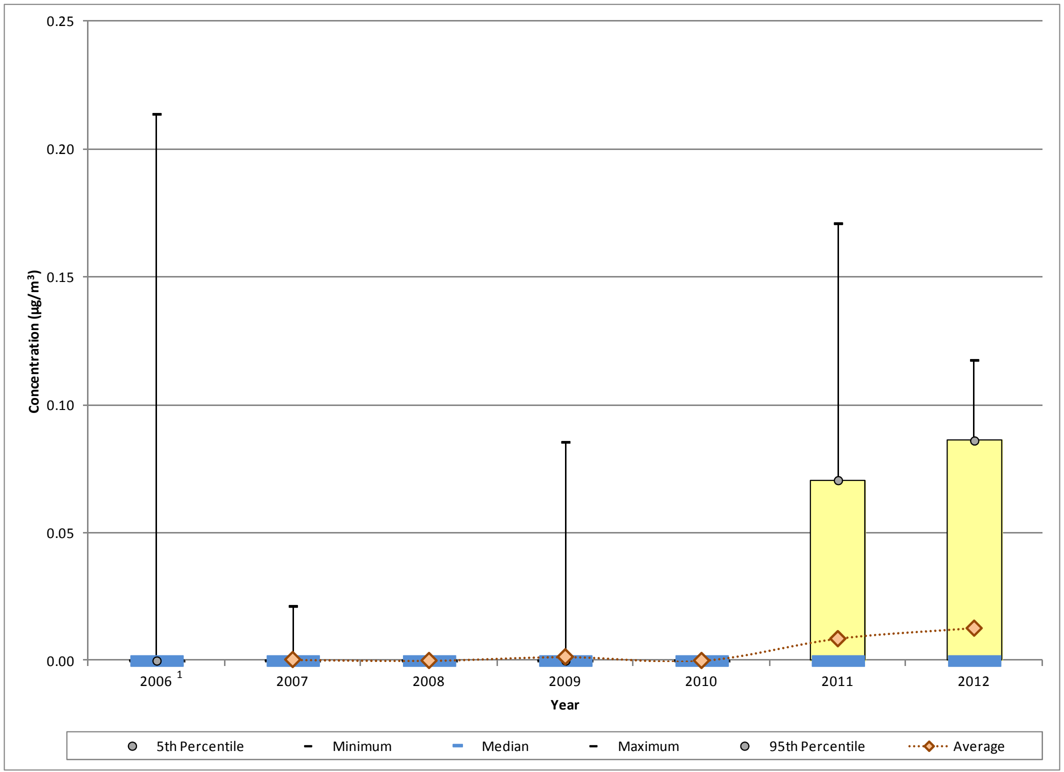


[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 20-45 for formaldehyde measurements collected at TOOK include the following:

- The maximum concentration of formaldehyde (12.80 µg/m^3) was measured at TOOK on June 26, 2012. Only one other measurement greater than 10 µg/m^3 has been measured at TOOK (10.1 µg/m^3 measured in 2011).
- All but two of the 71 formaldehyde measurements greater than 5 µg/m^3 were measured during the period between May and September, regardless of year.
- Similar to acetaldehyde, an increasing trend in the 1-year average concentration is shown for formaldehyde between 2009 and 2011. The 1-year average increased by 1 µg/m^3 over this period.
- Even though the maximum formaldehyde concentration was measured in 2012, all of the other statistical parameters exhibit slight decreases for this year. This is because there were fewer concentrations at the upper end of the concentration range for 2012. The number of formaldehyde measurements greater than 6 µg/m^3 decreased from 10 in 2011 to five in 2012. In addition, there were more concentrations at the lower end of the concentration range for 2012. The number of formaldehyde measurements less than 1.5 µg/m^3 increased from three in 2011 to eight in 2012.

Figure 20-46. Yearly Statistical Metrics for Hexachloro-1,3-Butadiene Concentrations Measured at TOOK



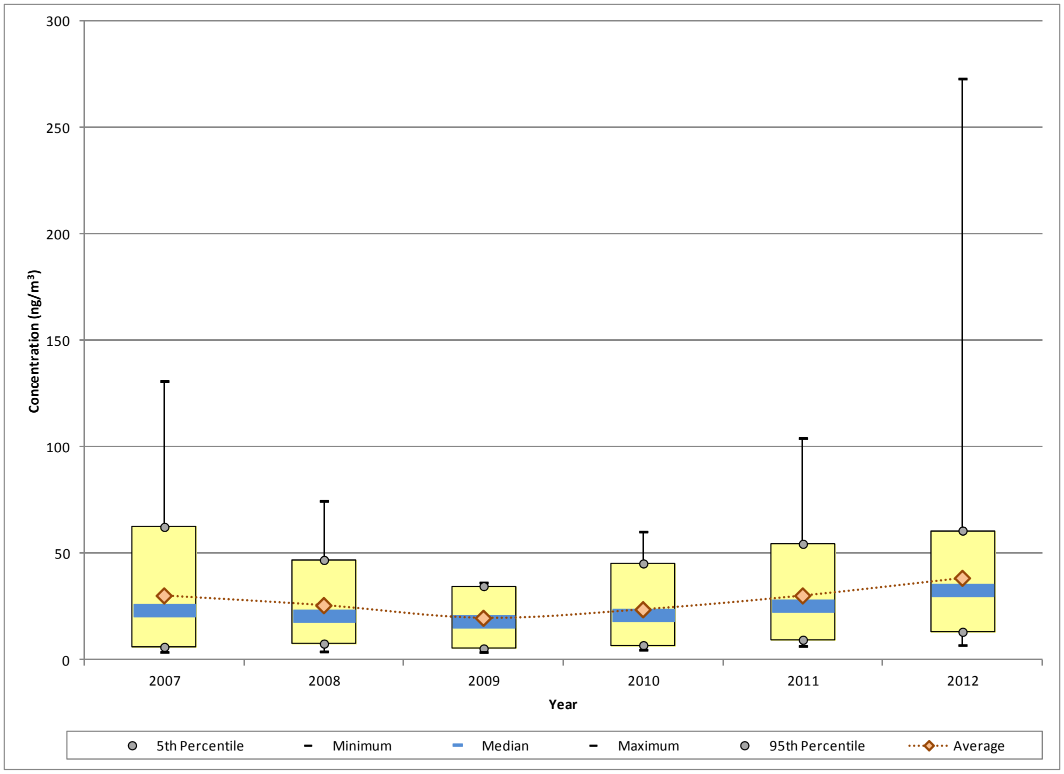
[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 20-46 for hexachloro-1,3-butadiene measurements collected at TOOK include the following:

- The trends graphs for hexachloro-1,3-butadiene resembles the trends graph for 1,2-dichloroethane in that there were few measured detections in the first few years of sampling at TOOK.

- The median concentration is zero for all years of sampling, indicating that at least half of the measurements were non-detects for each year. Between 2006 and 2010, there were a total of four measured detections. In 2011, five measured detections were reported. This number doubled for 2012.

Figure 20-47. Yearly Statistical Metrics for Manganese (TSP) Concentrations Measured at TOOK

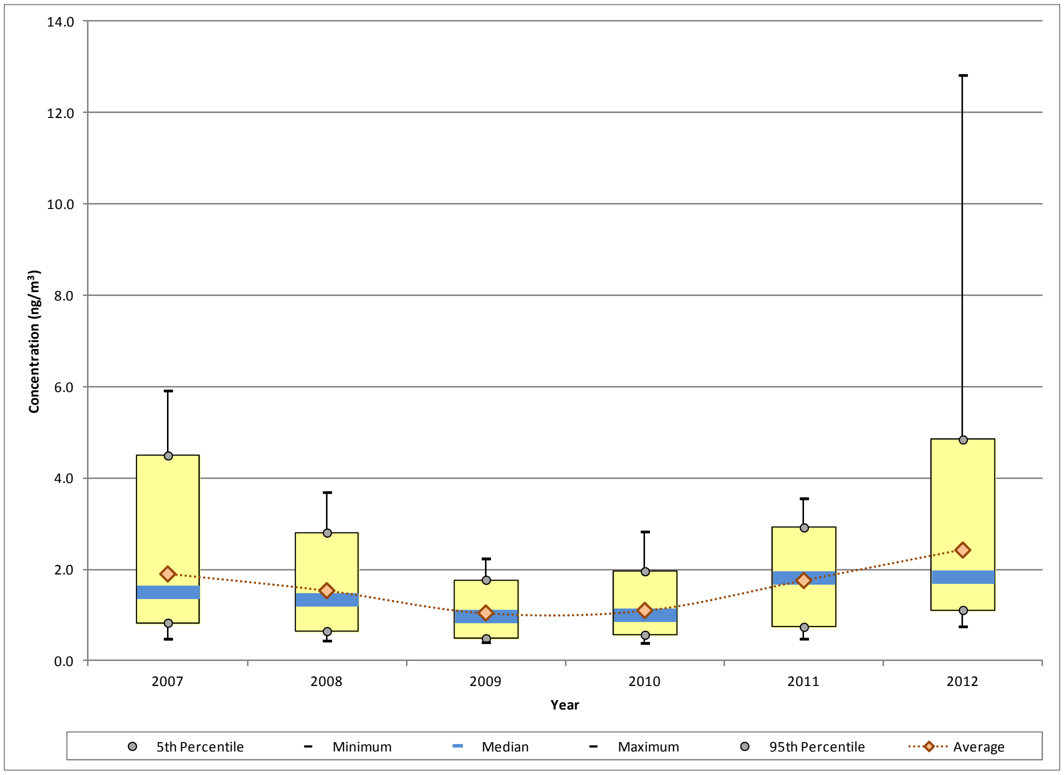


Observations from Figure 20-47 for manganese (TSP) measurements collected at TOOK include the following:

- The maximum concentration of manganese was measured in 2012 (273 ng/m^3), on the day of the dust storm. Measurements greater than 100 ng/m^3 were also measured in 2007 (131 ng/m^3) and 2011 (104 ng/m^3).

- A steady decreasing trend in the concentrations is shown through 2009, which was followed by an increasing trend through 2012. Even if the maximum concentration measured in 2012 was excluded from the calculations, the 1-year average and median concentrations would still exhibit an increasing trend for 2012. This is because there were more concentrations at the upper end of the concentration range for 2012 (the number of manganese measurements greater than 50 ng/m^3 increased from five in 2011 to 12 in 2012) as well as fewer concentrations at the lower end of the concentration range (the number of manganese measurements less than 25 ng/m^3 decreased from 26 in 2011 to 19 in 2012).

Figure 20-48. Yearly Statistical Metrics for Nickel (TSP) Concentrations Measured at TOOK



Observations from Figure 20-48 for nickel (TSP) measurements collected at TOOK include the following:

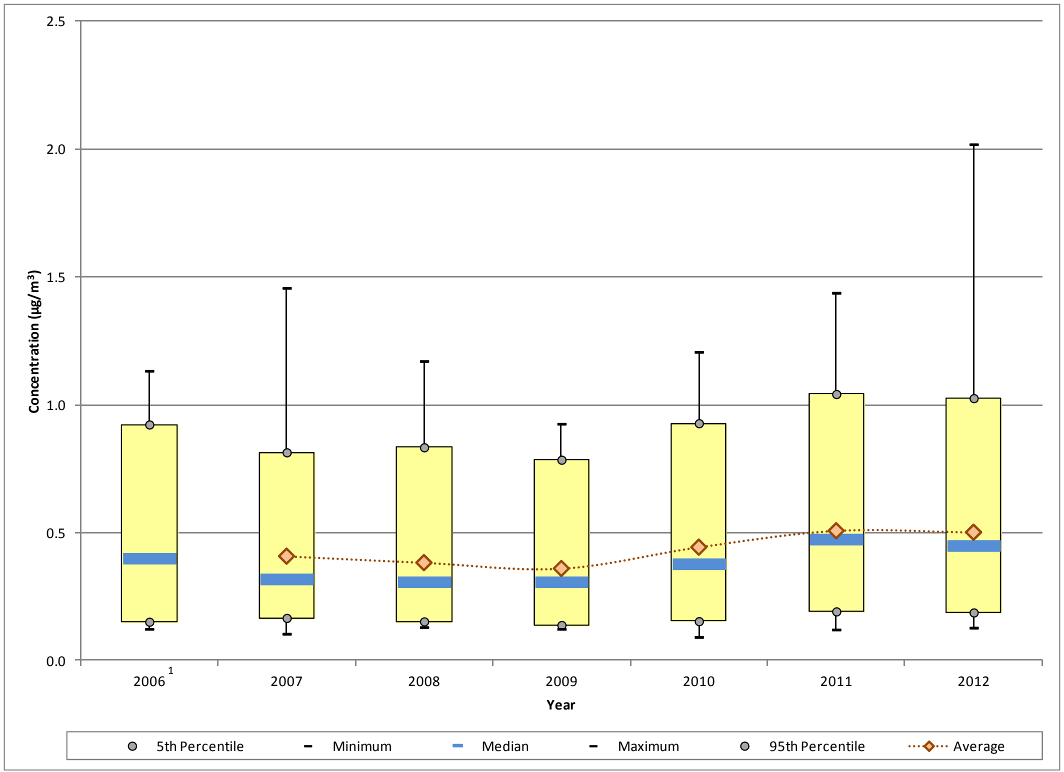
- The trends graph for nickel resembles the trends graph for manganese in several ways.

- The maximum concentration of nickel was measured at TOOK on the same day as the maximum concentration of manganese (October 18, 2012, the day of the dust storm). The next two highest concentrations of nickel were also measured in 2012. Collectively, these three measurements are the only nickel concentrations greater than 6 ng/m^3 measured at TOOK since the onset of sampling.

- A significant decreasing trend in the nickel concentrations measured at TOOK is shown through 2009. A slight increase is shown for 2010, which was followed by significant increases for 2011 and 2012. The minimum concentration shown for 2012 is greater than the 5th percentile for the four previous years.

- The median concentration for 2011 is very similar to the median concentration for 2012. For 2011, 75 percent of measurements lie between 1 ng/m^3 and 3 ng/m^3. For 2012, this number is 79 percent. The higher concentrations measured in 2012 (there are seven concentrations from 2012 that are greater than the maximum concentration measured in 2011) are balanced by the lower concentrations measured in 2011 (there are 11 measurements less than 1 ng/m^3 in 2011 compared to two in 2012), resulting in similar median concentrations.

Figure 20-49. Yearly Statistical Metrics for Propionaldehyde Concentrations Measured at TOOK



[1] A 1-year average is not presented because issues at the onset of sampling resulted in low completeness.

Observations from Figure 20-49 for propionaldehyde measurements collected at TOOK include the following:

- The maximum concentration of propionaldehyde (2.02 µg/m^3) was measured at TOOK on the same day as the maximum formaldehyde concentration (June 26, 2012). At least one measurement greater than 1.0 µg/m^3 has been measured at TOOK each year of sampling, except 2009.

- Similar to acetaldehyde and formaldehyde, an increasing trend in the 1-year average concentrations of propionaldehyde is shown between 2009 and 2011.

- With the exception of the maximum concentration, little change is shown for the statistical parameters for 2012.

20.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at each Oklahoma monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

20.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Oklahoma monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

20.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Oklahoma monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 20-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 20-6. Risk Approximations for the Oklahoma Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Tulsa, Oklahoma - TOOK						
Acetaldehyde	0.0000022	0.009	61/61	2.78 ± 0.42	6.11	0.31
Arsenic (TSP)[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	3.97	0.06
Benzene	0.0000078	0.03	60/60	2.21 ± 0.31	17.24	0.07
1,3-Butadiene	0.00003	0.002	60/60	0.10 ± 0.02	2.88	0.05
Carbon Tetrachloride	0.000006	0.1	60/60	0.66 ± 0.02	3.95	0.01
p-Dichlorobenzene	0.000011	0.8	55/60	0.09 ± 0.01	1.03	<0.01
1,2-Dichloroethane	0.000026	2.4	41/60	0.07 ± 0.01	1.88	<0.01
Ethylbenzene	0.0000025	1	60/60	0.91 ± 0.17	2.29	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.42 ± 0.54	44.48	0.35
Hexachloro-1,3-butadiene	0.000022	0.09	10/60	0.01 ± 0.01	0.28	<0.01
Manganese (TSP)[a]	--	0.00005	61/61	0.04 ± 0.01	--	0.77
Nickel (TSP)[a]	0.00048	0.00009	61/61	<0.01 ± <0.01	1.16	0.03
Propionaldehyde	--	0.008	61/61	0.50 ± 0.08	--	0.06

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 20-5.

Table 20-6. Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Tulsa, Oklahoma - TMOK						
Acetaldehyde	0.0000022	0.009	59/59	2.33 ± 0.32	5.13	0.26
Arsenic (TSP)[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	3.32	0.05
Benzene	0.0000078	0.03	61/61	1.25 ± 0.16	9.78	0.04
1,3-Butadiene	0.00003	0.002	60/61	0.12 ± 0.02	3.75	0.06
Carbon Tetrachloride	0.000006	0.1	61/61	0.68 ± 0.02	4.08	0.01
p-Dichlorobenzene	0.000011	0.8	54/61	0.08 ± 0.01	0.90	<0.01
1,2-Dichloroethane	0.000026	2.4	42/61	0.06 ± 0.01	1.67	<0.01
Ethylbenzene	0.0000025	1	61/61	0.56 ± 0.08	1.39	<0.01
Formaldehyde	0.000013	0.0098	59/59	3.63 ± 0.47	47.13	0.37
Manganese (TSP)[a]	--	0.00005	61/61	0.03 ± 0.01	--	0.52
Nickel (TSP)[a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.80	0.02
Pryor Creek, Oklahoma - PROK						
Acetaldehyde	0.0000022	0.009	51/51	1.56 ± 0.19	3.44	0.17
Arsenic (TSP)[a]	0.0043	0.000015	49/49	<0.01 ± <0.01	2.73	0.04
Benzene	0.0000078	0.03	51/51	0.61 ± 0.11	4.78	0.02
1,3-Butadiene	0.00003	0.002	39/51	0.05 ± 0.01	1.48	0.02
Carbon Tetrachloride	0.000006	0.1	51/51	0.69 ± 0.03	4.17	0.01
p-Dichlorobenzene	0.000011	0.8	45/51	0.09 ± 0.02	1.02	<0.01
1,2-Dichloroethane	0.000026	2.4	47/51	0.07 ± 0.01	1.84	<0.01
Formaldehyde	0.000013	0.0098	51/51	3.58 ± 0.65	46.53	0.37
Manganese (TSP)[a]	--	0.00005	49/49	0.02 ± 0.01	--	0.37

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 20-5.

Table 20-6. Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Oklahoma City, Oklahoma - ADOK						
Acetaldehyde	0.0000022	0.009	66/66	1.81 ± 0.24	3.98	0.20
Arsenic (TSP)[a]	0.0043	0.000015	64/64	<0.01 ± <0.01	2.12	0.03
Benzene	0.0000078	0.03	66/66	0.63 ± 0.08	4.93	0.02
1,3-Butadiene	0.00003	0.002	44/66	0.04 ± 0.01	1.29	0.02
Carbon Tetrachloride	0.000006	0.1	66/66	0.67 ± 0.03	4.03	0.01
p-Dichlorobenzene	0.000011	0.8	57/66	0.13 ± 0.04	1.38	<0.01
1,2-Dichloroethane	0.000026	2.4	54/66	0.06 ± 0.01	1.66	<0.01
Formaldehyde	0.000013	0.0098	66/66	3.00 ± 0.46	38.96	0.31
Manganese (TSP)[a]	--	0.00005	64/64	0.01 ± <0.01	--	0.26
Oklahoma City, Oklahoma - OCOK						
Acetaldehyde	0.0000022	0.009	60/60	2.34 ± 0.32	5.14	0.26
Arsenic (TSP)[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	2.46	0.04
Benzene	0.0000078	0.03	61/61	0.78 ± 0.12	6.07	0.03
1,3-Butadiene	0.00003	0.002	56/61	0.08 ± 0.04	2.30	0.04
Carbon Tetrachloride	0.000006	0.1	61/61	0.66 ± 0.03	3.96	0.01
p-Dichlorobenzene	0.000011	0.8	54/61	0.07 ± 0.01	0.74	<0.01
1,2-Dichloroethane	0.000026	2.4	52/61	0.07 ± 0.01	1.80	<0.01
Ethylbenzene	0.0000025	1	61/61	0.31 ± 0.09	0.78	<0.01
Formaldehyde	0.000013	0.0098	60/60	3.49 ± 0.54	45.35	0.36
Manganese (TSP)[a]	--	0.00005	61/61	0.02 ± <0.01	--	0.42
Propionaldehyde	--	0.008	60/60	0.48 ± 0.06	--	0.06

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 20-5.

Observations from Table 20-6 include the following:

- Formaldehyde and acetaldehyde have the highest annual average concentrations for each site. Among the TSP metals, the annual average concentration of manganese is the highest for each site.

- Formaldehyde and benzene have the highest cancer risk approximations among the pollutants of interest for the Oklahoma monitoring sites. Formaldehyde cancer risk approximations range from 38.96 in-a-million for ADOK to 47.13 in-a-million for TMOK. The cancer risk approximations for formaldehyde for TMOK, PROK, and OCOK rank fifth, sixth, and seventh highest among all cancer risk approximations program-wide. Benzene cancer risk approximations range from 4.78 in-a-million for PROK to 17.24 in-a-million for TOOK. The benzene cancer risk approximation for TOOK is the highest cancer risk approximation calculated for benzene program-wide.

- Among the metals, arsenic has the highest cancer risk approximations for all of the Oklahoma monitoring sites, ranging from 2.12 in-a-million for ADOK to 3.97 in-a-million for TOOK. Note that manganese do not have a cancer URE.

- None of the pollutants of interest have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants.

- Among the noncancer hazard approximations for the Oklahoma sites, formaldehyde and manganese have the highest noncancer hazard approximations for each site (albeit less than 1.0). The noncancer hazard approximation for manganese for TOOK (0.77) is the highest noncancer hazard approximations calculated across the program.

20.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 20-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 20-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 20-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 20-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 20-7. Table 20-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 20-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Oklahoma Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		**Top 10 Cancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Tulsa, Oklahoma (Tulsa County) - TOOK					
Benzene	303.37	POM, Group 1a	5.59E-03	Formaldehyde	44.48
Ethylbenzene	202.14	Benzene	2.37E-03	Benzene	17.24
Formaldehyde	166.00	Formaldehyde	2.16E-03	Acetaldehyde	6.11
Acetaldehyde	84.86	1,3-Butadiene	1.10E-03	Arsenic	3.97
POM, Group 1a	63.48	Hexavalent Chromium, PM	9.06E-04	Carbon Tetrachloride	3.95
1,3-Butadiene	36.70	Naphthalene	8.92E-04	1,3-Butadiene	2.88
Tetrachloroethylene	30.44	Ethylbenzene	5.05E-04	Ethylbenzene	2.29
Naphthalene	26.24	Nickel, PM	2.74E-04	1,2-Dichloroethane	1.88
Trichloroethylene	16.89	POM, Group 2b	2.33E-04	Nickel	1.16
Dichloromethane	8.60	Arsenic, PM	1.98E-04	*p*-Dichlorobenzene	1.03
Tulsa, Oklahoma (Tulsa County) - TMOK					
Benzene	303.37	POM, Group 1a	5.59E-03	Formaldehyde	47.13
Ethylbenzene	202.14	Benzene	2.37E-03	Benzene	9.78
Formaldehyde	166.00	Formaldehyde	2.16E-03	Acetaldehyde	5.13
Acetaldehyde	84.86	1,3-Butadiene	1.10E-03	Carbon Tetrachloride	4.08
POM, Group 1a	63.48	Hexavalent Chromium, PM	9.06E-04	1,3-Butadiene	3.75
1,3-Butadiene	36.70	Naphthalene	8.92E-04	Arsenic	3.32
Tetrachloroethylene	30.44	Ethylbenzene	5.05E-04	1,2-Dichloroethane	1.67
Naphthalene	26.24	Nickel, PM	2.74E-04	Ethylbenzene	1.39
Trichloroethylene	16.89	POM, Group 2b	2.33E-04	*p*-Dichlorobenzene	0.90
Dichloromethane	8.60	Arsenic, PM	1.98E-04	Nickel	0.80

Table 20-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Pryor Creek, Oklahoma (Mayes County) - PROK					
Benzene	30.82	Hexavalent Chromium, PM	2.94E-03	Formaldehyde	46.53
Formaldehyde	20.34	Arsenic, PM	2.31E-03	Benzene	4.78
Acetaldehyde	13.15	Nickel, PM	5.63E-04	Carbon Tetrachloride	4.17
Ethylbenzene	12.72	POM, Group 1a	2.97E-04	Acetaldehyde	3.44
POM, Group 1a	3.38	Formaldehyde	2.64E-04	Arsenic	2.73
1,3-Butadiene	3.07	Benzene	2.40E-04	1,2-Dichloroethane	1.84
Naphthalene	2.13	Beryllium, PM	1.14E-04	1,3-Butadiene	1.48
Chloromethylbenzene	1.55	1,3-Butadiene	9.20E-05	*p*-Dichlorobenzene	1.02
Nickel, PM	1.17	Chloromethylbenzene	7.58E-05		
Aniline	0.75	Naphthalene	7.23E-05		
Oklahoma City, Oklahoma (Oklahoma County) - ADOK					
Benzene	330.65	POM, Group 1a	1.01E-02	Formaldehyde	38.96
Ethylbenzene	224.06	Formaldehyde	2.84E-03	Benzene	4.93
Formaldehyde	218.33	Benzene	2.58E-03	Carbon Tetrachloride	4.03
POM, Group 1a	114.89	1,3-Butadiene	1.29E-03	Acetaldehyde	3.98
Acetaldehyde	114.57	Naphthalene	7.58E-04	Arsenic	2.12
1,3-Butadiene	42.92	Ethylbenzene	5.60E-04	1,2-Dichloroethane	1.66
Naphthalene	22.29	Hexavalent Chromium, PM	3.91E-04	*p*-Dichlorobenzene	1.38
Dichloromethane	14.78	POM, Group 2b	2.85E-04	1,3-Butadiene	1.29
Tetrachloroethylene	8.04	POM, Group 2d	2.56E-04		
POM, Group 2b	3.24	Acetaldehyde	2.52E-04		

Table 20-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Oklahoma City, Oklahoma (Oklahoma County) - OCOK					
Benzene	330.65	POM, Group 1a	1.01E-02	Formaldehyde	45.35
Ethylbenzene	224.06	Formaldehyde	2.84E-03	Benzene	6.07
Formaldehyde	218.33	Benzene	2.58E-03	Acetaldehyde	5.14
POM, Group 1a	114.89	1,3-Butadiene	1.29E-03	Carbon Tetrachloride	3.96
Acetaldehyde	114.57	Naphthalene	7.58E-04	Arsenic	2.46
1,3-Butadiene	42.92	Ethylbenzene	5.60E-04	1,3-Butadiene	2.30
Naphthalene	22.29	Hexavalent Chromium, PM	3.91E-04	1,2-Dichloroethane	1.80
Dichloromethane	14.78	POM, Group 2b	2.85E-04	Ethylbenzene	0.78
Tetrachloroethylene	8.04	POM, Group 2d	2.56E-04	*p*-Dichlorobenzene	0.74
POM, Group 2b	3.24	Acetaldehyde	2.52E-04		

Table 20-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Tulsa, Oklahoma (Tulsa County) - TOOK					
Toluene	1,823.14	Acrolein	443,042.58	Manganese	0.77
Ethylene glycol	742.90	1,3-Butadiene	18,352.00	Formaldehyde	0.35
Xylenes	742.04	Formaldehyde	16,939.11	Acetaldehyde	0.31
Hexane	689.70	Manganese, PM	12,843.28	Benzene	0.07
Methanol	360.74	Benzene	10,112.23	Propionaldehyde	0.06
Benzene	303.37	Acetaldehyde	9,429.01	Arsenic	0.06
Ethylbenzene	202.14	Naphthalene	8,747.25	1,3-Butadiene	0.05
Formaldehyde	166.00	Trichloroethylene	8,445.87	Nickel	0.03
Acetaldehyde	84.86	Xylenes	7,420.42	Carbon Tetrachloride	0.01
Methyl isobutyl ketone	78.48	Nickel, PM	6,347.63	Ethylbenzene	<0.01
Tulsa, Oklahoma (Tulsa County) - TMOK					
Toluene	1,823.14	Acrolein	443,042.58	Manganese	0.52
Ethylene glycol	742.90	1,3-Butadiene	18,352.00	Formaldehyde	0.37
Xylenes	742.04	Formaldehyde	16,939.11	Acetaldehyde	0.26
Hexane	689.70	Manganese, PM	12,843.28	1,3-Butadiene	0.06
Methanol	360.74	Benzene	10,112.23	Arsenic	0.05
Benzene	303.37	Acetaldehyde	9,429.01	Benzene	0.04
Ethylbenzene	202.14	Naphthalene	8,747.25	Nickel	0.02
Formaldehyde	166.00	Trichloroethylene	8,445.87	Carbon Tetrachloride	0.01
Acetaldehyde	84.86	Xylenes	7,420.42	Ethylbenzene	<0.01
Methyl isobutyl ketone	78.48	Nickel, PM	6,347.63	*p*-Dichlorobenzene	<0.01

Table 20-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		**Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Pryor Creek, Oklahoma (Mayes County) - PROK					
Toluene	128.09	Acrolein	83,815.30	Manganese	0.37
Hydrochloric acid	75.26	Chlorine	56,686.67	Formaldehyde	0.37
Xylenes	56.41	Arsenic, PM	35,830.19	Acetaldehyde	0.17
Ethylene glycol	50.78	Manganese, PM	15,273.86	Arsenic	0.04
Hexane	41.02	Nickel, PM	13,034.79	1,3-Butadiene	0.02
Benzene	30.82	Cyanide Compounds, PM	6,904.00	Benzene	0.02
Methanol	24.93	Lead, PM	6,528.90	Carbon Tetrachloride	0.01
Formaldehyde	20.34	Hydrochloric acid	3,763.00	*p*-Dichlorobenzene	<0.01
Acetaldehyde	13.15	Cadmium, PM	2,946.28	1,2-Dichloroethane	<0.01
Ethylbenzene	12.72	Hexavalent Chromium, PM	2,447.13		
Oklahoma City, Oklahoma (Oklahoma County) - ADOK					
Toluene	2,213.83	Acrolein	668,119.67	Formaldehyde	0.31
Ethylene glycol	943.84	Formaldehyde	22,278.35	Manganese	0.26
Xylenes	886.13	1,3-Butadiene	21,459.32	Acetaldehyde	0.20
Hexane	734.44	Acetaldehyde	12,730.19	Arsenic	0.03
Methanol	445.10	Benzene	11,021.63	1,3-Butadiene	0.02
Benzene	330.65	Xylenes	8,861.28	Benzene	0.02
Ethylbenzene	224.06	Naphthalene	7,429.80	Carbon Tetrachloride	0.01
Formaldehyde	218.33	Arsenic, PM	2,849.44	*p*-Dichlorobenzene	<0.01
Acetaldehyde	114.57	Ethylene glycol	2,359.59	1,2-Dichloroethane	<0.01
Methyl isobutyl ketone	71.17	Lead, PM	2,138.17		

Table 20-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Oklahoma City, Oklahoma (Oklahoma County) - OCOK					
Toluene	2,213.83	Acrolein	668,119.67	Manganese	0.42
Ethylene glycol	943.84	Formaldehyde	22,278.35	Formaldehyde	0.36
Xylenes	886.13	1,3-Butadiene	21,459.32	Acetaldehyde	0.26
Hexane	734.44	Acetaldehyde	12,730.19	Propionaldehyde	0.06
Methanol	445.10	Benzene	11,021.63	1,3-Butadiene	0.04
Benzene	330.65	Xylenes	8,861.28	Arsenic	0.04
Ethylbenzene	224.06	Naphthalene	7,429.80	Benzene	0.03
Formaldehyde	218.33	Arsenic, PM	2,849.44	Carbon Tetrachloride	0.01
Acetaldehyde	114.57	Ethylene glycol	2,359.59	Ethylbenzene	<0.01
Methyl isobutyl ketone	71.17	Lead, PM	2,138.17	*p*-Dichlorobenzene	<0.01

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 20.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 20-7 include the following:

- Benzene is the highest emitted pollutant with a cancer URE in Mayes, Oklahoma, and Tulsa Counties. The quantity of benzene emissions in Mayes County is an order of magnitude lower than the quantity of emissions for Oklahoma and Tulsa Counties.

- The pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Oklahoma and Tulsa Counties is POM Group 1a, followed by benzene, formaldehyde, and 1,3-butadiene (although not necessarily in that order). POM, Group 1a includes all unspeciated POM. The pollutants with the highest toxicity-weighted emissions for Mayes County are hexavalent chromium, arsenic, and nickel.

- Six of the highest emitted pollutants in Tulsa County also have the highest toxicity-weighted emissions. Seven of the highest emitted pollutants in Mayes County also have the highest toxicity-weighted emissions. Eight of the highest emitted pollutants in Oklahoma County also have the highest toxicity-weighted emissions. POM, Group 1a, benzene, formaldehyde, naphthalene, and 1,3-butadiene appear on both emissions-based lists for all three counties.

- Hexavalent chromium has the highest toxicity-weighted emissions for Mayes County and is also listed for Tulsa and Oklahoma Counties, yet it is not among the highest emitted pollutants for any of these counties (ranking 15th, 23rd, and 28th, respectively). This indicates that lower emissions can translate to higher risk levels. Hexavalent chromium was not sampled for at the Oklahoma monitoring sites.

- Formaldehyde and benzene have the highest cancer risk approximations among the Oklahoma sites' pollutants of interest. These pollutants also appear on both emissions-based lists for all five sites. Conversely, carbon tetrachloride, whose cancer risk approximation is in the top five for each site, appears on neither emissions-based list.

Observations from Table 20-8 include the following:

- Toluene is the highest emitted pollutant with a noncancer RfC in all three counties, although the quantity emitted is significantly higher in Tulsa and Oklahoma Counties than in Mayes County. Xylenes and ethylene glycol are also among the highest emitted pollutants in all three counties. Hydrochloric acid is also one of the highest emitted pollutants in Mayes County.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for all three counties. Yet, this pollutant is not among the highest emitted pollutants for any of the three counties. This indicates that lower emissions can translate to higher risk levels. Acrolein was sampled for at all of the Oklahoma sites, but this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Four of the highest emitted pollutants in Tulsa County also have the highest toxicity-weighted emissions; five of the highest emitted pollutants in Oklahoma County also have the highest toxicity-weighted emissions. Only one of the highest emitted pollutants in Mayes County also has one of the highest toxicity-weighted emissions (hydrochloric acid). Note that although toluene is the highest emitted pollutant in all three counties, this pollutant does not appear among those with the highest toxicity-weighted emissions.

- Six of the 10 pollutants with the highest noncancer toxicity-weighted emissions in Mayes County are metals. None of these appear among the highest emitted, though.

- Formaldehyde and manganese have the highest noncancer hazard approximations among the Oklahoma sites. Formaldehyde appears on both emissions-based lists for Tulsa and Oklahoma Counties but ranks 12th for toxicity-weighted emissions for Mayes County and therefore does not appear in Table 20-8 in that column. Manganese appears among the pollutants with the highest toxicity-weighted emissions for Tulsa and Mayes Counties but ranks 17th for toxicity-weighted emissions for Oklahoma County. There are no metals listed among the highest emitted pollutants for any of the three counties.

- Note that for the metals, the emissions-based lists are PM_{10} while the Oklahoma sites sampled TSP metals.

20.6 Summary of the 2012 Monitoring Data for the Oklahoma Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *Twenty-one pollutants failed at least one screen for TOOK; 19 pollutants failed screens for TMOK; 18 pollutants failed screens for PROK; 17 pollutants failed screens for ADOK; and 17 pollutants failed screens for OCOK.*

- *Formaldehyde and acetaldehyde had the highest annual average concentration for each site. Among the TSP metals, the annual average concentration of manganese was the highest for each site.*

- *The maximum manganese concentrations measured at TOOK, TMOK, and PROK correlate to the day a large dust storm affected the area.*

- *TOOK had the highest annual average of concentration of benzene and ethylbenzene among all NMP sites sampling this pollutant.*

- *Concentrations of ethylbenzene, manganese, and nickel exhibit increasing trends at TOOK. In addition, the detection rate of 1,2-dichloroethane has been increasing at TOOK over the last few years of sampling, particularly for 2012.*

21.0 Site in Rhode Island

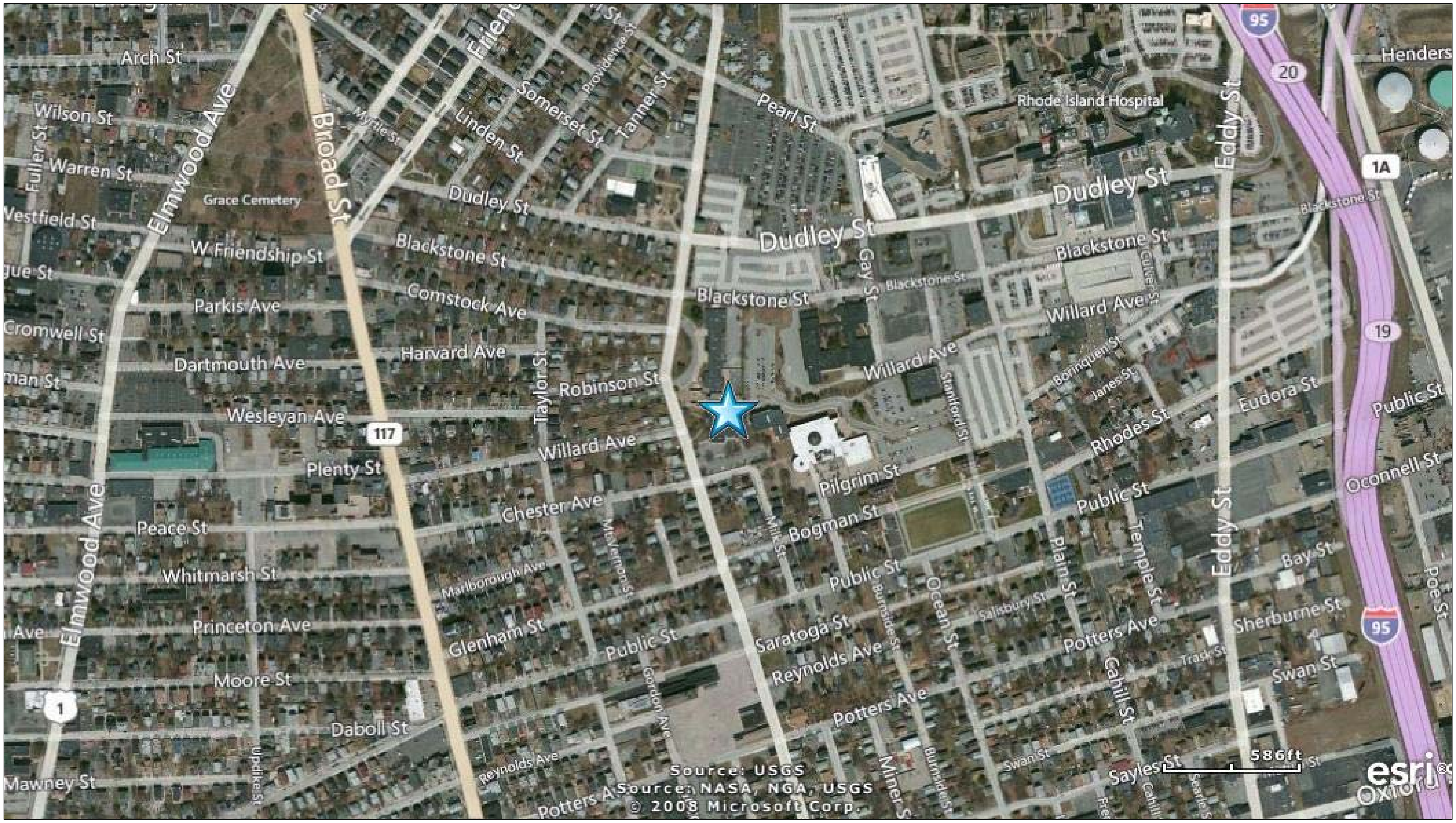
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Rhode Island, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

21.1 Site Characterization

This section characterizes the Rhode Island monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

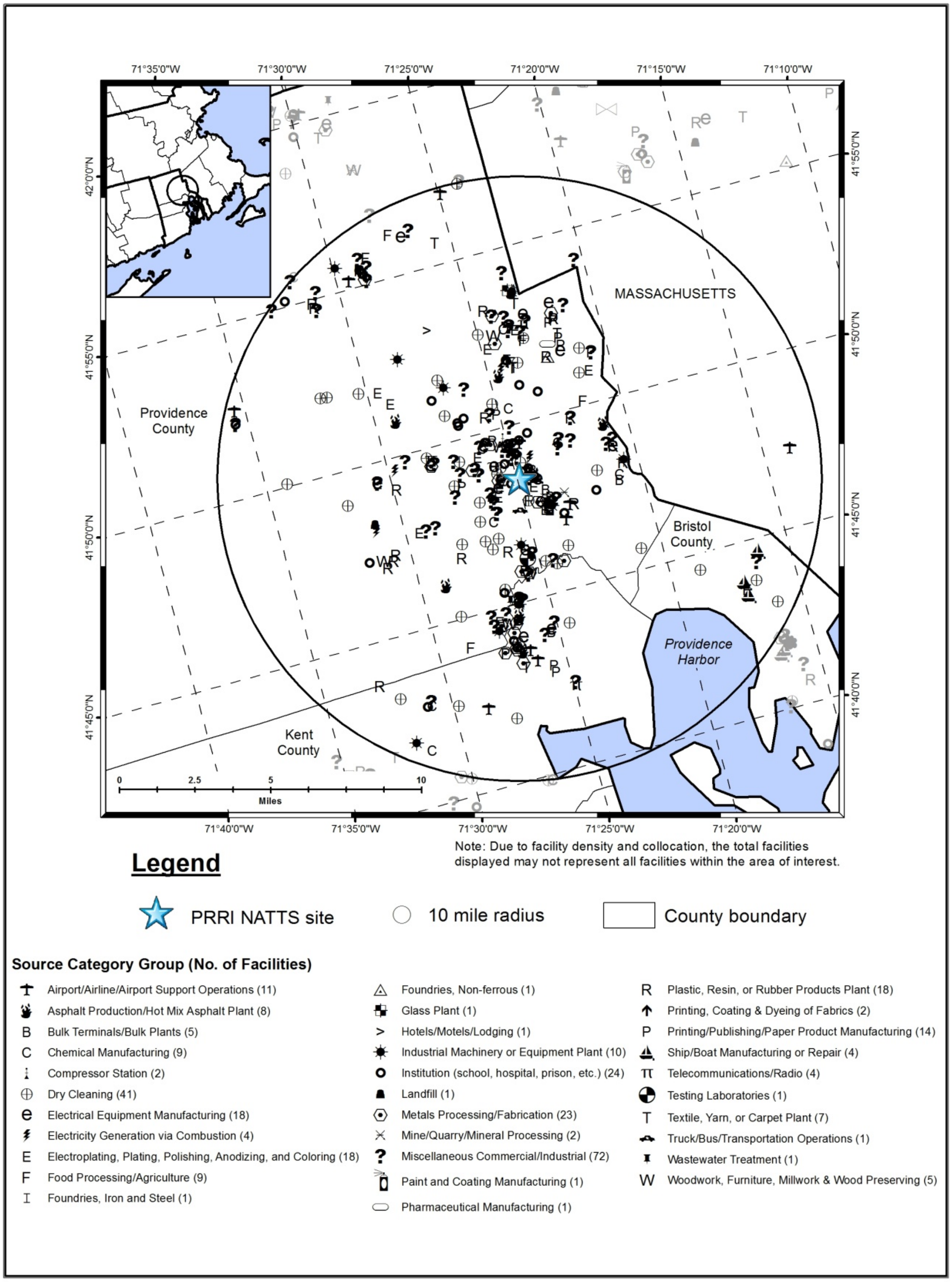
The PRRI monitoring site is located in south Providence. Figure 21-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 21-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 21-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 21-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 21-1. Providence, Rhode Island (PRRI) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 21-2. NEI Point Sources Located Within 10 Miles of PRRI



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 21-1. Geographical Information for the Rhode Island Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
PRRI	44-007-0022	Providence	Providence	Providence-Warwick, RI-MA MSA	41.807776, -71.415105	Residential	Urban/City Center	PAMS, VOCs, Carbonyl Compounds, Meteorological parameters, PM_{10}, PM_{10} Speciation, Black Carbon, $PM_{2.5}$, and $PM_{2.5}$ Metals, TSP Germanium.

[1] Data for additional pollutants are reported to AQS for PRRI (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

Figure 21-1 shows that the areas to the west and south of PRRI are primarily residential, but areas to the north and east are commercial. A hospital lies to the northeast of the site, just north of Dudley Street. Interstate-95 runs north-south about one-half mile to the east of the site, then turns northwestward, entering downtown Providence. The Providence River leads into Providence Harbor a few tenths of a mile farther to the east, just on the other side of I-95. Figure 21-2 shows that a large number of point sources are located within 10 miles of PRRI. The source categories with the greatest number of point sources within 10 miles of PRRI include dry cleaners; institutions (such as schools, prisons, and hospitals); metals processing and fabrication facilities; electroplating, plating, polishing, anodizing, and coloring facilities; plastic, resin, or rubber products plants; and facilities generating electricity via combustion. Sources within one-half mile of PRRI include several hospitals and a heliport at a hospital.

Table 21-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Rhode Island monitoring site. Table 21-2 includes the county-level population for the site. County-level vehicle registration data for Providence County were not available from the State of Rhode Island. Thus, state-level vehicle registration, which was obtained from the Federal Highway Administration, was allocated to the county level using the county-level proportion of the state population from the U.S. Census Bureau. Table 21-2 also contains traffic volume information for PRRI as well as the location for which the traffic volume was obtained. County-level VMT data were not readily available for Providence County.

Table 21-2. Population, Motor Vehicle, and Traffic Information for the Rhode Island Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
PRRI	628,323	548,763	136,800	I-95 near I-195	NA

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)

[2] County-level vehicle registration is based on 2011 state-level vehicle registration data from the FHWA and the 2011 county-level proportion of the state population data (FHWA, 2013a and Census Bureau, 2012)

[3] AADT reflects 2009 data (RI DOT, 2009)

[4] County-level VMT was not available for this site.

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 21-2 include the following:

- Providence County's population is in the middle of the range compared to other counties with NMP sites.

- The estimated county-level vehicle registration is also in the middle of the range compared to other counties with NMP sites.

- The traffic volume experienced near PRRI is the 10th highest compared to traffic volume near other NMP monitoring sites. The traffic estimate provided is for I-95 near the I-195 interchange.

21.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Rhode Island on sample days, as well as over the course of the year.

21.2.1 Climate Summary

Providence is a coastal city on the Narragansett Bay, which opens to the Rhode Island Sound and the Atlantic Ocean. The city's proximity to the Sound and the Atlantic Ocean temper cold air outbreaks, and breezes off the ocean moderate summertime heat. On average, southerly and southwesterly winds in the summer become northwesterly in the winter. Weather is fairly variable in Providence as storm systems frequently affect the New England region. Precipitation occurs in Providence about one day in every three and is distributed fairly evenly throughout the year. Thunderstorms are common between May and August, while coastal storms tend to produce the greatest amounts of rain and snow. Thirty inches of snow is typical in winter (Wood, 2004; CoCoRaHS, 2011).

21.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Rhode Island monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather station is located at Theodore F. Green State Airport (WBAN 14765). Additional information about the T.F. Green Airport weather station, such as the distance between the site and the weather station, is provided in Table 21-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 21-3. Average Meteorological Conditions near the Rhode Island Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Providence, Rhode Island - PRRI									
Theodore F. Green State Airport 14765 (41.72, -71.43)	6.0 miles 173° (S)	Sample Days (65)	62.2 ± 4.2	54.2 ± 4.0	42.9 ± 4.4	48.9 ± 3.7	68.7 ± 3.6	1015.9 ± 2.0	6.5 ± 0.6
		2012	62.1 ± 1.7	53.8 ± 1.6	42.2 ± 1.8	48.4 ± 1.5	68.0 ± 1.6	1015.7 ± 0.8	6.8 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 21-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 21-3 is the 95 percent confidence interval for each parameter. As shown in Table 21-3, average meteorological conditions on sample days are representative of average weather conditions experienced throughout the year near PRRI.

21.2.3 Back Trajectory Analysis

Figure 21-3 is the composite back trajectory map for days on which samples were collected at the PRRI monitoring site. Included in Figure 21-3 are four back trajectories per sample day. Figure 21-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 21-3 and 21-4 represents 100 miles.

Figure 21-3. Composite Back Trajectory Map for PRRI

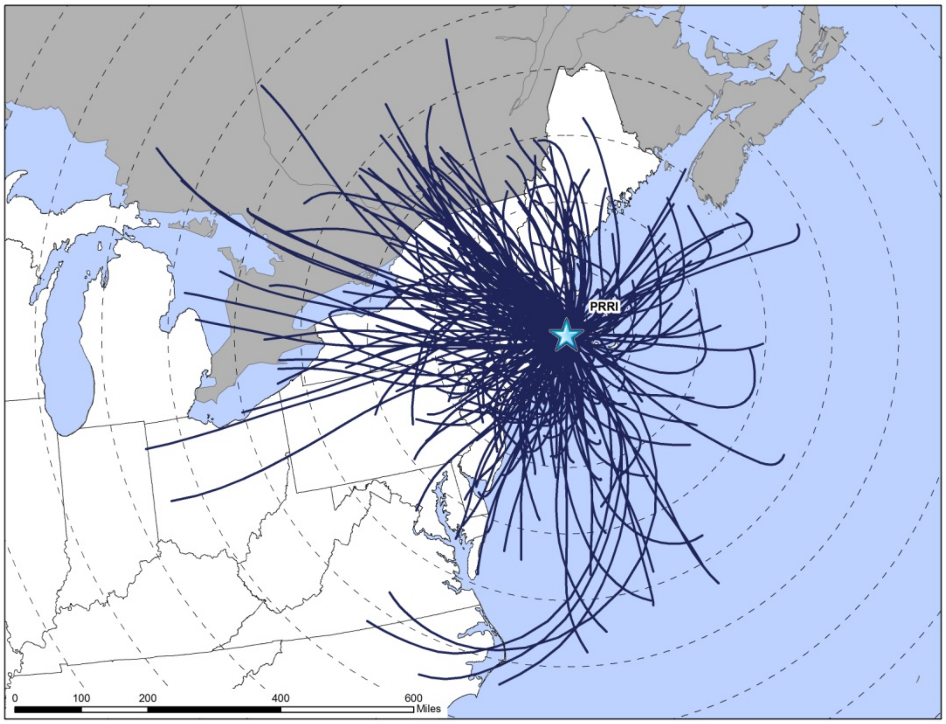
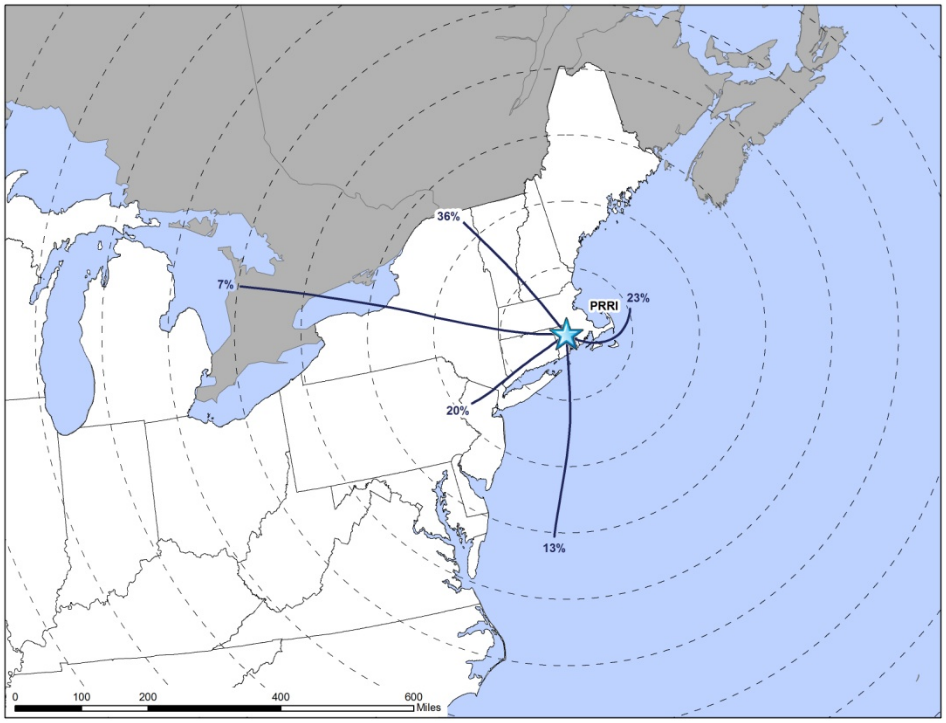


Figure 21-4. Back Trajectory Cluster Map for PRRI



Observations from Figures 21-3 and 21-4 for PRRI include the following:

- Back trajectories originated from a variety of directions at PRRI.

- The airshed domain for PRRI was similar in size to other NMP sites, based on the average back trajectory length. The average back trajectory length was 246 miles, although the farthest away a back trajectory originated was over south-central Ontario, Canada, or nearly 700 miles away. Yet, nearly 92 percent of back trajectories originated within 450 miles of the site.

- The cluster analysis shows that 36 percent of back trajectories originated to the northwest and north of PRRI, from the northern half of New York eastward toward Maine. Another 20 percent originated to the west and southwest of the site, over the southern half of New York, Pennsylvania, New Jersey and their offshore waters. Back trajectories originating from the west and northwest but farther away are represented by the longer cluster trajectory originating near Lake Huron (7 percent). Thirteen percent of back trajectories originated over the offshore waters of the Mid-Atlantic states. The back trajectories originating over North Carolina and Virginia and curving eastward and then northward toward PRRI are included in this cluster trajectory. These back trajectories represent the October 30, 2012 sample day, the day after Hurricane Sandy made landfall in New Jersey. Nearly one-quarter of back trajectories originated to the east of PRRI, over the Gulf of Maine and southward over the Atlantic Ocean.

21.2.4 Wind Rose Comparison

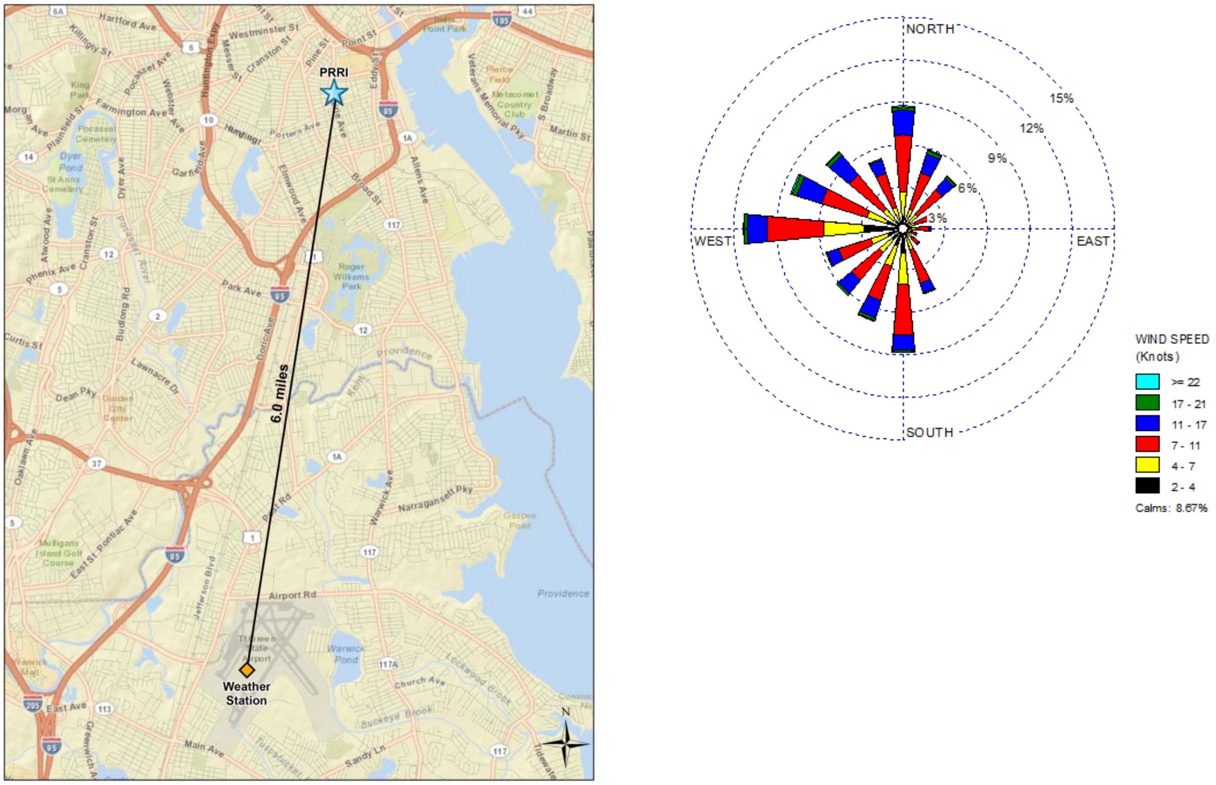
Hourly surface wind data from the weather station at T.F. Green Airport near PRRI were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 21-5 presents a map showing the distance between the weather station and PRRI, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 21-5 also presents three different wind roses for the PRRI monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

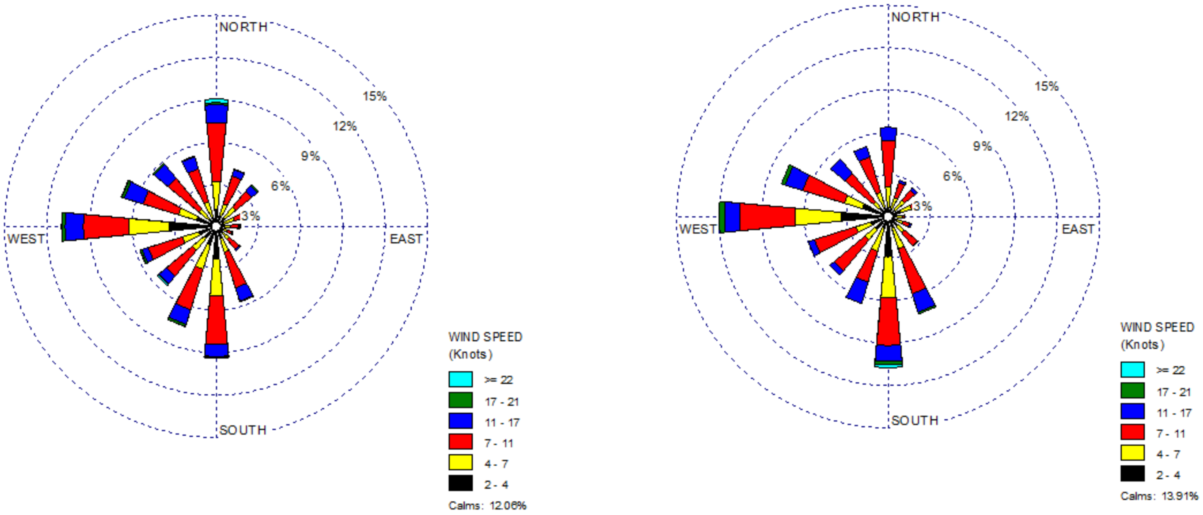
Observations from Figure 21-5 for PRRI include the following:

- The weather station at T.F. Green Airport is located 6 miles south of PRRI.
- The historical wind rose shows that while westerly winds were observed the most (approximately 11 percent of observations), winds from the western quadrants, due north, and due south are common near PRRI. Calm winds (≤ 2 knots) account for less than nine percent of the hourly measurements.
- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns, with winds from the western quadrants, due north, and due south prevalent near PRRI. The calm rate for 2012 is 12 percent, which is slightly higher than the calm rate for the historical wind rose.
- The wind patterns shown on the sample day wind rose continue the prevalence of winds from the western quadrants and due south, but the number of observations from the north is reduced. The sample day calm rate is nearly 14 percent compared to 12 percent for 2012 and 9 percent for the historical wind rose. Although still accounting for relatively few observations, the number of observations from the north-northeast and northeast on sample days is fewer (less than 3 percent each) than the percentages shown on the full-year and historical wind rose while the number of observations from the south-southeast is greater.

Figure 21-5. Wind Roses for the T.F. Green State Airport Weather Station near PRRI


Location of PRRI and Weather Station

2002-2011 Historical Wind Rose


2012 Wind Rose

Sample Day Wind Rose

21.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for PRRI in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 21-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 21-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. PAHs and hexavalent chromium were sampled for at PRRI.

Table 21-4. Risk-Based Screening Results for the Rhode Island Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Providence, Rhode Island - PRRI						
Naphthalene	0.029	55	60	91.67	94.83	94.83
Hexavalent Chromium	0.000083	2	41	4.88	3.45	98.28
Benzo(a)pyrene	0.00057	1	56	1.79	1.72	100.00
Total		58	157	36.94		

Observations from Table 21-4 include the following:

- Three pollutants failed at least one screen for PRRI; 37 percent of concentrations for these three pollutants were greater than their associated risk screening value (or failed screens).
- Concentration of naphthalene failed 55 of the 58 total screens, accounting for just less than 95 percent of all failed screens for PRRI.
- Naphthalene and hexavalent chromium contributed to 95 percent of failed screens for PRRI and therefore were identified as pollutants of interest.

21.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Rhode Island monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for the site.
- Annual concentration averages are presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for PRRI are provided in Appendices M and O.

21.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Rhode Island site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for PRRI are presented in Table 21-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 21-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Rhode Island Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Providence, Rhode Island - PRRI						
Hexavalent Chromium	41/61	0.006 ± 0.004	0.024 ± 0.027	0.023 ± 0.010	0.010 ± 0.007	0.016 ± 0.007
Naphthalene	60/60	74.35 ± 16.14	43.86 ± 11.91	73.48 ± 16.56	114.66 ± 39.59	76.41 ± 12.42

Observations for PRRI from Table 21-5 include the following:

- Hexavalent chromium was detected in 67 percent of the valid samples collected at PRRI while naphthalene was detected in 100 percent of samples collected.

- The quarterly and annual average concentrations of naphthalene are significantly higher than the quarterly and annual average concentrations of hexavalent chromium.

- The confidence interval for the second quarter average concentration of hexavalent chromium is greater than the average itself, indicating potential outliers. The maximum hexavalent chromium concentration was measured at PRRI on May 9, 2012 (0.207 ng/m^3). There were no other hexavalent chromium concentrations greater than 0.1 ng/m^3 measured at this site. The next highest concentration measured during the second quarter of 2012 is an order of magnitude less (0.0269 ng/m^3), explaining the large confidence interval calculated for this quarter.

- Concentrations of naphthalene measured at PRRI span an order of magnitude, ranging from 21.3 ng/m^3 to 212 ng/m^3. All four naphthalene concentrations greater than 200 ng/m^3 were measured in November and December. All five naphthalene concentrations less than 30 ng/m^3 were measured during the second quarter. This explains the variability exhibited by the quarterly averages of this pollutant.

21.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 21-4 for PRRI. Figures 21-6 and 21-7 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 21-6. Program vs. Site-Specific Average Hexavalent Chromium Concentration

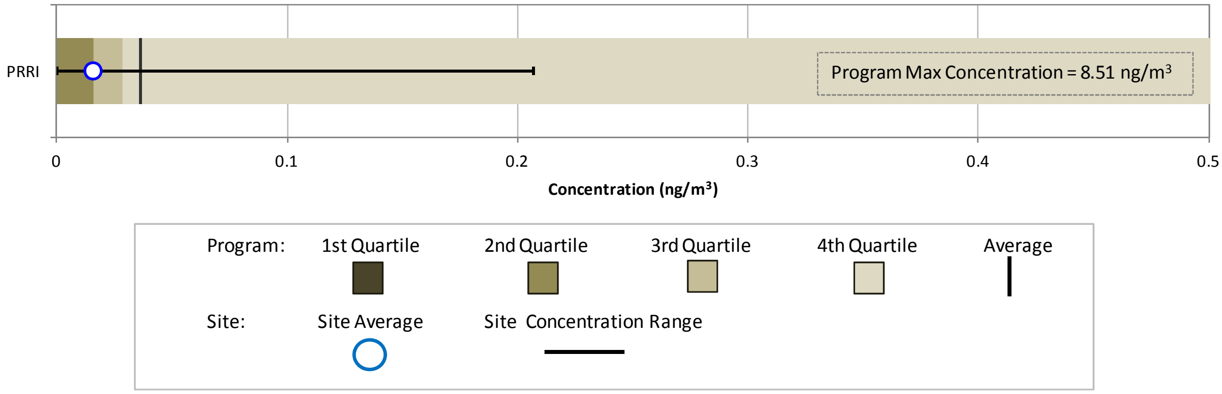
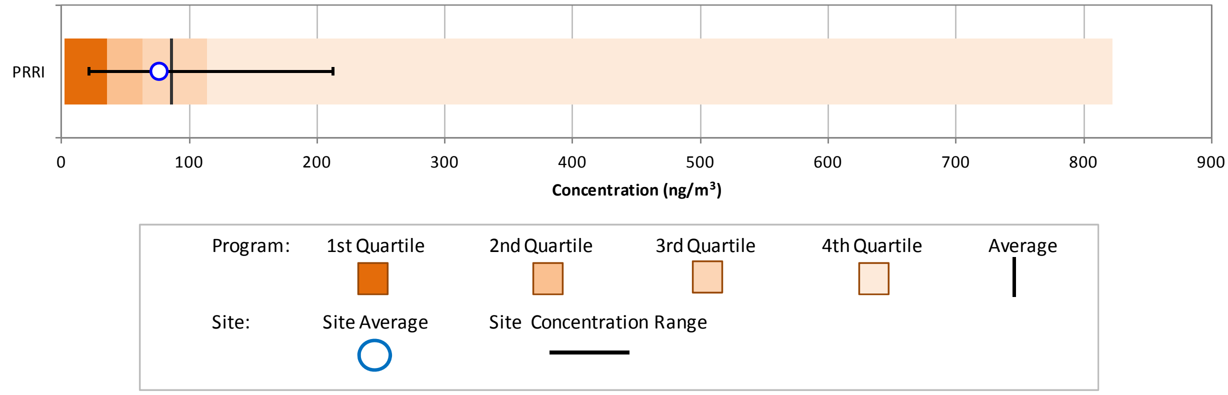


Figure 21-7. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 21-6 and 21-7 include the following:

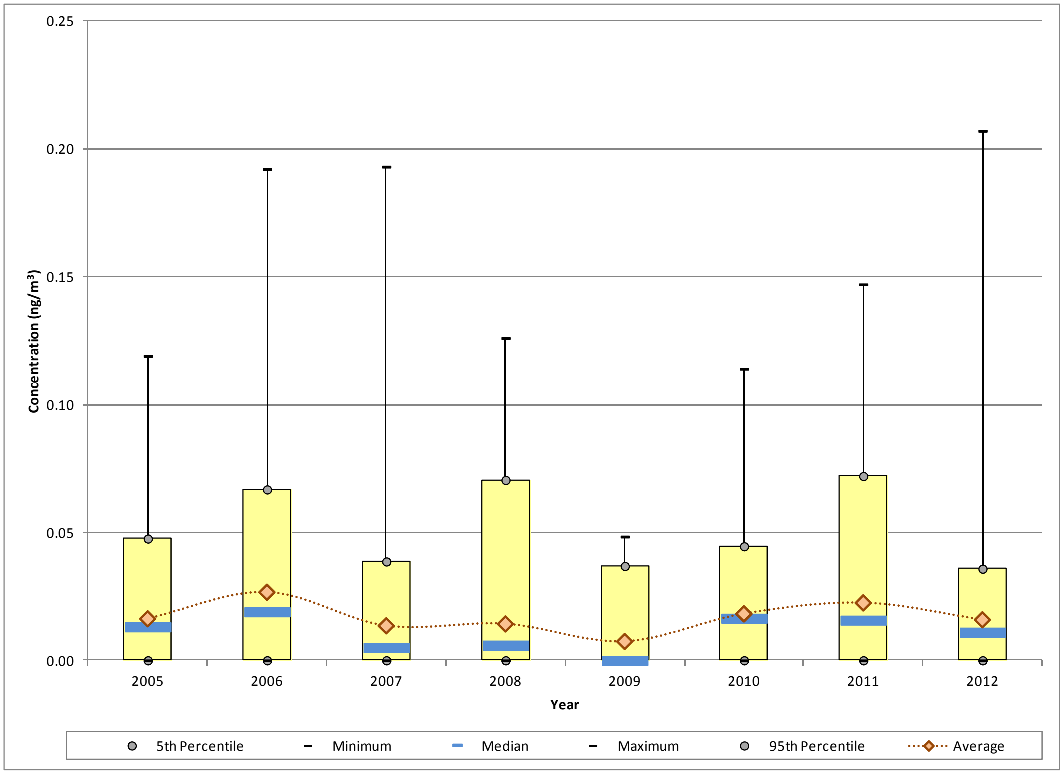
- Figure 21-6 is the box plot for hexavalent chromium. Note that the program-level maximum concentration (8.51 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 0.5 ng/m^3. In addition, the program-level first quartile is zero and therefore not visible on the box plot. The annual average concentration of hexavalent chromium for PRRI is less than the program-level average concentration and similar to program-level median concentration. The maximum concentration measured at PRRI is considerably less than the program-level maximum concentration. There were 20 non-detects of hexavalent chromium measured at PRRI.

- Figure 21-7 is the box plot for naphthalene. The annual average naphthalene concentration for PRRI is just less than the program-level average concentration. The maximum naphthalene concentration measured at PRRI is considerably less than the maximum concentration measured at the program-level. There were no non-detects of naphthalene measured at PRRI (or across the program).

21.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. PRRI has sampled hexavalent chromium under the NMP since 2005 and PAHs since 2008. Thus, Figure 21-8 and 21-9 present the 1-year statistical metrics for each of the pollutants of interest for PRRI. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 21-8. Yearly Statistical Metrics for Hexavalent Chromium Concentrations Measured at PRRI



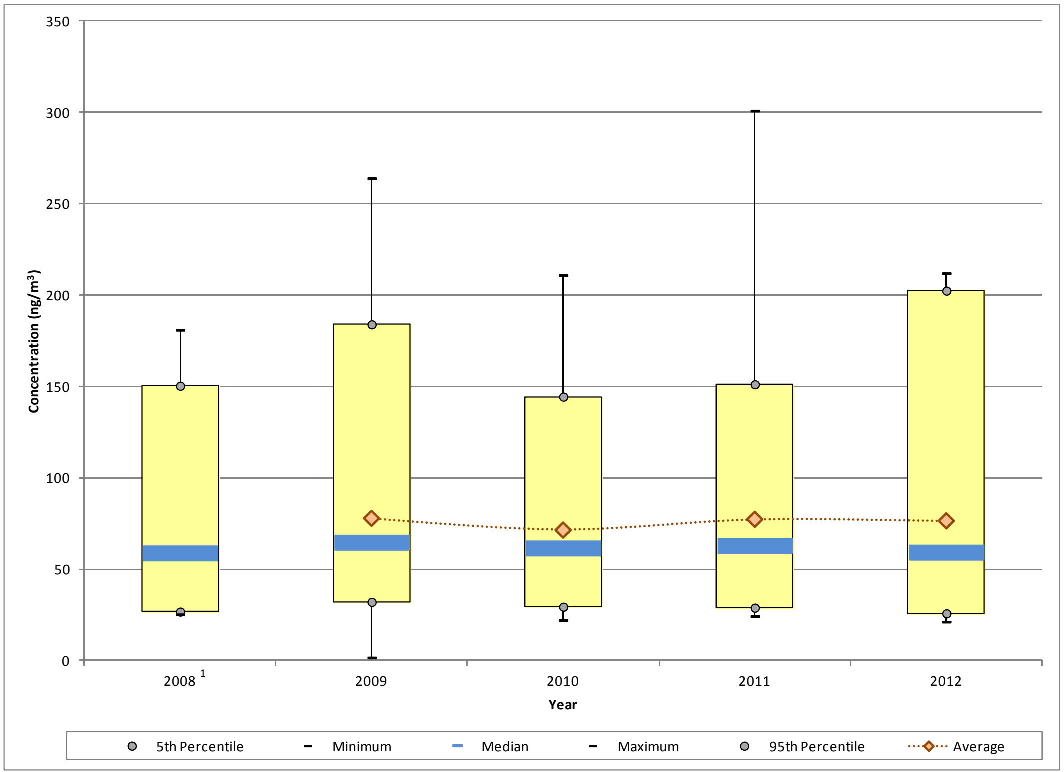
Observations from Figure 21-8 for hexavalent chromium measurements collected at PRRI include the following:

- The maximum hexavalent chromium concentration was measured on May 9, 2012 (0.207 ng/m^3), although similar concentrations were also measured in 2006 and 2007. No other measurements greater than 0.15 ng/m^3 have been measured at PRRI and only eight concentrations greater than 0.1 ng/m^3 have been measured since sampling began in 2005.

- The 1-year average concentration of hexavalent chromium has fluctuated over the years of sampling, with the 1-year average at a maximum for 2006 (0.027 ng/m^3) and a minimum for 2009 (0.007 ng/m^3).

- For each year shown, the minimum and 5th percentile are zero, indicating the presence of non-detects. The number of non-detects reported has varied by year, from as low as 9 percent in 2011 to as high as 65 percent in 2009. This explains why the median concentration is also zero for 2009.

Figure 21-9. Yearly Statistical Metrics for Naphthalene Concentrations Measured at PRRI



[1] A 1-year average is not presented because sampling under the NMP did not begin until July 2008.

Observations from Figure 21-9 for naphthalene measurements collected at PRRI include the following:

- PRRI began sampling PAHs under the NMP in July 2008. Because a full year's worth of data is not available, a 1-year average is not presented for 2008, although the range of measurements is provided.
- The maximum naphthalene concentration was measured in 2011 (301 ng/m^3). Seven of the 10 naphthalene concentrations greater than 200 ng/m^3 were measured in November of any given year.
- Although the maximum concentration measured each year varies, the 1-year average concentration of naphthalene exhibits little variability, ranging from 71.39 ng/m^3 for 2010 to 77.73 ng/m^3 for 2009. This is also true for the median concentration, which varies by less than 6 ng/m^3 across the years of sampling.

21.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the PRRI monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

21.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Rhode Island monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 day to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

21.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Rhode Island monitoring site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 21-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 21-6. Risk Approximations for the Rhode Island Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Providence, Rhode Island - PRRI						
Hexavalent Chromium	0.012	0.0001	41/61	0.02 ± 0.01	0.19	<0.01
Naphthalene	0.000034	0.003	60/60	76.41 ± 12.42	2.60	0.03

Observations for PRRI from Table 21-6 include the following:

- Both pollutants of interest for PRRI have a cancer URE and a noncancer RfC.
- The cancer risk approximation for naphthalene (2.60 in-a-million) is greater than the cancer risk approximation for hexavalent chromium (0.19 in-a-million).
- The noncancer hazard approximations for naphthalene and hexavalent chromium are negligible (0.03 in-a-million and <0.01 in-a-million, respectively), indicating that no adverse health effects are expected from these individual pollutants.

21.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 21-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 21-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 21-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for PRRI, as presented in Table 21-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 21-7. Table 21-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on the site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 21.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 21-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Rhode Island Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Providence, Rhode Island (Providence County) - PRRI					
Benzene	171.52	Formaldehyde	1.83E-03	Naphthalene	2.60
Formaldehyde	140.46	Benzene	1.34E-03	Hexavalent Chromium	0.19
Ethylbenzene	80.45	POM, Group 3	1.03E-03		
Acetaldehyde	68.23	1,3-Butadiene	8.09E-04		
1,3-Butadiene	26.97	POM, Group 1a	7.92E-04		
Tetrachloroethylene	17.76	Naphthalene	5.18E-04		
Naphthalene	15.23	POM, Group 2b	3.78E-04		
Trichloroethylene	9.08	POM, Group 2d	2.28E-04		
POM, Group 1a	9.00	POM, Group 5a	2.27E-04		
Dichloromethane	4.57	Ethylbenzene	2.01E-04		

Table 21-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Rhode Island Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Providence, Rhode Island (Providence County) - PRRI					
Toluene	1,262.41	Acrolein	296,350.76	Naphthalene	0.03
Ethylene glycol	776.88	Formaldehyde	14,333.09	Hexavalent Chromium	<0.01
Methanol	386.62	1,3-Butadiene	13,484.18		
Xylenes	338.43	Acetaldehyde	7,581.54		
Hexane	311.14	Benzene	5,717.41		
Benzene	171.52	Naphthalene	5,075.86		
Formaldehyde	140.46	Trichloroethylene	4,539.58		
Ethylbenzene	80.45	Xylenes	3,384.29		
Acetaldehyde	68.23	Arsenic, PM	2,555.13		
Methyl isobutyl ketone	41.59	Ethylene glycol	1,942.20		

Observations from Table 21-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Providence County.

- Formaldehyde is the pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs), followed by benzene and POM, Group 3.

- Six of the highest emitted pollutants also have the highest toxicity-weighted emissions for Providence County.

- Naphthalene, which has the highest cancer risk approximation among the pollutants of interest for PRRI, has the seventh highest emissions and the sixth highest toxicity-weighted emissions. Conversely, hexavalent chromium appears on neither emissions-based list, ranking 31st for quantity emitted and 13th for its toxicity-weighted emissions.

- Several POM Groups appear among the pollutants with the highest toxicity-weighted emissions for Providence County. POM, Group 2b and 2d rank seventh and eighth for their toxicity-weighted emissions, respectively. POM, Groups 2b and 2d include several PAHs sampled for at PRRI, although none of these pollutants failed screens.

- POM, Group 5a ranks ninth for toxicity-weighted emissions. POM, Group 5a includes benzo(a)pyrene, which failed a single screen for PRRI. POM, Group 5a is not among the highest emitted "pollutants" in Providence County.

Observations from Table 21-8 include the following:

- Toluene, ethylene glycol, and methanol are the highest emitted pollutants with noncancer RfCs in Providence County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene.

- Five of the highest emitted pollutants in Providence County also have the highest toxicity-weighted emissions.

- Although naphthalene ranks sixth among the pollutants with the highest toxicity-weighted emissions, it is not one of the highest emitted pollutants (with a noncancer RfC) in Providence County. Hexavalent chromium does not appear on either emissions-based list. These are the only two pollutants of interest for PRRI.

21.6 Summary of the 2012 Monitoring Data for PRRI

Results from several of the data treatments described in this section include the following:

- *Three pollutants failed at least one screen for PRRI, with naphthalene accounting for the majority of failed screens.*

- *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for PRRI.*

- *The maximum concentration of hexavalent chromium since the onset of sampling at PRRI was measured in 2012.*

22.0 Site in South Carolina

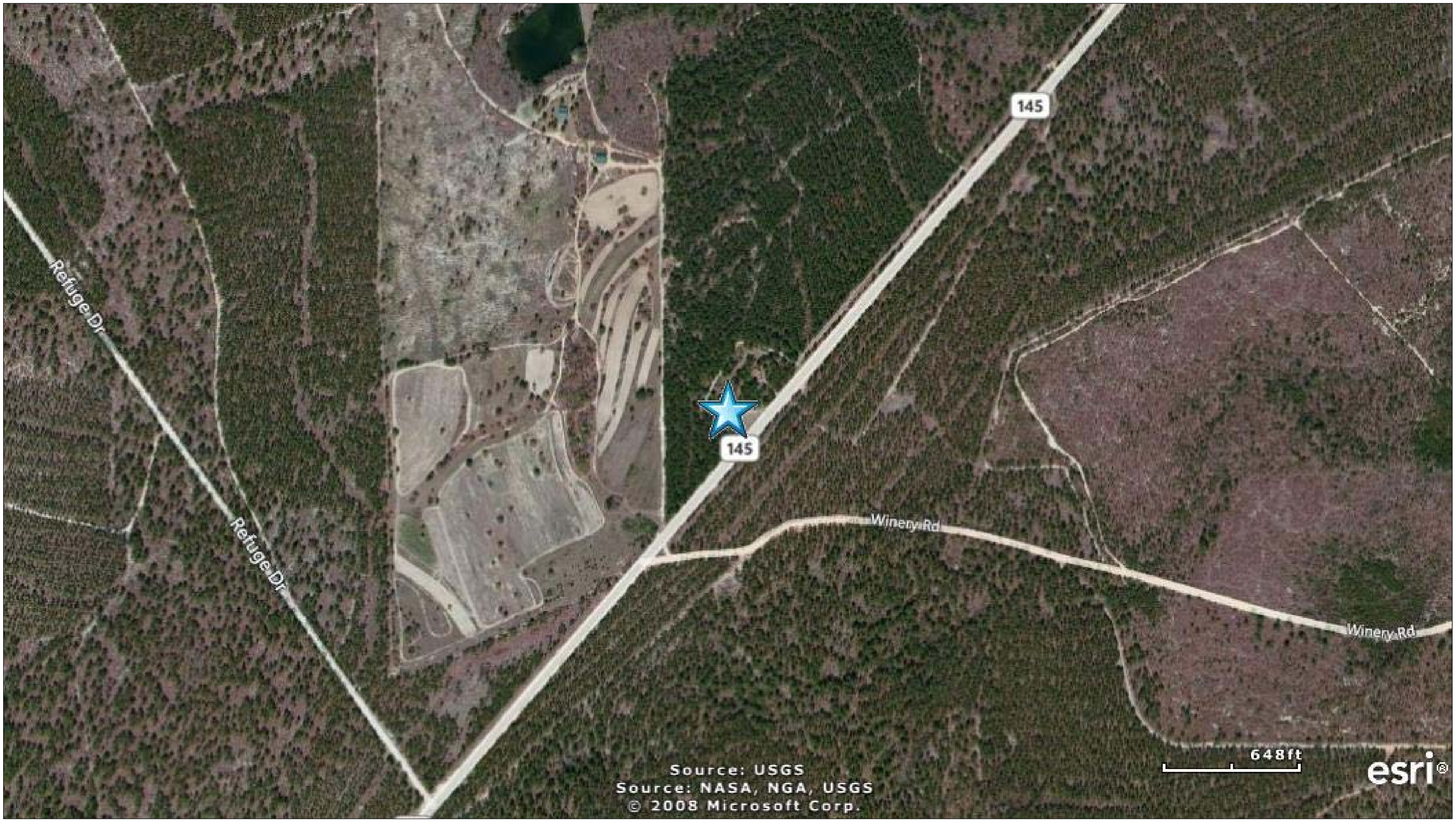
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in South Carolina, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

22.1 Site Characterization

This section characterizes the South Carolina monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

CHSC is located in central Chesterfield County, South Carolina. Figure 22-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 22-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 22-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 22-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 22-1. Chesterfield, South Carolina (CHSC) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 22-2. NEI Point Sources Located Within 10 Miles of CHSC

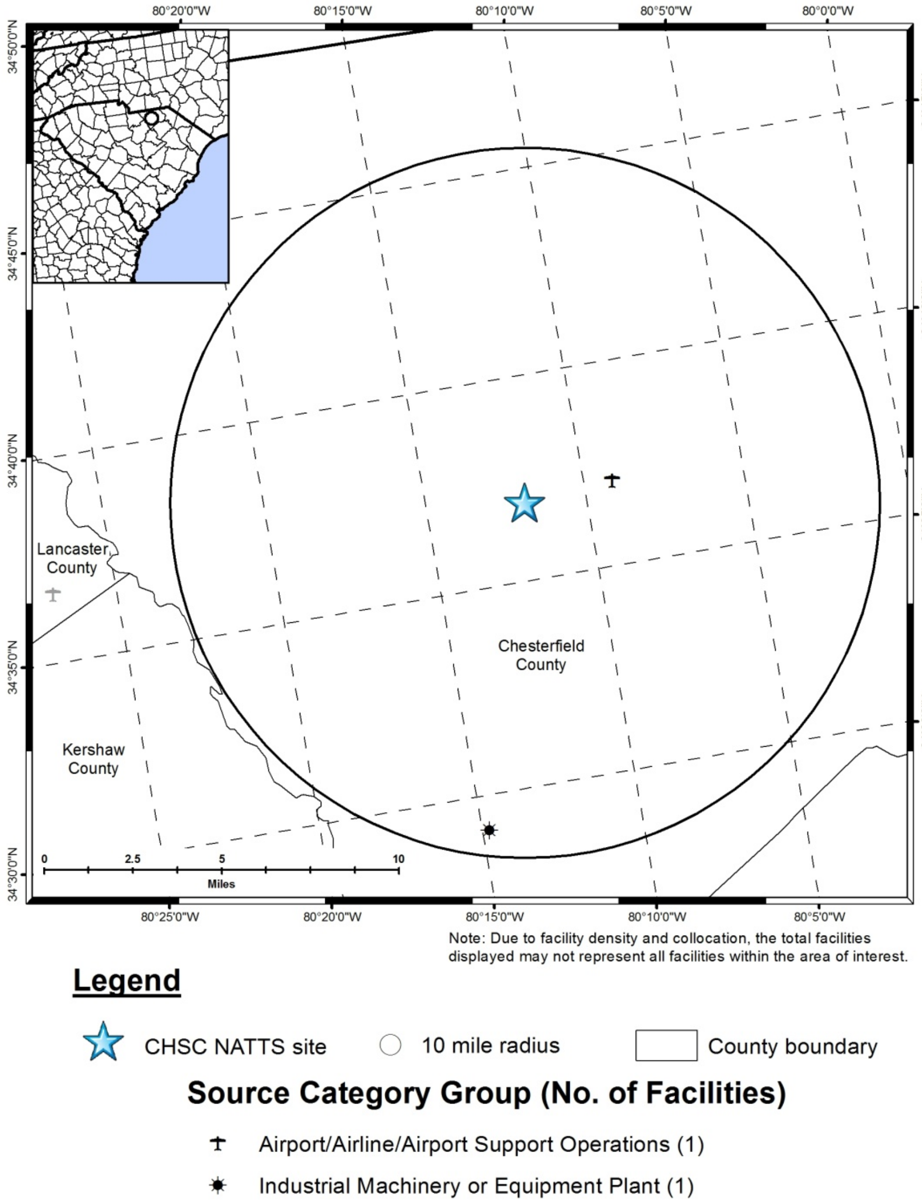


Table 22-1. Geographical Information for the South Carolina Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
CHSC	45-025-0001	Not in a city	Chesterfield	Not in an MSA	34.615367, -80.198787	Forest	Rural	VOCs, Carbonyl Compounds, Hexachlorobutadiene, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Black Carbon, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for CHSC (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.
BOLD ITALICS = EPA-designated NATTS Site

CHSC is located about 14 miles south of the North Carolina/South Carolina border, between the towns of McBee and Chesterfield. The monitoring site is located near the Ruby fire tower and, as Figure 22-1 shows, is located just off State Highway 145. The surrounding area is rural in nature and is part of the Carolina Sandhills Wildlife Refuge. Figure 22-2 shows that few point sources are located within 10 miles of CHSC, the closest of which is the Wild Irish Rose Airport.

Table 22-2 presents additional site-characterizing information, including indicators of mobile source activity, for the South Carolina monitoring site. Table 22-2 includes both county-level population and vehicle registration information. Table 22-2 also contains traffic volume information for CHSC as well as the location for which the traffic volume was obtained. Additionally, Table 22-2 presents the daily VMT for Chesterfield County.

Table 22-2. Population, Motor Vehicle, and Traffic Information for the South Carolina Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
CHSC	46,103	41,259	550	Hwy 145 between US-1 and 109	1,228,145

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (SC DMV, 2012)
[3] AADT reflects 2012 data (SC DOT, 2012)
[4] County-level VMT reflects 2012 data (SC DOT, 2013)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 22-2 include the following:

- Chesterfield County's population is among the lowest compared to other counties with NMP sites. A similar ranking was found for the county-level vehicle ownership.
- The traffic volume experienced near CHSC is the second lowest compared to other NMP monitoring sites. The traffic estimate provided is for State Highway 145 between State Highway 109 and US-1.
- The daily VMT for Chesterfield County is the third lowest VMT compared to other counties with NMP sites (where VMT data were available).

22.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in South Carolina on sample days, as well as over the course of the year.

22.2.1 Climate Summary

The town of Chesterfield is located just south of the North Carolina/South Carolina border, about 35 miles northwest of the city of Florence. Although the area experiences all four seasons, South Carolina's southeastern location ensures mild winters and long, hot summers. Summers are dominated by the Bermuda high pressure system over the Atlantic Ocean, which allows southwesterly winds to prevail, bringing in warm, moist air out of the Gulf of Mexico. During winter, winds out of the southwest shift northeasterly after frontal systems move across the area. The mountains to the northwest help shield the area from cold air outbreaks. Greater than 2 inches of precipitation can be expected any given month, with the maximum typically occurring in July (greater than 5 inches). Chesterfield County leads the state in the average number of sleet and freezing rain events per year (Bair, 1992; SC SCO, 2014).

22.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the South Carolina monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station with adequate data is located at the Monroe Airport in Monroe, North Carolina (WBAN 53872). Additional information about the Monroe Airport weather station, such as the distance between the site and the weather station, is provided in Table 22-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 22-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 22-3 is the 95 percent confidence interval for each parameter. As shown in Table 22-3, average meteorological conditions experienced on sample days were representative of average weather conditions experienced throughout the year near CHSC.

Table 22-3. Average Meteorological Conditions near the South Carolina Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Chesterfield, South Carolina - CHSC									
Monroe Airport 53872 (35.02, -80.62)	35.8 miles 311° (NW)	Sample Days (62)	72.0 ± 3.6	61.8 ± 3.5	50.8 ± 4.0	55.9 ± 3.4	70.5 ± 3.2	1018.9 ± 1.8	4.4 ± 0.6
		2012	72.4 ± 1.5	62.1 ± 1.4	51.4 ± 1.6	56.4 ± 1.4	71.3 ± 1.4	1018.2 ± 0.6	4.5 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

22.2.3 Back Trajectory Analysis

Figure 22-3 is the composite back trajectory map for days on which samples were collected at the CHSC monitoring site. Included in Figure 22-3 are four back trajectories per sample day. Figure 22-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 22-3 and 22-4 represents 100 miles.

Observations from Figures 22-3 and 22-4 for CHSC include the following:

- Back trajectories originated from a variety of directions at CHSC, with the longest back trajectories originating to the northwest of the site.

- The 24-hour air shed domain for CHSC was among the smaller in size compared to other NMP monitoring sites. Several of the longest back trajectories originated over Indiana, or greater than 500 miles away. However, the average back trajectory length was 183 miles and 87 percent of back trajectories originated within 300 miles of the site.

- The cluster analysis shows that 13 percent of back trajectories originated from the northwest of CHSC, over the Ohio Valley region. Nineteen percent of back trajectories originated from the west and southwest of CHSC, primarily over northwest South Carolina and Georgia. Another 24 percent of back trajectories originated to the east, southeast, and south of CHSC, along the coasts and adjacent waters of South Carolina, Georgia, and Florida. Twenty-one percent of back trajectories originated to the north of the site, over the Mid-Atlantic states. Another 23 percent of back trajectories are represented by the cluster trajectory that is covered up by the star symbol; thus, the cluster trajectory is presented in the inset map in Figure 22-4. This short trajectory represents back trajectories originating from varying directions but generally less than 100 miles from CHSC (plus a few originating near the western and northern border of North Carolina).

Figure 22-3. Composite Back Trajectory Map for CHSC

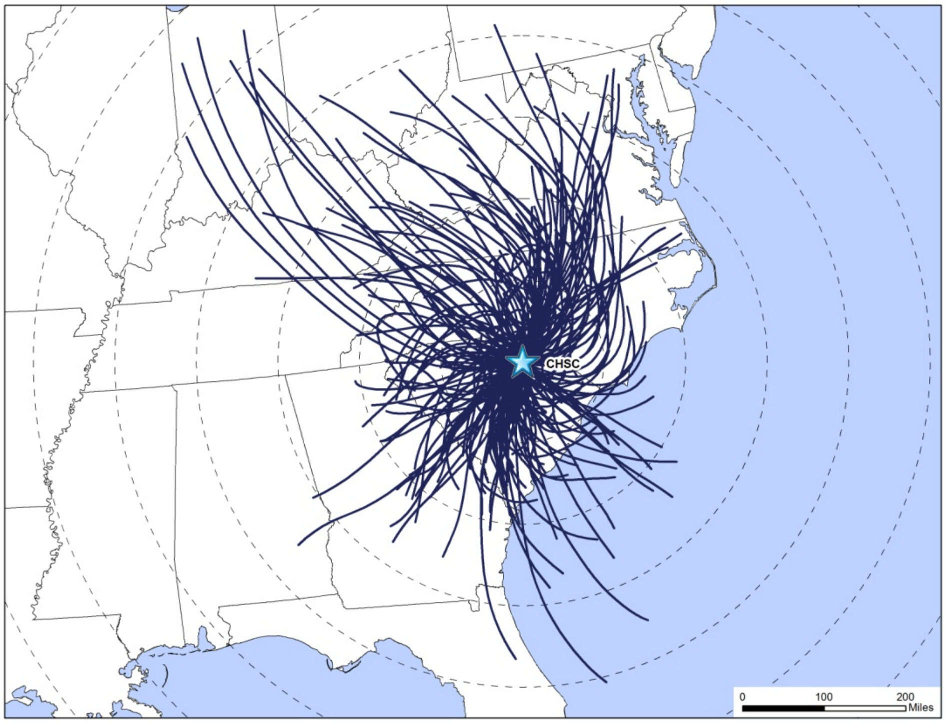
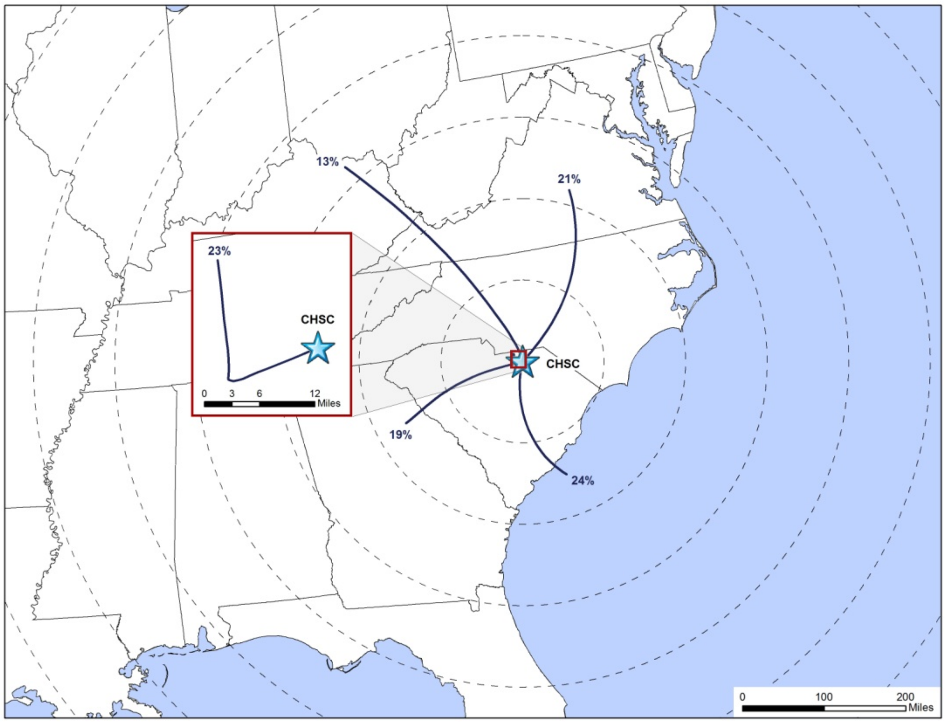


Figure 22-4. Back Trajectory Cluster Map for CHSC



22.2.4 Wind Rose Comparison

Hourly surface wind data from the weather station at Monroe Airport near CHSC were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 22-5 presents a map showing the distance between the weather station and CHSC, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 22-5 also presents three different wind roses for the CHSC monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 22-5 for CHSC include the following:

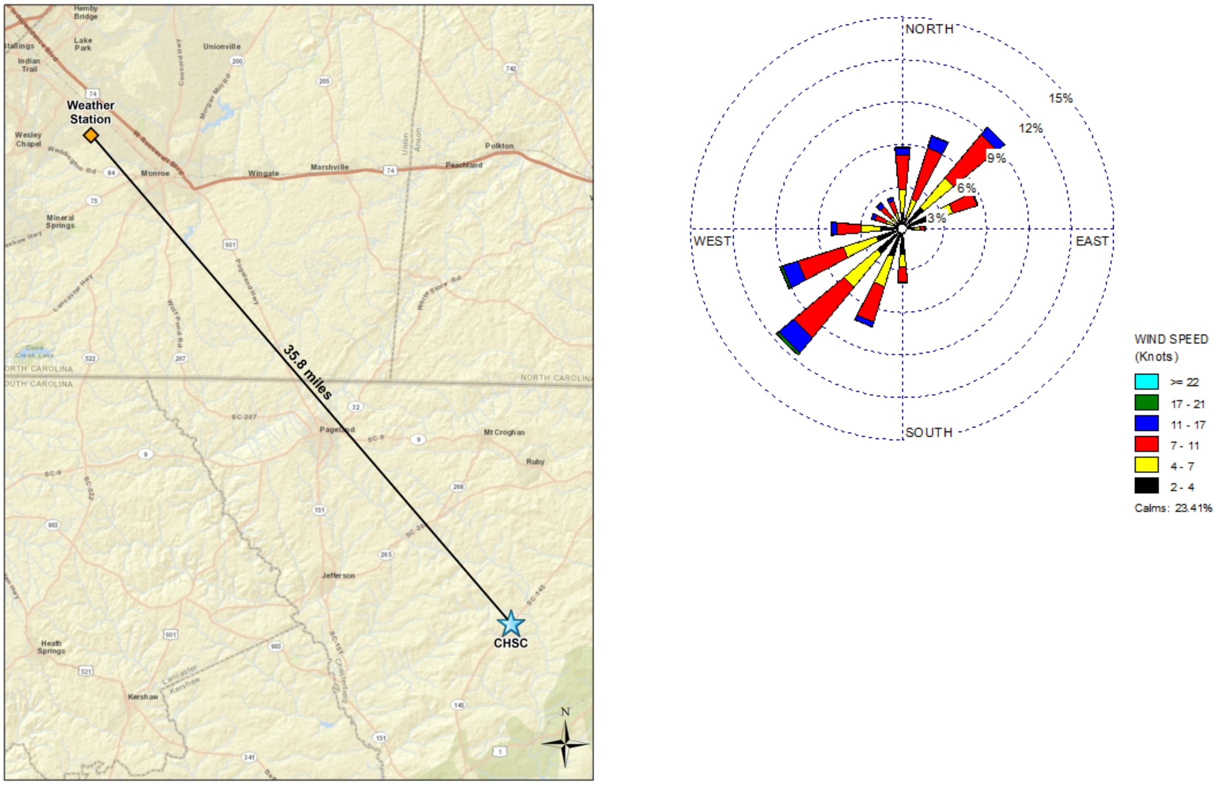
- The Monroe Airport weather station is located across the North Carolina/South Carolina border, approximately 36 miles northwest of CHSC.

- The historical wind rose for CHSC shows that calm winds (≤ 2 knots) account for 23 percent of the hourly measurements. Winds from the south-southwest to west account for approximately one-third of observations, just slightly more than winds from the north to east-northeast. Winds from the southeast quadrant are generally not observed.

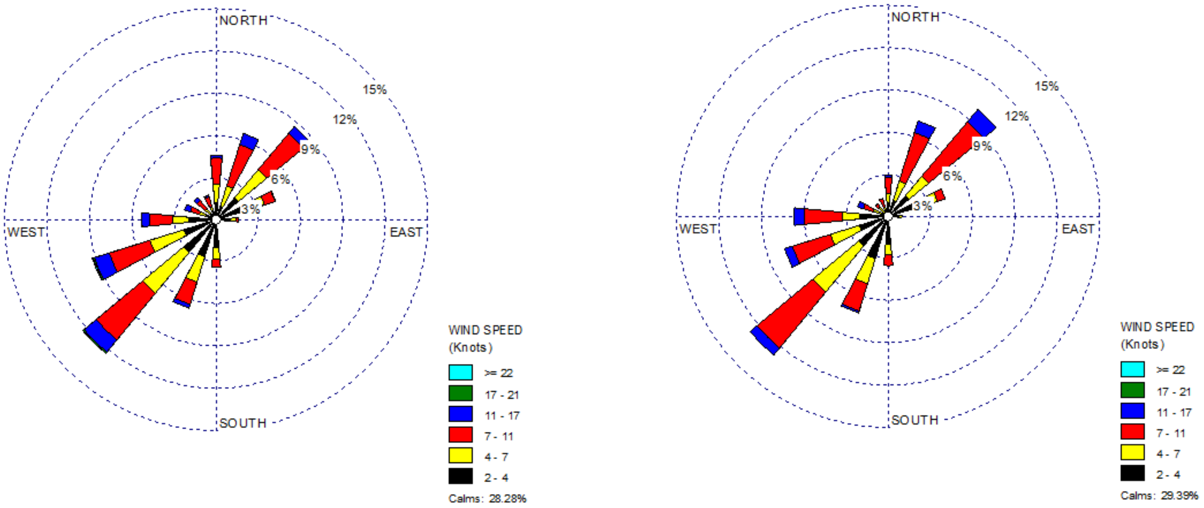
- The wind patterns shown on the 2012 wind rose for CHSC are similar to the historical wind patterns, although there were slightly more calm observations and fewer winds observations from the northeast quadrant. This indicates that wind conditions in 2012 were similar to what is expected climatologically near this site.

- The sample day wind patterns for 2012 also resemble the historical and full-year wind patterns. However, the calm rate for sample days is approaching 30 percent and the number of northerly observations is reduced to 3 percent.

Figure 22-5. Wind Roses for the Monroe Airport Weather Station near CHSC


Location of CHSC and Weather Station

2002-2011 Historical Wind Rose


2012 Wind Rose

Sample Day Wind Rose

22.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for CHSC in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 22-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 22-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis; CHSC sampled hexavalent chromium and PAHs.

Table 22-4. Risk-Based Screening Results for the South Carolina Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Chesterfield, South Carolina - CHSC						
Naphthalene	0.029	7	53	13.21	100.00	100.00
Total		7	53	13.21		

Observations from Table 22-4 include the following:

- Naphthalene was the only pollutant to fail screens for CHSC. This pollutant was detected in all 53 valid samples collected at CHSC and failed seven screens, or approximately 13 percent of screens.
- This site has the fourth lowest number of failed screens (7) among all NMP sites.

22.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the South Carolina monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for the site.
- Annual concentration averages are presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for CHSC are provided in Appendices M and O.

22.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the South Carolina site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual average* includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for CHSC are presented in Table 22-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 22-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the South Carolina Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Chesterfield, South Carolina - CHSC						
Naphthalene	53/53	24.41 ± 7.55	11.31 ± 1.88	9.50 ± 1.52	22.11 ± 7.63	17.26 ± 3.25

Observations for CHSC from Table 22-5 include the following:

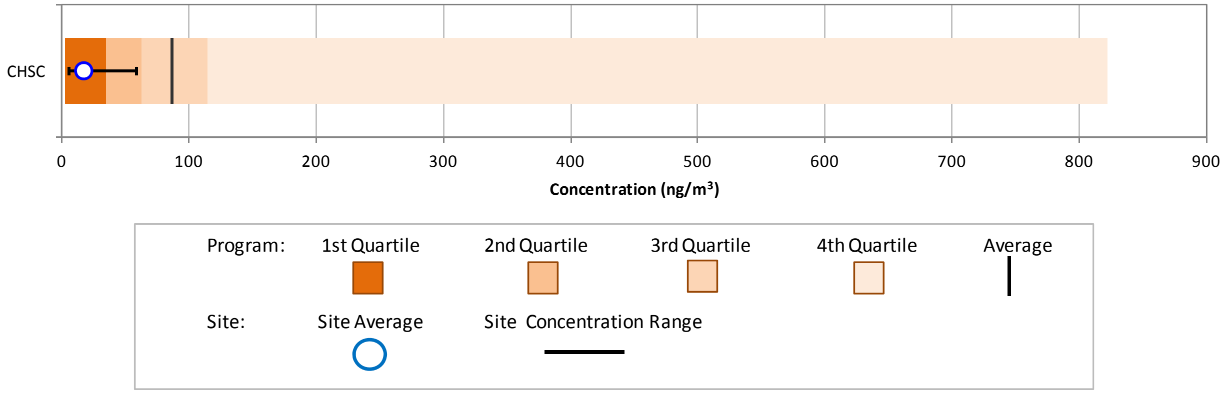
- Naphthalene concentrations measured at CHSC span an order of magnitude, ranging from 5.61 ng/m^3 to 58.3 ng/m^3, with a median concentration of 12.8 ng/m^3.
- The annual average concentration of naphthalene is 17.26 ± 3.25 ng/m^3. This is the third lowest annual average concentration of naphthalene among NMP sites sampling PAHs.

- The first and fourth quarter average concentrations of naphthalene are significantly higher than the other quarterly averages and have relatively large confidence intervals associated with them. The maximum naphthalene concentration was measured on November 11, 2012 (58.5 ng/m^3) although a similar measurement (53.1 ng/m^3) was also measured in March. The 17 highest concentrations of naphthalene were measured at CHSC between January and March or October and December 2012.

22.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, a box plot was created for the pollutants shaded in gray in Table 22-4 for CHSC. Figure 22-6 overlays the site's minimum, annual average, and maximum naphthalene concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations of naphthalene, as described in Section 3.5.3.1.

Figure 22-6. Program vs. Site-Specific Average Naphthalene Concentration



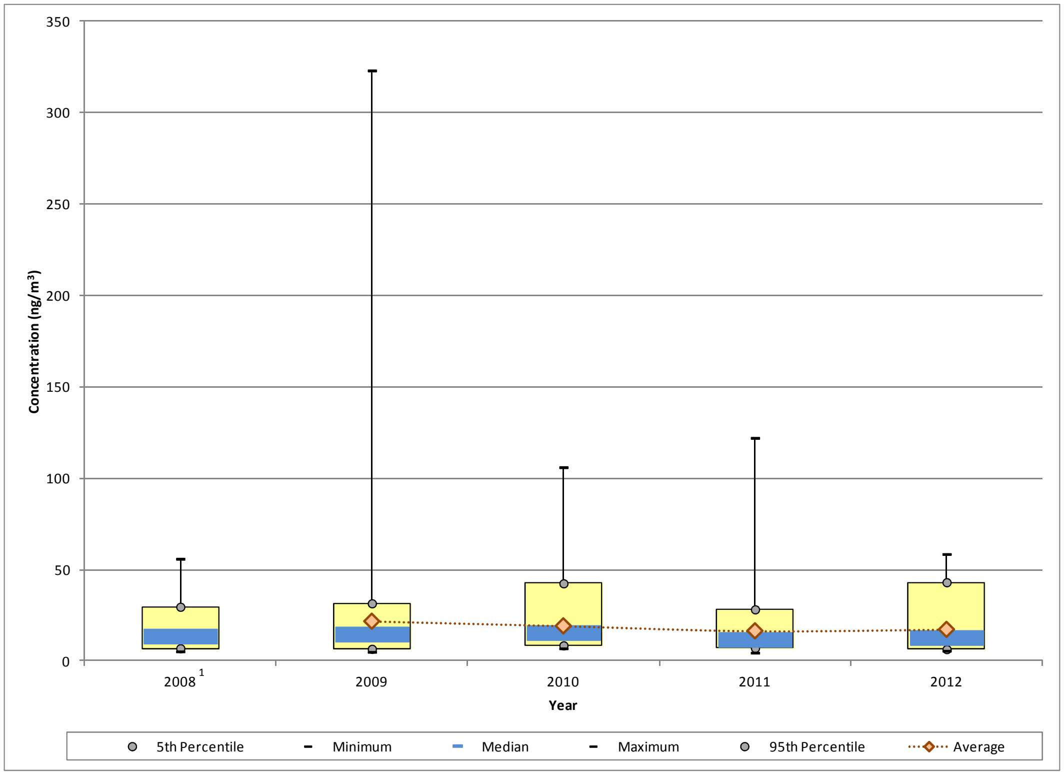
Observations from Figure 22-6 include the following:

- Figure 22-6 is the box plot for naphthalene. The annual average concentration of naphthalene for CHSC is less than the program-level first quartile. The maximum naphthalene concentration measured at CHSC is less than the program-level average concentration as well as the program-level median concentration. There were no non-detects of naphthalene measured at CHSC or across the program. The range of naphthalene measurements collected at CHSC is among the smallest measured at an NMP site sampling PAHs.

22.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. CHSC has sampled PAHs under the NMP since 2008. Thus, Figure 22-7 presents the 1-year statistical metrics for the pollutant of interest for CHSC. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 22-7. Yearly Statistical Metrics for Naphthalene Concentrations Measured at CHSC



[1] A 1-year average is not presented because sampling under the NMP did not begin until March 2008.

Observations from Figure 22-7 for naphthalene measurements collected at CHSC include the following:

- CHSC began sampling PAHs under the NMP in March 2008. Because a full year's worth of data is not available, a 1-year average is not presented for 2008, although the range of measurements is provided.

- The maximum concentration of naphthalene was measured on May 1, 2009 (323 ng/m^3). This is the only concentration of naphthalene greater than 200 ng/m^3 measured at CHSC since the onset of PAH sampling. Only two measurements greater than 100 ng/m^3 have been measured (one each in 2010 and 2011) and no other concentrations greater than 60 ng/m^3 have been measured at this site.

- The majority of naphthalene concentrations measured at CHSC fall within a relatively small range, as indicated by the 5th and 95th percentiles.
- The 1-year average concentration of naphthalene has changed relatively little of the years of sampling. The 1-year average has ranged from 16.42 ng/m^3 (2011) to 21.71 ng/m^3 (2009).

22.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the CHSC monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

22.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the South Carolina monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

22.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the South Carolina monitoring site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 22-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 22-6. Risk Approximations for the South Carolina Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Chesterfield, South Carolina - CHSC						
Naphthalene	0.000034	0.003	53/53	17.26 ± 3.25	0.59	0.01

Observations for CHSC from Table 22-6 include the following:

- Naphthalene has both a cancer URE and a noncancer RfC.
- The cancer risk approximation for naphthalene is less than 1 in-a-million (0.59 in-a-million).
- The noncancer hazard approximation for naphthalene is very low (0.01), indicating that no adverse health effects are expected from this individual pollutant.

22.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 22-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 22-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 22-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for the site, as presented in Table 22-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 22-7. Table 22-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 22-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the South Carolina Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Chesterfield, South Carolina (Chesterfield County) - CHSC					
Benzene	22.71	Formaldehyde	2.73E-04	Naphthalene	0.59
Formaldehyde	21.01	Benzene	1.77E-04		
Acetaldehyde	11.34	1,3-Butadiene	9.95E-05		
Ethylbenzene	10.96	Naphthalene	4.07E-05		
1,3-Butadiene	3.32	Arsenic, PM	3.20E-05		
Naphthalene	1.20	Ethylbenzene	2.74E-05		
Trichloroethylene	0.30	POM, Group 2b	2.64E-05		
POM, Group 2b	0.30	Acetaldehyde	2.49E-05		
POM, Group 1a	0.27	POM, Group 1a	2.38E-05		
POM, Group 2d	0.26	POM, Group 5a	2.36E-05		

Table 22-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the South Carolina Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Chesterfield, South Carolina (Chesterfield County) - CHSC					
Toluene	135.33	Acrolein	30,334.22	Naphthalene	0.01
Ethylene glycol	64.96	Formaldehyde	2,143.93		
Xylenes	48.09	Cyanide Compounds, gas	2,002.83		
Hexane	42.54	1,3-Butadiene	1,658.43		
Methanol	30.61	Acetaldehyde	1,259.78		
Benzene	22.71	Benzene	756.90		
Formaldehyde	21.01	Lead, PM	568.43		
Acetaldehyde	11.34	Arsenic, PM	495.51		
Ethylbenzene	10.96	Xylenes	480.89		
Methyl isobutyl ketone	4.44	Cadmium, PM	419.93		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 22.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 22-7 include the following:

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in Chesterfield County.
- Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Chesterfield County.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Chesterfield County.
- Naphthalene, the only pollutant of interest for CHSC, appears on both emissions-based lists, with the sixth highest emissions and the fourth highest toxicity-weighted emissions for Chesterfield County.
- Several POM Groups appear among the pollutants with the highest emissions and toxicity-weighted emissions. POM, Group 2b appears on both emissions-based lists and includes several PAHs sampled for at CHSC including acenaphthylene, fluoranthene, and perylene. POM, Group 2d, which includes phenanthrene and pyrene, ranks tenth for quantity emitted but is not among those with the highest toxicity-weighted emissions. POM, Group 5a, which includes benzo(a)pyrene, ranks tenth for toxicity weighted emissions but is not among the highest emitted. None of the pollutants sampled for at CHSC and included in POM, Groups 2b, 2d, or 5a failed screens for CHSC. POM, Group 1a, which appears on both emissions-based lists, does not include any PAHs sampled for at CHSC.

Observations from Table 22-8 include the following:

- Toluene, ethylene glycol, and xylenes are the highest emitted pollutants with noncancer RfCs in Chesterfield County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and cyanide compounds (gaseous).

- Four of the highest emitted pollutants in Chesterfield County also have the highest toxicity-weighted emissions.

- Naphthalene does not appear on either emissions-based list in Table 22-8, ranking 16th for quantity emitted and 12th for its toxicity-weighted emissions.

22.6 Summary of the 2012 Monitoring Data for CHSC

Results from several of the data treatments described in this section include the following:

- *Naphthalene was the only pollutant to fail screens for CHSC. This site has the fourth lowest number of failed screens (7) among all NMP sites.*

- *Concentrations of naphthalene measured during the colder months of the year were greater than those measured during the warmer months of the year.*

- *Concentrations of naphthalene have changed little since the onset of PAH sampling at CHSC.*

23.0 Site in South Dakota

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP site in South Dakota, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

23.1 Site Characterization

This section characterizes the monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The South Dakota monitoring site is located in Sioux Falls, South Dakota (SSSD). Figure 23-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 23-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 23-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 23-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 23-1. Sioux Falls, South Dakota (SSSD) Monitoring Site

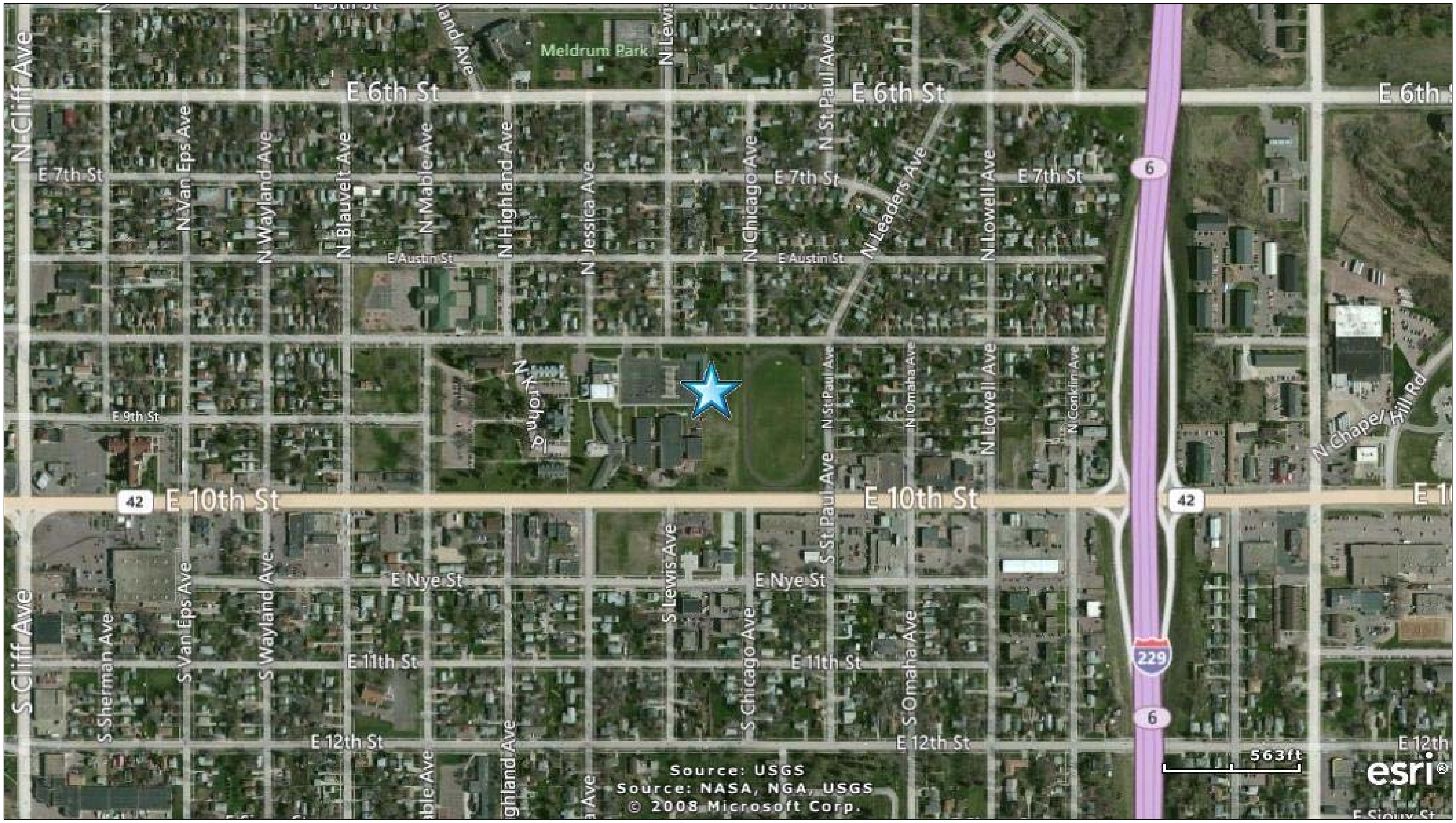
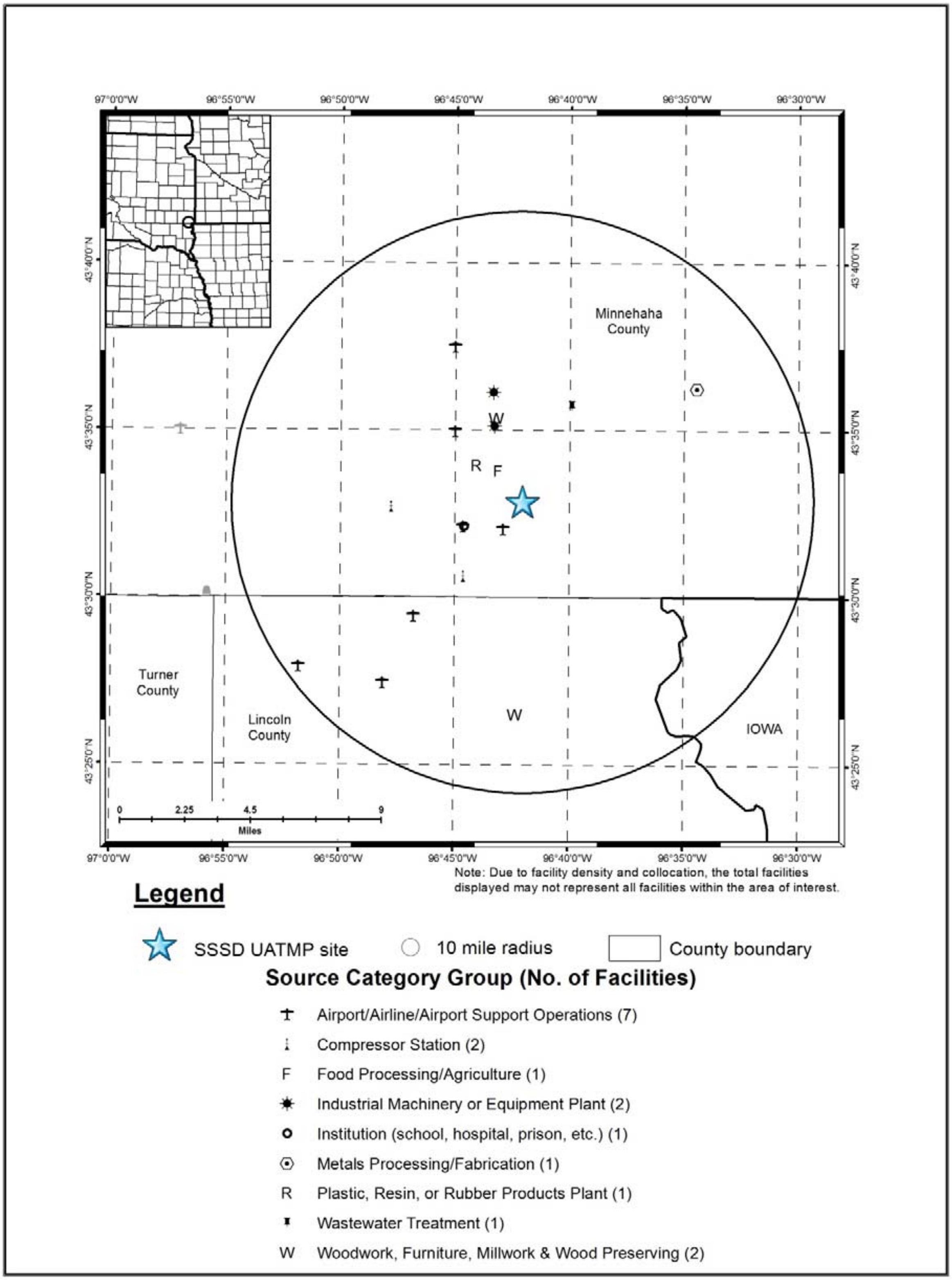


Figure 23-2. NEI Point Sources Located Within 10 Miles of SSSD



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 23-1. Geographical Information for the South Dakota Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
SSSD	46-099-0008	Sioux Falls	Minnehaha	Sioux Falls, SD MSA	43.54792, -96.700769	Commercial	Urban/City Center	CO, SO_2, NO, NO_2, NO_x, NOy, O_3, Meteorological parameters, PM_{10}, PM coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for SSSD (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

SSSD is located on the east side of Sioux Falls, in southeast South Dakota. The monitoring site is located at the South Dakota School for the Deaf. The surrounding area is mixed usage, with both commercial and residential areas surrounding the site. SSSD is less than one-half mile from the intersection of Highway 42 (East 10th Street) and I-229, as shown in Figure 23-1. As Figure 23-2 shows, relatively few emissions sources are located within 10 miles of SSSD. The source category with the greatest number of point sources shown in Figure 23-2 is the airport and airport support operations category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. The emissions sources closest to SSSD are a hospital heliport and a food processing facility.

Table 23-2 presents additional site-characterizing information, including indicators of mobile source activity, for the South Dakota monitoring site. Table 23-2 includes both county-level population and vehicle registration information. Table 23-2 also contains traffic volume information for SSSD site as well as the location for which the traffic volume was obtained. Additionally, Table 23-2 presents the county-level daily VMT for Minnehaha County.

Table 23-2. Population, Motor Vehicle, and Traffic Information for the South Dakota Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
SSSD	175,037	212,507	18,575	E 10th St, east of N. Mable Ave	3,778,321

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (SD DOR, 2012)
[3] AADT reflects 2012 data (SD DOT, 2012)
[4] County-level VMT reflects 2012 data (SD DOT, 2013)

Observations from Table 23-2 include the following:

- The county-level population for SSSD ranks in the bottom third compared to other counties with NMP sites. The county-level vehicle registration for SSSD is similarly ranked compared to other counties with NMP sites.

- The traffic volume for SSSD is in the middle of the range compared to other NMP sites. Traffic data for SSSD are provided for East 10th Street, east of N. Mable Avenue.

- The daily VMT for Minnehaha County is in the bottom third among counties with NMP sites (where VMT was available).

23.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in South Dakota on sample days, as well as over the course of the year.

23.2.1 Climate Summary

The Sioux Falls area has a continental climate, with cold winters, warm summers, and often drastic day-to-day variations. Precipitation varies throughout the year, with the spring and summer seasons receiving more than half of the annual rainfall, primarily in the form of thunderstorms. On average, a south wind blows in the summer and fall and a northwest wind blows in the winter and early spring. Flooding is often a concern in the area during springtime when snow begins to melt, although a flood control system, including levees and a diversion channel, was constructed to reduce the flood threat within the city limits. (Wood, 2004).

23.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the South Dakota monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station is located at Joe Foss Field Airport near SSSD, WBAN 14944. Additional information about this weather station, such as the distance between the site and the weather station, is provided in Table 23-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 23-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for the entire year. Also included in Table 23-3 is the 95 percent confidence interval for each parameter. As shown in Table 23-3, average meteorological conditions on sample days near SSSD were representative of average weather conditions experienced throughout the year.

Table 23-3. Average Meteorological Conditions near the South Dakota Monitoring Site

Closest Weather Station (WBAN and Coordinates)	**Distance and Direction from Site**	**Average Type[1]**	**Average Maximum Temperature (°F)**	**Average Temperature (°F)**	**Average Dew Point Temperature (°F)**	**Average Wet Bulb Temperature (°F)**	**Average Relative Humidity (%)**	**Average Sea Level Pressure (mb)**	**Average Scalar Wind Speed (kt)**
Sioux Falls, South Dakota - SSSD									
Joe Foss Field Airport 14944 (43.58, -96.75)	3.2 miles 310° (NW)	Sample Days (62)	61.3 ± 5.7	50.3 ± 5.2	37.4 ± 4.4	43.8 ± 4.4	65.8 ± 3.5	1014.8 ± 1.8	8.6 ± 1.1
		2012	62.1 ± 2.4	50.9 ± 2.2	37.4 ± 1.9	44.1 ± 1.9	64.5 ± 1.4	1014.8 ± 0.8	8.3 ± 0.4

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

23.2.3 Back Trajectory Analysis

Figure 23-3 is the composite back trajectory map for days on which samples were collected at the SSSD monitoring site. Included in Figure 23-3 are four back trajectories per sample day. Figure 23-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 23-3 and 23-4 represents 100 miles.

Observations from Figures 23-3 and 23-4 for SSSD include the following:

- Back trajectories originated from a variety of directions at the SSSD site. The longest back trajectories originated from the northwest.

- The 24-hour air shed domain for SSSD is among the largest air sheds compared to other NMP monitoring sites. The farthest away a back trajectory originated was over British Columbia, Canada or greater than 950 miles away, although additional back trajectories also originated over Alberta and Saskatchewan. SSSD is the only site with back trajectories greater than 900 miles in length, although the average back trajectory length was nearly 286 miles.

- The cluster analysis shows that back trajectories originating from the north, northwest quadrant, and west account for more than 40 percent of back trajectories, but are split into three clusters based on length. Another 17 percent of back trajectories originated to the south of SSSD, over Nebraska, Kansas, and Oklahoma. Ten percent of back trajectories originated to the southeast of SSSD, primarily over Iowa and Missouri. The shorter cluster trajectory (32 percent) originating to the north of SSSD represents shorter trajectories (< 200 miles in length) originating from a variety of directions, although primarily along and east of the South Dakota border.

Figure 23-3. Composite Back Trajectory Map for SSSD

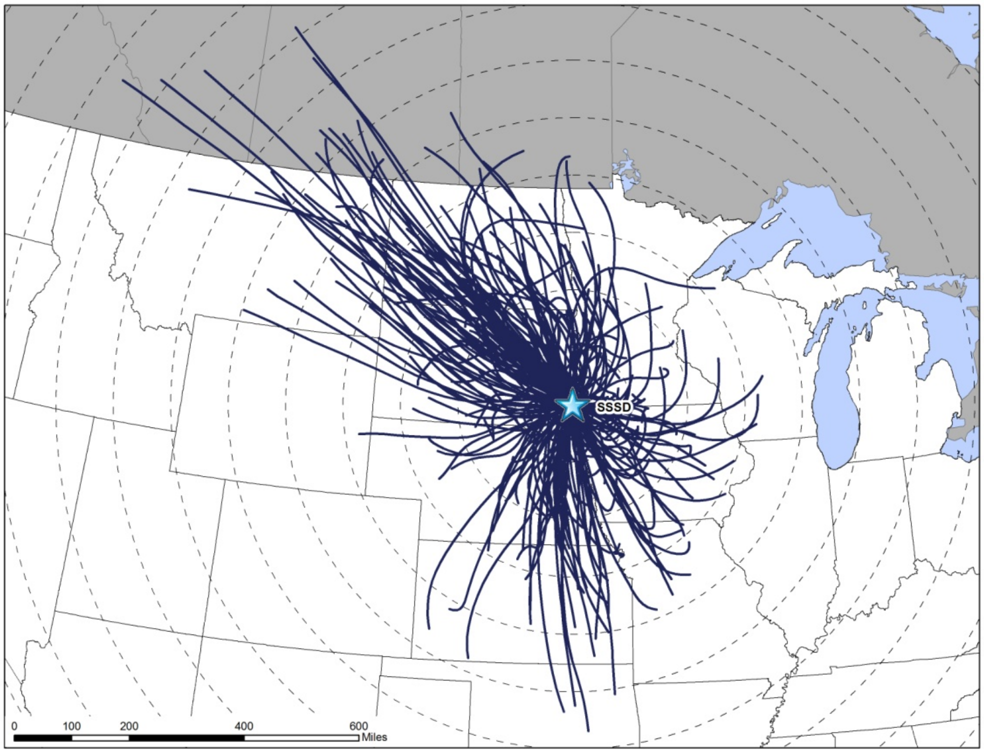
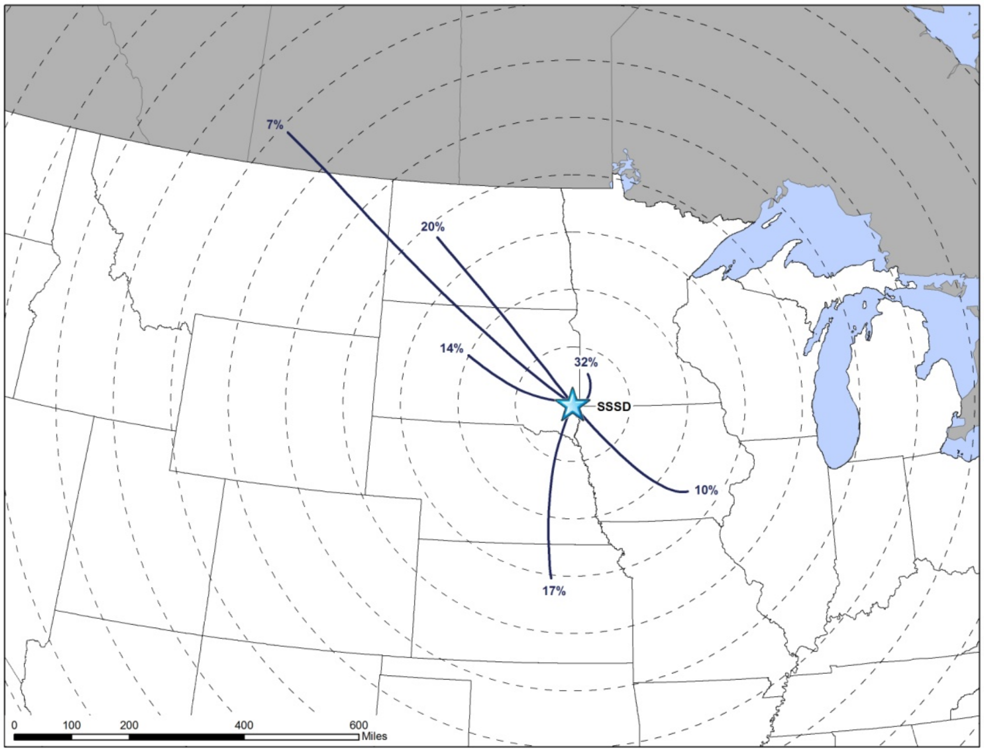


Figure 23-4. Back Trajectory Cluster Map for SSSD



23.2.4 Wind Rose Comparison

Hourly surface wind data from the weather station at Joe Foss Field Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 23-5 presents a map showing the distance between the weather station and SSSD, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 23-5 also presents three different wind roses for the SSSD monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 23-5 for SSSD include the following:

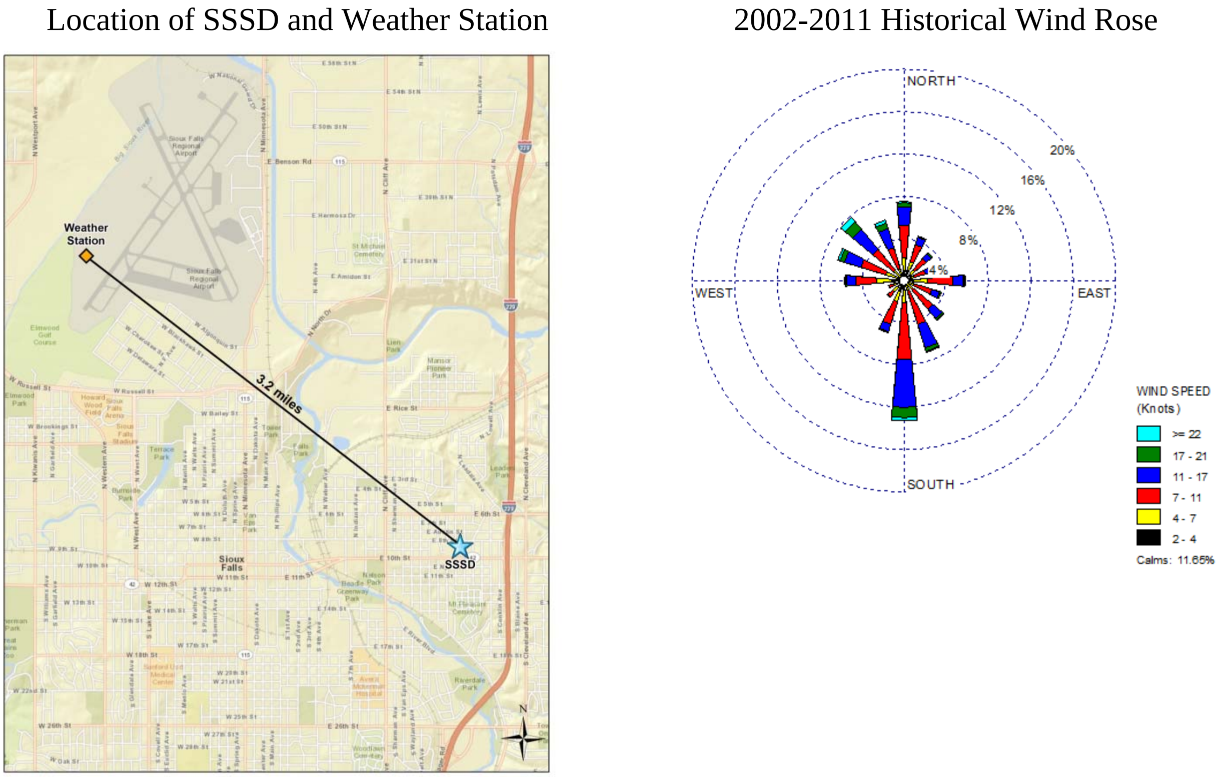
- The Joe Foss Field Airport weather station is located approximately 3.2 miles northwest of SSSD.

- The historical wind rose shows that winds from a variety of directions were observed near SSSD, although winds from the south were observed the most (13 percent), and southwesterly and west-southwesterly winds observed the least (less than 2 percent). Calm winds were observed for approximately 12 percent of the observations. The strongest winds tend to be from the south or the northwest quadrant.

- The 2012 wind patterns are very similar to the historical wind patterns, although calm winds account for greater than 14 percent of the observations. This indicates that wind conditions in 2012 near SSSD are similar to historical wind conditions.

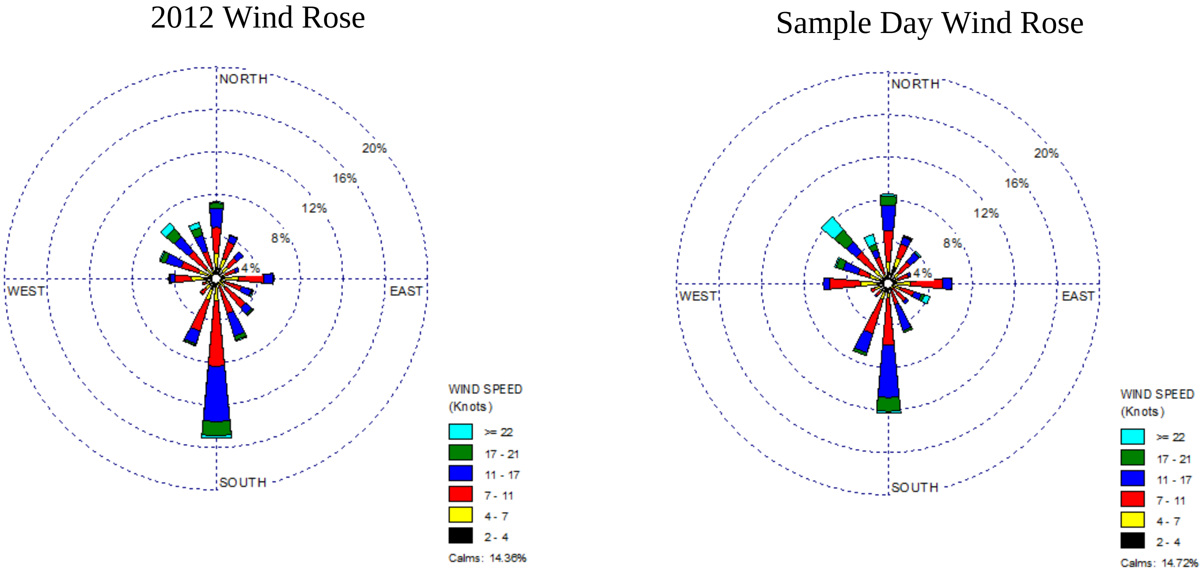
- The sample day wind rose also resembles the full-year wind rose, but does exhibit some differences. Southerly winds were still prominent, but there is a higher percentage of wind observations from the north, northwest, west, and south-southwest. There were also fewer observations from the southeast quadrant.

Figure 23-5. Wind Roses for the Joe Foss Field Airport Weather Station near SSSD



Location of SSSD and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

23.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the South Dakota monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 23-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 23-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. SSSD sampled for VOCs, SNMOCs, and carbonyl compounds.

Table 23-4. Risk-Based Screening Results for the South Dakota Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Sioux Falls, South Dakota - SSSD						
Benzene	0.13	61	61	100.00	16.99	16.99
Carbon Tetrachloride	0.17	60	61	98.36	16.71	33.70
Acetaldehyde	0.45	58	58	100.00	16.16	49.86
Formaldehyde	0.077	58	58	100.00	16.16	66.02
1,3-Butadiene	0.03	54	58	93.10	15.04	81.06
1,2-Dichloroethane	0.038	53	53	100.00	14.76	95.82
Ethylbenzene	0.4	4	61	6.56	1.11	96.94
Hexachloro-1,3-butadiene	0.045	4	4	100.00	1.11	98.05
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	1.11	99.16
p-Dichlorobenzene	0.091	2	25	8.00	0.56	99.72
Propionaldehyde	0.8	1	58	1.72	0.28	100.00
Total		359	501	71.66		

Observations from Table 23-4 include the following:

- Eleven pollutants failed at least one screen for SSSD; nearly 72 percent of concentrations for these 11 pollutants were greater than their associated risk screening value (or failed screens).

- Many of the pollutants listed in Table 23-4 failed 100 percent of screens. However, the detection rate of these pollutants varied. For example, benzene was detected in all 61 sampled collected at SSSD and failed all screens. Hexachloro-1,3-butadiene also failed 100 percent of screens but was detected only four times.

- Six pollutants contributed to 95 percent of failed screens for SSSD and therefore were identified as pollutants of interest. These six include two carbonyl compounds and four VOCs.

- Recall from Section 3.2 that if a pollutant was measured by both the TO-15 and SNMOC methods at the same site, the TO-15 results were used for the risk-based screening process. As SSSD sampled both VOCs (TO-15) and SNMOCs, the TO-15 results were used for the 12 pollutants these methods have in common.

23.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the South Dakota monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for the site.

- Annual concentration averages are presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for SSSD are provided in Appendices J through L.

23.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the South Dakota site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the South Dakota monitoring site are presented in Table 23-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 23-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the South Dakota Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Sioux Falls, South Dakota - SSSD						
Acetaldehyde	58/58	1.37 ± 0.32	1.39 ± 0.24	2.45 ± 0.70	1.57 ± 0.30	1.69 ± 0.23
Benzene	61/61	0.72 ± 0.12	0.52 ± 0.07	0.68 ± 0.26	0.60 ± 0.09	0.63 ± 0.08
1,3-Butadiene	58/61	0.06 ± 0.02	0.04 ± 0.01	0.12 ± 0.04	0.11 ± 0.04	0.08 ± 0.02
Carbon Tetrachloride	61/61	0.58 ± 0.08	0.69 ± 0.06	0.67 ± 0.04	0.62 ± 0.09	0.64 ± 0.03
1,2-Dichloroethane	53/61	0.08 ± 0.01	0.07 ± 0.02	0.05 ± 0.02	0.06 ± 0.02	0.07 ± 0.01
Formaldehyde	58/58	1.60 ± 0.27	1.85 ± 0.43	2.74 ± 0.41	1.30 ± 0.19	1.86 ± 0.21

Observations for SSSD from Table 23-5 include the following:

- The pollutants with the highest annual average concentrations are formaldehyde (1.86 ± 0.21 $\mu g/m^3$) and acetaldehyde (1.69 ± 0.23 $\mu g/m^3$). These are the only two pollutants of interest with an annual average greater than 1.0 $\mu g/m^3$.

- The third quarter average formaldehyde concentration is significantly higher than the other quarterly averages. A review of the data shows that formaldehyde concentrations measured at SSSD range from 0.68 $\mu g/m^3$ to 3.73 $\mu g/m^3$. The maximum concentration of formaldehyde was measured on September 30, 2012. Of the eight concentrations greater than 3 $\mu g/m^3$ measured at SSSD, six were measured during the third quarter, the maximum in September and the other five on each of the sample days in July (the other two were measured in June). Conversely, none of the seven concentrations of formaldehyde less than 1 $\mu g/m^3$ were measured during the third quarter of 2012 (two were measured during the first quarter, two were measured during the second, and three were measured during the fourth).

- The third quarterly average concentration of acetaldehyde for SSSD is also the highest quarterly average and has a relatively large confidence interval associated with it. A review of the data shows that acetaldehyde concentrations measured at SSSD range from 0.68 $\mu g/m^3$ to 6.73 $\mu g/m^3$. The maximum acetaldehyde concentration was measured on the same day at SSSD as the maximum formaldehyde concentration (September 30, 2012). The second highest acetaldehyde concentration measured at SSSD is roughly half as high (3.25 µg/m^3) and was measured in July. There is more variability in the dates of the higher acetaldehyde concentrations than there is with formaldehyde. But, similar to formaldehyde, none of 12 concentrations of acetaldehyde less than 1 µg/m^3 were measured during the third quarter of 2012 (five were measured during the first quarter, four were measured during the second, and three were measured during the fourth).

- The maximum concentration of benzene was also measured on September 30, 2012. The maximum benzene concentration is 2.49 µg/m^3 and is the only concentration greater than 2 µg/m^3 measured at SSSD. The next highest concentration measured during the third quarter is considerably less (0.95 µg/m^3). This explains the relatively large confidence interval shown for the third quarter. Only two benzene concentrations greater than 1 µg/m^3 were measured at SSSD and were both measured during the first quarter of 2012.

- The third and fourth quarter average concentrations of 1,3-butadiene are greater than the first and second quarter averages. A review of the data shows that 1,3-butadiene concentrations range from 0.024 µg/m^3 to 0.306 µg/m^3, with three non-detects also measured. The maximum 1,3-butadiene concentration measured at SSSD was also measured on September 30th. All six concentrations of 1,3-butadiene greater than 0.2 µg/m^3 were measured during September and October. Further, all but two of the 14 concentrations greater than 0.1 µg/m^3 were measured at SSSD between August and October 2012.

23.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 23-4 for SSSD. Figures 23-6 through 23-12 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 23-6. Program vs. Site-Specific Average Acetaldehyde Concentration

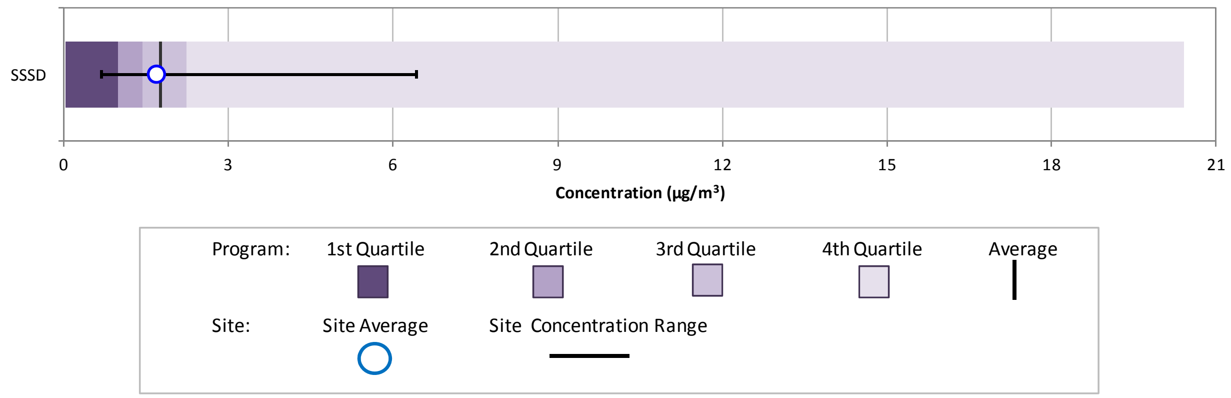


Figure 23-7. Program vs. Site-Specific Average Benzene Concentration

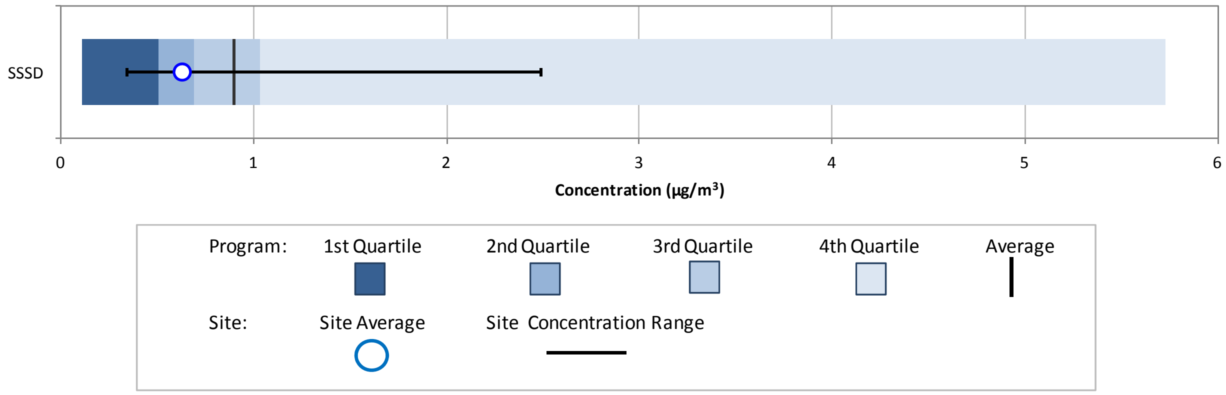


Figure 23-8. Program vs. Site-Specific Average 1,3-Butadiene Concentration

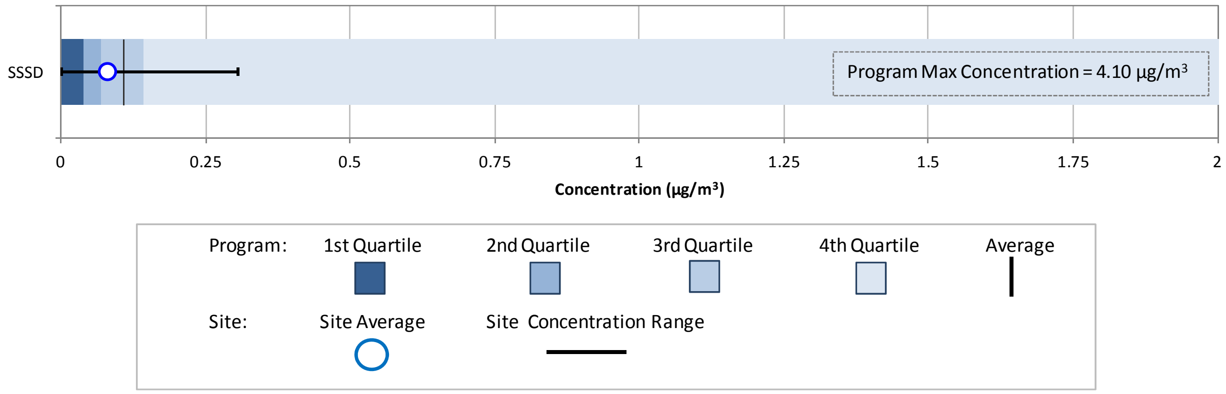


Figure 23-9. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

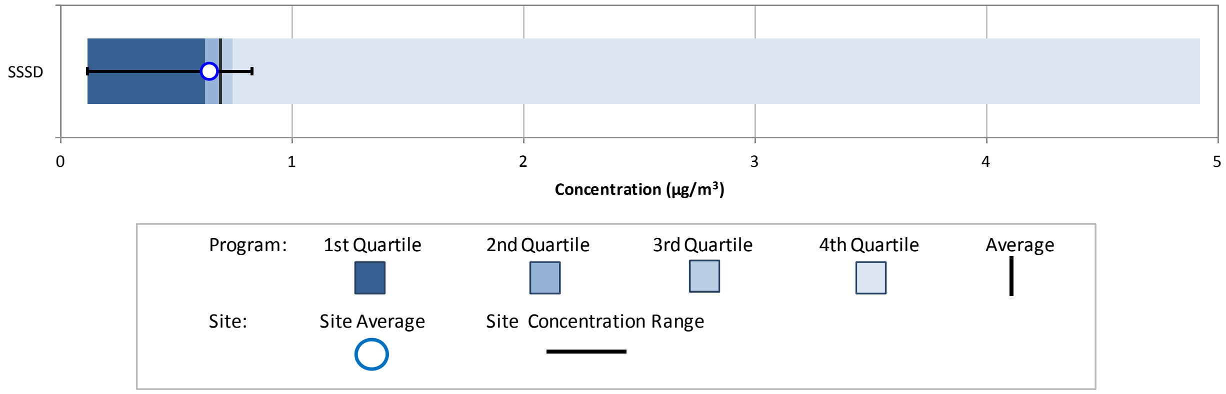


Figure 23-10. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

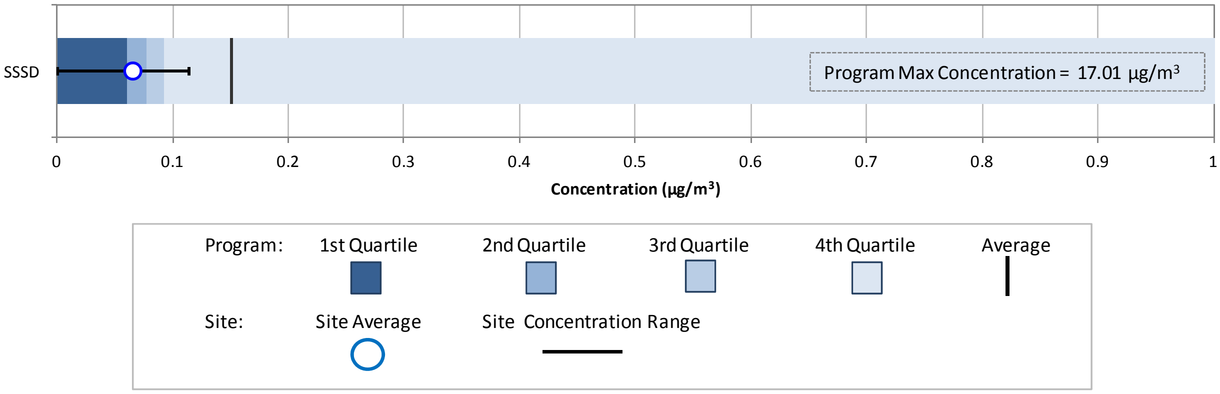
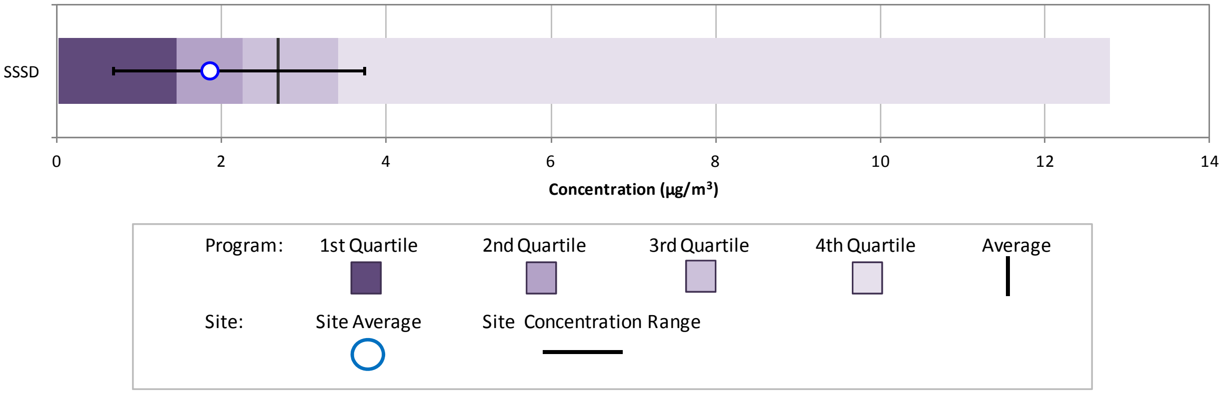


Figure 23-11. Program vs. Site-Specific Average Formaldehyde Concentration



Observations from Figures 23-6 through 23-11 include the following:

- Figure 23-6 shows that the annual average acetaldehyde concentration for SSSD is similar to the program-level average concentration. The maximum concentration measured at SSSD is considerably less than the maximum concentration measured across the program.

- Figure 23-7 shows that the annual average benzene concentration for SSSD is less than the program-level average and median concentrations. The annual average concentration of benzene for SSSD is among the lowest annual average concentrations among NMP sites sampling benzene. The maximum benzene concentration measured at SSSD is less than the maximum concentration measured across the program.

- The program-level maximum 1,3-butadiene concentration (4.10 µg/m^3) is not shown directly on the box plot in Figure 23-8 because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 2 µg/m^3. This figure shows that the annual average 1,3-butadiene for SSSD falls between the program-level average and median concentrations. The maximum 1,3-butadiene concentration measured at this site is considerably less than the maximum concentration measured across the program. A few non-detects of 1,3-butadiene were measured at this site.

- Figure 23-9 shows that the program-level average and median concentrations of carbon tetrachloride are about the same. The annual average concentration for SSSD is just less than these statistical parameters. The minimum carbon tetrachloride concentration measured across the program was measured at SSSD (0.11 $\mu g/m^3$).

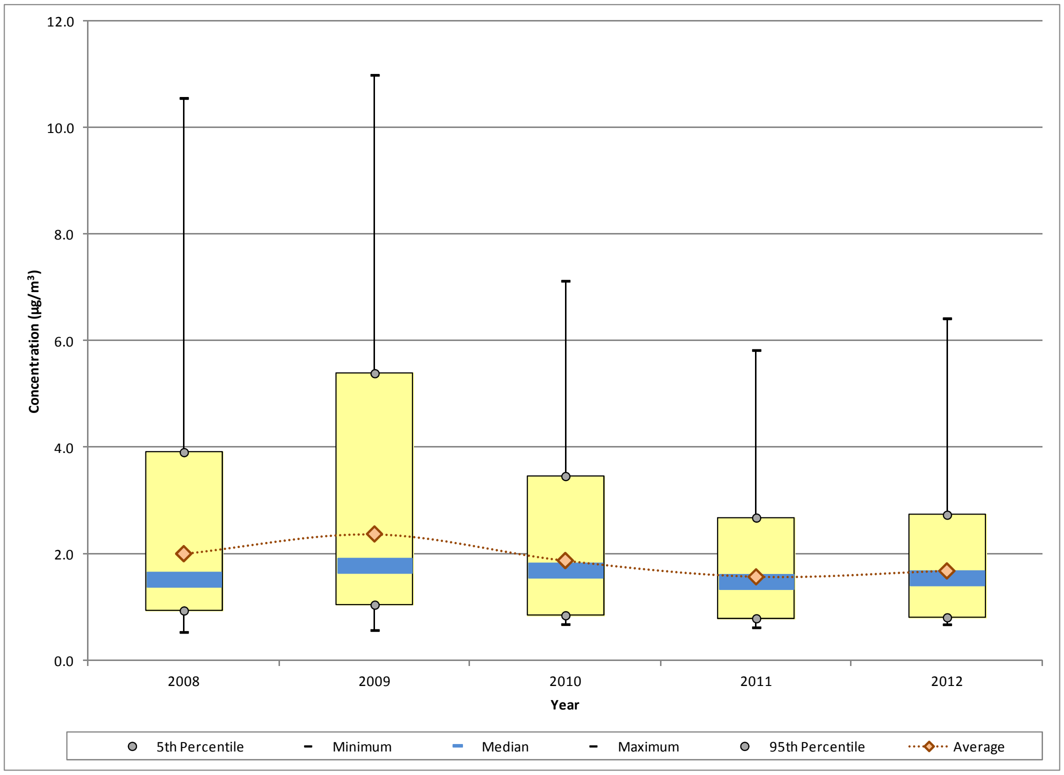
- Figure 23-10 presents the box plot for 1,2-dichloroethane. Similar to 1,3-butadiene, the program-level maximum concentration (17.01 $\mu g/m^3$) is not shown directly on the box plot as the scale has been reduced to 1 $\mu g/m^3$ in order to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is greater than the program third quartile for this pollutant and is greater than or similar to the maximum concentration measured at most sites sampling 1,2-dichloroethane. This is because the program-level average concentration is being driven by the higher measurements collected at a few monitoring sites. Figure 23-11 shows that the maximum 1,2-dichloroethane concentration measured at SSSD is two orders of magnitude less than the maximum concentration measured across the program and less than the program-level average concentration. The annual average concentration for SSSD is just greater than the program-level first quartile. Eight non-detects of 1,2-dichloroethane were measured at SSSD.

- Figure 23-11 shows that the annual average formaldehyde concentration for SSSD is less than both the program-level average and median concentrations. The maximum formaldehyde concentration measured at this site is considerably less than the maximum concentration measured across the program. There were no non-detects of formaldehyde measured at SSSD.

23.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. Sampling at SSSD began in 2008 after a re-location from a previous sampling site. Thus, Figures 23-12 through 23-17 present the 1-year statistical metrics for each of the pollutants of interest for SSSD. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 23-12. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SSSD



Observations from Figure 23-12 for acetaldehyde measurements collected at SSSD include the following:

- SSSD began sampling carbonyl compounds under the NMP in 2008.

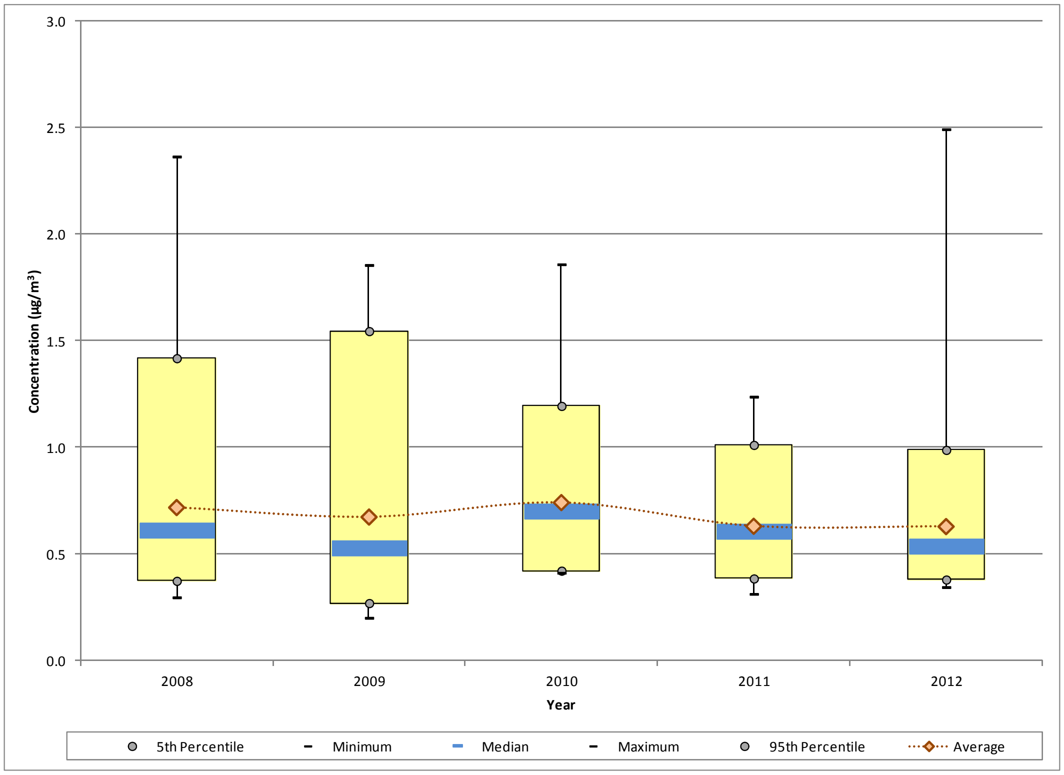
- The maximum acetaldehyde concentration (11.0 µg/m^3) was measured on February 6, 2009, although a similar measurement (10.6 µg/m^3) was also measured in January 2008. For both years, the second highest concentration measured was considerably less than the maximum concentration (5.22 µg/m^3 for 2008 and 6.57 µg/m^3 for 2009).

- Nearly all of the statistical parameters increased from 2008 to 2009, with the 95th percentile exhibiting the largest increase. The number of concentrations greater than 4 µg/m^3 increased from three in 2008 to eight in 2009. The 1-year average concentration increased from 2.00 µg/m^3 to 2.38 µg/m^3 from 2008 to 2009, although confidence intervals indicate that the change is not statistically significant.

- A steady decreasing trend in the acetaldehyde concentrations measured at SSSD is then shown through 2011, with little change shown for 2012. The range within which the majority of measurements fall, as indicated by the 5th and 95th percentiles, decreased by more than half from 2009 to 2011.

- Throughout the period of sampling, the median concentration exhibited little change, ranging from 1.49 µg/m^3 (2011) to 1.79 µg/m^3 (2009).

Figure 23-13. Yearly Statistical Metrics for Benzene Concentrations Measured at SSSD



Observations from Figure 23-13 for benzene measurements collected at SSSD include the following:

- SSSD also began sampling VOCs and SNMOCs under the NMP in 2008. Recall that if both VOCs and SNMOCs are sampled concurrently at a site, the TO-15 results are used for the 12 pollutants these methods have in common. Benzene is one of those 12 pollutants; thus, the results provided here are from TO-15.

- The maximum benzene concentration (2.49 µg/m^3) was measured at SSSD on September 30, 2012. Only one other benzene concentration greater than 2 µg/m^3 has been measured at SSSD (2.37 µg/m^3 on March 25, 2008).

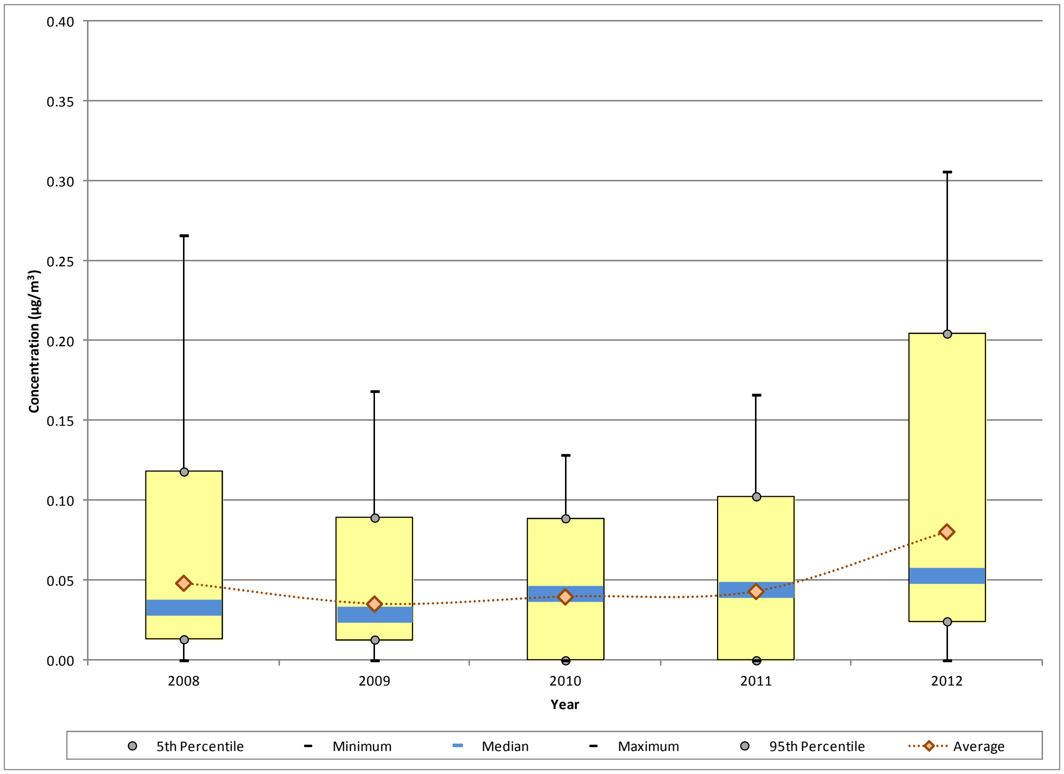
- With the exception of the 95th percentile, nearly all of the statistical parameters exhibit decreases from 2008 to 2009, which is the opposite of what is shown for acetaldehyde for the same time frame. However, both pollutants exhibit an increase in the range within which the majority of concentrations fall for 2009.

- The increases shown in the 1-year average and median concentrations for 2010 are partly a result of higher concentrations on the lower end of the concentration range. There were 14 concentrations in 2009 that are less than the minimum concentration measured in 2010. In addition, the number of concentrations between 0.5 µg/m^3 and 1 µg/m^3 increased by nearly 70 percent. These two factors resulted in the increases shown for 2010 as well as a tightening of the range within which a majority of the concentrations fell.

- All of the statistical parameters exhibit a decrease from 2010 to 2011.

- Even though the maximum concentration was measured in 2012, the difference between the 5th and 95th percentiles is at a minimum, as is the 1-year average concentration. Even so, the 1-year average concentration of benzene has changed relatively little over the years of sampling, ranging from 0.63 µg/m^3 (2012) to 0.74 µg/m^3 (2010).

Figure 23-14. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at SSSD



Observations from Figure 23-14 for 1,3-butadiene measurements collected at SSSD include the following:

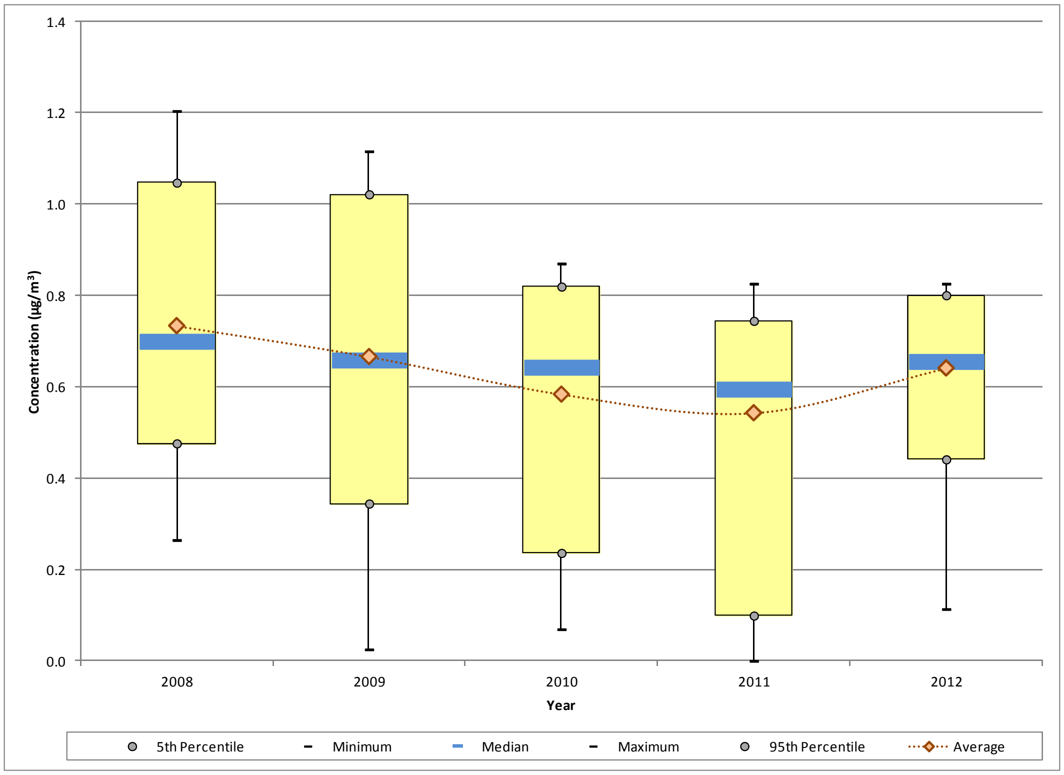
- The maximum 1,3-butadiene concentration (0.31 µg/m^3) was measured at SSSD on September 30, 2012, the same day as the maximum benzene concentration. Of the 14 1,3-butadiene concentration greater than 0.15 µg/m^3 measured at SSSD, 10 were measured in 2012.

- Nearly all of the statistical parameters exhibit a decrease from 2008 to 2009, with the exception of the minimum concentration. For both years, two non-detects were measured.

- The number of non-detects increased from 2009 to 2010, as indicated by the decrease in the 5th percentile. The number of non-detects increased from two for 2009 to 13 for 2010. Even so, the 1-year average and in particular, the median concentration exhibit increases. This is because the number of concentrations in the mid- to upper-end of the concentration range increased while those on the lower end of the range (but still detected) decreased. The number of 1,3-butadiene concentrations between 0.04 µg/m^3 and 0.08 µg/m^3 tripled from 2009 to 2010, increasing from nine to 27. Conversely, the number of measurements less than 0.04 µg/m^3 decreased from 44 in 2009 to 16 in 2010.

- While relatively little change in the concentrations of 1,3-butadiene is shown from 2010 to 2011, concentrations increased significantly for 2012. The maximum, 95th percentile, and 1-year average concentrations nearly doubled from 2011 to 2012. The median concentration also exhibits an increase. The number of non-detects also decreased significantly from 2011 to 2012, down to three from 17.

Figure 23-15. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at SSSD



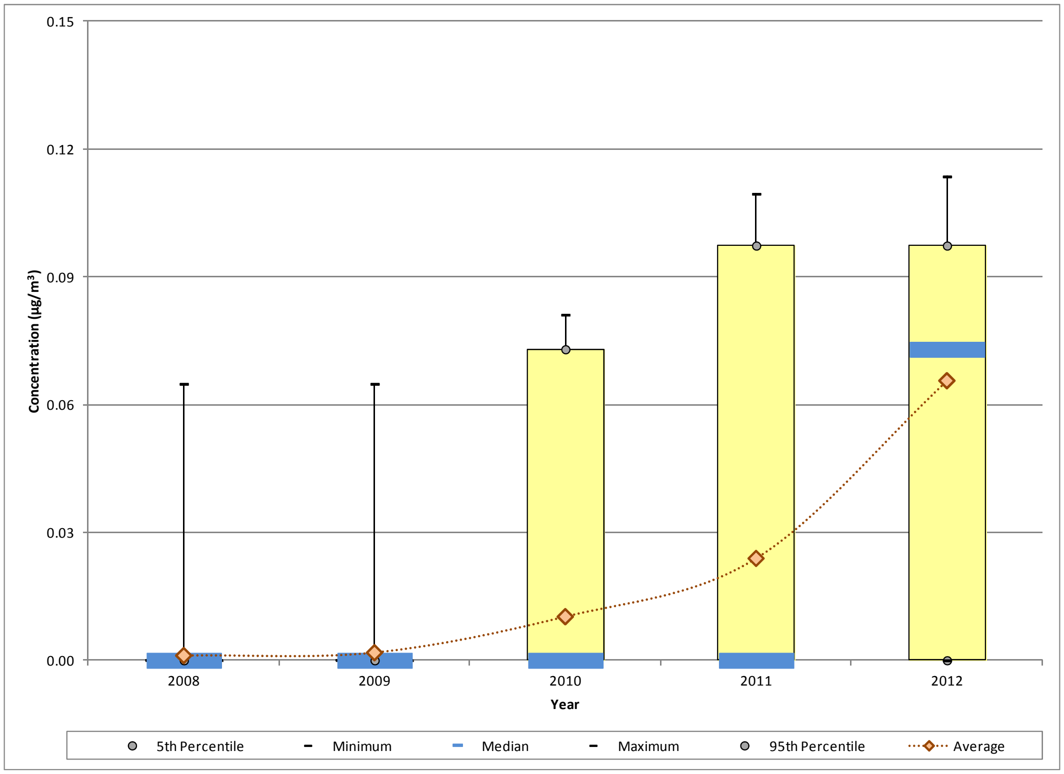
Observations from Figure 23-15 for carbon tetrachloride measurements collected at SSSD include the following:

- Eleven concentrations of carbon tetrachloride greater than 1.0 µg/m^3 have been measured at SSSD since the onset of sampling in 2008. All of these were measured in 2008 and 2009.

- The box and whisker plots for this pollutant appear "inverted," with the minimum concentration extending farther away from the majority of the measurements than the maximum (see benzene or 1,3-butadiene as examples). For 2010 and 2011, the central tendency statistics are closer to the 95th percentile than the 5th percentile, with the median concentration greater than the 1-year average concentration, both of which are a little unusual. The median concentration is the midpoint of a dataset. The difference between the maximum concentration and median for 2010 is 0.23 µg/m^3; the difference between the median and the minimum concentration is 0.57 µg/m^3. Thus, a greater number of concentrations are clustered around the upper end of the concentration range, while the concentrations on the lower end of the concentration range are more spread apart. Because the 1-year average concentration is influenced more by outlying concentrations, the 1-year average is being pulled downward by the concentrations at the lower end of the range. The same is true for 2011.

- The concentrations measured in 2012 exhibit less variability, as indicated by the difference between the 5th and 95th percentiles, which decreased by almost half from 2011 to 2012.
- Even though the range of measurements across the years of sampling vary by more than 1 µg/m^3, the median concentration for each year varied by 0.1 µg/m^3 and the 1-year average concentration varied by less than 0.2 µg/m^3.

Figure 23-16. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at SSSD



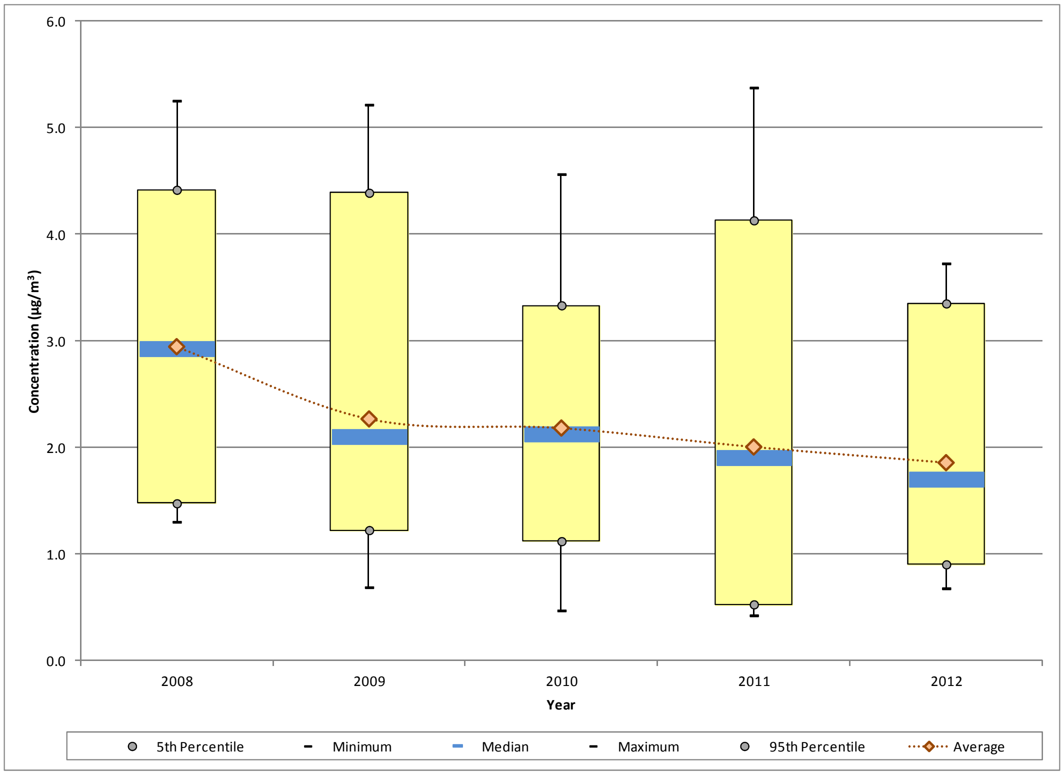
Observations from Figure 23-16 for 1,2-dichloroethane measurements collected at SSSD include the following:

- There was only one measured detection of 1,2-dichloromethane in 2008 and only two in 2009; as a result, nearly all of the statistical metrics are equal to or just greater than zero.

- The number of measured detections increased to nine in 2010 and to 17 in 2011. This explains the significant increases shown in the 95th percentiles and 1-year average concentrations. However, the median concentration is still zero because more than half of the measurements are still non-detects.

- For 2012, measured detections account for nearly 87 percent of the measurements. As a result, only the minimum and 5th percentile are zero for 2012 and both the median and 1-year average concentration exhibit significant increases.

Figure 23-17. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SSSD



Observations from Figure 23-17 for formaldehyde measurements collected at SSSD include the following:

- The maximum formaldehyde concentration (5.38 µg/m^3) was measured on May 1, 2011, although concentrations greater than 5 µg/m^3 were also measured in 2008 and 2009.

- While the maximum and 95th percentile did not change from 2008 to 2009, the remaining statistical parameters decreased, particularly the 1-year average and median concentrations. The number of concentrations greater than 3 μg/m^3 decreased from 25 in 2008 to seven in 2009 while the number of concentrations less than 2 μg/m^3 increased from 10 in 2008 to 29 in 2009.

- The significant decrease in formaldehyde concentrations shown from 2008 to 2009 is followed by a slight decreasing trend through 2012.

23.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the South Dakota monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

23.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the South Dakota monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

23.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the South Dakota site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 23-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 23-6. Risk Approximations for the South Dakota Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Sioux Falls, South Dakota - SSSD						
Acetaldehyde	0.0000022	0.009	58/58	1.69 ± 0.23	3.71	0.19
Benzene	0.0000078	0.03	61/61	0.63 ± 0.08	4.91	0.02
1,3-Butadiene	0.00003	0.002	58/61	0.08 ± 0.02	2.41	0.04
Carbon Tetrachloride	0.000006	0.1	61/61	0.64 ± 0.03	3.85	0.01
1,2-Dichloroethane	0.000026	2.4	53/61	0.07 ± 0.01	1.71	<0.01
Formaldehyde	0.000013	0.0098	58/58	1.86 ± 0.21	24.15	0.19

Observations from Table 23-6 for SSSD include the following:

- The pollutants with the highest annual average concentrations for SSSD are formaldehyde and acetaldehyde.
- Formaldehyde has the highest cancer risk approximation (24.15 in-a-million) among this site's pollutants of interest, followed by benzene (4.91 in-a-million) and carbon tetrachloride (3.85 in-a-million).
- Acetaldehyde and formaldehyde have the highest noncancer hazard approximations among SSSD's pollutants of interest, both with an HQ of 0.19. Because none of the noncancer hazard approximations were greater than 1.0, no adverse health effects are expected from these individual pollutants.

23.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 23-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 23-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 23-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for SSSD, as presented in Table 23-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 23-7. Table 23-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 23.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 23-7 include the following:

- Formaldehyde, benzene, and ethylbenzene are the highest emitted pollutants with cancer UREs in Minnehaha County.
- Formaldehyde, benzene, and POM, Group 1a are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Minnehaha County.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Minnehaha County.
- Formaldehyde and benzene top both emissions-based lists and have the highest cancer risk approximations for SSSD. Acetaldehyde and 1,3-butadiene also appear on all three lists. Conversely, carbon tetrachloride and 1,2-dichloroethane appear on neither emissions-based list but are among the pollutants of interest for SSSD.
- Naphthalene and several POM Groups appear among the highest emitted pollutants in Minnehaha County and are among those with the highest toxicity-weighted emissions. PAHs were not sampled for at SSSD.

Table 23-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the South Dakota Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Sioux Falls, South Dakota (Minnehaha County) - SSSD					
Formaldehyde	94.68	Formaldehyde	1.23E-03	Formaldehyde	24.15
Benzene	72.38	Benzene	5.65E-04	Benzene	4.91
Ethylbenzene	54.26	POM, Group 1a	4.28E-04	Carbon Tetrachloride	3.85
Acetaldehyde	48.96	1,3-Butadiene	4.17E-04	Acetaldehyde	3.71
1,3-Butadiene	13.91	Naphthalene	1.72E-04	1,3-Butadiene	2.41
Naphthalene	5.05	POM, Group 3	1.43E-04	1,2-Dichloroethane	1.71
POM, Group 1a	4.87	Ethylbenzene	1.36E-04		
POM, Group 2b	1.21	Hexavalent Chromium, PM	1.21E-04		
Trichloroethylene	1.14	Acetaldehyde	1.08E-04		
POM, Group 2d	0.98	POM, Group 2b	1.06E-04		

Table 23-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the South Dakota Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Sioux Falls, South Dakota (Minnehaha County) - SSSD					
Toluene	506.57	Acrolein	124,884.21	Formaldehyde	0.19
Xylenes	258.52	Formaldehyde	9,661.40	Acetaldehyde	0.19
Ethylene glycol	210.29	1,3-Butadiene	6,957.09	1,3-Butadiene	0.04
Hexane	148.02	Acetaldehyde	5,440.09	Benzene	0.02
Methanol	106.78	Xylenes	2,585.24	Carbon Tetrachloride	0.01
Formaldehyde	94.68	Benzene	2,412.62	1,2-Dichloroethane	<0.01
Benzene	72.38	Naphthalene	1,684.45		
Ethylbenzene	54.26	Hydrochloric acid	973.59		
Acetaldehyde	48.96	Arsenic, PM	958.91		
Styrene	22.93	Lead, PM	944.44		

Observations from Table 23-8 include the following:

- Toluene, xylenes, and ethylene glycol are the highest emitted pollutants with noncancer RfCs in Minnehaha County.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs), followed by formaldehyde and 1,3-butadiene. Although acrolein was sampled for at SSSD, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2. Acrolein is not one of the highest emitted pollutants in Minnehaha County.

- Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Minnehaha County.

- Formaldehyde and acetaldehyde, which have the highest noncancer hazard approximations for SSSD, appear on both emissions-based lists, as does benzene. 1,3-Butadiene appears among those with the highest toxicity-weighted emissions but is not one of the highest emitted (with a noncancer RfC) in Minnehaha County. Carbon tetrachloride and 1,2-dichloroethane again appear on neither emissions-based list.

23.6 Summary of the 2012 Monitoring Data for SSSD

Results from several of the data treatments described in this section include the following:

- ❖ *Eleven pollutants failed at least one screen for SSSD.*

- ❖ *Formaldehyde and acetaldehyde are the only pollutants of interest for which the annual average concentrations were greater than 1 µg/m^3.*

- ❖ *The maximum concentrations of several of SSSD's pollutants of interest were measured at SSSD on September 30, 2012.*

- ❖ *Concentrations of 1,3-butadiene increased significantly from 2011 to 2012. Conversely, formaldehyde concentrations measured at SSSD exhibit a steady decreasing trend across the years, although the most significant decreases were realized during the early years of sampling. In addition, the detection rate of 1,2-dichloroethane has been increasing steadily at SSSD over the years of sampling.*

24.0 Sites in Texas

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS sites in Texas, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

24.1 Site Characterization

This section characterizes the CAMS 35 and CAMS 85 monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The CAMS 35 monitoring site is located in the Houston-The Woodlands-Sugarland, Texas MSA and CAMS 85 is part of the Marshall, Texas MSA. Figure 24-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 24-2 identifies nearby point source emissions locations by source category for the site, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 24-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 24-3 and 24-4 are the composite satellite image and point emissions sources map for CAMS 85. Table 24-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 24-1. Deer Park, Texas (CAMS 35) Monitoring Site

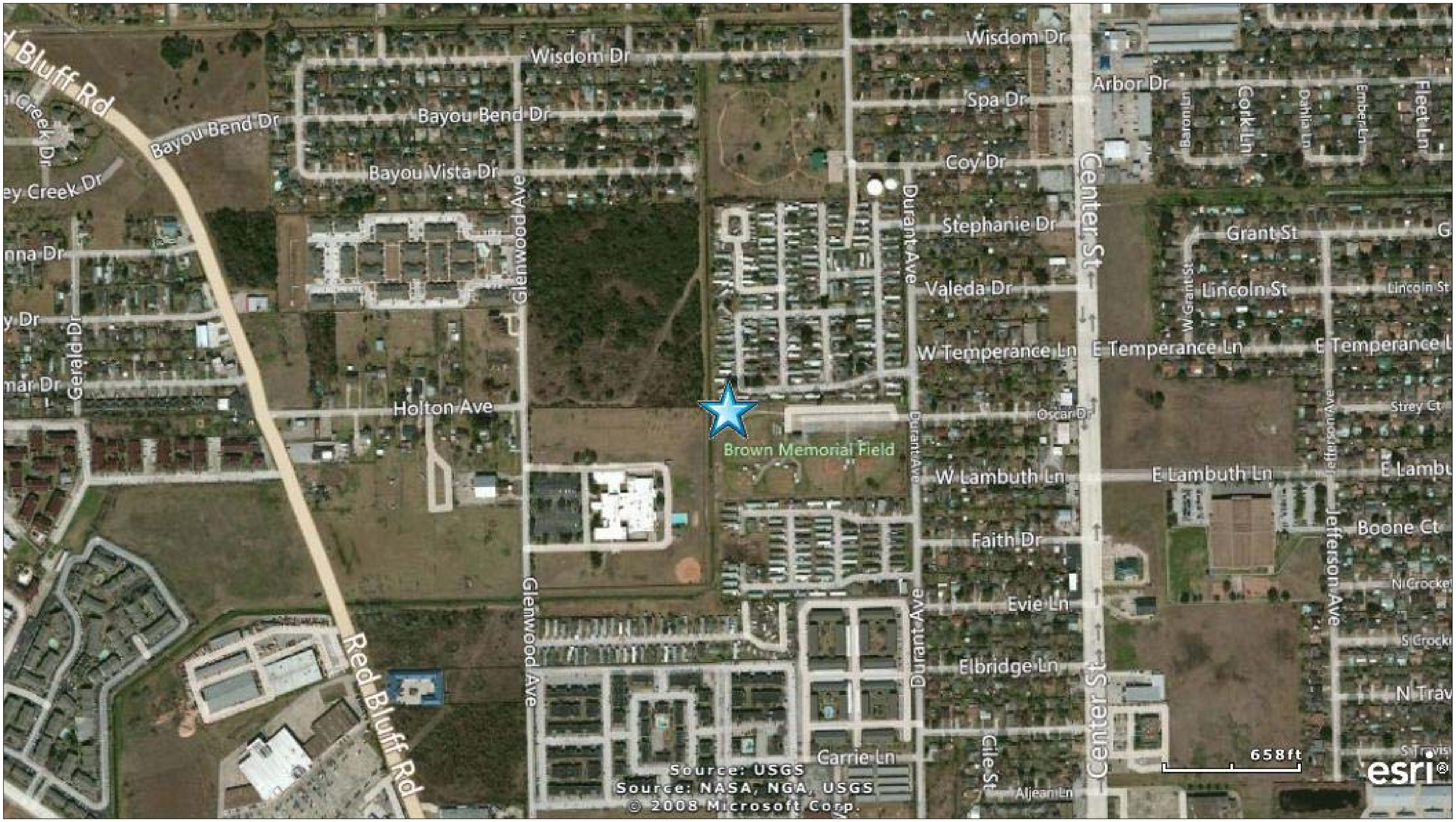


Figure 24-2. NEI Point Sources Located Within 10 Miles of CAMS 35

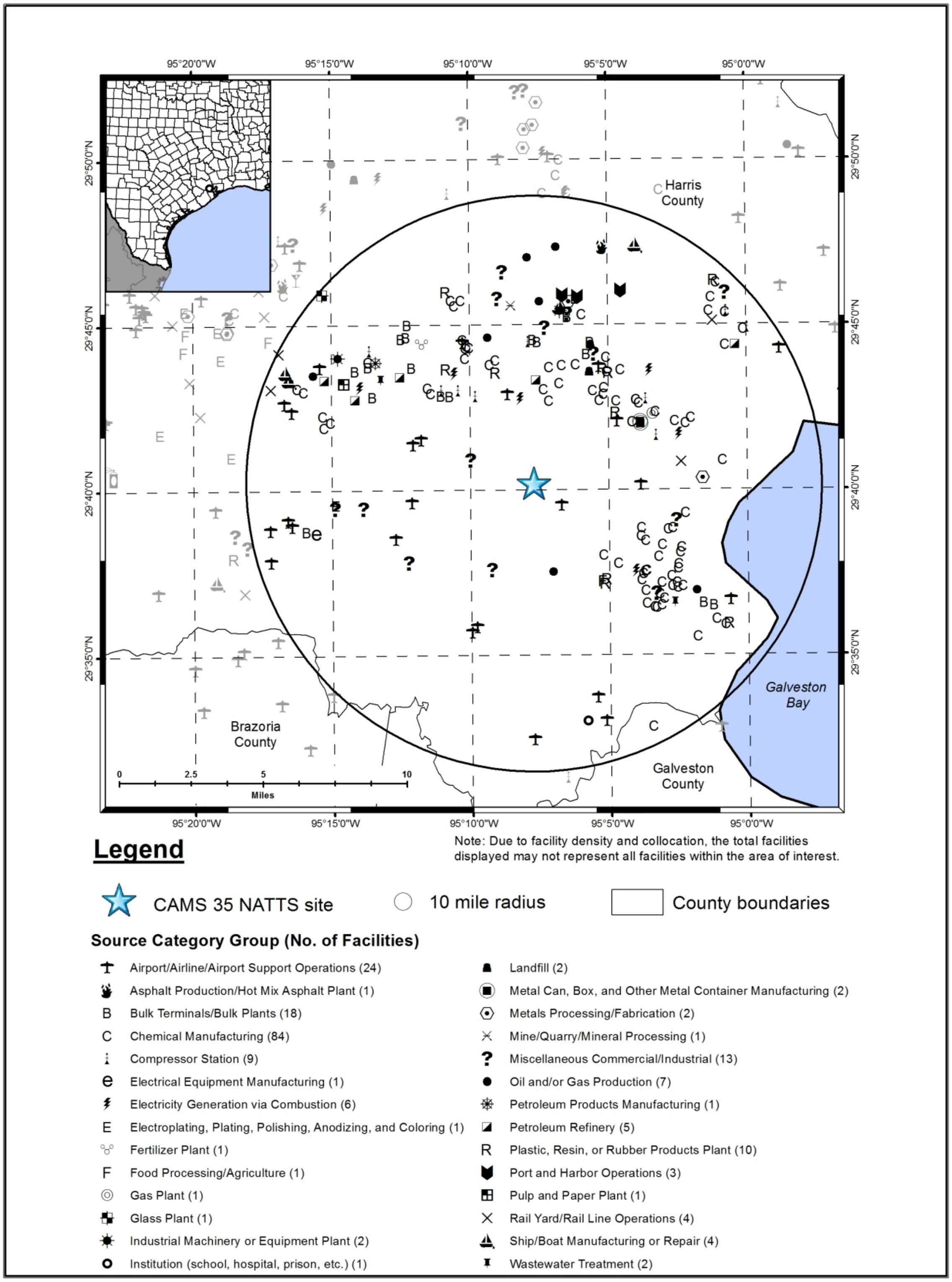
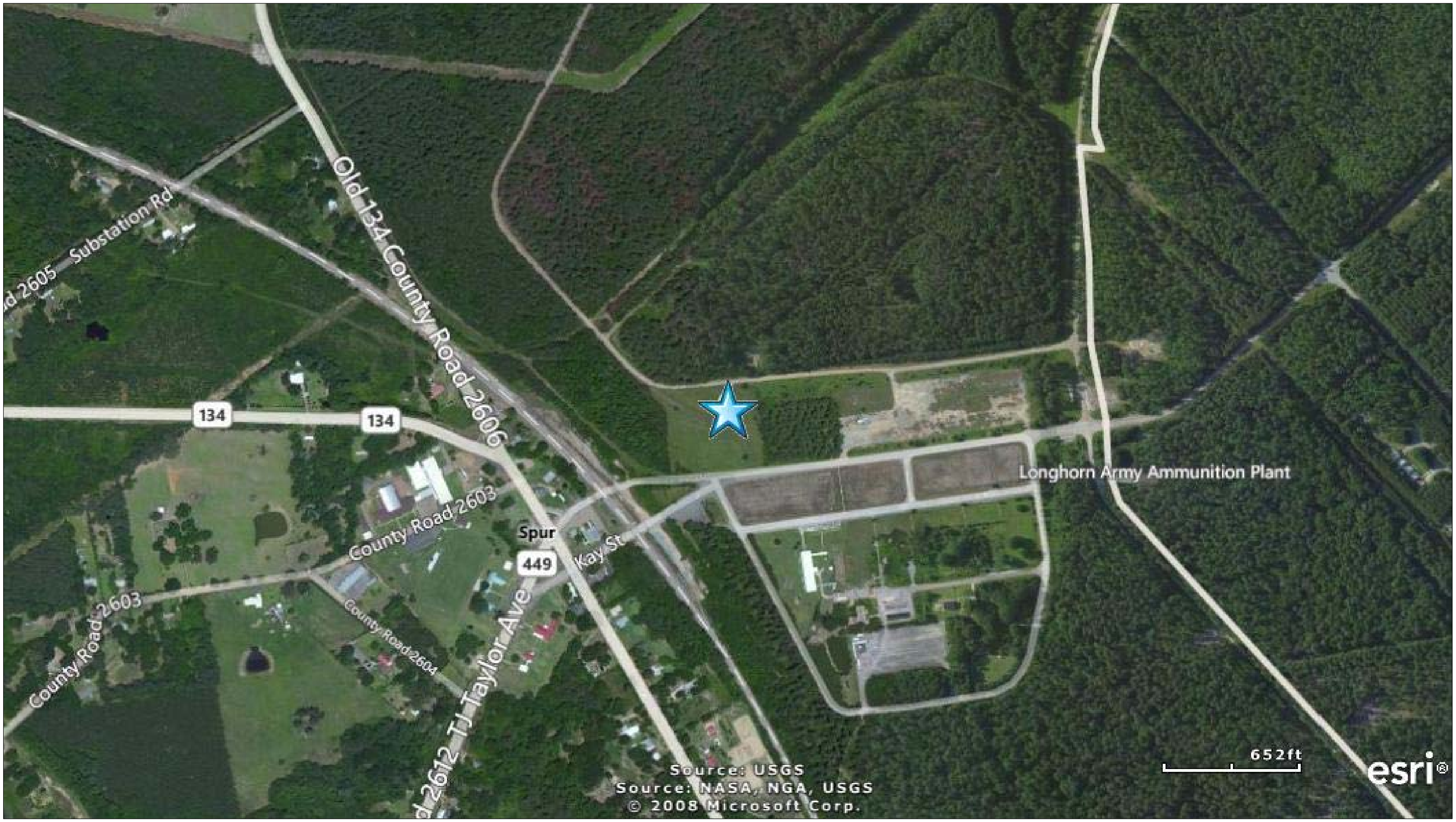
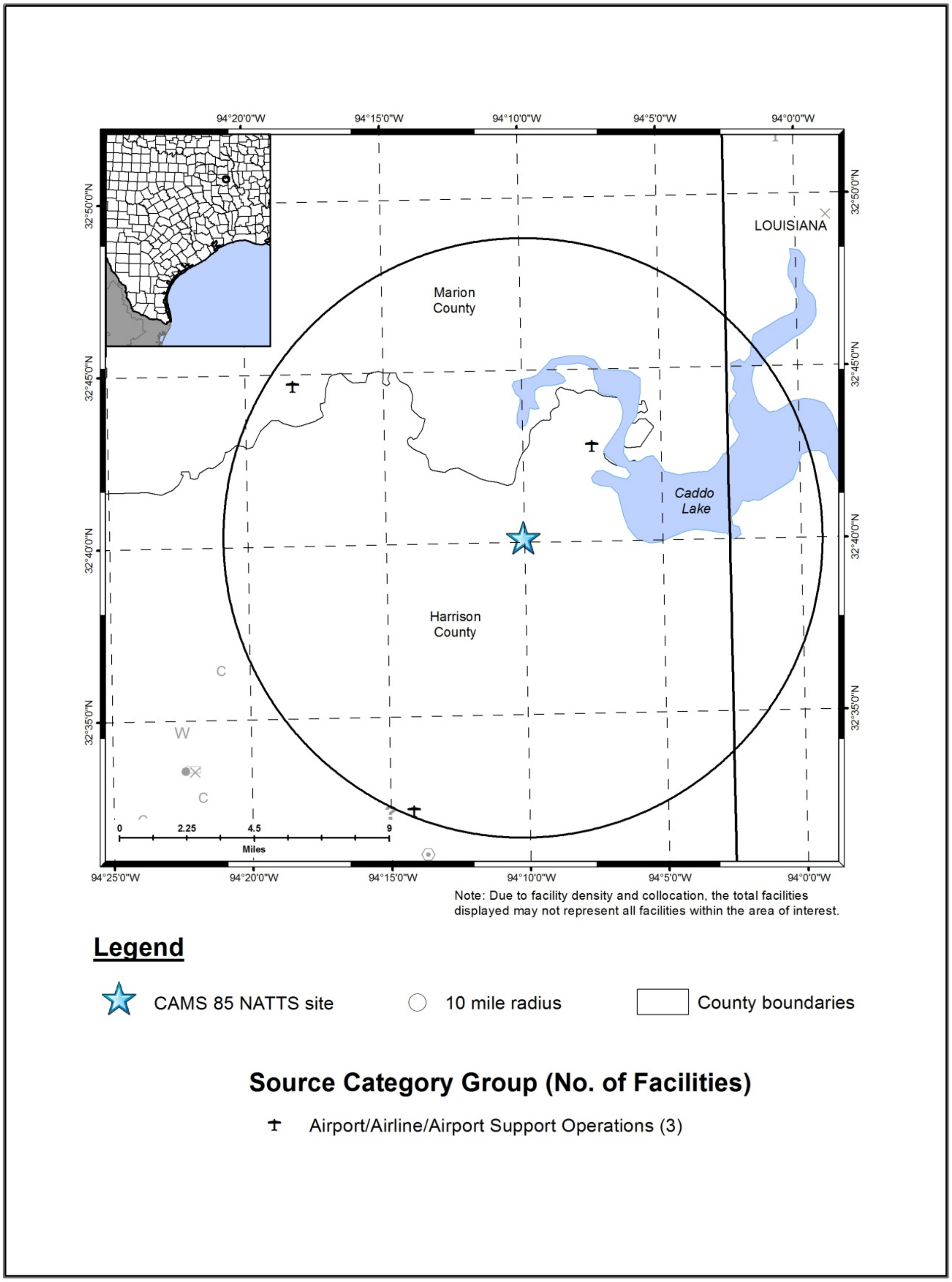


Figure 24-3. Karnack, Texas (CAMS 85) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 24-4. NEI Point Sources Located Within 10 Miles of CAMS 85



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 24-1. Geographical Information for the Texas Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
CAMS 35	48-201-1039	Deer Park	Harris	Houston-The Woodlands-Sugar Land, TX MSA	29.670025, -95.128508	Residential	Urban/City Center	Haze, TSP Lead, CO, SO_2, NO_y, NO, NO_2, NO_x, PAMS/SNMOCs, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM Coarse, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Black Carbon, IMPROVE Speciation, SVOCs.
CAMS 85	48-203-0002	Karnack	Harrison	Marshall, TX MSA	32.668987, -94.167457	Agricultural	Rural	SVOCs, NO_2, NO, NO_x, PAMS/SNMOCs, Carbonyl Compounds, VOCs, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The CAMS 35 monitoring site is located in Deer Park, southeast of Houston, in east Texas. This site serves as the Houston NATTS Site. The site is located at Brown Memorial Park, in a primarily residential area, as shown in Figure 24-1. Major thoroughfares are near the site, including Beltway 8 (1.6 miles to the west) and Highway 225 (2.8 miles to the north). Galveston Bay is located to the east and southeast of the site and the Houston Ship Channel, which runs from the Bay westward towards downtown Houston, is located to the north on the other side of Highway 225. The east side of Houston has significant industry, including several major oil refineries. As Figure 24-2 shows, a large number of emissions sources are located roughly along a line that runs east to west just north of the site (or along the Houston Ship Channel). A second cluster of emissions sources is located to the southeast of the monitoring site. The source category with the greatest number of sources (84) surrounding CAMS 35 is chemical manufacturing. Other source categories with a number of sources around CAMS 35 include the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; bulk terminals and bulk plants; plastic, resin, or rubber products plants; compressor stations; and oil and gas production. The point source located closest to the CAMS 35 monitoring site is a heliport at San Jacinto College's Central Campus in Pasadena

The CAMS 85 NATTS site is located in Karnack, in northeast Texas. The monitoring site is about 10 miles northeast of Marshall, Texas and about 7 miles west of the Texas-Louisiana border. This site is located on the property of the Longhorn Army Ammunition Plant near the intersection of FM Road 134 and Spur Road 449 (Taylor Avenue), as shown in Figure 24-3. The surrounding area is rural and agricultural. As Figure 24-4 shows, there are few point sources within 10 miles of CAMS 85 and these sources all fall into a single source category: the airport source category. The closest source to CAMS 85 is the Fly-N-Fish Lodge Airport near Caddo Lake.

Table 24-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Texas monitoring sites. Table 24-2 includes both county-level population and vehicle registration information. Table 24-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 24-2 presents the county-level daily VMT for Harris and Harrison Counties.

Table 24-2. Population, Motor Vehicle, and Traffic Information for the Texas Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
CAMS 35	4,253,700	3,252,420	31,043	Spencer Hwy, between Red Bluff Rd and Underwood Rd	57,020,660
CAMS 85	67,450	71,658	1,250	FM Rd 134 at intersection with 449	2,405,125

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (TX DMV, 2013)
[3] AADT reflects 2011 data for CAMS 85 and 2004 data for CAMS 35 (TX DOT, 2011 and HCPID, 2013)
[4] County-level VMT reflects 2012 data (TX DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 24-2 include the following:

- The population and vehicle ownership counts are significantly higher for CAMS 35 than CAMS 85. This is not surprising given the rural nature of the area surrounding the CAMS 85 site and the large urban area encompassed within Harris County.

- Compared to other counties with NMP monitoring sites, Harris County is third highest for both county-level population and county-level vehicle ownership. Conversely, Harrison County is among the lowest for both county-level population and vehicle ownership.

- The traffic volume passing CAMS 35 is substantially higher than the traffic volume passing CAMS 85. The traffic volume for CAMS 35 is in the middle of the range compared to other NMP sites while the traffic volume near CAMS 85 is among the lower traffic volumes for NMP sites. Traffic data for CAMS 35 are provided for Spencer Highway between Red Bluff Road and Underwood Road; the traffic data for CAMS 85 are provided for FM Road 134 at the intersection with Spur Road 449.

- Like the other mobile source activity indicators, county-level daily VMT is considerably higher for Harris County than Harrison County. Harris County ranks fourth compared to other counties with NMP sites for VMT, while Harrison County ranks in the bottom third.

24.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Texas on sample days, as well as over the course of the year.

24.2.1 Climate Summary

The eastern third of Texas is characterized by a subtropical humid climate, with the climate becoming more continental in nature farther north and west. The proximity to the Gulf of Mexico acts as a moderating influence as temperatures soar in the summer or dip in the winter.

Areas closer to the coast, such as Houston, remain slightly cooler in the summer than neighboring areas to the north. The reverse is also true, as coastal areas are warmer in the winter than areas farther inland, although East Texas winters are relatively mild. The onshore flow from the Gulf of Mexico also allows humidity levels to remain high in East Texas, particularly near the coast. The winds flow out of the Gulf of Mexico a majority of the year, with the winter months being the exception, as frontal systems allow colder air to filter in from the north. Abundant rainfall is also typical of the region, again due in part to the nearness to the Gulf of Mexico. Greater than 45 inches of precipitation can be expected annually. Severe weather is most common in spring, particularly in May, and tropical systems can be a threat to the state during the summer and fall. Snowfall is rare in East Texas but ice storms are more common in northeast Texas than in other parts of the state (Wood, 2004; TAMU, 2014).

24.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the Texas monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather station to CAMS 35 is located at William P. Hobby Airport, WBAN 12918; the closest weather station to CAMS 85 is located at Shreveport Regional Airport, WBAN 13957. Additional information about the Hobby Airport and Shreveport Regional Airport weather stations, such as the distance between the sites and the weather stations, is provided in Table 24-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 24-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for the entire year. Also included in Table 24-3 is the 95 percent confidence interval for each parameter. As shown in Table 24-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year near both sites.

Table 24-3. Average Meteorological Conditions near the Texas Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Deer Park, Texas - CAMS 35									
William P. Hobby Airport 12918 (29.65, -95.28)	9.1 miles 256° (WSW)	Sample Days (61)	80.3 ± 2.8	72.1 ± 2.8	61.9 ± 3.2	65.9 ± 2.7	72.9 ± 2.8	1016.7 ± 1.2	6.3 ± 0.6
		2012	80.7 ± 1.1	71.9 ± 1.1	61.2 ± 1.3	65.5 ± 1.1	71.8 ± 1.2	1016.7 ± 0.5	6.1 ± 0.3
Karnack, Texas - CAMS 85									
Shreveport Regional Airport 13957 (32.45, -93.82)	24.4 miles 127° (SE)	Sample Days (61)	79.3 ± 3.4	68.4 ± 3.3	56.7 ± 3.5	61.5 ± 3.0	69.3 ± 2.8	1016.2 ± 1.3	6.2 ± 0.7
		2012	79.0 ± 1.4	68.3 ± 1.4	56.5 ± 1.5	61.4 ± 1.3	69.4 ± 1.2	1016.2 ± 0.6	5.8 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

24.2.3 Back Trajectory Analysis

Figure 24-5 is the composite back trajectory map for days on which samples were collected at the CAMS 35 monitoring site. Included in Figure 24-5 are four back trajectories per sample day. Figure 24-6 is the corresponding cluster analysis. Similarly, Figures 24-7 and 24-8 are the composite back trajectory map and corresponding cluster analysis for days on which samples were collected at CAMS 85. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 24-5 through 24-8 represents 100 miles.

Observations from Figures 24-5 and 24-6 for CAMS 35 include the following:

- Back trajectories originated from a variety of directions at the CAMS 35 monitoring site, although the majority of trajectories originated over the Gulf of Mexico or to the north of the site and rarely to the west of the site.

- The 24-hour air shed domain for CAMS 35 is similar in size to many other NMP monitoring sites. Although the farthest away a back trajectory originated was over the Gulf of Mexico, or nearly 600 miles away, the average back trajectory length was 252 miles. Approximately 85 percent of back trajectories originated within 400 miles of the site.

- The cluster analysis shows that greater than 50 percent of back trajectories originated over the Gulf of Mexico, although the position over the Gulf and the trajectory length varies. Another common trajectory origin is from the northeast to east (13 percent), over Louisiana and Mississippi. Another 7 percent of back trajectories originated over Oklahoma and north-central Texas. One cluster trajectory for CAMS 35 is short enough that it is covered up by the star symbol; thus, the cluster trajectory is presented in the inset map in Figure 24-6. This cluster trajectory includes back trajectories of varying directions but generally short distances (less than 200 miles in length). The back trajectories are frequently curved in nature, looping around Southeast Texas or offshore before arriving at the monitoring site. Most of these back trajectories are obscured in Figure 24-5 by the density of trajectory pathways nearest the site.

Figure 24-5. Composite Back Trajectory Map for CAMS 35

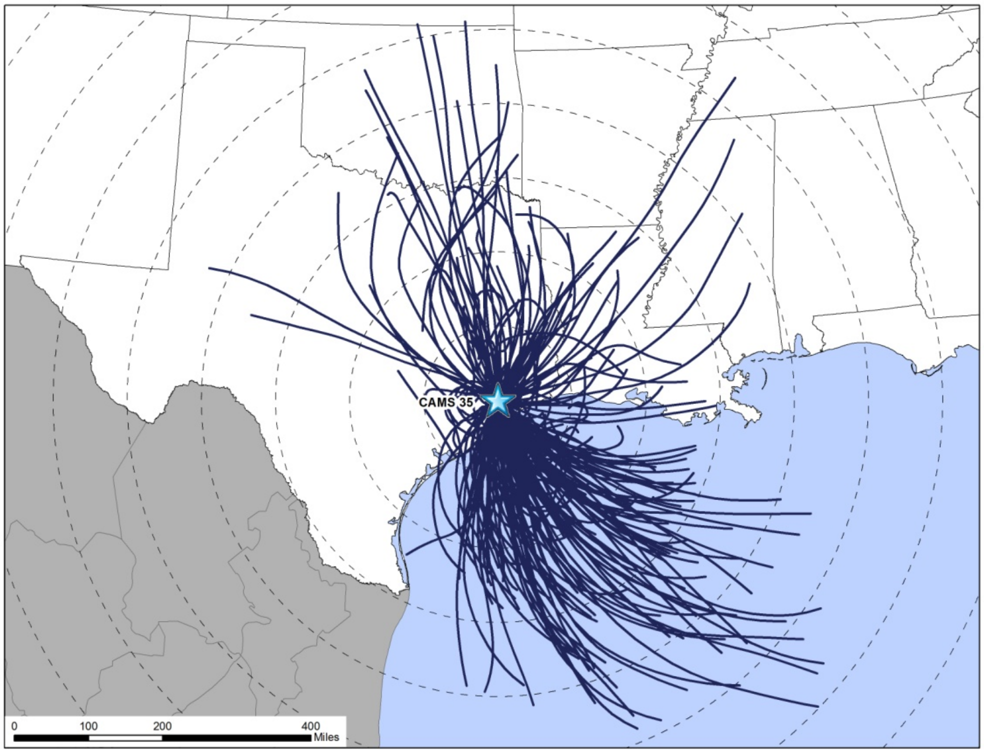


Figure 24-6. Back Trajectory Cluster Map for CAMS 35

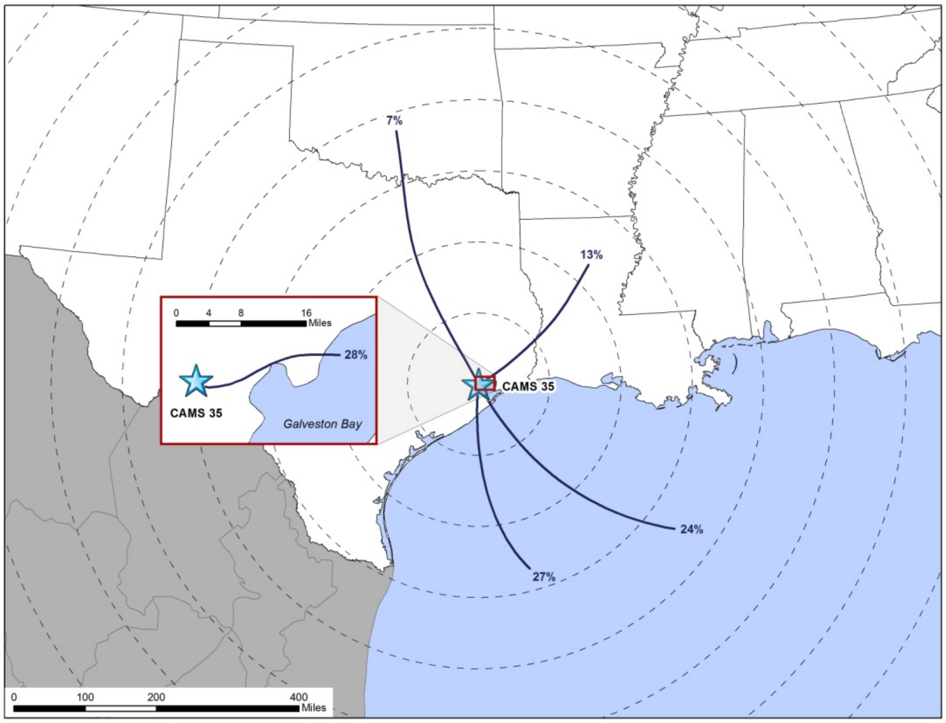


Figure 24-7. Composite Back Trajectory Map for CAMS 85

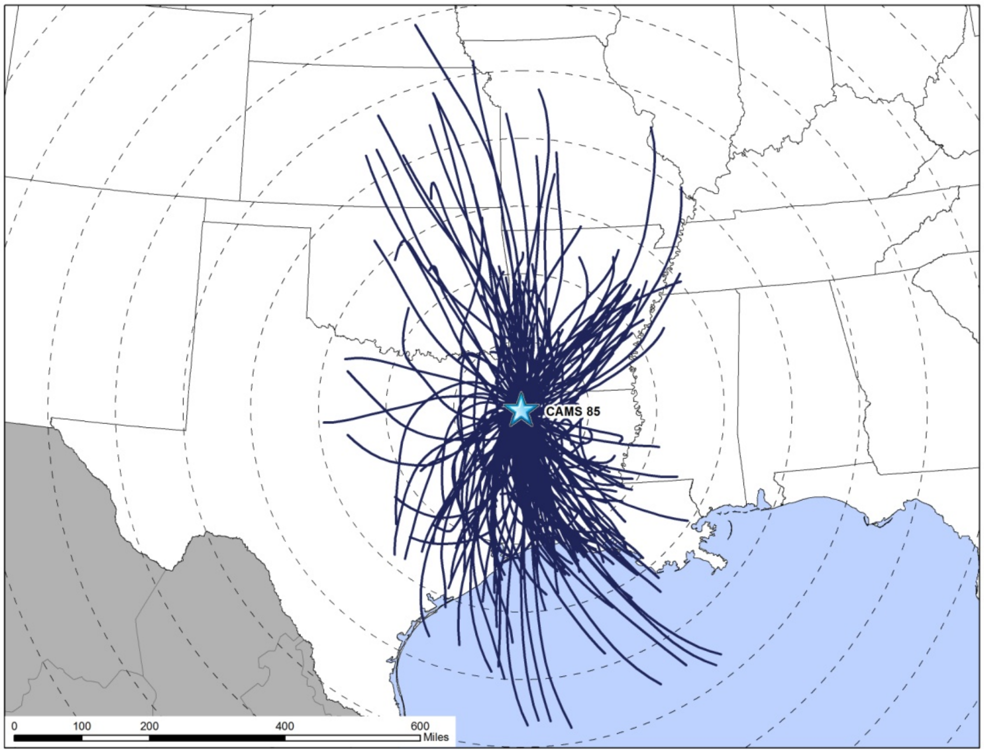
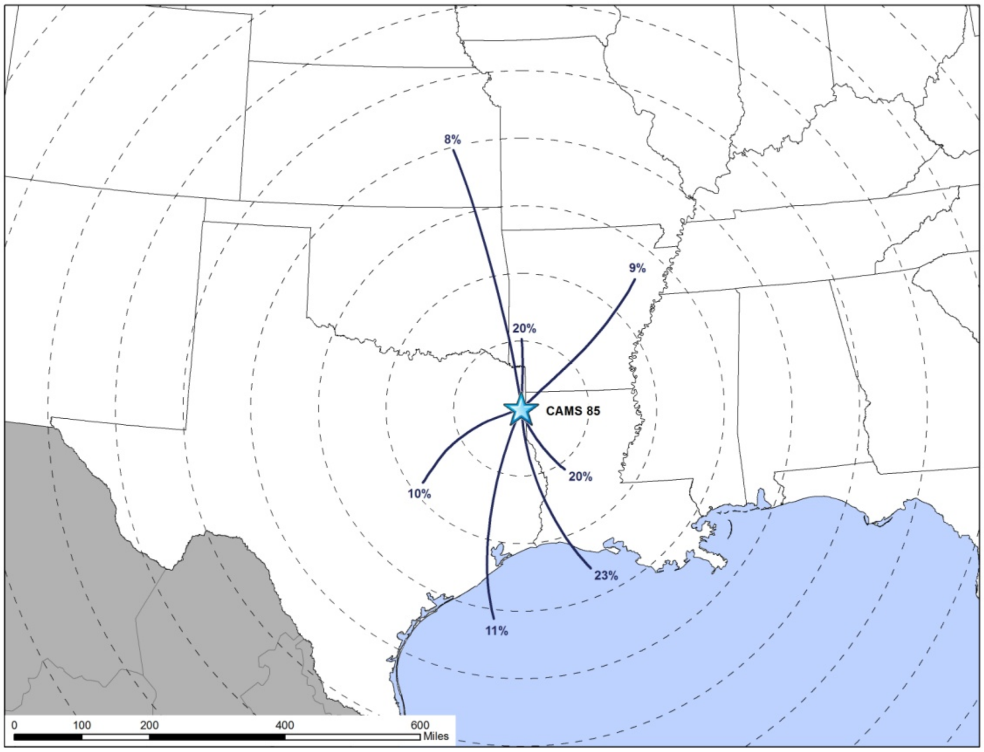


Figure 24-8. Back Trajectory Cluster Map for CAMS 85



Observations from Figures 24-7 and 24-8 for CAMS 85 include the following:

- Back trajectories originated from a variety of directions at the CAMS 85 monitoring site, although back trajectories originating to the east and west are rare.

- The 24-hour air shed domain for CAMS 85 is slightly smaller in size compared to CAMS 35. The average back trajectory length is 219 miles and most trajectories (83 percent) originated less than 300 miles from CAMS 85. The farthest away a back trajectory originated was nearly 600 miles away, over Nebraska.

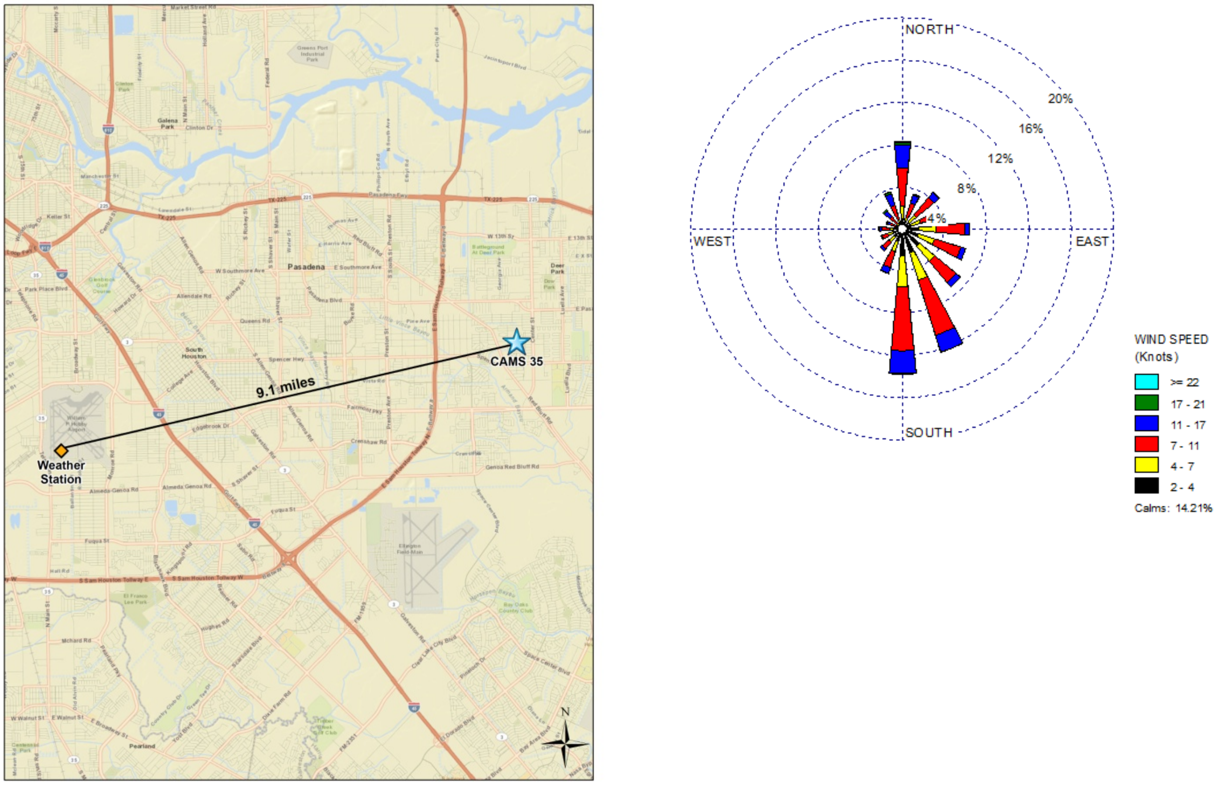
- The cluster analysis for CAMS 85 shows that greater than one-third of back trajectories originated to the south of the site, but are split into two different cluster trajectories. Another 20 percent of back trajectories originated over East Texas and Louisiana. Nine percent of back trajectories originated over eastern Arkansas and along the Mississippi River. An additional 28 percent of back trajectories originated to the north of the site, as indicated by the short cluster (20 percent) representing relatively short back trajectories originating over the Ark-La-Tex region and eastern Oklahoma, and the longer cluster (8 percent) originating over the central Plains.

24.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations at Hobby Airport near CAMS 35 and Shreveport Regional Airport near CAMS 85 were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

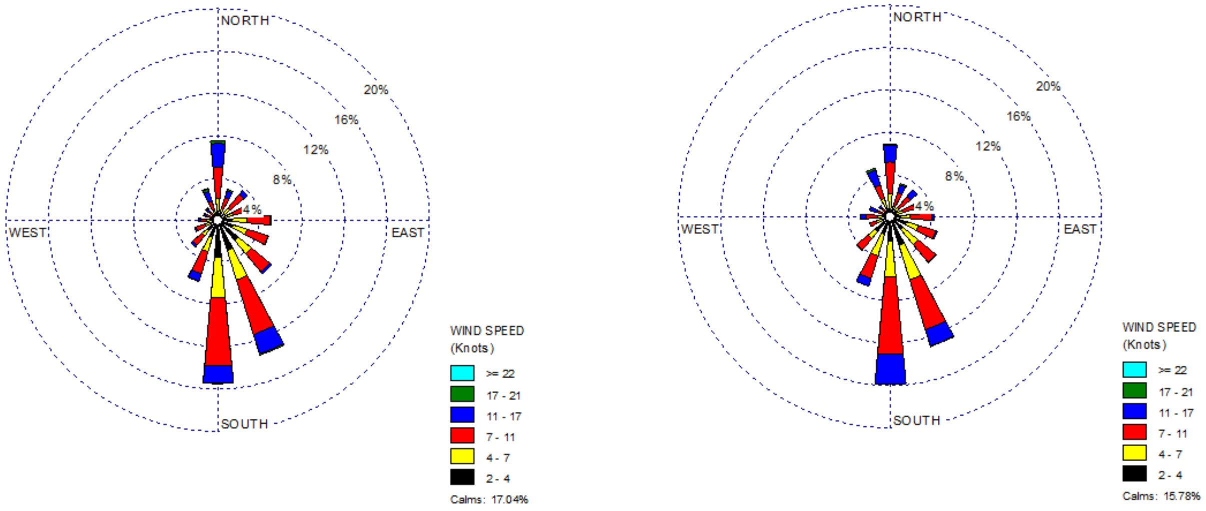
Figure 24-9 presents a map showing the distance between the weather station and CAMS 35, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 24-9 also presents three different wind roses for the CAMS 35 monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 24-10 presents the distance map and three wind roses for CAMS 85.

Figure 24-9. Wind Roses for the William P. Hobby Airport Weather Station near CAMS 35



Location of CAMS 35 and Weather Station

2002-2011 Historical Wind Rose



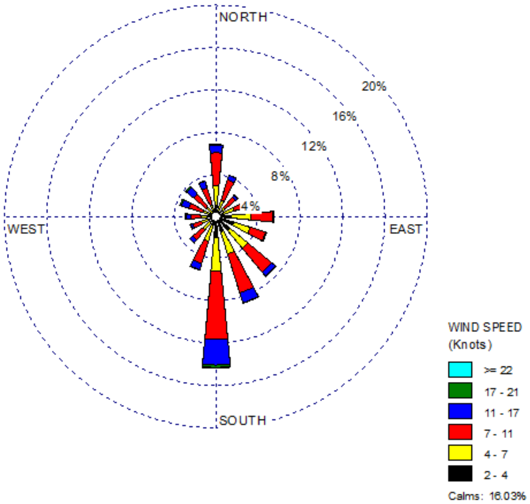
2012 Wind Rose

Sample Day Wind Rose

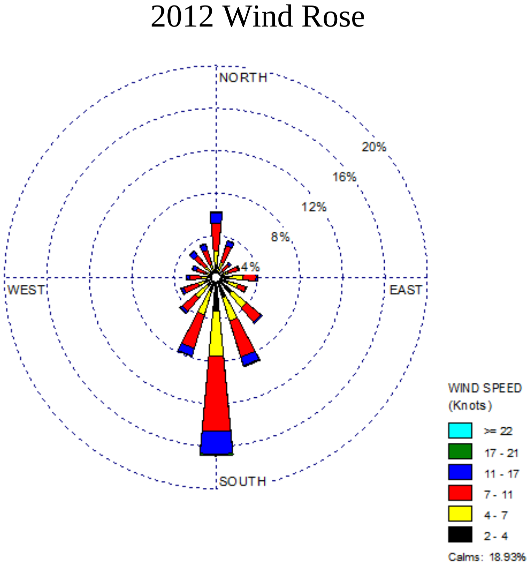
Figure 24-10. Wind Roses for the Shreveport Regional Airport Weather Station near CAMS 85

Location of CAMS 85 and Weather Station

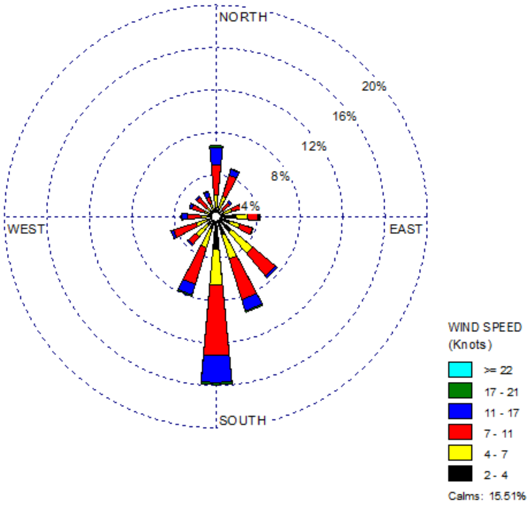
2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose



Observations from Figure 24-9 for CAMS 35 include the following:

- The Hobby Airport weather station is located approximately 9 miles west-southwest of CAMS 35.
- The historical wind rose shows that winds from the southeast quadrant, including both easterly and southerly winds, prevailed near the CAMS 35 site. Northerly winds were also observed fairly often. Calm winds (≤2 knots) were observed for approximately 14 percent of the wind measurements.
- The wind patterns on the wind rose for 2012 resemble the historical wind patterns. However, the percentage of calm winds was slightly higher for 2012 (17 percent).
- The wind patterns shown on the sample day wind rose resemble the wind patterns shown on both the full-year and historical wind roses, indicating that conditions experienced near CAMS 35 on sample days are representative of those experienced throughout the year and over time.

Observations from Figure 24-10 for CAMS 85 include the following:

- The Shreveport Regional Airport weather station is located across the Texas-Louisiana border, approximately 24 miles southeast of CAMS 85.
- The wind patterns on the historical wind rose for CAMS 85 bear some resemblance to those on the historical wind rose for CAMS 35. The historical wind rose shows that winds from the southeast to south account for approximately 30 percent of the wind observations near the CAMS 85 site. Northerly winds were also observed fairly often. Calm winds were observed for approximately 16 percent of the wind measurements.
- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns, although the number of southerly and south-southwesterly winds increased for 2012. The calm rate also increased for 2012 (19 percent).
- The sample day wind patterns resemble the full-year wind patterns, although the calm rate is slightly less (16 percent) while the number of southeasterly wind observations increased.

24.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Texas monitoring site in order to identify site-specific “pollutants of interest,” which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” The site-specific results of this risk-based screening process are presented in Table 24-4.

Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 24-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Although CAMS 35 sampled for hexavalent chromium and PAHs, sampling for PAHs was discontinued at the end of February 2012. CAMS 85 sampled for hexavalent chromium only.

Table 24-4. Risk-Based Screening Results for the Texas Monitoring Sites

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Deer Park, Texas - CAMS 35						
Naphthalene	0.029	8	9	88.89	61.54	61.54
Hexavalent Chromium	0.000083	5	60	8.33	38.46	100.00
Total		13	69	18.84		
Karnack, Texas - CAMS 85						
Hexavalent Chromium	0.000083	0	47	0.00	0.00	0.00
Total		0	47	0.00		

Observations from Table 24-4 include the following:

- Nine valid PAH samples were collected at CAMS 35 before sampling was discontinued.
- Naphthalene was the only PAH to fail screens for CAMS 35. Of the nine valid samples collected, naphthalene failed screens for eight of them (89 percent).
- Hexavalent chromium was detected in 60 of the 61 valid samples collected at CAMS 35. This pollutant failed five screens (8 percent).
- Naphthalene accounted for roughly 62 percent of the failed screens for CAMS 35, with hexavalent chromium accounting for the other 38 percent. Thus, both pollutants were identified as pollutants of interest for this site.
- Hexavalent chromium is the only pollutant sampled for at CAMS 85. This pollutant did not fail any screens during the 2012 monitoring effort. This was also true for 2011.
- Because CAMS 85 does not have any pollutants of interest, this site is excluded from the sections that follow, with the exception of the emissions section (Section 24.5.3).

24.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the CAMS 35 site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for CAMS 35.
- Annual concentration averages are presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for CAMS 35 are provided in Appendices M and O. A site-specific statistical summary is also provided for CAMS 85 in Appendix O.

24.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for CAMS 35, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the CAMS 35 monitoring site are presented in Table 24-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 24-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Texas Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Deer Park, Texas - CAMS 35						
Hexavalent Chromium	60/61	0.037 ± 0.007	0.040 ± 0.012	0.053 ± 0.009	0.058 ± 0.027	0.047 ± 0.008
Naphthalene	9/9	NA	NA	NA	NA	NA

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
Note: There are no pollutants of interest for CAMS 85.

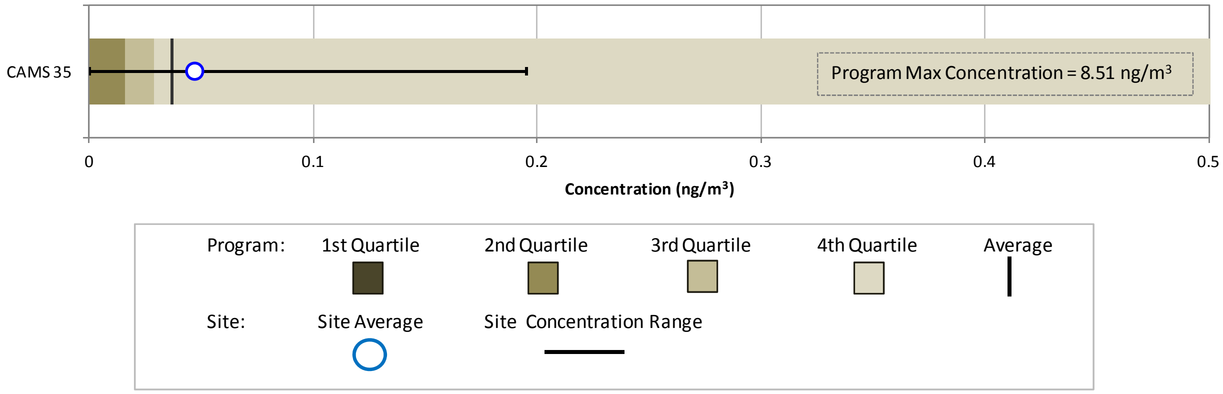
Observations from Table 24-5 include the following:

- Concentrations of hexavalent chromium measured at CAMS 35 range from 0.0044 ng/m^3 to 0.195 ng/m^3, including a single non-detect. The median concentration for the dataset is 0.042 ng/m^3.
- Concentrations of hexavalent chromium appear lower during the first half of the year and higher during the second half of the year, as indicated by the quarterly averages. In addition, the fourth quarter average has a relatively large confidence interval associated with it. A review of the data shows that the three highest concentrations of this pollutant (those greater than 0.1 ng/m^3) were measured between October and December at CAMS 35. Further, 16 of the 22 measurements greater than 0.05 ng/m^3 were measured at CAMS 35 between July and December (with only one measured during the first quarter and five during the second).
- Compared to other NMP sites sampling hexavalent chromium, the annual average concentration for CAMS 35 is among the higher annual averages, ranking fifth among the NMP sites sampling hexavalent chromium.
- Concentrations of naphthalene measured at CAMS 35 range from 24.0 ng/m^3 to 181 ng/m^3.
- Because sampling for PAHs was discontinued in February 2012, no quarterly or annual averages could be calculated.

24.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, a box plot was created for hexavalent chromium for CAMS 35. Figure 24-11 overlays the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 24-11. Program vs. Site-Specific Average Hexavalent Chromium Concentration



Observations from Figure 24-11 include the following:

- Figure 24-11 is the box plot for hexavalent chromium for CAMS 35. Note that the program-level maximum concentration (8.51 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 0.5 ng/m^3. In addition, the program-level first quartile is zero and therefore not visible on the box plot. Figure 24-11 shows that the annual average hexavalent chromium concentration for CAMS 35 is just greater than the program-level average concentration. The maximum hexavalent chromium concentration measured at CAMS 35 is significantly less than the maximum concentration measured at the program-level.

24.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. Although CAMS 35 has sampled PAHs continuously since 2008 under the NMP, sampling was discontinued at this site in February 2012. Hexavalent chromium sampling under the NMP did not begin until 2010 and therefore does not meet the criteria specified above. As a result, a trends analysis was not conducted.

24.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at CAMS 35. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

24.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Texas monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

24.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for CAMS 35 and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 24-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 24-6. Risk Approximations for the Texas Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Deer Park, Texas - CAMS 35						
Hexavalent Chromium	0.012	0.0001	60/61	0.047 ± 0.008	0.56	<0.01
Naphthalene	0.000034	0.003	9/9	NA	NA	NA

NA = Not available due to the criteria for calculating an annual average.
Note: There are no pollutants of interest for CAMS 85.

Observations from Table 24-6 include the following:

- The cancer risk approximation for hexavalent chromium for CAMS 35 is 0.56 in-a-million, which is less than a level of concern.
- The noncancer hazard approximation for hexavalent chromium for CAMS 35 is considerably less than 1.0, indicating that no adverse health effects are expected from this individual pollutant.

24.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 24-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 24-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 24-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 24-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 24-7. Table 24-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 24.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

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Table 24-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Texas Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Deer Park, Texas (Harris County) - CAMS 35					
Benzene	1,003.70	1,3-Butadiene	9.96E-03	Hexavalent Chromium	0.56
Formaldehyde	609.51	Benzidine, gas	8.83E-03		
Ethylbenzene	600.25	Formaldehyde	7.92E-03		
Acetaldehyde	358.08	Benzene	7.83E-03		
1,3-Butadiene	332.11	Hexavalent Chromium, PM	3.84E-03		
Methyl *tert* butyl ether	109.34	Naphthalene	3.09E-03		
Naphthalene	90.96	Ethylene oxide	2.23E-03		
Propylene oxide	59.07	Nickel, PM	1.98E-03		
Dichloromethane	49.15	Acrylonitrile	1.79E-03		
Trichloroethylene	27.58	Arsenic, PM	1.66E-03		
Karnack, Texas (Harrison County) - CAMS 85					
Formaldehyde	90.96	Formaldehyde	1.18E-03		
Benzene	57.39	Ethylene oxide	5.91E-04		
Acetaldehyde	45.99	Naphthalene	4.53E-04		
Ethylbenzene	28.97	Benzene	4.48E-04		
Naphthalene	13.32	Nickel, PM	3.50E-04		
1,3-Butadiene	9.78	1,3-Butadiene	2.93E-04		
Ethylene oxide	6.72	Hexavalent Chromium, PM	1.98E-04		
Dichloromethane	2.56	Arsenic, PM	1.39E-04		
Tetrachloroethylene	1.71	Acetaldehyde	1.01E-04		
Chloromethylbenzene	1.37	Ethylbenzene	7.24E-05		

Table 24-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Texas Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Deer Park, Texas (Harris County) - CAMS 35					
Toluene	8,992.02	Acrolein	1,939,768.88	Hexavalent Chromium	<0.01
Ethylene glycol	5,139.15	1,3-Butadiene	166,053.00		
Hexane	3,952.83	Chlorine	120,895.98		
Methanol	2,806.38	Titanium tetrachloride	77,090.00		
Xylenes	2,282.67	Manganese, PM	71,991.08		
Benzene	1,003.70	Formaldehyde	62,195.29		
Formaldehyde	609.51	Nickel, PM	45,806.59		
Methyl isobutyl ketone	609.01	Acetaldehyde	39,786.75		
Ethylbenzene	600.25	Cadmium, PM	37,360.45		
Acetaldehyde	358.08	Benzene	33,456.71		
Karnack, Texas (Harrison County) - CAMS 85					
Toluene	237.26	Acrolein	444,426.16		
Ethylene glycol	159.89	Hexamethylene-1,6-diisocyanate, gas	48,091.54		
Xylenes	109.93	Manganese, PM	24,602.50		
Hexane	98.06	Chlorine	22,528.15		
Formaldehyde	90.96	Formaldehyde	9,281.93		
Benzene	57.39	Cyanide Compounds, PM	9,151.68		
Chloromethane	48.40	Nickel, PM	8,103.67		
Methanol	46.62	Maleic anhydride	7,969.71		
Acetaldehyde	45.99	Acetaldehyde	5,109.47		
Glycol ethers, gas	30.73	1,3-Butadiene	4,887.61		

Observations from Table 24-7 include the following:

- Because Table 24-7 includes emissions data from the NEI, which is independent of the sampling results at a specific site, data for Harrison County, where CAMS 85 is located, is included.
- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Harris County. Formaldehyde, benzene, and acetaldehyde are the highest emitted pollutants with cancer UREs in Harrison County. The magnitude of the emissions is significantly higher in Harris County than Harrison County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Harris County are 1,3-butadiene, benzidine (gaseous), and formaldehyde. The pollutants with the highest toxicity-weighted emissions for Harrison County are formaldehyde, ethylene oxide, and naphthalene.
- Four of the highest emitted pollutants in Harris County also have the highest toxicity-weighted emissions (1,3-butadiene, formaldehyde, benzene, and naphthalene).
- Formaldehyde tops both emissions-based lists for Harrison County. Another five of the highest emitted pollutants in Harrison County also are among those with the highest toxicity-weighted emissions.
- Naphthalene is the only pollutant of interest for CAMS 35 that appears on both emissions-based lists for Harris County. The total emissions of naphthalene for Harris County rank seventh while its toxicity-weighted emissions rank sixth.
- Although hexavalent chromium, the only pollutant for which a cancer risk approximation could be calculated for CAMS 35, ranks fifth for its toxicity-weighted emissions, this pollutant is not one of the highest emitted in Harris County (its emissions rank 34th).
- Hexavalent chromium is the only pollutant sampled for at CAMS 85 under the NMP. This pollutant has the seventh highest toxicity-weighted emissions for Harrison County, but is not among the 10 highest emitted (its emissions rank 27th).

Observations from Table 24-8 include the following:

- Table 24-8 includes emissions data for Harrison County, similar to Table 24-7.
- Toluene and ethylene glycol are the highest emitted pollutants with noncancer RfCs in both Harris and Harrison Counties. The magnitude of the emissions is significantly higher for Harris County than Harrison County.
- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties is acrolein.

- Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Harris County (formaldehyde, acetaldehyde, and benzene) while only two of the highest emitted pollutants (formaldehyde and acetaldehyde) also have the highest toxicity-weighted emissions for Harrison County.

- Neither naphthalene nor hexavalent chromium appear on either emissions-based list for Harris County, although naphthalene ranks 11th for its toxicity-weighted emissions (of the pollutants with noncancer RfCs).

- Hexavalent chromium appears on neither emissions-based list for Harrison County (ranking 58th for quantity emitted and 28th for its toxicity-weighted emissions).

24.6 Summary of the 2012 Monitoring Data for CAMS 35 and CAMS 85

Results from several of the data treatments described in this section include the following:

- ❖ *Naphthalene and hexavalent chromium failed at least one screen for CAMS 35, with naphthalene accounting for 62 percent of the total failed screens, even though sampling was discontinued in February.*

- ❖ *Hexavalent chromium, the only pollutant sampled for at CAMS 85, did not fail any screens.*

- ❖ *The highest concentrations of hexavalent chromium were measured at CAMS 35 during the fourth quarter of 2012.*

25.0 Site in Utah

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Utah, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

25.1 Site Characterization

This section characterizes the Utah monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The BTUT monitoring site is located in Bountiful, in northern Utah. Figure 25-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 25-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 25-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 25-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 25-1. Bountiful, Utah (BTUT) Monitoring Site

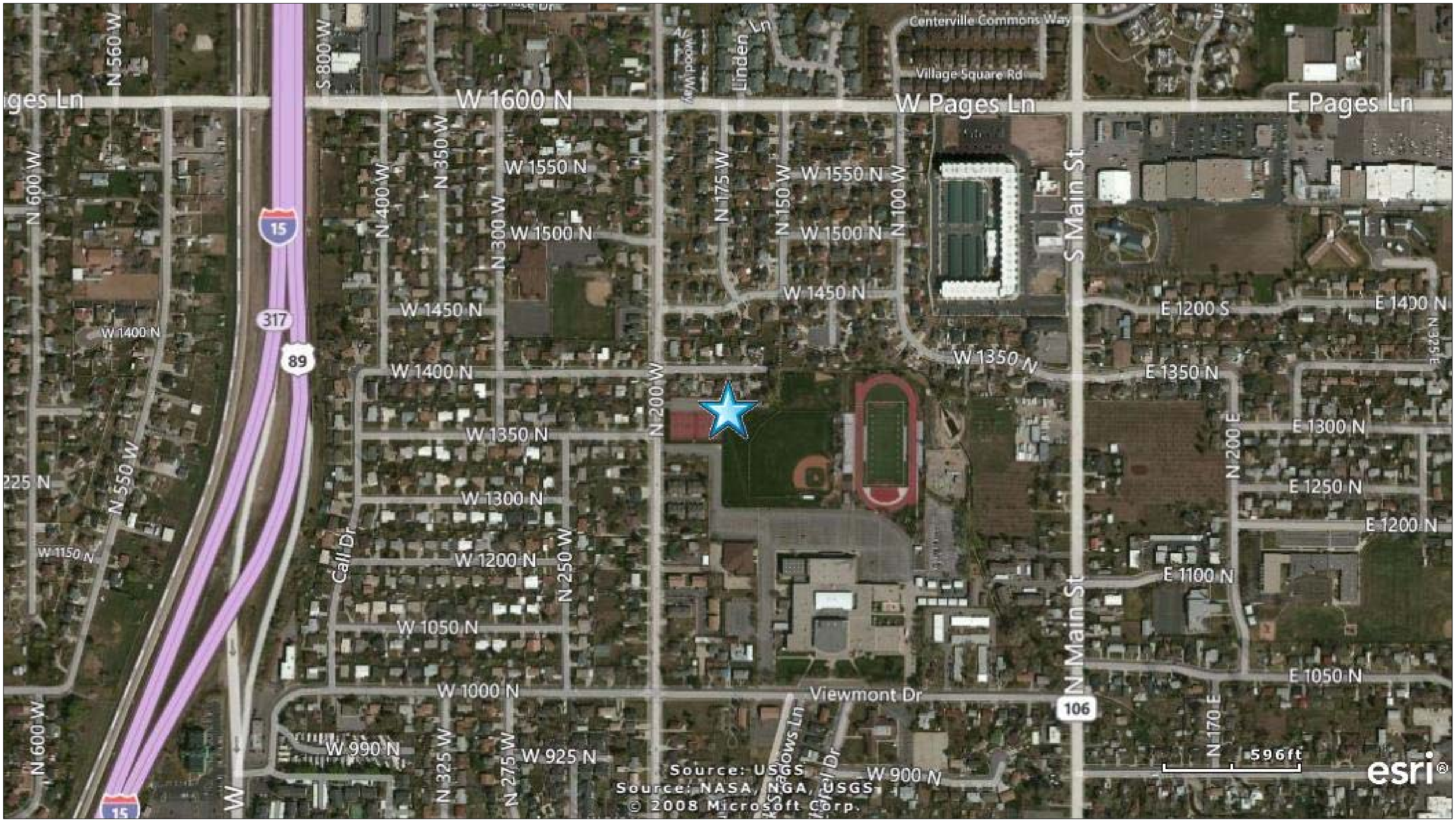


Figure 25-2. NEI Point Sources Located Within 10 Miles of BTUT

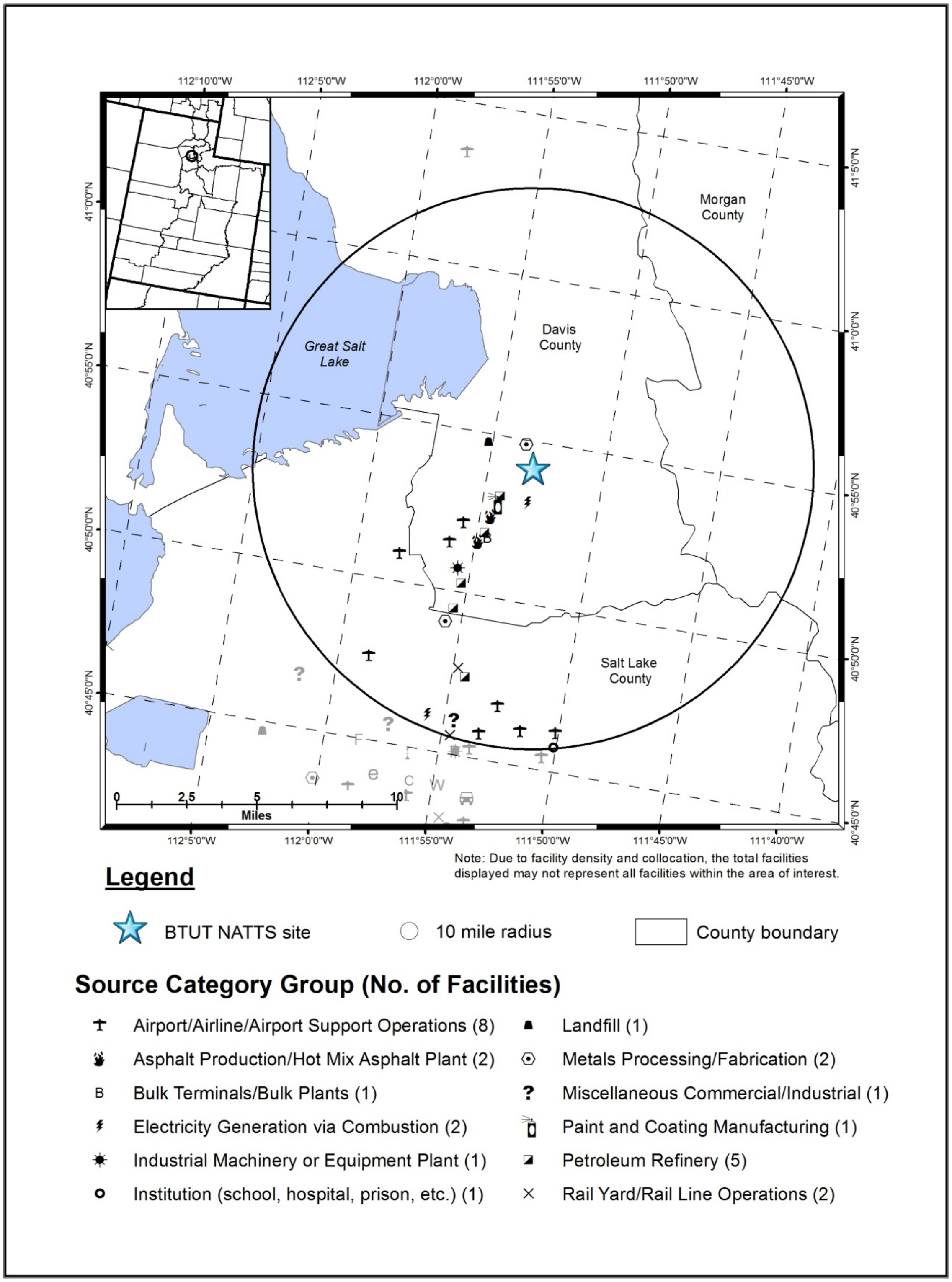


Table 25-1. Geographical Information for the Utah Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
BTUT	49-011-0004	Bountiful	Davis	Ogden-Clearfield, UT MSA	40.902967, -111.884467	Residential	Suburban	SO_2, NO, NO_2, NO_x, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, $PM_{2.5}$ Speciation, Black Carbon, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for BTUT (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

Bountiful is north of Salt Lake City and is situated in a valley between the Great Salt Lake to the west and the Wasatch Mountains to the east. Figure 25-1 shows that BTUT is located on the property of Viewmont High School, in a primarily residential area. The site is located about one-third of a mile from I-15, which runs north-south through most of the surrounding urban area including Salt Lake City, Clearfield, and Ogden. Figure 25-2 shows that most of the point sources near BTUT are located to the south of the site and run parallel to I-15. The facilities surrounding BTUT are involved in a variety of industries, although the source categories with the greatest number of point sources surrounding BTUT are the airport and airport support operations, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations, and petroleum refineries. Point sources within 2 miles of BTUT include a metals processing/fabrication facility, a facility generating electricity via combustion, a petroleum refinery, and a painting and coatings manufacturer.

Table 25-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Utah monitoring site. Table 25-2 includes both county-level population and vehicle registration information. Table 25-2 also contains traffic volume information for BTUT as well as the location for which the traffic volume was obtained. Additionally, Table 25-2 presents the county-level daily VMT for Davis County.

Table 25-2. Population, Motor Vehicle, and Traffic Information for the Utah Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
BTUT	315,809	259,319	129,145	I-15, north of Hwy-89 junction	6,866,779

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (UT TC, 2012)
[3] AADT reflects 2011 data (UT DOT, 2011)
[4] County-level VMT reflects 2011 data (UT DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 25-2 include the following:

- Davis County's population is in the middle of the range compared to other counties with NMP sites. The county-level vehicle registration ranking is similar to the population ranking.

- The traffic volume experienced near BTUT is in the top third compared to the traffic volumes for other NMP sites. The traffic estimate provided is for I-15, north of the Highway 89 junction, just west of the site.

- The daily VMT for Davis County is in the middle of the range compared to other counties with NMP sites (where VMT was available).

25.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Utah on sample days, as well as over the course of the year.

25.2.1 Climate Summary

The Salt Lake City area's climate can be described as semi-arid and continental with considerable seasonal variations. Summers are hot and dry while winters are cold and snow is common. The area is generally dry, though, and sunshine prevails across the area during much of the year. Most months average less than 2 inches of precipitation, with spring as the wettest season. Precipitation that does fall can be enhanced over the eastern parts of the valley as storm systems move up the side of the Wasatch Mountains, located to the east. Smaller mountain ranges to the southwest and south protect the valley from winter storm systems moving in from the southwest. The Great Salt Lake has a moderating influence on the area's temperature, as the lake never freezes, and can enhance precipitation from storm systems that move over the lake. Moderate winds flow out of the southeast on average, although there is a valley breeze/lake breeze system that affects the area. High pressure systems that occasionally settle over the area can result in stagnation episodes (Wood 2004; WRCC, 2013).

25.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Utah monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station to BTUT is located at Salt Lake City International Airport (WBAN 24127). Additional information about the Salt Lake City International Airport weather station, such as the distance between the site and the weather station, is provided in Table 25-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 25-3. Average Meteorological Conditions near the Utah Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Bountiful, Utah - BTUT									
Salt Lake City International 24127 (40.79, -111.97)	9.6 miles 216° (SW)	Sample Days (71)	65.9 ± 4.5	55.5 ± 4.2	32.1 ± 2.2	43.8 ± 2.7	47.8 ± 4.3	1015.5 ± 1.8	7.1 ± 0.7
		2012	67.1 ± 2.1	56.5 ± 1.9	32.7 ± 1.0	44.4 ± 1.2	47.7 ± 1.9	1014.6 ± 0.8	7.2 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 25-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 25-3 is the 95 percent confidence interval for each parameter. As shown in Table 25-3, average meteorological conditions on sample days near BTUT were representative of average weather conditions experienced throughout the year.

25.2.3 Back Trajectory Analysis

Figure 25-3 is the composite back trajectory map for days on which samples were collected at the BTUT monitoring site. Included in Figure 25-3 are four back trajectories per sample day. Figure 25-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 25-3 and 25-4 represents 100 miles.

Figure 25-3. Composite Back Trajectory Map for BTUT

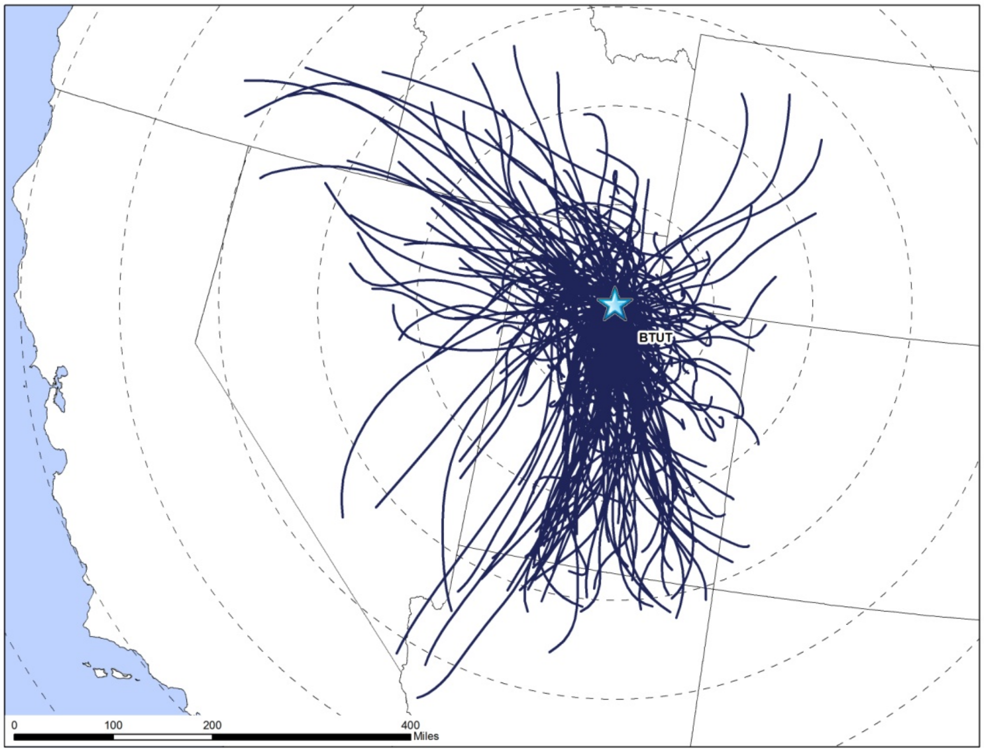
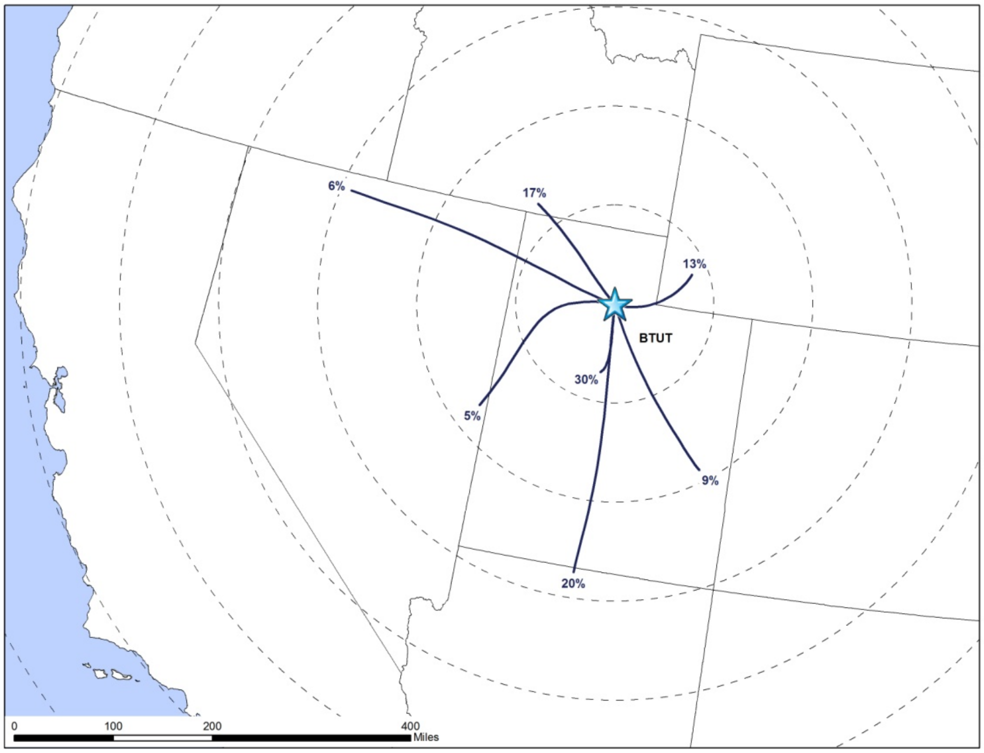


Figure 25-4. Back Trajectory Cluster Map for BTUT



Observations from Figures 25-3 and 25-4 include the following:

- Back trajectories originated from a variety of directions at BTUT. Back trajectories often originated from the northwest and south of the site. Back trajectories originating from a direction with a westerly component tended to be longer than those originating from a direction with an easterly component.

- Similar to other sites located in the inter-mountain west, the 24-hour air shed domain for BTUT is smaller in size than many other NMP sites. The farthest away a back trajectory originated was over the south-central Oregon, or nearly 450 miles away. However, the average back trajectory length was 162 miles and nearly 90 percent of back trajectories originated within 300 miles of the site.

- The cluster analysis shows that 30 percent of back trajectories are represented by the short cluster trajectory originating just south of the site. This cluster represents back trajectories originating primarily to the south and within roughly 150 miles of BTUT and those looping over the northern half of Utah. Nearly one-quarter of back trajectories originated to the west and northwest of BTUT, although of varying lengths, as indicated by the shorter cluster trajectory (17 percent), which represents back trajectories originating over the southern half of Idaho and the northeast corner of Nevada, and the longer cluster trajectory (6 percent), which represents longer back trajectories originating over northern Nevada and southeast Oregon. Five percent of back trajectories originated to southwest of BTUT, but are varied in length. Twenty percent of back trajectories originated to the south of BTUT, over the southern half of Utah and northern half of Arizona. Another 9 percent of back trajectories originated to the southeast of BTUT. The final 13 percent of back trajectories originated to the east and northeast of the site, and include short back trajectories originating over the Wasatch Mountains as well as longer back trajectories originating over central Wyoming.

25.2.4 Wind Rose Comparison

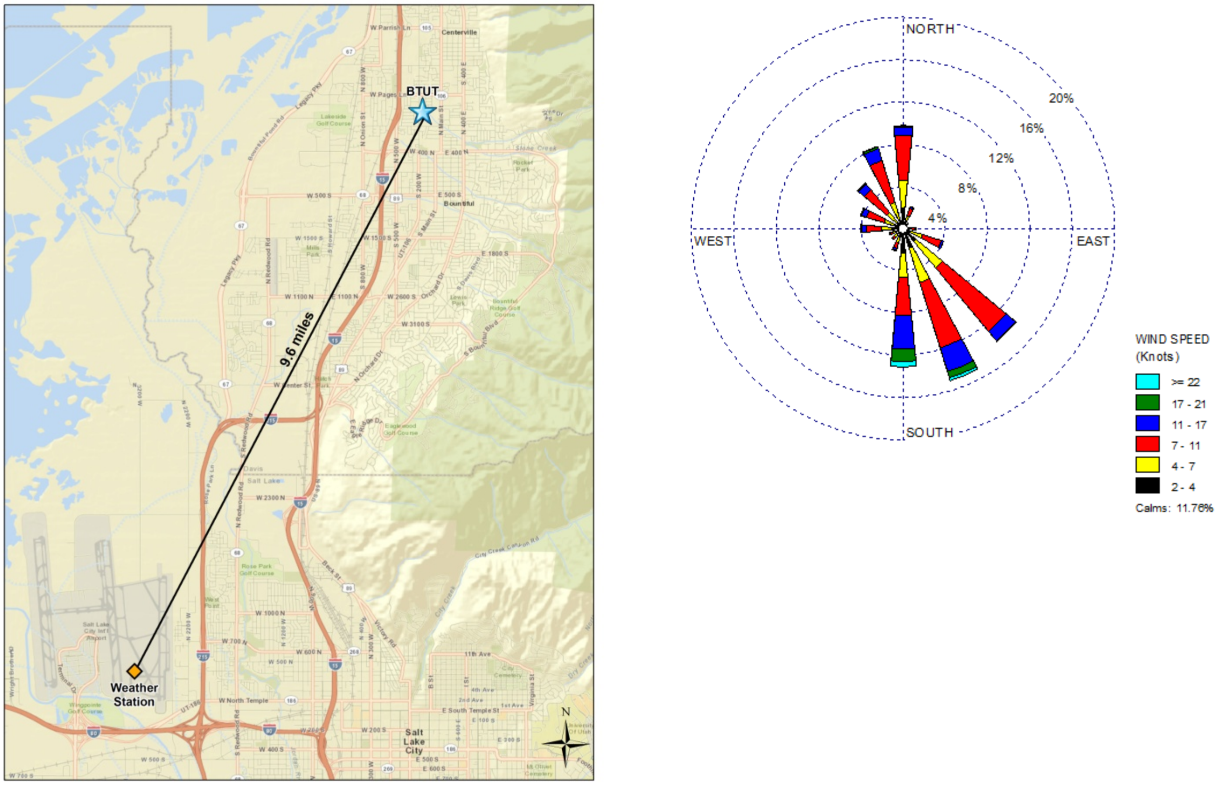
Hourly surface wind data from the weather station at Salt Lake City International Airport near BTUT were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 25-5 presents a map showing the distance between the weather station and BTUT, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 25-5 also presents three different wind roses for the BTUT monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 25-5 for BTUT include the following:

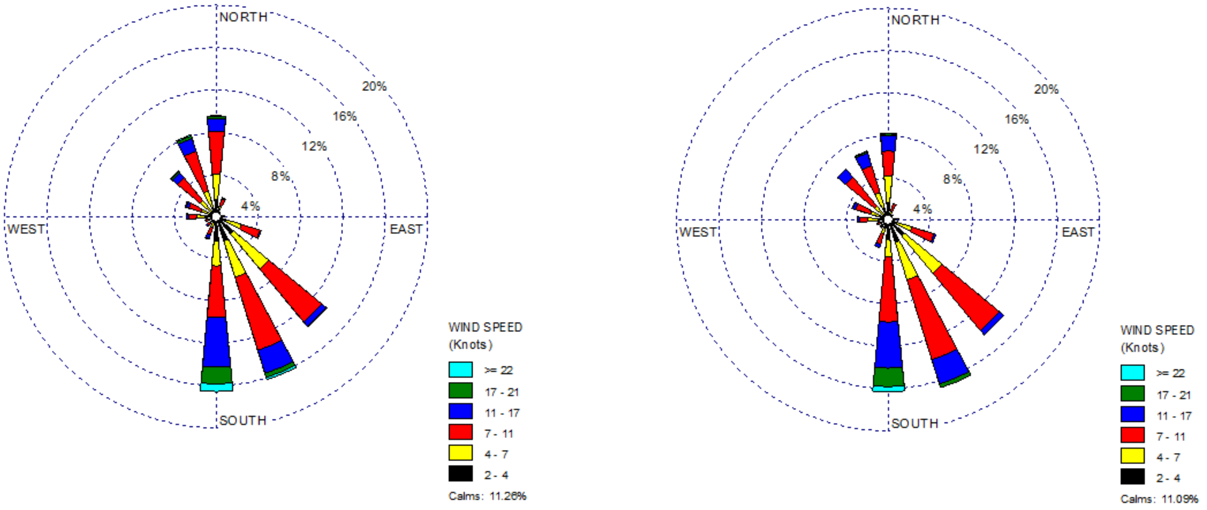
- The Salt Lake City International Airport weather station is located 9.6 miles southwest of BTUT.
- The historical wind rose shows that southeasterly, south-southeasterly, and southerly winds were prevalent near BTUT, accounting for more than 40 percent of the wind observations. Winds from the north-northwest and north were also common. Winds from the northeast and southwest quadrants were rarely observed. Calm winds (≤2 knots) were observed for approximately 12 percent of the hourly measurements. The strongest wind speeds were observed with south-southeasterly and southerly winds.
- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns, indicating that wind conditions in 2012 were similar to wind conditions experienced historically near BTUT. This is also true for the sample day wind rose.

Figure 25-5. Wind Roses for the Salt Lake City International Airport Weather Station near BTUT



Location of BTUT and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

25.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Utah monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 25-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 25-4. It is important to note which pollutants each site sampled for when reviewing the results of this analysis. BTUT sampled for VOCs, carbonyl compounds, SNMOCs, PAHs, metals (PM_{10}), and hexavalent chromium and is one of only two sites sampling the entire suite of pollutants under the NMP (NBIL is the other).

Table 25-4. Risk-Based Screening Results for the Utah Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Bountiful, Utah - BTUT						
Benzene	0.13	56	56	100.00	11.02	11.02
Carbon Tetrachloride	0.17	56	56	100.00	11.02	22.05
Acetaldehyde	0.45	54	54	100.00	10.63	32.68
Formaldehyde	0.077	54	54	100.00	10.63	43.31
1,3-Butadiene	0.03	52	55	94.55	10.24	53.54
1,2-Dichloroethane	0.038	49	49	100.00	9.65	63.19
Arsenic (PM_{10})	0.00023	45	55	81.82	8.86	72.05
Naphthalene	0.029	41	59	69.49	8.07	80.12
Manganese (PM_{10})	0.005	37	57	64.91	7.28	87.40
Ethylbenzene	0.4	21	56	37.50	4.13	91.54
Propionaldehyde	0.8	10	54	18.52	1.97	93.50
Dichloromethane	7.7	7	56	12.50	1.38	94.88
Nickel (PM_{10})	0.0021	7	57	12.28	1.38	96.26
p-Dichlorobenzene	0.091	5	24	20.83	0.98	97.24
1,1,2,2-Tetrachloroethane	0.017	5	5	100.00	0.98	98.23
Hexachloro-1,3-butadiene	0.045	3	3	100.00	0.59	98.82
1,2-Dibromoethane	0.0017	2	2	100.00	0.39	99.21
Benzo(a)pyrene	0.00057	1	16	6.25	0.20	99.41
Chloroprene	0.0021	1	1	100.00	0.20	99.61
Lead (PM_{10})	0.015	1	57	1.75	0.20	99.80
Trichloroethylene	0.2	1	12	8.33	0.20	100.00
Total		508	838	60.62		

Observations from Table 25-4 include the following:

- Twenty-one pollutants failed at least one screen for BTUT; nearly 61 percent of concentrations for these 21 pollutants were greater than their associated risk screening value (or failed screens).

- Thirteen pollutants contributed to 95 percent of failed screens for BTUT and therefore were identified as pollutants of interest for this site. These 13 include three carbonyl compounds, six VOCs, three PM_{10} metals, and one PAH.

- Acetaldehyde, benzene, carbon tetrachloride, and formaldehyde were detected in every valid carbonyl compound and VOC sample collected at BTUT and failed 100 percent of screens. Other pollutants also failed 100 percent of screens but were detected much less frequently.

- Recall from Section 3.2 that if a pollutant was measured by both the TO-15 and SNMOC methods at the same site, the TO-15 results were used for the risk-based screening process. As BTUT sampled both VOCs (TO-15) and SNMOCs, the TO-15 results were used for the 12 pollutants these methods have in common.

25.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Utah monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for the monitoring site.

- Annual concentration averages are presented graphically for BTUT to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for BTUT are provided in Appendix J through Appendix O.

25.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for BTUT, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Utah monitoring site are presented in Table 25-5, where applicable. Note that concentrations of the PAHs and PM_{10} metals are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects “0” because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 25-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Utah Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Bountiful, Utah - BTUT						
Acetaldehyde	54/54	1.71 ± 0.46	1.91 ± 0.33	3.05 ± 0.78	NA	2.54 ± 0.35
Benzene	56/56	1.10 ± 0.38	0.84 ± 0.19	0.99 ± 0.25	1.14 ± 0.24	1.02 ± 0.13
1,3-Butadiene	55/56	0.11 ± 0.05	0.06 ± 0.01	0.10 ± 0.03	0.21 ± 0.06	0.12 ± 0.02
Carbon Tetrachloride	56/56	0.62 ± 0.05	0.68 ± 0.07	0.68 ± 0.06	0.67 ± 0.03	0.66 ± 0.03
1,2-Dichloroethane	49/56	0.09 ± 0.01	0.09 ± 0.01	0.06 ± 0.02	0.06 ± 0.03	0.08 ± 0.01
Dichloromethane	56/56	1.22 ± 0.68	0.57 ± 0.15	10.79 ± 9.56	20.85 ± 26.90	7.82 ± 6.53
Ethylbenzene	56/56	0.36 ± 0.17	0.32 ± 0.08	0.36 ± 0.06	0.42 ± 0.11	0.36 ± 0.06
Formaldehyde	54/54	2.26 ± 0.34	2.90 ± 0.39	5.65 ± 1.46	NA	4.44 ± 0.75
Propionaldehyde	54/54	0.34 ± 0.09	0.47 ± 0.09	0.65 ± 0.13	NA	0.55 ± 0.07
Arsenic (PM_{10})[a]	55/57	0.47 ± 0.30	0.33 ± 0.12	0.51 ± 0.11	0.60 ± 0.21	0.48 ± 0.10
Manganese (PM_{10})[a]	57/57	5.77 ± 2.01	9.09 ± 2.73	11.14 ± 2.70	6.01 ± 1.84	7.97 ± 1.24
Naphthalene[a]	59/59	51.84 ± 21.35	34.29 ± 10.66	48.54 ± 8.71	64.56 ± 20.13	49.56 ± 8.02
Nickel (PM_{10})[a]	57/57	1.39 ± 0.52	1.53 ± 0.43	1.53 ± 0.36	1.20 ± 0.25	1.41 ± 0.19

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations for BTUT from Table 25-5 include the following:

- The pollutants with the highest annual average concentrations are dichloromethane, formaldehyde, acetaldehyde, and benzene, consistent with the last several years of sampling.

- Dichloromethane has the highest annual average concentration for BTUT again in 2012, but is considerably less than the annual average for 2011. Th annual average concentration for 2012 has a very large confidence interval associated it, indicating the likely presence of outliers. A review of the quarterly averages shows that the third and fourth quarter average concentrations are significantly higher than the other two quarterly averages and that their confidence intervals are nearly as high (third quarter) or higher (fourth quarter) than the averages themselves. Concentrations of dichloromethane measured at BTUT in 2012 range from 0.244 µg/m^3 to 153 µg/m^3. The maximum concentration of this pollutant was measured on December 5, 2012 and is the only one greater than 100 µg/m^3. However, two additional concentrations are greater than 50 µg/m^3 were also measured at BTUT. Of the 22 dichloromethane concentrations greater than 10 µg/m^3 measured across the program, six were measured at BTUT. However, the median concentration of dichloromethane for BTUT is 0.80 µg/m^3, as over half of the measurements are less than 1 µg/m^3.

- There are no fourth quarter average concentrations for the carbonyl compounds because sampler issues during this quarter resulted in fewer valid samples than the 75 percent criteria. However, the maximum formaldehyde concentration measured at BTUT was measured on December 5, 2012 (12.6 µg/m^3), the same day as the maximum dichloromethane measurement. This formaldehyde concentration is the third highest formaldehyde concentration measured across the program.

- The third quarter average formaldehyde concentration is significantly greater than the first and second quarter averages. This is also true for acetaldehyde. Although no fourth quarter average is provided, a review of the data shows that this trend likely carries into the fourth quarter. The 18 highest formaldehyde concentrations measured at BTUT (those greater than or equal to 4.5 µg/m^3) were all measured in the third and fourth quarters of 2012. Conversely, all but one of the 23 formaldehyde concentrations less than 3 µg/m^3 were measured during the first two quarters of 2012. For acetaldehyde, all but one of the 11 concentrations greater than 4 µg/m^3 were measured during the third and fourth quarters while all 14 concentrations less than 1.6 µg/m^3 were measured during the first and second quarters. The difference among the quarterly averages is less significant for propionaldehyde, but the data shows a similar pattern with the higher concentrations measured during the second half of the year and lower concentrations measured during the first half of the year.

- Although the first quarter averages for benzene and ethylbenzene are slightly less than the fourth quarter averages, the first quarter averages have higher confidence intervals. A review of the data shows that the maximum concentrations of each of these pollutants were measured at BTUT on the first and second sample days of the year (January 4, 2012 and January 10, 2012). For benzene, these represent two of three concentrations greater than 2 µg/m^3 measured at BTUT. For ethylbenzene, the January 4th measurement (1.29 µg/m^3) is the only concentration greater than 1 µg/m^3

measured at BTUT; the January 10th measurement (0.89 µg/m^3) is the only other concentrations greater than 0.70 µg/m^3 measured at BTUT.

- Concentrations of 1,3-butadiene appear highest during the fourth quarter of 2012. A review of the data shows that eight of the 11 concentrations greater than 0.2 µg/m^3 were measured at BTUT during the fourth quarter. Of the three measured outside the fourth quarter, one was measured on January 4th and one was measured on January 10th, the same days the highest benzene and ethylbenzene concentrations were measured. The 1,3-butadiene concentrations for these days are the second and fourth highest 1,3-butadiene concentrations, respectively, measured at BTUT.

- Concentrations of naphthalene appear highest during the colder months of the year, although the confidence intervals shown for the first and fourth quarter averages indicate that there is a considerable amount of variability associated with these measurements. Concentrations of naphthalene measured at BTUT range from 5.50 ng/m^3 to 142 ng/m^3. The maximum concentration of naphthalene was also measured on January 4, 2012. The five concentrations of naphthalene greater than 100 ng/m^3 were measured in January, November, or December. Of the 16 concentrations greater than 60 ng/m^3 measured at BTUT, six were measured during the first quarter and six were measured during the fourth quarter (with one measured during the second and three measured during the third).

- Of the PM_{10} metals identified as pollutants of interest for BTUT, manganese has the highest annual average concentration. Manganese concentrations appear to be higher during the warmer months of the year, although the confidence intervals calculated for the quarterly averages indicate considerable variability in the individual measurements. The maximum manganese concentration was measured at BTUT on July 20, 2012 (24.78 ng/m^3). The 10 highest manganese concentrations measured at BTUT were all measured between May and September while 10 of the 12 lowest manganese concentrations were measured during the first or fourth quarters of the year.

- The first quarter average arsenic concentration has a relatively large confidence interval associated with it. A review of the data shows that the two highest arsenic concentrations measured at BTUT were measured on March 10, 2012 (1.87 ng/m^3) and January 10, 2012 (1.54 ng/m^3). The next highest concentration measured during the first quarter is one-third as high (0.55 ng/m^3). In addition, the two lowest measured detections of arsenic were also measured during the first quarter, explaining the relatively high level of variability shown for this quarter.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for BTUT from those tables include the following:

- BTUT appears in Table 4-9 through 4-12 a total of eight times for the program-level pollutants of interest.

- BTUT is listed for several of the program-level VOC pollutants of interest shown in Table 4-9. BTUT ranks highest for 1,2-dichloroethane, ranking fourth among other NMP sites sampling this pollutant.

- For the second year in a row, BTUT has the highest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds, as shown in Table 4-10. BTUT also has the sixth highest annual average concentration of acetaldehyde.

- BTUT does not appear in Table 4-11 for PAHs. This site's annual average concentrations of the PAHs are among the lower averages for sites sampling PAHs.

- BTUT ranks sixth for both manganese and nickel, as shown in Table 4-12. BTUT does not appear in Table 4-12 for arsenic.

25.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 25-4 for BTUT. Figures 25-6 through 25-18 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 25-6. Program vs. Site-Specific Average Acetaldehyde Concentration

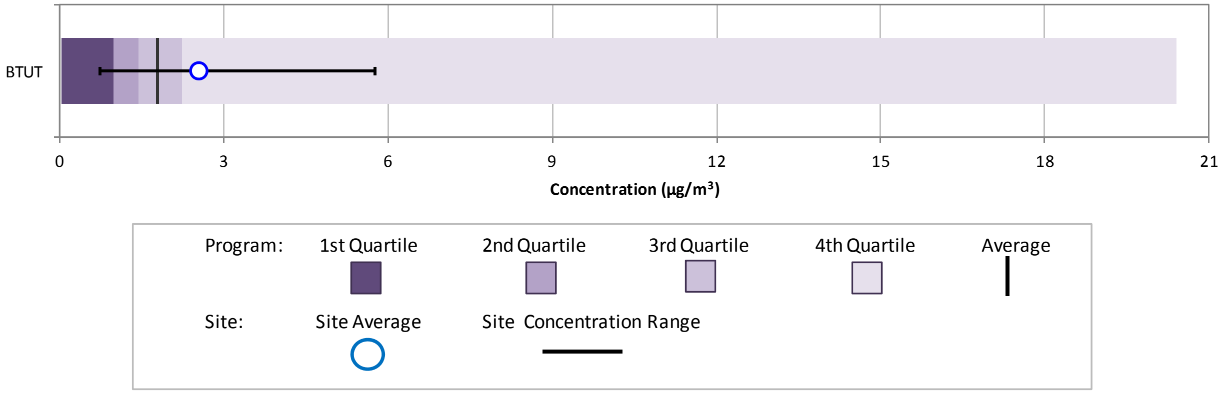


Figure 25-7. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

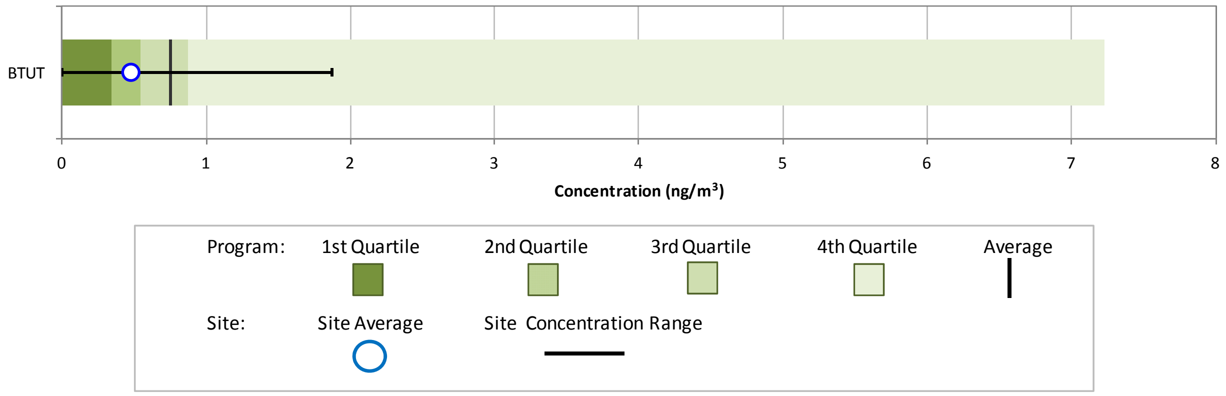


Figure 25-8. Program vs. Site-Specific Average Benzene Concentration

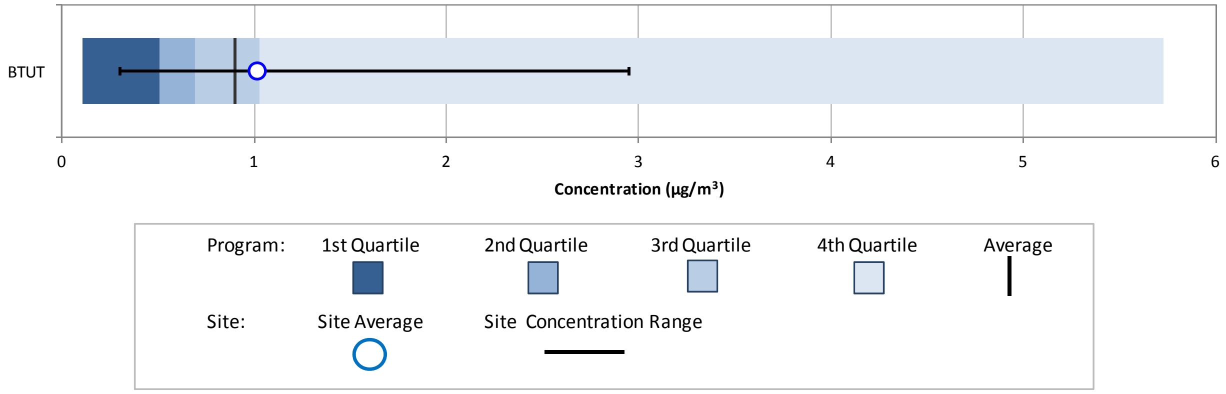


Figure 25-9. Program vs. Site-Specific Average 1,3-Butadiene Concentration

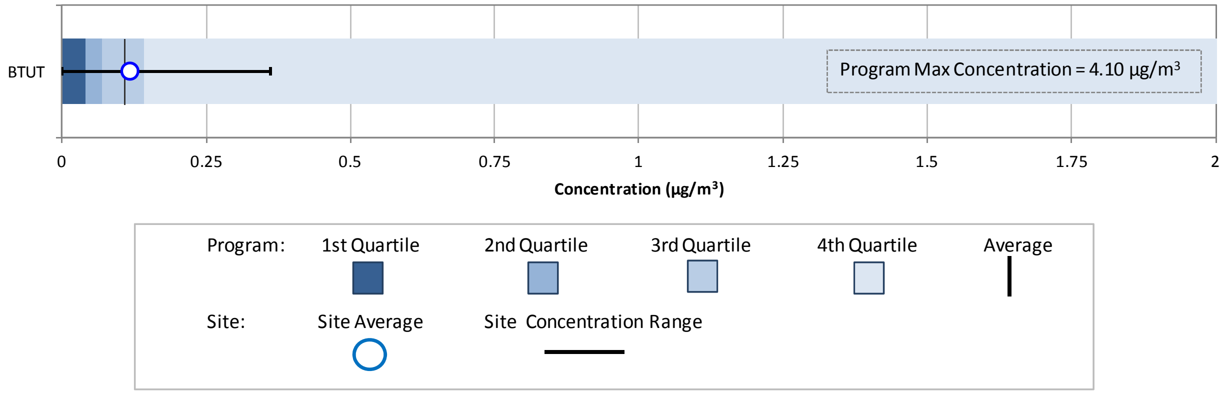


Figure 25-10. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

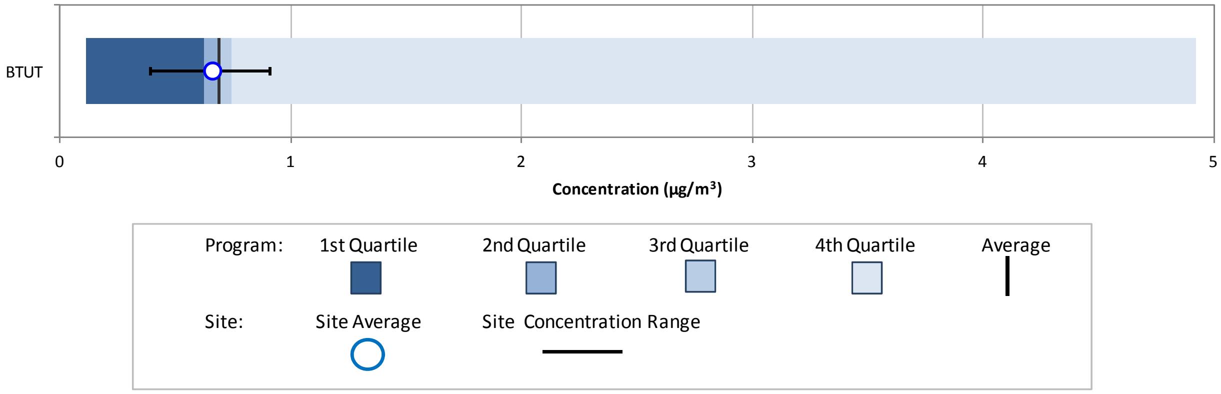


Figure 25-11. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

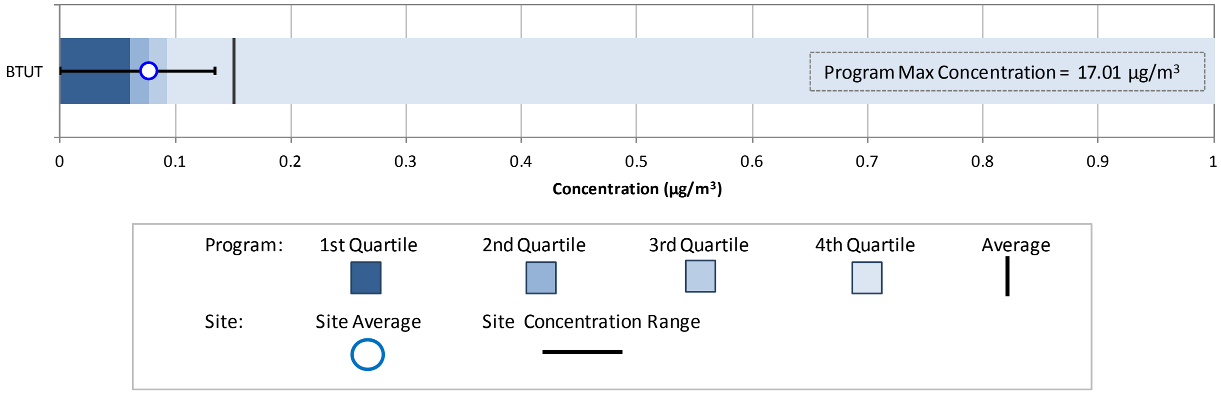


Figure 25-12. Program vs. Site-Specific Average Dichloromethane Concentration

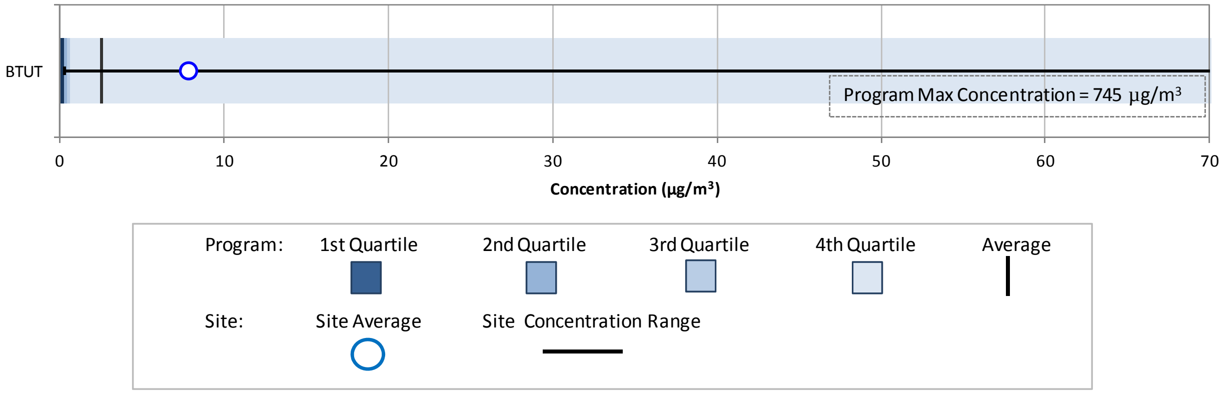


Figure 25-13. Program vs. Site-Specific Average Ethylbenzene Concentration

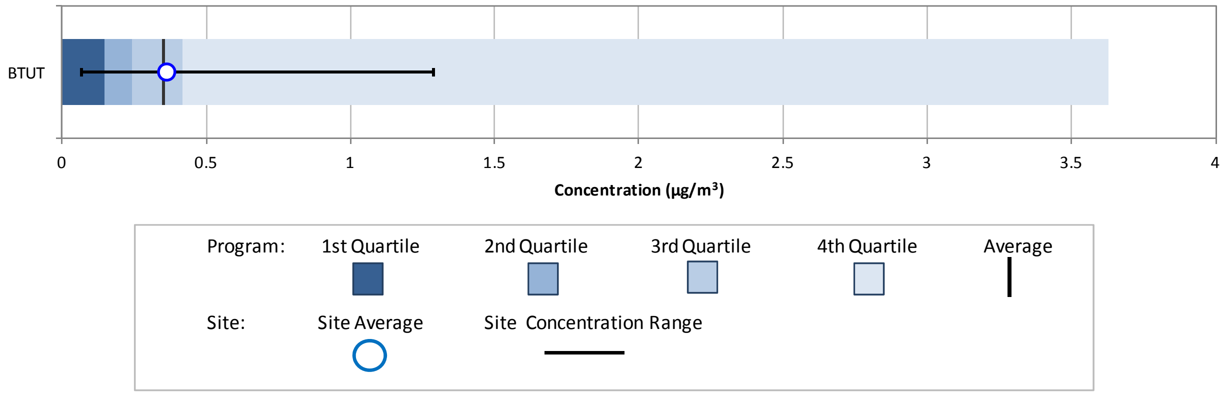


Figure 25-14. Program vs. Site-Specific Average Formaldehyde Concentration

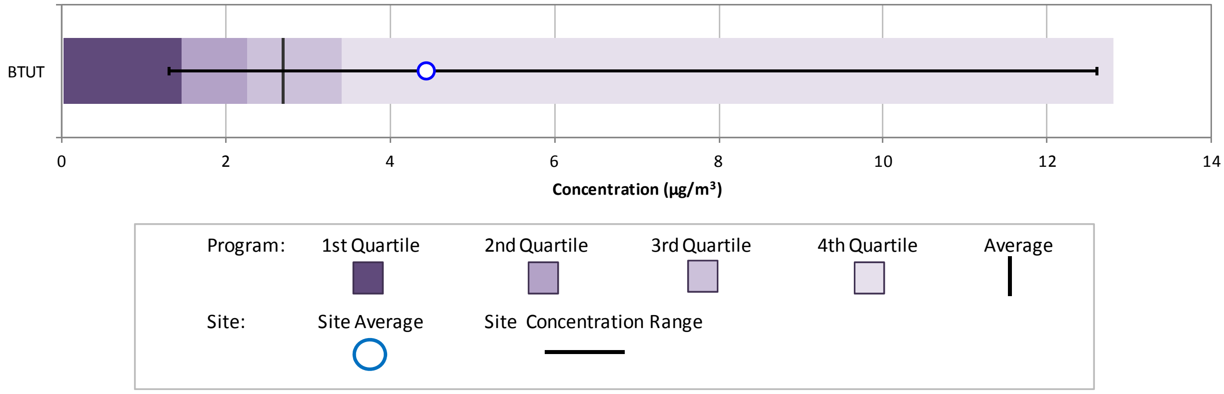


Figure 25-15. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

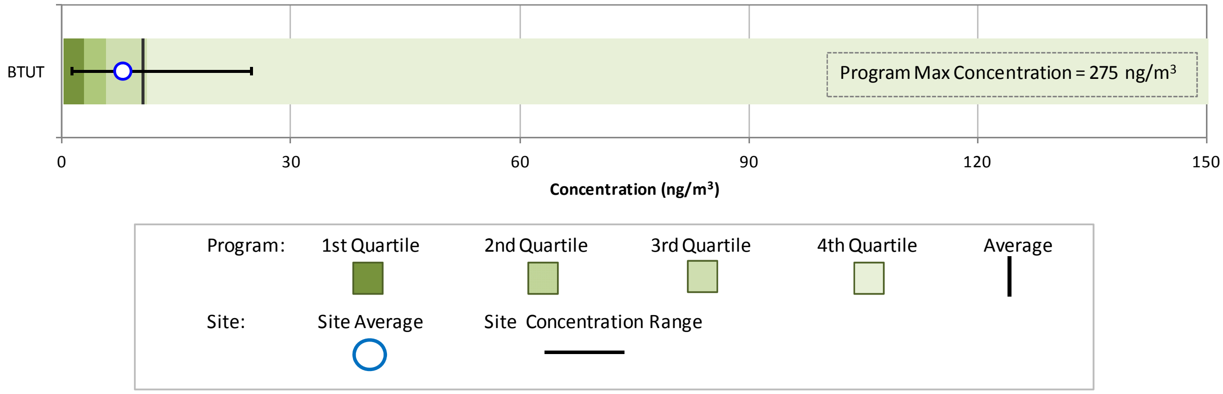


Figure 25-16. Program vs. Site-Specific Average Naphthalene Concentration

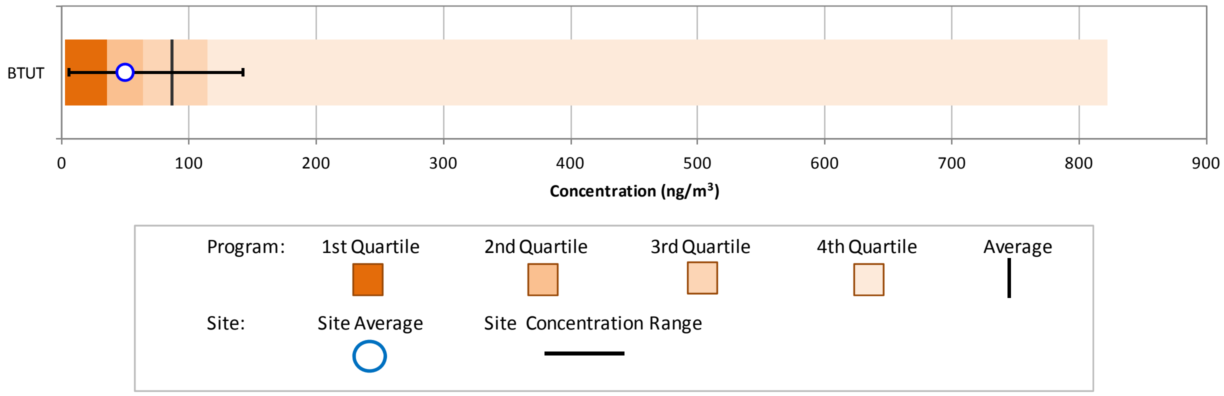


Figure 25-17. Program vs. Site-Specific Average Nickel (PM_{10}) Concentration

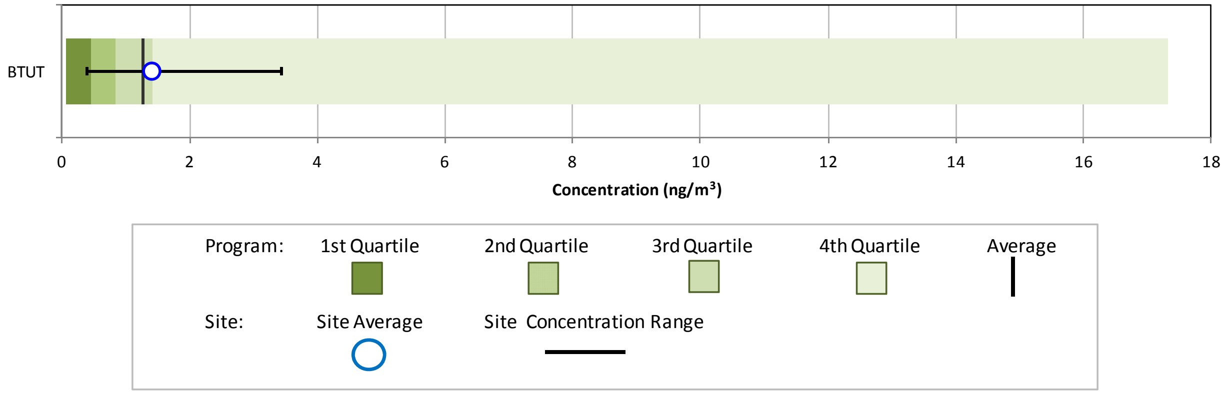
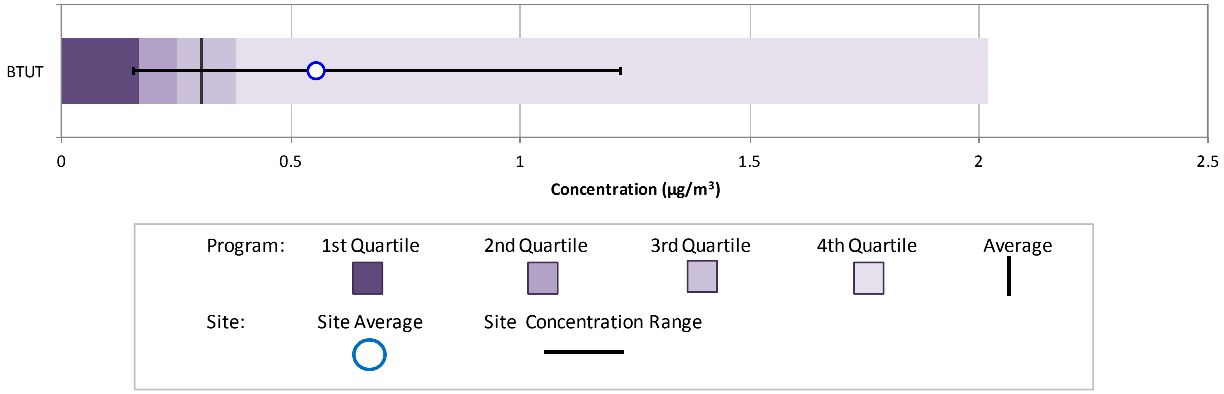


Figure 25-18. Program vs. Site-Specific Average Propionaldehyde Concentration



Observations from Figures 25-6 through 25-18 include the following:

- Figure 25-6 shows that the annual average acetaldehyde concentration for BTUT is greater than the program-level average concentration as well as the program-level third quartile. The maximum acetaldehyde concentration measured at BTUT is considerably less than the maximum acetaldehyde concentration measured at the program-level. There were no non-detects of acetaldehyde measured at BTUT or across the program.

- Figure 25-7 shows that BTUT's annual average arsenic concentration is less than the program-level average as well as the program-level median concentration. Concentrations of arsenic measured at BTUT range from non-detect to less than 2 ng/m^3.

- Figure 25-8 shows that the annual average benzene concentration for BTUT is greater than the program-level average concentration and similar to the program-level third quartile, although the maximum concentration measured at BTUT is roughly half the maximum concentration measured at the program level. There were no non-detects of benzene measured at BTUT or across the program.

- Figure 25-9 the box plot for 1,3-butadiene. Note that the program-level maximum 1,3-butadiene concentration (4.10 µg/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 2 µg/m^3. Figure 25-9 shows that the annual average concentration for BTUT is just greater than the program-level average concentration. The maximum concentration of benzene measured at BTUT is an order of magnitude less than the maximum concentration measured across the program. There was a single non-detect of 1,3-butadiene measured at BTUT.

- Figure 25-10 shows that the annual average concentration of carbon tetrachloride for BTUT is just less than the program-level average concentration and the program-level median concentration. The range of carbon tetrachloride concentrations for BTUT spans roughly 0.5 µg/m^3, with the maximum concentration less than 1 µg/m^3. There were no non-detects of carbon tetrachloride measured at BTUT or across the program.

- Figure 25-11 is the box plot for 1,2-dichloroethane. Note that the program-level maximum concentration (17.01 µg/m^3) is not shown directly on the box plot as the scale has been reduced to 1 µg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is greater than the program third quartile for this pollutant and is greater than or similar to the maximum concentration measured at most sites sampling 1,2-dichloroethane. This is because the program-level average is being driven by the higher measurements collected at a few monitoring sites. Figure 25-11 shows that the maximum 1,2-dichloroethane concentration measured at BTUT is two orders of magnitude less than the maximum concentration measured across the program. The annual average for BTUT is similar to the median concentration at the program level. The maximum

1,2-dichloroethane concentration measured at BTUT is less than the program-level average concentration. Seven non-detects of 1,2-dichloroethane were measured at BTUT.

- Similar to other pollutants, the program-level maximum concentration of dichloromethane (745 µg/m^3) is not shown directly on the box plot in Figure 25-12 to allow for the observation of data points at the lower end of the concentration range; thus, as the scale has been reduced to 70 µg/m^3, although reducing the scale by an order of magnitude still does not allow for the first three quartiles to be readily viewed. This is a result of a few measurements at the upper end of the concentrations range driving the data. Two dichloromethane concentrations measured at BTUT are greater than the top of the scale in Figure 25-12. The maximum concentration measured at BTUT (153 µg/m^3) is the sixth highest concentration program-wide, but is still considerably less than the maximum dichloromethane concentration measured across the program. BTUT's annual average dichloromethane concentration is roughly three times greater than the program-level average concentration. BTUT has the second highest annual average concentration of dichloromethane among sites sampling this pollutant, behind only GPCO.

- Figure 25-13 shows that the annual average ethylbenzene concentration for BTUT is similar to the program-level average concentration. The maximum ethylbenzene concentration measured at BTUT is less than the maximum concentration measured across the program. There were no non-detects of ethylbenzene measured at BTUT.

- Figure 25-14 shows that the range of formaldehyde concentrations measured at BTUT is large and that the maximum concentration measured at BTUT is just less than the maximum formaldehyde concentration measured across the program. The annual average formaldehyde concentration for BTUT is greater than both the program-level average and third quartile. As discussed in the previous section, BTUT has the highest annual average formaldehyde concentration among NMP sites sampling carbonyl compounds.

- Figure 25-15 is the box plot for manganese (PM_{10}). The program-level maximum manganese concentration (275 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 150 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. Figure 25-15 shows that the annual average concentration of manganese (PM_{10}) for BTUT is less than the program-level average concentration. The maximum concentration measured at BTUT is an order of magnitude less than the program-level maximum concentration. There were no non-detects of manganese measured at BTUT or across the program.

- Figure 25-16 is the box plot for naphthalene, which shows that the annual average naphthalene concentration for BTUT is less than both the program-level average and median concentrations. The annual average concentration of naphthalene for BTUT ranks 16th among the 20 sites for which annual averages could be calculated. The maximum naphthalene concentration measured at BTUT is considerably less than the program-level maximum concentration. There were no non-detects of naphthalene measured at BTUT or across the program.

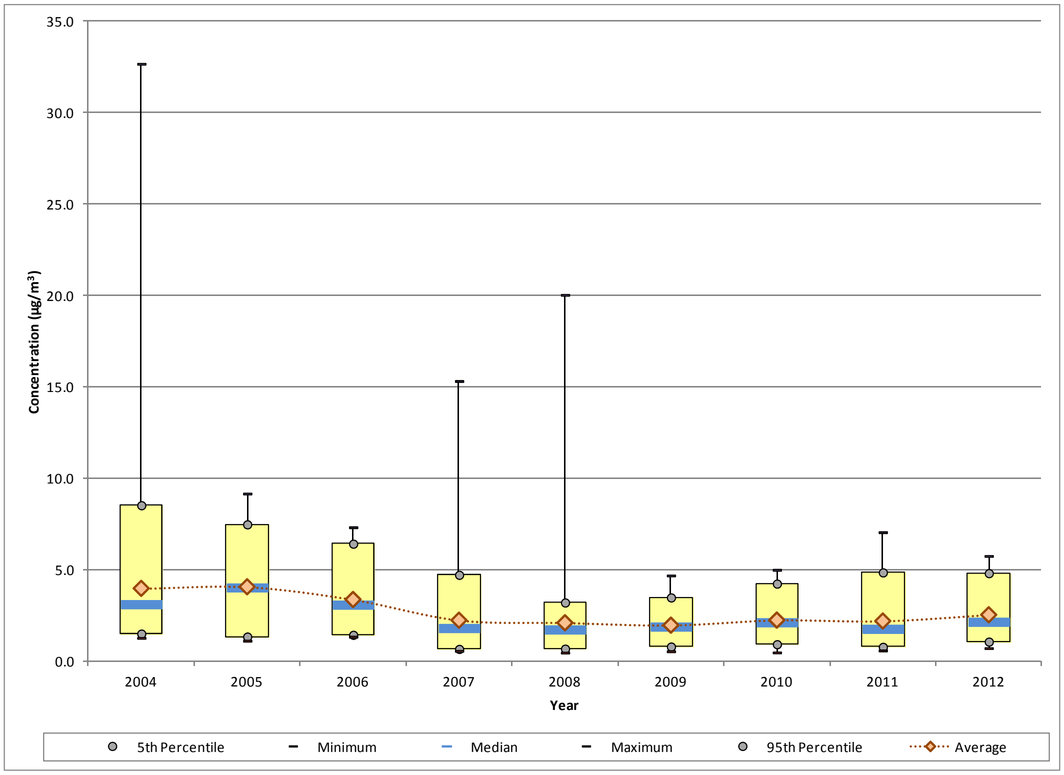
- Figure 25-17 is the box plot for nickel (PM_{10}). The maximum concentration of nickel measured at BTUT is considerably less than the program-level maximum concentration. The annual average concentration of nickel for BTUT is greater than the program-level average concentration and similar to the program-level third quartile. The minimum concentration of nickel measured at BTUT is just less than the program-level first quartile.

- Figure 25-18 shows that the annual average concentration of propionaldehyde for BTUT is greater than the program-level average concentration and third quartile. This site has the highest annual average concentration of this pollutant among NMP sites sampling carbonyl compounds. The maximum propionaldehyde concentration was not measured at BTUT. There minimum concentration of this pollutant measured at BTUT is just less than the program-level first quartile.

25.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. BTUT has sampled carbonyl compounds, VOCs, metals, and SNMOCs under the NMP since 2003. Thus, Figures 25-19 through 25-30 present the 1-year statistical metrics for each of the pollutants of interest for BTUT. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented. Because sampling for PAHs did not begin in earnest at BTUT until late 2008, a trend analysis was not performed for naphthalene.

Figure 25-19. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at BTUT



Observations from Figure 25-19 for acetaldehyde measurements collected at BTUT include the following:

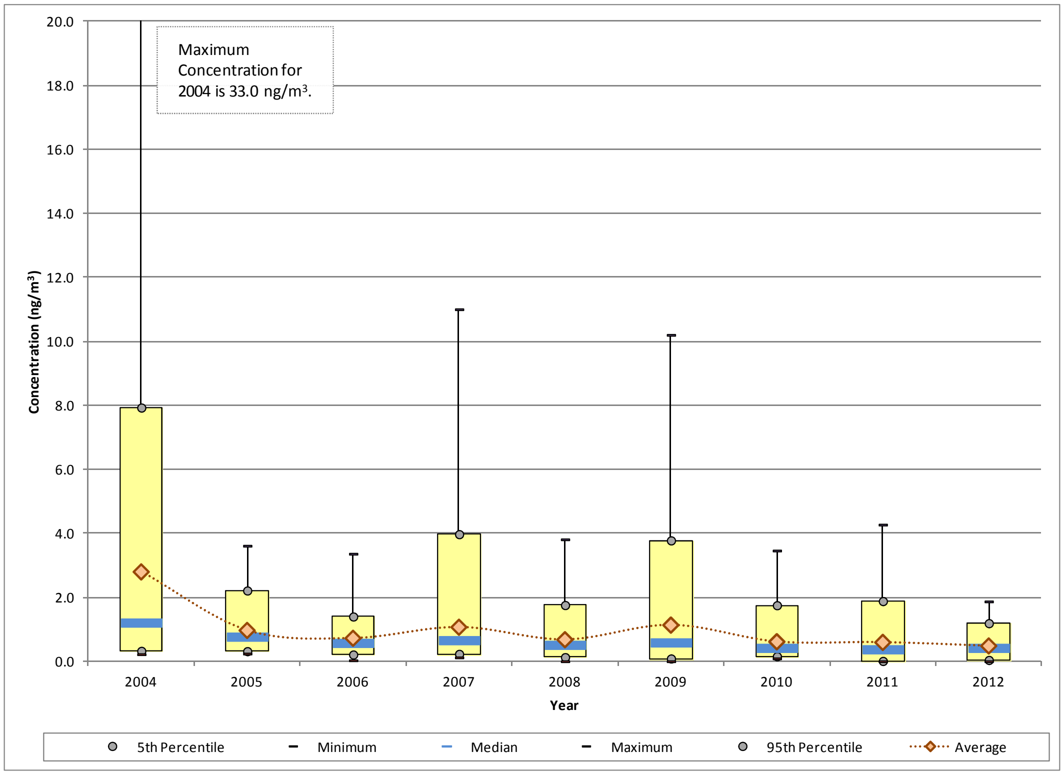
- Sampling for carbonyl compounds under the NMP began at BTUT in late July 2003. Because this represents less than half of the sampling year, Figure 25-19 excludes data from 2003.

- The maximum acetaldehyde concentration was measured in 2004 (32.7 µg/m^3). The next highest concentrations of acetaldehyde were measured at BTUT in 2008 (20.0 µg/m^3) and 2007 (15.3 µg/m^3). No acetaldehyde concentrations greater than 8 µg/m^3 have been measured at BTUT since 2008.

- The 1-year average concentration exhibits a steady decreasing trend beginning with 2006 and continuing through 2009, after which the 1-year average concentration changes little, ranging from 1.97 µg/m^3 (2009) to 2.54 µg/m^3 (2012).

- The range within which the majority of concentrations fall, as indicated by the difference between the 5th and 95th percentiles, decreased steadily through 2008, where it reached a minimum. This range then increased for 2009, an increasing trend that continued through 2011, after which a slight decrease is shown for 2012. This is due to a slight increase in the concentrations at the lower end of the concentration range for 2012.

Figure 25-20. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at BTUT



Observations from Figure 25-20 for arsenic measurements collected at BTUT include the following:

- Sampling for PM_{10} metals under the NMP began at BTUT in late July 2003. Because this represents less than half of the sampling year, Figure 25-20 excludes data from 2003.

- The maximum arsenic concentration was also measured at BTUT in 2004 (33.0 ng/m^3) and is nearly twice the next highest concentration (16.8 ng/m^3), also measured in 2004. The three highest measurements of arsenic were all measured at BTUT in 2004; further, eight of the 11 highest concentrations of arsenic (those greater than 5 ng/m^3) were measured in 2004.

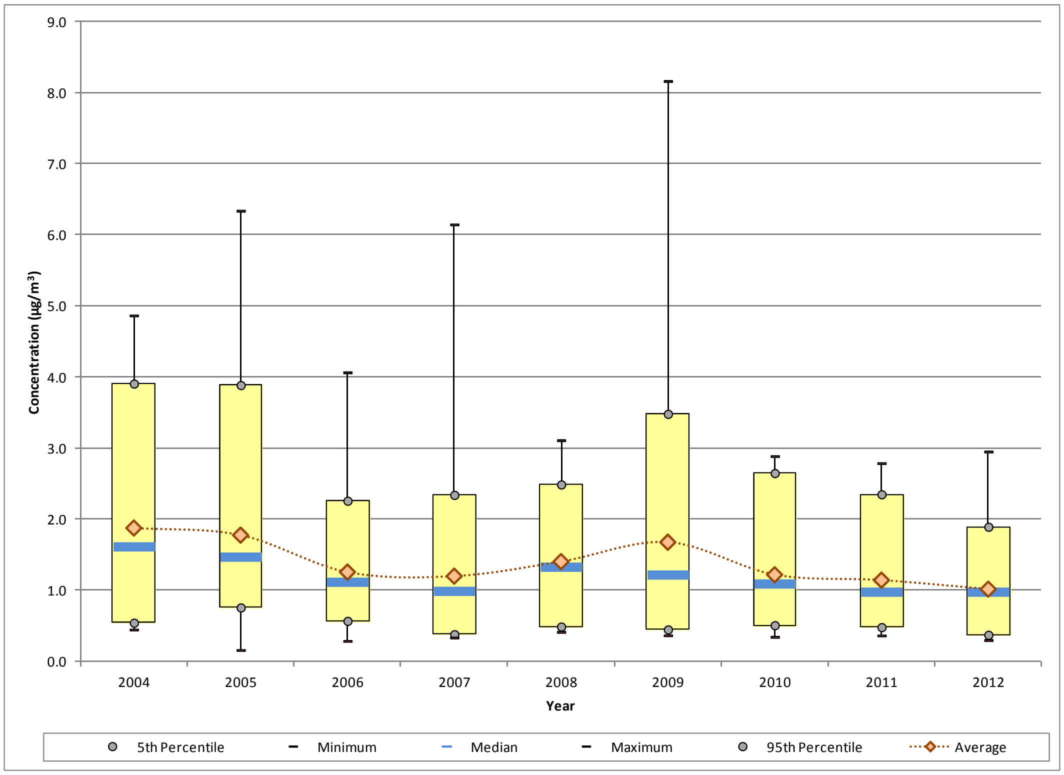
- Of the 20 highest arsenic concentrations measured at BTUT, 12 were measured during the first quarter of the calendar year and eight were measured during the fourth quarter of the calendar year, suggesting a seasonality in the measurements.

- The average concentration of arsenic decreased significantly from 2004 to 2005, with the 1-year average decreasing from 2.79 ng/m^3 to 0.96 ng/m^3. Between 2006 and 2010, there is an undulating pattern in the 1-year average concentrations, with years with higher concentrations followed by years with lower concentrations. During this period, the 1-year average arsenic concentration fluctuated between 0.61 ng/m^3 (2010) to 1.13 ng/m^3 (2009). However, the statistical parameters for 2007 and 2009 are being driven primarily by a single “high” measurement. If the maximum concentrations measured in 2007 and 2009 were removed from the data set, the

1-year average concentrations for this period would all be less than 1 ng/m^3. The maximum concentrations for 2007 and 2009 were both measured in January.

- A slight decreasing trend is shown in the arsenic concentrations measured between 2009 and 2012. The 1-year average concentration is at a minimum for 2012. The maximum arsenic concentration measured in 2012 is less than 2 ng/m^3, the only year for which this is true.

Figure 25-21. Yearly Statistical Metrics for Benzene Concentrations Measured at BTUT



Observations from Figures 25-21 for benzene measurements collected at BTUT include the following:

- Sampling for VOCs under the NMP began at BTUT in late July 2003. Because this represents less than half of the sampling year, Figure 25-21 excludes data from 2003.

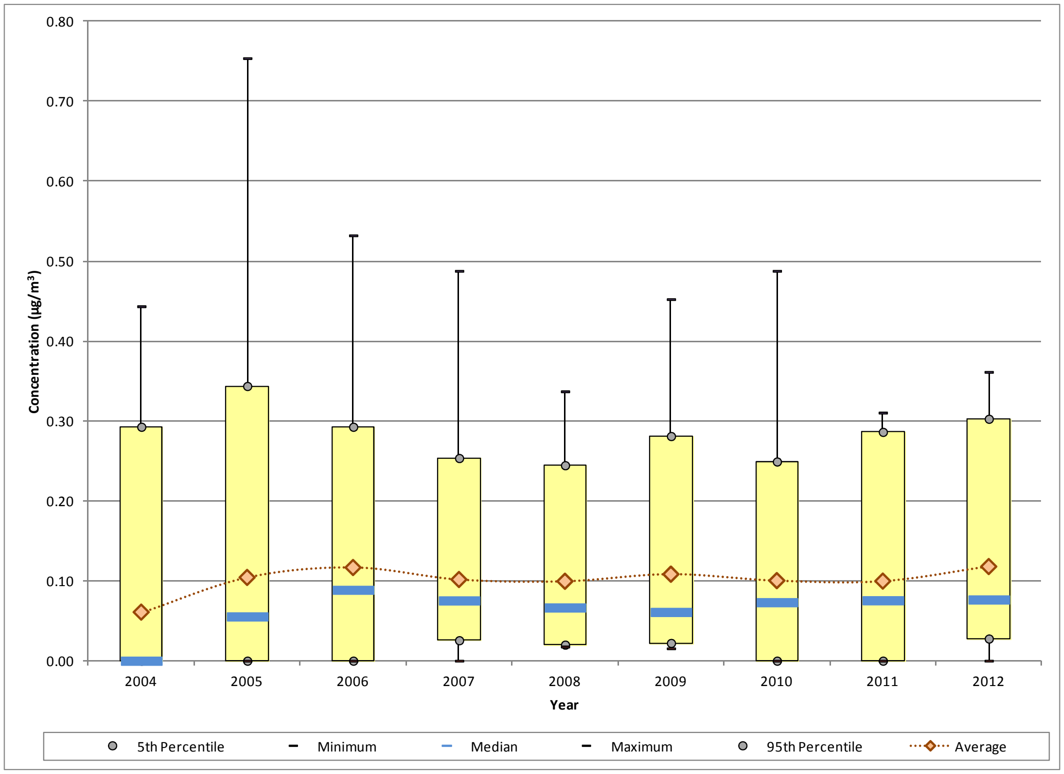
- The maximum concentration of benzene shown was measured in 2009 (8.16 µg/m^3). The next highest concentration (6.56 µg/m^3) was also measured in 2009, although concentrations greater than 6 µg/m^3 were also measured in 2005 and 2007.

- Concentrations of benzene appear to be higher during the colder months of the year, as all but one of the 40 highest concentrations (those greater than 2.75 µg/m^3) were measured during the first or fourth quarters of the calendar year.

- The 1-year average and median benzene concentrations have a decreasing trend through 2007. An increasing trend in the 1-year average is then shown through 2009, after which another decreasing trend follows. The 1-year average benzene concentrations for each year fall between 1 µg/m^3 and 2 µg/m^3, with the 1-year average concentration at a minimum for 2012 (1.02 µg/m^3).

- Although the 1-year average concentration increased for 2009, the median concentration decreased. The difference between these two parameters is highest for 2009, a reflection of increased variability in the measurements. The 1-year average is being driven by a few higher concentrations measured in 2009, as discussed above.

Figure 25-22. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at BTUT



Observations from Figure 25-22 for 1,3-butadiene measurements collected at BTUT include the following:

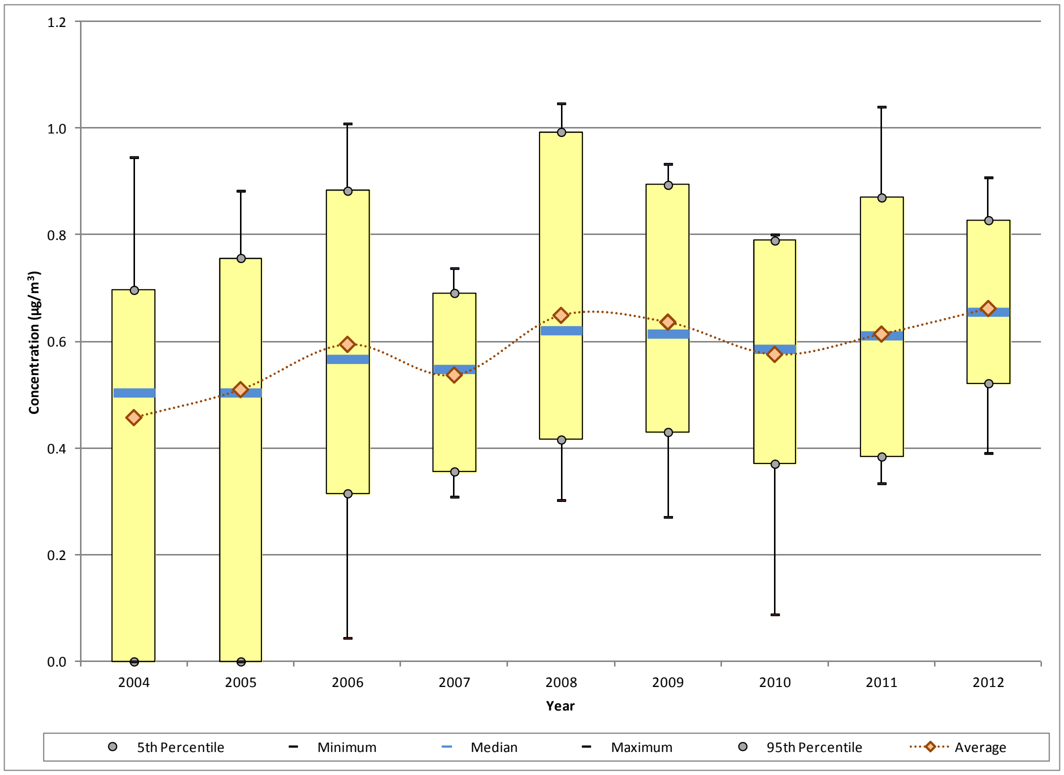
- The maximum concentration of 1,3-butadiene shown was measured in 2005 (0.75 µg/m^3). The second highest concentration was also measured in 2005 (0.53 µg/m^3), although a similar measurement was also collected in 2006. These are the only concentrations of 1,3-butadiene greater than 0.5 µg/m^3 measured at BTUT.

- The minimum, 5th percentile, and median concentrations are all zero for the 2004, indicating that at least half of the measurements were non-detects. The detection rate of 1,3-butadiene increased after 2004, as indicated by the increase in the median concentration for 2005 and 2006 and then the 5th percentile for 2007. The percentage of non-detects decreased from 75 percent for 2004 to 0 percent for 2008 and 2009. The percentage of non-detects increased to 7 percent for 2010 and 18 percent for

2011, explaining why the 5th percentile returned to zero. For 2012, there was a single non-detect of this pollutant.

- The 1-year average concentration increased from 0.061 µg/m^3 for 2004 to 0.104 µg/m^3 for 2005. This increase is likely due to the decrease in non-detects (and thus zeros substituted for them) as well as the higher concentrations measured in 2005, as discussed above. Between 2005 and 2012, the 1-year average concentration has changed little, ranging from 0.099 µg/m^3 (2008, 2011) to 0.118 µg/m^3 (2012).

Figure 25-23. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at BTUT



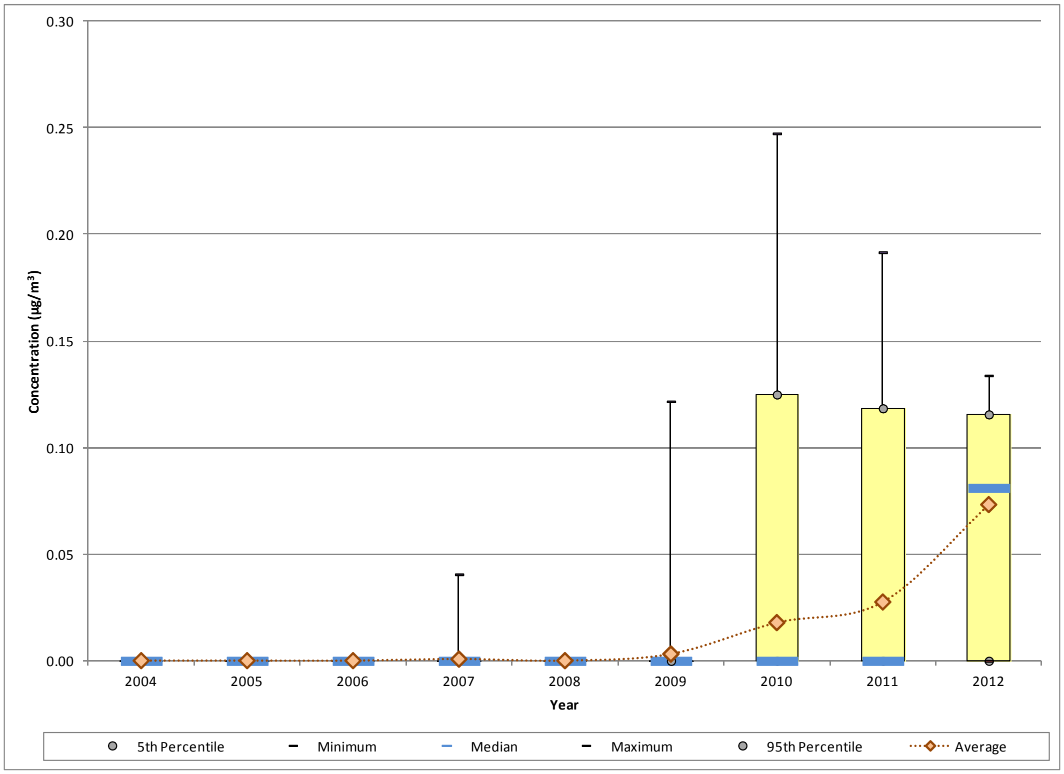
Observations from Figures 25-23 for carbon tetrachloride measurements collected at BTUT include the following:

- Non-detects of carbon tetrachloride were measured only in 2004 (nine) and 2005 (five). Concentrations of carbon tetrachloride greater than 1 µg/m^3 were measured in 2006 (two), 2008 (three), and 2011 (one).

- A significant increasing trend is shown in the 1-year average concentrations between 2004 and 2008, with the exception of 2007. The range of concentrations measured decreased substantially for 2007, which is reflected in the dip in the 1-year average concentration. A slight decreasing trend in the carbon tetrachloride measurements is shown between 2008 and 2010, after which an increasing trend is shown through the end of the sampling period.

- Although the overall range within which most of the concentrations fall is decreasing, the central tendency of the measurements has increased since the onset of sampling.

Figure 25-24. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at BTUT

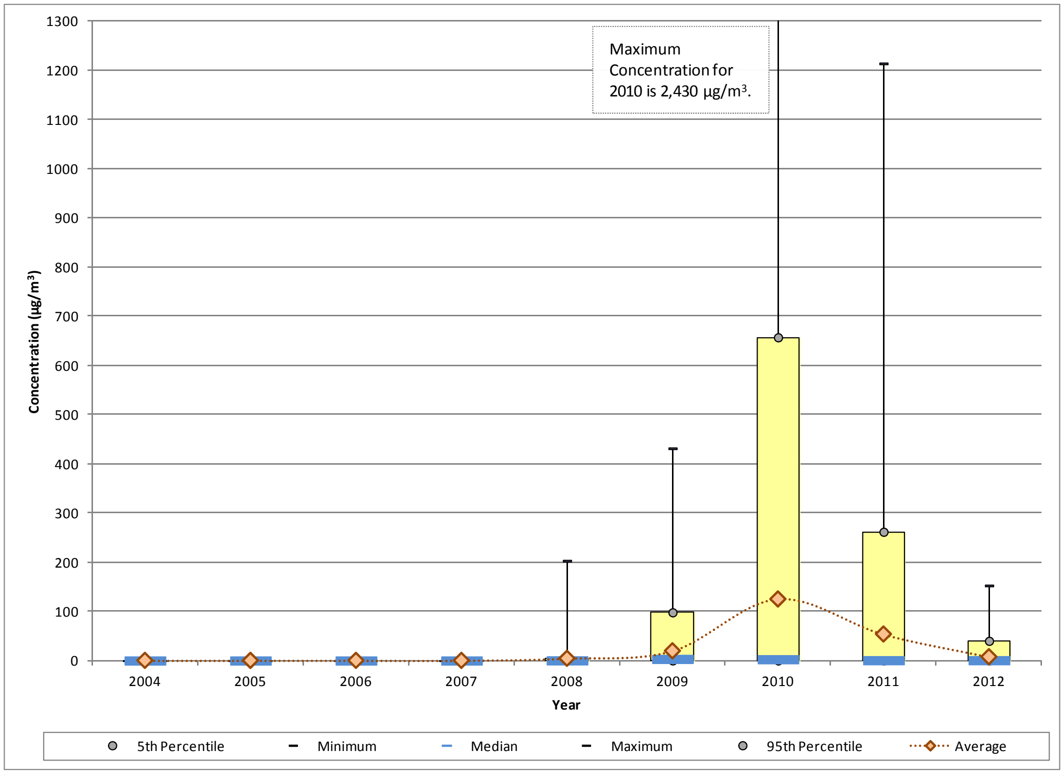


Observations from Figures 25-24 for 1,2-dichloroethane measurements collected at BTUT include the following:

- For the first several years of sampling, all of the statistical parameters shown were zero. Between 2004 and 2008, there was a single measured detection of 1,2-dichloroethane, which was measured in 2007. Beginning with 2009, the number of measured detections began to increase; there were two in 2009, seven in 2010, 15 in 2011, and 47 in 2012. This explains the increases shown in the 1-year average concentrations for 2010, 2011, and 2012.

- The first year with a median concentration greater than zero is 2012. This indicates that there were more measured detections than non-detects for the first time. The median concentration is actually greater than the annual average concentration for 2012. This is because there were still seven non-detects (or zeros) factoring into the average concentration for the year.

Figure 25-25. Yearly Statistical Metrics for Dichloromethane Concentrations Measured at BTUT



Observations from Figures 25-25 for dichloromethane measurements collected at BTUT include the following:

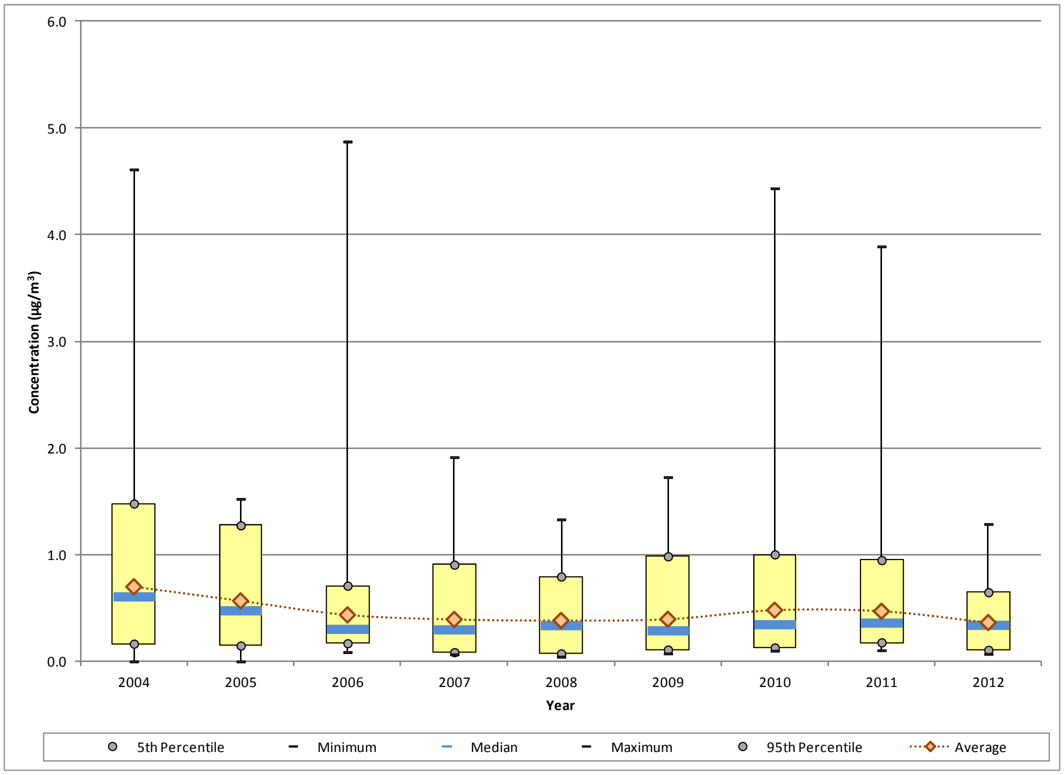
- Prior to 2008, the maximum concentration of dichloromethane measured at BTUT was 1.64 µg/m^3 (in 2005). However, due to the scale on the graph, none of the statistical parameters for the early years are visible.

- Beginning in 2008, "higher" concentrations of dichloromethane began to be measured at BTUT. In 2008, concentrations of 33 µg/m^3 and 203 µg/m^3 were measured, both in November. In 2009, four concentrations greater than 100 µg/m^3 and five concentrations between 20 µg/m^3 and 80 µg/m^3 were measured. In 2010, three dichloromethane concentrations greater than 1,000 µg/m^3 were measured, along with six more greater than 100 µg/m^3. For 2011, there was only one concentration greater than 1,000 µg/m^3 measured, although two more greater than 500 µg/m^3 were also measured. The maximum concentration for 2012 (152 µg/m^3) is considerably less, but still greater than 100 µg/m^3.

- There does not appear to be a pattern in the time of year that these higher measurements are collected. Of the 20 concentrations measured at BTUT greater than 100 µg/m^3, at least one has been measured in each month of the year except March, April, and May. There is a 3-way tie for month with the greatest number of these higher measurements: January, September, and December.

- Even with these measurements, the median concentration for each year is less than 4 µg/m^3 and is less than 1 µg/m^3 for most years of sampling.

Figure 25-26. Yearly Statistical Metrics for Ethylbenzene Concentrations Measured at BTUT



Observations from Figures 25-26 for ethylbenzene measurements collected at BTUT include the following:

- The maximum concentration of ethylbenzene measured at BTUT was measured in 2006 (4.87 µg/m^3), although concentrations greater than 4 µg/m^3 were also measured in 2004 and 2010. Only one additional concentration greater than 2 µg/m^3 has been measured at BTUT (3.89 µg/m^3 in 2011).

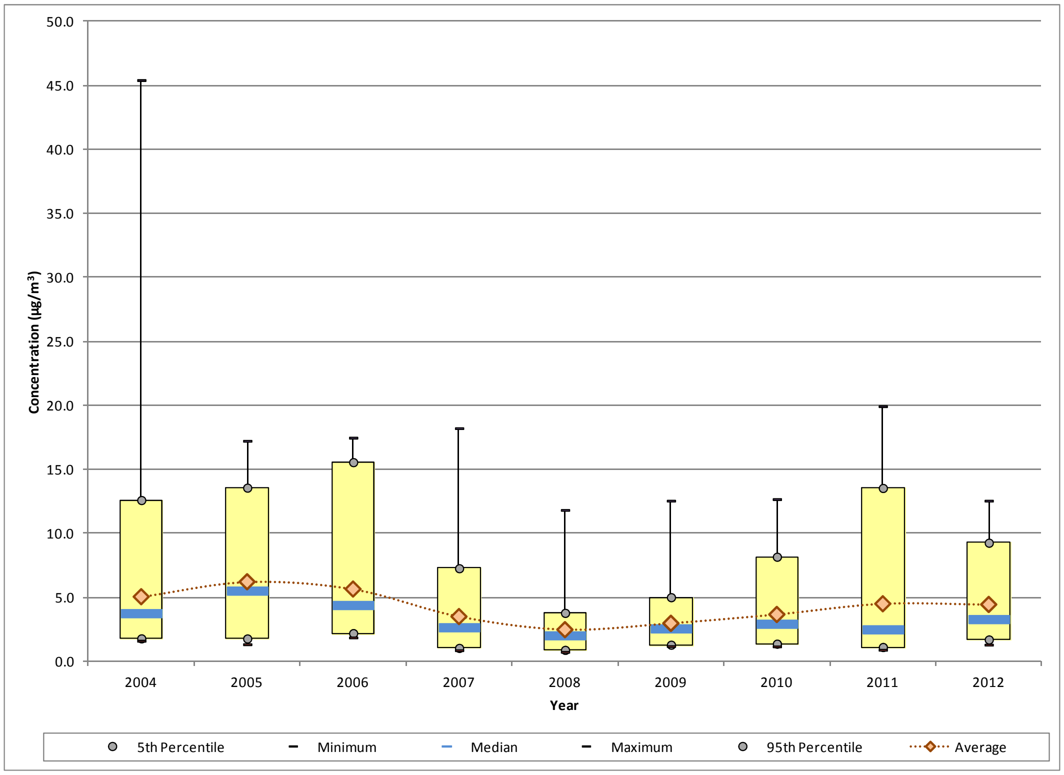
- A steady decreasing trend in the 1-year average concentration is shown from 2004 through 2007, representing just less than a 50 percent decrease (from 0.70 µg/m^3 for 2004 to 0.39 µg/m^3 for 2007). However, most of the change is realized between 2004 and 2006.

- Between 2007 and 2009, little change is shown, with the 1-year average concentrations varying by less than 0.012 µg/m^3.

- Nearly all of the statistical parameters exhibit increases for 2010, particularly the maximum concentration. However, it is this concentration driving most of the increases shown, as removing the maximum concentration from the data set would result in a 1-year average concentration similar to those shown for 2007 through 2009. This is also true for 2011.

- The range of ethylbenzene concentrations measured in 2012 is the smallest among the years of sampling. The 1-year average concentration is also at a minimum for 2012.

Figure 25-27. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at BTUT



Observations from Figure 25-27 for formaldehyde measurements collected at BTUT include the following:

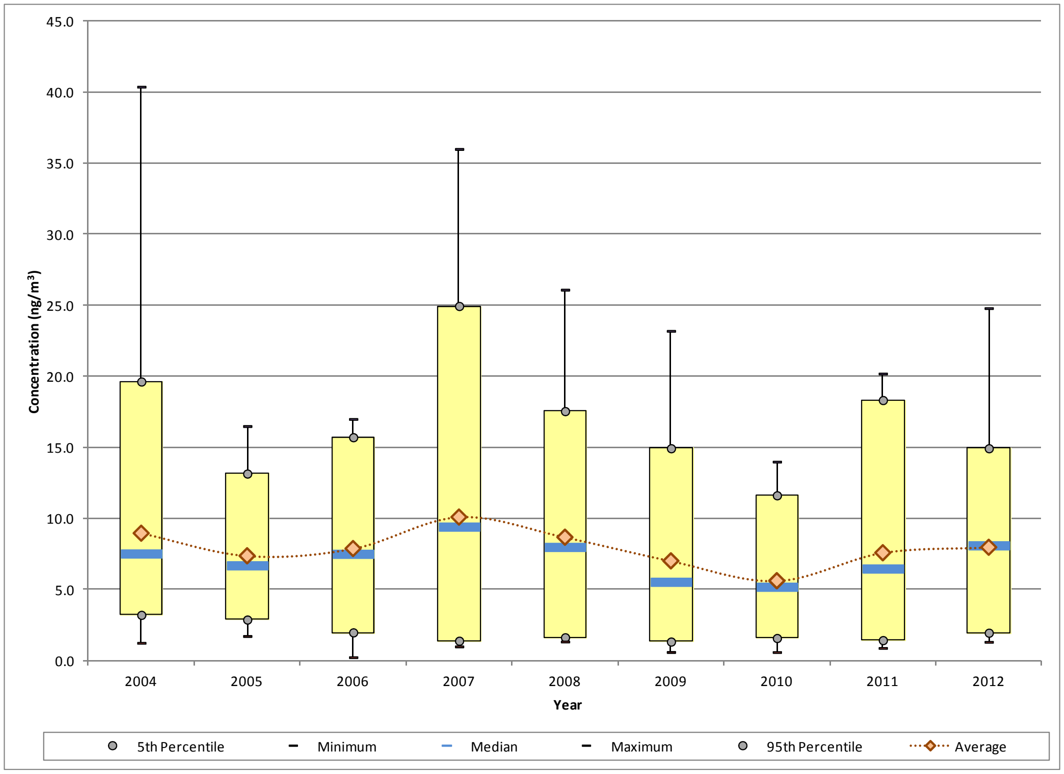
- The maximum formaldehyde concentration (45.4 µg/m^3) was measured on August 31, 2004, on the same day as the highest acetaldehyde concentration. This measurement is more than twice the next highest concentration (19.9 µg/m^3), measured in 2011. Concentrations greater than 15 µg/m^3 were measured in 2004, 2005, 2006, 2007, and 2011.

- Although the maximum concentration decreased significantly from 2004 to 2005, the other statistical metrics exhibit increases. The median increased by nearly 2 µg/m^3 from 2004 to 2005, indicating that concentrations ran higher in 2005 than 2004 (as opposed to being driven by an outlier, as in 2004). As an illustration, there were 11 concentrations greater than 5 µg/m^3 measured in 2004 compared to 31 in 2005.

- After 2005, the 1-year average concentration began to decrease, reaching a minimum for 2008. After 2008, a steady increasing trend is shown in the 1-year average formaldehyde concentrations, as well as most other statistical parameters. This trend, however, levels out for 2012.

- Although little change is shown in the 1-year average between 2011 and 2012, the range of concentrations measured is smaller for 2012 and the median actually exhibits an increase. The decrease in the concentrations in the upper end of the range from 2011 to 2012 are balanced out by a higher number of measurements in the mid-to-upper part of the range. The number of measurements greater than 10 µg/m^3 decreased from nine to one from 2011 to 2012 while the number of measurements between 5 µg/m^3 and 10 µg/m^3 increased from six to 14 during the same period. In addition, there are six concentrations measured in 2011 that are less than the minimum concentration measured in 2012; thus, the concentrations at the lower end of the concentration range increased for 2012.

Figure 25-28. Yearly Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at BTUT



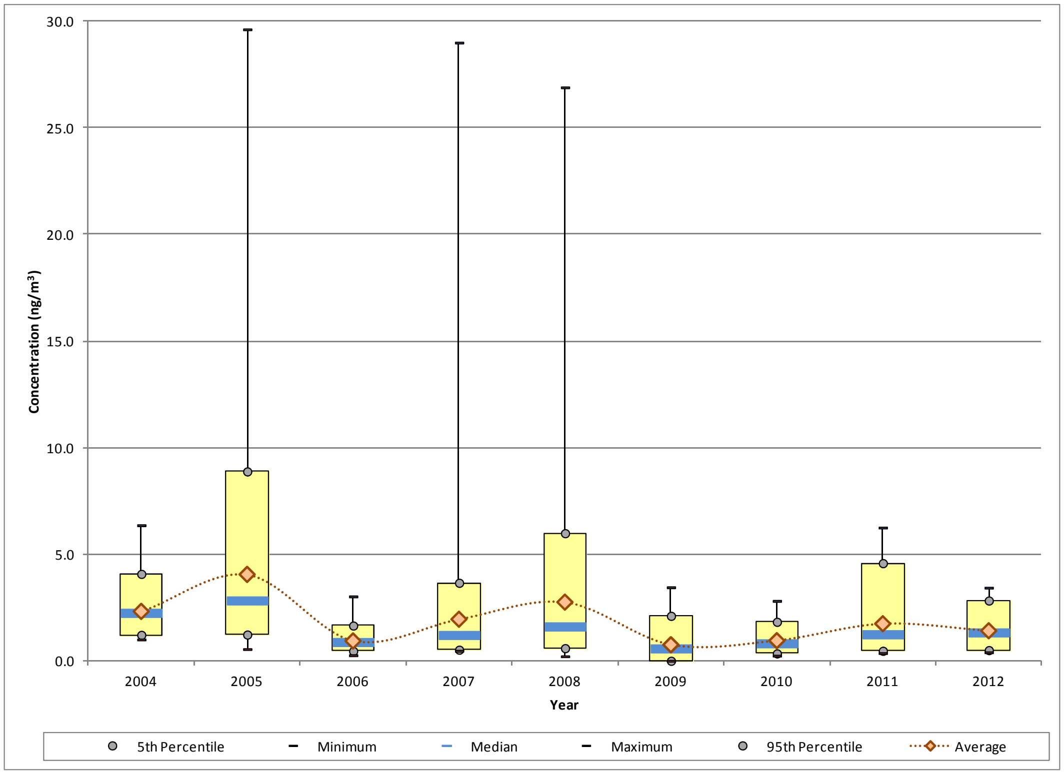
Observations from Figure 25-28 for manganese measurements collected at BTUT include the following:

- The maximum manganese concentration (40.4 ng/m^3) was measured in 2004, although the next highest concentration, measured in 2007, is similar in magnitude (36.0 ng/m^3). The third (28.3 ng/m^3) and the fourth (27.2 ng/m^3) highest concentrations were also measured in 2007.

- The 1-year average concentration decreased from 2004 to 2005, after which an increase shown through 2007, although these changes are not statistically significant. However, a significant decrease in manganese concentrations is shown between 2007 and 2010, which is followed by an increase for 2011. The median concentration follows a similar trend.

- The 1-year average manganese concentration changed very little from 2011 to 2012, while the median concentration increased considerably (from 6.48 ng/m^3 to 8.11 ng/m^3). The number of manganese concentrations in the mid- to upper-end of the concentration range (between 8 ng/m^3 and 15 ng/m^3) increased from 19 to 27 from 2011 to 2012. At the same time, the number of manganese concentrations at the lower end of the concentration range (less than 2 ng/m^3) decreased from eight to three from 2011 to 2012.

Figure 25-29. Yearly Statistical Metrics for Nickel (PM_{10}) Concentrations Measured at BTUT



Observations from Figure 25-29 for nickel measurements collected at BTUT include the following:

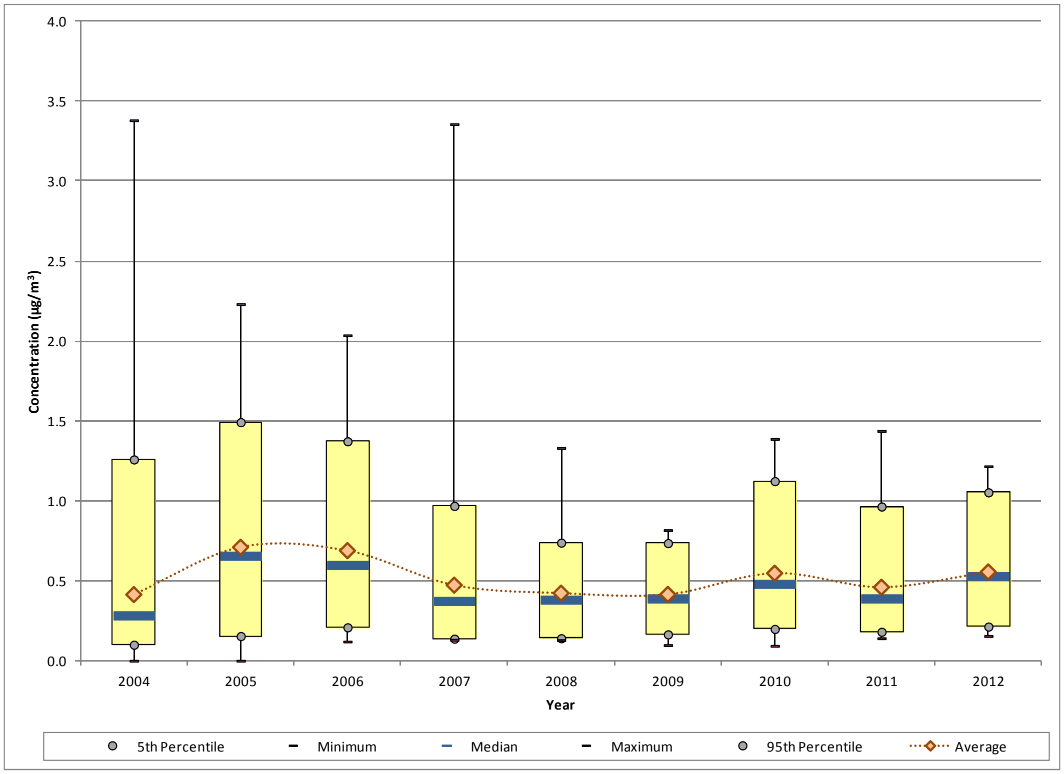
- The maximum nickel concentration was measured in 2005 (29.6 ng/m^3), although a similar concentration was also measured in 2007. Two additional nickel concentrations greater than 20 ng/m^3 were also measured in 2008. The fifth highest concentration measured was half as high (less than 10 ng/m^3) and was also measured in 2005.

- All 24 non-detects of nickel were measured in 2009.

- The range of nickel concentrations measured each year is highly variable. Concentrations measured over a given year have spanned a little as 2.5 ng/m^3 (2010)

or up to nearly 30 ng/m^3 (2005). This variability is reflected in the undulating pattern shown in the central tendency statistics. The 1-year average concentrations have ranged from 0.75 ng/m^3 (2009) to 4.05 ng/m^3 (2005).

Figure 25-30. Yearly Statistical Metrics for Propionaldehyde Concentrations Measured at BTUT



Observations from Figure 25-30 for propionaldehyde measurements collected at BTUT include the following:

- The maximum propionaldehyde concentration (3.38 µg/m^3) was measured on the same day as the maximum acetaldehyde and formaldehyde concentrations (August 31, 2004), although a similar concentration was also measured in 2007. No other propionaldehyde concentrations greater than 2.5 µg/m^3 have been measured at BTUT.

- Even though the maximum concentration decreased considerably from 2004 to 2005, the other statistical metrics exhibit increases (similar to the formaldehyde concentrations). The median increased four-fold from 2004 to 2005, indicating that concentrations ran higher in 2005 than 2004 (as opposed to being driven by an outlier, as in 2004). The number of concentrations greater than 1 µg/m^3 tripled from 2004 to 2005 and the number of concentrations between 0.5 µg/m^3 and 1 µg/m^3 quadrupled during this period.

- After 2005, the 1-year average concentration began to decrease, reaching a minimum for 2009, where the entire set of measurements span less than 1 µg/m^3. The propionaldehyde concentrations increase significantly from 2009 to 2010, with an undulating pattern in the 1-year average concentrations developing afterward.

25.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the BTUT monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

25.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Utah monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites are greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

25.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for BTUT and where annual average concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 25-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 25-6. Risk Approximations for the Utah Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Bountiful, Utah - BTUT						
Acetaldehyde	0.0000022	0.009	54/54	2.54 ± 0.35	5.58	0.28
Arsenic (PM_{10})[a]	0.0043	0.000015	55/57	<0.01 ± <0.01	2.05	0.03
Benzene	0.0000078	0.03	56/56	1.02 ± 0.13	7.92	0.03
1,3-Butadiene	0.00003	0.002	55/56	0.12 ± 0.02	3.53	0.06
Carbon Tetrachloride	0.000006	0.1	56/56	0.66 ± 0.03	3.97	0.01
1,2-Dichloroethane	0.000026	2.4	49/56	0.08 ± 0.01	2.00	<0.01
Dichloromethane	0.00000013	0.6	56/56	7.82 ± 6.53	1.02	0.01
Ethylbenzene	0.0000025	1	56/56	0.36 ± 0.06	0.91	<0.01
Formaldehyde	0.000013	0.0098	54/54	4.44 ± 0.75	57.67	0.45
Manganese (PM_{10})[a]	--	0.00005	57/57	0.01 ± <0.01	--	0.16
Naphthalene[a]	0.000034	0.003	59/59	0.05 ± 0.01	1.68	0.02
Nickel (PM_{10})[a]	0.00048	0.00009	57/57	<0.01 ± <0.01	0.67	0.02
Propionaldehyde	--	0.008	54/54	0.55 ± 0.07	--	0.07

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 25-5.

Observations for BTUT from Table 25-6 include the following:

- The pollutants with the highest annual average concentrations are dichloromethane, formaldehyde, acetaldehyde, and benzene, as discussed in Section 25.4.1.
- The pollutants with the highest cancer risk approximations are formaldehyde, benzene, acetaldehyde, and carbon tetrachloride. The cancer risk approximation for formaldehyde for BTUT (57.67 in-a-million) is the highest cancer risk approximation calculated across the program.
- There were no pollutants of interest with noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for formaldehyde (0.45), which is the sixth highest noncancer hazard approximation calculated among the site-specific pollutants of interest with noncancer toxicity factors. (Note that the five highest noncancer hazard approximations are all for manganese.)

- Dichloromethane’s relatively high annual average concentration does not translate into high risk approximations. This is an indication of the toxicity potential of dichloromethane.

25.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 25-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 25-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 25-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for BTUT, as presented in Table 25-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 25-7. Table 25-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site’s annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 25.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 25-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Utah Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Bountiful, Utah (Davis County) - BTUT					
Benzene	111.98	Formaldehyde	8.95E-04	Formaldehyde	57.67
Formaldehyde	68.81	Benzene	8.73E-04	Benzene	7.92
Ethylbenzene	65.63	Hexavalent Chromium, PM	6.56E-04	Acetaldehyde	5.58
Dichloromethane	46.45	1,3-Butadiene	4.29E-04	Carbon Tetrachloride	3.97
Acetaldehyde	40.38	POM, Group 3	3.20E-04	1,3-Butadiene	3.53
1,3-Butadiene	14.29	Naphthalene	2.92E-04	Arsenic	2.05
Naphthalene	8.58	Ethylbenzene	1.64E-04	1,2-Dichloroethane	2.00
Methyl *tert* butyl ether	4.85	POM, Group 2b	1.62E-04	Naphthalene	1.68
POM, Group 2b	1.84	POM, Group 2d	1.21E-04	Dichloromethane	1.02
POM, Group 2d	1.37	Acetaldehyde	8.88E-05	Ethylbenzene	0.91

Table 25-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Utah Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Bountiful, Utah (Davis County) - BTUT					
Toluene	881.72	Acrolein	179,411.58	Formaldehyde	0.45
Ethylene glycol	438.24	1,3-Butadiene	7,147.14	Acetaldehyde	0.28
Hexane	373.79	Formaldehyde	7,021.22	Manganese	0.16
Xylenes	282.06	Acetaldehyde	4,486.93	Propionaldehyde	0.07
Methanol	205.65	Benzene	3,732.63	1,3-Butadiene	0.06
Benzene	111.98	Naphthalene	2,860.46	Benzene	0.03
Formaldehyde	68.81	Xylenes	2,820.62	Arsenic	0.03
Ethylbenzene	65.63	Ethylene glycol	1,095.59	Naphthalene	0.02
Methyl isobutyl ketone	51.38	Lead, PM	980.24	Nickel	0.02
Dichloromethane	46.45	Arsenic, PM	707.34	Dichloromethane	0.01

Observations from Table 25-7 include the following:

- Benzene, formaldehyde, ethylbenzene, and dichloromethane are the highest emitted pollutants with cancer UREs in Davis County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, hexavalent chromium, and 1,3-butadiene.

- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions in Davis County.

- Formaldehyde and benzene, which have the highest and second highest cancer risk approximations for BTUT, appear at or near the top of both emissions-based lists. Acetaldehyde, 1,3-butadiene, naphthalene, and ethylbenzene also appear on all three lists in Table 25-7. Dichloromethane, which has the highest annual average concentration and the ninth highest cancer risk approximation for BTUT, ranks fourth for emissions in Davis County but does not have one of the highest toxicity-weighted emissions (it ranks 16th). Carbon tetrachloride, which has the fourth highest cancer risk approximation for BTUT, appears on neither emissions-based list.

- POM, Group 2b is the ninth highest emitted “pollutant” in Davis County and ranks eighth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at BTUT including acenaphthylene, fluoranthene, and perylene. None of the PAHs included in POM, Group 2b were identified as pollutants of interest for BTUT.

- POM, Group 2d is the tenth highest emitted “pollutant” in Davis County and ranks ninth for toxicity-weighted emissions. POM, Group 2d also includes several PAHs sampled for at BTUT including phenanthrene, anthracene, and pyrene. None of the PAHs included in POM, Group 2b were identified as pollutants of interest for BTUT.

Observations from Table 25-8 include the following:

- Toluene, ethylene glycol, and hexane are the highest emitted pollutants with noncancer RfCs in Davis County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, 1,3-butadiene, and formaldehyde. Although acrolein was sampled for at BTUT, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Four of the highest emitted pollutants also have the highest toxicity-weighted emissions.

- Although less than 1.0, formaldehyde, acetaldehyde, and manganese have the highest noncancer hazard approximations for BTUT. Formaldehyde and acetaldehyde rank third and fourth (respectively) for toxicity-weighted emissions and formaldehyde ranks seventh for total emissions (acetaldehyde does not appear for total emissions because it ranks 11th). Manganese does not appear on either emissions-based list in Table 25-8.

25.6 Summary of the 2012 Monitoring Data for BTUT

Results from several of the data treatments described in this section include the following:

- ❖ *Twenty-one pollutants failed at least one screen for BTUT.*
- ❖ *Dichloromethane had the highest annual average concentration among the pollutants of interest for BTUT, followed by formaldehyde and acetaldehyde.*
- ❖ *For the second year in a row, BTUT has the highest annual average formaldehyde concentration among NMP sites sampling this pollutant.*
- ❖ *Concentrations of benzene have an overall decreasing trend at BTUT. The 1-year average concentration for 2012 is the lowest 1-year average concentration of benzene calculated since the onset of sampling at BTUT. In addition, the detection rate of 1,2-dichloroethane has been increasing steadily at BTUT over the last few years of sampling.*

26.0 Sites in Vermont

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP and NATTS sites in Vermont, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

26.1 Site Characterization

This section characterizes the Vermont monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

The Vermont NATTS site (UNVT) and one of the UATMP sites (BURVT) are located in northwest Vermont in the Burlington-South Burlington, VT MSA. The third site (RUVT) is located farther south in Rutland, Vermont. Figures 26-1 and 26-2 are the composite satellite images retrieved from ArcGIS Explorer showing the Burlington monitoring sites and their immediate surroundings. Figure 26-3 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 26-3. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring sites. Further, this boundary provides both the proximity of emissions sources to the monitoring sites as well as the quantity of such sources within a given distance of the sites. Sources outside the 10-mile radii are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 26-4 and 26-5 are the composite satellite image and emissions sources map for the Rutland site. Table 26-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

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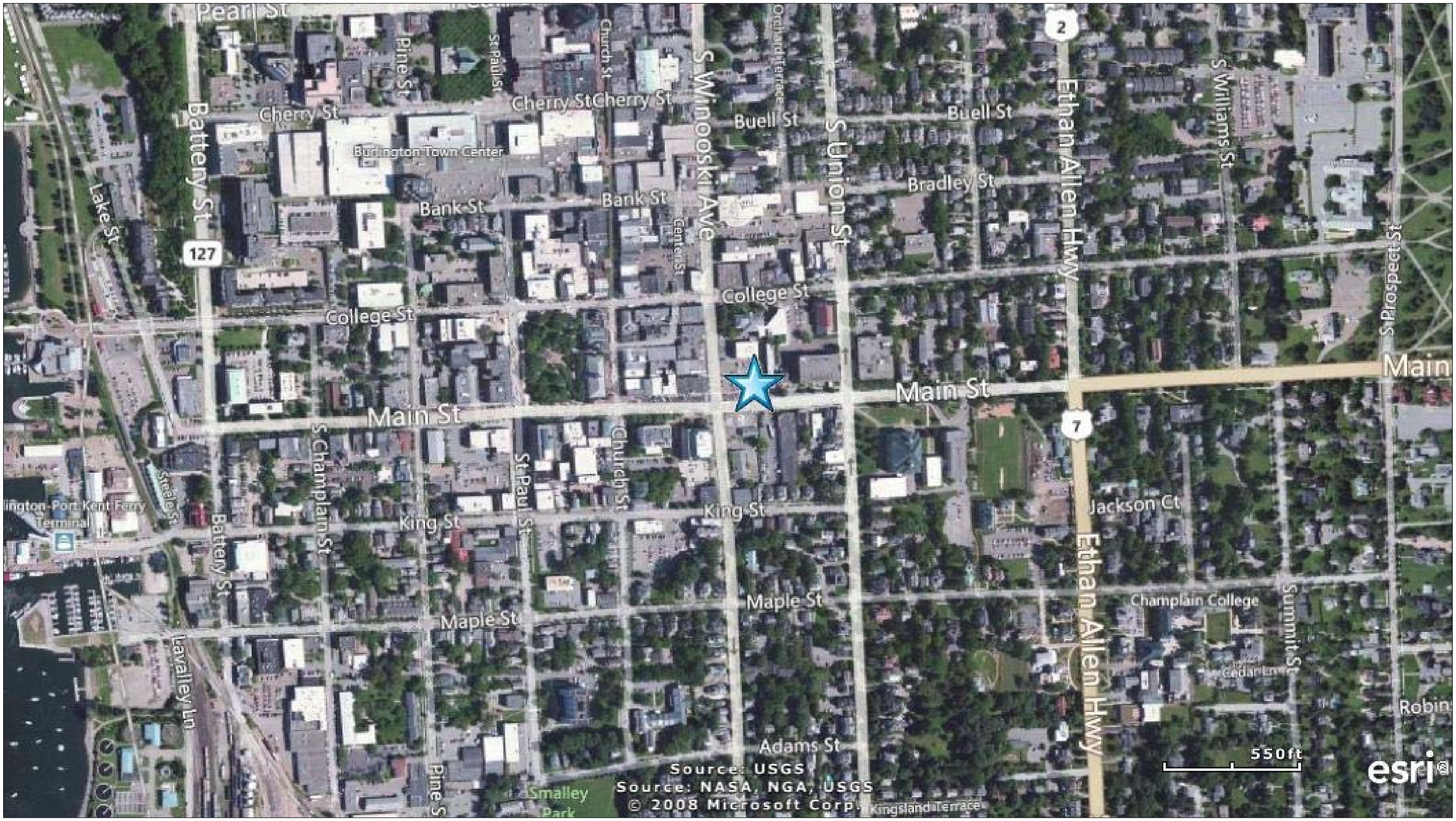
Figure 26-1. Burlington, Vermont (BURVT) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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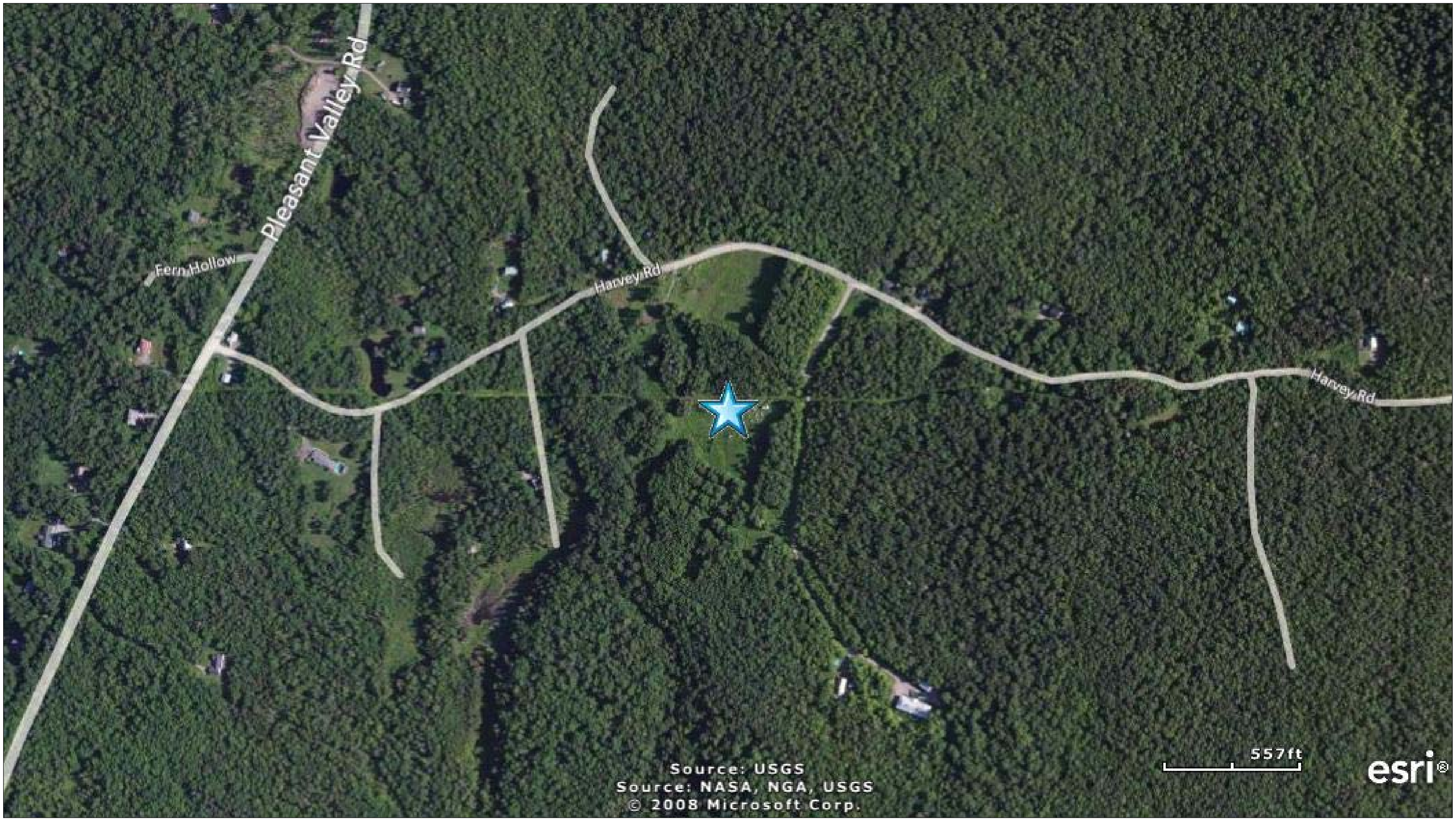
Figure 26-2. Underhill, Vermont (UNVT) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 26-3. NEI Point Sources Located Within 10 Miles of BURVT and UNVT

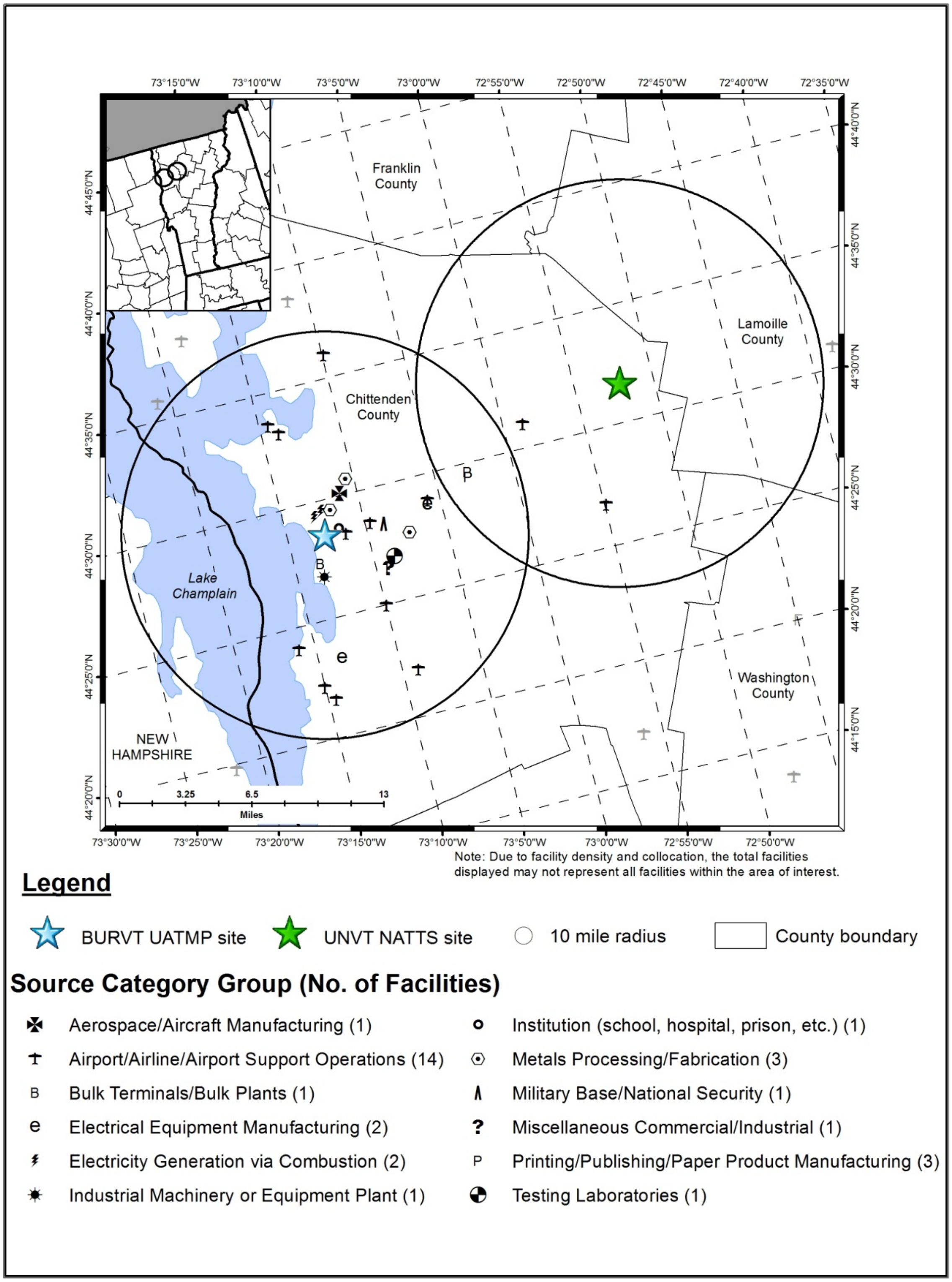


Figure 26-4. Rutland, Vermont (RUVT) Monitoring Site

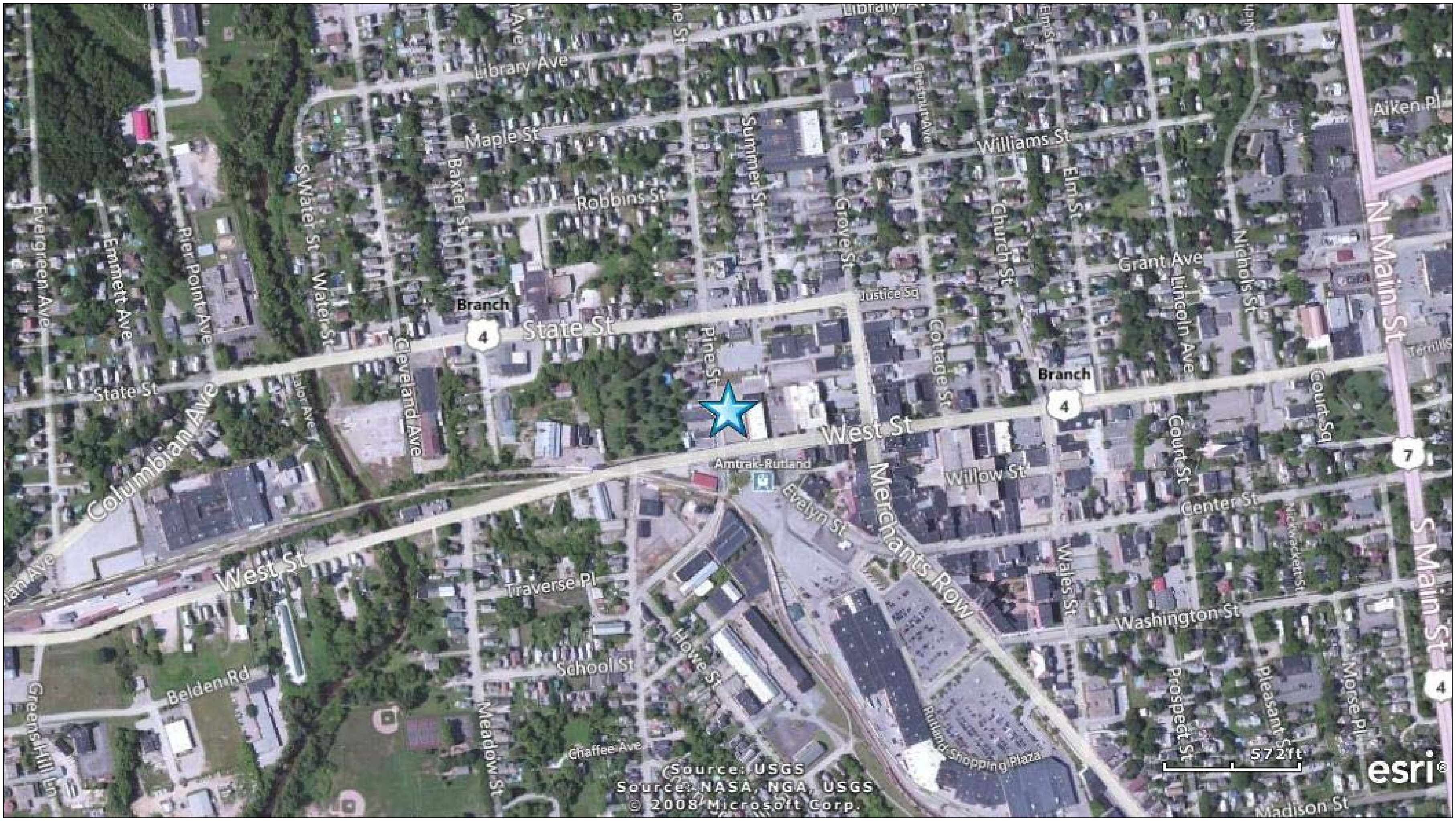


Figure 26-5. NEI Point Sources Located Within 10 Miles of RUVT

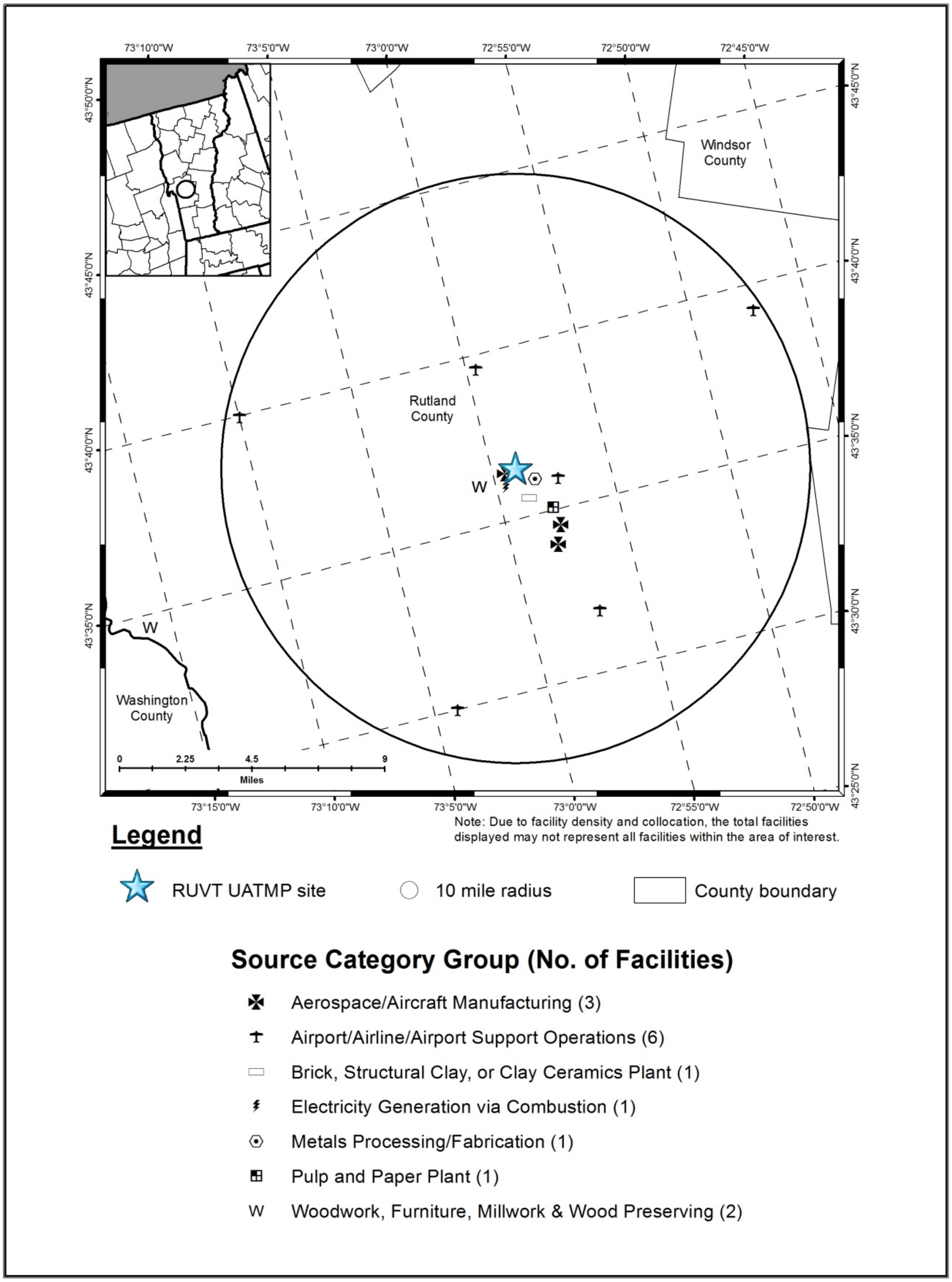


Table 26-1. Geographical Information for the Vermont Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
BURVT	50-007-0014	Burlington	Chittenden	Burlington-South Burlington, VT MSA	44.4762, -73.2106	Commercial	Urban/City Center	CO, NO, NO_2, NO_x, Meteorological parameters, $PM_{2.5}$.
UNVT	50-007-0007	Underhill	Chittenden	Burlington-South Burlington, VT MSA	44.52839, -72.86884	Forest	Rural	Haze, Sulfate, CO, SO_2, NO, NO_y, O_3, Meteorological parameters, PM_{10}, PM Coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
RUVT	50-021-0002	Rutland	Rutland	Rutland, VT MSA	43.608056, -72.982778	Commercial	Urban/City Center	CO, SO_2, NO, NO_2, NO_x, Meteorological parameters, $PM_{2.5}$.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

BURVT is located in a municipal parking lot in downtown Burlington near the intersection of Main Street and South Winooski Avenue. This location is less than 1 mile east of Burlington Bay on Lake Champlain. The areas to the west of the site are primarily commercial while the areas to the east are primarily residential, as shown in Figure 26-1. Route 2 (Main Street) and Route 7 (South Willard Street) intersect two blocks east of the monitoring site and I-89 runs north-south just over 1 mile east of the site. Between the two roadways and the interstate lies the University of Vermont.

The UNVT monitoring site is located on the Proctor Maple Research Farm in Underhill, Vermont, which is east of the Burlington area. Mount Mansfield, the highest peak in Vermont, lies to the east in Underhill State Park, less than 3 miles away. The Underhill Artillery Range is located a few miles to the south. Figure 26-2 shows that the area surrounding the site is rural in nature and heavily forested. This site is intended to serve as a background site for the region for trends assessment, standards compliance, and long-range transport assessment.

UNVT and BURVT are located approximately 16 miles apart, as shown in Figure 26-3. Most of the emissions sources are located between these two sites, although closer to BURVT. The source category with the greatest number of emissions sources surrounding these sites is the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations. The sources closest to BURVT are a medical school/hospital, a heliport at the medical school, and two facilities generating electricity via combustion. The sources closest to UNVT are private airports.

The RUVT monitoring site is located in Rutland, in central Vermont. The city of Rutland is in a valley between the Green Mountains to the east and Taconic Mountains to the west. The monitoring site is located in the courthouse parking lot in downtown Rutland, just north of West Street. Commercial areas are located to the east and south, while residential areas are located to the north and west, as shown in Figure 26-4. A railway parallels Route 4 coming into Rutland from the west, crosses under Route 4, then meanders around a shopping plaza just south of Route 4. The intersection of Route 4-Business (West Street) and Route 7 is approximately one-half mile east of the site. Figure 26-5 shows that relatively few point sources are located within 10 miles of RUVT. Most of the emissions sources near RUVT are located along Route 7 (Main Street), just south of the monitoring site. The source categories with the greatest number of sources within 10 miles of the site include airport operations (6) and aerospace/aircraft manufacturing (3). The source closest to RUVT is an aerospace/aircraft manufacturer.

Table 26-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Vermont monitoring sites. Table 26-2 includes both county-level population and vehicle registration information. Table 26-2 also contains traffic volume information for each site as well as the location for which the traffic volume was obtained. Additionally, Table 26-2 presents the county-level daily VMT for Chittenden and Rutland Counties.

Table 26-2. Population, Motor Vehicle, and Traffic Information for the Vermont Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
BURVT	158,504	169,767	14,000	Main St. between S. Union St. and S. Willard St.	4,032,329
UNVT			1,100	Pleasant Valley Rd, north of Harvey Rd	
RUVT	60,869	70,900	6,700	Bus US-4 between Grove St & West St./Merchants Row	1,745,205

[1] County-level population estimates reflect 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (VT DMV, 2012)
[3] AADT reflects 2007 for BURVT and 2011 data for UNVT (CCRPC, 2013) and 2012 data for RUVT (VTrans, 2013a)
[4] County-level VMT reflects 2011 data (Vtrans, 2013b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 26-2 include the following:

- The population for Chittenden County is more than twice the population for Rutland County. The populations for both counties are in the bottom third compared to other counties with NMP sites.

- A similar pattern is shown for the rankings of the vehicle ownership data for both counties, although the number of vehicles registered in each county is higher than the population counts.

- The traffic volume is highest near BURVT and lowest near UNVT among the Vermont sites. The traffic estimate near BURVT is in the middle of the range compared to other NMP sites while the traffic volumes for RUVT and UNVT are in the bottom third compared to other NMP sites. The traffic estimate for BURVT is provided for Main Street between South Union Street and South Willard Street; for UNVT, the data is for Pleasant Valley Road, north of Harvey Road; and for RUVT, the data is for US-4 Business between Merchants Row and Grove Street.

- Even though the county-level daily VMT for Chittenden County is more than twice the VMT for Rutland County, both VMTs are in the bottom third compared to other counties with NMP sites (where VMT data were available).

26.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Vermont on sample days, as well as over the course of the year.

26.2.1 Climate Summary

The city of Burlington resides just to the east of Lake Champlain in northwest Vermont. Lake Champlain has a moderating affect on the city, keeping the city slightly warmer in winter than it could be given its New England location. The town of Underhill is located to the east of Burlington but still within the Burlington MSA. The city of Rutland is located 60 miles south of the Burlington area. Rutland resides within the same climatic division of Vermont as Burlington, but misses the moderating influences of Lake Champlain. The state of Vermont is affected by most storm systems that track across the country, producing variable weather and often cloudy skies. Summers in Vermont are pleasant, with warm days and cool nights, escaping much of the heat and humidity most of the East Coast experiences. Winters are warmer in the Champlain Valley region than in other portions of the state but snow is common state-wide. The highest precipitation amounts are generally received during the summer months while greater than 15 inches of snow can be expected each month during the winter. Average annual winds parallel the valleys, generally from the south ahead of advancing weather systems, or from the north behind these systems. These storm systems tend to be moderated somewhat due to the Adirondacks to the west and Green Mountains to the east (Wood, 2004; NCDC, 2014; NOAA, 2014b).

26.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the Vermont monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather station to BURVT is located at Burlington International Airport; nearest RUVT is Rutland State Airport; and nearest UNVT is Morrisville-Stowe State Airport (WBANs 14742, 94737, and 54771, respectively). Additional information about these weather stations, such as the distance between the sites and the weather stations, is provided in Table 26-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 26-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 26-3 is the 95 percent confidence interval for each parameter. As shown in Table 26-3, meteorological conditions on sample days were representative of weather conditions experienced throughout the year at these sites. The greatest difference shown is for sea level pressure at BURVT, although the difference is not statistically significant. Note that the number of sample days included in the sample day average for UNVT is twice the number of sample days for BURVT and RUVT. This is because sampling at UNVT occurs on a 1-in-6 day schedule, while sampling at BURVT and RUVT occurs on a 1-in-12 day schedule.

26.2.3 Back Trajectory Analysis

Figure 26-6 is the composite back trajectory map for days on which samples were collected at the BURVT monitoring site. Included in Figure 26-6 are four back trajectories per sample day. Figure 26-7 is the corresponding cluster analysis. Similarly, Figures 26-8 through 26-11 are the composite back trajectory maps and corresponding cluster analyses for RUVT and UNVT. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 26-6 through 26-11 represents 100 miles.

Table 26-3. Average Meteorological Conditions near the Vermont Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Burlington, Vermont - BURVT									
Burlington Intl. Airport 14742 (44.48, -73.16)	2.9 miles 87° (E)	Sample Days (31)	59.3 ± 7.1	50.8 ± 6.8	39.5 ± 6.4	45.3 ± 6.0	67.9 ± 3.9	1013.5 ± 2.7	6.7 ± 1.0
		2012	58.7 ± 2.1	50.0 ± 1.9	38.1 ± 1.8	44.4 ± 1.7	66.7 ± 1.1	1015.1 ± 0.8	6.1 ± 0.3
Rutland, Vermont - RUVT									
Rutland State Airport 94737 (43.53, -72.95)	5.4 miles 149° (SSE)	Sample Days (31)	58.5 ± 6.7	49.0 ± 6.3	37.2 ± 5.6	43.3 ± 5.4	66.9 ± 4.6	NA	6.6 ± 0.9
		2012	57.3 ± 2.0	48.4 ± 1.8	36.1 ± 1.6	42.6 ± 1.5	65.6 ± 1.3	NA	6.0 ± 0.3
Underhill, Vermont - UNVT									
Morrisville-Stowe State Airport 54771 (44.53, -72.61)	11.8 miles 73° (ENE)	Sample Days (64)	55.8 ± 5.1	45.3 ± 4.8	36.2 ± 4.6	41.1 ± 4.4	73.6 ± 2.5	1016.0 ± 2.0	2.7 ± 0.5
		2012	56.8 ± 2.1	46.4 ± 1.9	36.8 ± 1.8	42.0 ± 1.7	72.4 ± 1.1	1015.8 ± 0.8	2.9 ± 0.2

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA = Sea level pressure was not recorded at the Rutland State Airport.

Figure 26-6. Composite Back Trajectory Map for BURVT

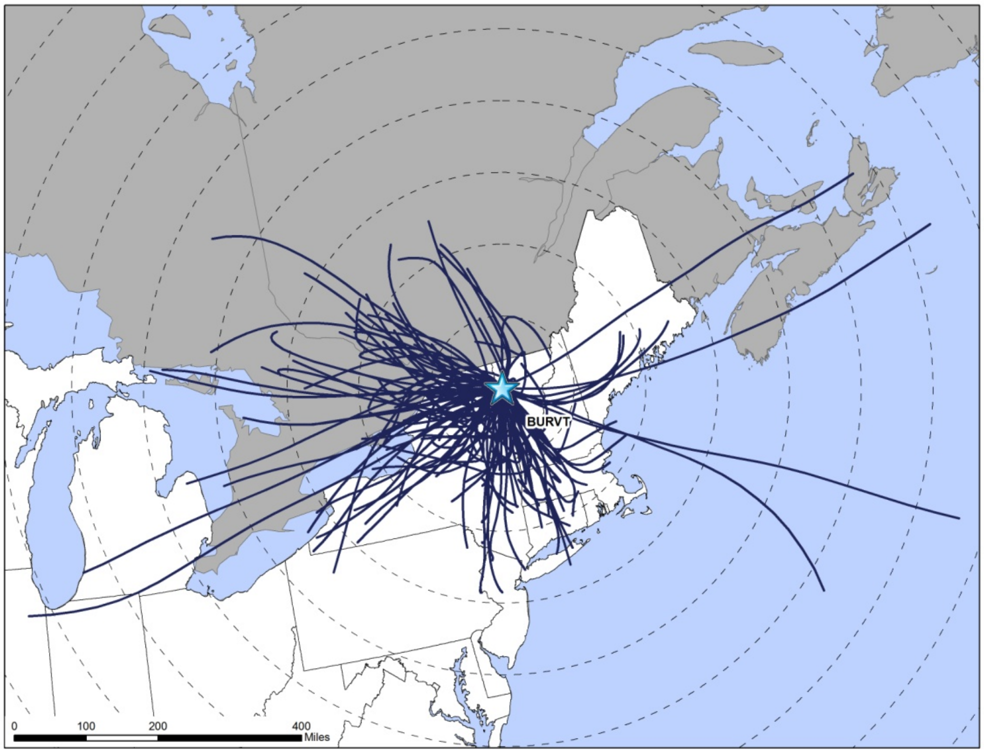


Figure 26-7. Back Trajectory Cluster Map for BURVT

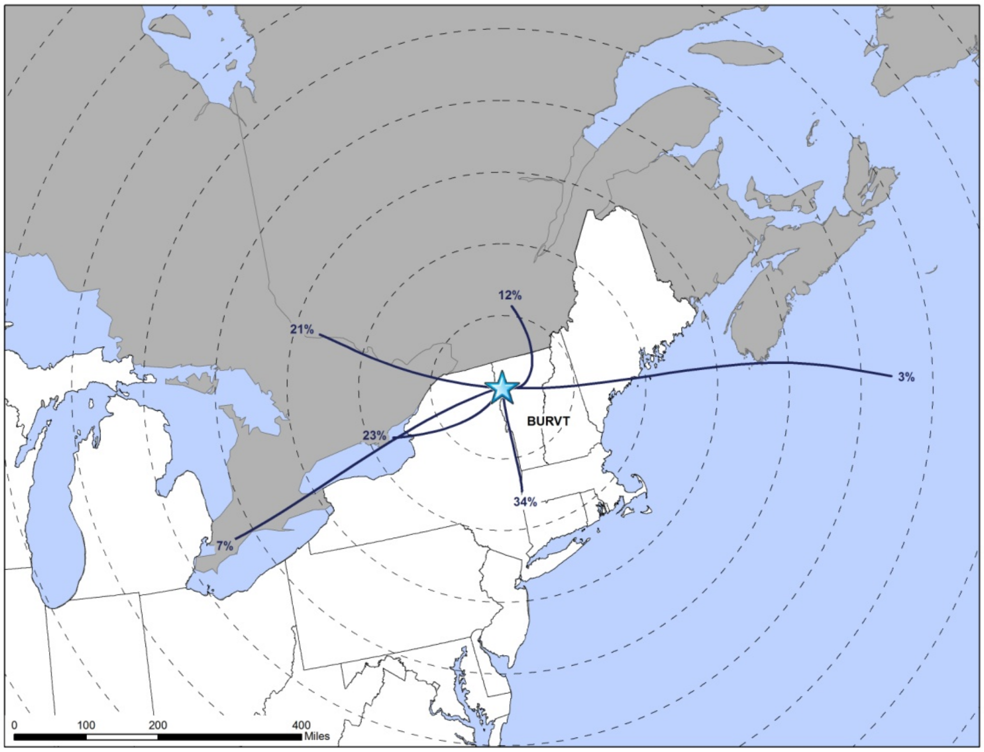


Figure 26-8. Composite Back Trajectory Map for RUVT

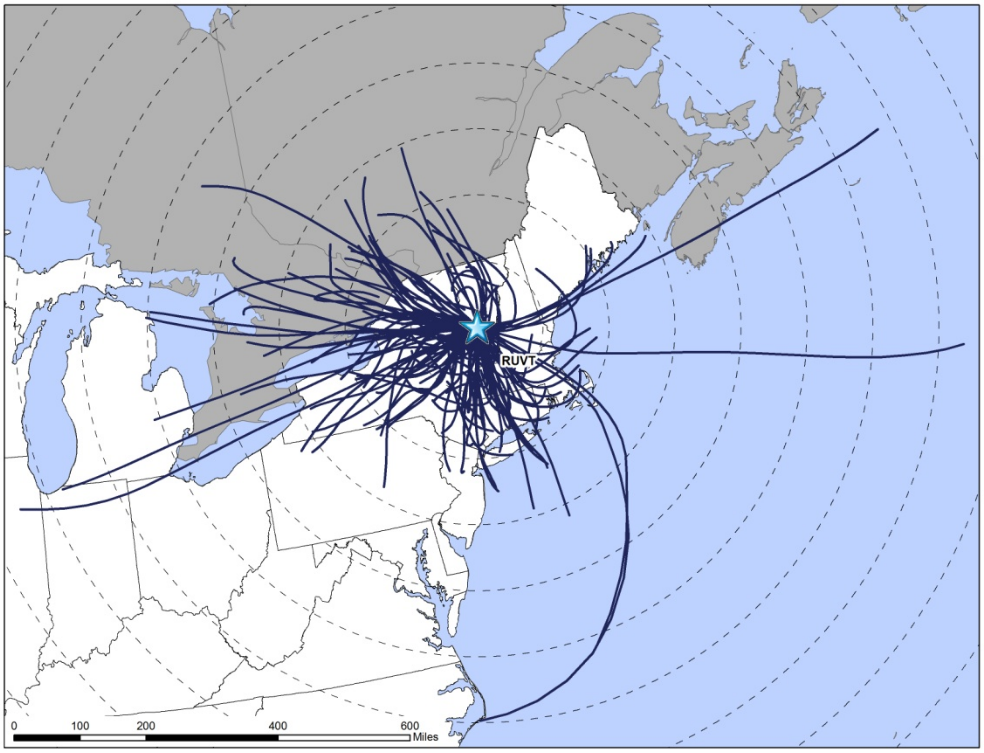


Figure 26-9. Back Trajectory Cluster Map for RUVT

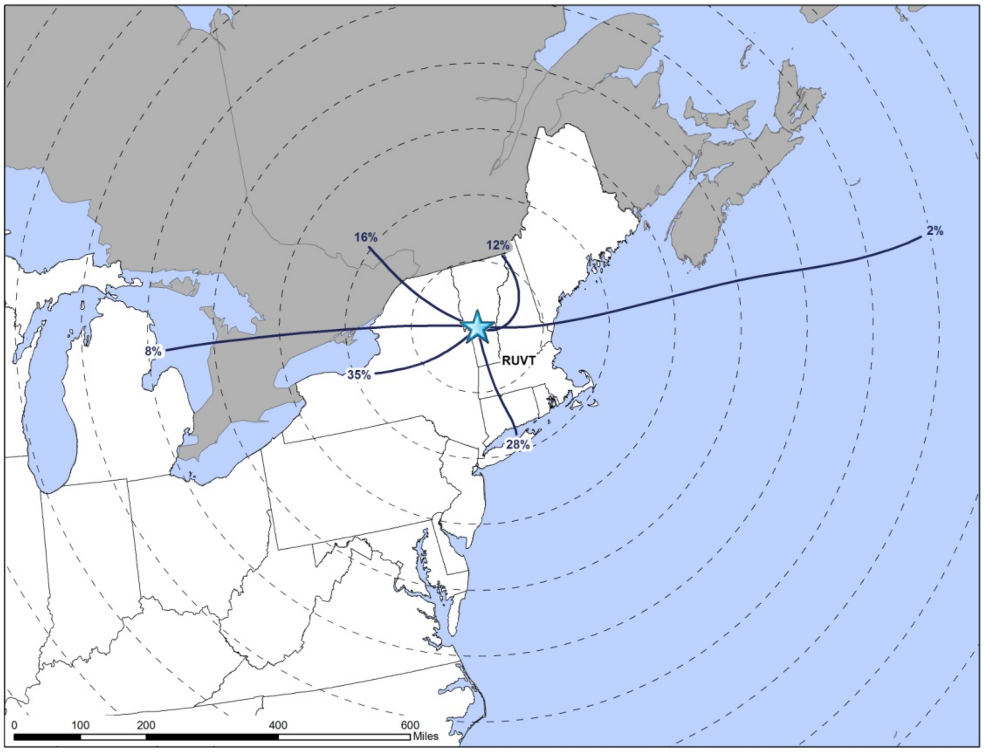


Figure 26-10. Composite Back Trajectory Map for UNVT

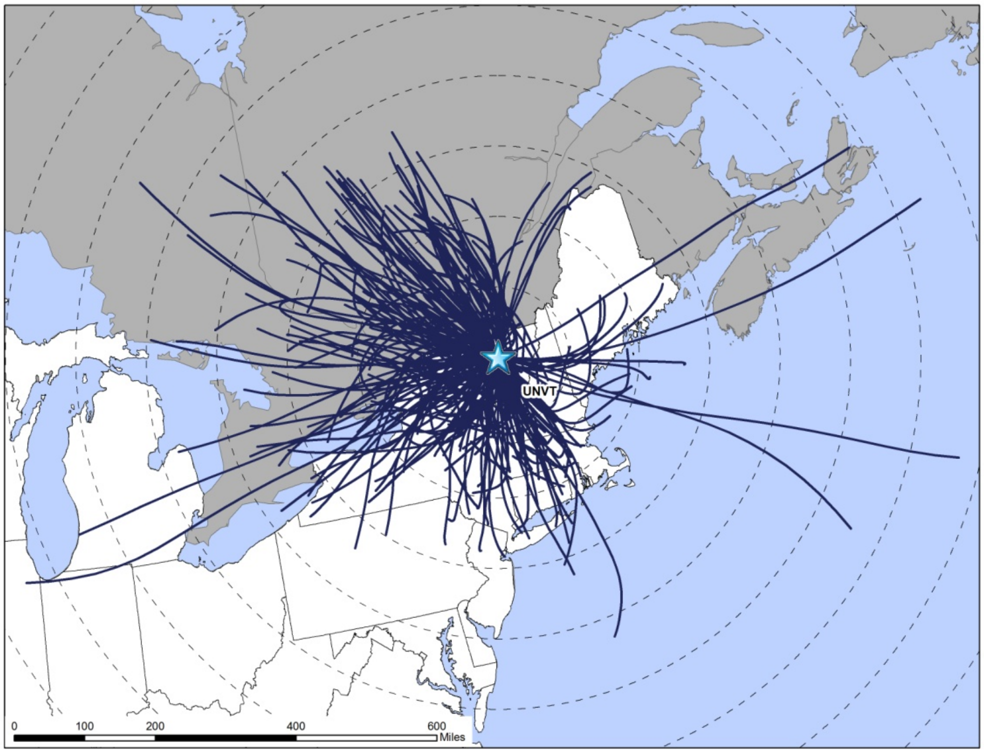
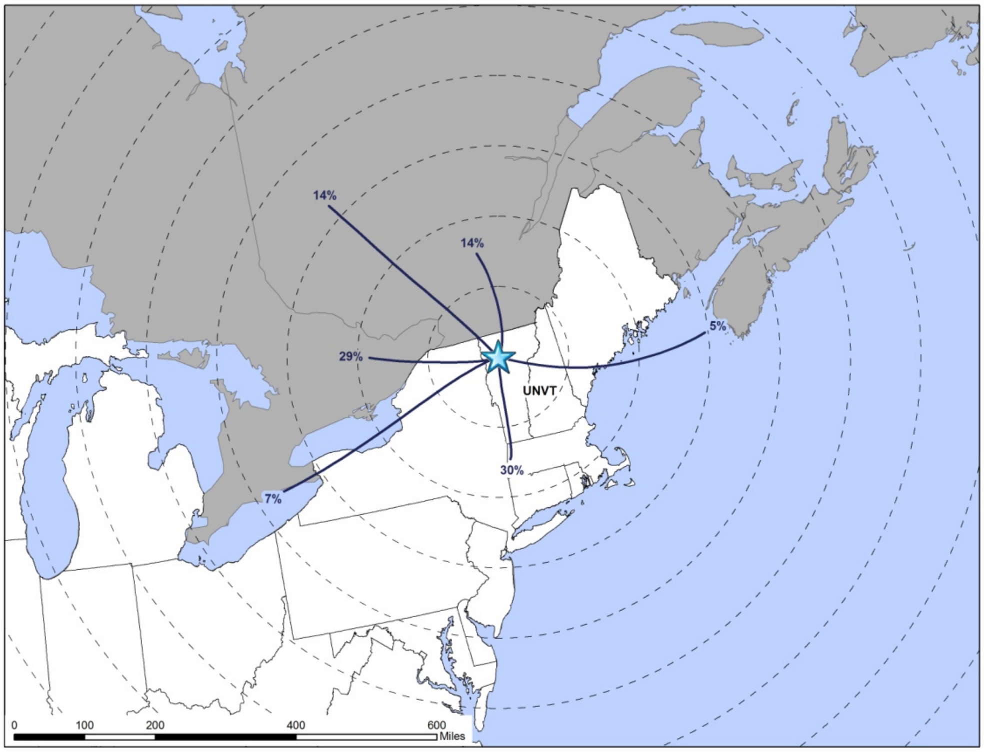


Figure 26-11. Back Trajectory Cluster Map for UNVT



Observations from Figures 26-6 through 26-11 for the Vermont monitoring sites include the following:

- Even though there are roughly half as many back trajectories on the composite maps for BURVT and RUVT as there are for UNVT (due to the sampling schedules), the composite back trajectory maps for the Vermont sites exhibit similarities.

- An imaginary line drawn roughly northwest to southeast through the site on each composite map shows that the majority of back trajectories originated on the southwestern side of that line. Few back trajectories originated from the northeast and east of the sites.

- For each site, the farthest away a back trajectory originated was near Chicago, or nearly 750 miles away. Back trajectories greater than 600 miles also originated well offshore over the Atlantic Ocean. However, back trajectories of these lengths were the exception rather than the norm, as nearly 90 percent of back trajectories originated within 350 miles of each site. The average back trajectory length for both UNVT and BURVT is 223 miles, while the average back length for RUVT is 218 miles.

- The cluster analysis for BURVT shows that greater than 50 percent of back trajectories originated to the west of the site but are grouped into three clusters based on distance and exact direction: 1) those originating over and just north of Lake Huron and Georgian Bay, 2) those originating over New York and Lake Ontario, and 3) those originating farther west, primarily over Lake Erie, Michigan, and Lake Michigan. Another one-third of back trajectories originated to the south of BURVT. The cluster trajectory originating to the north of BURVT represents those back trajectories originating to the north, northeast, and east of the site and generally less than 200 miles in length. The long cluster trajectory originating well off-shore represents the four long back trajectories originating over the Atlantic Ocean. These are associated with Hurricane Sandy's landfall and subsequent inland motion on the October 30, 2012 sample day.

- The cluster analysis for RUVT is similar directionally to the cluster analysis for BURVT, although the percentages vary. Nearly 60 percent of back trajectories originated to the west of the site, and like the cluster analysis for BURVT, are divided into three clusters based on length and exact direction. Nearly 30 percent of back trajectories originated to the south of the site. The two back trajectories originating off the North Carolina coast are associated with Hurricane Sandy's landfall. The cluster trajectory originating to the north of RUVT represents those back trajectories originating to the north, northeast, and east of the site and generally less than 200 miles in length. The long cluster trajectory originating well off-shore represents the two long back trajectories originating over the Atlantic Ocean. These are also associated with Hurricane Sandy's inland motion.

- The cluster analysis for UNVT is similar to the cluster analyses for BURVT and RUVT in the geographic distribution of back trajectories. Fifty percent of back trajectories originated from a direction with a westerly component and are grouped into three cluster trajectories: 1) those originating from the northwest, 2) those originating from the west, and 3) those originating from the southwest along Lake Ontario, Lake Huron, and Michigan. Another 30 percent of back trajectories originated to the south of UNVT. The cluster trajectory originating to the north of UNVT represents those back trajectories originating primarily over south-central Quebec, Canada. The final 5 percent of back trajectories originated to the east of the site, although the length of these back trajectories varied.

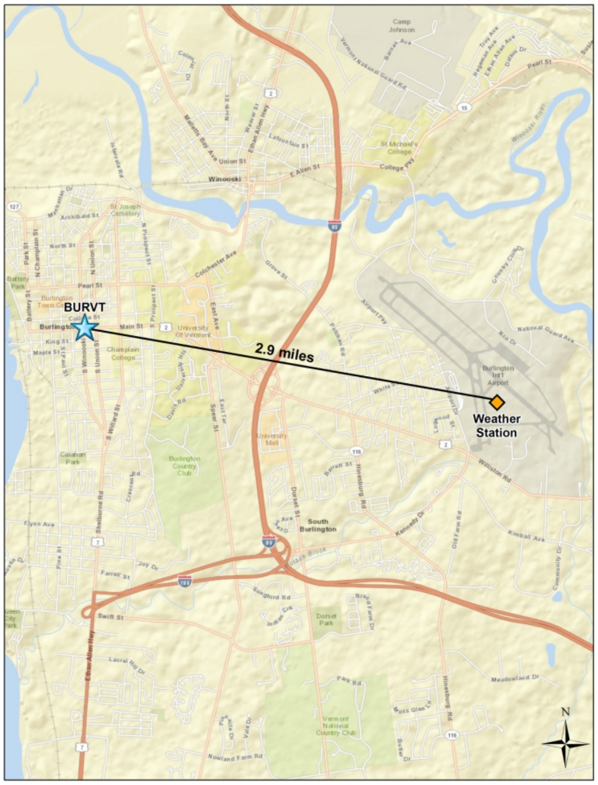
26.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations at Burlington International Airport (for BURVT), Rutland State Airport (for RUVT), and Morrisville-Stowe State Airport (for UNVT) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

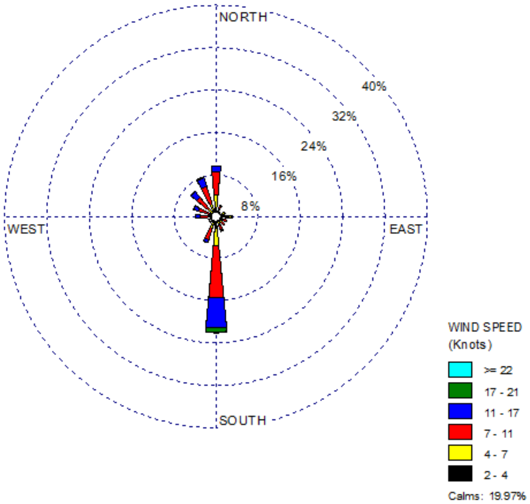
Figure 26-12 presents a map showing the distance between the weather station and BURVT, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 26-12 also presents three different wind roses for the BURVT monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction in 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 26-13 and 26-14 present the three wind roses and distance maps for the RUVT and UNVT monitoring sites, respectively.

Figure 26-12. Wind Roses for the Burlington International Airport Weather Station near BURVT

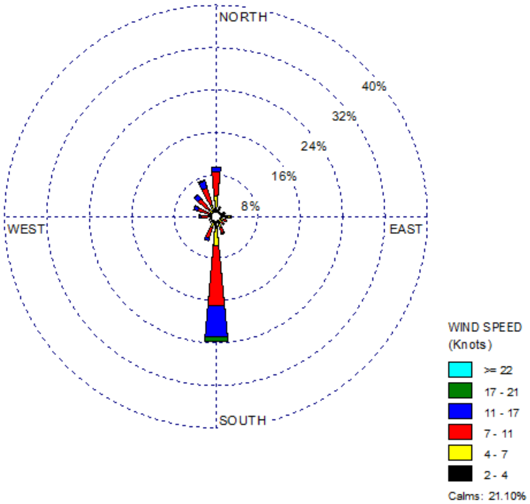
Location of BURVT and Weather Station



2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

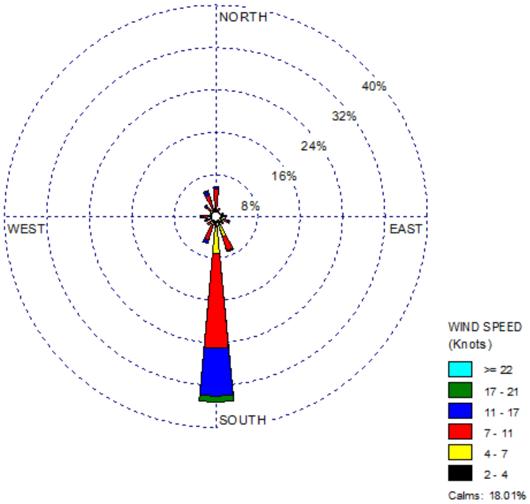
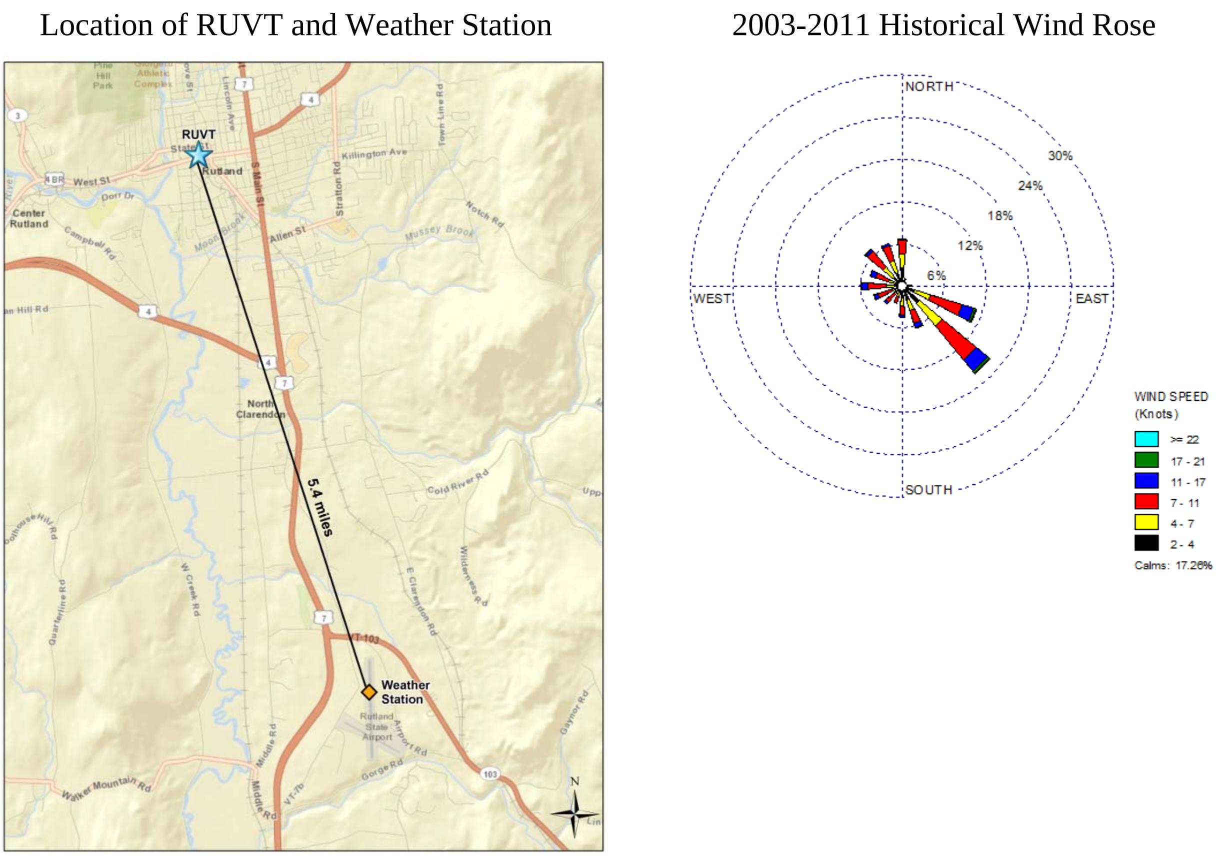
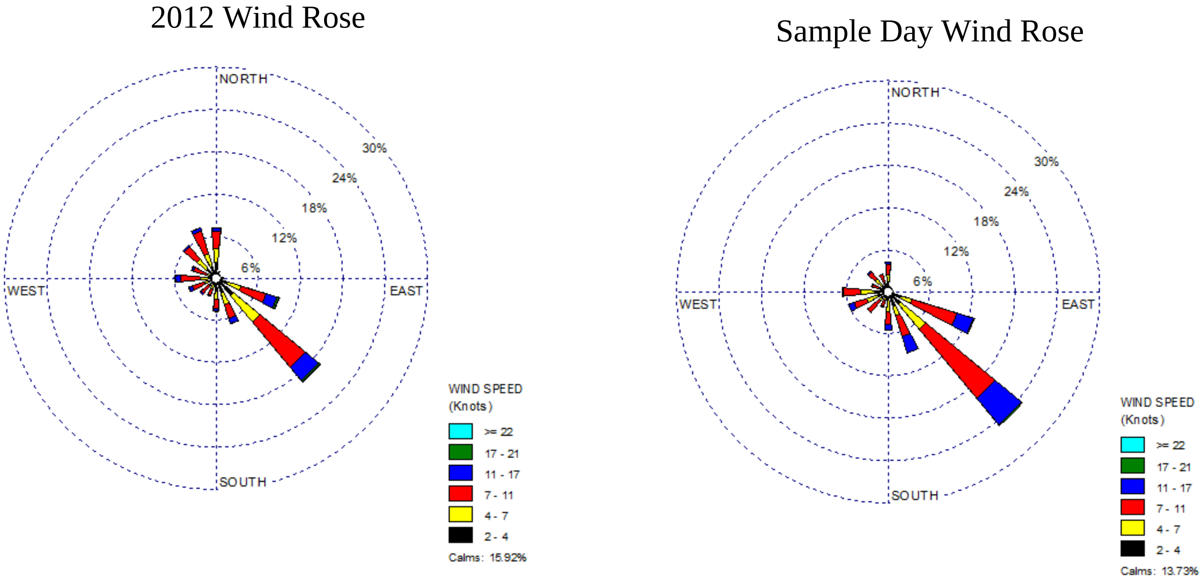


Figure 26-13. Wind Roses for the Rutland State Airport Weather Station near RUVT



Location of RUVT and Weather Station

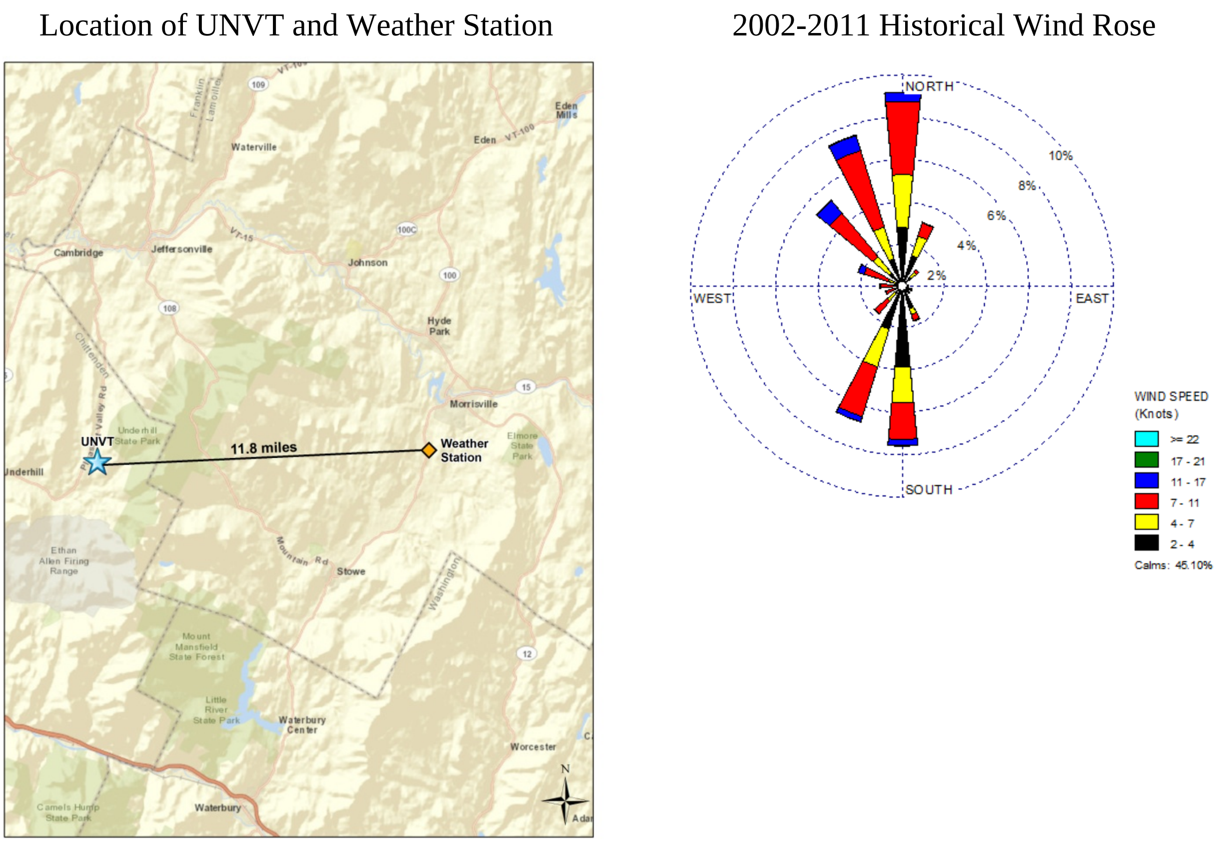
2003-2011 Historical Wind Rose



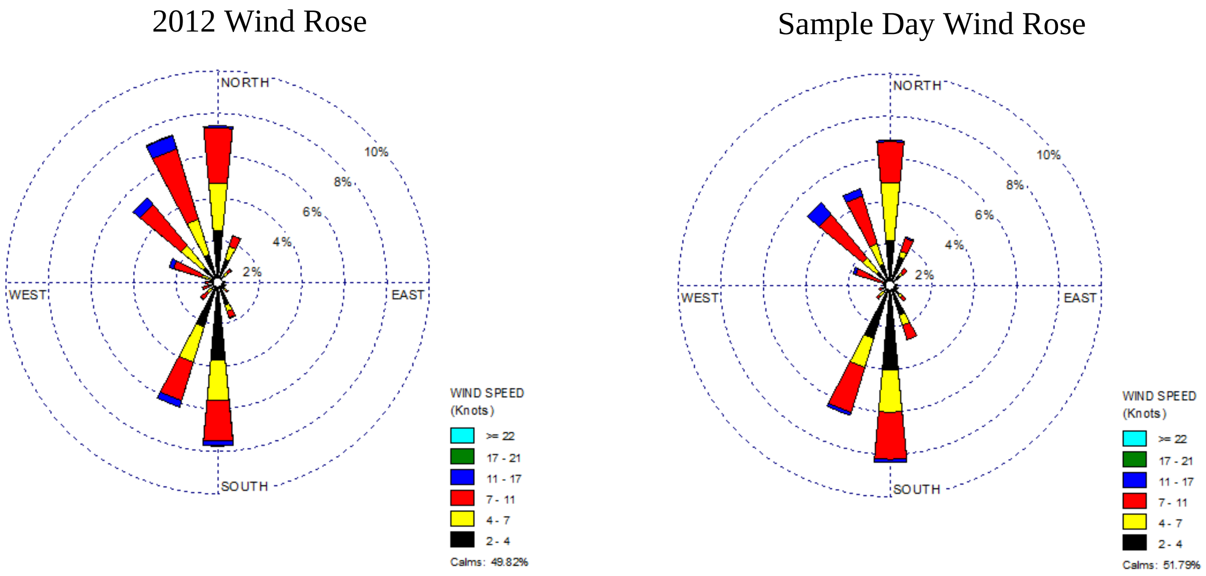
2012 Wind Rose

Sample Day Wind Rose

Figure 26-14. Wind Roses for the Morrisville-Stowe State Airport Weather Station near UNVT


Location of UNVT and Weather Station

2002-2011 Historical Wind Rose


2012 Wind Rose

Sample Day Wind Rose

Observations from Figure 26-12 for BURVT include the following:

- The Burlington International Airport weather station is located approximately 3 miles east of BURVT.

- The historical wind rose shows that southerly winds are prevalent near BURVT, accounting for nearly 22 percent of the hourly measurements. Calm winds (≤ 2 knots) account for another 20 percent of measurements. Winds from the northwest quadrant, including north, account for another one-quarter of the wind observations. Winds from the eastern quadrants are rarely observed.

- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns, indicating that wind conditions observed during 2012 were similar to those observed over the previous 10 years.

- The sample day wind rose shows that southerly winds prevailed on sample days, but accounted for a higher percentage of observations (35 percent). In addition, fewer winds from the north and northwest quadrant were observed while a higher percentage of south-southeasterly winds was observed.

Observations from Figure 26-13 for RUVT include the following:

- The Rutland State Airport weather station is located 5.4 miles south-southeast of RUVT.

- The historical wind rose shows that east-southeasterly and southeasterly winds were prevalent near RUVT, as these directions account for more than one-quarter of the hourly measurements. Winds from the southwest and northwest quadrants were also observed while winds from the northeast quadrant were generally not observed. Calm winds were observed for 17 percent of the hourly measurements.

- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns, although a slightly higher percentage of winds from the southeast and slightly fewer east-southeasterly winds were observed in 2012.

- The sample day wind rose exhibits similar wind patterns as the historical and full-year wind roses, but with higher percentages of east-southeasterly and southeasterly winds (together accounting for more than one-third of wind observations). This corresponds with fewer calm observations (less than 14 percent).

Observations from Figure 26-14 for UNVT include the following:

- The Morrisville-Stowe Airport weather station is located approximately 12 miles east of UNVT. Between the site and the weather station lie the Green Mountains.

- The historical wind rose shows that calm winds were prevalent near UNVT, as calm winds were observed for nearly 45 percent of the hourly measurements. Winds from the northwest to north account for 20 percent of the wind observations greater than

2 knots. Winds from the south to south-southwest account for another 15 percent of observations.

- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns, although calm winds account for nearly 50 percent of the observations.
- The sample day wind rose shows that wind conditions on sample days were similar to those experienced throughout 2012, although number of observations from the north-northwest is less while the number of calms is up to nearly 52 percent.

26.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Vermont monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 26-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 26-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. BURVT and RUVT sampled for year-round for VOCs, while UNVT sampled for hexavalent chromium, PAHs, and metals (PM_{10}) in addition to VOCs. All three sites began sampling carbonyl compounds under the NMP in July 2012.

Table 26-4. Risk-Based Screening Results for the Vermont Monitoring Sites

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Burlington, Vermont - BURVT						
Benzene	0.13	31	31	100.00	17.51	17.51
1,3-Butadiene	0.03	31	31	100.00	17.51	35.03
Carbon Tetrachloride	0.17	31	31	100.00	17.51	52.54
1,2-Dichloroethane	0.038	29	29	100.00	16.38	68.93
Acetaldehyde	0.45	16	16	100.00	9.04	77.97
Formaldehyde	0.077	16	16	100.00	9.04	87.01
p-Dichlorobenzene	0.091	7	28	25.00	3.95	90.96
Hexachloro-1,3-butadiene	0.045	5	6	83.33	2.82	93.79
1,2-Dibromoethane	0.0017	4	4	100.00	2.26	96.05
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	2.26	98.31
Ethylbenzene	0.4	3	31	9.68	1.69	100.00
Total		177	227	77.97		

Table 26-4. Risk-Based Screening Results for the Vermont Monitoring Sites (Continued)

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Rutland, Vermont - RUVT						
Benzene	0.13	31	31	100.00	17.82	17.82
Carbon Tetrachloride	0.17	31	31	100.00	17.82	35.63
1,3-Butadiene	0.03	30	30	100.00	17.24	52.87
1,2-Dichloroethane	0.038	29	29	100.00	16.67	69.54
Acetaldehyde	0.45	16	16	100.00	9.20	78.74
Formaldehyde	0.077	16	16	100.00	9.20	87.93
Ethylbenzene	0.4	9	31	29.03	5.17	93.10
p-Dichlorobenzene	0.091	4	26	15.38	2.30	95.40
Hexachloro-1,3-butadiene	0.045	3	5	60.00	1.72	97.13
1,2-Dibromoethane	0.0017	2	2	100.00	1.15	98.28
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	1.15	99.43
Trichloroethylene	0.2	1	4	25.00	0.57	100.00
Total		174	223	78.03		
Underhill Vermont - UNVT						
Benzene	0.13	61	61	100.00	21.18	21.18
Carbon Tetrachloride	0.17	61	61	100.00	21.18	42.36
1,2-Dichloroethane	0.038	52	53	98.11	18.06	60.42
Formaldehyde	0.077	31	31	100.00	10.76	71.18
Arsenic (PM_{10})	0.00023	27	55	49.09	9.38	80.56
Acetaldehyde	0.45	19	31	61.29	6.60	87.15
1,3-Butadiene	0.03	10	16	62.50	3.47	90.63
Hexachloro-1,3-butadiene	0.045	8	10	80.00	2.78	93.40
1,1,2,2-Tetrachloroethane	0.017	6	6	100.00	2.08	95.49
1,2-Dibromoethane	0.0017	5	5	100.00	1.74	97.22
Naphthalene	0.029	5	58	8.62	1.74	98.96
Manganese (PM_{10})	0.005	2	61	3.28	0.69	99.65
Ethylbenzene	0.4	1	56	1.79	0.35	100.00
Total		288	504	57.14		

Observations from Table 26-4 include the following:

- Eleven pollutants failed at least one screen for BURVT; 78 percent of concentrations for these 11 pollutants were greater than their associated risk screening value (or failed screens).

- Ten pollutants contributed to 95 percent of failed screens for BURVT and therefore were identified as pollutants of interest for this site. These 10 include two carbonyl compounds and eight VOCs. Although the first nine pollutants listed account for more than 95 percent of the total failed screens for BURVT, 1,1,2,2-tetrachloroethane failed the same number of screens as 1,2-dibromoethane (4); thus, 1,1,2,2-tetrachloroethane was also added as a pollutant of interest for BURVT, per the procedure described in Section 3.2.

- Twelve pollutants failed at least one screen for RUVT; 78 percent of concentrations for these 12 pollutants were greater than their associated risk screening value (or failed screens).

- Eight pollutants contributed to 95 percent of failed screens for RUVT and therefore were identified as pollutants of interest for this site. These eight include two carbonyl compounds and six VOCs.

- Thirteen pollutants failed at least one screen for UNVT; 57 percent of concentrations for these 13 pollutants were greater than their associated risk screening value (or failed screens).

- Nine pollutants contributed to 95 percent of failed screens for UNVT and therefore were identified as pollutants of interest for this site. These nine include two carbonyl compounds, six VOCs, and one PM_{10} metal.

- BURVT and RUVT have seven pollutants of interest in common. Even though three additional pollutant groups were sampled for at UNVT, the Vermont sites have six pollutants of interest in common (two carbonyl compounds and four VOCs).

26.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Vermont monitoring sites. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for each monitoring site.

- Annual concentration averages are presented graphically for each site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.

- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for BURVT, RUVT, and UNVT are provided in Appendices J, L, M, N, and O.

26.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Vermont site, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Vermont monitoring sites are presented in Table 26-5, where applicable. Note that concentrations of arsenic for UNVT are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 26-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Vermont Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Burlington, Vermont - BURVT						
Acetaldehyde	16/16	NA	NA	1.43 ± 0.36	1.19 ± 0.35	NA
Benzene	31/31	0.97 ± 0.18	0.74 ± 0.09	0.65 ± 0.09	0.78 ± 0.12	0.78 ± 0.07
1,3-Butadiene	31/31	0.09 ± 0.03	0.07 ± 0.01	0.09 ± 0.03	0.07 ± 0.02	0.08 ± 0.01
Carbon Tetrachloride	31/31	0.60 ± 0.10	0.73 ± 0.04	0.65 ± 0.03	0.71 ± 0.05	0.67 ± 0.03
1,2-Dibromoethane	4/31	0.01 ± 0.01	0.01 ± 0.02	0.01 ± 0.02	0	0.01 ± 0.01
p-Dichlorobenzene	28/31	0.06 ± 0.02	0.08 ± 0.03	0.06 ± 0.03	0.04 ± 0.02	0.06 ± 0.01
1,2-Dichloroethane	29/31	0.09 ± 0.03	0.09 ± 0.01	0.06 ± 0.02	0.07 ± 0.01	0.08 ± 0.01
Formaldehyde	16/16	NA	NA	3.41 ± 0.94	2.38 ± 0.79	NA
Hexachloro-1,3-butadiene	6/31	0.02 ± 0.02	0.02 ± 0.04	0.01 ± 0.02	0	0.01 ± 0.01
1,1,2,2-Tetrachloroethane	4/31	0.01 ± 0.01	0.01 ± 0.02	0.01 ± 0.01	0	0.01 ± 0.01

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutant below the blue line are presented in ng/m^3 for ease of viewing.

Table 26-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Vermont Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m^3)	2nd Quarter Average (µg/m^3)	3rd Quarter Average (µg/m^3)	4th Quarter Average (µg/m^3)	Annual Average (µg/m^3)
Rutland, Vermont - RUVT						
Acetaldehyde	16/16	NA	NA	1.21 ± 0.32	1.56 ± 0.67	NA
Benzene	31/31	1.33 ± 0.34	0.75 ± 0.17	0.76 ± 0.14	1.33 ± 0.61	1.05 ± 0.20
1,3-Butadiene	30/31	0.17 ± 0.07	0.06 ± 0.02	0.09 ± 0.04	0.19 ± 0.10	0.13 ± 0.04
Carbon Tetrachloride	31/31	0.60 ± 0.13	0.75 ± 0.05	0.68 ± 0.04	0.70 ± 0.03	0.68 ± 0.04
p-Dichlorobenzene	26/31	0.06 ± 0.02	0.09 ± 0.03	0.06 ± 0.02	0.03 ± 0.02	0.06 ± 0.01
1,2-Dichloroethane	29/31	0.08 ± 0.02	0.09 ± 0.01	0.06 ± 0.02	0.06 ± 0.02	0.07 ± 0.01
Ethylbenzene	31/31	0.28 ± 0.07	0.35 ± 0.12	0.43 ± 0.11	0.38 ± 0.11	0.36 ± 0.05
Formaldehyde	16/16	NA	NA	2.56 ± 0.91	2.57 ± 0.81	NA
Underhill, Vermont - UNVT						
Acetaldehyde	31/31	NA	NA	0.56 ± 0.11	0.47 ± 0.13	NA
Benzene	61/61	0.49 ± 0.08	0.33 ± 0.07	0.29 ± 0.04	0.42 ± 0.07	0.38 ± 0.04
1,3-Butadiene	16/61	<0.01 ± <0.01	<0.01 ± <0.01	0.03 ± 0.02	0.03 ± 0.04	0.02 ± 0.01
Carbon Tetrachloride	61/61	0.61 ± 0.05	0.70 ± 0.06	0.66 ± 0.03	0.71 ± 0.04	0.67 ± 0.02
1,2-Dichloroethane	53/61	0.08 ± 0.01	0.08 ± 0.01	0.04 ± 0.01	0.05 ± 0.02	0.06 ± 0.01
Formaldehyde	31/31	NA	NA	1.48 ± 0.40	0.68 ± 0.20	NA
Hexachloro-1,3-butadiene	10/61	0.01 ± 0.01	0.02 ± 0.02	0.01 ± 0.01	0	0.01 ± 0.01
1,1,2,2-Tetrachloroethane	6/61	0.01 ± 0.01	0.01 ± 0.01	<0.01 ± 0.01	0	0.01 ± <0.01
Arsenic (PM_{10})[a]	55/61	0.21 ± 0.08	0.26 ± 0.09	0.24 ± 0.08	0.27 ± 0.15	0.25 ± 0.05

NA = Not available due to the criteria for calculating a quarterly and/or annual average.

[a] Average concentrations provided for the pollutant below the blue line are presented in ng/m^3 for ease of viewing.

Observations for BURVT and RUVT from Table 26-5 include the following:

- BURVT and RUVT sampled VOCs on a 1-in-12 day schedule. Carbonyl compounds were also sampled at these sites on a 1-in-12 day schedule beginning in July 2012. As a result of this start date, first quarter, second quarter, and annual average concentrations are not available for the carbonyl compound pollutants of interest.

- Benzene is the pollutant with the highest annual average concentration for BURVT, followed by carbon tetrachloride. All of the annual average concentrations for the pollutants of interest for BURVT are less than 1 µg/m^3, where they could be calculated.

- Concentrations of benzene measured at BURVT range from 0.505 µg/m^3 to 1.41 µg/m^3, with a median benzene concentration of 0.75 µg/m^3. Three of the four concentrations greater than 1 µg/m^3 were measured during the first quarter of 2012, and all but two of the eight first quarter measurements are greater than the median concentration. This explains why the first quarter average is higher than the other quarterly averages. The difference, however, is not statistically significant. A similar observation was made in the 2011 NMP report.

- A few of the VOCs listed for BURVT were detected relatively few times. Three of these pollutants were not detected at all during the fourth quarter, resulting in a fourth quarter average concentration of zero.

- The quarterly average concentrations of formaldehyde are at least twice the quarterly averages of acetaldehyde. Concentrations of formaldehyde measured at BURVT range from 1.33 µg/m^3 to 5.89 µg/m^3; concentrations of acetaldehyde range from 0.62 µg/m^3 to 2.31 µg/m^3.

- Benzene, carbon tetrachloride, and ethylbenzene have the highest annual average concentrations for RUVT. Only benzene has an annual average concentration greater than 1 µg/m^3 (1.05 ± 0.20 µg/m^3). This is the highest annual average concentration among the Vermont sites' pollutants of interest, where they could be calculated.

- The first and fourth quarter average concentrations of benzene are greater than the other quarterly averages and have relatively large confidence intervals associated with them. Concentrations of benzene measured at RUVT range from 0.54 µg/m^3 to 2.64 µg/m^3, with a median concentration of 0.90 µg/m^3. Of the 14 benzene concentrations greater than 1 µg/m^3 measured at RUVT, seven were measured in the first quarter and four were measured in the fourth quarter. The three concentrations greater than 2 µg/m^3 were measured in January, November, and December.

- Concentrations of 1,3-butadiene also appear higher during the first and fourth quarters of 2012. The three highest concentrations of 1,3-butadiene (those greater than 0.3 µg/m^3) were measured at RUVT on the same days as the three highest concentrations of benzene (although not necessarily in same order). Concentrations of 1,3-butadiene measured at RUVT span an order of magnitude, ranging from 0.038 µg/m^3 to 0.364 µg/m^3, including one non-detect.

- Concentrations of formaldehyde measured at RUVT range from 1.37 µg/m^3 to 4.96 g/m^3; concentrations of acetaldehyde range from 0.57 µg/m^3 to 2.71 µg/m^3.

Observations for UNVT from Table 26-5 include the following:

- UNVT sampled VOCs, PAHs, PM_{10} metals, and hexavalent chromium on a 1-in-6 day schedule. Carbonyl compound sampling on the same schedule was added in July 2012.

- All of the annual average concentrations for the pollutants of interest for UNVT are less than 1 µg/m^3, where they could be calculated.

- Carbon tetrachloride has the highest annual average concentration for UNVT (0.67 ± 0.02 µg/m^3). The annual average concentrations of this pollutant are similar across the three Vermont sites, differing by less than 0.01 µg/m^3.

- Benzene has the second highest annual average concentration of the pollutants of interest for UNVT (0.38 ± 0.04 µg/m^3). However, this is the lowest annual average concentration among all NMP sites sampling benzene. Similar to the other Vermont sites, concentrations of benzene appear higher during the colder months of the year. Of the 12 measurements greater than 0.5 µg/m^3, all but one was measured during the first or fourth quarters of the year. Conversely, the nine lowest concentrations were all measured during the second and third quarters.

- The first and second quarter average concentrations of 1,3-butadiene are at least an order of magnitude less than the third and fourth quarter average concentrations. A review of the data shows that this pollutant was detected only once during the first quarter and twice during the second. Thus, the remaining the 13 measurements are spread across the third and fourth quarters of the year, but with the majority measured during the third quarter.

- A few of the VOCs listed for UNVT were detected relatively few times. Two pollutants were not detected at all during the fourth quarter, resulting in fourth quarter average concentrations of zero.

- Concentrations of formaldehyde measured at UNVT range from 0.22 µg/m^3 to 3.74 g/m^3; concentrations of acetaldehyde range from 0.20 µg/m^3 to 1.21 µg/m^3.

- Arsenic was detected in most of the metals samples collected at UNVT. In addition to six non-detects, concentrations of arsenic range from 0.01 ng/m^3 to 0.90 ng/m^3. Among NMP sites sampling arsenic, UNVT has the lowest annual average concentration of this pollutant (0.25 ± 0.05 ng/m^3).

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for the Vermont monitoring sites from those tables include the following:

- BURVT appears twice in Table 4-9 for VOCs. BURVT has the fifth highest annual average concentration of hexachloro-1,3-butadiene and the sixth highest annual average concentration of 1,2-dichloroethane among NMP sites sampling VOCs.

- RUVT appears in Table 4-9 five times, but ranks no higher than seventh for any of the pollutants for which is appears.

- UNVT appears in Table 4-9 only once; UNVT has the seventh highest annual average concentration of hexachloro-1,3-butadiene. UNVT does not appear in any of the other tables.

26.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 26-4 for BURVT, RUVT and UNVT. Figures 26-15 through 26-24 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 26-15. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

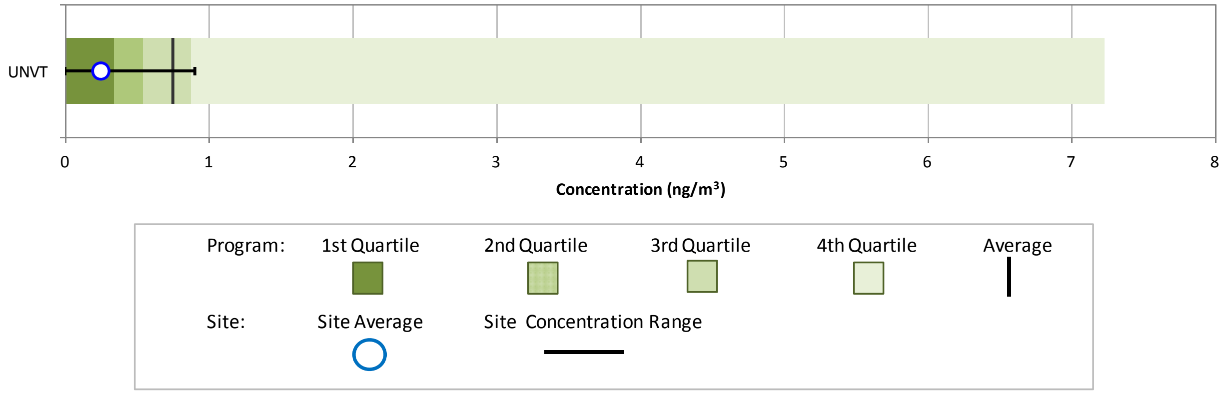


Figure 26-16. Program vs. Site-Specific Average Benzene Concentrations

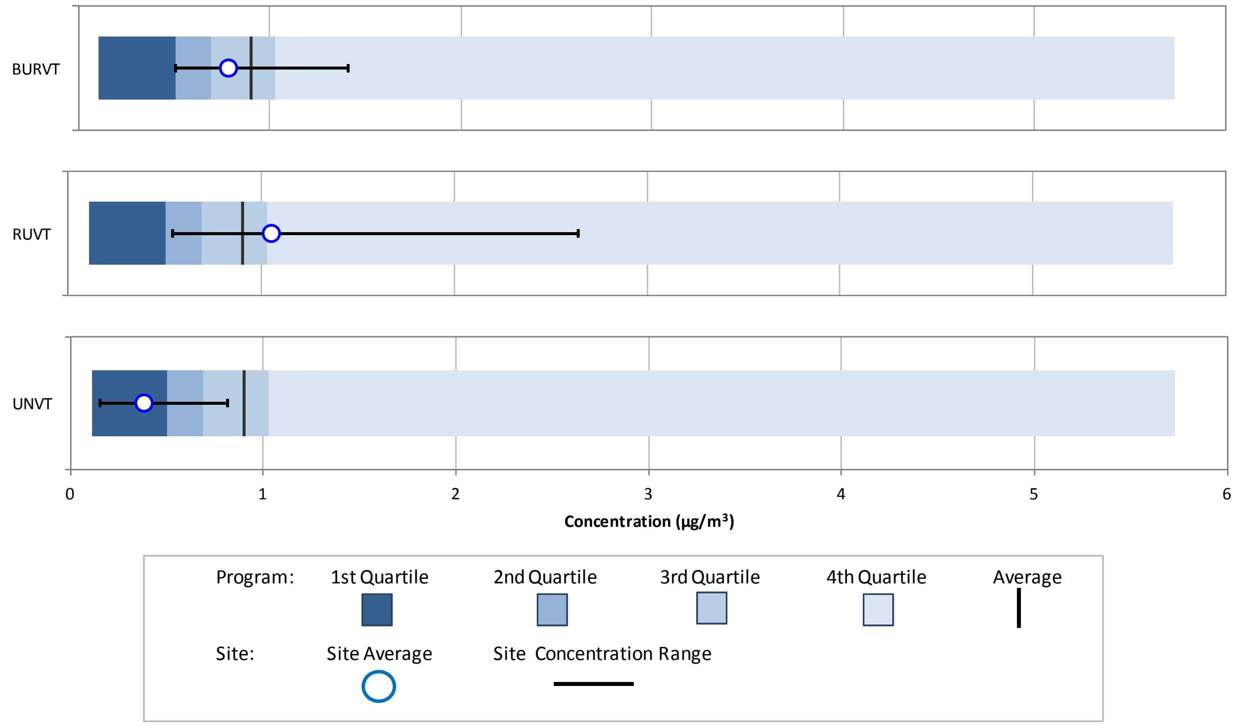


Figure 26-17. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

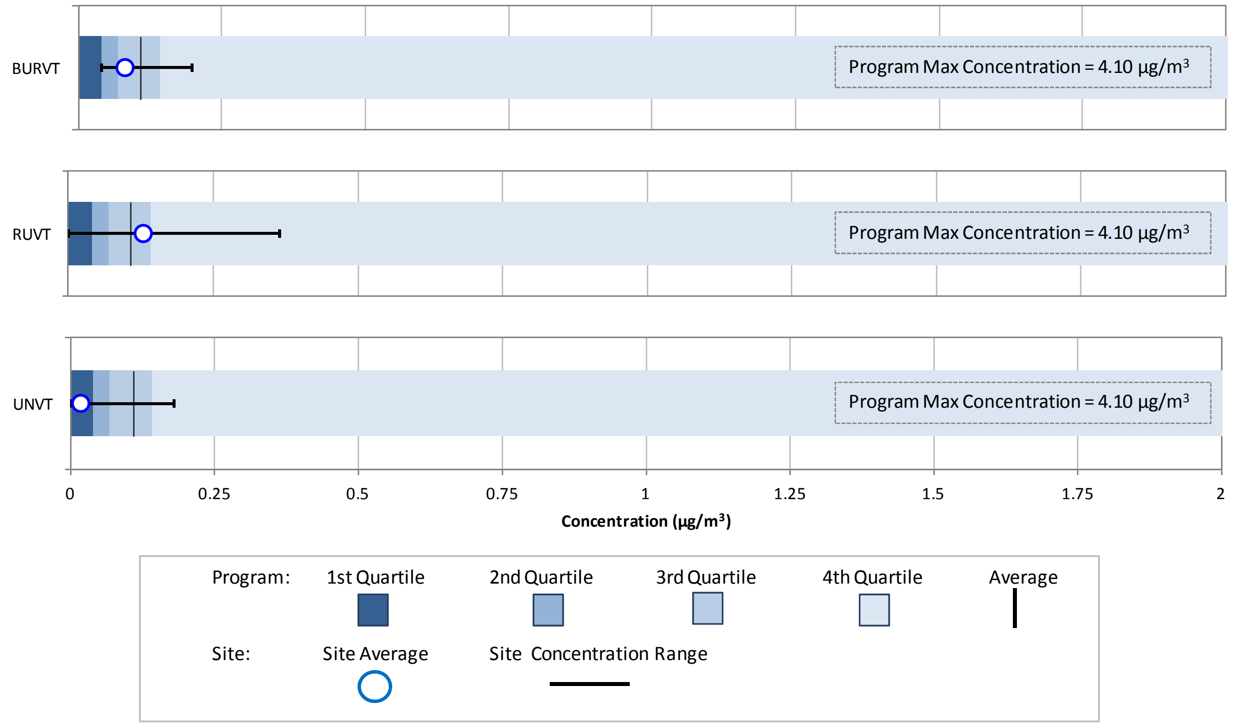


Figure 26-18. Program vs. Site-Specific Average Carbon Tetrachloride Concentrations

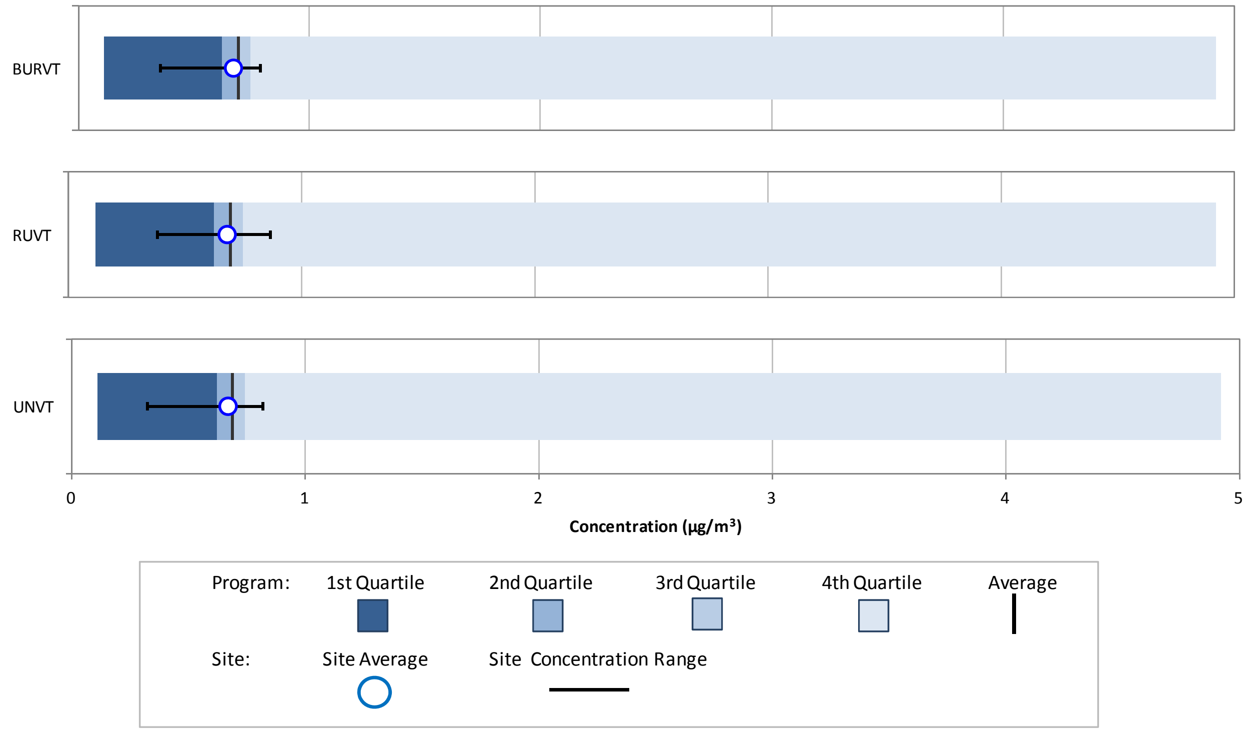


Figure 26-19. Program vs. Site-Specific Average 1,2-Dibromoethane Concentration

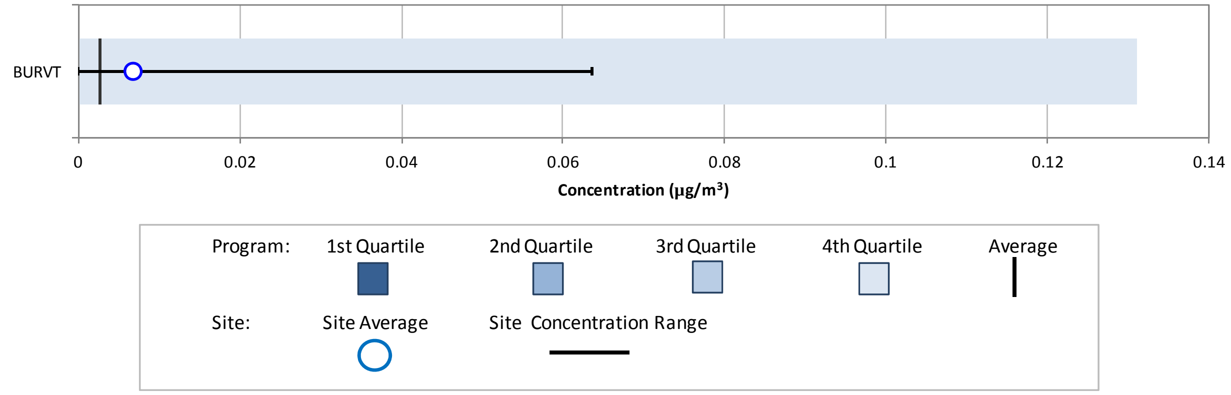


Figure 26-20. Program vs. Site-Specific Average *p*-Dichlorobenzene Concentrations

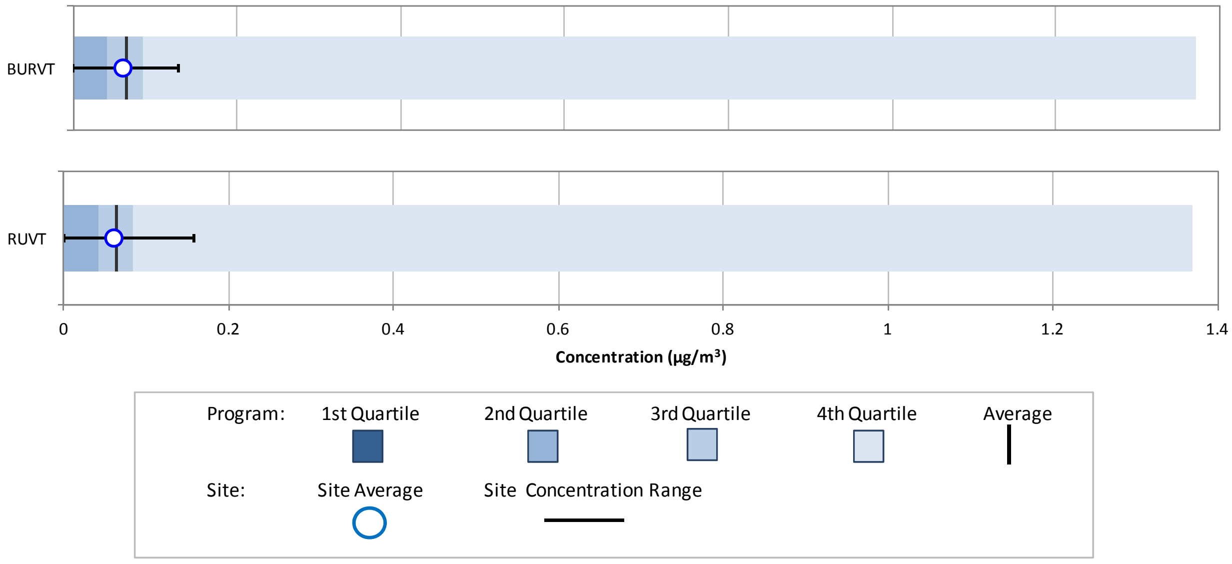


Figure 26-21. Program vs. Site-Specific Average 1,2-Dichloroethane Concentrations

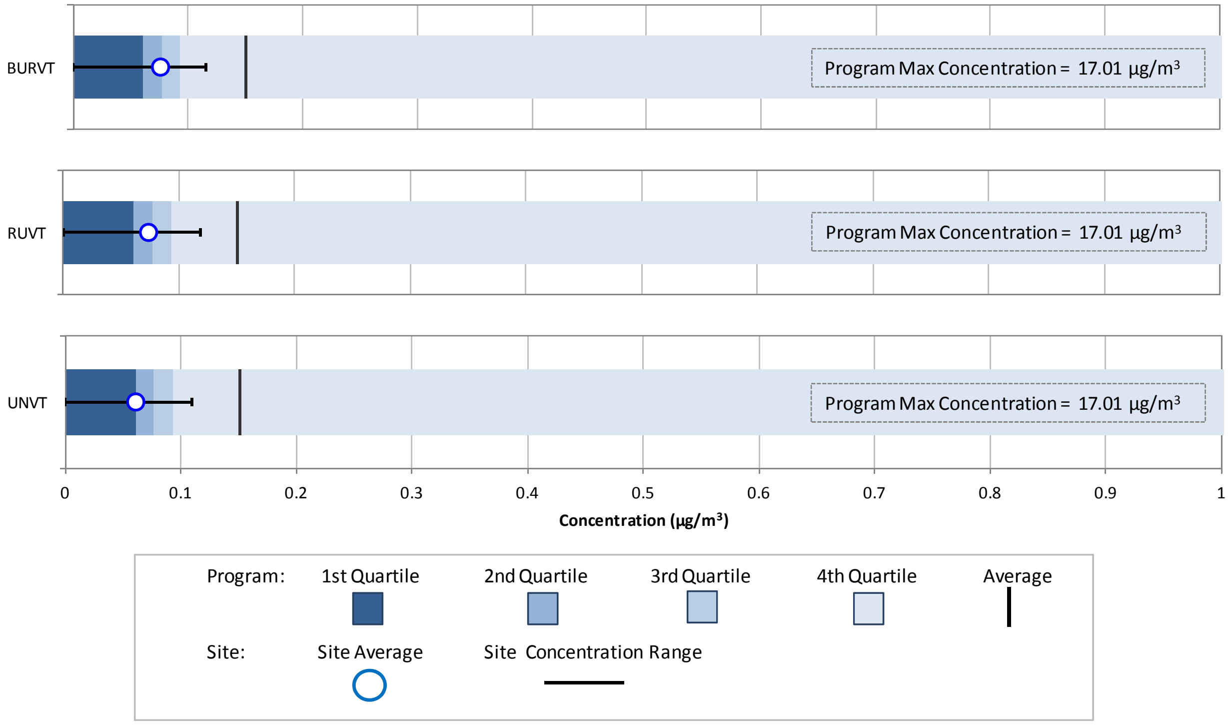


Figure 26-22. Program vs. Site-Specific Average Ethylbenzene Concentration

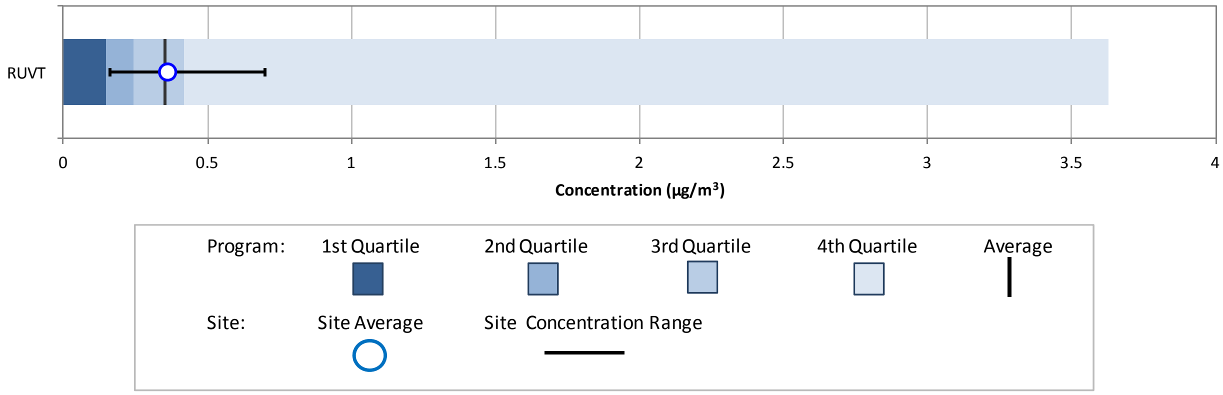


Figure 26-23. Program vs. Site-Specific Average Hexachloro-1,3-Butadiene Concentrations

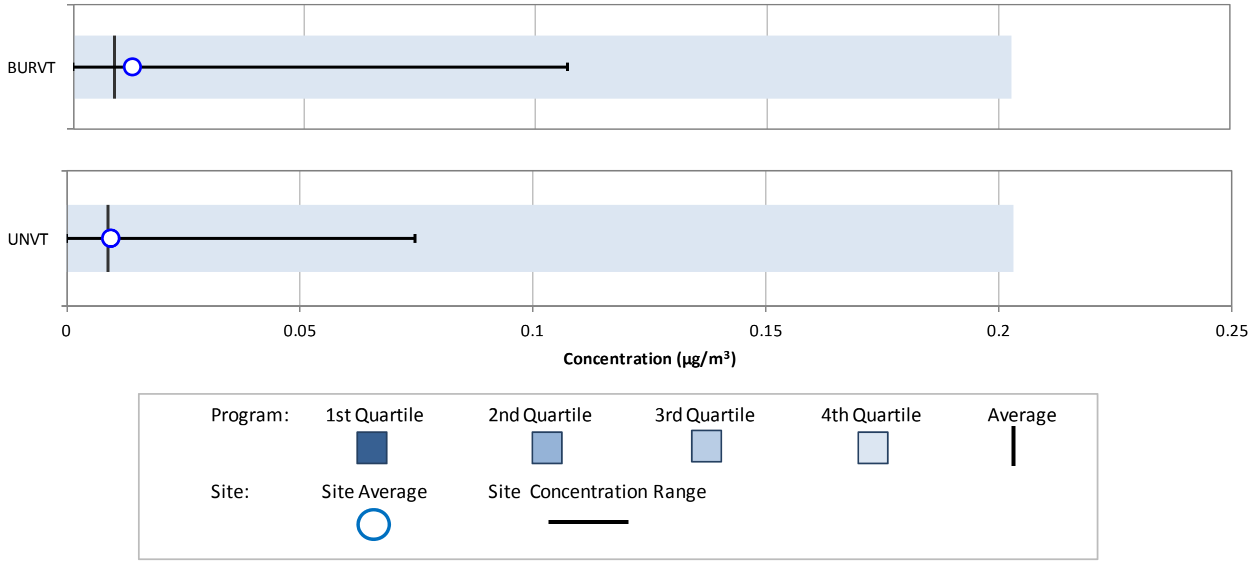
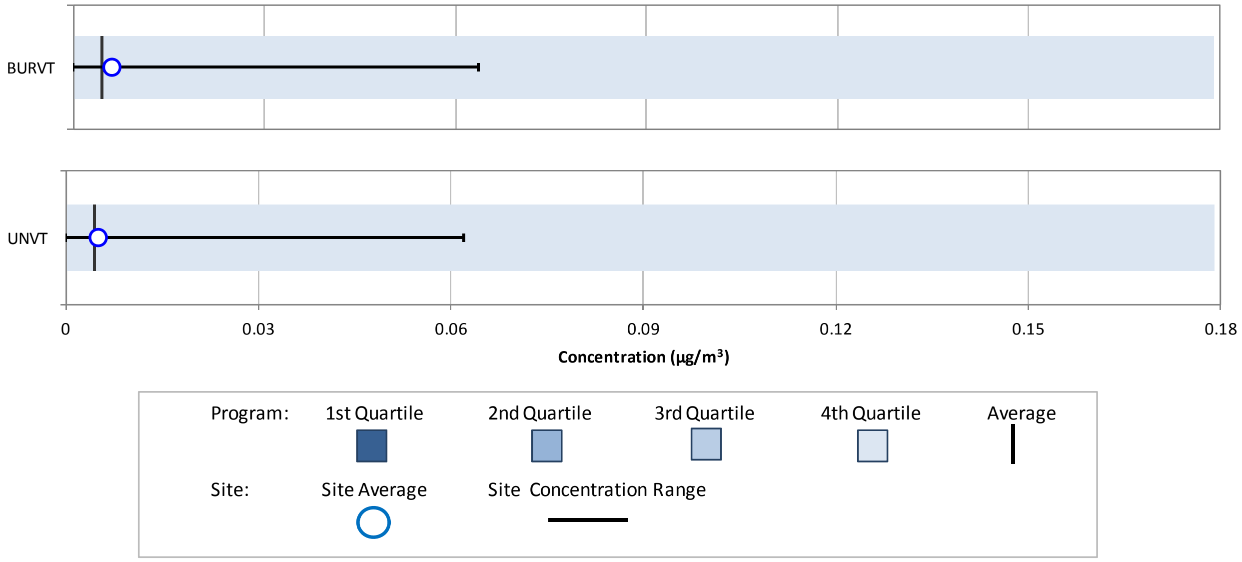


Figure 26-24. Program vs. Site-Specific Average 1,1,2,2-Tetrachloroethane Concentrations



Observations from Figures 26-15 through 26-24 include the following:

- Figure 26-15 is the box plot for arsenic. UNVT is the only Vermont site that sampled PM_{10} metals. UNVT's annual average arsenic (PM_{10}) concentration is less than the program-level first quartile (25th percentile). As discussed previously, the annual average concentration of arsenic for UNVT is the lowest annual average arsenic concentration among NMP sites sampling this pollutant. The maximum arsenic concentration measured at UNVT is just greater than the program-level third quartile. A few non-detects of arsenic were measured at UNVT.

- Figure 26-16 for benzene shows all three Vermont sites. The annual average concentration of benzene is highest for RUVT and lowest for UNVT. The annual average concentration for RUVT is the only one greater than the program-level average concentration. The annual average for BURVT is less than the program-level average but greater than the program-level median concentration. UNVT's annual average benzene concentration is less than the program-level average, median, and first quartile concentrations. The minimum benzene concentration measured at BURVT and RUVT are greater than the annual average for UNVT and the program-level first quartile.

- Figure 26-17 for 1,3-butadiene also shows all three sites. Note that the program-level maximum concentration (4.10 $\mu g/m^3$) is not shown directly on the box plots because the scale of the box plots would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plots has been reduced to 2 $\mu g/m^3$. The box plots for 1,3-butadiene are similar to the box plots for benzene: The annual average concentration for RUVT is the only one greater than the program-level average concentration; the annual average for BURVT is less than the program-level average but greater than the program-level median concentration; and the annual average concentration for UNVT is less than the program-level average, median, and first quartile concentrations. The maximum 1,3-butadiene concentration measured at each site is at least an order of magnitude less than the maximum concentration measured across the program. One non-detect was measured at RUVT. Nearly 75 percent of the 1,3-butadiene measurements were non-detects for UNVT. The minimum concentration of 1,3-butadiene measured at BURVT is the same as the program-level first quartile.

- Figure 26-18 presents the box plots for carbon tetrachloride for all three sites. The range of measurements collected at the Vermont sites are very similar to each other. The annual average concentration for each site is similar to the program-level average concentration of carbon tetrachloride. The maximum concentrations measured at these sites are significantly less than the maximum concentration measured across the program.

- Figure 26-19 presents the box plot for 1,2-dibromoethane for BURVT. This pollutant is not a pollutant of interest for RUVT or UNVT. The first, second, and third quartiles are not visible on the box plot because they are all zero due to the large number of non-detects of this pollutant. This pollutant was detected four times at BURVT. BURVT is one of only two NMP sites for which 1,2-dibromoethane is a pollutant of interest.

- Figure 26-20 is the box plot for *p*-dichlorobenzene for BURVT and RUVT. This pollutant is not a pollutant of interest for UNVT. The range of *p*-dichlorobenzene measurements is similar between these two sites. The annual average concentrations for BURVT and RUVT were similar to each other and to the program-level average concentration. The maximum concentration measured at each of these two sites is considerably less than the maximum concentration measured across the program.

- Figure 26-21 presents the box plots for 1,2-dichloroethane for all three sites. Note that the program-level maximum concentration (17.01 µg/m^3) is not shown directly on the box plot as the scale has been reduced to 1 µg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is greater than the program-level third quartile for this pollutant and is greater than or similar to the maximum concentration measured at most sites sampling 1,2-dichloroethane. This is because the program-level average is being driven by the higher measurements collected at a few monitoring sites. Figure 26-21 shows that the maximum 1,2-dichloroethane concentrations measured at the Vermont sites are two orders of magnitude less than the maximum concentration measured across the program. The maximum concentrations measured at the Vermont sites are also less than the program-level average concentration. The annual averages for BURVT and RUVT are similar to the median concentration at the program level, while the annual average for UNVT is similar to the program-level first quartile. At least two non-detects of 1,2-dichloroethane were measured at each Vermont site.

- Figure 26-22 is the box plot for ethylbenzene for RUVT, the only Vermont site for which ethylbenzene is a pollutant of interest. The range of ethylbenzene concentrations measured at RUVT is relatively small. The annual average concentration for RUVT is similar to the program-level average concentration. The maximum ethylbenzene concentration measured at RUVT is considerably less than the maximum concentration measured across the program. The minimum ethylbenzene concentration measured at RUVT is greater than the program-level first quartile.

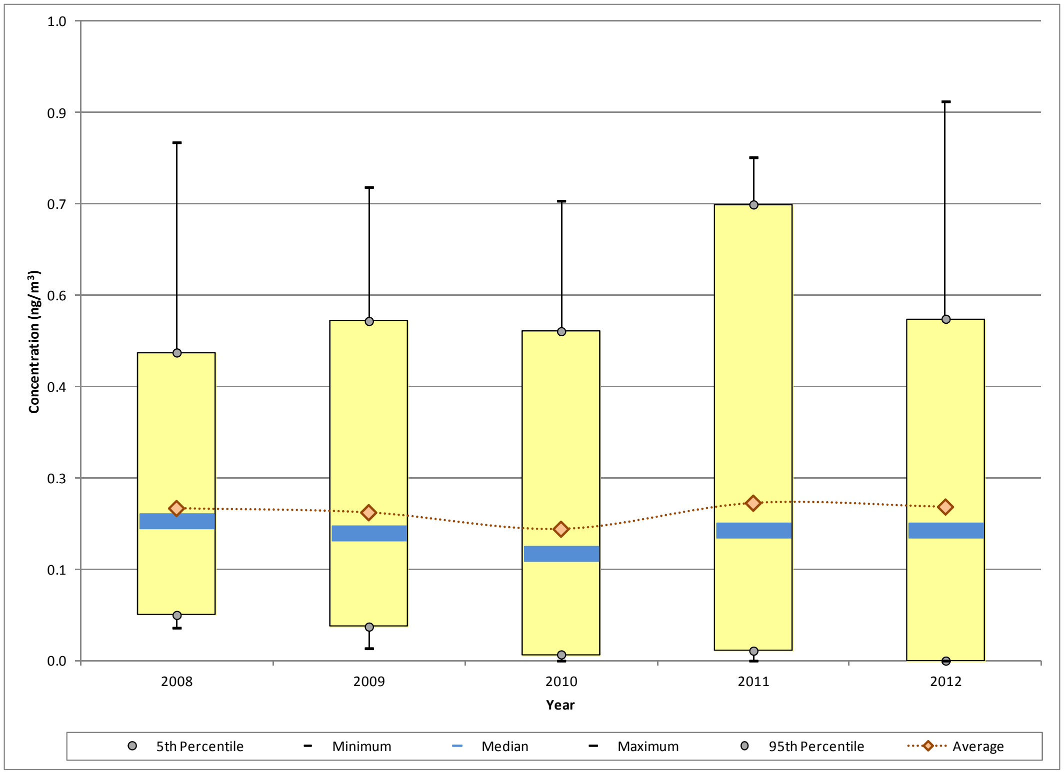
- Figure 26-23 presents the box plots for hexachloro-1,3-butadiene for BURVT and UNVT. This pollutant is not a pollutant of interest for RUVT. The first, second, and third quartiles are not visible on the box plots because they are all zero due to the large number of non-detects of this pollutant. This pollutant was detected in fewer than 20 percent of the samples collected at BURVT and UNVT in 2012. The range of measurements is greater for BURVT than UNVT. The annual average concentration for BURVT is slightly greater than the program-level average while the annual average concentration for UNVT is similar to the program-level average concentration.

- Figure 26-24 presents the box plots for 1,1,2,2-tetrachloroehtane for BURVT and UNVT. This pollutant is not a pollutant of interest for RUVT. The first, second, and third quartiles are not visible on the box plots because they are all zero due to the large number of non-detects of this pollutant. This pollutant was detected in relatively few of the samples collected at BURVT and UNVT in 2012. The range of measurements for BURVT is similar to the range of measurements for UNVT. The annual average concentration for BURVT is just slightly greater than the program-level average while the annual average concentration for UNVT is similar to the program-level average concentration.

26.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. UNVT has sampled PM_{10} metals under the NMP since 2008. Thus, Figure 26-25 presents the annual statistical metrics for arsenic for UNVT, respectively. Sampling under the NMP did not begin at BURVT or RUVT until 2009; thus, a trends analysis was not performed for these sites. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 26-25. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at UNVT



Observations from Figure 26-25 for arsenic measurements collected at UNVT include the following:

- The maximum arsenic concentration was measured at UNVT on November 11, 2012 (0.90 ng/m^3).

- With the exception of the 95th percentile, a slight decreasing trend is shown for all of the statistical metrics between 2008 and 2010. The 1-year average concentration during this time decreased slightly from 0.25 ng/m^3 to 0.21 ng/m^3. The minimum in 2008 was 0.05 ng/m^3, which decreased to 0.02 ng/m^3 for 2009, and the first non-detects were measured in 2010 (three).

- Most of the statistical metrics exhibit increases for 2011, particularly the 95th percentile, which is roughly equivalent to the previous year's maximum concentration. Only the minimum concentration stayed the same for 2011 (zero), as three non-detects were measured in 2011.

- Although the maximum concentration exhibits further increases for 2012, most of the other statistical parameters either decreased slightly (5th percentile, 1-year average, and 95th percentile) or did not change (minimum and median concentration). The number of non-detects doubled for 2012. That is why the minimum concentration and 5th percentile are both zero for 2012.

26.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the Vermont monitoring sites. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

26.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Vermont monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

26.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Vermont monitoring sites and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 26-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 26-6. Risk Approximations for the Vermont Monitoring Sites

Pollutant	Cancer URE ($\mu g/m^3$)$^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu g/m^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Burlington, Vermont - BURVT						
Acetaldehyde	0.0000022	0.009	16/16	NA	NA	NA
Benzene	0.0000078	0.03	31/31	0.78 ± 0.07	6.12	0.03
1,3-Butadiene	0.00003	0.002	31/31	0.08 ± 0.01	2.44	0.04
Carbon Tetrachloride	0.000006	0.1	31/31	0.67 ± 0.03	4.03	0.01
1,2-Dibromoethane	0.0006	0.009	4/31	0.01 ± 0.01	4.06	<0.01
p-Dichlorobenzene	0.000011	0.8	28/31	0.06 ± 0.01	0.67	<0.01
1,2-Dichloroethane	0.000026	2.4	29/31	0.08 ± 0.01	1.98	<0.01
Formaldehyde	0.000013	0.0098	16/16	NA	NA	NA
Hexachloro-1,3-butadiene	0.000022	0.09	6/31	0.01 ± 0.01	0.28	<0.01
1,1,2,2-Tetrachloroethane	0.000058	--	4/31	0.01 ± 0.01	0.35	--
Rutland, Vermont - RUVT						
Acetaldehyde	0.0000022	0.009	16/16	NA	NA	NA
Benzene	0.0000078	0.03	31/31	1.05 ± 0.20	8.20	0.04
1,3-Butadiene	0.00003	0.002	30/31	0.13 ± 0.04	3.88	0.06
Carbon Tetrachloride	0.000006	0.1	31/31	0.68 ± 0.04	4.07	0.01
p-Dichlorobenzene	0.000011	0.8	26/31	0.06 ± 0.01	0.67	<0.01
1,2-Dichloroethane	0.000026	2.4	29/31	0.07 ± 0.01	1.91	<0.01
Ethylbenzene	0.0000025	1	31/31	0.36 ± 0.05	0.90	<0.01
Formaldehyde	0.000013	0.0098	16/16	NA	NA	NA

Table 26-6. Risk Approximations for the Vermont Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Underhill, Vermont - UNVT						
Acetaldehyde	0.0000022	0.009	31/31	NA	NA	NA
Arsenic (PM_{10})[a]	0.0043	0.000015	55/61	<0.01 ± <0.01	1.06	0.02
Benzene	0.0000078	0.03	61/61	0.38 ± 0.04	2.98	0.01
1,3-Butadiene	0.00003	0.002	16/61	0.02 ± 0.01	0.54	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.67 ± 0.02	4.02	0.01
1,2-Dichloroethane	0.000026	2.4	53/61	0.06 ± 0.01	1.58	<0.01
Formaldehyde	0.000013	0.0098	31/31	NA	NA	NA
Hexachloro-1,3-butadiene	0.000022	0.09	10/61	0.01 ± 0.01	0.21	<0.01
1,1,2,2-Tetrachloroethane	0.000058	--	6/61	0.01 ± <0.01	0.29	--

-- = a Cancer URE or Noncancer RfC is not available.
NA = Not available due to the criteria for calculating an annual average.
[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 26-5.

Observations from Table 26-6 include the following:

- For BURVT, benzene and carbon tetrachloride have the highest annual average concentrations. Benzene and 1,2-dibromoethane have the highest cancer risk approximations for BURVT (6.12 in-a-million and 4.06 in-a-million, respectively), with carbon tetrachloride ranking third (4.03 in-a-million).

- Benzene and carbon tetrachloride have the highest annual average concentrations for RUVT. These pollutants also have the highest cancer risk approximations for RUVT (8.20 in-a-million and 4.07 in-a-million, respectively).

- Carbon tetrachloride and benzene have the highest annual average concentrations for UNVT. These two pollutants also have the highest cancer risk approximations for UNVT (4.02 in-a-million and 2.98 in-a-million, respectively).

- The noncancer hazard approximations for the pollutants of interest for all three Vermont sites are all considerably less than 1.0, indicating that no adverse health effects are expected from these individual pollutants.

- Annual averages could not be calculated for the carbonyl compound pollutants of interest due to the short sampling duration; as a result, cancer and noncancer hazard approximations could not be calculated.

26.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 26-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 26-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 26-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 26-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 26-7. Table 26-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 26.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 26-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Vermont Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Burlington, Vermont (Chittenden County) - BURVT					
Benzene	87.16	Formaldehyde	7.28E-04	Benzene	6.12
Formaldehyde	55.98	Benzene	6.80E-04	1,2-Dibromoethane	4.06
Acetaldehyde	32.76	1,3-Butadiene	3.39E-04	Carbon Tetrachloride	4.03
Ethylbenzene	32.08	Hexavalent Chromium, PM	3.22E-04	1,3-Butadiene	2.44
1,3-Butadiene	11.30	Arsenic, PM	2.71E-04	1,2-Dichloroethane	1.98
Naphthalene	6.46	POM, Group 3	2.50E-04	*p*-Dichlorobenzene	0.67
Dichloromethane	2.54	Naphthalene	2.20E-04	1,1,2,2-Tetrachloroethane	0.35
Tetrachloroethylene	2.21	POM, Group 2b	1.44E-04	Hexachloro-1,3-butadiene	0.28
POM, Group 2b	1.63	POM, Group 5a	1.02E-04		
POM, Group 2d	0.96	Nickel, PM	9.56E-05		
Underhill, Vermont (Chittenden County) - UNVT					
Benzene	87.16	Formaldehyde	7.28E-04	Carbon Tetrachloride	4.02
Formaldehyde	55.98	Benzene	6.80E-04	Benzene	2.98
Acetaldehyde	32.76	1,3-Butadiene	3.39E-04	1,2-Dichloroethane	1.58
Ethylbenzene	32.08	Hexavalent Chromium, PM	3.22E-04	Arsenic	1.06
1,3-Butadiene	11.30	Arsenic, PM	2.71E-04	1,3-Butadiene	0.54
Naphthalene	6.46	POM, Group 3	2.50E-04	1,1,2,2-Tetrachloroethane	0.29
Dichloromethane	2.54	Naphthalene	2.20E-04	Hexachloro-1,3-butadiene	0.21
Tetrachloroethylene	2.21	POM, Group 2b	1.44E-04		
POM, Group 2b	1.63	POM, Group 5a	1.02E-04		
POM, Group 2d	0.96	Nickel, PM	9.56E-05		

Table 26-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Vermont Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Rutland, Vermont (Rutland County) - RUVT					
Benzene	49.23	Benzene	3.84E-04	Benzene	8.20
Formaldehyde	25.76	Formaldehyde	3.35E-04	Carbon Tetrachloride	4.07
Acetaldehyde	18.18	1,3-Butadiene	1.67E-04	1,3-Butadiene	3.88
Ethylbenzene	16.11	POM, Group 3	1.38E-04	1,2-Dichloroethane	1.91
1,3-Butadiene	5.57	Naphthalene	1.19E-04	Ethylbenzene	0.90
Naphthalene	3.49	POM, Group 2b	7.21E-05	*p*-Dichlorobenzene	0.67
POM, Group 2b	0.82	POM, Group 5a	6.43E-05		
POM, Group 2d	0.47	Arsenic, PM	4.26E-05		
Tetrachloroethylene	0.38	POM, Group 2d	4.12E-05		
Trichloroethylene	0.30	Ethylbenzene	4.03E-05		

Table 26-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Vermont Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Burlington, Vermont (Chittenden County) - BURVT					
Toluene	385.94	Acrolein	508,436.14	1,3-Butadiene	0.04
Ethylene glycol	192.75	Manganese, PM	59,493.59	Benzene	0.03
Xylenes	135.31	Chlorine	12,098.33	Carbon Tetrachloride	0.01
Hexane	100.90	Formaldehyde	5,712.53	1,2-Dibromoethane	<0.01
Methanol	90.73	1,3-Butadiene	5,649.93	Hexachloro-1,3-butadiene	<0.01
Benzene	87.16	Arsenic, PM	4,200.83	*p*-Dichlorobenzene	<0.01
Formaldehyde	55.98	Acetaldehyde	3,639.92	1,2-Dichloroethane	<0.01
Hydrochloric acid	35.41	Benzene	2,905.47		
Acetaldehyde	32.76	Nickel, PM	2,212.99		
Ethylbenzene	32.08	Cadmium, PM	2,178.46		
Underhill, Vermont (Chittenden County) - UNVT					
Toluene	385.94	Acrolein	508,436.14	Arsenic	0.02
Ethylene glycol	192.75	Manganese, PM	59,493.59	Benzene	0.01
Xylenes	135.31	Chlorine	12,098.33	1,3-Butadiene	0.01
Hexane	100.90	Formaldehyde	5,712.53	Carbon Tetrachloride	0.01
Methanol	90.73	1,3-Butadiene	5,649.93	Hexachloro-1,3-butadiene	<0.01
Benzene	87.16	Arsenic, PM	4,200.83	1,2-Dichloroethane	<0.01
Formaldehyde	55.98	Acetaldehyde	3,639.92		
Hydrochloric acid	35.41	Benzene	2,905.47		
Acetaldehyde	32.76	Nickel, PM	2,212.99		
Ethylbenzene	32.08	Cadmium, PM	2,178.46		

Table 26-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Vermont Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		**Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)**		**Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Rutland, Vermont (Rutland County) - RUVT					
Toluene	183.66	Acrolein	76,839.04	1,3-Butadiene	0.06
Ethylene glycol	76.00	1,3-Butadiene	2,784.50	Benzene	0.04
Xylenes	64.79	Formaldehyde	2,628.93	Carbon Tetrachloride	0.01
Benzene	49.23	Acetaldehyde	2,020.27	Ethylbenzene	<0.01
Hexane	40.83	Benzene	1,641.04	*p*-Dichlorobenzene	<0.01
Methanol	35.39	Naphthalene	1,162.51	1,2-Dichloroethane	<0.01
Formaldehyde	25.76	Arsenic, PM	659.72		
Acetaldehyde	18.18	Xylenes	647.86		
Ethylbenzene	16.11	Lead, PM	572.30		
1,3-Butadiene	5.57	Nickel, PM	521.39		

Observations from Table 26-7 include the following:

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in both Chittenden and Rutland Counties, although the emissions in Chittenden County were nearly twice those in Rutland County.

- Formaldehyde, benzene, and 1.3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for both counties, although not necessarily in that order.

- Five of the highest emitted pollutants also have the highest toxicity-weighted emissions for Chittenden County while seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Rutland County.

- Benzene is at or near the top of all three lists for both counties (for the emissions) and for all three sites (for the cancer risk approximations). The cancer risk approximation for carbon tetrachloride is among the highest for all three sites, but this pollutant appears on neither emissions-based list for either county. Formaldehyde is also at or near the top of the emissions-based lists for both counties, although a full-year's worth of sampling is needed to determine how the concentrations of formaldehyde rank among each site's pollutants of interest. 1,3-Butadiene is another pollutant for which a cancer risk approximation could be calculated for all sites and that appears near the top of both emissions-based lists.

- Arsenic has the fourth highest cancer risk approximation for UNVT and ranks fifth for its toxicity-weighted emissions, but is not one of the highest emitted in Chittenden County.

- Naphthalene ranks seventh for its toxicity-weighted emissions and ranks sixth for its total emissions for Chittenden County. Naphthalene failed screens for UNVT but was not identified as a pollutant of interest for this site.

- Several POM Groups appear on the emissions-based lists for Chittenden and Rutland Counties. Several of the PAHs sampled for at UNVT are included in various POM Groups. Benzo(a)pyrene is part of POM, Group 5a; POM, Group 2b includes acenaphthylene, fluoranthene, and perylene; and POM, Group 2d includes anthracene, phenanthrene, and pyrene. None of the pollutants sampled for at UNVT and included in these POM groups failed screens.

Observations from Table 26-8 include the following:

- Toluene, ethylene glycol, and xylenes are the highest emitted pollutants with noncancer RfCs in Chittenden and Rutland Counties, although the emissions in Chittenden County were more than twice those in Rutland County.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both Chittenden and Rutland Counties. Although acrolein was sampled for at all three sites, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Three of the highest emitted pollutants for Chittenden County also have the highest toxicity-weighted emissions while five of the highest emitted pollutants for Rutland County also have the highest toxicity-weighted emissions.

- Although very low, 1,3-butadiene and benzene have the highest noncancer hazard approximations for BURVT and RUVT. Benzene appears on both emissions-based lists for both counties. Although 1,3-butadiene also appears on both emissions-based lists for Rutland County, this pollutant ranks fifth for toxicity-weighted emissions in Chittenden County but is not among the highest emitted.

- Although very low, arsenic has the highest noncancer hazard approximation for UNVT. While this pollutant ranks sixth among the toxicity-weighted emissions for Chittenden County, it is not among the highest emitted. Four of the metals sampled for at UNVT appear among the pollutants with the highest toxicity-weighted emissions but are not among the highest emitted.

26.6 Summary of the 2012 Monitoring Data for the Vermont Monitoring Sites

Results from several of the data treatments described in this section include the following:

- ❖ *A total of 11 pollutants failed screens for BURVT; 12 pollutants failed screens for RUVT; and 13 pollutants failed screens for UNVT.*

- ❖ *Among the site-specific pollutants of interest, only the annual average benzene concentration for RUVT was greater than 1 µg/m*^{3}.

- ❖ *The annual average concentrations for several of UNVT's pollutants of interest were the lowest annual averages among NMP sites sampling those pollutants.*

27.0 Site in Virginia

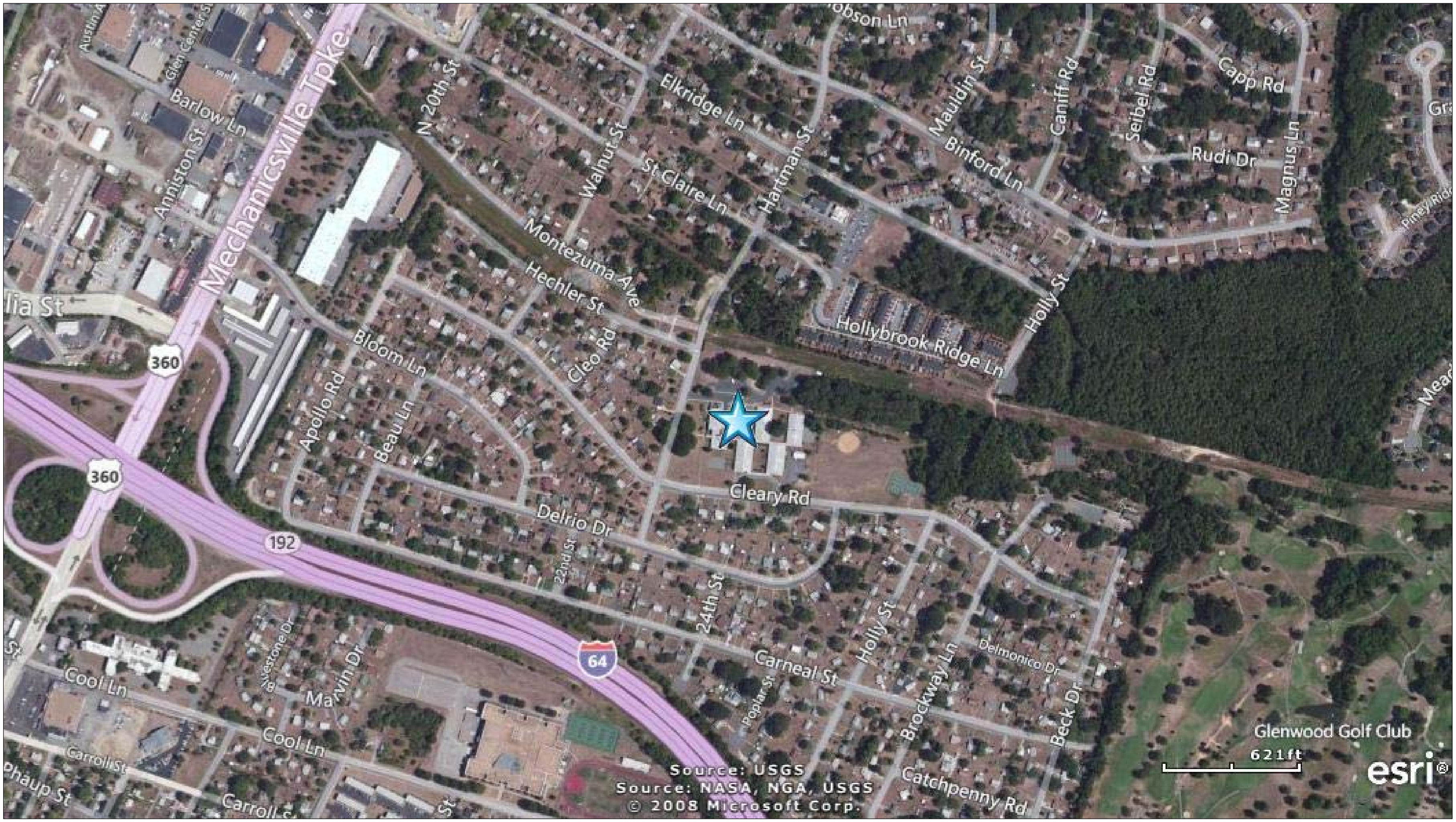
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Virginia, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

27.1 Site Characterization

This section characterizes the Virginia monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The RIVA monitoring site is located just outside the Richmond, Virginia city limits in East Highland Park. Figure 27-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 27-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 27-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 27-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 27-1. East Highland Park, Virginia (RIVA) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 27-2. NEI Point Sources Located Within 10 Miles of RIVA

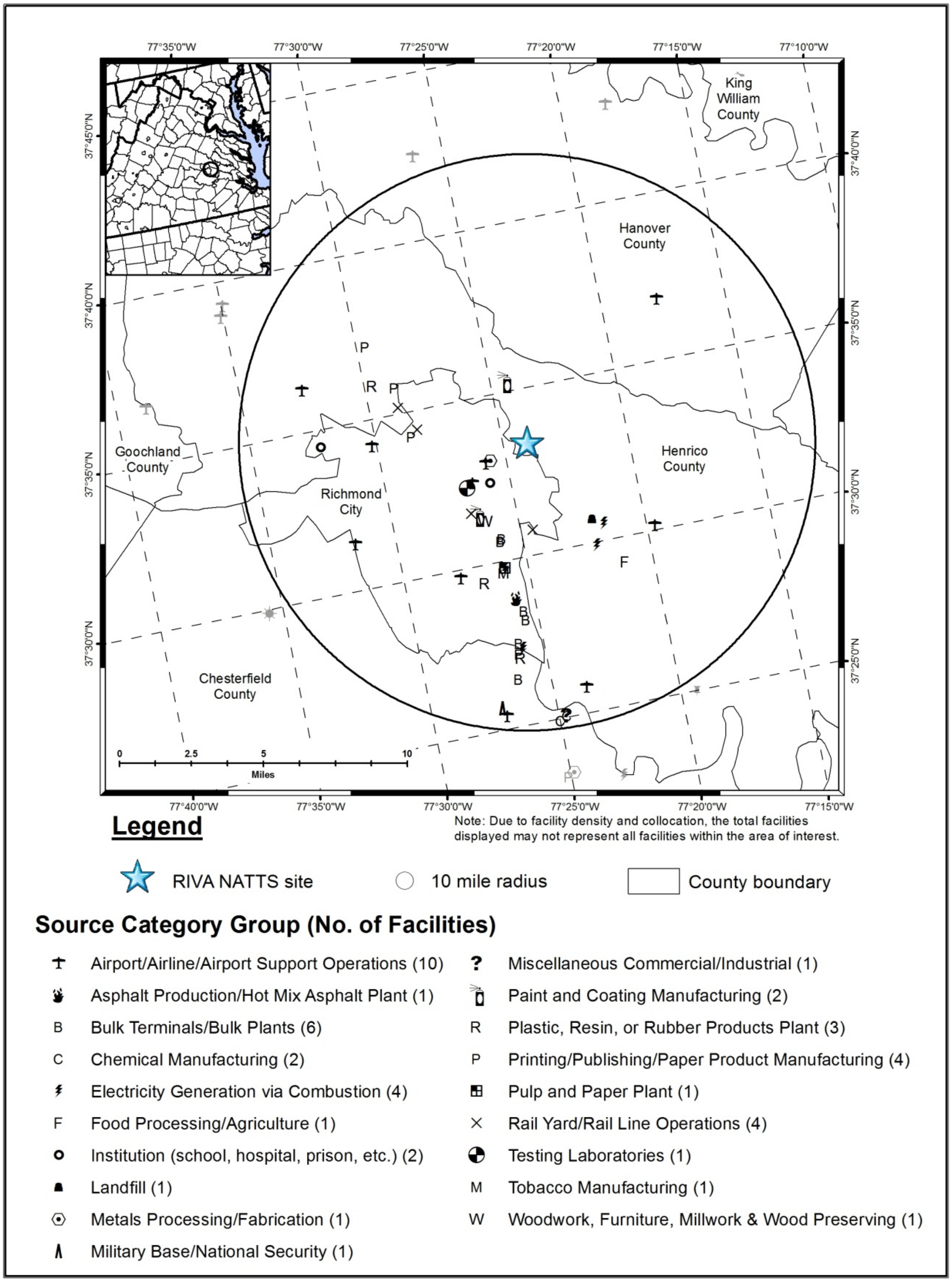


Table 27-1. Geographical Information for the Virginia Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
RIVA	51-087-0014	East Highland Park	Henrico	Richmond, VA MSA	37.55652, -77.40027	Residential	Suburban	TSP Metals, CO, SO_2, NO_y, NO, NO_2, NO_x, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Metals, PM Coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The RIVA monitoring site is located just northeast of the capital city of Richmond, in east-central Virginia. The site is located at the MathScience Innovation Center in a residential area about one-quarter mile from I-64. The I-64 interchange with Mechanicsville Turnpike (US-360) is less than one-half mile west of the site, as shown in Figure 27-1. Beyond the residential areas surrounding the school property are a golf course to the southeast, a high school to the south (on the south side of I-64), and commercial areas to the west. As Figure 27-2 shows, RIVA is located near several point sources, most of which are located to the southwest and south of the site and within the city of Richmond. The sources closest to RIVA are a metals processing and fabrication facility and a heliport at the Medical College of Virginia. The source categories with the greatest number of emissions sources within 10 miles of RIVA are the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; bulk terminals and bulk plants; printing, publishing, and paper product manufacturers; rail yard and rail line operations; and facilities generating electricity via combustion.

Table 27-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Virginia monitoring site. Table 27-2 includes both county-level population and vehicle registration information. Table 27-2 also contains traffic volume information for RIVA as well as the location for which the traffic volume was obtained. Additionally, Table 27-2 presents the county-level daily VMT for Henrico County.

Table 27-2. Population, Motor Vehicle, and Traffic Information for the Virginia Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
RIVA	314,932	354,419	72,000	I-64 at Mechanicsville Turnpike	8,232,198

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c).
[2] County-level vehicle registration reflects 2012 data (Henrico County, 2013).
[3] AADT reflects 2012 data (VA DOT, 2012).
[4] County-level VMT reflects 2012 data (VA DOT, 2013).
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 27-2 include the following:

- RIVA's county-level population is in the middle third of the range compared to other counties with NMP sites, as is its county-level vehicle ownership.

- The traffic volume experienced near RIVA is also in the middle of the range compared to other NMP monitoring sites. The traffic volume provided is for I-64 at US-360 (Mechanicsville Turnpike).

- The daily VMT for Henrico County is also in the middle of the range compared to other counties with NMP sites (where VMT data are available).

27.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Virginia on sample days, as well as over the course of the year.

27.2.1 Climate Summary

The city of Richmond is located in east-central Virginia, east of the Blue Ridge Mountains and west of the Chesapeake Bay and Atlantic Ocean. The James River flows through the west, center, and south parts of town. Richmond has a modified continental climate. Winters tend to be mild, as the mountains act as a barrier to cold air and the proximity to the Atlantic Ocean prevents temperatures from plummeting too low. Summers are warm and humid, also due to these influences. Precipitation is well distributed throughout the year, with 3 inches to 4 inches typical during most months of the year. A northerly wind is common during the winter months while southerly winds prevail during the warmest months of the year (Wood, 2004).

27.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Virginia monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station is located at Richmond International Airport (WBAN 13740). Additional information about the Richmond International Airport weather station, such as the distance between the site and the weather station, is provided in Table 27-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 27-3. Average Meteorological Conditions near the Virginia Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
East Highland Park, Virginia - RIVA									
Richmond International Airport 13740 (37.51, -77.32)	5.5 miles 119° (ESE)	Sample Days (67)	71.6 ± 4.0	61.0 ± 3.8	48.7 ± 4.3	54.6 ± 3.6	67.5 ± 3.4	1017.6 ± 1.8	5.7 ± 0.5
		2012	71.0 ± 1.6	60.9 ± 1.5	48.7 ± 1.7	54.5 ± 1.5	68.0 ± 1.4	1017.4 ± 0.7	5.9 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 27-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 27-3 is the 95 percent confidence interval for each parameter. As shown in Table 27-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year.

27.2.3 Back Trajectory Analysis

Figure 27-3 is the composite back trajectory map for days on which samples were collected at the RIVA monitoring site. Included in Figure 27-3 are four back trajectories per sample day. Figure 27-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 27-3 and 27-4 represents 100 miles.

Observations from Figures 27-3 and Figure 27-4 for RIVA include the following:

- Back trajectories originated from a variety of directions near RIVA, although a greater number of them originated from a direction with a westerly component.

- The 24-hour air shed domain for RIVA was similar in size to many other NMP monitoring sites. The farthest away a back trajectory originated was over Lake Michigan, or approximately 650 miles away. However, the average back trajectory length is 214 miles and most back trajectories (89 percent) originated within 350 miles of the site.

- The cluster analysis shows that 10 percent of back trajectories originated to the northeast and east of RIVA. Eighteen percent of back trajectories originated to the north and northwest of the site, primarily over Pennsylvania, West Virginia, Mayland, and Northern Virginia. Another 17 percent also originated to the northwest of the site but farther away, over Michigan, Indiana, and Ohio. Nearly 30 percent of back trajectories originated from the west, southwest, and south of the site, over western Virginia and the Carolinas. The relatively short cluster trajectory originating over southeast Virginia (26 percent) represents short back trajectories originating from a variety of directions as well as back trajectories originating from the east, southeast, and south of the site, primarily over eastern North Carolina but also over the offshore waters of Virginia, North Carolina, and South Carolina.

Figure 27-3. Composite Back Trajectory Map for RIVA

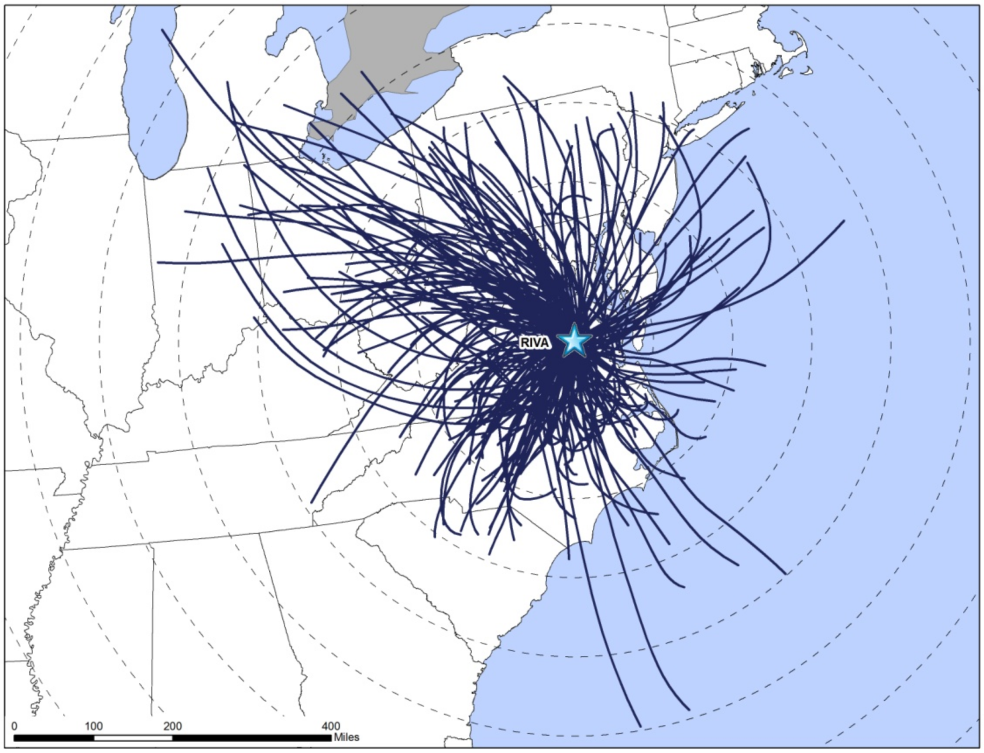


Figure 27-4. Back Trajectory Cluster Map for RIVA

27.2.4 Wind Rose Comparison

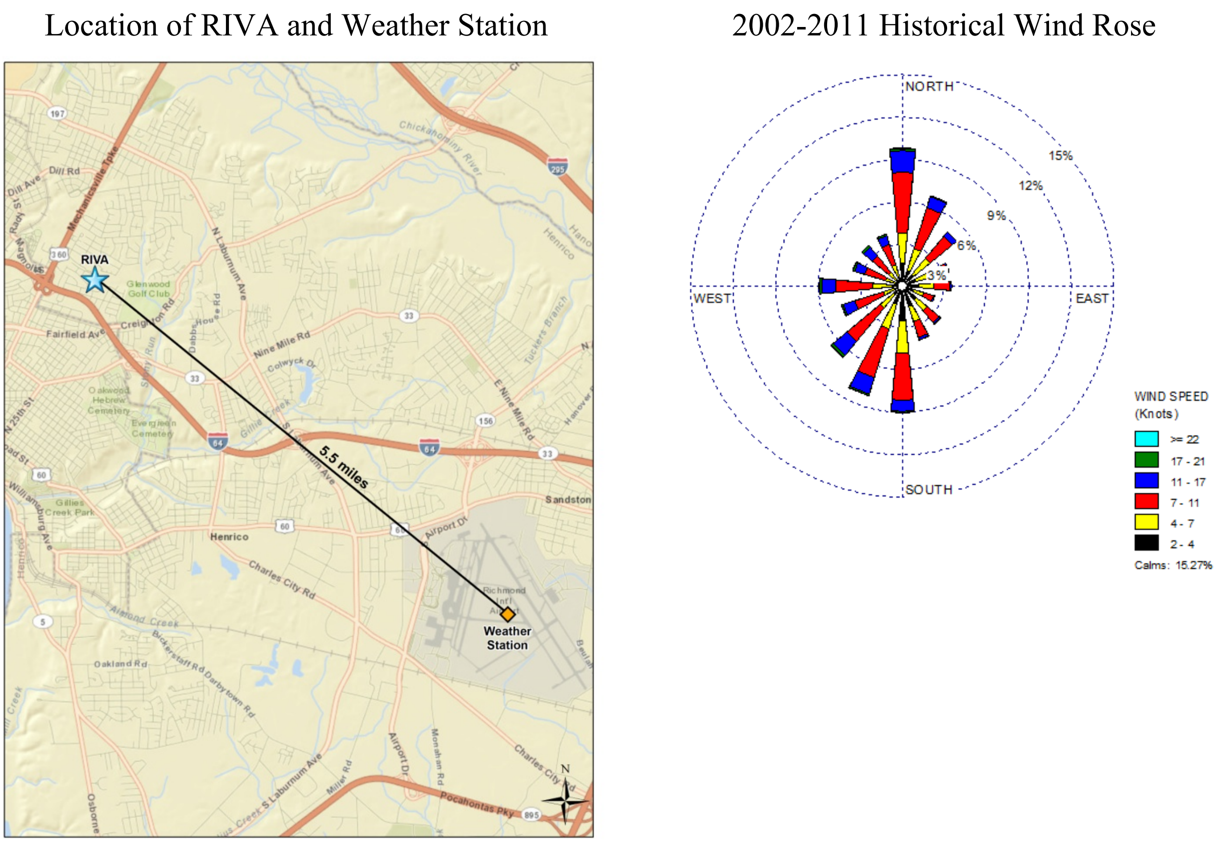
Hourly surface wind data from the weather station at Richmond International Airport near RIVA were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 27-5 presents a map showing the distance between the weather station and RIVA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 27-5 also presents three different wind roses for the RIVA monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 27-5 for RIVA include the following:

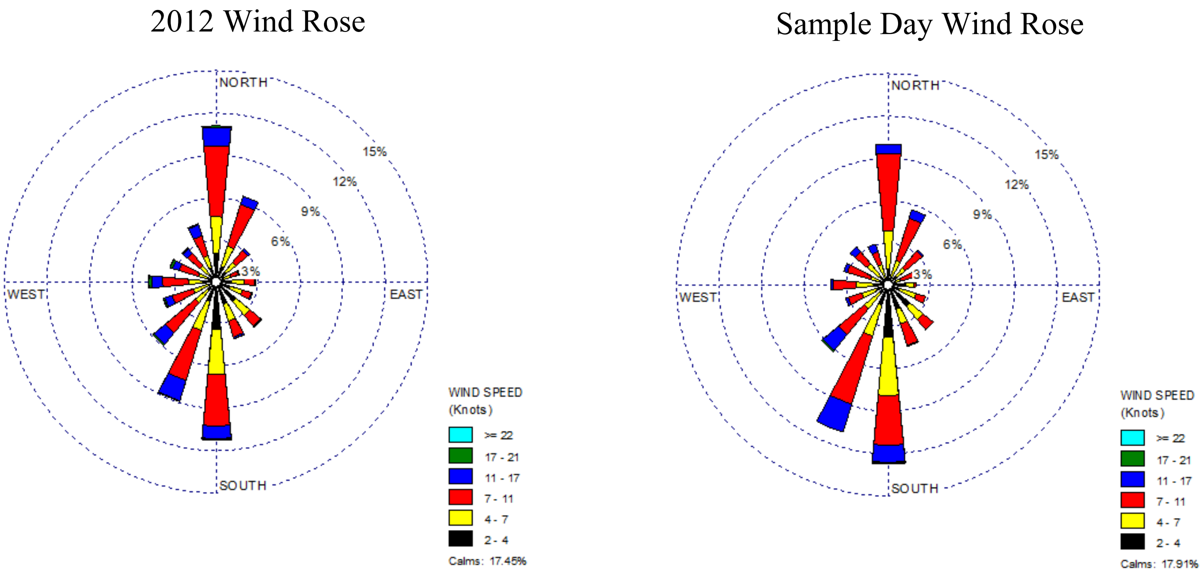
- The Richmond International Airport weather station is located 5.5 miles east-southeast of RIVA.
- The historical wind rose shows that the most commonly observed wind direction is north, although winds from the north-northeast, south, south-southwest, and southwest were also frequently observed. Winds from the southeast and northwest quadrants were observed less frequently. Calm winds (≤ 2 knots) were observed for approximately 15 percent of the hourly wind measurements.
- The 2012 wind rose resembles the historical wind rose in some ways but exhibits differences as well. Northerly, southerly and south-southwesterly winds were still prominent but accounted for a higher percentage of observations in 2012 while fewer southwesterly to westerly and northeasterly winds were observed. Calm winds were observed slightly more often in 2012.
- Southerly winds account for the greatest number of wind observations on sample days near RIVA (approximately 13 percent), followed by south-southwesterly winds (roughly 11 percent), both of which are greater than the number of northerly wind observations (10 percent). The calm rate on sample days is nearly 18 percent.

Figure 27-5. Wind Roses for the Richmond International Airport Weather Station near RIVA



Location of RIVA and Weather Station

2002-2011 Historical Wind Rose



2012 Wind Rose

Sample Day Wind Rose

27.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for the Virginia monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 27-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 27-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. RIVA sampled for PAHs and hexavalent chromium.

Table 27-4. Risk-Based Screening Results for the Virginia Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
East Highland Park, Virginia - RIVA						
Naphthalene	0.029	55	56	98.21	93.22	93.22
Fluorene	0.011	2	55	3.64	3.39	96.61
Acenaphthene	0.011	1	56	1.79	1.69	98.31
Benzo(a)pyrene	0.00057	1	33	3.03	1.69	100.00
Total		59	200	29.50		

Observations from Table 27-4 include the following:

- Although four PAHs failed screens for RIVA, naphthalene contributed to 93 percent of the total failed screens, while the other pollutants accounted for only one or two failed screens each.

- Naphthalene and fluorene contributed to 95 percent of failed screens for RIVA and therefore were identified as pollutants of interest for this site.

- Naphthalene failed greater than 98 percent of its screens, with 55 of 56 measured detections of naphthalene failing screens. Conversely, only four percent of fluorene concentrations failed screens.

27.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Virginia monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for the site.
- Annual concentration averages are presented graphically for the site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for RIVA are provided in Appendices M and O.

27.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for RIVA, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Virginia monitoring site are presented in Table 27-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 27-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Virginia Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
East Highland Park, Virginia - RIVA						
Fluorene	55/56	3.22 ± 0.79	5.14 ± 1.52	5.44 ± 1.62	2.84 ± 0.63	4.16 ± 0.65
Naphthalene	56/56	100.00 ± 20.81	87.51 ± 28.20	73.84 ± 14.44	114.50 ± 33.71	93.95 ± 12.47

Observations for RIVA from Table 27-5 include the following:

- The quarterly and annual average concentrations of naphthalene are significantly higher than the annual average concentrations of fluorene.

- Concentrations of naphthalene appear higher during the first and fourth quarters of the year, although the confidence intervals indicate that naphthalene concentrations measured at RIVA are fairly variable. Concentrations of naphthalene measured at RIVA range from 23.9 ng/m^3 to 268 ng/m^3. Of the 21 concentrations greater than 100 ng/m^3, five were measured during the first quarter, five were measured during the second quarter, one was measured during the third quarter, and nine were measured during the fourth quarter. Four of the five naphthalene concentrations greater than 100 ng/m^3 and measured during the second quarter were measured in June.

- Concentrations of fluorene measured at RIVA span an order of magnitude, ranging from 1.17 ng/m^3 to 11.3 ng/m^3. The quarterly averages of fluorene appear higher in the warmer months of the year and lower in the colder months of the year, although the differences are not statistically significant. Of the nine fluorene concentrations greater than 6 ng/m^3, eight were measured between June and August.

27.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the two pollutants shaded in gray in Table 27-4 for RIVA. Figures 27-6 and 27-7 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 27-6. Program vs. Site-Specific Average Fluorene Concentration

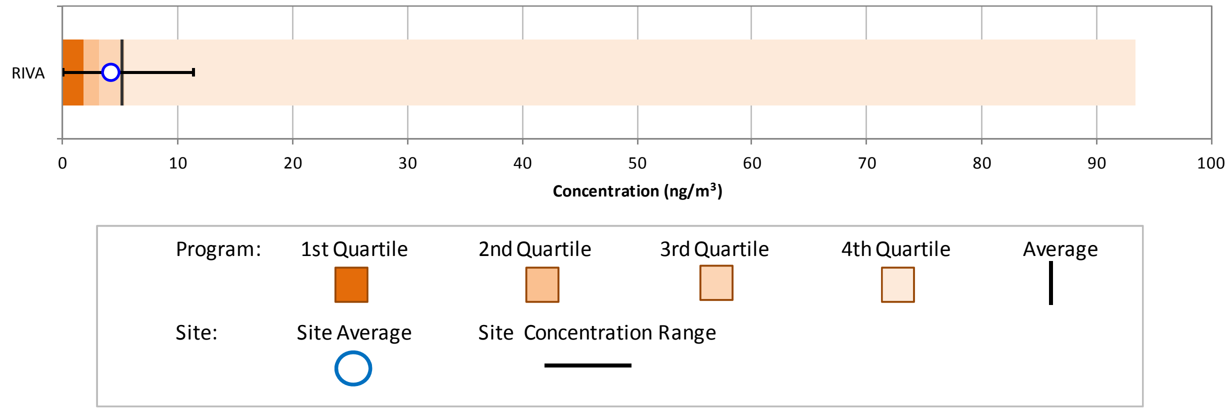
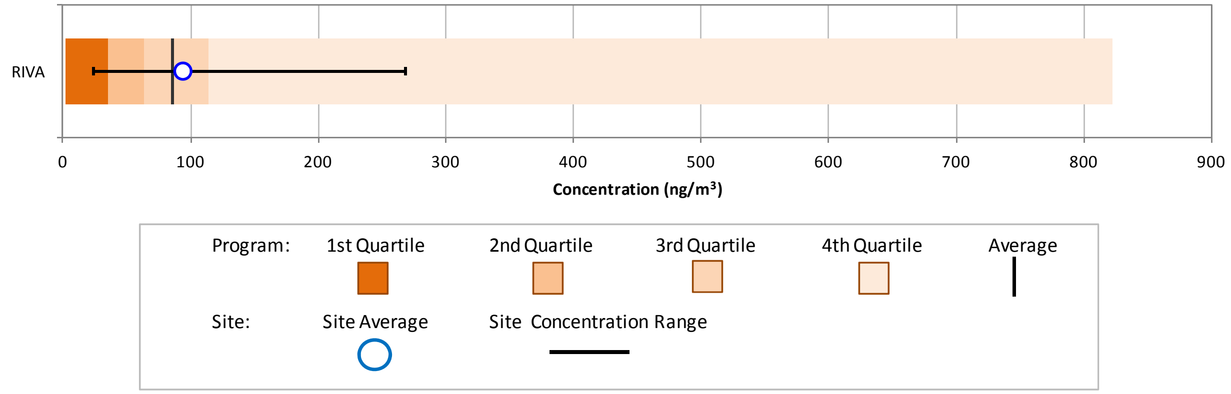


Figure 27-7. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 27-6 and 27-7 include the following:

- Figure 27-6 is the box plot for fluorene. This box plot shows that the annual average concentration for RIVA is about half way between the program-level median and average concentration. Figure 27-6 also shows that the maximum fluorene concentration measured at RIVA is considerably less than the maximum concentration measured across the program. A single non-detect of fluorene was measured at RIVA.

- Figure 27-7 is the box plot for naphthalene and shows that the annual average concentration of naphthalene for RIVA is just greater than the program-level average concentration. The maximum naphthalene concentration measured at RIVA is considerably less than the program-level maximum concentration. There were no non-detects of naphthalene measured at RIVA or across the program.

27.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. RIVA did not begin sampling PAHs under the NMP until October 2008. Because a minimum of 6 months of sampling is required for inclusion in the trends analysis and 2008 does not meet this criterion, the trends analysis was not conducted.

27.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the RIVA monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

27.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Virginia monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

27.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for RIVA and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 27-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 27-6. Risk Approximations for the Virginia Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
East Highland Park, Virginia - RIVA						
Fluorene	0.000088	--	55/56	4.16 ± 0.65	0.37	--
Naphthalene	0.000034	0.003	56/56	93.95 ± 12.47	3.19	0.03

-- = A Cancer URE or Noncancer RfC is not available.

Observations for RIVA from Table 27-6 include the following:

- The annual average concentration of naphthalene is greater than the annual average concentration of fluorene.
- The cancer risk approximation for naphthalene is 3.19 in-a-million. The cancer risk approximation for fluorene is less than 1.0 in-a-million.
- Only naphthalene has a noncancer toxicity factor. The noncancer hazard approximation for naphthalene is considerably less than 1.0 (0.03), indicating that no adverse health effects are expected from this individual pollutant.

27.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 27-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 27-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 27-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for RIVA, as presented in Table 27-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 27-7. Table 27-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 27-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Virginia Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
East Highland Park, Virginia (Henrico County) - RIVA					
Benzene	105.08	Formaldehyde	1.30E-03	Naphthalene	3.19
Formaldehyde	100.16	Benzene	8.20E-04	Fluorene	0.37
Acetaldehyde	55.95	1,3-Butadiene	5.68E-04		
Ethylbenzene	51.83	POM, Group 3	4.57E-04		
1,3-Butadiene	18.95	Naphthalene	3.52E-04		
Tetrachloroethylene	17.17	POM, Group 2b	2.28E-04		
Naphthalene	10.37	POM, Group 2d	1.41E-04		
POM, Group 2b	2.59	Ethylbenzene	1.30E-04		
POM, Group 2d	1.60	Acetaldehyde	1.23E-04		
Trichloroethylene	0.85	POM, Group 5a	8.27E-05		

Table 27-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Virginia Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
East Highland Park, Virginia (Henrico County) - RIVA					
Toluene	833.14	Acrolein	303,722.52	Naphthalene	0.03
Ethylene glycol	383.38	Formaldehyde	10,220.27		
Xylenes	205.40	1,3-Butadiene	9,474.82		
Hexane	197.92	Acetaldehyde	6,216.90		
Methanol	181.20	Benzene	3,502.59		
Benzene	105.08	Naphthalene	3,455.66		
Formaldehyde	100.16	Xylenes	2,054.03		
Acetaldehyde	55.95	Arsenic, PM	1,052.35		
Ethylbenzene	51.83	Ethylene glycol	958.44		
Methyl isobutyl ketone	24.42	Lead, PM	807.68		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 27.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 27-7 include the following:

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in Henrico County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, and 1,3-butadiene.
- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for Henrico County.
- Naphthalene, one of two pollutants of interest for RIVA, has the seventh highest emissions and the fifth highest toxicity-weighted emissions for Henrico County.
- POM, Group 2b is the eighth highest emitted "pollutant" in Henrico County and ranks sixth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at RIVA, including fluorene. Acenaphthene, which failed one screen for RIVA, is also part of this group.
- Several other POM Groups also appear in Table 27-7, particularly for toxicity-weighted emissions. POM, Group 2d appears on both emissions-based lists for Henrico County and includes anthracene, phenanthrene, and pyrene. POM, Groups 3 and 5a are also listed among those with the highest toxicity-weighted emission. POM, Group 5a includes benzo(a)pyrene, which failed a single screen for RIVA but is not a pollutant of interest. None of the PAHs sampled for at RIVA are included in POM, Group 3.

Observations from Table 27-8 include the following:

- Toluene, ethylene glycol, and xylenes are the highest emitted pollutants with noncancer RfCs in Henrico County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, formaldehyde, and 1,3-butadiene.

- Five of the highest emitted pollutants in Henrico County also have the highest toxicity-weighted emissions.

- Naphthalene has the sixth highest toxicity-weighted emissions for Henrico County but is not among the highest emitted pollutants with a noncancer toxicity factor in Henrico County.

27.6 Summary of the 2012 Monitoring Data for RIVA

Results from several of the data treatments described in this section include the following:

- ❖ *Four PAHs failed screens for RIVA, with naphthalene accounting for greater than 90 percent of the total failed screens. Hexavalent chromium did not fail any screens.*

- ❖ *Naphthalene and fluorene were identified as pollutants of interest for RIVA. The annual average concentration of naphthalene was significantly higher than the annual average concentration of fluorene.*

28.0 Site in Washington

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Washington, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

28.1 Site Characterization

This section characterizes the monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in the interpretation of the ambient monitoring measurements.

The NATTS site in Washington is located in Seattle. Figure 28-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 28-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 28-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Table 28-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 28-1. Seattle, Washington (SEWA) Monitoring Site

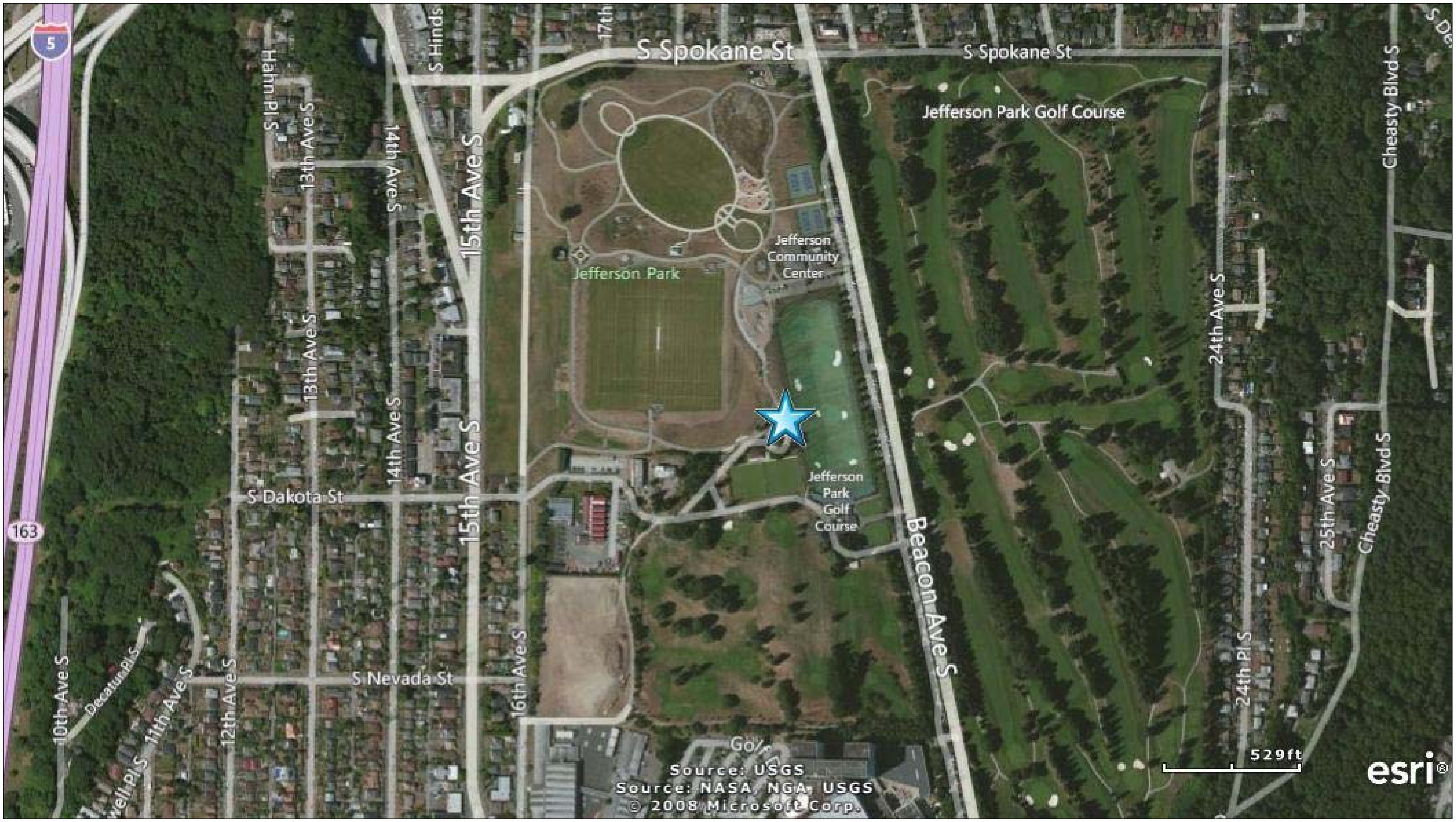


Figure 28-2. NEI Point Sources Located Within 10 Miles of SEWA

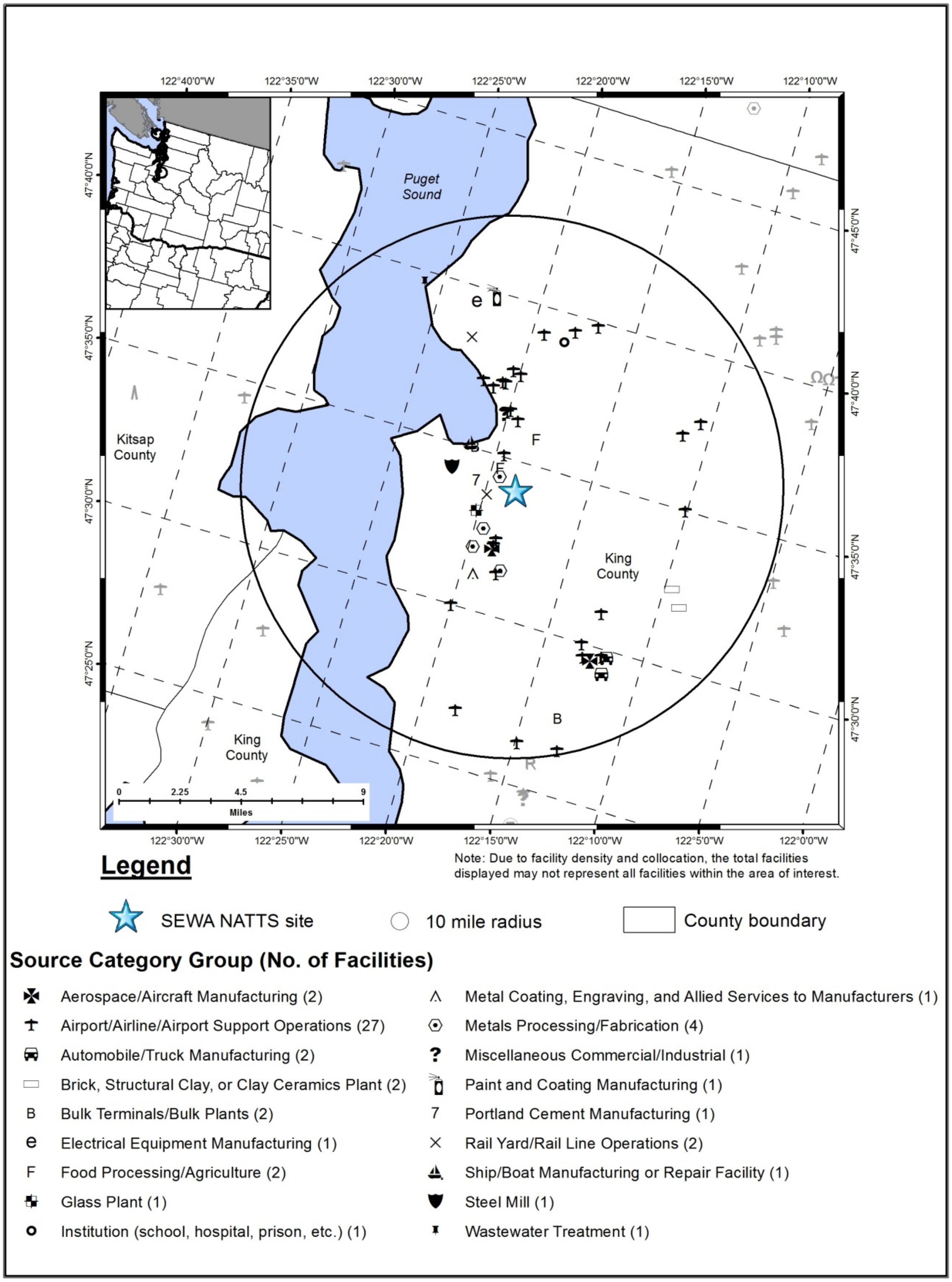


Table 28-1. Geographical Information for the Washington Monitoring Site

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
SEWA	53-033-0080	Seattle	King	Seattle-Tacoma-Bellevue, WA MSA	47.568236, -122.308628	Residential	Urban/City Center	Haze, CO, SO_2, NO_y, NO, O_3, Meteorological parameters, PM Coarse, PM_{10}, Black Carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for SEWA (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The SEWA monitoring site is located in Seattle, at the southeast corner of the Beacon Hill Reservoir. The reservoir and the Jefferson Park Golf Course to the east are separated by Beacon Avenue. A middle school and a hospital can be seen to the south of the site in the bottom-most portion of Figure 28-1. The site is surrounded by residential neighborhoods to the west, north, and east. Interstate-5, which runs north-south through Seattle, is less than 1 mile to the west and intersects with I-90 a couple of miles to the north of the site. The area to the west of I-5 is industrial while the area to the east is primarily residential. Although the emissions sources within 10 miles of the site are involved in a variety of industries, the airport source category, which includes airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations, has the greatest number of sources. The point sources located within 1 mile of SEWA are a metals processing and fabrication facility and a food processing facility, as shown in Figure 28-2.

Table 28-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Washington monitoring site. Table 28-2 includes both county-level population and vehicle registration information. Table 28-2 also contains traffic volume information for SEWA as well as the location for which the traffic volume was obtained. Additionally, Table 28-2 presents the county-level daily VMT for King County.

Table 28-2. Population, Motor Vehicle, and Traffic Information for the Washington Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
SEWA	2,007,440	1,403,968	224,000	I-5, south of the Columbian Way exit/Spokane St. Viaduct	23,044,858

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (WA DOL, 2012)
[3] AADT reflects 2012 data (WA DOT, 2012a)
[4] County-level VMT reflects 2012 data (WA DOT, 2012b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 28-2 include the following:

- King County has the sixth highest county-level population among counties with NMP sites.

- King County has the seventh highest county-level vehicle registration among counties with NMP sites.

- The traffic volume experienced near SEWA is the fourth highest compared to other NMP monitoring sites. The traffic estimate provided is for I-5 south of the Columbian Way exit/Spokane Street Viaduct.

- The daily VMT for King County is in the top third compared to other counties with NMP sites (where VMT data were available).

28.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring site in Washington on sample days, as well as over the course of the year.

28.2.1 Climate Summary

The city of Seattle is located between Puget Sound and Lake Washington. The entire urban area is situated between the Olympic Mountains to the west and the Cascades to the east. The area experiences a mild climate as the mountains moderate storm systems that move into the Pacific Northwest and both the mountains and the sound shield the city from temperature extremes. Although the city is known for its cloudy, rainy conditions, actual precipitation totals tend to be comparable or less than many locations east of the Rocky Mountains. The majority of precipitation falls during the winter months, with monthly totals greater than 5 inches common between November and January while less than 2 inches is typical during the summer. Normal annual snowfall amounts are around 10 inches. Prevailing winds in the Seattle area are out of the south to southwest for much of the year (Wood, 2004; WRCC 2013).

28.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather station closest to the Washington monitoring site (NCDC, 2012), as described in Section 3.5.2. The closest weather station to SEWA is located at Boeing Field/King County International Airport (WBAN 24234). Additional information about this weather station, such as the distance between the site and the weather station, is provided in Table 28-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

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Table 28-3. Average Meteorological Conditions near the Washington Monitoring Site

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Seattle, Washington - SEWA									
Boeing Field/ King County Intl Airport 24234 (47.53, -122.30)	2.6 miles 189° (S)	Sample Days (68)	59.8 ± 2.7	53.0 ± 2.2	43.2 ± 1.9	48.2 ± 1.8	72.0 ± 2.7	1015.9 ± 1.8	4.6 ± 0.6
		2012	59.1 ± 1.2	52.4 ± 1.0	43.1 ± 0.8	47.8 ± 0.8	72.9 ± 1.1	1016.2 ± 0.7	4.5 ± 0.2

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

Table 28-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 28-3 is the 95 percent confidence interval for each parameter. As shown in Table 28-3, average meteorological conditions on sample days were representative of average weather conditions experienced throughout the year.

28.2.3 Back Trajectory Analysis

Figure 28-3 is the composite back trajectory map for days on which samples were collected at the SEWA monitoring site. Included in Figure 28-3 are four back trajectories per sample day. Figure 28-4 is the corresponding cluster analysis. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite map, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analysis, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the site in Figures 28-3 and 28-4 represents 100 miles.

Figure 28-3. Composite Back Trajectory Map for SEWA

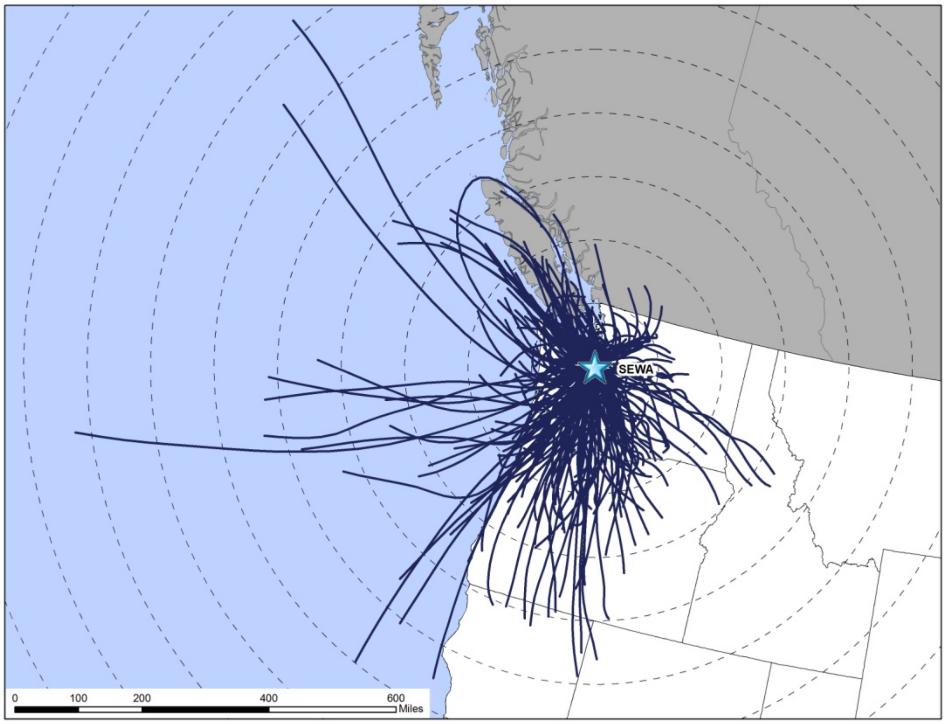
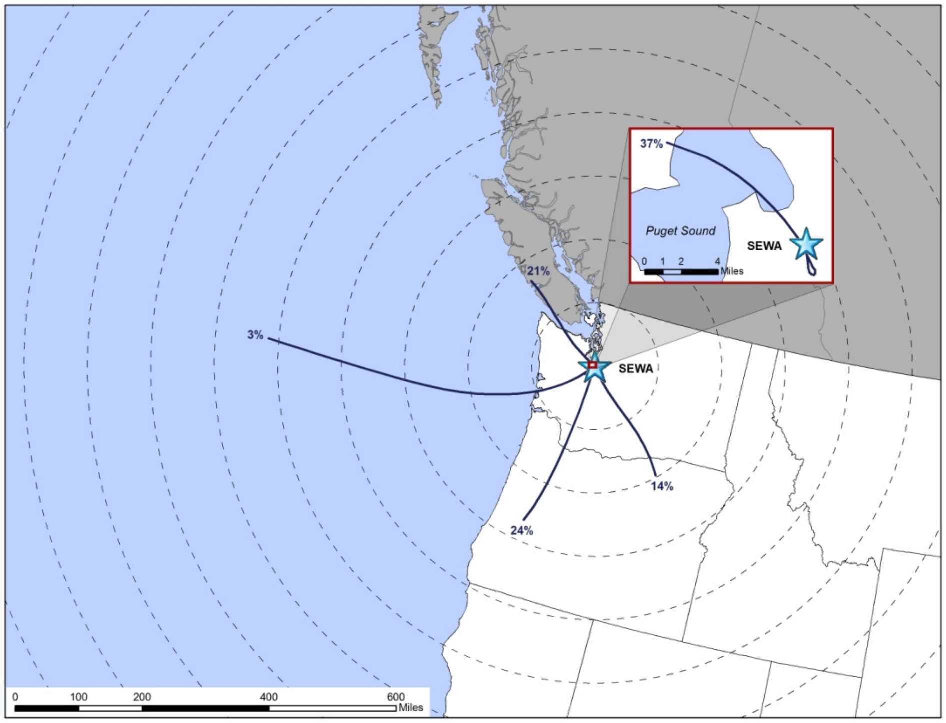


Figure 28-4. Back Trajectory Cluster Map for SEWA



Observations from Figures 28-3 and 28-4 for SEWA include the following:

- Back trajectories originated from a variety of directions from SEWA, although less frequently from the northeast quadrant. The longest back trajectories originated offshore.

- The 24-hour air shed domain for SEWA is smaller in size compared to many other NMP sites. Although the longest trajectory originated 800 miles away over the Pacific Ocean, the average back trajectory length was less than 200 miles long and nearly 85 percent of trajectories originated within 300 miles of the site.

- The cluster analysis shows that 37 percent of back trajectories are represented by the short cluster trajectory originating over the Puget Sound (and presented in the insert map in Figure 28-4). This cluster trajectory includes back trajectories originating from nearly any direction and generally less than 100 miles from the monitoring site. Twenty-one percent of back trajectories originated over northwest Washington, Vancouver Island, and the adjacent waters. Three percent of back trajectories originated well offshore and over the Pacific Ocean. Nearly one-quarter of back trajectories originated over southwest Washington and the western half of Oregon. Another 14 percent of back trajectories originated primarily over southeast Washington and northeast Oregon.

28.2.4 Wind Rose Comparison

Hourly surface wind data from the weather station at Boeing Field/King County International Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

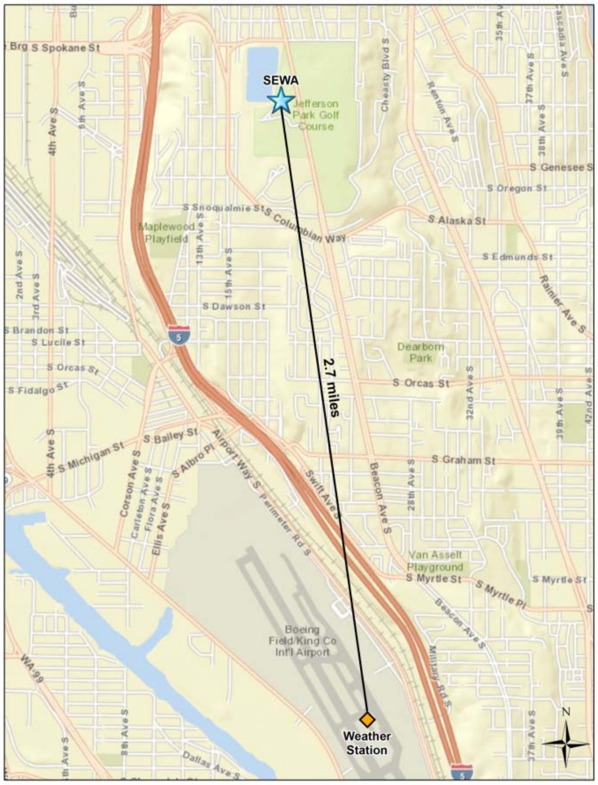
Figure 28-5 presents a map showing the distance between the weather station and SEWA, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 28-5 also presents three different wind roses for the SEWA monitoring site. First, a historical wind rose representing 2002 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind data for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 28-5 for SEWA include the following:

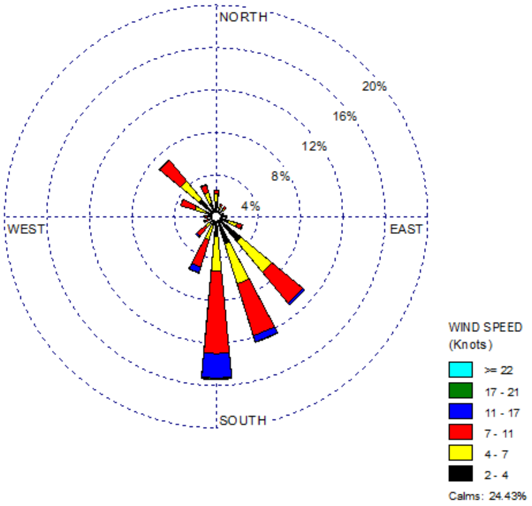
- The Boeing Field/King County Airport weather station is located 2.7 miles south of SEWA.
- The historical wind rose shows that southeasterly, south-southeasterly, and southerly winds were frequently observed, accounting for nearly 40 percent of observations. Calm winds (≤ 2 knots) accounted for 24 percent of wind observations near SEWA.
- The wind patterns shown on the 2012 wind rose are similar to the historical wind patterns, although the percentage of calm winds is slightly higher (nearly 28 percent) and the percentage of south-southeasterly winds is slightly lower in 2012.
- The wind patterns shown on the sample day wind rose resemble the 2012 wind patterns, indicating that conditions on sample days were representative of those experienced over the entire year (and historically).

Figure 28-5. Wind Roses for the Boeing Field/King County International Airport Weather Station near SEWA

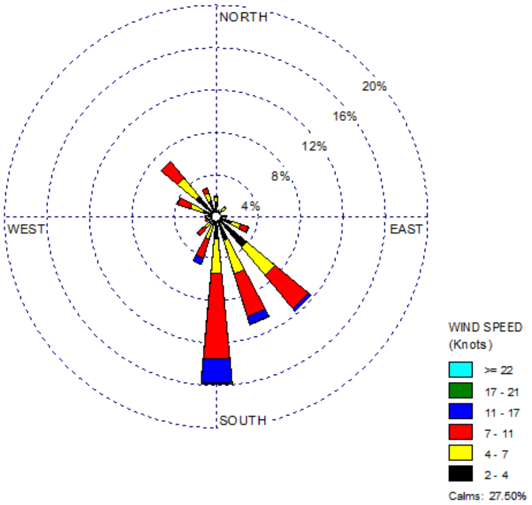
Location of SEWA and Weather Station



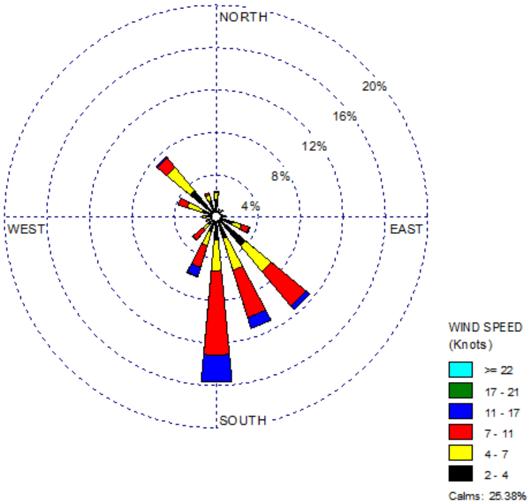
2002-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose



28.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for SEWA in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 28-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 28-4. It is important to note which pollutants were sampled for at the site when reviewing the results of this analysis. SEWA sampled for PM_{10} metals, VOCs, PAHs, carbonyl compounds, and hexavalent chromium.

Table 28-4. Risk-Based Screening Results for the Washington Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Seattle, Washington - SEWA						
Benzene	0.13	60	60	100.00	11.72	11.72
Carbon Tetrachloride	0.17	60	60	100.00	11.72	23.44
Formaldehyde	0.077	60	60	100.00	11.72	35.16
1,2-Dichloroethane	0.038	57	57	100.00	11.13	46.29
Arsenic (PM_{10})	0.00023	56	59	94.92	10.94	57.23
1,3-Butadiene	0.03	55	58	94.83	10.74	67.97
Naphthalene	0.029	53	59	89.83	10.35	78.32
Acetaldehyde	0.45	43	60	71.67	8.40	86.72
Manganese (PM_{10})	0.005	29	59	49.15	5.66	92.38
Nickel (PM_{10})	0.0021	22	59	37.29	4.30	96.68
Ethylbenzene	0.4	8	60	13.33	1.56	98.24
Acenaphthene	0.011	3	58	5.17	0.59	98.83
Hexavalent Chromium	0.000083	3	53	5.66	0.59	99.41
Fluorene	0.011	2	59	3.39	0.39	99.80
Lead (PM_{10})	0.015	1	59	1.69	0.20	100.00
Total		512	880	58.18		

Observations from Table 28-4 for SEWA include the following:

- Fifteen pollutants failed at least one screen for SEWA; 58 percent of concentrations for these 15 pollutants were greater than their associated risk screening value (or failed screens).

- Ten pollutants contributed to 95 percent of failed screens for SEWA and therefore were identified as pollutants of interest for the site. These 10 include two carbonyl compounds, four VOCs, three PM_{10} metals, and one PAH.

- Benzene, carbon tetrachloride, and formaldehyde were detected in every valid sample collected at SEWA and failed 100 percent of screens. 1,2-Dichloroethane also failed 100 percent of screens for SEWA, but was not detected in every sample collected.

28.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Washington monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for the site.
- Annual concentration averages are presented graphically for the site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at the site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for SEWA are provided in Appendices J, L, M, N, and O.

28.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for SEWA, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for the Washington monitoring site are presented in Table 28-5, where applicable. Note that concentrations of the PAHs and PM_{10} metals are presented in ng/m^3 for ease of viewing. Also note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 28-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Washington Monitoring Site

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Seattle, Washington - SEWA						
Acetaldehyde	60/60	0.63 ± 0.19	0.52 ± 0.10	1.15 ± 0.30	0.62 ± 0.14	0.74 ± 0.12
Benzene	60/60	0.75 ± 0.18	0.45 ± 0.07	0.53 ± 0.16	0.64 ± 0.10	0.59 ± 0.07
1,3-Butadiene	58/60	0.09 ± 0.03	0.05 ± 0.01	0.09 ± 0.04	0.10 ± 0.03	0.08 ± 0.02
Carbon Tetrachloride	60/60	0.68 ± 0.06	0.71 ± 0.02	0.68 ± 0.03	0.73 ± 0.04	0.70 ± 0.02
1,2-Dichloroethane	57/60	0.08 ± 0.01	0.08 ± <0.01	0.05 ± 0.01	0.07 ± <0.0.1	0.07 ± <0.01
Formaldehyde	60/60	0.47 ± 0.23	0.37 ± 0.09	0.83 ± 0.27	0.44 ± 0.10	0.53 ± 0.10
Arsenic (PM_{10})[a]	59/59	0.65 ± 0.30	0.61 ± 0.19	0.78 ± 0.20	0.67 ± 0.27	0.68 ± 0.11
Manganese (PM_{10})[a]	59/59	8.20 ± 4.14	9.95 ± 5.99	14.13 ± 6.76	6.43 ± 5.87	9.80 ± 2.88
Naphthalene[a]	59/59	72.97 ± 24.56	52.01 ± 14.50	93.82 ± 28.34	61.39 ± 13.01	70.87 ± 10.90
Nickel (PM_{10})[a]	59/59	2.22 ± 1.31	2.29 ± 0.91	5.14 ± 1.84	1.08 ± 0.30	2.74 ± 0.71

[a] Average concentrations provided for the pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Observations from Table 28-5 include the following:

- The annual average concentrations for all of SEWA's pollutants of interest are less than 1.0 $\mu g/m^3$. The pollutants with the highest annual average concentrations are acetaldehyde (0.74 ± 0.12 $\mu g/m^3$), carbon tetrachloride (0.70 ± 0.02 $\mu g/m^3$), benzene (0.59 ± 0.07 $\mu g/m^3$), and formaldehyde (0.53 ± 0.10 $\mu g/m^3$).

- Even though acetaldehyde has the highest annual average concentration among SEWA's pollutants of interest, this annual average is one of the lowest among other NMP sites sampling carbonyl compounds. SEWA's annual average concentration of formaldehyde is the lowest among all NMP sites. No other NMP site has an annual average concentration of formaldehyde less than 1 $\mu g/m^3$. Similar observations were made in previous NMP reports.

- The third quarter average acetaldehyde concentration is significantly higher than the other quarterly average concentrations and has a larger confidence interval. Of the 10 concentrations of acetaldehyde greater than 1 $\mu g/m^3$ measured at SEWA, seven were collected in the third quarter of 2012, including the maximum concentration of 3.12 $\mu g/m^3$, which was measured on September 18, 2012.

- The maximum formaldehyde concentration was also measured on September 18th (2.67 µg/m^3). The second highest formaldehyde concentration was measured in January (1.76 µg/m^3). The only other formaldehyde concentration greater than 1 µg/m^3 was measured in August. The remaining 60 concentrations are less than 1 µg/m^3 and have a median concentration of 0.41 µg/m^3. This explains the large confidence intervals associated with the first and third quarter averages of formaldehyde.

- The maximum benzene concentration was also measured at SEWA on September 18th (1.47 µg/m^3). Six measurements of benzene greater than 1 µg/m^3 were measured at SEWA (one in January, two in February, two in September, and one in October).

- Of the metal pollutants of interest for SEWA, manganese has the highest annual average concentration (9.80 ± 2.88 ng/m^3), followed by nickel (2.74 ± 0.71 ng/m^3) and arsenic (0.68 ± 0.11 ng/m^3).

- The third quarter average concentration of manganese is higher than the other quarterly averages, although all of the quarterly averages have relatively large confidence intervals. This indicates a relatively high level of variability in the measurements. Concentrations of manganese range from 0.767 ng/m^3 to 45.0 ng/m^3, with a median concentration of 4.91 ng/m^3. The maximum concentration of manganese was measured on October 18, 2012, although concentrations of similar magnitude were also measured on September 8th and September 18th (the same day the maximum concentrations of acetaldehyde, formaldehyde, and benzene were measured).

- The highest concentration of arsenic was also measured on October 18, 2012 (2.02 ng/m^3). This is the only arsenic measurement greater than 2 ng/m^3 measured at SEWA. Ten additional arsenic concentrations greater than 1 ng/m^3 were measured at SEWA and are spread across the calendar quarters (two each in the first and second quarter, four in the third quarter, and three in the fourth quarter).

- The third quarter average concentration of nickel is more than twice the other quarterly averages and has a larger confidence intervals associated with it (although the first and second quarterly averages also have relatively large confidence intervals). A review of the data shows that concentrations of nickel range from 0.495 ng/m^3 to 14.3 ng/m^3. The maximum concentration of nickel was measured on September 18, 2012, the same day as several of SEWA's other pollutants of interest and is the second highest nickel concentration measured among NMP sites sampling this pollutant. Of the 25 nickel concentrations greater than 5 ng/m^3 measured across the program, eight were measured at SEWA (which is the highest for any single site). Of the 20 concentrations greater than 3 ng/m^3 measured at SEWA, three were measured during the first quarter of 2012, five in the second quarter, 12 in the third quarter, and none in the fourth quarter. This explains why the fourth quarter average concentration is less than the other averages.

- The third quarter average concentration of naphthalene is greater than the other quarterly averages and has a large confidence interval associated with it. A review of the data shows that naphthalene concentrations measured at SEWA range from 17.1 g/m^3 to 234 ng/m^3, with a median concentration of 61.8 ng/m^3. The maximum concentration of naphthalene was also measured on September 18, 2012. Two additional concentrations greater than 150 ng/m^3 were measured in August and September.

Tables 4-9 through 4-12 present the sites with the 10 highest annual average concentrations for each of the program-level pollutants of interest. Observations for SEWA from those tables include the following:

- SEWA only appears in Table 4-9 for VOCs once; SEWA has the third highest annual average concentration of carbon tetrachloride among sites sampling VOCs. Note, however, that concentrations of carbon tetrachloride in Table 4-9 span only 0.03 µg/m^3.

- SEWA does not appear in Table 4-10 for carbonyl compounds or Table 4-11 for PAHs.

- As shown in Table 4-12, SEWA has the second highest annual average concentration of nickel among all sites sampling metals (PM_{10} and TSP), behind only ASKY-M. SEWA had the highest annual average nickel concentration for the 2010 and 2011 NMP reports.

- SEWA also has the fourth highest concentrations of manganese and ranks eighth highest for arsenic.

28.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, box plots were created for the pollutants shaded in gray in Table 28-4 for SEWA. Figures 28-6 through 28-15 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations for each pollutant, as described in Section 3.5.3.1.

Figure 28-6. Program vs. Site-Specific Average Acetaldehyde Concentration

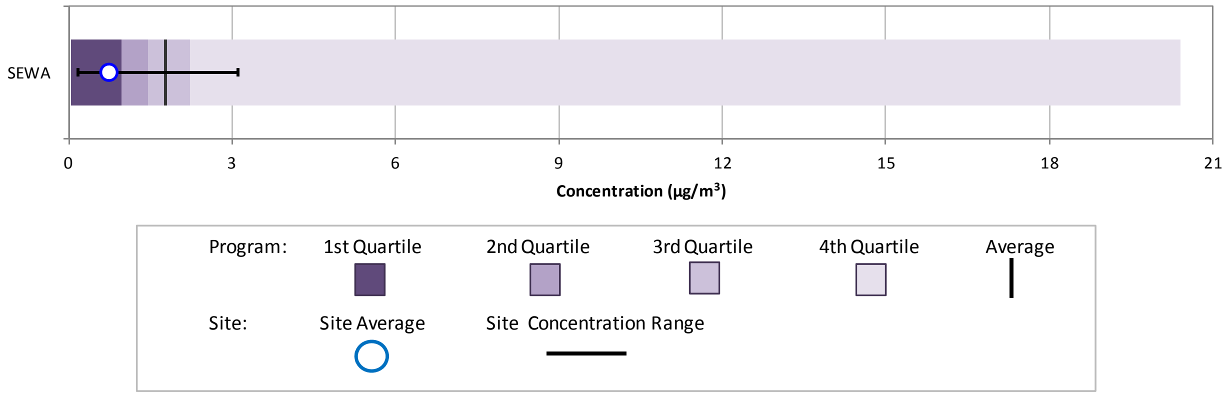


Figure 28-7. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

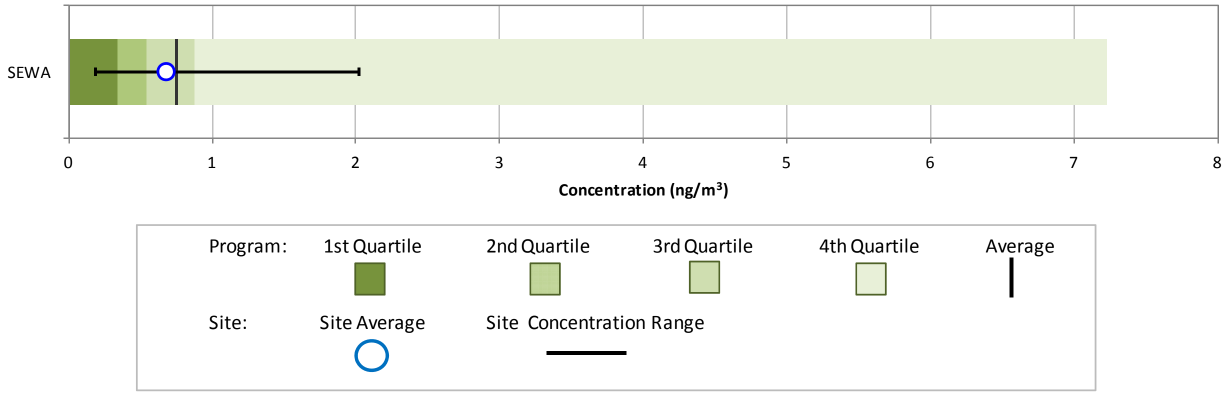


Figure 28-8. Program vs. Site-Specific Average Benzene Concentration

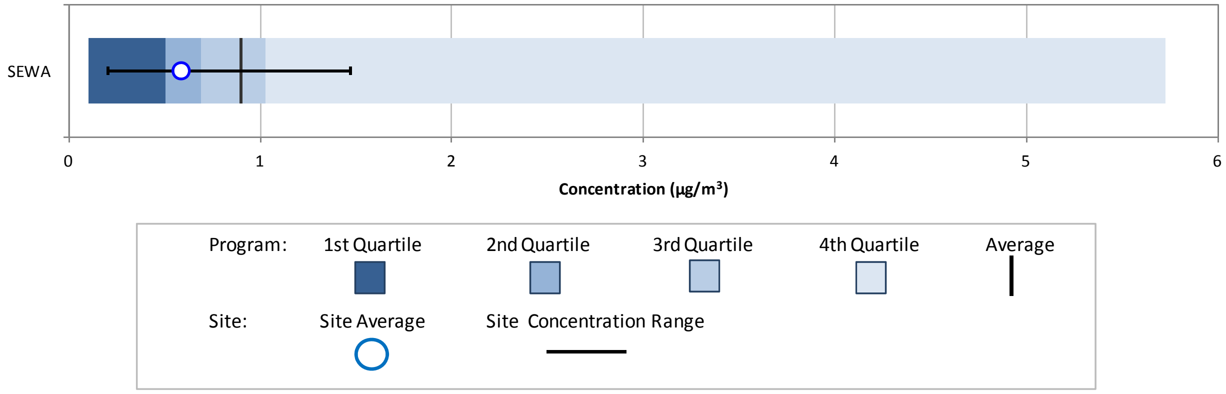


Figure 28-9. Program vs. Site-Specific Average 1,3-Butadiene Concentration

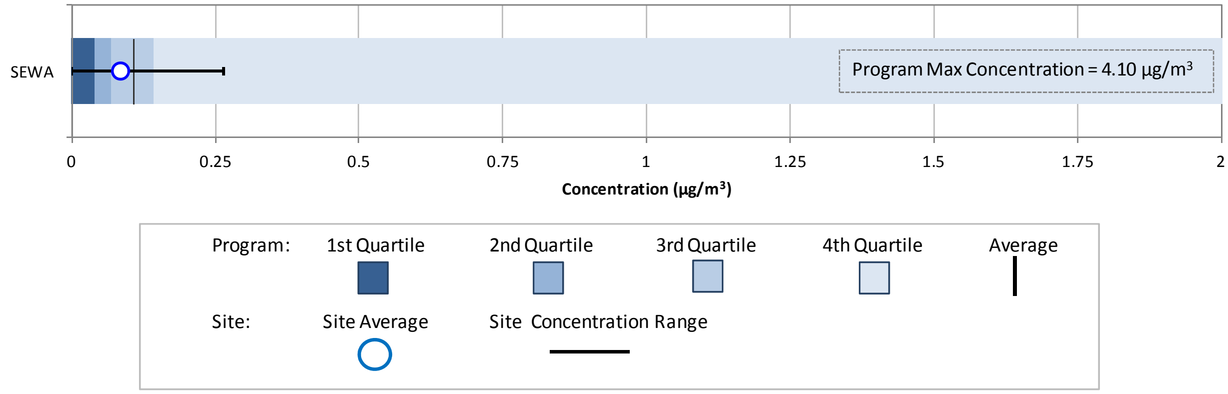


Figure 28-10. Program vs. Site-Specific Average Carbon Tetrachloride Concentration

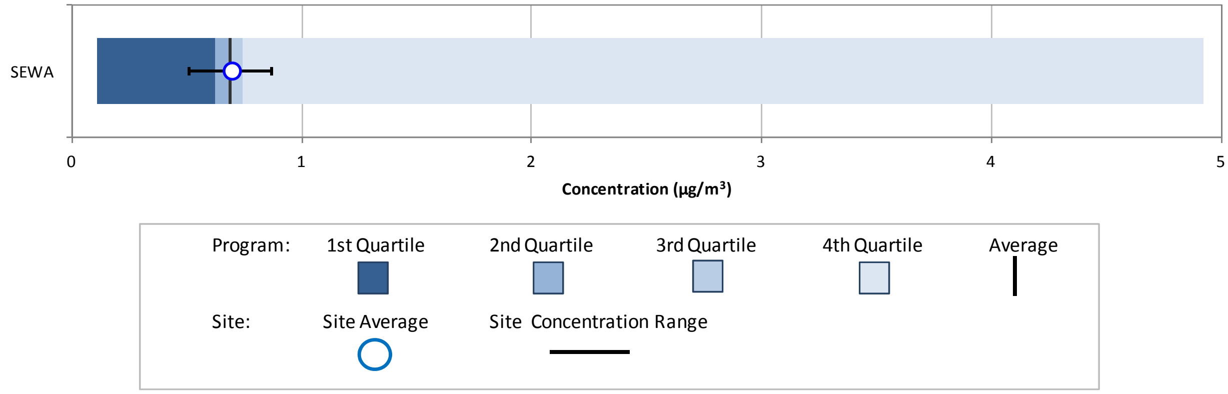


Figure 28-11. Program vs. Site-Specific Average 1,2-Dichloroethane Concentration

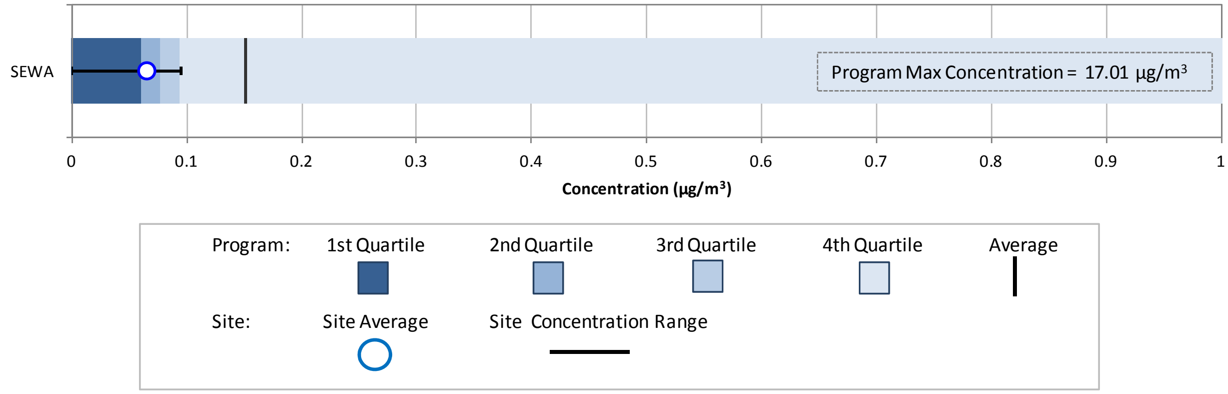


Figure 28-12. Program vs. Site-Specific Average Formaldehyde Concentration

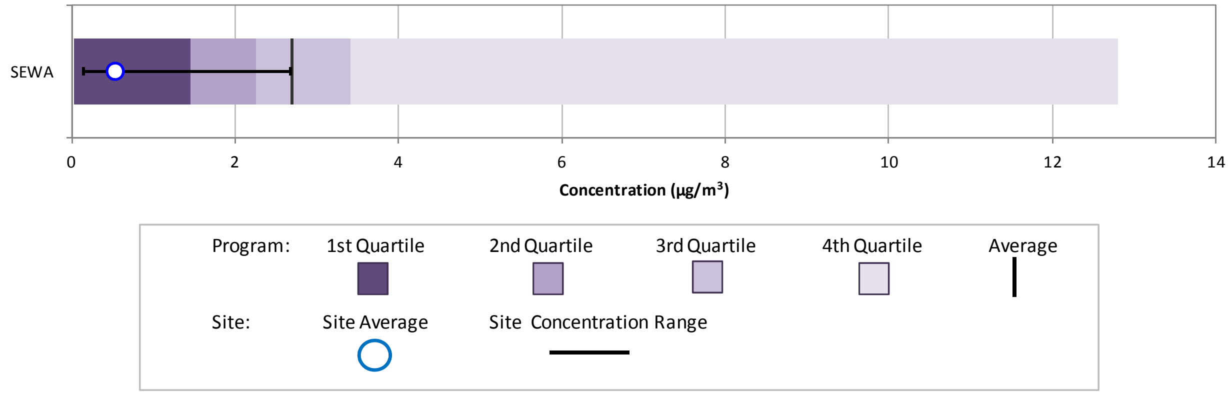


Figure 28-13. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

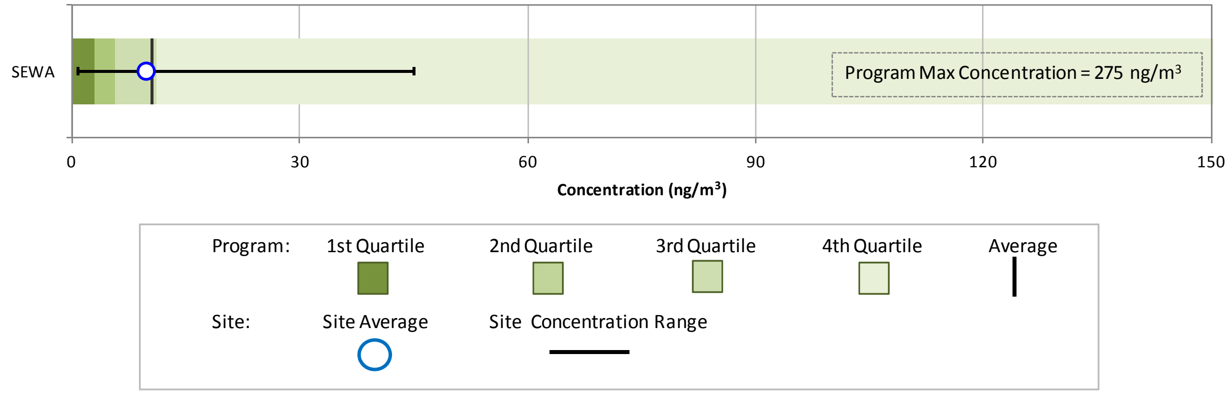


Figure 28-14. Program vs. Site-Specific Average Naphthalene Concentration

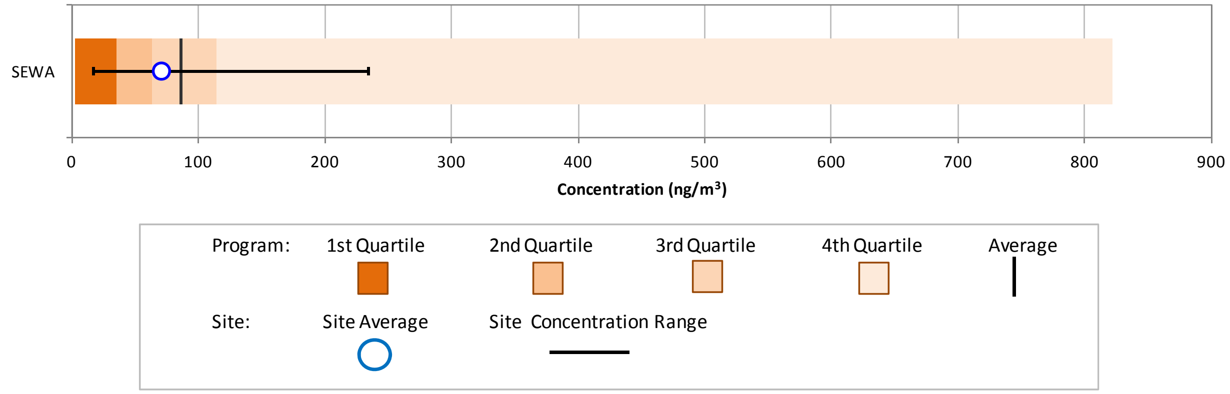
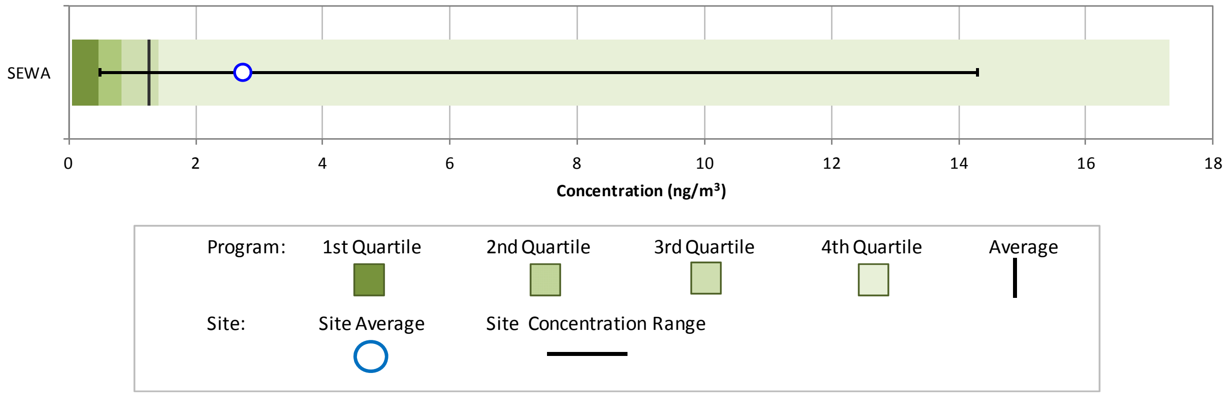


Figure 28-15. Program vs. Site-Specific Average Nickel (PM_{10}) Concentration



Observations from Figures 28-6 through 28-15 include the following:

- Figure 28-6 shows that SEWA’s annual average acetaldehyde concentration is considerably less than the program-level average concentration for acetaldehyde and is actually less than the program-level first quartile (25th percentile). This site has the third lowest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds.

- Figure 28-7 shows that SEWA’s annual average arsenic (PM_{10}) concentration is just less than the program-level average concentration of arsenic (PM_{10}). The maximum arsenic concentration measured at SEWA is considerably less than the maximum concentration measured across the program. There were no non-detects of arsenic measured at SEWA, although there were a few measured across the program.

- Figure 28-8 shows that the annual average benzene concentration for SEWA is less than the program-level average concentration as well as the program-level median concentration. SEWA’s annual average benzene concentration is the third lowest annual average among sites sampling benzene. The maximum benzene concentration measured at SEWA is considerably less than the maximum benzene concentration measured across the program.

- Figure 28-9 is the box plot for 1,3-butadiene. Note that the program-level maximum concentration (4.10 $\mu g/m^3$) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale of the box plot has been reduced to 2 $\mu g/m^3$. This figure shows that the annual average 1,3-butadiene concentration for SEWA is less than the program-level average concentration but greater than the program-level median concentration, although the difference between the average and median concentrations is less than 0.04 $\mu g/m^3$. Figure 28-9 also shows that the maximum 1,3-butadiene concentration measured at SEWA is considerably less than the maximum concentration measured across the program. Two non-detects of 1,3-butadiene were measured at SEWA.

- Figure 28-10 for carbon tetrachloride shows that the range of concentrations measured at SEWA for this pollutant is relatively small. The annual average concentration of carbon tetrachloride for SEWA is similar to the program-level average and median concentrations (less than 0.012 $\mu g/m^3$ separates these three values).

- Figure 28-11 is the box plot for 1,2-dichloroethane. Note that the program-level maximum concentration (17.01 $\mu g/m^3$) is not shown directly on the box plot as the scale has been reduced to 1 $\mu g/m^3$ in order to allow for the observation of data points at the lower end of the concentration range. The program-level average concentration is greater than the program third quartile for this pollutant and is greater than or similar to the maximum concentration measured at most sites sampling 1,2-dichloroethane. This is because the program-level average is being driven by the higher measurements collected at a few monitoring sites. Figure 28-11 shows that the maximum 1,2-dichloroethane concentration measured at SEWA is similar to the program-level third quartile. The annual average for SEWA is just less than the program-level median concentration but greater than the first quartile. Three non-detects of 1,2-dichloroethane were measured at SEWA.

- Figure 28-12 shows that SEWA's annual average formaldehyde concentration is less than the program-level first quartile, similar to acetaldehyde. The entire range of formaldehyde concentrations measured at SEWA is less than the program-level average concentration. As previously discussed, SEWA has the lowest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds.

- Figure 28-13 is the box plot for manganese. The program-level maximum concentration (275 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 150 $\mu g/m^3$ in order to allow for the observation of data points at the lower end of the concentration range. This figure shows that the annual average concentration of manganese (PM_{10}) for SEWA is just less than the program-level average concentration. The maximum manganese concentration measured at SEWA is considerably less than the maximum concentration measured across the program. There were no non-detects of manganese measured at SEWA.

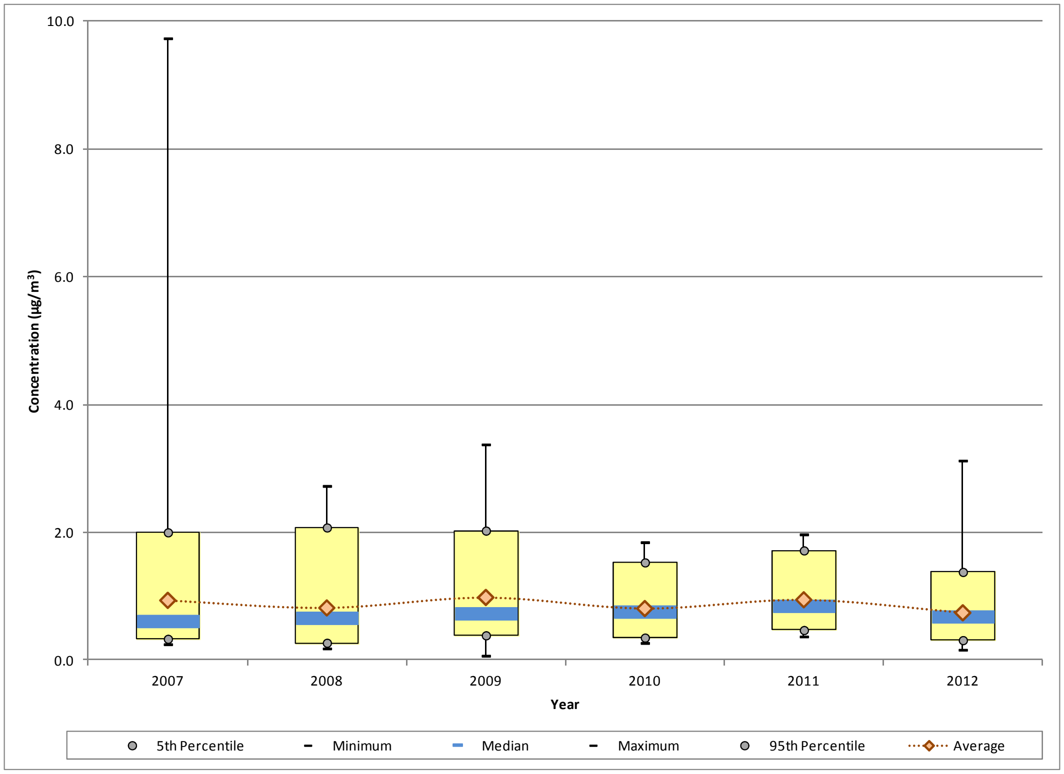
- Figure 28-14 shows that the annual average concentration of naphthalene for SEWA is less than the program-level average concentration. The maximum naphthalene concentration measured at SEWA is considerably less than the program-level maximum concentration. There were no non-detects of naphthalene measured at SEWA or across the program.

- Figure 28-15 is the box plot for nickel. Although the maximum nickel concentration measured at SEWA is not the maximum concentration measured across the program, it is the second highest concentration program-wide. The minimum concentration of nickel measured at SEWA is greater than the program-level first quartile. SEWA's annual average concentration is the second highest among NMP sites sampling this pollutant and is more than twice the program-level average concentration.

28.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. Sampling for PM_{10} metals, VOCs, and carbonyl compounds under the NMP began in 2007 and sampling for PAHs began in 2008. Thus, Figures 28-16 through 28-25 present the 1-year statistical metrics for each of the pollutants of interest for SEWA. If sampling began mid-year, a minimum of 6 months of sampling is required for inclusion in the trends analysis; in these cases, a 1-year average is not provided, although the range and quartiles are still presented.

Figure 28-16. Yearly Statistical Metrics for Acetaldehyde Concentrations Measured at SEWA



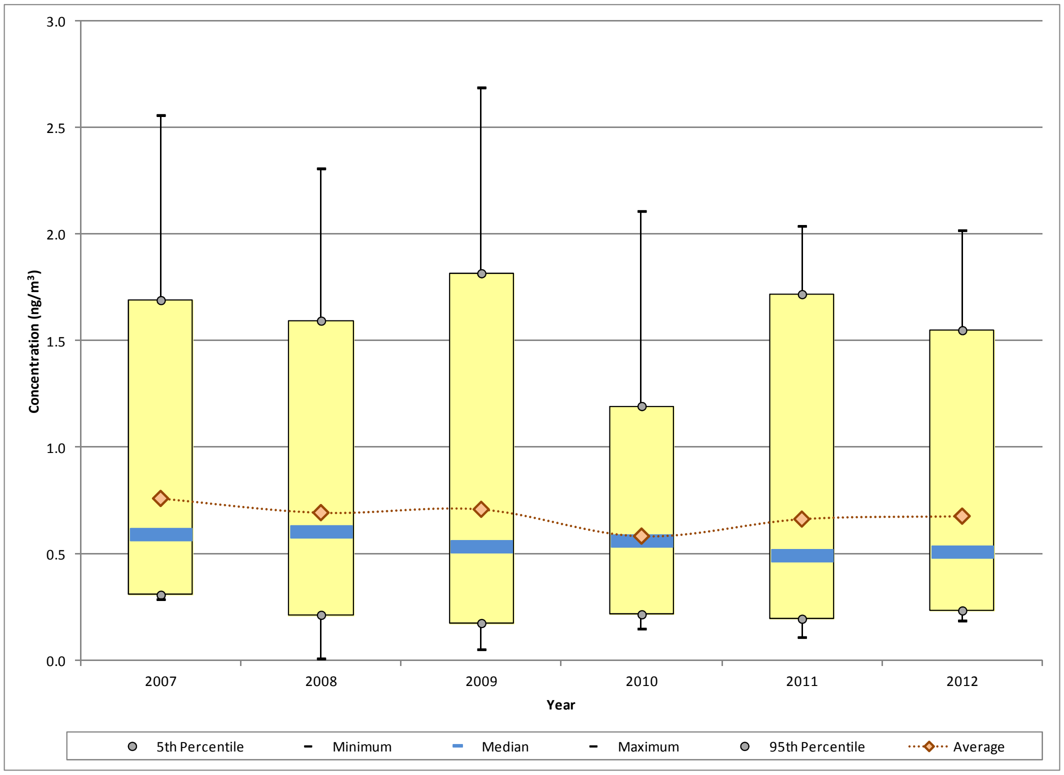
Observations from Figure 28-16 for acetaldehyde measurements collected at SEWA include the following:

- The maximum acetaldehyde concentration was measured at SEWA on July 17, 2007 (9.73 µg/m^3). The next highest concentration was considerably less (3.36 µg/m^3, measured in September 2009). Only one other acetaldehyde concentration greater than 3 µg/m^3 has been measured at SEWA and is the maximum concentration for 2012 measured on September 18th (3.12 µg/m^3).

- Even though the third highest acetaldehyde concentration was measured in 2012, the 1-year average acetaldehyde concentration is at a minimum for 2012 as compared to the other years of sampling. However, the range is rather small, with the 1-year average concentrations ranging from 0.74 µg/m^3 (2012) to 0.98 µg/m^3 (2009). Confidence intervals calculated indicate that the 1-year average concentrations are not statistically different.

- The median concentration exhibits a steady increasing trend for the first 5 years of sampling, ranging from 0.61 µg/m^3 (2007) to 0.85 µg/m^3 (2011). The median then decreased from 2011 to 2012 (0.68 µg/m^3). These changes, though, are also relatively small.

Figure 28-17. Yearly Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at SEWA



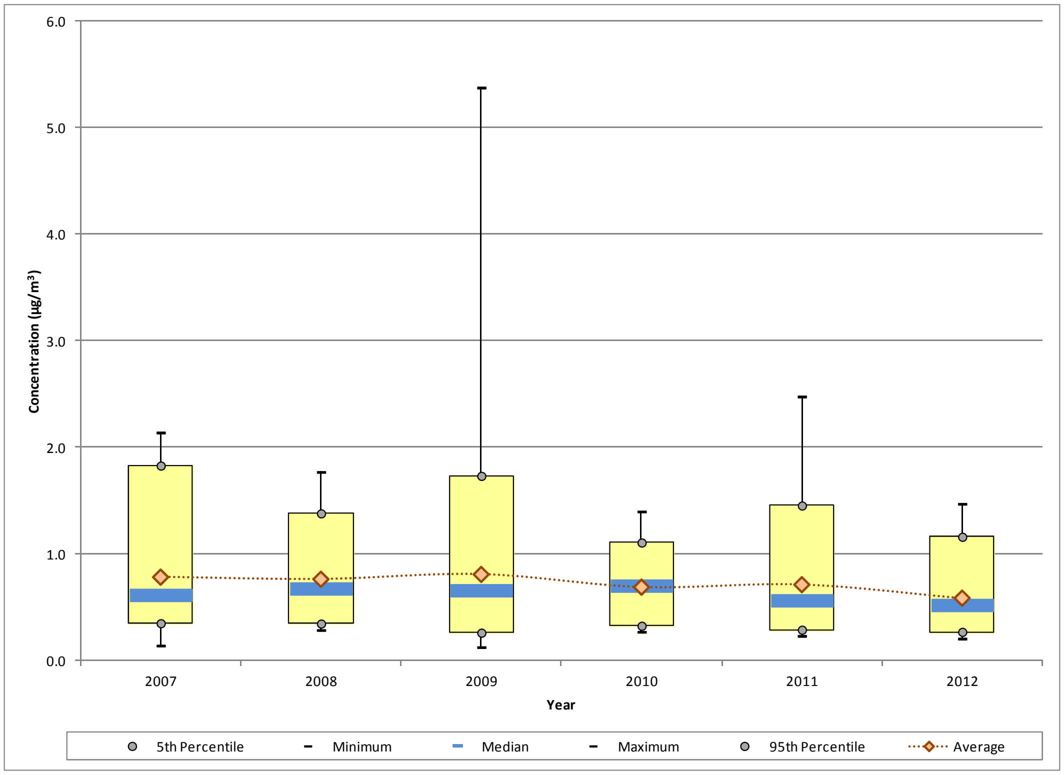
Observations from Figure 28-17 for arsenic (PM_{10}) measurements collected at SEWA include the following:

- The maximum arsenic concentration was measured at SEWA on January 19, 2009 (2.69 ng/m^3), although a similar concentration was also measured in 2007 (2.56 g/m^3).

- The 1-year average concentration fluctuated only slightly between 2007 and 2009, ranging from 0.69 ng/m^3 (2008) to 0.76 µg/m^3 (2007). Although a decrease is shown from 2009 to 2010, confidence intervals indicate that the change is not statistically significant. Nearly all of the statistical parameters for 2011 returned to levels similar to 2010. Little change in the 1-year average concentration is shown for 2012.

- There have been no non-detects of arsenic measured since the onset of sampling, including in 2008, where it appears the minimum concentration is zero. For 2008, the minimum is 0.011 ng/m^3.

Figure 28-18. Yearly Statistical Metrics for Benzene Concentrations Measured at SEWA



Observations from Figure 28-18 for benzene measurements collected at SEWA include the following:

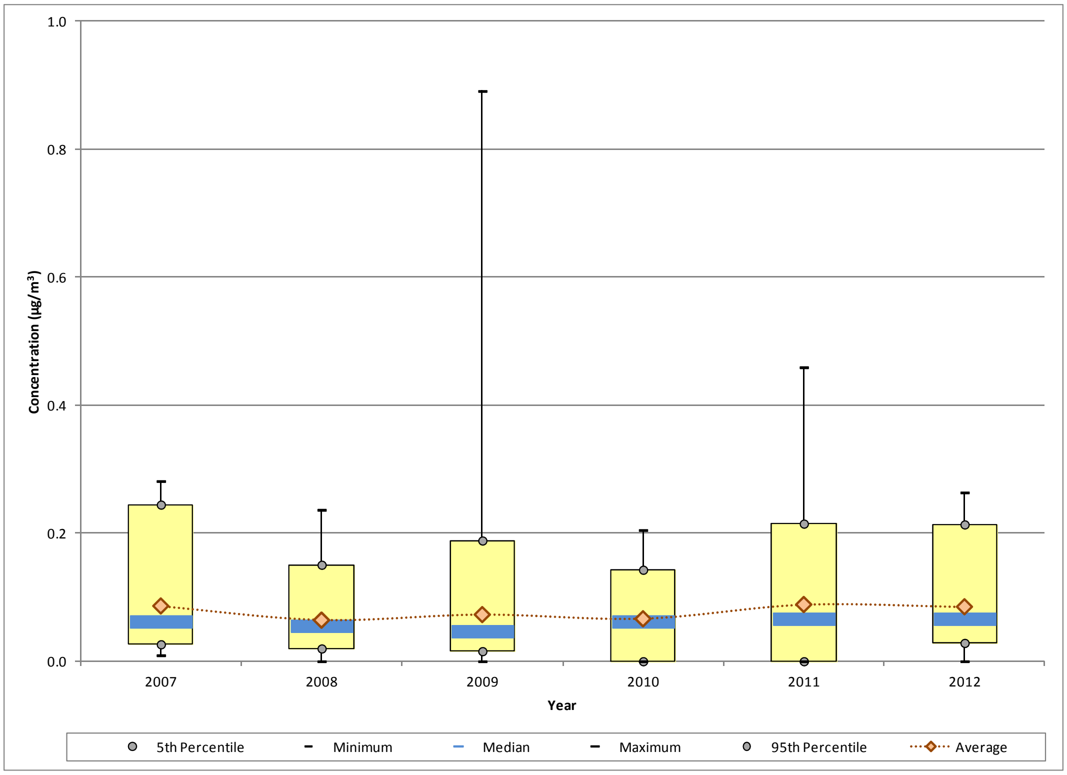
- The maximum benzene concentration was measured at SEWA on January 19, 2009 (5.38 µg/m^3), which is the same day the maximum arsenic concentration was measured. The next highest concentration was roughly half as high (2.48 µg/m^3, measured in January 2011). Only five benzene concentrations greater than 2 µg/m^3 have been measured at SEWA.

- The 1-year average concentration of benzene ranges from 0.59 µg/m^3 (2012) to 0.81 µg/m^3 (2009). If the maximum concentration measured in 2009 was removed from the calculation, the 1-year average concentration for 2009 would fall in line with the others and the averages would exhibit a steady decreasing trend through 2010, albeit very slight.

- The median concentration decreased from 2010 to 2011 because the number of concentrations less than 0.4 µg/m^3 nearly doubled. However, the 1-year average concentration increased because it is being driven by the higher concentrations measured in 2011 (there are five concentrations measured in 2011 greater than the maximum concentration measured in 2010).

- All of the statistical metrics exhibit slight decreases for 2012.

Figure 28-19. Yearly Statistical Metrics for 1,3-Butadiene Concentrations Measured at SEWA



Observations from Figure 28-19 for 1,3-butadiene measurements collected at SEWA include the following:

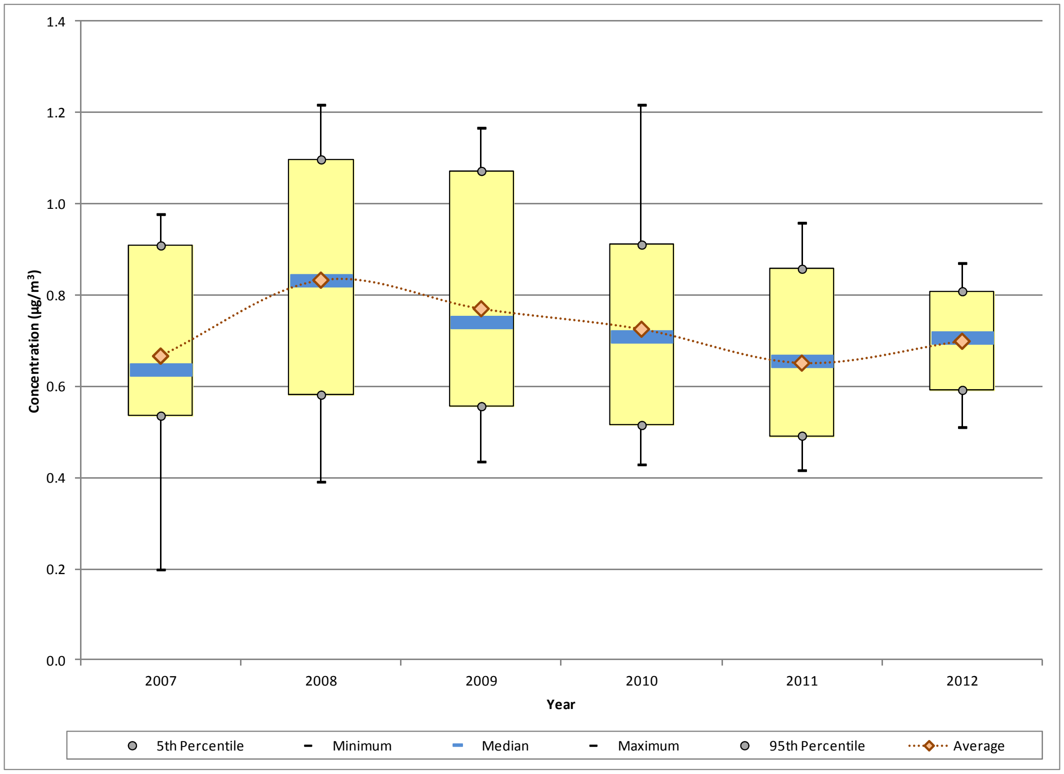
- The maximum 1,3-butadiene concentration (0.89 µg/m^3) was measured at SEWA on the same day as the maximum arsenic and benzene concentrations were measured, January 19, 2009. The next highest concentration was roughly half as high (0.46 µg/m^3) and was measured on the same day in January 2011 as the second highest benzene concentration.

- At least one non-detect has been measured each year at SEWA since the onset of sampling, with the exception of 2007, as indicated by the minimum concentration. For 2010 and 2011, both the minimum and 5th percentile are zero, indicating that the number of non-detects has increased. Ten percent of the measurements were non-detects for 2010, which increased to 15 percent for 2011. The number of non-detects decreased to 3 percent for 2012.

- The 1-year average concentration has changed little over the course of sampling, ranging from 0.064 µg/m^3 (2008) to 0.089 µg/m^3 (2011). Interestingly, the year with the greatest number of non-detects (or zeros) also has the greatest number of measurements greater than 0.2 µg/m^3 (seven).

- Little change is shown in the 1-year average and median concentration from 2011 to 2012. The decrease in the maximum concentration is balanced by the decrease in the number of non-detects.

Figure 28-20. Yearly Statistical Metrics for Carbon Tetrachloride Concentrations Measured at SEWA



Observations from Figure 28-20 for carbon tetrachloride measurements collected at SEWA include the following:

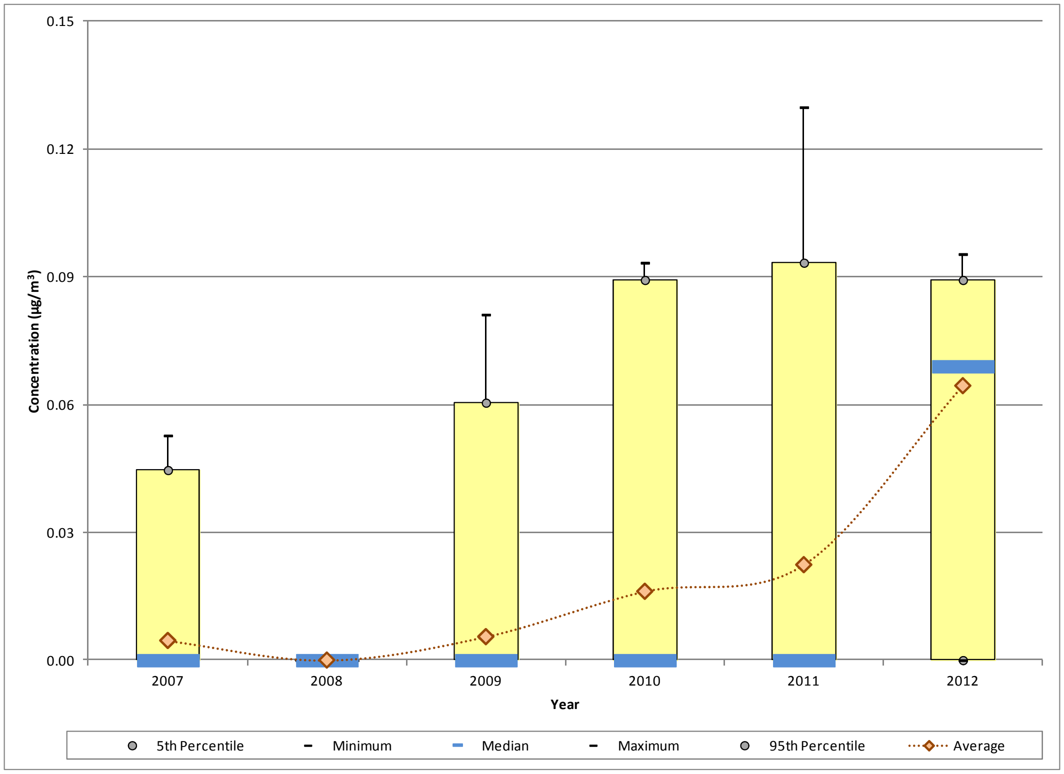
- Eighteen concentrations of carbon tetrachloride greater than 1.0 µg/m^3 have been measured since the onset of sampling in 2007. All but one of these were measured in 2008 and 2009. The maximum carbon tetrachloride concentration (1.22 µg/m^3) has been measured twice at SEWA, once in 2008 and once in 2010.

- All of the statistical metrics increased from 2007 to 2008, particularly the 1-year average concentration. Between 2008 and 2011, a steady decreasing trend in the concentrations is shown.

- The range of measurements compressed somewhat for 2012 and is the smallest range of measurements since the onset of sampling. Yet, both the 1-year average and median concentrations exhibit increases.

- The confidence intervals calculated for each year are very small, indicating that most the concentrations fall within a relatively small range, particularly for 2012. The difference between the median and 1-year average concentration is less than 0.03 µg/m^3 for each year, with one year having no difference. This indicates little variability in the central tendency of this pollutant.

Figure 28-21. Yearly Statistical Metrics for 1,2-Dichloroethane Concentrations Measured at SEWA

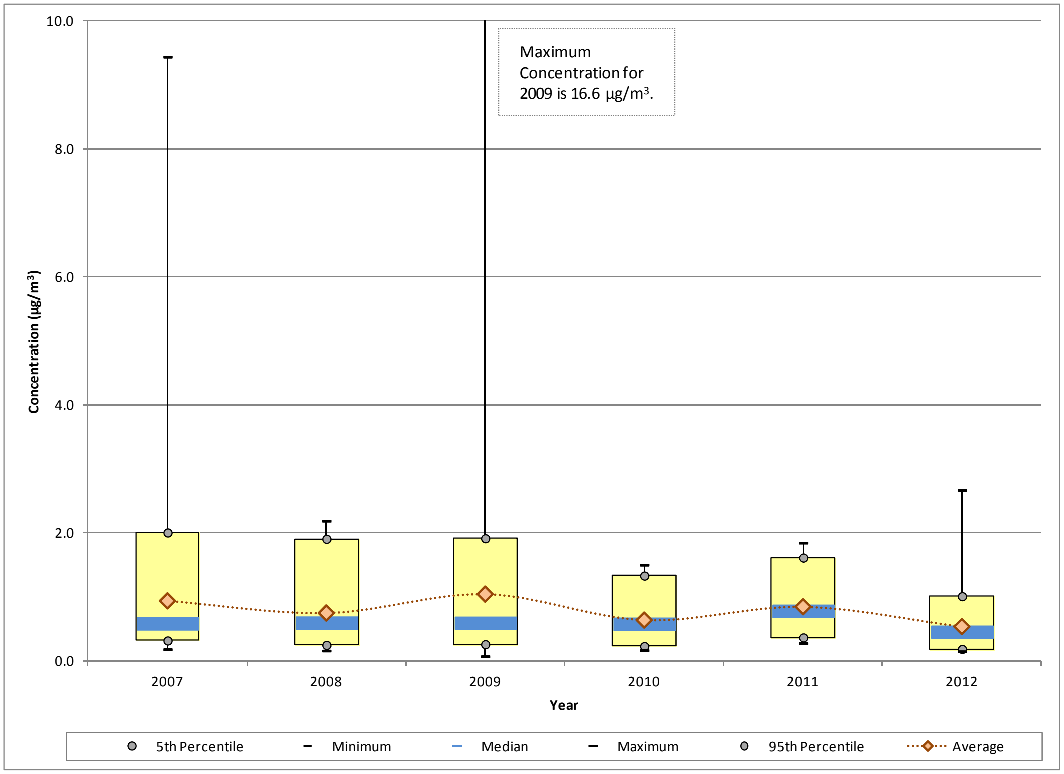


Observations from Figure 28-21 for 1,2-dichloroethane measurements collected at SEWA include the following:

- The minimum, 5th percentile, and median concentrations are zero for 2007 through 2011. This indicates that at least half of the measurements were non-detects. In 2008, there were no measured detections of 1,2-dichloroethane. The percentage of measured detections in 2007 and 2009 was around 10 percent, after which there is an increasing trend. By 2012, the percentage of measured detections is at 93 percent, a significant increase from 26 percent in 2011.

- As the number of measured detections increased, particularly for 2012, the median and 1-year average concentrations increased correspondingly. The median concentration is actually greater than the 1-year average for 2012. This is because there were still 14 non-detects (or zeros) factoring into the 1-year average concentration for 2012, while the range of measured detections is rather small (0.040 µg/m^3 to 0.095 µg/m^3).

Figure 28-22. Yearly Statistical Metrics for Formaldehyde Concentrations Measured at SEWA



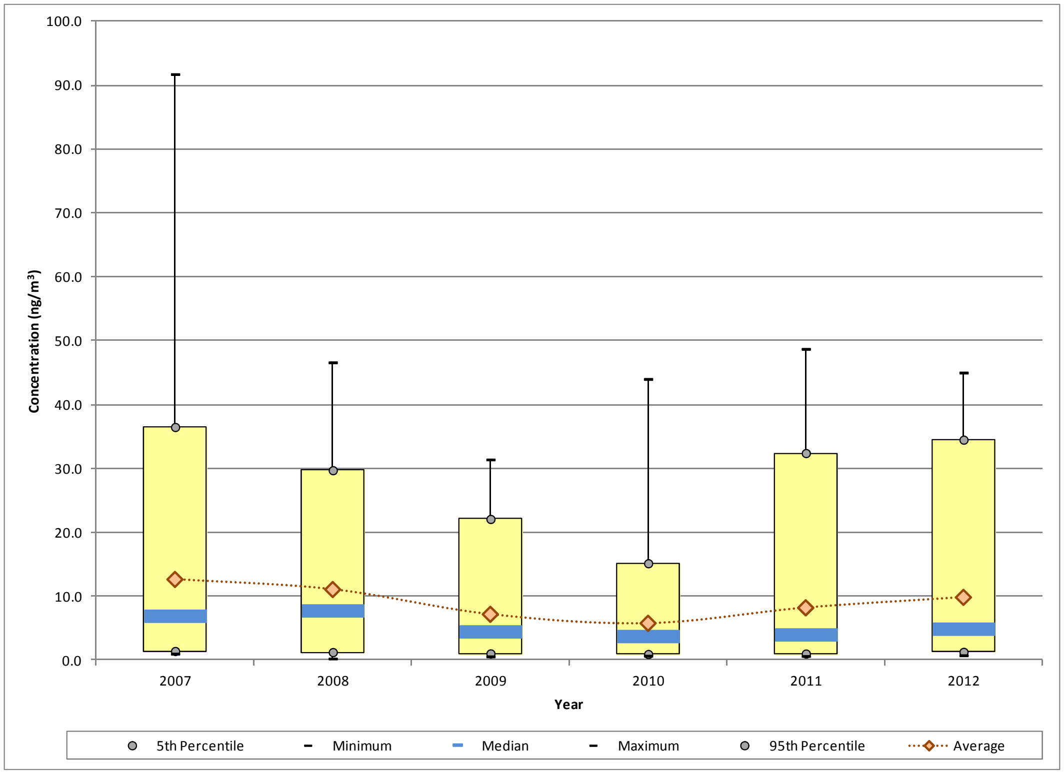
Observations from Figure 28-22 for formaldehyde measurements collected at SEWA include the following:

- The maximum formaldehyde concentration was measured at SEWA on January 13, 2009 (16.6 µg/m^3). The next highest concentration (9.44 µg/m^3) was measured on the same day in 2007 as the maximum acetaldehyde concentration. Only one other formaldehyde concentration greater than 3 µg/m^3 has been measured at SEWA and was also measured in 2009. The fourth highest concentration is the September 18, 2012 measurement (2.67 µg/m^3). A total of nine concentrations greater than 2 µg/m^3 has been measured since the onset of carbonyl compound sampling at SEWA.

- The 1-year average concentrations have an undulating pattern across the period of sampling, with a "down" year followed by an "up" year. The 1-year average formaldehyde concentration has ranged from 0.53 µg/m^3 (2012) to 1.04 µg/m^3 (2009).

- The level of variability in the measurements decreased significantly from 2009 to 2010. The difference between the 1-year average and median concentrations is less than 0.1 µg/m^3 for 2010, 2011, and 2012. Further, the difference between the 5th and 95th percentiles is at a minimum for 2012. Thus, the majority of measurements fell into a smaller range in 2012.

Figure 28-23. Yearly Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at SEWA



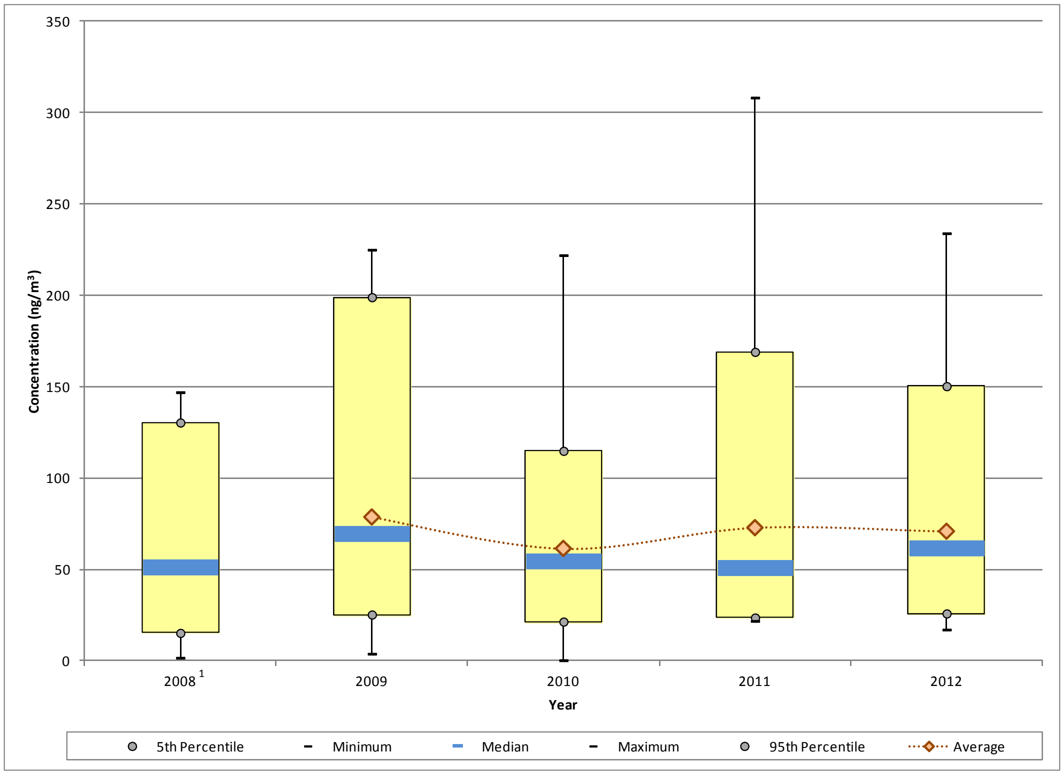
Observations from Figure 28-23 for manganese (PM_{10}) measurements collected at SEWA include the following:

- The three highest manganese concentrations measured at SEWA were all measured in 2007 and are the only three measurements greater than 50 ng/m^3 measured at this site, although the maximum concentrations measured for several years are just less than 50 ng/m^3.

- A steady decreasing trend in the 1-year average manganese concentration is shown through 2010. The 95th percentiles also exhibit this decrease. The maximum and median concentrations exhibit this trend for most years but not throughout the entire 4-year period.

- Most of the statistical metrics increased from 2010 to 2011. Although the 95th percentile more than doubled and the 1-year average increased by 40 percent, the median concentration increased just slightly and the minimum concentration decreased. Additional increases are shown for most of the statistical parameters for 2012.

Figure 28-24. Yearly Statistical Metrics for Naphthalene Concentrations Measured at SEWA



[1] A 1-year average is not presented because sampling under the NMP did not begin until March 2008.

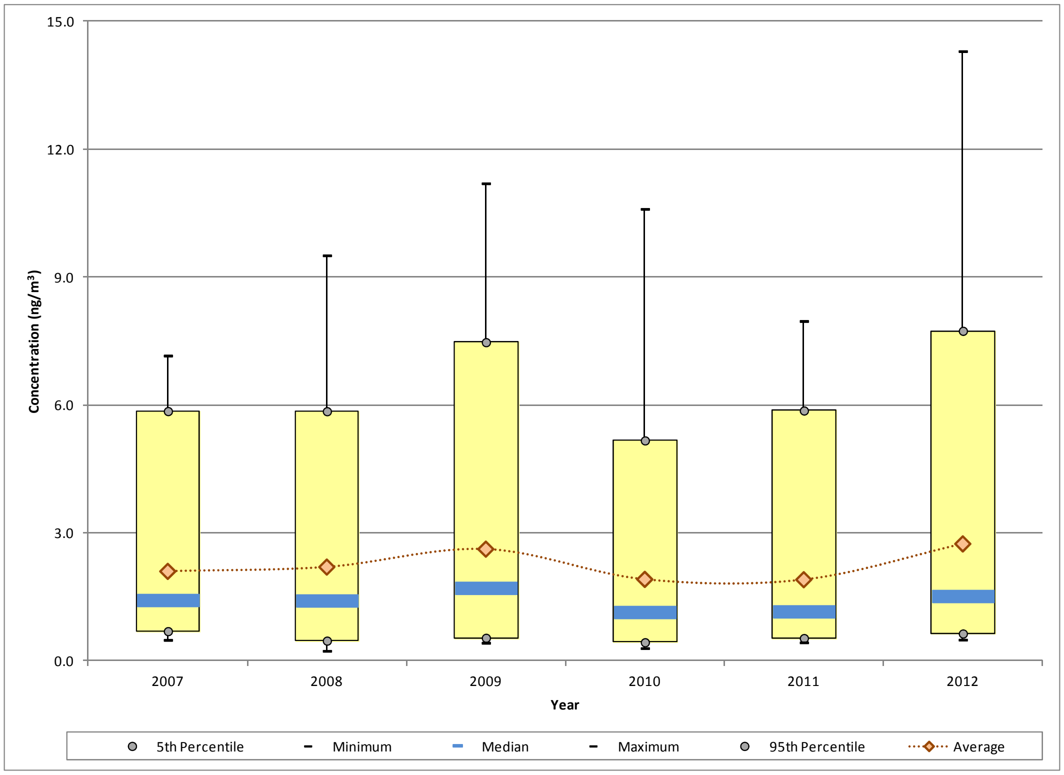
Observations from Figure 28-24 for naphthalene measurements collected at SEWA include the following:

- SEWA began sampling PAHs under the NMP in March 2008. Because a full year's worth of data is not available, a 1-year average is not presented for 2008, although the range of measurements is provided.

- The maximum naphthalene concentration measured at SEWA was measured in 2011 (308 ng/m^3). This is the only measurement greater than 250 ng/m^3 measured at this site. Seven additional measurements greater than 200 ng/m^3 have been measured at SEWA and are spread across the years of sampling, except 2008.

- The 1-year average concentrations of naphthalene have an undulating pattern across the period of sampling, ranging from 61.44 ng/m^3 (2010) to 78.67 ng/m^3 (2009). Little change in the 1-year average concentration is shown from 2011 to 2012.

Figure 28-25. Yearly Statistical Metrics for Nickel (PM_{10}) Concentrations Measured at SEWA



Observations from Figure 28-25 for nickel measurements collected at SEWA include the following:

- The maximum concentration of nickel was measured at SEWA on September 18, 2012. The largest range of measurements was collected during 2012. Further, the range within which the majority of concentrations fall (as determined by the 5th and 95th percentiles) is largest for 2012.

- The maximum and 1-year average concentrations exhibit an increasing trend between 2007 and 2009, after which a decrease in shown for 2010. Although the maximum concentration decreased for 2011, the 95th percentile increased while little change is shown for the 1-year average and median concentrations. All of the statistical metrics exhibit increases for 2012. However, confidence intervals calculated on the dataset indicate that the changes shown are not statistically significant.

- The difference between the 1-year average and median concentrations is greater than 0.65 ng/m^3 for all years and greater than 1.0 ng/m^3 for 2012. This indicates that there is considerable variability in the measurements of nickel.

28.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the Washington monitoring site. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

28.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Washington monitoring site to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

28.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Washington site and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutants of interest. Although the use of these approximations is limited, they may help identify where policy-makers may want to shift their air-monitoring priorities. Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 28-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 28-6. Risk Approximations for the Washington Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Seattle, Washington - SEWA						
Acetaldehyde	0.0000022	0.009	60/60	0.74 ± 0.12	1.63	0.08
Arsenic (PM_{10})[a]	0.0043	0.000015	59/59	<0.01 ± <0.01	2.92	0.05
Benzene	0.0000078	0.03	60/60	0.59 ± 0.07	4.58	0.02
1,3-Butadiene	0.00003	0.002	58/60	0.08 ± 0.02	2.55	0.04
Carbon Tetrachloride	0.000006	0.1	60/60	0.70 ± 0.02	4.19	0.01
1,2-Dichloroethane	0.000026	2.4	57/60	0.07 ± <0.01	1.70	<0.01
Formaldehyde	0.000013	0.0098	60/60	0.53 ± 0.10	6.91	0.05
Manganese (PM_{10}) [a]	--	0.00005	59/59	0.01 ± <0.01	--	0.20
Naphthalene [a]	0.000034	0.003	59/59	0.07 ± 0.01	2.41	0.02
Nickel (PM_{10}) [a]	0.00048	0.00009	59/59	<0.01 ± <0.01	1.31	0.03

-- = A Cancer URE or Noncancer RfC is not available.

[a] For the annual average concentration of this pollutant in ng/m^3, refer to Table 28-5.

Observations from Table 28-6 for SEWA include the following:

- The pollutants with the highest annual average concentrations for SEWA are acetaldehyde, carbon tetrachloride, benzene, and formaldehyde.

- The pollutants with the highest cancer risk approximations are formaldehyde, benzene, carbon tetrachloride, and arsenic. Although the pollutant with the highest cancer risk approximation is formaldehyde, its cancer risk approximation is the lowest among NMP sites sampling carbonyl compounds.

- The noncancer hazard approximations for SEWA are all less than 1.0, with the highest calculated for manganese (0.20), indicating that no adverse health effects are expected from these individual pollutants.

28.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 28-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 28-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 28-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for the site, as presented in Table 28-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 28-7. Table 28-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 28.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Table 28-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Washington Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Seattle, Washington (King County) - SEWA					
Benzene	900.20	Formaldehyde	9.75E-03	Formaldehyde	6.91
Formaldehyde	750.12	Benzene	7.02E-03	Benzene	4.58
Ethylbenzene	465.05	Hexavalent Chromium, PM	4.47E-03	Carbon Tetrachloride	4.19
Acetaldehyde	421.81	1,3-Butadiene	4.16E-03	Arsenic	2.92
1,3-Butadiene	138.68	POM, Group 3	3.86E-03	1,3-Butadiene	2.55
Tetrachloroethylene	95.67	Naphthalene	2.97E-03	Naphthalene	2.41
Naphthalene	87.42	POM, Group 2b	1.48E-03	1,2-Dichloroethane	1.70
POM, Group 2b	16.86	Ethylbenzene	1.16E-03	Acetaldehyde	1.63
POM, Group 2d	11.80	POM, Group 2d	1.04E-03	Nickel	1.31
Trichloroethylene	11.73	Acetaldehyde	9.28E-04		

Table 28-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Washington Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Seattle, Washington (King County) - SEWA					
Toluene	5,086.22	Acrolein	2,427,912.38	Manganese	0.20
Ethylene glycol	2,460.80	Formaldehyde	76,542.48	Acetaldehyde	0.08
Xylenes	1,920.76	1,3-Butadiene	69,341.11	Formaldehyde	0.05
Hexane	1,505.63	Acetaldehyde	46,868.07	Arsenic	0.05
Methanol	1,144.61	Benzene	30,006.57	1,3-Butadiene	0.04
Benzene	900.20	Naphthalene	29,138.59	Nickel	0.03
Formaldehyde	750.12	Xylenes	19,207.63	Naphthalene	0.02
Ethylbenzene	465.05	Lead, PM	16,885.21	Benzene	0.02
Acetaldehyde	421.81	Nickel, PM	12,603.60	Carbon Tetrachloride	0.01
Methyl isobutyl ketone	205.29	Manganese, PM	7,804.03	1,2-Dichloroethane	<0.01

Observations from Table 28-7 for SEWA include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in King County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for King County are formaldehyde, benzene, and hexavalent chromium.

- Eight of the highest emitted pollutants also have the highest toxicity-weighted emissions for King County.

- Formaldehyde and benzene have the highest cancer risk approximations for SEWA. These two pollutants top both emissions-based lists as well. Naphthalene, 1,3-butadiene, and acetaldehyde also appear on all three lists.

- Carbon tetrachloride, arsenic, and nickel, which rank third, fourth, and ninth, respectively, for cancer risk approximations for SEWA, do not appear on either emissions-based list.

- POM, Group 2b is the eighth highest emitted "pollutant" in King County and ranks seventh for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at SEWA including acenaphthene, fluorene, and perylene. POM, Group 2d ranks ninth for total emissions and its toxicity-weighted emissions. POM, Group 2d includes several PAHs sampled for at SEWA including anthracene, phenanthrene, and pyrene. None of the PAHs included in POM, Groups 2b or 2d were identified as pollutants of interest for SEWA, although fluorene and acenapthalene each failed a few screens.

Observations from Table 28-8 for SEWA include the following:

- Toluene, ethylene glycol, and xylenes are the highest emitted pollutants with noncancer RfCs in King County. The emissions of the pollutants with noncancer RfCs are considerably higher than the emissions for the pollutants listed in Table 28-7.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for King County, followed by formaldehyde and 1,3-butadiene. Although acrolein was sampled for at SEWA, this pollutant was excluded from the pollutants of interest designation, and thus subsequent risk-based screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for King County.

- Acetaldehyde, formaldehyde, and benzene appear on all three lists in Table 28-8.

- Manganese, which has the highest noncancer hazard approximation for SEWA, albeit low, does not appear among the highest emitted pollutants but ranks 10th for its toxicity-weighted emissions. Nickel, naphthalene, and 1,3-butadiene also appear among those with the highest toxicity-weighted emissions but are not among the highest emitted in King County (of those with a noncancer RfC).

28.6 Summary of the 2012 Monitoring Data for SEWA

Results from several of the data treatments described in this section include the following:

- *Fifteen pollutants failed at least one screen for SEWA.*

- *Acetaldehyde had the highest annual average concentration for SEWA, although all of the pollutants of interest for SEWA had annual average concentrations less than 1 µg/m^3.*

- *The annual average concentration of nickel for SEWA is the second highest among NMP sites sampling metals. Conversely, the annual average concentration of formaldehyde is the lowest among NMP sites sampling carbonyl compounds.*

- *Concentrations of carbon tetrachloride and manganese exhibited decreasing trends over much of the sampling period, although these trends did not continue into the later years of sampling.*

29.0 Sites in Wisconsin

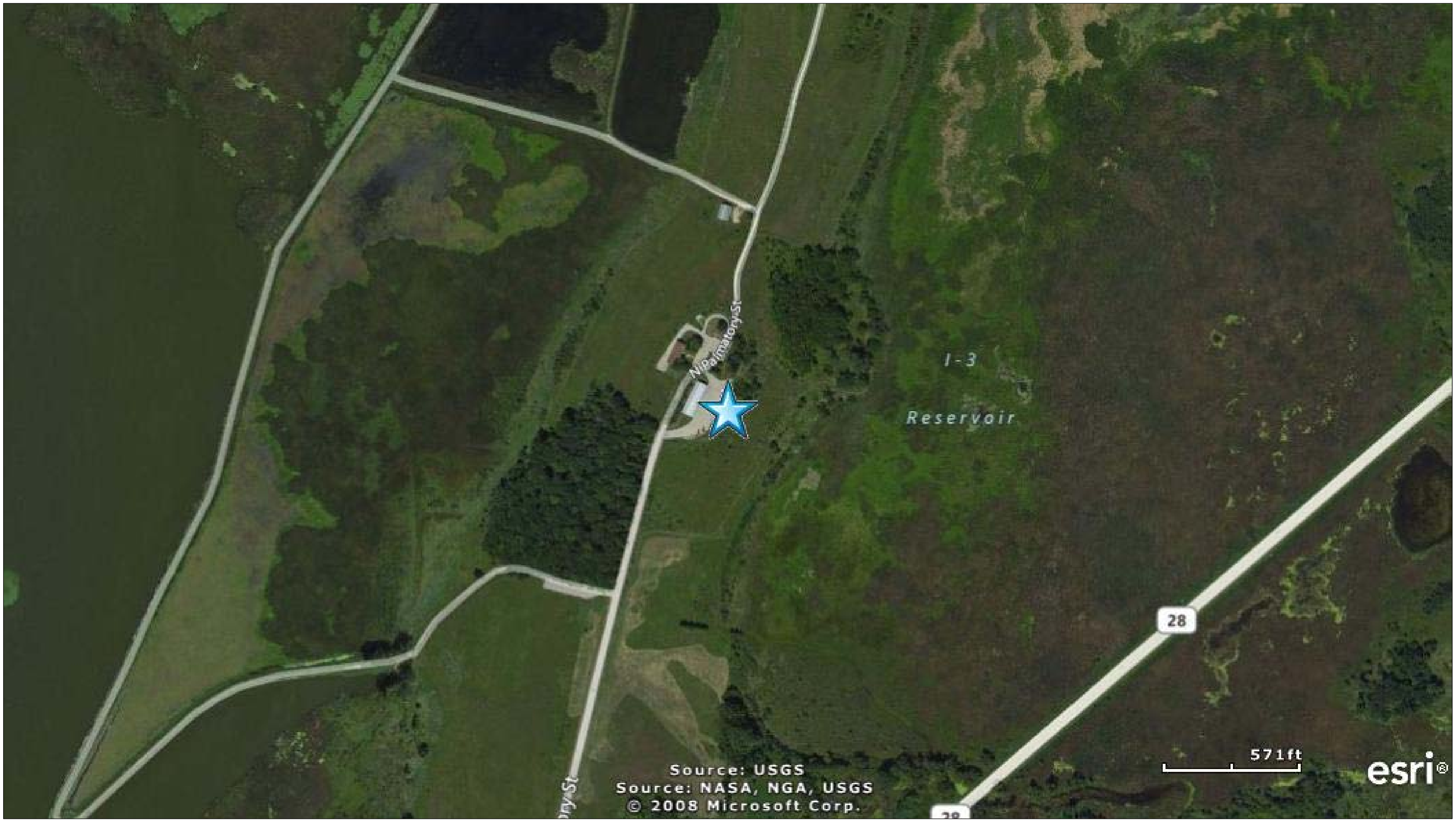
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Wisconsin, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses contained in this report. Readers are encouraged to refer to Sections 1 through 4 and the glossary (Appendix P) for detailed discussions and definitions regarding the various data analyses presented below.

29.1 Site Characterization

This section characterizes the monitoring sites by providing geographical and physical information about the location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

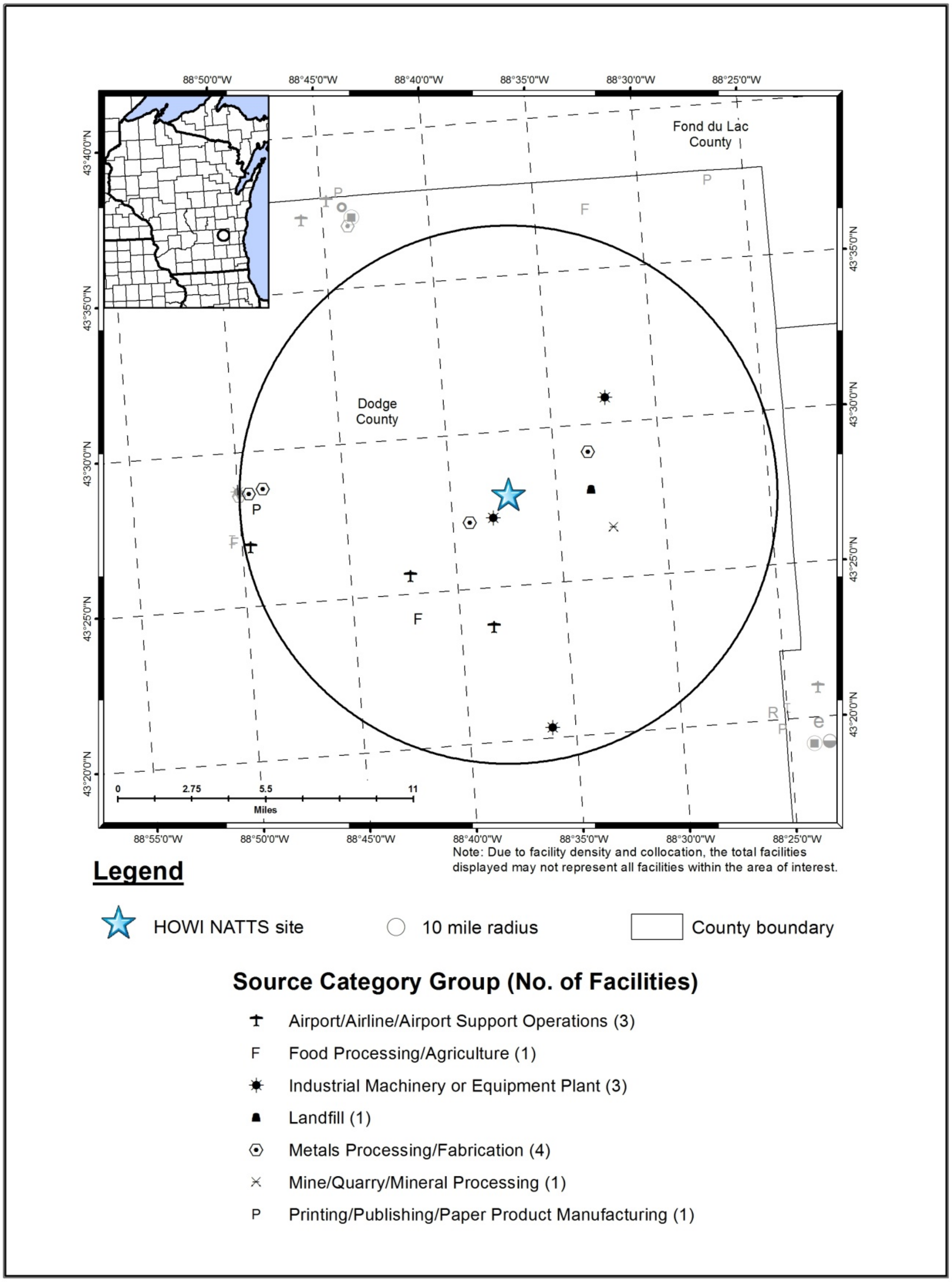
The HOWI site is located in Horicon, Wisconsin and is the relocated Mayville NATTS site. The MIWI site is located in Milwaukee. Figure 29-1 is the composite satellite image retrieved from ArcGIS Explorer showing the monitoring site and its immediate surroundings. Figure 29-2 identifies nearby point source emissions locations by source category, as reported in the 2011 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 29-2. A 10-mile boundary was chosen to give the reader an indication of which emissions sources and emissions source categories could potentially have a direct effect on the air quality at the monitoring site. Further, this boundary provides both the proximity of emissions sources to the monitoring site as well as the quantity of such sources within a given distance of the site. Sources outside the 10-mile radius are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 29-3 and 29-4 are the composite satellite image and point emissions sources map for MIWI. Table 29-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 29-1. Horicon, Wisconsin (HOWI) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 29-2. NEI Point Sources Located Within 10 Miles of HOWI



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 29-3. Milwaukee, Wisconsin (MIWI) Monitoring Site

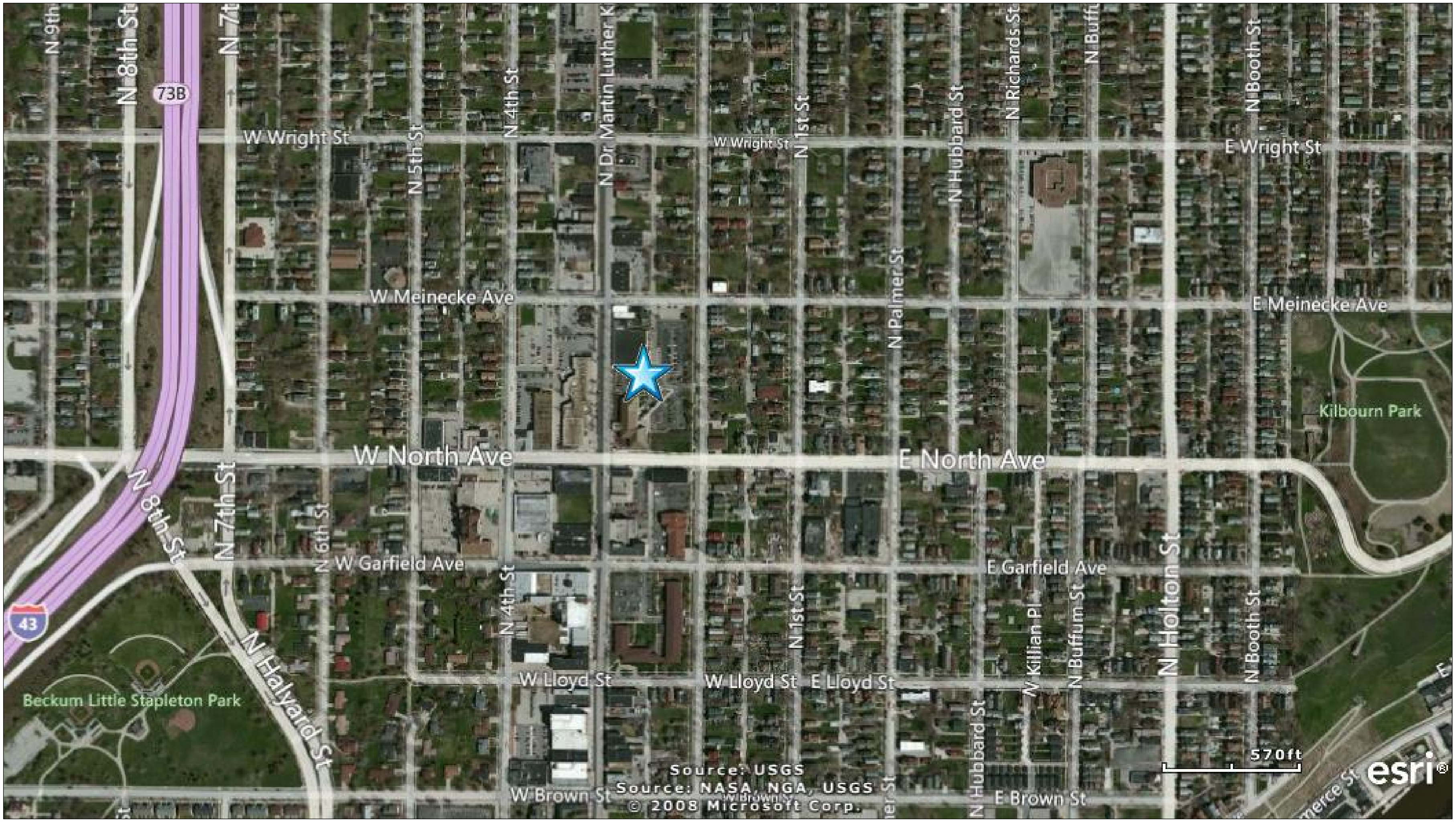
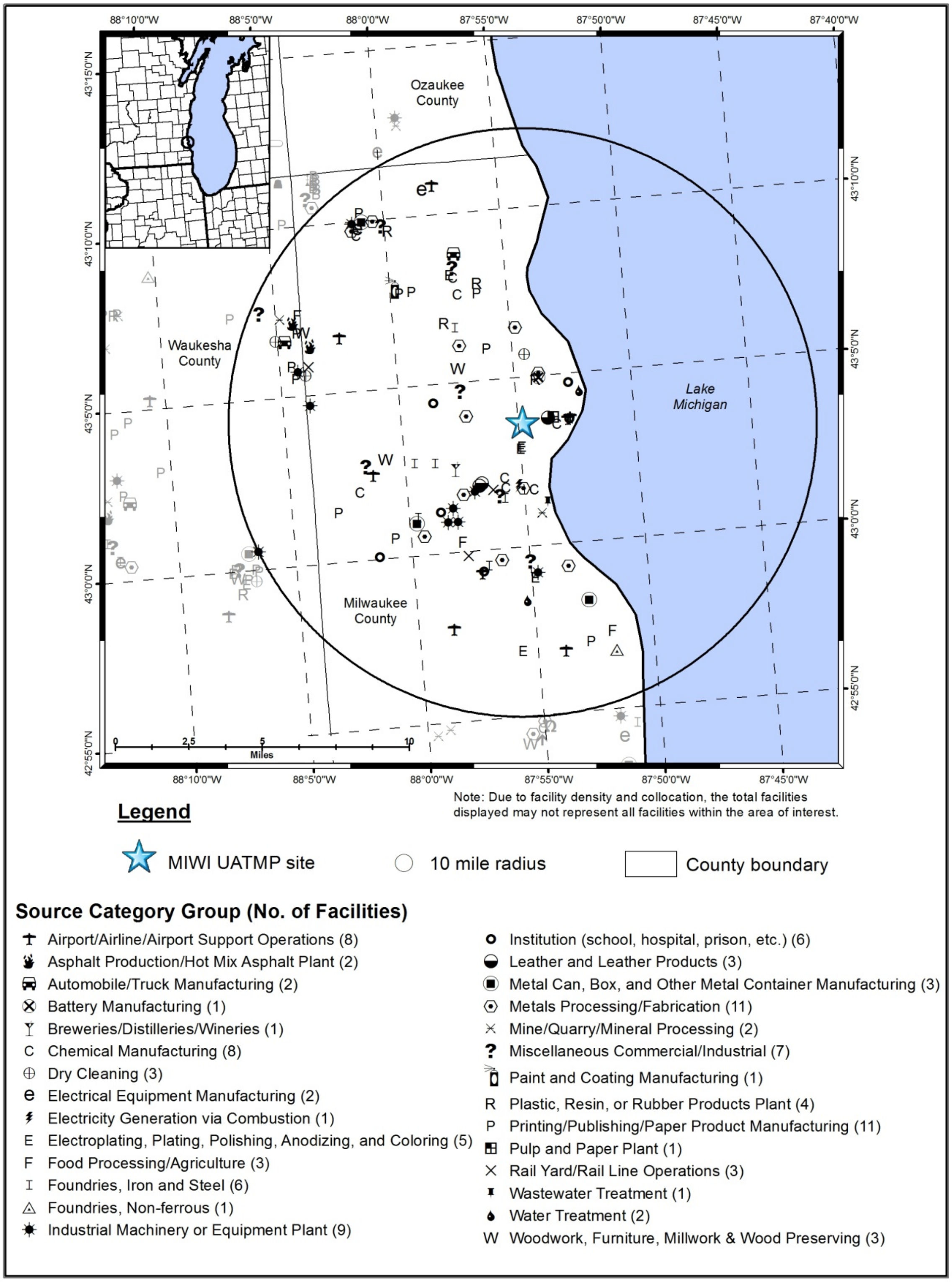


Figure 29-4. NEI Point Sources Located Within 10 Miles of MIWI



Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Table 29-1. Geographical Information for the Wisconsin Monitoring Sites

Site Code	AQS Code	Location	County	Micro- or Metropolitan Statistical Area	Latitude and Longitude	Land Use	Location Setting	Additional Ambient Monitoring Information[1]
HOWI	55-027-0001	Horicon	Dodge	Beaver Dam, WI MSA	43.466111, -88.621111	Agricultural	Rural	SVOCs, PCBs, CO, SO_2, NO_y, NO, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Metals, PM Coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.
MIWI	55-079-0026	Milwaukee	Milwaukee	Milwaukee-Waukesha-West Allis, WI MSA	43.061258, -87.913520	Commercial	Urban/City Center	SNMOCs, SO_2, NO_y, NO, NO_2, NO_x, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM Coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation, IMPROVE Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2013b); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The HOWI monitoring site is located just north of the town of Horicon, in southeast Wisconsin, within the boundaries of the Horicon Marsh Wildlife Area. HOWI is located roughly in the center of a triangle formed by Milwaukee (32 miles to the southeast), Madison (37 miles to the southwest), and Fond Du Lac (20 miles to the northeast). The surrounding area is rural and agricultural in nature, although a residential subdivision is located just south of the site. The HOWI monitoring site serves as a rural background site. However, the area is affected by nearby urban areas, and thus, could show the effects on the wildlife sanctuary. State Highway 28, which can be seen on the lower right-hand side of Figure 29-1, is the closest major roadway.
Figure 29-2 shows that a couple of point sources are located just south and west of HOWI, in the town of Horicon. The closest point source to HOWI is an industrial machinery or equipment plant. The source categories with the most emissions sources within 10 miles of HOWI are metal processing/fabrication facilities; airport and airport support operations, which include airports and related operations as well as small runways and heliports, such as those associated with hospitals or television stations; and industrial machinery or equipment plants.

The city of Milwaukee is located in southeast Wisconsin on the western shores of Lake Michigan. The MIWI monitoring site is located in the parking lot behind the Wisconsin Department of Natural Resources headquarters building. The site is located in a commercial area surrounded by residential areas, as shown in Figure 29-3. Interstate-43 runs north-south less than one-half mile west of the site. The Milwaukee River runs roughly north-south about one-half of a mile east of the site with the Milwaukee Bay and Lake Michigan approximately 2 miles farther east. Figure 29-4 shows this proximity to Lake Michigan as well as the numerous point sources within 10 miles of MIWI. A cluster of point sources is located to the east of the site as well as to the south. The source categories with the most emissions sources within 10 miles of MIWI are metals processing/fabrication; printing, publishing, and paper product manufacturing; industrial machinery or equipment; chemical manufacturing; and airport and airport support operations. Within 1.5 miles of MIWI are electroplating, plating, polishing, anodizing, and coloring facilities to the south and a pulp and paper plant, a leather and leather products facility, and a chemical manufacturing facility to the east.

Table 29-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Wisconsin monitoring sites. Table 29-2 includes both county-level population and vehicle registration information. Table 29-2 also contains traffic volume information for HOWI and MIWI as well as the location for which each traffic volume was obtained. Additionally, Table 29-2 presents the county-level daily VMT for Dodge County and Milwaukee County.

Table 29-2. Population, Motor Vehicle, and Traffic Information for the Wisconsin Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Annual Average Daily Traffic[3]	Intersection Used for Traffic Data	County-level Daily VMT[4]
HOWI	88,415	96,912	5,100	Route 28 (Clason St), north of Route 33	2,626,054
MIWI	955,205	632,914	12,800	N. Martin Luther King Jr. Drive, north of W. North Ave.	17,532,434

[1] County-level population estimate reflects 2012 data (Census Bureau, 2013c)
[2] County-level vehicle registration reflects 2012 data (WI DOT, 2012a)
[3] AADT reflects 2011 data for HOWI and 2013 data for MIWI (WI DOT, 2011 and 2013)
[4] County-level VMT reflects 2011 data (WI DOT, 2012b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 29-2 include the following:

- Dodge County's population is an order of magnitude less than the population for Milwaukee County and in the bottom-third compared to other counties with NMP sites. This is not unexpected given the rural nature of the area. Conversely, Milwaukee County's population is in the top third compared to other counties with NMP sites.

- The county-level vehicle registration for HOWI is considerably less than the vehicle registration for MIWI, ranking similarly to the ranking for population among other counties with NMP sites. The county-level vehicle registration for MIWI is not as high as its ranking for population compared to other NMP sites, putting it in the middle third of the range.

- The traffic volume near MIWI is more than twice the traffic volume near HOWI. The traffic volume near HOWI is also on the low end compared to other NMP sites while the traffic near MIWI falls in the middle of the range. The traffic estimate provided for HOWI is for State Road 28 near State Road 33 on the east side of Horicon. The traffic estimate for MIWI is for N. Martin Luther King Jr. Drive, north of W. North Avenue.

- The daily VMT for Milwaukee County is considerably higher than the VMT for Dodge County. VMTs for these sites rank 18th and 33rd, respectively, compared to VMTs for other counties with NMP sites (and where VMT data were available).

29.2 Meteorological Characterization

The following sections characterize the meteorological conditions near the monitoring sites in Wisconsin on sample days, as well as over the course of the year.

29.2.1 Climate Summary

HOWI and MIWI are both located in southeast Wisconsin. The city of Milwaukee is located along the western shores of Lake Michigan, while the town of Horicon is located about 40 miles west of Lake Michigan, between the towns of West Bend and Beaver Dam. The climate in this part of the state is continental in nature, with an active weather pattern, as storm systems frequently move eastward across the region. Lake Michigan has a significant influence on the area, although the town of Horicon is far enough inland to limit some of the moderating influences of the lake. Precipitation falls predominantly in the spring and summer months, with thunderstorms most common in the summer. Summers tend to be mild, although southerly winds out of the Gulf of Mexico can occasionally advect warm, humid air into the area while easterly winds off Lake Michigan have a cooling effect on the Milwaukee area. Winters are cold and snowfall is common, with an annual average snowfall around 50 inches near Milwaukee. Lake Michigan can moderate cold air masses moving in from the north and may induce lake-effect snow events. Lake effect snows can occur with winds with a northeasterly and easterly component, although lake effect snows are often reduced farther inland. The number of days per season with at least 1 inch snow cover on the ground can range from less than 20 days to greater than 100 days (Wood, 2004; WI SCO, 2013a and 2013b).

29.2.2 Meteorological Summary

Hourly meteorological data for 2012 were retrieved from NCDC for the weather stations closest to the Wisconsin monitoring sites (NCDC, 2012), as described in Section 3.5.2. The closest weather stations are located at Dodge County Airport near HOWI and Lawrence J. Timmerman Airport near MIWI (WBANs 04898 and 94869, respectively). Additional information about these weather stations, such as the distance between each site and the weather station, is provided in Table 29-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 29-3. Average Meteorological Conditions near the Wisconsin Monitoring Sites

Closest Weather Station (WBAN and Coordinates)	Distance and Direction from Site	Average Type[1]	Average Maximum Temperature (°F)	Average Temperature (°F)	Average Dew Point Temperature (°F)	Average Wet Bulb Temperature (°F)	Average Relative Humidity (%)	Average Sea Level Pressure (mb)	Average Scalar Wind Speed (kt)
Horicon, Wisconsin - HOWI									
Dodge County Airport 04898 (43.43, -88.70)	4.7 miles 230° (SW)	Sample Days (63)	60.3 ± 5.2	50.7 ± 4.6	36.5 ± 3.8	43.9 ± 3.8	63.9 ± 4.1	NA	7.4 ± 0.9
		2012	58.5 ± 2.1	49.6 ± 1.9	34.4 ± 1.6	43.3 ± 1.6	65.6 ± 1.6	NA	6.9 ± 0.3
Milwaukee, Wisconsin - MIWI									
Lawrence J. Timmerman Airport 94869 (43.11, -88.03)	6.5 miles 295° (WNW)	Sample Days (52)	63.6 ± 5.2	54.6 ± 4.7	40.1 ± 4.2	47.3 ± 4.0	62.7 ± 3.8	NA	6.9 ± 1.1
		2012	59.2 ± 2.1	50.5 ± 1.9	37.5 ± 1.6	44.2 ± 1.6	65.6 ± 1.5	NA	6.8 ± 0.3

[1] Sample day averages are shaded in orange to help differentiate the sample day averages from the full-year averages.

NA = Sea level pressure was not recorded at either airport.

Table 29-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for all of 2012. Also included in Table 29-3 is the 95 percent confidence interval for each parameter. As shown in Table 29-3, average meteorological conditions on sample days near HOWI appear slightly warmer than average weather conditions experienced throughout 2012, although the differences are not statistically significant. The differences are a little larger for MIWI. However, sampling at MIWI did not begin until the end of February, thereby missing some of the coldest days of the year.

29.2.3 Back Trajectory Analysis

Figure 29-5 is the composite back trajectory map for days on which samples were collected at the HOWI monitoring site. Included in Figure 29-5 are four back trajectories per sample day. Figure 29-6 is the corresponding cluster analysis. Similarly, Figures 29-7 and 29-8 are the composite back trajectory map and corresponding cluster analysis for days on which samples were collected at MIWI. An in-depth description of these maps and how they were generated is presented in Section 3.5.2.1. For the composite maps, each line represents the 24-hour trajectory along which a parcel of air traveled toward the monitoring site on a given sample day and time, based on an initial height of 50 meters AGL. For the cluster analyses, each line corresponds to a trajectory representative of a given cluster of back trajectories. Each concentric circle around the sites in Figures 29-5 through 29-8 represents 100 miles.

Figure 29-5. Composite Back Trajectory Map for HOWI

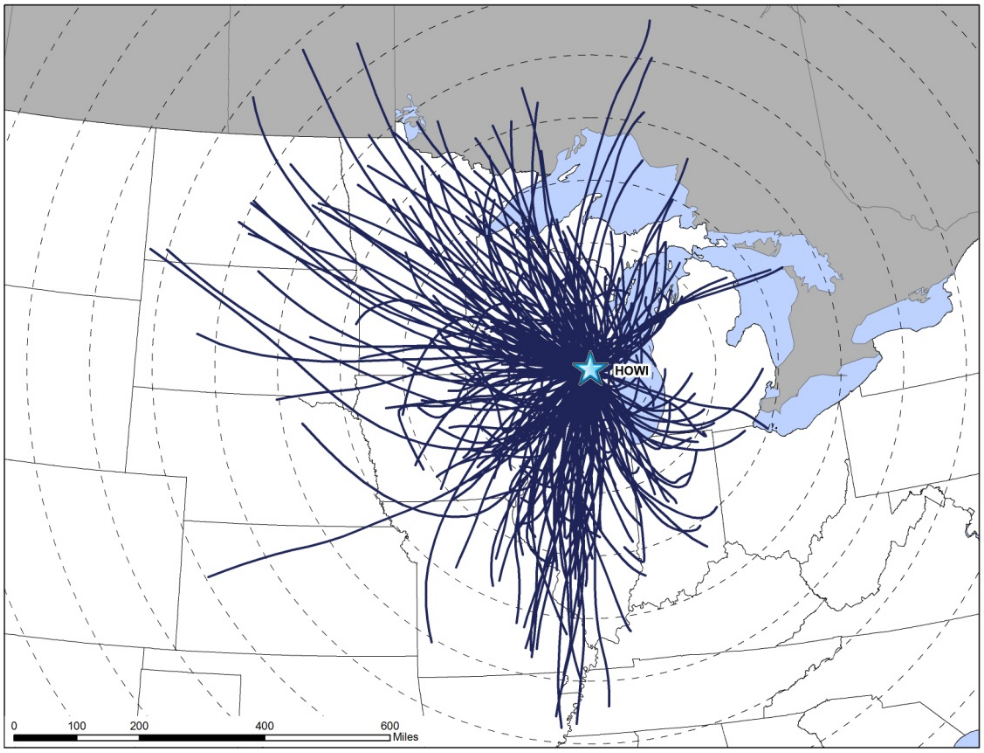


Figure 29-6. Back Trajectory Cluster Map for HOWI

Figure 29-7. Composite Back Trajectory Map for MIWI

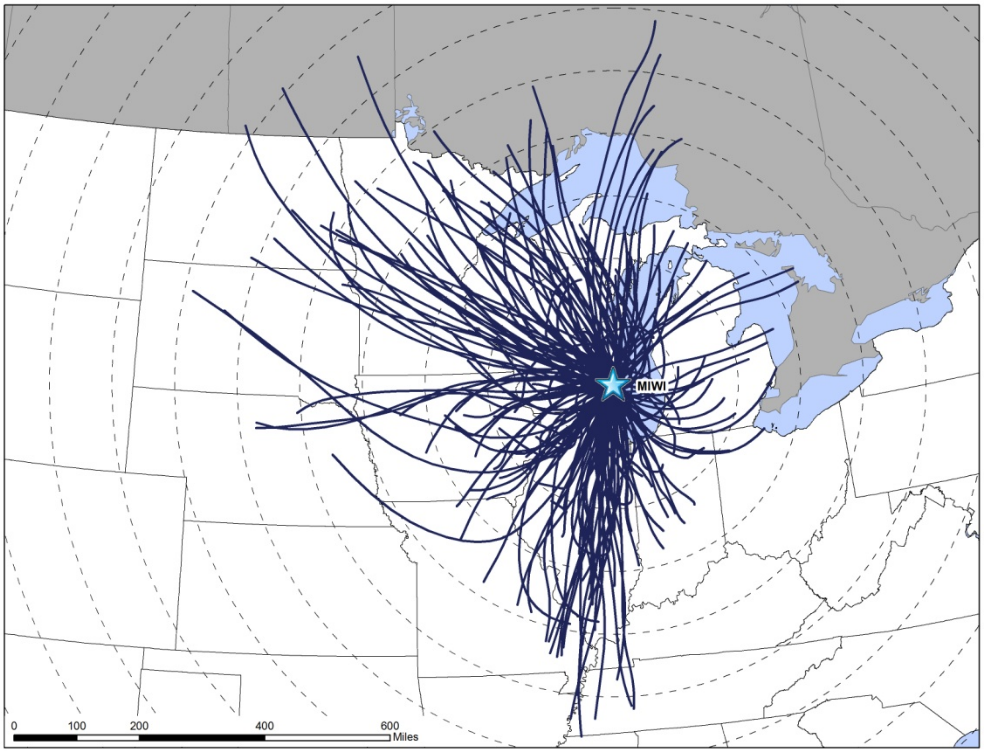
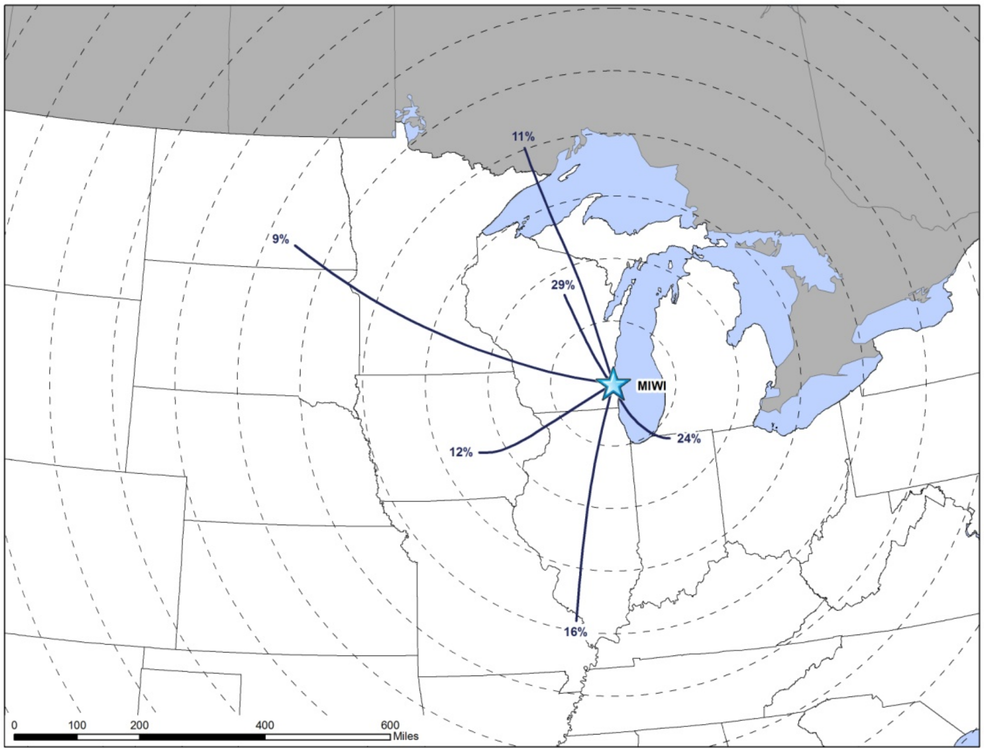


Figure 29-8. Back Trajectory Cluster Map for MIWI



Observations from Figures 29-5 through 29-8 for HOWI and MIWI include the following:

- The composite back trajectory maps for HOWI and MIWI resemble each other, although there are fewer individual back trajectories on the composite map for MIWI. Back trajectories originated from a variety of directions at these sites, although fewer back trajectories originate from a direction with an easterly component. Back trajectories from the northwest quadrant tended to be the longest while those with an easterly component tended to be the shortest.

- The 24-hour air shed domains for the Wisconsin sites are among the largest in size compared to other NMP sites. Both of the sites have back trajectories greater than 700 miles in length. MIWI has the highest average back trajectory length among all NMP sites (290 miles) while HOWI's average back trajectory length ranked third (286 miles). These two sites have the second and third highest number of back trajectories greater than 500 miles in length.

- The cluster analyses for these two sites have many similarities. The primary difference is how the model groups the shorter back trajectories with a northerly component. For HOWI, the shorter back trajectories originating to the north and northeast are represented by the short cluster trajectory originating over Green Bay; the shorter back trajectories originating over northwest Wisconsin and Minnesota are grouped with those shorter back trajectories originating over Iowa and are represented by the westward originating cluster trajectory. For MIWI, the shorter back trajectories originating from the northwest, north, and north-northeast are grouped together and are represented by the cluster trajectory originating in the center of Wisconsin. The shorter back trajectories originating over Michigan are included with those originating from the east and southeast.

- Both cluster analyses show that the longest back trajectories originated to the northwest over the Northern Plains, Minnesota, and Manitoba and Ontario, Canada. Back trajectories of varying lengths also originated to the south of the sites, over Illinois and Missouri. Shorter, westward-originating back trajectories were also common. Back trajectories originating from a direction with an easterly component account for less than 25 percent of back trajectories.

29.2.4 Wind Rose Comparison

Hourly surface wind data from the weather stations at Dodge County Airport near HOWI and Lawrence J. Timmerman Airport near MIWI were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 29-9 presents a map showing the distance between the weather station and HOWI, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 29-9 also presents three different wind roses for the HOWI monitoring site. First, a historical wind rose representing 2003 to 2011 wind data is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose representing wind observations for all of 2012 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2012 is presented. These can be used to identify the predominant wind speed and direction for 2012 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 29-10 presents the distance map and three wind roses for MIWI.

Observations from Figure 29-9 for HOWI include the following:

- The Dodge County Airport weather station is located less than 5 miles southwest of HOWI.

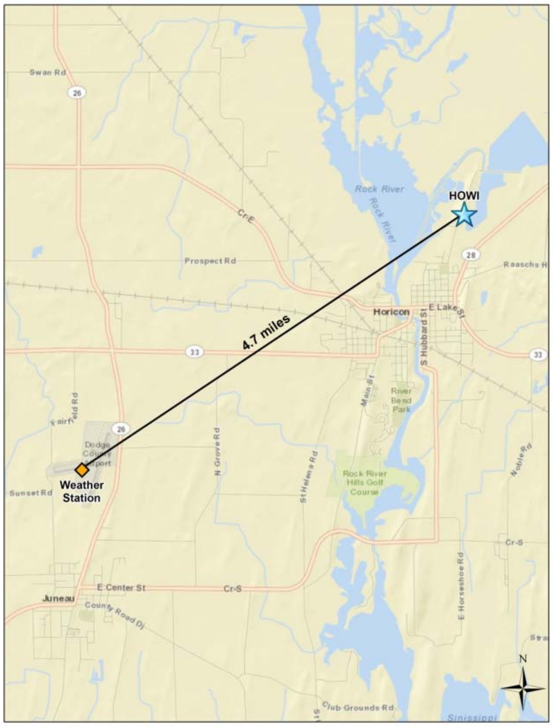
- The historical wind rose shows that winds from a variety of directions were observed near HOWI. Winds from the south, southwest quadrant, and west account for one-third of wind observations. The strongest wind speeds were associated with southerly to west-southwesterly winds. Calm winds (≤2 knots) were observed for approximately 14 percent of the hourly measurements.

- The wind patterns shown on the 2012 wind rose resemble the historical wind patterns, although winds from the south and south-southwest were observed more frequently as were winds from the southeast and south-southeast. The percentage of calm winds was less than 12 percent in 2012.

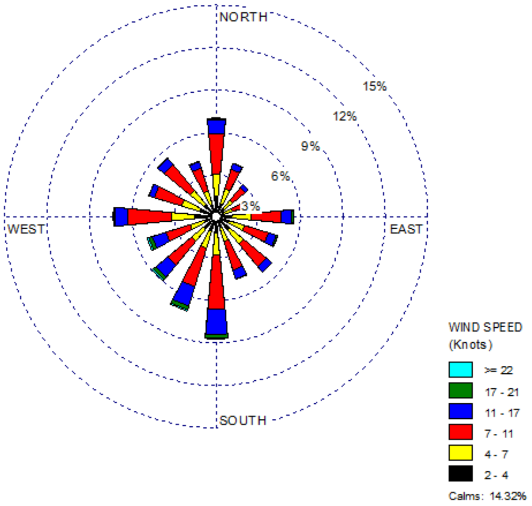
- The sample day wind rose shows that winds from the southeast and southwest quadrants were observed even more frequently on sample days and that a higher percentage of strong (> 22 knots) winds were observed with winds from the south-southeast to south-southwest. Calm winds accounted for even fewer observations on sample days (roughly 10 percent).

Figure 29-9. Wind Roses for the Dodge County Airport Weather Station near HOWI

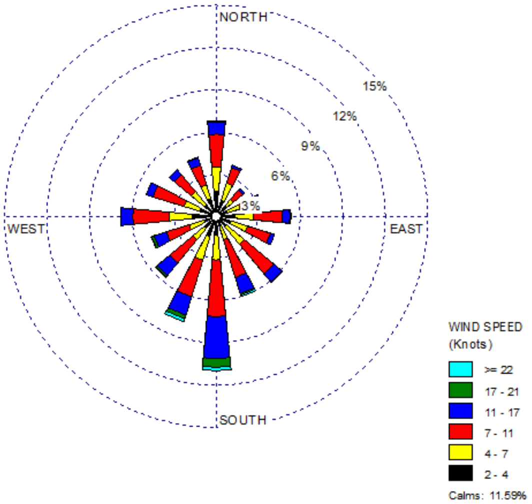
Location of HOWI and Weather Station



2003-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose

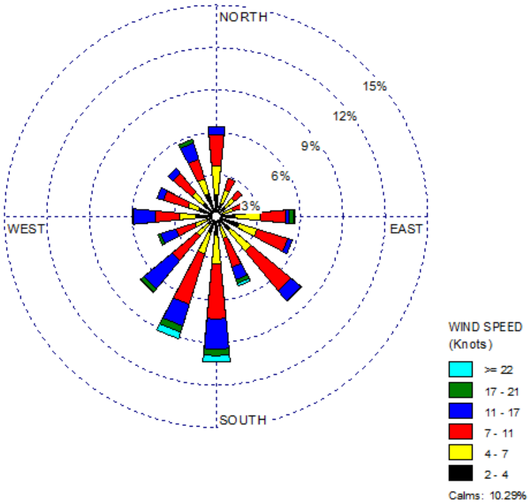
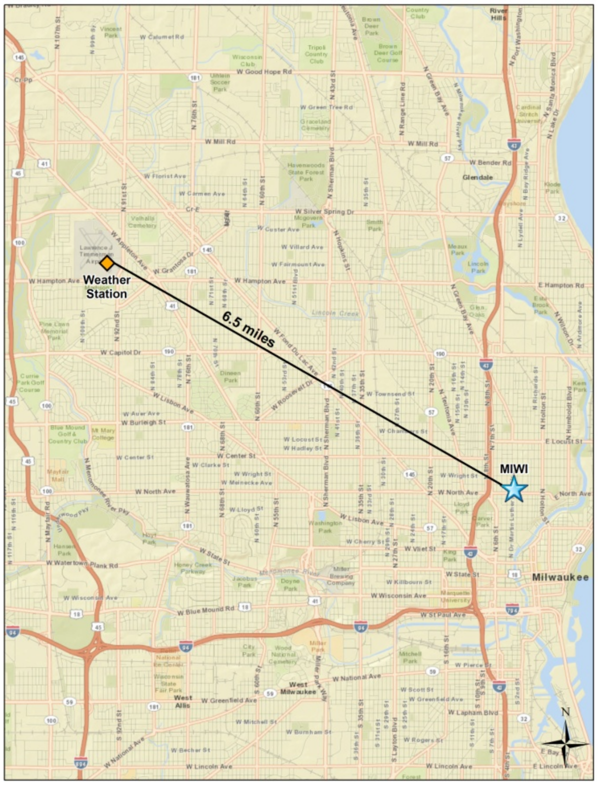
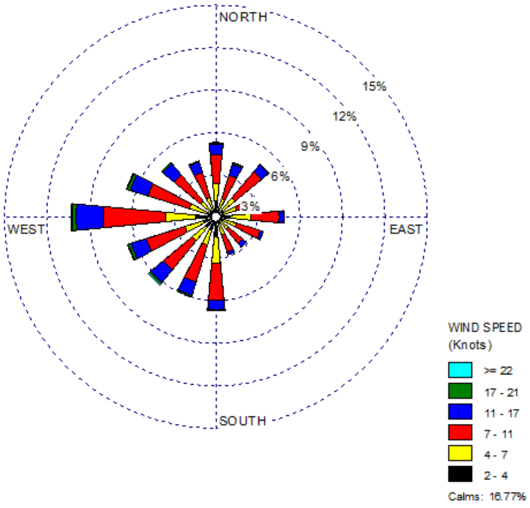


Figure 29-10. Wind Roses for the Lawrence J. Timmerman Airport Weather Station near MIWI

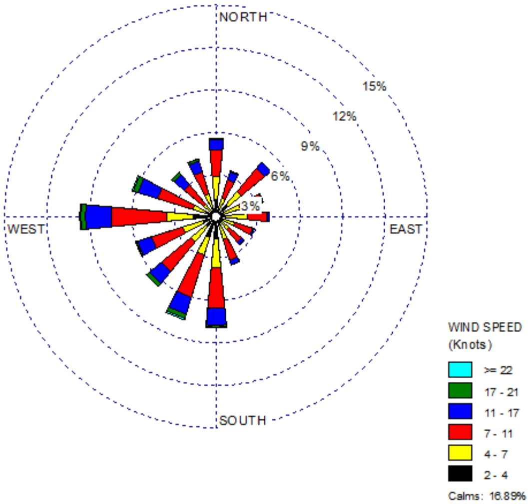
Location of MIWI and Weather Station



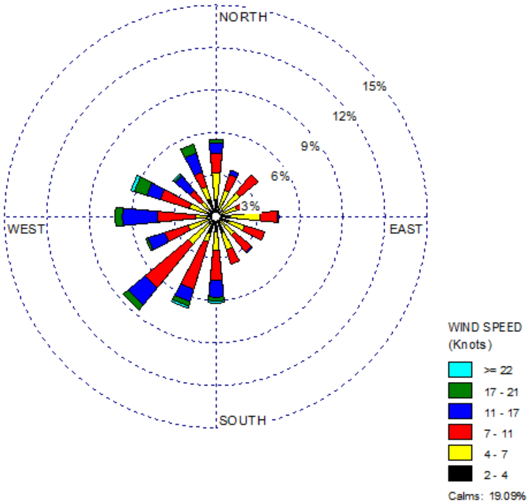
2006-2011 Historical Wind Rose



2012 Wind Rose



Sample Day Wind Rose



Observations from Figure 29-10 for MIWI include the following:

- The Timmerman Airport weather station is located 6.5 miles west-northwest of MIWI. Note that the airport location is considerably farther inland than the monitoring site location.

- The historical wind rose shows that winds from a variety of directions were observed near MIWI, although westerly winds account for the greatest number of observations greater than 2 knots. Winds with a westerly component were observed more frequently than winds with an easterly component. Calm winds (≤2 knots) were observed for approximately 17 percent of the hourly measurements.

- The wind patterns shown on the 2012 wind rose resemble the historical wind patterns, although winds from the south and south-southwest were observed more frequently.

- The sample day wind rose does not show the prominence of the westerly wind. Instead, southwesterly winds account for the highest percentage of wind observations. However, winds from the south-southwest, west, and west-northwest each account for approximately 7 percent of wind observations on sample days. Calm winds accounted for a greater percentage of wind observations on sample days (roughly 19 percent). Some of the differences between the full-year and sample day wind rose may be attributable to the shortened sampling duration (sampling at MIWI did not begin until the end of February).

29.3 Pollutants of Interest

The risk-based screening process described in Section 3.2 was performed for each Wisconsin monitoring site in order to identify site-specific "pollutants of interest," which allows analysts and readers to focus on a subset of pollutants through the context of risk. For each site, each pollutant's preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration "failed the screen." The site-specific results of this risk-based screening process are presented in Table 29-4. Pollutants of interest are those for which the individual pollutant's total failed screens contribute to the top 95 percent of the site's total failed screens and are shaded in gray in Table 29-4. It is important to note which pollutants were sampled for at each site when reviewing the results of this analysis. Only hexavalent chromium was sampled for at these two sites.

Table 29-4. Risk-Based Screening Results for the Wisconsin Monitoring Sites

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Horicon, Wisconsin - HOWI						
Hexavalent Chromium	0.000083	0	35	0.00	0.00	0.00
Total		0	35	0.00		
Milwaukee, Wisconsin - MIWI						
Hexavalent Chromium	0.000083	12	41	29.27	100.00	100.00
Total		12	41	29.27		

Observations from Table 29-4 include the following:

- Hexavalent chromium was detected in 35 of the 61 valid samples collected at HOWI.
- Hexavalent chromium did not fail any screens during the 2012 monitoring effort at HOWI. This was also true for 2011.
- Because HOWI does not have any pollutants of interest, this site is excluded from the sections that follow, with the exception of the emissions section (Section 29.5.3).
- Hexavalent chromium was detected in 41 of the 52 valid samples collected at MIWI.
- Hexavalent chromium failed 12 screens for MIWI (or nearly 30 percent); thus, hexavalent chromium is a pollutant of interest for MIWI.

29.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the MIWI monitoring site. Where applicable, the following calculations and data analyses were performed for each of the site-specific pollutants of interest:

- Time period-based concentration averages (quarterly and annual) are provided for MIWI.
- Annual concentration averages are presented graphically for the site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1.
- Concentration averages and other statistical metrics are presented from previous years of sampling in order to characterize concentration trends at each site.

Each analysis is performed where the data meet the applicable criteria specified in the appropriate sections discussed below. Additional site-specific statistical summaries for MIWI are provided in Appendix O. A site-specific statistical summary for HOWI is also provided in Appendix O.

29.4.1 2012 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for MIWI, as described in Section 3.1. The *quarterly average* of a particular pollutant is simply the average concentration of the preprocessed daily measurements over a given calendar quarter. Quarterly average concentrations include the substitution of zeros for all non-detects. A site must have a minimum of 75 percent valid samples compared to the total number of samples possible within a given quarter for a quarterly average to be calculated. An *annual* average includes all measured detections and substituted zeros for non-detects for the entire year of sampling. Annual averages were calculated for pollutants where three valid quarterly averages could be calculated and where method completeness was greater than or equal to 85 percent, as presented in Section 2.4. Quarterly and annual average concentrations for MIWI are presented in Table 29-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

Table 29-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Wisconsin Monitoring Sites

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Milwaukee, Wisconsin - MIWI						
Hexavalent Chromium	41/52	NA	0.115 ± 0.128	0.273 ± 0.308	0.062 ± 0.064	0.166 ± 0.111

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
Note: There are no pollutants of interest for HOWI.

Observations for MIWI from Table 29-5 include the following:

- Concentrations of hexavalent chromium span three orders of magnitude, ranging from 0.0045 ng/m^3 to 2.30 ng/m^3 (as well as 11 non-detects). Three of the six hexavalent chromium concentrations greater than 1 ng/m^3 measured across the program were measured at MIWI (while the other three were measured at STMN).
- The maximum hexavalent chromium concentration for MIWI was measured on August 13, 2012. Although this is the third highest hexavalent chromium concentration measured across the program in 2012, it is also one of the highest concentrations of this pollutant measured across all years of hexavalent chromium sampling.

- A first quarter average concentration could not be calculated because sampling at MIWI did not begin until February 27, 2012.

- For each available quarterly average, the confidence interval is larger than the average itself, indicating that the measurements factoring into each average are highly variable.

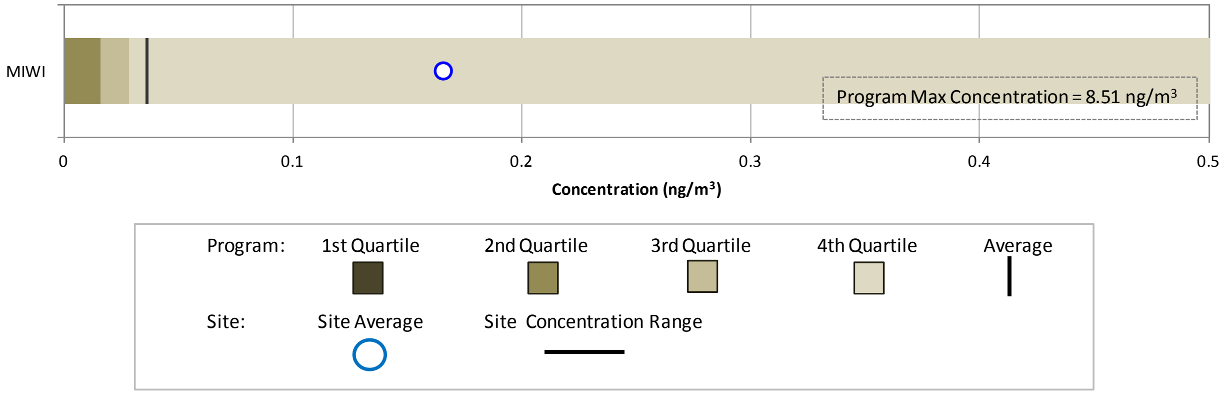
- Of the 11 non-detects, seven were measured during the fourth quarter, with the other four measured during the second quarter.

- MIWI has the second highest annual average concentration of hexavalent chromium among all NMP sites sampling this pollutant. MIWI (and STMN) are the only two NMP sites with annual averages greater than 0.1 ng/m^3.

29.4.2 Concentration Comparison

In order to better illustrate how a site's annual average concentrations compare to the program-level averages, a site-specific box plot was created for each of the site-specific pollutants of interest, where applicable. Thus, a box plot was created for hexavalent chromium for MIWI. Figure 29-11 overlays the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.1.

Figure 29-11. Program vs. Site-Specific Average Hexavalent Chromium Concentration



Observations from Figure 29-11 include the following:

- The program-level maximum concentration (8.51 ng/m^3) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 0.5 ng/m^3. In addition, the program-level first quartile is zero and therefore not visible on the box plot. Figure 29-11 shows that the annual average hexavalent chromium concentration for MIWI is more than four times greater than the program-level average concentration. The maximum hexavalent chromium concentration measured at MIWI is greater than the scale in Figure 29-11 but is not the maximum concentration measured at the program-level, as previously discussed.

29.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the pollutants of interest for 5 consecutive years or longer, as described in Section 3.5.3.2. MIWI is a new site under the NMP for 2012 and therefore does not meet the criteria specified above. As a result, a trends analysis was not conducted.

29.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at MIWI. Refer to Sections 3.3 and 3.5.3 for definitions and explanations regarding the various toxicity factors, time frames, and calculations associated with these risk-based screenings.

29.5.1 Risk-Based Screening Assessment Using MRLs

A risk-based screening was conducted by comparing the concentration data from the Wisconsin monitoring sites to the ATSDR MRLs, where available. As described in Section 3.3, MRLs are noncancer health risk benchmarks and are defined for three exposure periods: acute (exposures of 1 day to 14 days); intermediate (exposures of 15 days to 364 days); and chronic (exposures of 1 year or greater). The preprocessed daily measurements of the pollutants of interest were compared to the acute MRLs; the quarterly averages were compared to the intermediate MRLs; and the annual averages were compared to the chronic MRLs.

As discussed in Section 4.2.2, none of the measured detections or time-period average concentrations for any of the monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks for any of the pollutants measured under the NMP for 2012.

29.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for MIWI and where *annual average* concentrations could be calculated, risk was examined by calculating cancer risk and noncancer hazard approximations. These approximations can be used as risk estimates for cancer and noncancer effects attributable to the pollutant of interest. Although the use of these approximations is limited, they may help identify where policy-makers want to shift their air-monitoring priorities.

Refer to Section 3.5.3.4 for an explanation of how cancer risk and noncancer hazard approximations are calculated and what limitations are associated with them. Annual averages, cancer UREs and/or noncancer RfCs, and cancer risk and noncancer hazard approximations are presented in Table 29-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 29-6. Risk Approximations for the Wisconsin Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Milwaukee, Wisconsin - MIWI						
Hexavalent Chromium	0.012	0.0001	41/52	0.166 ± 0.111	1.99	<0.01

Observations for MIWI from Table 29-6 include the following:

- The cancer risk approximation for hexavalent chromium is 1.99 in-a-million, one of only two cancer risk approximations for this pollutant greater than 1 in-a-million program-wide.
- The noncancer hazard approximation for hexavalent chromium is less than 0.01, indicating that no adverse health effects are expected from this pollutant.

29.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, this section presents an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 29-7 presents the 10 pollutants with the highest emissions from the 2011 NEI that have cancer toxicity factors. Table 29-7 also presents the 10 pollutants with the highest toxicity-weighted emissions, based on the weighting schema described in Section 3.5.3.5. Lastly, Table 29-7 provides the 10 pollutants with the highest cancer risk approximations (in-a-million) for each site, as presented in Table 29-6. The emissions, toxicity-weighted emissions, and cancer risk approximations are shown in descending order in Table 29-7. Table 29-8 presents similar information, but is limited to those pollutants with noncancer toxicity factors.

Table 29-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Wisconsin Monitoring Sites

Top 10 Total Emissions for Pollutants with Cancer UREs (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Approximation (in-a-million)**
Horicon, Wisconsin (Dodge County) - HOWI					
Benzene	80.96	Benzene	6.31E-04		
Formaldehyde	48.25	Formaldehyde	6.27E-04		
Acetaldehyde	33.00	POM, Group 3	2.56E-04		
Ethylbenzene	22.67	1,3-Butadiene	2.41E-04		
1,3-Butadiene	8.03	Naphthalene	1.99E-04		
Naphthalene	5.84	POM, Group 2b	1.12E-04		
POM, Group 2b	1.27	POM, Group 5a	1.09E-04		
Trichloroethylene	0.85	Acetaldehyde	7.26E-05		
POM, Group 2d	0.81	POM, Group 2d	7.15E-05		
POM, Group 6	0.17	Hexavalent Chromium, PM	6.00E-05		
Milwaukee, Wisconsin (Milwaukee County) - MIWI					
Benzene	229.78	POM, Group 1a	1.58E-02	Hexavalent Chromium	1.99
Formaldehyde	183.31	Hexavalent Chromium, PM	3.19E-03		
POM, Group 1a	179.42	Formaldehyde	2.38E-03		
Ethylbenzene	145.70	Benzene	1.79E-03		
Acetaldehyde	111.59	1,3-Butadiene	1.12E-03		
1,3-Butadiene	37.48	Nickel, PM	1.08E-03		
Naphthalene	20.83	Naphthalene	7.08E-04		
Dichloromethane	14.76	Arsenic, PM	4.78E-04		
POM, Group 2b	3.92	POM, Group 3	4.27E-04		
POM, Group 2d	2.97	Ethylbenzene	3.64E-04		

Table 29-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Wisconsin Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer RfCs (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Hazard Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Hazard Approximation (HQ)**
Horicon, Wisconsin (Dodge County) - HOWI					
Toluene	423.43	Acrolein	131,802.77		
Ethylene glycol	113.15	Manganese, PM	5,388.88		
Xylenes	109.42	Formaldehyde	4,923.22		
Benzene	80.96	1,3-Butadiene	4,012.73		
Hexane	72.68	Acetaldehyde	3,667.03		
Methanol	50.62	Benzene	2,698.61		
Formaldehyde	48.25	Cyanide Compounds, gas	2,508.26		
Acetaldehyde	33.00	Naphthalene	1,947.34		
Ethylbenzene	22.67	Lead, PM	1,151.06		
Hydrochloric acid	18.25	Xylenes	1,094.24		
Milwaukee, Wisconsin (Milwaukee County) - MIWI					
Toluene	2,087.97	Acrolein	563,909.98	Hexavalent Chromium	<0.01
Ethylene glycol	1,316.47	Manganese, PM	63,774.13		
Methanol	644.01	Nickel, PM	24,907.34		
Xylenes	581.41	Hydrochloric acid	22,589.06		
Hexane	578.74	1,3-Butadiene	18,738.94		
Hydrochloric acid	451.78	Formaldehyde	18,705.01		
Benzene	229.78	Acetaldehyde	12,398.97		
Formaldehyde	183.31	Hydrofluoric acid	9,117.92		
Ethylbenzene	145.70	Benzene	7,659.40		
Hydrofluoric acid	127.65	Arsenic, PM	7,409.16		

Because not all pollutants have both cancer and noncancer toxicity factors, the highest emitted pollutants in the cancer table may be different from the noncancer table, although the actual quantity of emissions is the same. The cancer risk and noncancer hazard approximations based on each site's annual averages are limited to the pollutants of interest identified for each site. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.3.5. Similar to the cancer risk and noncancer hazard approximations provided in Section 29.5.2, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 29-7 include the following:

- Because Table 29-7 includes emissions data from the NEI, which is independent of the sampling results at a specific site, data for Dodge County, where HOWI is located, is included.
- Benzene and formaldehyde are the highest emitted pollutants with cancer UREs in both Dodge and Milwaukee County, although the emissions are higher in Milwaukee County.
- Benzene is the pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs), followed by formaldehyde and POM, Group 3 for Dodge County. POM, Group 1a, hexavalent chromium, and formaldehyde are the pollutants with the highest toxicity-weighted emissions for Milwaukee County.
- Seven of the highest emitted pollutants in Dodge County also have the highest toxicity-weighted emissions. Six of the highest emitted pollutants in Milwaukee County also have the highest toxicity-weighted emissions.
- Hexavalent chromium, which is the only pollutant sampled for at MIWI, has the second highest toxicity-weighted emissions for Milwaukee County, but is not among the highest emitted. Hexavalent chromium emissions in Milwaukee County rank 17th.
- Several POM Groups rank among Milwaukee County's highest total emissions and toxicity-weighted emissions. PAHs were not sampled at this site.

Observations from Table 29-8 include the following:

- Toluene and ethylene glycol are the highest emitted pollutants with noncancer RfCs in both counties, although the emissions are considerably higher for Milwaukee County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties are acrolein and manganese.

- Four of the highest emitted pollutants in Dodge County also have the highest toxicity-weighted emissions. The same is true for Milwaukee County, although the actual pollutants differ.

- Hexavalent chromium does not appear among the pollutants with the highest emissions or toxicity-weighted emissions for either county (among pollutants with noncancer RfCs).

29.6 Summary of the 2012 Monitoring Data for HOWI and MIWI

Results from several of the data treatments described in this section include the following:

- ❖ *Hexavalent chromium was the only pollutant sampled for at HOWI and did not fail any screens.*

- ❖ *Hexavalent chromium was also the only pollutant sampled for at MIWI; hexavalent chromium failed 30 percent of screens for this site.*

- ❖ *Concentrations of hexavalent chromium measured at MIWI ranged from 0.0045 ng/m*^{3} *to 2.30 ng/m*^{3}*, including several of the highest concentrations program-wide. The annual average concentration of hexavalent chromium for MIWI ranked second highest compared to other NMP sites sampling this pollutant.*

30.0 Data Quality

This section discusses the data quality of the ambient air measurements that constitute the 2012 NMP dataset. Each monitoring program under the NMP has its own specific Data Quality Objectives (DQOs) which have been established and approved by EPA, consistent with the specific data use needs of the individual monitoring program. Because the DQOs are program-specific and the ERG laboratory is contracted to perform services for a subset of the overall program participants, attainment of the individual program DQO(s) is not assessed in this report. This section establishes data quality through the assessment of Data Quality Indicators (DQI) in the form of Measurement Quality Objectives (MQOs) specific to the program elements conducted by the ERG laboratory. MQOs are designed to control and evaluate the various phases of the measurement process (sampling, preparation, analysis, etc.) to ensure that the total measurement quality meets the overall program data quality needs. In accordance with ERG's EPA-approved QAPP (ERG, 2012), the following MQOs were assessed: completeness, precision, and accuracy (also called bias).

The quality assessments presented in this section show that the 2012 monitoring data are of a known and high quality, consistent with the intended data use. The overall method-specific completeness was greater than 90 percent for each method. The method precision for collocated and duplicate analyses met the precision MQO of 15 percent CV for all methods. The analytical precision for replicate analyses also met the precision MQO of 15 percent CV. Audit samples show that ERG is meeting the accuracy requirements of the NATTS TAD (EPA, 2009b). These data quality indicators are discussed in further detail in the following sections.

30.1 Completeness

Completeness refers to the number of valid samples successfully collected and analyzed compared to the number of total samples scheduled to be collected and analyzed. The MQO for completeness based on the EPA-approved QAPP specifies that at least 85 percent of samples collected at a given monitoring site must be analyzed successfully to be considered sufficient for data trends analysis (ERG, 2012). The MQO of 85 percent completeness was met by all but five of 144 site-method combinations. Completeness statistics are presented and discussed more thoroughly in Section 2.4.

30.2 Method Precision

Precision defines the level of agreement between independent measurements performed according to identical protocols and procedures. *Method precision*, which includes s*ampling and analytical precision*, quantifies random errors associated with collecting ambient air samples and analyzing the samples in the laboratory. Method precision is evaluated by comparing concentrations measured in duplicate or collocated samples. A *duplicate* sample is a sample collected simultaneously with a primary sample using the same sampling system (i.e., two separate samples through the same sampling system at the same time). This simultaneous collection is typically achieved by teeing the line from the sampler to two canisters (or other sampling media) and doubling the flow rate applied to achieve integration over the 24-hour collection period. *Collocated* samples are samples collected simultaneously using two independent collection systems at the same location at the same time.

Both approaches provide valuable, but different, assessments of method precision:

- Analysis of duplicate samples provides information on the potential for variability (or precision) expected from a single collection system (intra-system assessment).

- Analysis of collocated samples provides information on the potential for variability (or precision) expected between different collection systems (inter-system assessment).

During the 2012 sampling year, duplicate and collocated samples were collected on at least 10 percent of the scheduled sample days, as outlined in the EPA-approved QAPP. This provides a minimum of six pairs of either duplicate or collocated samples per site and method. For the VOC, SNMOC, and carbonyl compound methods, samples may be duplicate or collocated. For PAHs, metals, and hexavalent chromium, only collocated samples may be collected due to limitations of the sampling media/instrumentation. These duplicate or collocated samples were then analyzed in replicate. *Replicate measurements* are repeated analyses performed on a duplicate or collocated pair of samples and are discussed in greater detail in Section 30.3. In the event duplicate or collocated events were not possible at a given monitoring site, additional replicate samples were run on individual samples to provide an indication of analytical precision.

Method precision was calculated by comparing the concentrations of the duplicates/collocates for each pollutant. The CV for duplicate or collocated samples was calculated for each pollutant and each site. The following approach was employed to estimate how closely the collected and analyzed samples agree with one another:

> ***Coefficient of Variation (CV)*** provides a relative measure of data dispersion compared to the mean. CV can be calculated two ways. The first, which expresses the CV as a ratio of the standard deviation and the mean, is used for a single variable. The second, which is provided below, is ideal when comparing paired values, such as a primary concentration vs. a duplicate concentration. A coefficient of variation of 1 percent would indicate that the analytical results could vary slightly due to sampling error, while a variation of 50 percent means that the results are more imprecise.
>
> $$CV = 100 \times \sqrt{\frac{\sum_{i=1}^{n}\left[\frac{(p-r)}{0.5 \times (p+r)}\right]^2}{2n}}$$
>
> Where:
>
> p = the primary result from a duplicate or collocated pair;
> r = the secondary result from a duplicate or collocated pair;
> n = the number of valid data pairs (the 2 adjusts for the fact that there are two values with error).

Coefficients of variation were based on every pair of duplicate or collocated samples collected during the program year. However, only results at or above the MDL were used in these calculations. Thus, the number of pairs included in the calculations varies significantly from pollutant to pollutant. This is a change in procedure compared to NMP reports prior to 2010, where comparison to the MDL was not considered and 1/2 MDL was substituted for non-detects. To make an overall estimate of method precision, program-level average CVs were calculated as follows:

- A site-specific CV was calculated for each pollutant, per the equation above.
- A pollutant-specific average CV was calculated for each method.
- A method-specific average CV was calculated and compared to the precision MQO.

Table 30-1 presents the 2012 NMP method precision for VOCs, SNMOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, presented as the average CV (expressed as a percentage). Each analytical method met the program MQO of 15 percent CV for precision. This table also includes the number of pairs that were included in the calculation of the method precision. The total number of pairs for each method is also included in Table 30-1 to provide an indication of the effect that excluding those with concentrations less than the MDL has on the population of pairs in the dataset.

Table 30-1. Method Precision by Analytical Method

Method/Pollutant Group	Average Coefficient of Variation (%)	Number of Pairs Included in the Calculation	Total Number of Pairs Without the > MDL exclusion
VOC (TO-15)	9.28	3,147	4,046
SNMOC	8.84	857	1,127
Carbonyl Compounds (TO-11A)	9.14	1,740	1,761
PAH (TO-13)	14.72	351	494
Metals Analysis (Method IO-3.5/FEM)	9.12	1,733	2,157
Hexavalent Chromium (ASTM D7614)	13.77	102	109
MQO	15.00 percent CV		

Tables 30-2 through 30-7 present method precision for VOCs, SNMOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, respectively, as the CV per pollutant per site and the average CV per site, per pollutant, and per method. Also included in these tables is the number of duplicate and/or collocated pairs included in the CV calculations. CVs exceeding the 15 percent MQO are bolded in each table. The CVs that exceed the program MQO for precision are often driven by relatively low concentrations, even though they are greater than the MDL, as these may result in relatively large CVs.

30.2.1 VOC Method Precision

Table 30-2 presents the method precision for all duplicate and collocated VOC samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across all VOCs listed. The individual method precision results exhibit low- to high-level variability, where the CV ranged from 0 percent for a few pollutants for several sites to 56.50 percent (methyl isobutyl ketone for ROIL, although a similar CV was also calculated for GLKY and this pollutant). The pollutant-specific average CV ranged from 2.43 percent (*trans*-1,2-dichloroethylene) to 27.46 percent (methyl isobutyl ketone). The site-specific average CV ranged from 5.08 percent (GPCO) to 14.40 percent (PROK). None of the sites had a site-specific average CV greater than 15 percent. The overall average method precision for VOCs was 9.28 percent. Note that the results for acrolein, acetonitrile, acrylonitrile, and carbon disulfide were excluded from the precision calculations due to the issues described in Section 3.2.

Table 30-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant

Pollutant	ADOK	***BTUT***	BURVT	CHNJ	***DEMI***	ELNJ
Acetylene	9.81	2.40	5.40	14.91	4.24	8.66
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	**16.40**	9.02	8.96	4.78	7.76	7.74
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA
Bromomethane	5.66	NA	4.45	**26.67**	5.66	6.93
1,3-Butadiene	8.87	7.75	6.29	12.29	5.62	11.09
Carbon Tetrachloride	8.88	10.87	12.67	7.01	6.96	5.41
Chlorobenzene	NA	NA	NA	NA	5.05	NA
Chloroethane	NA	NA	14.24	NA	NA	NA
Chloroform	13.29	9.33	9.75	6.41	**28.96**	8.02
Chloromethane	9.96	4.18	4.80	4.48	4.31	7.35
Chloroprene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	NA	NA	6.73	NA	0.00	7.41
Dichlorodifluoromethane	7.36	4.04	4.10	4.54	3.83	6.44
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	6.46	8.01	10.91	3.43	6.40	6.55
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	NA	NA	0.00	NA	1.99	NA
Dichloromethane	**17.81**	**27.68**	14.94	**17.09**	6.32	**19.58**

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	ADOK	***BTUT***	BURVT	CHNJ	***DEMI***	ELNJ
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	8.03	10.27	5.57	8.92	2.99	9.85
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	6.93	NA	**21.99**	NA	5.90
Ethylbenzene	14.60	6.73	11.73	13.42	10.35	5.71
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	**29.00**	14.18	**25.03**	**37.35**	12.81	**24.44**
Methyl Methacrylate	NA	NA	NA	NA	NA	7.55
Methyl *tert*-Butyl Ether	NA	12.76	NA	4.48	NA	10.04
n-Octane	9.05	8.43	12.42	11.22	6.92	10.90
Propylene	12.06	5.45	12.15	**21.94**	5.42	11.74
Styrene	14.36	0.00	14.18	7.39	**17.06**	8.51
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	NA	**17.80**	6.61	5.72	4.70	2.00
Toluene	**21.95**	5.18	7.82	8.16	**15.27**	6.35
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA
Trichloroethylene	NA	NA	NA	NA	NA	0.00
Trichlorofluoromethane	7.41	3.94	4.24	5.42	3.48	7.87
Trichlorotrifluoroethane	10.29	3.12	**16.32**	4.26	4.47	5.77
1,2,4-Trimethylbenzene	4.35	5.43	12.83	**15.96**	8.74	3.68
1,3,5-Trimethylbenzene	2.22	6.21	12.18	0.00	8.60	4.01
Vinyl chloride	NA	NA	NA	NA	NA	NA
m,p-Xylene	**15.14**	6.63	12.00	**23.57**	11.18	6.15
o-Xylene	**15.93**	5.36	12.76	**22.69**	**15.30**	4.36
Average by Site	11.69	8.07	9.97	11.64	7.94	7.93

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	***GLKY***	***GPCO***	***NBIL***	**NBNJ**	**OCOK**	**PROK**
Acetylene	**18.52**	2.50	7.11	4.87	9.56	**44.43**
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	10.55	6.01	10.94	9.03	**17.88**	**27.25**
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	**26.88**	NA	NA	2.60
Bromoform	NA	NA	5.05	NA	NA	NA
Bromomethane	0.00	3.52	**15.71**	7.52	NA	NA
1,3-Butadiene	8.21	4.22	8.97	7.16	11.91	1.06
Carbon Tetrachloride	7.18	**15.48**	9.28	12.25	9.48	7.04
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	NA	NA	5.81	4.08	NA	NA
Chloroform	**21.05**	7.44	**20.77**	3.87	12.86	**17.65**
Chloromethane	6.10	1.97	5.87	7.06	9.44	4.81
Chloroprene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	**18.94**	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	NA	1.94	6.12	2.48	NA	NA
Dichlorodifluoromethane	4.23	2.69	6.20	3.87	9.25	2.85
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	7.34	7.56	7.66	4.52	11.48	11.13
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
Dichloromethane	**40.04**	8.69	14.18	**16.94**	7.90	**32.56**
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	11.76	6.04	5.37	3.68	11.44	3.34
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	4.65	5.24	NA	NA
Ethylbenzene	4.81	3.70	5.57	7.56	6.24	14.29
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	**55.94**	12.80	**15.46**	**17.40**	**28.66**	**19.23**
Methyl Methacrylate	NA	2.24	4.04	NA	NA	NA
Methyl *tert*-Butyl Ether	NA	NA	3.29	**26.73**	NA	NA
n-Octane	6.75	4.24	7.96	11.32	**15.29**	6.91
Propylene	3.56	2.68	11.96	6.42	10.51	11.17
Styrene	13.85	3.24	1.59	8.41	2.22	10.99

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	***GLKY***	***GPCO***	***NBIL***	**NBNJ**	**OCOK**	**PROK**
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	NA	5.90	6.38	7.86	7.86	NA
Toluene	11.68	5.01	9.70	7.28	5.50	**30.20**
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA
Trichloroethylene	NA	NA	10.48	NA	7.97	NA
Trichlorofluoromethane	5.01	3.02	5.37	4.28	8.22	2.35
Trichlorotrifluoroethane	8.04	5.50	5.64	3.51	9.16	5.67
1,2,4-Trimethylbenzene	4.12	2.49	5.35	**15.51**	7.08	**20.14**
1,3,5-Trimethylbenzene	4.88	4.33	4.02	9.56	5.63	5.89
Vinyl chloride	NA	NA	NA	NA	NA	NA
m,p-Xylene	**22.10**	3.87	5.85	8.11	5.69	**33.15**
o-Xylene	4.70	4.86	5.73	10.31	5.18	**16.55**
Average by Site	12.19	5.08	8.72	8.46	9.85	14.40

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	***PXSS***	ROIL	***S4MO***	***SEWA***	SPIL	SSSD
Acetylene	6.29	9.13	5.24	8.30	**18.82**	11.75
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	2.24	12.93	8.95	6.32	6.77	12.85
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA
Bromomethane	4.56	3.70	9.68	5.66	NA	0.00
1,3-Butadiene	4.52	7.45	7.81	3.50	**23.04**	5.35
Carbon Tetrachloride	3.74	**15.73**	**17.93**	8.33	6.94	12.21
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	8.21	0.00	NA	NA	NA	NA
Chloroform	2.86	9.31	4.85	14.14	10.02	2.70
Chloromethane	4.58	4.40	2.66	5.77	4.29	7.85
Chloroprene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	6.73	NA	8.16	NA	NA	NA
Dichlorodifluoromethane	1.71	3.81	2.72	5.91	1.22	6.80
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	3.37	2.83	8.81	0.00	4.23	4.76
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	NA	NA	5.73	NA	NA	NA
Dichloromethane	**38.57**	10.63	11.23	**21.65**	**20.40**	**16.46**
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	3.63	4.01	4.39	**19.40**	0.00	10.75
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	NA
Ethylbenzene	5.95	13.28	9.65	9.37	4.59	**18.04**
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	**30.63**	**56.50**	**15.50**	14.62	**17.80**	**21.64**
Methyl Methacrylate	NA	NA	NA	NA	NA	NA
Methyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	NA
n-Octane	3.23	9.88	**18.08**	5.96	11.62	8.77
Propylene	4.33	7.28	6.39	7.47	8.89	9.15
Styrene	5.07	**17.98**	**16.99**	6.48	10.05	**15.94**

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	***PXSS***	**ROIL**	***S4MO***	***SEWA***	**SPIL**	**SSSD**
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	4.37	NA	10.65	2.32	2.83	NA
Toluene	4.93	8.83	8.09	7.49	12.69	**15.72**
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	13.86	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA
Trichloroethylene	NA	NA	2.05	NA	12.50	NA
Trichlorofluoromethane	1.59	3.75	2.98	5.49	1.41	6.77
Trichlorotrifluoroethane	2.90	5.51	3.84	5.31	3.45	8.19
1,2,4-Trimethylbenzene	6.25	11.82	12.69	9.63	5.57	11.78
1,3,5-Trimethylbenzene	7.77	14.77	14.09	1.66	8.08	9.32
Vinyl chloride	NA	NA	NA	NA	NA	NA
m,*p*-Xylene	5.88	10.94	10.42	7.37	3.82	8.23
o-Xylene	5.76	14.11	11.66	8.94	4.85	9.48
Average by Site	7.17	10.77	8.93	7.96	8.49	10.20

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	TMOK	TOOK	TVKY	# of Pairs	Average by Pollutant
Acetylene	3.16	3.40	10.63	149	9.96
tert-Amyl Methyl Ether	NA	NA	NA	0	NA
Benzene	4.54	5.70	12.79	148	9.97
Bromochloromethane	NA	NA	NA	0	NA
Bromodichloromethane	NA	NA	NA	7	14.74
Bromoform	NA	NA	NA	1	5.05
Bromomethane	**27.90**	**15.71**	4.29	28	8.68
1,3-Butadiene	4.30	9.39	6.09	135	7.85
Carbon Tetrachloride	4.01	7.21	11.15	148	9.51
Chlorobenzene	NA	NA	NA	1	5.05
Chloroethane	NA	NA	11.59	11	7.32
Chloroform	6.29	7.71	13.80	93	11.00
Chloromethane	5.28	5.36	6.90	149	5.59
Chloroprene	NA	NA	NA	0	NA
Dibromochloromethane	NA	NA	NA	3	**18.94**
1,2-Dibromoethane	NA	NA	NA	0	NA
m-Dichlorobenzene	NA	NA	NA	0	NA
o-Dichlorobenzene	NA	NA	NA	0	NA
p-Dichlorobenzene	1.59	13.69	NA	20	5.48
Dichlorodifluoromethane	2.20	3.70	6.09	149	4.45
1,1-Dichloroethane	NA	NA	5.26	2	5.26
1,2-Dichloroethane	5.46	7.88	**34.06**	104	7.76
1,1-Dichloroethene	NA	NA	8.76	1	8.76
cis-1,2-Dichloroethylene	NA	NA	14.14	1	14.14
trans-1,2-Dichloroethylene	NA	NA	1.99	4	2.43
Dichloromethane	**31.20**	3.60	**35.31**	149	**19.66**
1,2-Dichloropropane	NA	NA	NA	0	NA
cis-1,3-Dichloropropene	NA	NA	NA	0	NA
trans-1,3-Dichloropropene	NA	NA	NA	0	NA
Dichlorotetrafluoroethane	5.53	7.08	10.08	149	7.24
Ethyl Acrylate	NA	NA	NA	0	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	19	8.94
Ethylbenzene	6.19	2.68	9.33	140	8.75
Hexachloro-1,3-butadiene	NA	NA	NA	0	NA
Methyl Isobutyl Ketone	**46.64**	**35.11**	**45.92**	129	**27.46**
Methyl Methacrylate	**19.64**	NA	NA	6	8.37
Methyl *tert*-Butyl Ether	NA	NA	NA	16	11.46
n-Octane	7.55	5.81	13.65	130	9.33
Propylene	12.01	5.35	**37.54**	149	10.16
Styrene	9.85	6.54	**16.16**	93	9.85

NA = No pairs with concentrations greater than or equal to the MDL.

BOLD ITALICS = EPA-designated NATTS Site

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	TMOK	TOOK	TVKY	# of Pairs	Average by Pollutant
1,1,2,2-Tetrachloroethane	NA	NA	NA	0	NA
Tetrachloroethylene	8.66	5.62	NA	49	6.62
Toluene	3.90	4.79	**19.90**	149	10.50
1,2,4-Trichlorobenzene	NA	NA	NA	0	NA
1,1,1-Trichloroethane	NA	NA	NA	1	13.86
1,1,2-Trichloroethane	NA	NA	6.82	2	6.82
Trichloroethylene	NA	NA	NA	7	6.60
Trichlorofluoromethane	2.31	4.15	12.18	149	4.82
Trichlorotrifluoroethane	2.96	4.74	6.81	149	5.97
1,2,4-Trimethylbenzene	6.07	5.69	**16.32**	130	9.12
1,3,5-Trimethylbenzene	6.37	4.93	8.82	88	6.83
Vinyl chloride	NA	NA	6.24	6	6.24
m,p-Xylene	4.14	3.34	9.23	143	10.32
o-Xylene	5.24	4.34	9.74	140	9.42
Average by Site	9.35	7.34	13.72	--	9.28

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.2.2 SNMOC Method Precision

The SNMOC method precision for duplicate and collocated samples is presented in Table 30-3 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across all SNMOCs listed. The results from duplicate and collocated samples exhibit low- to high-level variability among the pollutants and sites, ranging from a CV of 0 percent (*m,p*-xylene for BRCO) to 71.98 percent (*n*-undecane for SSSD). The pollutant-specific average CV ranged from 0.97 percent (*cis*-2-butene) to 59.60 percent (*n*-undecane). The site-specific average CV ranged from 4.31 percent (BRCO) to 11.02 percent (SSSD), with an overall method average of 8.84 percent.

Table 30-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant

Pollutant	**BMCO**	**BRCO**	***BTUT***	***NBIL***	**SSSD**	**# of Pairs**	**Average by Pollutant**
Acetylene	9.43	5.21	6.56	3.74	9.33	22	6.86
Benzene	6.47	1.24	3.76	5.52	11.33	21	5.66
1,3-Butadiene	NA	NA	4.98	4.67	4.97	8	4.88
n-Butane	6.67	5.89	5.85	4.14	2.82	22	5.08
cis-2-Butene	NA	NA	0.97	NA	NA	2	0.97
trans-2-Butene	NA	NA	4.98	NA	8.91	9	6.95
Cyclohexane	8.64	5.06	2.85	6.20	6.66	18	5.88
Cyclopentane	NA	3.43	3.69	4.49	**30.90**	17	10.63
Cyclopentene	NA	NA	NA	NA	NA	0	NA
n-Decane	**15.87**	**16.55**	7.24	**20.15**	5.15	16	12.99
1-Decene	NA	NA	NA	4.24	NA	1	4.24
m-Diethylbenzene	NA	NA	8.43	**47.02**	3.00	5	**19.48**
p-Diethylbenzene	NA	NA	NA	NA	**39.27**	1	**39.27**
2,2-Dimethylbutane	NA	7.82	3.16	7.63	10.38	14	7.25
2,3-Dimethylbutane	NA	NA	3.86	2.34	2.56	13	2.92
2,3-Dimethylpentane	NA	1.36	3.74	4.34	9.00	16	4.61
2,4-Dimethylpentane	NA	0.93	4.30	3.59	3.41	15	3.06
n-Dodecane	NA	NA	NA	6.03	NA	1	6.03
1-Dodecene	NA	NA	NA	NA	NA	0	NA
Ethane	5.81	4.32	3.45	10.40	3.35	22	5.46
2-Ethyl-1-butene	NA	NA	NA	NA	NA	0	NA
Ethylbenzene	**29.63**	NA	9.79	8.85	12.34	20	**15.15**
Ethylene	3.61	3.29	3.80	3.18	6.79	22	4.13
m-Ethyltoluene	NA	NA	6.70	6.41	4.18	14	5.77
o-Ethyltoluene	NA	NA	13.31	12.71	2.20	5	9.41
p-Ethyltoluene	NA	NA	5.03	3.53	NA	4	4.28
n-Heptane	11.19	1.27	8.07	3.15	5.08	20	5.75
1-Heptene	NA	6.33	NA	NA	NA	1	6.33
n-Hexane	1.96	5.36	3.11	5.01	**23.93**	22	7.87
1-Hexene	NA	NA	NA	NA	NA	0	NA
cis-2-Hexene	NA	NA	NA	NA	NA	0	NA
trans-2-Hexene	NA	NA	NA	NA	NA	0	NA
Isobutane	8.76	5.39	13.19	2.58	12.12	21	8.41
Isobutene/1-Butene	NA	NA	NA	NA	NA	0	NA
Isopentane	9.59	5.22	6.48	8.87	**21.73**	14	10.38
Isoprene	NA	NA	12.79	3.10	7.29	9	7.73
Isopropylbenzene	NA	NA	NA	NA	NA	0	NA
2-Methyl-1-butene	NA	NA	5.63	NA	5.01	7	5.32
3-Methyl-1-butene	NA	NA	NA	NA	NA	0	NA
2-Methyl-1-pentene	NA	NA	NA	NA	NA	0	NA

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	BMCO	BRCO	*BTUT*	*NBIL*	SSSD	# of Pairs	Average by Pollutant
4-Methyl-1-pentene	NA	NA	NA	NA	NA	0	NA
2-Methyl-2-butene	NA	NA	1.67	1.68	4.48	6	2.61
Methylcyclohexane	12.30	4.20	3.39	7.87	6.53	19	6.86
Methylcyclopentane	10.98	3.55	2.67	5.66	8.99	22	6.37
2-Methylheptane	NA	0.76	2.86	9.63	NA	9	4.42
3-Methylheptane	NA	1.39	5.99	4.35	0.47	10	3.05
2-Methylhexane	8.74	4.15	3.73	13.82	9.40	22	7.97
3-Methylhexane	NA	4.36	6.70	6.38	14.60	14	8.01
2-Methylpentane	13.72	4.68	2.97	4.81	3.00	21	5.84
3-Methylpentane	11.72	4.46	4.45	4.07	6.82	22	6.31
n-Nonane	10.41	0.26	5.53	10.84	3.13	17	6.03
1-Nonene	NA	NA	NA	NA	11.89	4	11.89
n-Octane	**16.37**	1.74	3.84	**32.66**	10.59	17	13.04
1-Octene	NA	NA	NA	14.67	NA	1	14.67
n-Pentane	1.59	5.29	3.42	**23.74**	**29.80**	22	12.77
1-Pentene	NA	NA	**23.95**	8.00	6.68	15	12.88
cis-2-Pentene	NA	NA	NA	NA	NA	0	NA
trans-2-Pentene	NA	NA	5.08	1.74	6.01	13	4.27
a-Pinene	NA	NA	6.63	3.11	NA	5	4.87
b-Pinene	NA	10.34	13.28	**38.46**	**15.24**	8	**19.33**
Propane	4.66	4.67	2.10	4.99	3.98	22	4.08
n-Propylbenzene	NA	NA	3.15	10.87	NA	4	7.01
Propylene	0.57	4.19	3.95	7.37	6.51	22	4.52
Propyne	NA	NA	NA	1.46	NA	1	1.46
Styrene	NA	NA	NA	NA	NA	0	NA
Toluene	6.05	4.01	4.78	10.75	11.89	22	7.50
n-Tridecane	NA	NA	NA	NA	NA	0	NA
1-Tridecene	NA	NA	NA	NA	NA	0	NA
1,2,3-Trimethylbenzene	NA	NA	9.98	2.97	3.84	6	5.60
1,2,4-Trimethylbenzene	**21.45**	NA	2.66	10.27	4.23	19	9.65
1,3,5-Trimethylbenzene	NA	NA	3.55	**16.50**	NA	5	10.03
2,2,3-Trimethylpentane	NA	NA	NA	NA	NA	0	NA
2,2,4-Trimethylpentane	NA	NA	5.62	4.28	8.70	20	6.20
2,3,4-Trimethylpentane	NA	NA	6.99	4.26	11.12	15	7.45
n-Undecane	NA	NA	NA	**47.22**	**71.98**	3	**59.60**
1-Undecene	NA	NA	NA	8.84	NA	1	8.84
m-Xylene/*p*-Xylene	8.51	0.00	3.37	9.44	7.45	22	5.75
o-Xylene	12.98	6.58	4.88	11.90	5.13	22	8.30
SNMOC (Sum of Knowns)	6.99	4.56	2.54	4.07	**39.24**	22	11.48
Sum of Unknowns	**35.28**	3.08	9.89	14.09	9.81	22	14.43
Average by Site	10.71	4.31	5.73	9.53	11.02	--	8.84

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.2.3 Carbonyl Compound Method Precision

Table 30-4 presents the method precision for duplicate and collocated carbonyl compound samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across all carbonyl compounds listed. The duplicate and collocated sample results exhibit low- to high-level variability, ranging from a CV of 0.94 percent (acetaldehyde for OCOK) to 120.31 percent (benzaldehyde for BMCO). The pollutant-specific average CV ranged from 3.83 percent (acetaldehyde) to 18.84 percent (tolualdehydes). The site-specific average CV ranged from 2.74 percent (OCOK) to 56.45 percent (BMCO). Only two sites have average CVs greater than 15 percent; while ROIL is just outside the MQO (16.40 percent), BMCO is significantly higher (56.45 percent). The precision for BMCO is based on a single pair of samples with poor precision. The overall average method precision was 9.14 percent for carbonyl compounds.

Table 30-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant

Pollutant	ADOK	AZFL	BMCO	***BTUT***	BURVT	CHNJ	***DEMI***
Acetaldehyde	0.96	4.18	**27.40**	3.65	1.99	2.92	6.63
Acetone	**19.12**	9.15	**80.77**	9.28	2.26	7.80	3.99
Benzaldehyde	4.72	5.70	**120.31**	4.26	5.67	5.32	6.48
2-Butanone	**18.10**	9.78	**20.05**	5.83	3.25	5.79	4.71
Butyraldehyde	1.63	10.35	**47.14**	5.15	4.69	6.67	**16.11**
Crotonaldehyde	4.31	5.21	6.15	7.33	2.40	7.69	8.48
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	4.98	10.35	13.17	3.88	3.70	3.48	11.19
Hexaldehyde	13.99	8.78	**106.79**	9.97	5.19	6.33	7.82
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	4.65	4.43	**65.54**	7.51	3.22	7.04	12.84
Tolualdehydes	**34.00**	**34.61**	NA	**37.89**	4.94	7.59	6.14
Valeraldehyde	11.57	9.02	**77.14**	6.26	4.04	7.18	**17.88**
Average by Site	10.73	10.14	**56.45**	9.18	3.76	6.16	9.30

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	**ELNJ**	***GLKY***	***GPCO***	**INDEM**	***NBIL***	**NBNJ**	**OCOK**
Acetaldehyde	2.12	1.58	1.37	8.04	2.63	3.44	0.94
Acetone	**16.37**	3.97	6.27	6.71	5.76	5.99	2.90
Benzaldehyde	3.00	5.78	5.28	9.06	6.87	4.08	3.62
2-Butanone	11.86	3.49	3.87	7.05	5.15	10.22	3.63
Butyraldehyde	4.56	3.28	2.99	6.19	4.75	6.57	1.48
Crotonaldehyde	4.86	7.08	3.12	6.86	5.78	3.03	2.69
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	2.51	2.08	0.97	9.59	3.86	10.25	1.32
Hexaldehyde	7.06	3.74	4.72	6.01	5.02	7.22	3.71
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	2.19	2.38	2.96	8.35	4.15	11.03	1.85
Tolualdehydes	10.12	10.82	14.54	6.03	**18.80**	5.71	4.77
Valeraldehyde	5.05	10.65	5.49	7.53	5.84	6.28	3.17
Average by Site	6.34	4.98	4.69	7.40	6.24	6.71	2.74

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	**ORFL**	**PROK**	***PXSS***	**ROIL**	***S4MO***	***SEWA***	***SKFL***
Acetaldehyde	1.32	1.82	3.50	1.57	1.84	1.73	4.24
Acetone	3.90	1.63	1.65	11.51	7.77	1.54	13.83
Benzaldehyde	4.85	5.91	4.83	**32.86**	2.27	9.39	11.46
2-Butanone	6.30	2.96	6.68	**17.81**	4.69	2.63	10.87
Butyraldehyde	2.48	6.15	4.54	**23.25**	3.98	3.92	14.61
Crotonaldehyde	5.87	8.46	2.92	7.19	3.77	4.85	6.85
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	2.17	2.44	11.00	7.31	2.50	3.13	5.33
Hexaldehyde	7.99	8.49	7.09	**27.65**	1.99	4.89	12.15
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	2.85	4.72	3.70	6.84	4.89	3.70	5.24
Tolualdehydes	**35.79**	6.70	12.39	**21.77**	**41.59**	**20.28**	**27.21**
Valeraldehyde	7.74	5.75	6.52	**22.65**	6.88	4.73	11.05
Average by Site	7.39	5.00	5.89	**16.40**	7.47	5.53	11.17

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site and Pollutant (Continued)

Pollutant	**SPIL**	**SSSD**	***SYFL***	**TMOK**	**TOOK**	**WPIN**	**# of Pairs**	**Average by Pollutant**
Acetaldehyde	4.59	3.24	4.34	1.47	1.64	4.42	163	3.83
Acetone	8.46	9.22	**16.57**	1.90	4.27	7.61	163	10.01
Benzaldehyde	8.18	6.46	7.70	6.27	5.94	5.42	159	11.17
2-Butanone	5.36	7.60	11.24	1.91	4.14	7.07	154	7.48
Butyraldehyde	7.37	5.89	8.16	2.33	3.05	6.56	163	7.92
Crotonaldehyde	9.78	3.86	6.22	4.33	2.97	8.35	161	5.57
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	0	NA
Formaldehyde	7.86	3.38	12.07	1.71	1.98	4.35	163	5.43
Hexaldehyde	10.60	6.02	**22.08**	3.12	7.96	10.50	158	12.11
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	0	NA
Propionaldehyde	2.00	4.70	6.71	1.87	4.21	5.10	163	7.21
Tolualdehydes	8.89	**42.64**	**33.07**	**23.00**	7.81	12.73	131	**18.84**
Valeraldehyde	6.94	9.99	**18.71**	4.43	5.50	8.20	162	10.97
Average by Site	7.28	9.36	13.35	4.76	4.50	7.30	--	9.14

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.2.4 PAH Method Precision

The method precision results for collocated PAH samples are shown in Table 30-5 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the PAHs listed. All samples evaluated in this section are collocated samples. Collocated systems were the responsibility of the participating agency for sites sampling PAHs. Thus, collocated samples were not collected at most PAH sites because few sites had collocated samplers. Therefore, the method precision for PAHs is based on data from five sites for 2012.

The results from collocated samples exhibit low- to high-level variability, ranging from a CV of 2.97 percent (acenaphthene for DEMI) to 71.02 percent (anthracene for SDGA). The pollutant-specific average CV ranged from 7.94 percent (phenanthrene) to 25.05 percent (chrysene). The site-specific average CV ranged from 9.28 percent (SEWA) to 27.33 percent (SDGA). SDGA was the only site with a site-specific average CV greater than 15 percent. The overall average method precision was 14.72 percent.

Table 30-5. PAH Method Precision: Coefficient of Variation Based on Collocated Samples by Site and Pollutant

Pollutant	***DEMI***	***RUCA***	***SDGA***	***SEWA***	***SYFL***	# of Pairs	Average by Pollutant
Acenaphthene	2.97	7.93	**15.64**	5.66	10.81	28	8.60
Acenaphthylene	**18.88**	**32.88**	NA	**19.66**	8.76	11	**20.05**
Anthracene	8.46	**18.79**	**71.02**	10.44	12.63	22	**24.27**
Benzo(a)anthracene	**15.20**	9.89	NA	10.09	6.21	8	10.35
Benzo(a)pyrene	14.89	NA	NA	12.62	NA	5	13.75
Benzo(b)fluoranthene	10.18	8.26	**26.95**	5.26	8.66	18	11.86
Benzo(e)pyrene	10.43	10.21	13.08	8.99	**17.98**	10	12.14
Benzo(g,h,i)perylene	11.73	8.34	13.50	7.13	**18.23**	11	11.79
Benzo(k)fluoranthene	14.34	NA	NA	**18.84**	NA	5	**16.59**
Chrysene	11.71	**15.36**	**65.08**	7.12	**25.97**	26	**25.05**
Coronene	**18.10**	NA	NA	13.21	NA	6	**15.66**
Cyclopenta[cd]pyrene	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	**20.20**	NA	NA	11.29	NA	2	**15.75**
Fluoranthene	6.76	5.63	**34.77**	8.17	13.28	29	13.72
Fluorene	3.82	6.09	**18.59**	7.52	11.02	29	9.41
9-Fluorenone	9.20	8.12	**16.28**	8.74	**15.76**	29	11.62
Indeno(1,2,3-cd)pyrene	11.94	9.37	**18.91**	8.03	**27.33**	9	**15.11**
Naphthalene	6.03	14.02	14.72	4.55	10.73	29	10.01
Perylene	**18.49**	NA	NA	NA	NA	1	**18.49**
Phenanthrene	5.56	5.08	13.23	4.90	10.94	29	7.94
Pyrene	7.81	6.68	**46.63**	8.47	**19.77**	29	**17.87**
Retene	5.89	**52.67**	14.20	4.87	**17.36**	15	**19.00**
Average by Site	11.08	13.71	**27.33**	9.28	14.72	--	14.72

NA=No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.2.5 Metals Method Precision

The method precision for all collocated metals samples are presented in Table 30-6 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the metals listed. All samples evaluated in this section are collocated samples. The results from collocated samples exhibit low- to high-level variability among sites, ranging from a CV of 0 percent (antimony and cobalt for UNVT) to 33.91 percent (arsenic for UNVT). The pollutant-specific average CV ranged from 4.38 percent (lead) to 16.87 percent (cadmium).

The site-specific average CV ranged from 6.14 percent (NBIL) to 12.02 percent (S4MO). The overall average method precision for metals was 9.12 percent.

Table 30-6. Metals Method Precision: Coefficient of Variation Based on Collocated Samples by Site and Pollutant

Pollutant	**ASKY-M**	***BOMA***	***BTUT***	***GLKY***	***NBIL***
Antimony	2.87	2.63	3.78	7.12	5.90
Arsenic	6.40	3.00	11.79	**16.87**	3.61
Beryllium	9.30	12.01	14.29	NA	9.43
Cadmium	**16.42**	**27.86**	10.59	**29.63**	4.95
Chromium	NA	4.28	NA	NA	NA
Cobalt	5.27	7.86	13.37	**17.71**	12.22
Lead	4.15	3.82	5.94	4.07	0.32
Manganese	3.99	2.37	9.87	3.44	0.15
Mercury	9.14	14.88	NA	NA	5.89
Nickel	7.00	8.02	11.20	1.21	**16.47**
Selenium	5.44	3.24	NA	8.36	2.42
Average by Site	7.00	8.18	10.10	11.05	6.14

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-6. Metals Method Precision: Coefficient of Variation Based on Collocated Samples by Site and Pollutant (Continued)

Pollutant	***S4MO***	**TOOK**	***UNVT***	**# of Pairs**	**Average by Pollutant**
Antimony	4.54	11.56	0.00	191	4.80
Arsenic	11.22	5.05	**33.91**	191	11.48
Beryllium	**15.92**	8.61	NA	94	11.59
Cadmium	11.90	13.90	**19.68**	197	**16.87**
Chromium	NA	7.68	NA	61	5.98
Cobalt	**15.15**	**18.85**	0.00	163	11.30
Lead	4.25	6.97	5.51	199	4.38
Manganese	5.23	5.98	6.39	199	4.68
Mercury	**27.67**	**15.78**	NA	102	14.67
Nickel	**17.00**	7.08	6.63	165	9.33
Selenium	7.32	4.46	NA	172	5.21
Average by Site	12.02	9.63	10.30	--	9.12

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.2.6 Hexavalent Chromium Method Precision

Table 30-7 presents the method precision results from collocated hexavalent chromium samples as the CV per site and the overall average CV for the method. All samples evaluated in this section are collocated samples. The site-specific CV ranged from 0.74 percent (SYFL) to 40.12 percent (WADC), with an overall average method precision of 13.77 percent.

Table 30-7. Hexavalent Chromium Method Precision: Coefficient of Variation Based on Collocated Samples by Site

Site	**Average CV (%)**
BOMA	5.80
BTUT	9.20
BXNY	12.66
CAMS 35	**21.89**
CHSC	9.71
DEMI	6.49
GLKY	5.22
GPCO	**15.45**
HOWI	**16.50**
MIWI	**16.68**
MONY	5.28
NBIL	**25.69**
PRRI	6.20
PXSS	10.11
RIVA	13.86
ROCH	13.85
S4MO	6.08
SDGA	**31.87**
SEWA	8.59
SKFL	**21.04**
SYFL	0.74
WADC	**40.12**
# of Pairs	102
Average by Site	13.77

BOLD ITALICS = EPA-designated NATTS Site
Orange shading indicates the average CV for this method.

30.3 Analytical Precision

Analytical precision is a measurement of random errors associated with the process of analyzing environmental samples. These errors may result from various factors, including random "noise" inherent to analytical instruments. Laboratories can evaluate the analytical precision of ambient air samples by comparing concentrations measured during multiple analyses of a single sample (i.e., replicate samples). Replicate analyses were run on duplicate or collocated samples collected during the program year. CVs were calculated for every replicate analysis run on duplicate or collocated samples collected during the program year. In addition, replicate analyses were also run on select individual samples to provide an indication of analytical precision for monitoring sites unable to collect duplicate or collocated samples. Individual samples with replicate analyses were also factored into the CV calculations for analytical precision. However, only results at or above the MDL were used in these calculations, similar to the calculation of method precision discussed in Section 30.2.

Table 30-8 presents the 2012 NMP analytical precision for VOCs, SNMOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, presented as average CV (expressed as a percentage). The average CV for each method met the program MQO of 15 percent for precision. The analytical precision for all six methods was less than 7 percent. This table also includes the number of pairs that were included in the calculation of the analytical precision. The number of pairs including those with concentrations less than the MDL is also included in Table 30-8 to provide an indication of the effect that excluding those with concentrations less than the MDL has on the population of pairs in the dataset.

Table 30-8. Analytical Precision by Analytical Method

Method/Pollutant Group	Average Coefficient of Variation (%)	Number of Pairs Included in the Calculation	Total Number of Pairs Without the > MDL exclusion
VOC (TO-15)	6.88	7,242	9,441
SNMOC	5.29	1,755	2,241
Carbonyl Compounds (TO-11A)	2.91	3,592	3,613
PAH (TO-13)	3.93	1,411	1,868
Metals Analysis (Method IO-3.5/FEM)	4.94	3,859	4,771
Hexavalent Chromium (ASTM D7641)	6.65	223	223
MQO	15.00 percent CV		

Tables 30-9 through 30-14 present analytical precision for VOCs, SNMOCs, carbonyl compounds, PAHs, metals, hexavalent chromium, respectively, as the CV per pollutant per site and the average CV per pollutant, per site, and per method. Pollutants exceeding the 15 percent MQO for CV are bolded in each table. In Tables 30-9 through 30-14, the number of pairs in comparison to the respective tables listed for duplicate or collocated analyses in Tables 30-2 through 30-7, is higher, the reason for which is two-fold. One reason is because each duplicate (or collocated) sample produces a replicate analysis. The second reason is due to replicates run on individual samples. This is also the reason the number of sites provided in Tables 30-9 through 30-14 is higher than Tables 30-2 through 30-7. The replicate analyses of duplicate, collocated, and individual samples indicate that the analytical precision level is within the program MQOs.

30.3.1 VOC Analytical Precision

Table 30-9 presents analytical precision results from replicate analyses of duplicate, collocated, and select individual VOC samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the VOCs listed. The analytical precision results from replicate analyses show that, for most of the pollutants, the VOC analytical precision was within the program MQO of 15 percent. The CV ranged from 0 percent for several pollutants and several sites to 74.57 percent (methyl *tert*-butyl ether for SEWA). The pollutant-specific average CV ranged from 0 percent (*m*-dichlorobenzene) to 20.02 percent (methyl *tert*-butyl ether). The site-specific average CV ranged from 4.78 percent (ELNJ) to 9.25 percent (NBIL). The overall average analytical precision was 6.88 percent. Note that the results for acrolein, acetonitrile, acrylonitrile, and carbon disulfide were excluded from the precision calculations due to the issues described in Section 3.2.

Table 30-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant

Pollutant	**ADOK**	***BTUT***	**BURVT**	**CHNJ**	***DEMI***	**ELNJ**
Acetylene	7.82	5.21	4.31	7.33	5.54	3.66
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	10.42	8.61	7.15	5.63	4.20	4.44
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA
Bromomethane	8.91	13.69	7.68	5.75	8.28	5.00
1,3-Butadiene	6.36	7.99	4.70	5.30	4.53	3.58
Carbon Tetrachloride	6.96	9.36	6.00	5.22	3.90	5.49
Chlorobenzene	NA	NA	NA	NA	3.80	NA
Chloroethane	NA	NA	8.03	NA	NA	NA
Chloroform	7.85	9.33	**16.81**	5.96	3.52	5.15
Chloromethane	6.99	5.73	3.56	2.82	3.63	3.27
Chloroprene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	2.94	NA	6.90	NA	2.13	6.88
Dichlorodifluoromethane	5.89	5.78	3.34	2.78	3.64	3.27
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	5.82	9.26	7.89	6.21	6.44	7.34
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	NA	NA	3.03	NA	0.53	NA
Dichloromethane	6.68	5.58	5.10	3.99	2.99	4.31
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	7.60	11.12	7.54	5.59	4.13	5.22
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	9.16	NA	4.28	NA	5.08
Ethylbenzene	8.46	5.70	8.32	6.51	5.83	5.02
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	**ADOK**	***BTUT***	**BURVT**	**CHNJ**	***DEMI***	**ELNJ**
Methyl Isobutyl Ketone	11.80	10.38	7.71	8.76	3.53	8.86
Methyl Methacrylate	NA	NA	NA	NA	4.56	3.21
Methyl *tert*-Butyl Ether	NA	13.24	NA	5.22	NA	7.67
n-Octane	5.34	6.19	9.74	6.99	9.04	5.12
Propylene	8.08	5.81	4.27	3.30	4.75	3.89
Styrene	5.07	6.85	9.65	7.96	**19.75**	6.65
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	NA	13.25	6.70	4.03	3.02	3.31
Toluene	11.61	6.02	6.21	4.75	4.01	3.59
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA
Trichloroethylene	NA	NA	NA	NA	NA	0.00
Trichlorofluoromethane	5.64	6.16	3.39	2.82	2.72	3.32
Trichlorotrifluoroethane	6.46	5.85	4.27	2.96	5.56	3.52
1,2,4-Trimethylbenzene	5.21	4.51	7.88	6.70	4.46	5.94
1,3,5-Trimethylbenzene	4.88	4.64	7.29	9.23	6.68	6.82
Vinyl chloride	NA	NA	NA	NA	NA	NA
m,p-Xylene	7.75	4.60	6.15	6.85	4.24	3.98
o-Xylene	8.15	5.77	7.10	6.90	4.20	5.06
Average by Site	7.20	7.68	6.69	5.53	4.99	4.78

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***GLKY***	***GPCO***	***NBIL***	**NBNJ**	**OCOK**	**PROK**
Acetylene	7.91	3.99	8.33	5.71	6.76	4.78
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	7.86	4.15	10.44	5.50	6.54	6.86
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	11.74	NA	NA	1.37
Bromoform	NA	NA	14.38	NA	NA	NA
Bromomethane	5.08	9.37	8.35	5.99	4.00	NA
1,3-Butadiene	5.51	5.10	9.75	6.53	8.84	2.53
Carbon Tetrachloride	7.82	3.71	8.34	6.45	6.79	5.98
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	NA	NA	14.85	5.55	NA	NA
Chloroform	13.22	7.03	5.52	6.42	9.60	10.41
Chloromethane	4.15	4.01	5.89	4.47	5.68	2.90
Chloroprene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	12.50	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	NA	13.99	8.67	8.06	3.99	8.50
Dichlorodifluoromethane	3.95	3.68	5.27	4.54	5.58	2.78
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	4.80	8.83	10.35	8.50	9.28	9.58
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
Dichloromethane	6.16	5.90	8.10	5.52	5.24	5.09
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	6.63	7.99	6.41	6.69	8.03	7.59
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	5.94	6.06	NA	NA
Ethylbenzene	8.26	2.51	8.00	7.50	8.45	13.56
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	11.90	**15.86**	13.44	8.20	8.31	8.47
Methyl Methacrylate	NA	6.06	12.76	NA	NA	NA
Methyl *tert*-Butyl Ether	0.00	NA	5.73	6.71	NA	NA
n-Octane	6.81	3.43	9.12	9.21	5.56	13.01
Propylene	5.56	4.26	7.01	6.23	5.49	4.37
Styrene	5.15	3.06	9.62	7.60	10.18	**17.55**

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***GLKY***	***GPCO***	***NBIL***	**NBNJ**	**OCOK**	**PROK**
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	NA	7.41	9.75	6.61	11.69	0.53
Toluene	5.76	2.39	11.79	5.89	4.09	5.61
1,2,4-Trichlorobenzene	NA	NA	11.31	NA	NA	NA
1,1,1-Trichloroethane	NA	NA	NA	3.45	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA
Trichloroethylene	NA	NA	**15.09**	NA	5.67	NA
Trichlorofluoromethane	4.47	3.84	5.16	4.48	5.29	2.84
Trichlorotrifluoroethane	4.68	4.46	4.85	5.26	6.44	8.40
1,2,4-Trimethylbenzene	7.62	2.87	7.08	10.43	7.66	**20.04**
1,3,5-Trimethylbenzene	9.14	4.24	10.39	8.00	8.38	13.14
Vinyl chloride	NA	NA	NA	NA	NA	NA
m,p-Xylene	14.47	2.06	9.40	7.04	7.11	8.74
o-Xylene	6.50	2.02	9.23	7.64	8.42	11.75
Average by Site	6.81	5.47	9.25	6.56	7.04	7.85

NA = No pairs with concentrations greater than or equal to the MDL.

BOLD ITALICS = EPA-designated NATTS Site

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***PXSS***	ROIL	RUVT	***S4MO***	***SEWA***	SPAZ
Acetylene	9.80	11.29	6.13	3.32	5.09	6.94
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	4.01	4.77	4.31	4.65	6.99	6.25
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA
Bromomethane	9.34	5.26	8.05	5.72	**19.71**	4.56
1,3-Butadiene	4.11	7.75	4.43	5.89	5.79	3.66
Carbon Tetrachloride	4.47	4.43	3.43	4.65	8.15	5.15
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	3.59	7.47	NA	NA	NA	NA
Chloroform	4.24	5.48	NA	7.19	3.41	3.60
Chloromethane	3.53	5.30	2.60	2.92	3.17	2.85
Chloroprene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	4.56	NA	5.44	4.26	NA	6.67
Dichlorodifluoromethane	4.11	5.34	2.52	2.87	3.15	4.33
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	7.10	9.15	6.53	10.07	5.01	7.20
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	NA	NA	5.66	4.96	NA	NA
Dichloromethane	3.99	5.70	3.19	3.84	3.38	3.40
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	3.82	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	5.09	5.68	5.81	8.06	4.50	4.05
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	**58.23**	NA	NA	**25.71**	NA	NA
Ethylbenzene	3.38	7.70	5.59	6.57	5.78	5.21
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	9.59	8.65	5.91	5.52	12.71	8.91
Methyl Methacrylate	NA	NA	NA	2.67	NA	2.69
Methyl *tert*-Butyl Ether	**45.92**	NA	NA	**21.13**	**74.57**	NA
n-Octane	3.74	7.63	6.31	7.79	7.95	7.17
Propylene	3.56	4.75	3.53	3.46	3.00	6.19
Styrene	5.05	10.69	11.30	10.68	3.34	7.75

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***PXSS***	**ROIL**	**RUVT**	***S4MO***	***SEWA***	**SPAZ**
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	4.31	NA	7.11	6.26	1.93	2.59
Toluene	3.37	5.98	4.37	4.83	4.26	5.19
1,2,4-Trichlorobenzene	NA	NA	0.00	NA	NA	NA
1,1,1-Trichloroethane	4.10	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA
Trichloroethylene	NA	NA	NA	7.61	NA	NA
Trichlorofluoromethane	4.03	4.87	2.27	3.11	3.05	2.57
Trichlorotrifluoroethane	5.81	6.14	4.63	4.21	3.47	3.40
1,2,4-Trimethylbenzene	3.61	8.31	6.69	6.59	5.26	5.37
1,3,5-Trimethylbenzene	4.77	11.52	11.17	10.38	2.58	6.71
Vinyl chloride	NA	NA	NA	NA	NA	NA
m,p-Xylene	3.68	6.50	5.43	5.56	4.21	4.90
o-Xylene	3.33	7.41	6.61	6.17	5.92	5.71
Average by Site	7.94	6.99	5.35	6.89	8.26	5.12

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	**SPIL**	**SSSD**	**TMOK**	**TOOK**	**TVKY**	***UNVT***	**# of Pairs**	**Average by Pollutant**
Acetylene	5.09	6.68	4.16	5.00	5.86	6.38	338	6.13
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA	0	NA
Benzene	5.31	10.97	4.27	4.55	6.69	7.48	334	6.34
Bromochloromethane	NA	NA	NA	NA	NA	NA	0	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA	14	6.56
Bromoform	NA	NA	NA	NA	NA	NA	2	14.38
Bromomethane	7.44	7.80	7.80	14.08	6.20	9.37	104	8.15
1,3-Butadiene	6.37	8.70	4.00	6.14	5.29	2.86	295	5.65
Carbon Tetrachloride	5.87	9.84	5.09	6.21	6.49	5.35	337	6.05
Chlorobenzene	NA	NA	NA	NA	NA	NA	2	3.80
Chloroethane	NA	NA	5.82	NA	6.39	NA	29	7.39
Chloroform	7.68	7.59	7.03	10.01	5.45	**15.35**	215	7.73
Chloromethane	4.66	3.94	3.54	5.43	4.49	5.13	338	4.19
Chloroprene	NA	NA	NA	NA	NA	NA	0	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA	7	12.50
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA	0	NA
m-Dichlorobenzene	NA	NA	0.00	NA	NA	NA	1	0.00
o-Dichlorobenzene	NA	NA	NA	NA	NA	NA	0	NA
p-Dichlorobenzene	NA	NA	13.34	10.70	NA	NA	68	7.14
Dichlorodifluoromethane	4.38	3.87	3.49	5.13	4.04	4.32	338	4.09
1,1-Dichloroethane	NA	NA	NA	NA	4.39	NA	4	4.39
1,2-Dichloroethane	7.84	5.62	9.64	6.66	4.01	5.77	239	7.45
1,1-Dichloroethene	NA	NA	NA	NA	5.17	NA	2	5.17
cis-1,2-Dichloroethylene	NA	NA	NA	NA	**16.01**	NA	2	**16.01**
trans-1,2-Dichloroethylene	NA	NA	NA	NA	3.84	NA	11	3.60
Dichloromethane	4.73	6.69	4.57	4.89	5.40	6.34	338	5.03
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA	0	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	1	3.82
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	0	NA
Dichlorotetrafluoroethane	3.37	7.19	7.46	7.91	5.92	8.37	338	6.58
Ethyl Acrylate	NA	NA	NA	NA	NA	NA	0	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	4.88	NA	6.15	43	13.94
Ethylbenzene	6.96	8.69	4.62	4.35	7.62	9.42	318	6.83
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA	0	NA
Methyl Isobutyl Ketone	7.83	12.78	6.71	7.23	11.82	7.89	304	9.28
Methyl Methacrylate	NA	NA	**25.33**	NA	NA	NA	17	8.18
Methyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	NA	38	**20.02**
n-Octane	9.25	12.58	6.79	5.08	8.72	7.21	300	7.49
Propylene	5.02	3.94	4.07	4.84	4.19	6.25	338	4.83
Styrene	7.85	10.04	8.79	10.37	7.75	11.76	219	8.94

NA = No pairs with concentrations greater than or equal to the MDL.

BOLD ITALICS = EPA-designated NATTS Site

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	SPIL	SSSD	TMOK	TOOK	TVKY	***UNVT***	# of Pairs	Average by Pollutant
Propylene	5.02	3.94	4.07	4.84	4.19	6.25	338	4.83
Styrene	7.85	10.04	8.79	10.37	7.75	11.76	219	8.94
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	0	NA
Tetrachloroethylene	6.00	NA	11.08	11.02	4.71	NA	110	6.39
Toluene	6.08	8.35	4.20	3.67	6.50	6.46	338	5.62
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	2	5.66
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	NA	3	3.78
1,1,2-Trichloroethane	NA	NA	NA	NA	3.27	NA	4	3.27
Trichloroethylene	5.56	NA	NA	3.14	NA	NA	15	6.18
Trichlorofluoromethane	4.23	4.23	3.23	5.13	4.38	3.74	338	3.96
Trichlorotrifluoroethane	4.09	5.09	3.90	5.92	4.44	5.54	337	4.97
1,2,4-Trimethylbenzene	6.70	11.82	5.59	5.35	9.10	9.33	296	7.25
1,3,5-Trimethylbenzene	6.62	**15.15**	6.87	6.84	9.06	3.42	208	7.83
Vinyl chloride	NA	NA	NA	NA	3.15	NA	13	3.15
m,p-Xylene	4.52	8.33	3.90	3.87	6.98	8.93	327	6.22
o-Xylene	5.84	8.62	4.65	3.95	7.71	8.93	317	6.57
Average by Site	5.97	8.20	6.43	6.38	6.29	7.16	--	6.88

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.3.2 SNMOC Analytical Precision

Table 30-10 presents analytical precision results from replicate analyses of duplicate, collocated, and select individual samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the SNMOCs listed. The CV ranged from 0 percent (methylcyclopentane and 3-methylhexane for BRCO) to 41.15 percent (*n*-undecane for SSSD). The pollutant-specific average CV ranged from 0.94 percent (propyne) to 27.12 percent (*p*-diethylbenzene). The site-specific average CV ranged from 1.73 percent (BRCO) to 8.61 percent (SSSD). The overall program average CV was 5.29 percent.

Table 30-10. SNMOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant

Pollutant	BMCO	BRCO	***BTUT***	***NBIL***	SSSD	# of Pairs	Average by Pollutant
Acetylene	4.91	0.77	6.09	6.64	11.55	44	5.99
Benzene	2.63	1.66	2.82	3.65	9.26	41	4.01
1,3-Butadiene	NA	NA	8.16	4.75	6.91	18	6.60
n-Butane	0.13	0.95	1.28	1.14	1.32	44	0.96
cis-2-Butene	NA	NA	2.25	NA	NA	4	2.25
trans-2-Butene	NA	NA	5.45	1.56	7.16	20	4.72
Cyclohexane	1.43	0.70	1.99	3.59	8.48	36	3.24
Cyclopentane	2.08	2.59	3.59	5.53	7.63	35	4.28
Cyclopentene	NA	NA	NA	NA	NA	0	NA
n-Decane	9.95	3.06	5.86	6.00	8.70	32	6.71
1-Decene	NA	NA	NA	2.45	NA	2	2.45
m-Diethylbenzene	NA	NA	6.30	8.58	9.53	9	8.14
p-Diethylbenzene	NA	NA	NA	NA	**27.12**	2	**27.12**
2,2-Dimethylbutane	NA	2.81	5.85	6.56	14.29	29	7.38
2,3-Dimethylbutane	NA	NA	2.24	1.90	10.12	27	4.75
2,3-Dimethylpentane	2.43	4.14	2.87	3.10	6.12	34	3.73
2,4-Dimethylpentane	NA	2.51	4.58	3.51	9.10	30	4.92
n-Dodecane	NA	NA	NA	3.00	NA	3	3.00
1-Dodecene	NA	NA	NA	13.47	NA	2	13.47
Ethane	0.49	0.26	2.16	1.80	3.91	44	1.72
2-Ethyl-1-butene	NA	NA	NA	NA	NA	0	NA
Ethylbenzene	5.66	NA	9.21	5.14	8.34	40	7.09
Ethylene	2.68	0.59	3.02	2.31	2.04	44	2.13
m-Ethyltoluene	NA	NA	4.53	3.92	6.42	28	4.96
o-Ethyltoluene	NA	NA	13.09	3.44	4.76	10	7.09
p-Ethyltoluene	NA	NA	4.07	2.31	13.26	12	6.55
n-Heptane	2.79	0.96	4.24	5.04	4.89	40	3.58
1-Heptene	NA	1.26	3.85	NA	NA	3	2.56
n-Hexane	1.10	1.38	2.51	2.65	4.85	44	2.50
1-Hexene	NA	NA	NA	NA	NA	0	NA
cis-2-Hexene	NA	NA	NA	NA	NA	0	NA
trans-2-Hexene	NA	NA	NA	NA	NA	0	NA
Isobutane	0.91	0.67	0.88	1.38	2.18	43	1.20
Isobutene/1-Butene	NA	NA	NA	NA	NA	0	NA
Isopentane	1.66	0.59	3.80	1.25	6.23	29	2.71
Isoprene	NA	NA	2.69	3.55	9.87	18	5.37
Isopropylbenzene	NA	NA	NA	NA	NA	0	NA
2-Methyl-1-butene	NA	NA	5.34	NA	4.40	14	4.87
3-Methyl-1-butene	NA	NA	NA	NA	NA	0	NA
2-Methyl-1-pentene	NA	NA	NA	NA	NA	0	NA

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-10. SNMOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	BMCO	BRCO	***BTUT***	***NBIL***	SSSD	# of Pairs	Average by Pollutant
4-Methyl-1-pentene	NA	NA	NA	NA	NA	0	NA
2-Methyl-2-butene	NA	NA	6.20	1.08	2.98	14	3.42
Methylcyclohexane	3.12	1.50	3.33	8.35	8.84	38	5.03
Methylcyclopentane	0.93	0.00	1.89	5.51	4.65	44	2.60
2-Methylheptane	9.80	2.42	6.50	6.59	NA	20	6.33
3-Methylheptane	2.77	4.22	3.62	4.23	13.79	21	5.73
2-Methylhexane	2.07	2.24	2.90	3.86	7.80	44	3.77
3-Methylhexane	3.00	0.00	8.09	7.63	4.39	29	4.62
2-Methylpentane	1.10	1.00	2.44	2.86	2.75	43	2.03
3-Methylpentane	1.69	0.82	2.60	4.34	6.23	44	3.14
n-Nonane	4.33	2.76	2.87	5.56	8.13	35	4.73
1-Nonene	NA	NA	NA	NA	12.79	8	12.79
n-Octane	3.46	1.94	2.98	10.05	8.82	37	5.45
1-Octene	NA	NA	NA	3.39	NA	2	3.39
n-Pentane	0.59	0.74	1.31	1.65	3.69	44	1.60
1-Pentene	NA	NA	3.99	6.49	8.96	32	6.48
cis-2-Pentene	NA	NA	NA	NA	NA	0	NA
trans-2-Pentene	NA	NA	3.00	5.42	8.64	27	5.69
a-Pinene	4.71	NA	4.66	4.21	**26.57**	13	10.04
b-Pinene	4.47	1.65	2.71	2.09	3.96	18	2.98
Propane	0.41	0.38	1.09	0.98	2.09	44	0.99
n-Propylbenzene	NA	NA	10.16	4.31	NA	6	7.23
Propylene	3.53	0.70	2.21	3.44	2.28	44	2.43
Propyne	NA	NA	NA	NA	NA	2	0.94
Styrene	NA	NA	NA	NA	NA	0	NA
Toluene	2.13	0.83	3.10	5.28	4.48	44	3.16
n-Tridecane	NA	NA	NA	NA	NA	0	NA
1-Tridecene	NA	NA	NA	NA	NA	0	NA
1,2,3-Trimethylbenzene	NA	NA	6.33	3.18	11.28	13	6.93
1,2,4-Trimethylbenzene	3.74	NA	3.53	3.92	6.07	39	4.31
1,3,5-Trimethylbenzene	NA	NA	5.62	11.12	NA	10	8.37
2,2,3-Trimethylpentane	NA	NA	NA	NA	NA	0	NA
2,2,4-Trimethylpentane	1.48	NA	3.90	4.20	5.00	41	3.64
2,3,4-Trimethylpentane	1.58	NA	3.93	8.81	8.05	32	5.59
n-Undecane	NA	NA	2.49	2.13	**41.15**	8	**15.26**
1-Undecene	NA	NA	NA	5.12	NA	2	5.12
m-Xylene/*p*-Xylene	4.83	1.83	2.99	7.04	5.67	44	4.47
o-Xylene	6.23	6.99	3.21	7.31	6.91	44	6.13
SNMOC (Sum of Knowns)	0.61	0.51	1.36	1.41	**24.57**	44	5.69
Sum of Unknowns	2.33	5.09	**18.43**	5.29	6.19	44	7.46
Average by Site	2.91	1.73	4.32	4.43	8.61	--	5.29

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.3.3 Carbonyl Compound Analytical Precision

Table 30-11 presents the analytical precision results from replicate analyses of duplicate, collocated, and select individual carbonyl compound samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV for the carbonyl compounds listed. The overall average variability was 2.91 percent, which is well within the program MQO of 15 percent CV. The analytical precision results from replicate analyses range from 0 percent (several pollutants at different sites) to 29.88 percent (crotonaldehyde for BRCO). The pollutant-specific average CV ranged from 0.73 percent (acetone) to 5.69 percent (tolualdehydes). The site-specific average CV ranged from 1.93 percent (BTUT) to 5.65 percent (PACO).

Table 30-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant

Pollutant	ADOK	AZFL	BMCO	BRCO	***BTUT***	BURVT	CHNJ
Acetaldehyde	0.34	1.47	1.53	0.60	0.47	1.10	0.63
Acetone	0.42	1.85	1.11	0.61	0.38	0.95	0.39
Benzaldehyde	2.71	3.52	9.13	0.00	2.30	2.51	5.54
2-Butanone	1.89	2.31	1.30	0.83	1.24	3.21	2.28
Butyraldehyde	1.85	3.66	4.80	2.48	1.00	2.43	2.96
Crotonaldehyde	2.52	1.29	4.00	**29.88**	1.55	2.56	4.55
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	0.84	2.03	1.50	0.90	0.32	1.00	0.77
Hexaldehyde	3.10	3.00	0.00	7.44	4.60	2.80	5.17
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	2.64	3.07	4.65	1.89	2.06	2.73	3.46
Tolualdehydes	**18.83**	7.57	0.00	0.00	5.09	3.57	5.09
Valeraldehyde	2.86	4.15	3.03	0.00	2.19	3.22	4.21
Average by Site	3.45	3.08	2.82	4.06	1.93	2.37	3.19

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***DEMI***	**ELNJ**	***GLKY***	***GPCO***	**INDEM**	***NBIL***	**NBNJ**
Acetaldehyde	0.62	0.55	0.70	0.59	1.48	1.12	0.66
Acetone	0.56	0.38	0.78	0.35	0.49	0.92	0.53
Benzaldehyde	2.49	2.81	3.17	1.05	3.87	3.29	4.51
2-Butanone	2.29	1.28	3.53	2.13	1.56	2.73	1.67
Butyraldehyde	2.57	3.58	3.42	1.66	3.99	3.08	3.17
Crotonaldehyde	3.35	2.69	1.03	3.39	3.77	4.32	1.59
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	1.27	0.79	0.88	0.52	1.26	1.87	1.20
Hexaldehyde	3.52	4.55	4.41	4.41	4.24	4.16	3.95
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	1.71	2.66	1.96	2.14	2.65	2.58	2.57
Tolualdehydes	4.36	3.81	6.41	4.43	4.17	3.55	5.08
Valeraldehyde	4.52	2.73	2.06	3.28	3.90	4.01	4.06
Average by Site	2.48	2.35	2.58	2.18	2.85	2.88	2.64

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	**OCOK**	**ORFL**	**PACO**	**PROK**	***PXSS***	**RICO**	**ROIL**
Acetaldehyde	2.59	0.45	0.00	0.68	0.51	0.99	0.47
Acetone	2.64	1.43	0.00	0.43	0.60	0.00	0.42
Benzaldehyde	3.13	2.64	6.73	2.32	2.45	3.01	2.12
2-Butanone	2.74	2.95	4.26	1.90	2.07	5.67	4.36
Butyraldehyde	2.96	3.81	12.86	3.53	1.72	10.88	3.22
Crotonaldehyde	1.89	3.11	NA	2.10	1.91	NA	1.38
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	2.63	0.74	0.22	0.70	0.90	0.27	1.19
Hexaldehyde	4.16	3.42	8.32	4.59	3.26	4.04	5.22
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	3.30	2.68	0.00	3.75	2.57	5.98	4.18
Tolualdehydes	4.36	4.78	NA	3.81	6.83	**18.45**	4.66
Valeraldehyde	3.41	3.80	**18.45**	4.29	3.47	0.00	7.74
Average by Site	3.07	2.71	5.65	2.56	2.39	4.93	3.18

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	RRMI	***S4MO***	***SEWA***	***SKFL***	SPIL	SSSD	SWMI
Acetaldehyde	0.47	0.41	1.57	1.35	1.05	0.47	0.00
Acetone	0.45	0.78	0.60	0.66	0.65	0.52	0.00
Benzaldehyde	2.37	2.15	3.22	4.76	3.44	3.56	1.89
2-Butanone	0.52	1.32	1.06	4.04	1.66	2.22	3.63
Butyraldehyde	2.82	2.53	3.25	3.16	2.15	2.56	4.60
Crotonaldehyde	3.70	2.10	3.84	2.92	3.26	3.44	0.00
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	0.68	0.86	2.22	1.76	0.63	1.20	0.69
Hexaldehyde	3.33	3.72	4.72	3.85	5.21	4.24	3.01
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	2.17	2.67	3.06	2.24	3.53	2.32	4.68
Tolualdehydes	2.80	9.59	4.68	5.48	4.83	3.13	4.56
Valeraldehyde	3.23	2.61	3.72	2.54	5.26	2.74	3.45
Average by Site	2.05	2.61	2.90	2.98	2.88	2.40	2.41

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***SYFL***	TMOK	TOOK	WPIN	# of Pairs	Average by Pollutant
Acetaldehyde	0.52	1.01	0.49	1.70	335	0.83
Acetone	0.99	1.28	0.40	1.65	335	0.73
Benzaldehyde	4.05	3.60	2.93	3.74	327	3.28
2-Butanone	3.90	2.37	1.82	2.51	315	2.41
Butyraldehyde	3.12	2.28	2.65	3.27	335	3.50
Crotonaldehyde	2.00	2.49	2.84	2.02	329	3.52
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	0	NA
Formaldehyde	1.62	0.91	0.46	1.44	335	1.07
Hexaldehyde	4.88	3.97	5.68	4.24	327	4.23
Isovaleraldehyde	NA	NA	NA	NA	0	NA
Propionaldehyde	1.90	3.69	3.42	3.88	335	2.90
Tolualdehydes	11.31	2.22	5.07	7.84	286	5.69
Valeraldehyde	3.48	3.90	3.42	4.09	333	3.87
Average by Site	3.43	2.52	2.65	3.31	--	2.91

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.3.4 PAH Analytical Precision

Table 30-12 presents analytical precision results from replicate analyses of collocated and select individual PAH samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the PAHs listed. The analytical precision results exhibit low- to mid-level variability, ranging from a CV of 0 percent (several pollutants at different sites) to 36.70 percent (pyrene for SDGA, although fluoranthene had a similar CV). The pollutant-specific average CV ranged from 1.56 percent (perylene) to 6.92 percent (acenaphthylene). The site-specific average CV ranged from 1.67 percent (UNVT) to 10.63 percent (SDGA). The overall average CV was 3.93 percent.

Table 30-12. PAH Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant

Pollutant	***BOMA***	***BTUT***	***BXNY***	***CELA***	***CHSC***	***DEMI***
Acenaphthene	1.60	5.42	2.37	1.14	4.23	2.81
Acenaphthylene	**21.41**	3.84	3.16	0.37	NA	3.61
Anthracene	0.77	4.43	2.57	1.90	NA	3.28
Benzo(a)anthracene	1.99	NA	6.13	NA	NA	2.73
Benzo(a)pyrene	1.90	NA	2.56	NA	NA	4.08
Benzo(b)fluoranthene	0.34	4.89	2.62	NA	NA	2.42
Benzo(e)pyrene	2.62	NA	3.64	NA	NA	4.06
Benzo(g,h,i)perylene	4.14	NA	1.71	NA	NA	2.08
Benzo(k)fluoranthene	4.01	NA	NA	NA	NA	8.81
Chrysene	1.31	4.29	0.75	NA	NA	1.38
Coronene	NA	NA	1.42	NA	NA	3.43
Cyclopenta[cd]pyrene	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	4.04
Fluoranthene	0.17	0.40	1.41	0.62	1.19	2.85
Fluorene	0.41	NA	1.27	2.57	0.00	2.62
9-Fluorenone	0.99	0.60	0.68	1.96	3.04	2.37
Indeno(1,2,3-cd)pyrene	4.60	NA	1.72	NA	NA	3.41
Naphthalene	3.54	10.99	6.90	11.40	2.53	2.09
Perylene	NA	NA	NA	NA	NA	1.90
Phenanthrene	0.98	1.18	0.81	1.99	1.41	1.67
Pyrene	2.64	0.74	1.95	0.73	0.27	2.99
Retene	NA	0.81	NA	4.88	5.01	3.86
Average by Site	3.14	3.42	2.45	2.75	2.21	3.17

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-12. PAH Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***GLKY***	**LBHCA**	***MONY***	***PRRI***	***PXSS***	***RIVA***
Acenaphthene	4.46	3.82	4.60	1.91	1.91	1.21
Acenaphthylene	1.01	NA	8.87	11.21	NA	5.00
Anthracene	4.66	NA	4.31	1.50	5.44	6.23
Benzo(a)anthracene	1.23	NA	NA	NA	NA	1.78
Benzo(a)pyrene	1.99	NA	NA	NA	NA	10.10
Benzo(b)fluoranthene	3.67	NA	NA	NA	NA	0.94
Benzo(e)pyrene	2.85	NA	NA	NA	NA	1.66
Benzo(g,h,i)perylene	3.42	NA	NA	NA	NA	2.15
Benzo(k)fluoranthene	3.03	NA	NA	NA	NA	8.71
Chrysene	5.18	4.71	3.50	1.39	5.46	5.24
Coronene	NA	NA	NA	NA	NA	4.63
Cyclopenta[cd]pyrene	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA
Fluoranthene	1.57	5.49	4.65	2.53	0.48	2.91
Fluorene	1.74	2.21	3.61	1.52	0.40	1.92
9-Fluorenone	1.72	3.67	4.98	1.99	1.50	2.57
Indeno(1,2,3-cd)pyrene	2.88	NA	9.08	6.43	NA	0.33
Naphthalene	2.67	5.33	2.73	3.11	1.05	0.47
Perylene	NA	NA	NA	NA	NA	NA
Phenanthrene	1.04	0.40	3.35	0.67	1.22	0.87
Pyrene	2.68	9.67	5.60	2.62	0.67	2.84
Retene	3.87	NA	NA	7.24	0.40	4.07
Average by Site	2.76	4.41	5.00	3.66	1.85	3.35

NA = No pairs with concentrations greater than or equal to the MDL.

BOLD ITALICS = EPA-designated NATTS Site

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-12. PAH Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***ROCH***	***RUCA***	***S4MO***	***SDGA***	***SEWA***	***SJJCA***
Acenaphthene	2.08	5.25	2.83	10.79	3.30	4.97
Acenaphthylene	NA	12.79	2.96	NA	10.69	NA
Anthracene	3.15	10.55	4.33	12.09	11.83	8.71
Benzo(a)anthracene	1.94	6.54	1.48	3.84	1.47	NA
Benzo(a)pyrene	2.02	4.92	7.42	3.11	3.06	NA
Benzo(b)fluoranthene	6.37	7.65	3.92	3.92	4.44	NA
Benzo(e)pyrene	1.69	4.48	1.41	2.24	4.40	NA
Benzo(g,h,i)perylene	2.55	2.30	4.80	3.32	5.24	NA
Benzo(k)fluoranthene	0.99	1.96	2.50	3.70	7.76	NA
Chrysene	3.55	5.41	2.31	5.06	3.62	9.56
Coronene	NA	0.46	2.68	4.86	5.35	NA
Cyclopenta[cd]pyrene	NA	NA	6.31	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	4.14	3.51	4.97	NA
Fluoranthene	3.87	2.85	1.51	**36.68**	3.35	3.15
Fluorene	2.11	3.30	3.22	**17.20**	3.46	2.58
9-Fluorenone	2.85	3.87	1.45	**17.58**	3.76	7.88
Indeno(1,2,3-cd)pyrene	8.57	3.40	5.38	6.87	1.40	NA
Naphthalene	1.93	12.77	4.75	2.74	2.28	1.18
Perylene	NA	NA	1.10	1.54	1.71	NA
Phenanthrene	1.15	1.91	1.04	**30.09**	1.56	2.42
Pyrene	4.89	3.51	1.33	**36.70**	3.65	1.31
Retene	8.37	6.59	1.45	6.77	3.27	NA
Average by Site	3.42	5.29	3.11	10.63	4.31	4.64

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-12. PAH Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***SKFL***	***SYFL***	***UNVT***	***WADC***	# of Pairs	Average by Pollutant
Acenaphthene	2.88	2.01	6.15	1.01	107	3.49
Acenaphthylene	7.79	4.22	NA	NA	45	6.92
Anthracene	7.57	7.31	NA	11.21	88	5.89
Benzo(a)anthracene	6.55	NA	NA	NA	41	3.76
Benzo(a)pyrene	3.71	NA	NA	NA	31	4.06
Benzo(b)fluoranthene	1.80	3.12	NA	0.00	78	3.18
Benzo(e)pyrene	4.91	1.77	NA	NA	43	2.85
Benzo(g,h,i)perylene	3.96	3.16	NA	NA	53	3.90
Benzo(k)fluoranthene	1.71	2.10	NA	NA	27	4.12
Chrysene	0.61	5.27	NA	5.03	98	3.88
Coronene	NA	NA	NA	NA	19	3.26
Cyclopenta[cd]pyrene	NA	NA	NA	NA	1	6.31
Dibenz(a,h)anthracene	NA	NA	NA	NA	7	4.17
Fluoranthene	1.75	2.50	2.52	0.88	110	3.79
Fluorene	0.79	3.28	0.00	4.56	109	2.80
9-Fluorenone	2.41	2.55	0.39	1.23	110	3.18
Indeno(1,2,3-cd)pyrene	3.66	3.93	NA	NA	43	4.40
Naphthalene	0.88	3.38	0.68	0.63	110	3.82
Perylene	NA	NA	NA	NA	6	1.56
Phenanthrene	1.17	1.23	0.27	0.50	110	2.59
Pyrene	2.34	3.29	NA	0.00	109	4.31
Retene	3.26	3.18	NA	NA	66	4.20
Average by Site	3.21	3.41	1.67	2.50	--	3.93

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.3.5 Metals Analytical Precision

Table 30-13 presents analytical precision results from replicate analyses of collocated and select individual metals samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV across the metals listed. The results from replicate analyses exhibit low- to mid-level variability among sites, ranging from a CV of 0 percent (beryllium for UNVT) to 28.61 percent (arsenic for UNVT). The pollutant-specific average CV ranged from 1.59 percent (antimony) to 9.19 percent (beryllium). The site-specific average CV ranged from 2.64 percent (SEWA) to 8.31 percent (UNVT). The overall average analytical precision was 4.94 percent.

Table 30-13. Metals Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant

Pollutant	ADOK	ASKY-M	BAKY	***BOMA***	***BTUT***	CCKY	***GLKY***
Antimony	3.09	0.95	0.61	1.41	0.85	1.19	1.70
Arsenic	4.08	9.57	4.53	2.56	13.63	11.93	13.68
Beryllium	3.45	8.70	**28.28**	7.55	11.15	NA	NA
Cadmium	2.09	3.37	3.13	5.70	3.86	6.14	9.67
Chromium	0.94	NA	NA	2.83	NA	NA	NA
Cobalt	1.29	3.36	3.72	5.14	5.43	8.31	**20.15**
Lead	**25.08**	1.25	1.02	1.42	0.48	0.58	0.75
Manganese	3.35	0.58	0.69	1.50	0.61	1.75	1.28
Mercury	6.73	9.62	NA	11.04	NA	NA	NA
Nickel	7.32	1.51	1.53	3.51	1.14	1.66	1.66
Selenium	2.04	10.65	10.52	3.17	NA	3.44	7.46
Average by Site	5.41	4.96	6.00	4.17	4.64	4.37	7.04

NA = No pairs with concentrations greater than or equal to the MDL.

BOLD ITALICS = EPA-designated NATTS Site

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-13. Metals Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	LEKY	***NBIL***	OCOK	PAFL	PROK	***PXSS***	***S4MO***
Antimony	0.75	1.31	3.57	2.97	1.82	2.79	1.16
Arsenic	8.11	1.50	2.51	3.15	3.88	14.26	9.16
Beryllium	11.11	10.63	3.61	7.69	4.34	12.98	**16.67**
Cadmium	3.27	1.63	1.57	4.18	9.83	6.81	4.49
Chromium	NA	1.98	3.29	NA	0.57	NA	NA
Cobalt	1.60	4.98	4.17	NA	5.04	4.61	**18.92**
Lead	3.09	2.38	5.91	1.62	2.18	3.09	0.97
Manganese	0.37	1.29	3.13	2.28	3.01	2.37	0.92
Mercury	NA	4.20	14.59	5.26	2.21	NA	7.14
Nickel	1.60	3.02	3.35	2.53	1.82	3.97	10.42
Selenium	11.14	1.43	2.66	4.14	3.40	NA	6.26
Average by Site	4.56	3.12	4.40	3.76	3.46	6.36	7.61

NA = No pairs with concentrations greater than or equal to the MDL.

BOLD ITALICS = EPA-designated NATTS Site

Green shading indicates the site-specific average CV for this method.

Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

Table 30-13. Metals Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site and Pollutant (Continued)

Pollutant	***SEWA***	***SJJCA***	TMOK	TOOK	***UNVT***	# of Pairs	Average by Pollutant
Antimony	0.45	1.38	1.99	1.46	0.84	425	1.59
Arsenic	1.16	4.60	1.66	2.48	**28.61**	420	7.42
Beryllium	NA	NA	7.44	4.22	0.00	224	9.19
Cadmium	3.34	7.66	12.28	3.37	**19.60**	436	5.89
Chromium	0.25	NA	2.47	1.64	NA	140	1.75
Cobalt	1.06	**23.86**	2.05	3.49	12.65	363	7.21
Lead	1.73	0.66	2.10	1.94	2.61	441	3.10
Manganese	1.84	0.67	3.31	1.66	1.01	441	1.66
Mercury	10.90	NA	2.77	6.44	NA	222	7.36
Nickel	1.22	1.37	10.54	2.65	1.19	373	3.26
Selenium	4.43	**18.74**	1.60	2.63	NA	375	5.86
Average by Site	2.64	7.37	4.38	2.91	8.31	--	4.94

NA = No pairs with concentrations greater than or equal to the MDL.
BOLD ITALICS = EPA-designated NATTS Site
Green shading indicates the site-specific average CV for this method.
Orange shading indicates the pollutant-specific average CV; the overall average CV for this method is calculated from the pollutant-specific averages and is provided in the final column of the table.

30.3.6 Hexavalent Chromium Analytical Precision

Table 30-14 presents analytical precision results from replicate analyses of collocated and select individual hexavalent chromium samples as the CV per site and the overall average CV for hexavalent chromium. The range of variability for hexavalent chromium was 0.46 percent (STMN) to 11.97 percent (GLKY), with an overall average analytical precision of 6.65 percent.

Table 30-14. Hexavalent Chromium Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site

Site	Average CV (%)
BOMA	5.03
BTUT	8.84
BXNY	10.50
CAMS 35	3.46
CAMS 85	4.34
CHSC	8.01
DEMI	4.77
GLKY	11.97
GPCO	10.69
HOWI	10.03
MIWI	8.27
MONY	4.66
NBIL	5.75
PRRI	7.51
PXSS	4.29
RIVA	7.99
ROCH	4.01
S4MO	6.13
SDGA	5.60
SEWA	4.70
SKFL	9.27
STMN	0.46
SYFL	5.64
UNVT	7.30
WADC	7.06
# of Pairs	223
Average by Site	6.65

BOLD ITALICS = EPA-designated NATTS Site

Orange shading indicates the average CV for this method.

30.4 Accuracy

Laboratories typically evaluate their accuracy (or bias) by analyzing audit samples that are prepared by an external source. The pollutants and the respective concentrations of the audit samples are unknown to the laboratory. The laboratory analyzes the samples and the external source compares the measured concentrations to the reference concentrations of those audit samples and calculates a percent difference. Accuracy, or bias, indicates the extent to which experimental measurements represent their corresponding “true” or “actual” values.

Laboratories participating in the NATTS program are provided with proficiency test (PT) audit samples for VOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, which are used to quantitatively measure analytical accuracy. However, due to a change in the external source for the NATTS program in 2012, PT samples were not supplied for all methods within the calendar year. For these methods, internal audit samples were prepared by task leaders and analyzed by a separate analyst. Thus, Tables 30-15 through 30-20 present ERG’s results for both internal and external audit samples. Results for internal audit samples are provided for VOCs and carbonyl compounds. Results for externally prepared NATTS PT audit samples are provided for PAHs and metals. Results for both internal and external audit samples are provided for hexavalent chromium. The program MQO for the percent difference from the true value is ± 25 percent, and the values exceeding this criterion are bolded in the tables. The percent difference calculation is:

$$\text{Percent Difference} = \frac{X_1 - X_2}{X_2} \times 100$$

Where:

X_1 is the analytical result from the laboratory;
X_2 is the true concentration of the audit sample

Note that for the PAH results in Table 30-17, the difference from the “true” value is based on the mean value of all the participating laboratories’ results rather than the “true” value from the external source.

The results of the audit samples show that few of the pollutants for which audit samples were analyzed exceed the MQO for accuracy. Of the 90 results provided in Tables 30-15 through Table 30-20, only two exceed ± 25 percent. The two that exceeded ± 25 percent

(1,2,4-trichlorobenzene and acetone) were internal audit samples. More than 60 percent of the results were less than 10 percent different from the true value.

Table 30-15. VOC Internal PT Audit Samples-Percent Difference from True Value

Pollutant	October 2012
Acetonitrile	-13.8
Acetylene	-23.6
Acrolein	-4.6
Acrylonitrile	-13.2
tert-Amyl Methyl Ether	-14.2
Benzene	0.6
Bromochloromethane	-1.1
Bromodichloromethane	5.5
Bromoform	-7.3
Bromomethane	-2.2
1,3-Butadiene	-12.0
Carbon Disulfide	-3.5
Carbon Tetrachloride	1.5
Chlorobenzene	-2.7
Chloroethane	-3.0
Chloroform	-1.3
Chloromethane	-3.4
Chloroprene	-9.4
Dibromochloromethane	-3.7
1,2-Dibromoethane	-5.2
m-Dichlorobenzene	-8.5
o-Dichlorobenzene	-10.5
p-Dichlorobenzene	-10.2
Dichlorodifluoromethane	-4.3
cis-1,2-Dichloroethylene	-1.3
trans-1,2-Dichloroethylene	-4.6
1,1-Dichloroethane	-2.9
1,1-Dichloroethene	-3.2
1,2-Dichloroethane	-3.2
Dichloromethane	-1.8
1,2-Dichloropropane	3.0
cis-1,3-Dichloropropene	-8.0
trans-1,3-Dichloropropene	-15.2
Dichlorotetrafluoroethane	-0.8
Ethyl Acrylate	-15.0
Ethyl *tert*-Butyl Ether	-20.3
Ethylbenzene	-13.3
Hexachloro-1,3-butadiene	-16.2

Table 30-15. VOC Internal PT Audit Samples-Percent Difference from True Value (Continued)

Pollutant	October 2012
Methyl Isobutyl Ketone	-12.2
Methyl Methacrylate	-13.4
Methyl *tert*-Butyl Ether	-17.9
n-Octane	-12.8
Propylene	-8.3
Styrene	-17.0
Tetrachloroethylene	0.3
Toluene	-10.1
1,2,4-Trichlorobenzene	**-28.2**
1,1,1-Trichloroethane	-1.1
1,1,2-Trichloroethane	4.7
Trichloroethylene	5.9
Trichlorofluoromethane	-2.2
Trichlorotrifluoroethane	-4.6
1,2,4-Trimethylbenzene	-22.3
1,3,5-Trimethylbenzene	-21.2
1,1,2,2-Tetrachloroethane	-5.4
Vinyl Chloride	-2.2
m,p-Xylene	-15.5
o-Xylene	-13.7

Table 30-16. Carbonyl Compound Internal PT Audit Sample-Percent Difference from True Value

Pollutant	September 2012
Acetaldehyde	-9.4
Acetone	**27.7**
Benzaldehyde	4.9
2-Butanone	-5.6
Butyraldehyde	-3.5
Crotonaldehyde	-9.5
2,5-Dimethylbenzaldehyde	-16.9
Formaldehyde	-6.9
Hexaldehyde	-21.4
Isovaleraldehyde	-20.8
Propionaldehyde	-22.5
Tolualdehydes	-9.7
Valeraldehyde	-9.3

Table 30-17. PAH NATTS PT Audit Samples-Percent Difference from Mean

Pollutant	February 2012
Acenaphthene	9.5
Anthracene	3.9
Benzo(a)pyrene	0.2
Fluoranthene	-1.3
Fluorene	5.1
Naphthalene	15.5
Phenanthrene	-1.9
Pyrene	-1.1

Table 30-18. Metals NATTS PT Audit Samples-Percent Difference from True Value

Pollutant	February 2012
Arsenic	9.1
Beryllium	8.9
Cadmium	10.4
Cobalt	13.0
Lead	6.1
Manganese	11.2
Nickel	12.2
Selenium	14.3

Table 30-19. Hexavalent Chromium NATTS PT Audit Samples-Percent Difference from True Value

Pollutant	February 2012
Hexavalent Chromium	2.7

Table 30-20. Hexavalent Chromium Internal PT Audit Samples-Percent Difference from True Value

Pollutant	December 2012	
	Concentration #1	Concentration #2
Hexavalent Chromium	8.2	15.2

In mid-2012, ERG's use of the ICP/MS to analyze speciated metals, in particular lead, was approved as a Federal Equivalent Method (FEM) for the sampling and analysis of lead for adherence to the National Ambient Air Quality Standards (NAAQS) (EPA 2012a). This approval requires additional quality assurance steps, including the analysis of quarterly audit strips. Table 30-21 provides the results of the quarterly NAAQS audit results for lead for ERG. All results are within the ± 25 percent MQO.

Table 30-21. NAAQS Lead PT Audit Samples-Percent Difference from True Value for Multiple Concentrations

Pollutant	June 2012		September 2012		December 2012	
	Concentration #1	Concentration #2	Concentration #1	Concentration #2	Concentration #1	Concentration #2
Lead	-14.9	-5.7	-10.6	-4.8	-12.5	-14.5
Lead	-13.6	-6.4	-4.8	-6.0	-7.6	-8.5
Lead	-12.4	-5.6	-6.3	-5.2	-10.9	-11.2

The accuracy of the 2012 monitoring data can also be assessed qualitatively by reviewing the accuracy of the monitoring methods and how they were implemented:

- The sampling and analytical methods used in the 2012 monitoring effort have been approved by EPA for accurately measuring ambient levels of various pollutants - an approval that is based on many years of research into the development of ambient air monitoring methodologies.

- When collecting and analyzing ambient air samples, all field sampling staff and laboratory analysts are required to strictly adhere to quality control and quality assurance guidelines detailed in the respective monitoring methods. This strict adherence to the well-documented sampling and analytical methods suggests that the 2012 monitoring data accurately represent ambient air quality.

31.0 Results, Conclusions, and Recommendations

The following discussion summarizes the results of the data analyses contained in this report, renders conclusions based on those results, and presents recommendations applicable to future air monitoring efforts. As demonstrated by the results of the data analyses discussed throughout this report, NMP data offer a wealth of information for assessing air quality by evaluating trends, patterns, correlations, and the potential for health risk and should ultimately assist a wide range of audiences understand the complex nature of air pollution.

31.1 Summary of Results

Analyses of the 2012 monitoring data identified the following notable results, observations, trends, and patterns in the program-level and state- and site-specific air monitoring data.

31.1.1 National-level Results Summary

- *Number of participating sites.* Twenty-six of the 64 monitoring sites are EPA-designated NATTS sites (BOMA, BTUT, BXNY, CAMS 35, CAMS 85, CELA, CHSC, DEMI, GLKY, GPCO, HOWI, MONY, NBIL, PRRI, PXSS, RIVA, ROCH, RUCA, S4MO, SDGA, SEWA, SJJCA, SKFL, SYFL, UNVT, and WADC). Thirty-seven UATMP sites participated in 2012. Data from one CSATAM site (LBHCA) are included in the 2012 NMP report.

- *Total number of samples collected and analyzed.* Over 9,600 samples were collected yielding 233,600 valid measurements of air toxics.

- *Detects.* The detection of a given pollutant is subject to the sensitivity limitation associated with the analytical methods used and the limitations of the instruments. Simply stated, an MDL is the lowest concentration of a target pollutant that can be measured and reported with 99 percent confidence that the pollutant concentration is greater than zero. Approximately 53 percent of the reported measurements were greater than the associated MDLs. Each of the 171 pollutants monitored were detected at least once over the course of the 2012 monitoring effort. Quantification below the MDL is possible; these results are considered valid measurements and are therefore incorporated into the data analyses. These measurements account for 11 percent of concentrations. Non-detects account for the remaining 36 percent of results.

- *Program-level Pollutants of Interest.* The pollutants of interest at the program-level are based on the number of exceedances, or "failures," of the risk screening values. Thirty-eight pollutants failed at least one risk screening value; of those pollutants, 15 were identified as program-level pollutants of interest.

- *Noncancer Risk-Based Screening using ATSDR MRLs*. All of the preprocessed daily measurements for which an MRL is available were less than the associated ATSDR acute MRLs. Additionally, all of the quarterly or annual average concentrations of the pollutants with available MRLs were less than the associated ATSDR intermediate or chronic MRLs.

- *Mobile Sources.* Site-specific hydrocarbon concentrations had positive correlations with county-level motor vehicle ownership data, traffic data, and VMT data. While these correlations were not "strong", they do indicate that hydrocarbon concentrations tend to increase with increasing motor vehicle activity data.

- *Seasonal Trends.* Formaldehyde concentrations tended to be highest during the third quarter of 2012, or during the period from July to September. Acenaphthene, acetaldehyde, and fluorene concentrations exhibit a similar pattern. Conversely, benzene concentrations tended to be higher during the first or fourth quarters of the year, or between January through March and October through December. Concentrations of 1,3-butadiene tended to be higher during the fourth quarter of the year, or from October to December. Arsenic concentrations for TSP metals tended to be highest during the second quarter of 2012, during the period from April to June (note however, that all of the sites monitoring TSP metals are located in Oklahoma).

31.1.2 State-level Results Summary

Arizona.

- The Arizona monitoring sites are located in Phoenix. PXSS is a NATTS site; SPAZ is a UATMP site.

- PXSS sampled for VOCs, carbonyl compounds, PAHs, metals (PM_{10}), and hexavalent chromium. SPAZ sampled for VOCs only.

- Twenty-one pollutants failed screens for PXSS, 12 of which contributed to 95 percent of failed screens. PXSS failed the second highest number of screens among all NMP sites. Seven pollutants failed screens for SPAZ, six of which contributed to 95 percent of failed screens.

- Of the pollutants of interest for PXSS, formaldehyde had the highest annual average concentration, followed by acetaldehyde and benzene. These are the only pollutants of interest with annual average concentrations greater than 1 $\mu g/m^3$.

- Benzene had the highest annual average concentration for SPAZ, and was the only pollutant with an annual average concentration greater than 1 $\mu g/m^3$.

- PXSS had the highest annual average concentration of acetaldehyde and second highest annual average concentrations of 1,3-butadiene, *p*-dichlorobenzene, and manganese among NMP sites sampling these pollutants.

- SPAZ had the highest annual average concentrations of 1,3-butadiene and *p*-dichlorobenzene and the second highest annual average concentrations of benzene and ethylbenzene among NMP sites sampling these pollutants.

- Sampling for the site-specific pollutants of interest has occurred at PXSS and SPAZ for at least 5 consecutive years; thus, a trends analysis was conducted for each site for the site-specific pollutants of interest. The most significant changes in recent years are in the nickel concentrations measured at PXSS, which have been increasing over the last few years. The detection rate of 1,2-dichloroethane at both sites has been steadily increasing over the years, with a significant increase for 2012 at both sites.

- Formaldehyde and benzene had the highest cancer risk approximations for PXSS and benzene had the highest cancer risk approximation for SPAZ. These are the only pollutants of interest with cancer risk approximations greater than 10 in-a-million. None of the pollutants of interest for either site had a noncancer hazard approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Maricopa County, while toluene was the highest emitted pollutant with a noncancer toxicity factor. Formaldehyde had the highest cancer toxicity-weighted emissions, while acrolein had the highest noncancer toxicity-weighted emissions for Maricopa County.

California.

- The four California monitoring sites are located in Los Angeles (CELA), Long Beach (LBHCA), Rubidoux (RUCA), and San Jose (SJJCA). CELA, RUCA, and SJJCA are NATTS sites; LBHCA is a CSATAM site.

- CELA, LBHCA, and RUCA sampled for PAHs only. SJJCA sampled for PAHs and metals (PM_{10}).

- Naphthalene failed the majority of screens at CELA, LBHCA, and RUCA. Naphthalene and arsenic contributed almost equally to the total number of failed screens at SJJCA, together accounting for nearly 70 percent of failed screens at the site.

- Naphthalene had the highest annual average concentration for each site. The annual average concentration of naphthalene for CELA was the second highest compared to NMP sites sampling PAHs. Annual average concentrations could not be calculated for LBHCA because sampling did not begin until July 2012.

- Sampling for the site-specific pollutants of interest has occurred at CELA, RUCA, and SJJCA for at least 5 consecutive years; thus, a trends analysis was conducted for each site for the site-specific pollutants of interest. Concentrations of naphthalene and fluorene increased at CELA for 2012; naphthalene concentrations have been increasing at RUCA as well. Concentrations of manganese and nickel measured at SJJCA increased significantly between 2010 and 2011.

- Of the pollutants of interest for each site, naphthalene exhibited the highest cancer risk approximation for all three California sites. The noncancer hazard approximation for each pollutant of interest was considerably less than 1.0 for all three sites.

- Formaldehyde was the highest emitted pollutant with a cancer toxicity factor in Los Angeles, Riverside, and Santa Clara Counties; formaldehyde also had the highest cancer toxicity-weighted emissions for Los Angeles and Riverside Counties while POM, Group 1a had the highest cancer toxicity-weighted emissions for Santa Clara County.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in Los Angeles, Riverside, and Santa Clara Counties, while acrolein had the highest noncancer toxicity-weighted emissions for all three counties.

Colorado.

- The NATTS site in Colorado is located in Grand Junction (GPCO). There are also five UATMP sites located northeast of Grand Junction in Garfield County. The sites are located in the towns of Battlement Mesa (BMCO), Silt (BRCO), Parachute (PACO), Carbondale (RFCO), and Rifle (RICO).

- GPCO sampled for VOCs, carbonyl compounds, PAHs, and hexavalent chromium. The Garfield County sites sampled for SNMOCs and carbonyl compounds.

- Nineteen pollutants failed at least one screen for GPCO, 13 of which contributed to 95 percent of failed screens. The number of pollutants that failed screens for the Garfield County sites ranged from four (BRCO and RFCO) to five (BMCO, PACO, and RICO).

- Of the pollutants of interest for GPCO, dichloromethane had the highest annual average concentration, which was an order of magnitude higher than the next highest annual average concentration.

- Formaldehyde had the highest annual average concentration for three of the Garfield County sites (BRCO, PACO, and RICO). Although benzene had the highest annual average for BMCO, it should be noted that annual averages could not be calculated for the carbonyl compounds for this site. Annual average concentrations could not be calculated for RFCO because sampling did not begin until June 2012.

- GPCO had the highest annual average concentrations of naphthalene, acenaphthene, and fluorene among NMP sites sampling PAHs. GPCO also had the second highest annual average concentrations of 1,2-dichloroethane and acetaldehyde among all NMP sites sampling these pollutants.

- Sampling for the site-specific pollutants of interest has occurred at GPCO, BRCO, PACO, and RICO for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Benzene concentrations at GPCO have an overall decreasing trend across the years of sampling, as do benzene concentrations measured at BRCO and, in more recent years, RICO. Concentrations of *p*-dichlorobenzene have an increasing trend at GPCO. The range of concentrations of naphthalene, fluorene, and acenaphthene measured at GPCO exhibit significant increases for 2012. In addition, the detection rate of 1,2-dichloroethane at GPCO has been increasing steadily over the last few years of sampling, particularly for 2012.

- Formaldehyde had the highest cancer risk approximation for each of the Colorado sites, where an annual average could be calculated. All noncancer hazard approximations were less than 1.0 for all five Colorado sites, where noncancer risk approximations could be calculated.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Mesa County, while formaldehyde was the highest emitted pollutant with a cancer toxicity factor in Garfield County. Formaldehyde had the highest cancer toxicity-weighted emissions for both counties.

- While toluene was the highest emitted pollutant with a noncancer toxicity factor for both Mesa and Garfield Counties, acrolein had the highest noncancer toxicity-emissions.

District of Columbia.

- The Washington, D.C. monitoring site (WADC) is a NATTS site.

- WADC sampled for hexavalent chromium and PAHs. Naphthalene accounted for over 97 percent of failed screens for this site and was the only pollutant identified as a pollutant of interest.

- The annual average concentration of naphthalene for WADC was fifth highest annual average concentration among NMP sites sampling this pollutant.

- Sampling for the site-specific pollutants of interest has occurred at WADC for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of naphthalene have not change significantly since the onset of PAH sampling at WADC.

- The cancer risk approximation for naphthalene was 3.55 in-a-million. The noncancer risk approximation for naphthalene was considerably less than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in the District of Columbia, while toluene was the highest emitted pollutant with a noncancer toxicity factor. Formaldehyde had the highest cancer toxicity-weighted emissions, while acrolein had the highest noncancer toxicity-weighted emissions in the District.

Florida.

- Three of the Florida monitoring sites are located in the Tampa-St. Petersburg-Clearwater MSA (SYFL, AZFL, and SKFL) and two are located in the Orlando-Kissimmee-Sanford MSA (ORFL and PAFL). SKFL and SYFL are NATTS sites while the other three are UATMP sites.

- AZFL and ORFL sampled for carbonyl compounds only. SKFL and SYFL sampled for hexavalent chromium and PAHs in addition to carbonyl compounds. PAFL sampled for only metals (PM_{10}).

- Acetaldehyde and formaldehyde were the only pollutants to fail screens for AZFL and ORFL, where only carbonyl compounds were sampled. Eight pollutants failed screens for SKFL and five pollutants failed screens for SYFL. Arsenic, manganese and lead failed screens for PAFL, where only metals were sampled.

- Formaldehyde had the highest annual average concentrations for each of the Florida sites where carbonyl compounds were sampled. The annual average concentration of naphthalene for SKFL was more than twice the annual average concentration of naphthalene for SYFL and ranked eighth highest among NMP sites sampling this pollutant. The annual average concentration of arsenic for PAFL is the third highest among NMP sites sampling PM_{10} metals.

- Sampling for the site-specific pollutants of interest has occurred at the Florida sites for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of formaldehyde have an overall decreasing trend at ORFL. A similar trend in formaldehyde concentrations is shown at SKFL until recent years where an increasing trend is shown. Concentrations of acetaldehyde decreased significantly between 2010 and 2012 at AZFL and SKFL with a significant decrease also shown at ORFL from 2011 and 2012. Acetaldehyde concentrations at SYFL increased significantly from 2011 to 2012. Concentrations of naphthalene have not changed significantly at SKFL or SYFL. Both arsenic and manganese exhibit increases at PAFL from 2011 to 2012.

- For the Florida sites sampling carbonyl compounds, formaldehyde had the highest cancer risk approximations. Arsenic had the highest cancer risk approximation for PAFL. All noncancer hazard approximations for the pollutants of interest for the Florida sites were less than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in all three Florida counties. Benzene also had the highest cancer toxicity-weighted emissions for Pinellas County, while formaldehyde had the highest cancer toxicity-weighted emissions for Hillsborough County, and hexavalent chromium had the highest cancer toxicity-weighted emissions for Orange County.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in all three Florida counties. Acrolein had the highest noncancer toxicity-weighted emissions for all three counties.

Georgia.

- The SDGA monitoring site located in Decatur, east of Atlanta, is a NATTS site.

- SDGA sampled for PAHs and hexavalent chromium, although sampling for PAHs was discontinued in June. Naphthalene, hexavalent chromium, and benzo(a)pyrene failed screens for SDGA, with naphthalene accounting for the majority of the total failed screens.

- Hexavalent chromium was the only pollutant of interest for which an annual average concentration could be calculated.

- Sampling for the site-specific pollutants of interest has occurred at SDGA for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. This analysis shows that concentrations of hexavalent chromium have not changed significantly at SDGA over the last few years of sampling.

- The cancer risk approximation for hexavalent chromium for SDGA was considerably less than 1 in-a-million. Hexavalent chromium’s noncancer hazard approximation for SDGA was considerably less than an HQ of 1.0.

- Tetrachloroethylene was the highest emitted pollutant with a cancer and noncancer toxicity factor in DeKalb County. Formaldehyde had the highest cancer toxicity-weighted emissions, while acrolein had the highest noncancer toxicity-weighted emissions for DeKalb County.

Illinois.

- Two Illinois monitoring sites are located near Chicago. NBIL is a NATTS site located in Northbrook and SPIL is a UATMP site located in Schiller Park. A third site, ROIL, is located in Roxana, near St. Louis.

- All three Illinois sites sampled for VOCs and carbonyl compounds. NBIL also sampled for SNMOCs, PAHs, hexavalent chromium, and metals (PM_{10}), and is one of two NMP sites sampling all six pollutant groups.

- Twenty-two pollutants failed screens for NBIL; 13 pollutants failed screens for SPIL; and 11 pollutants failed screens for ROIL.

- Of the pollutants of interest for NBIL and SPIL, formaldehyde and acetaldehyde had the highest annual average concentrations. Annual averages could not be calculated for ROIL due to the short sampling duration. The maximum acetaldehyde and formaldehyde concentrations across the program were measured at SPIL. This was also true of trichloroethylene.

- NBIL had the second highest annual average concentration of fluorene among NMP sites sampling PAHs. The maximum fluorene and fluoranthene concentrations across the program were measured at NBIL.

- Sampling for the site-specific pollutants of interest has occurred at NBIL and SPIL for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. This analysis shows that concentrations of acetaldehyde and manganese have an increasing trend at NBIL in recent years. In addition, the detection rate of 1,2-dichloroethane at both NBIL and SPIL has been increasing steadily over the last few years of sampling, particularly for 2012.

- Formaldehyde had the highest cancer risk approximation for both NBIL and SPIL. All noncancer hazard approximations for the pollutants of interest for the Chicago sites were less than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Cook County, while coke oven emissions was the highest emitted “pollutant” with a cancer toxicity factor in Madison County. Toluene was the highest emitted pollutant with a noncancer toxicity factor for both counties, while acrolein had the highest noncancer toxicity-weighted emissions for both counties.

Indiana.

- There are two Indiana monitoring sites, one located in Indianapolis (WPIN) and a second located in Gary, near Chicago (INDEM). Both are UATMP sites.

- WPIN and INDEM sampled for carbonyl compounds only.

- Formaldehyde and acetaldehyde failed screens for both INDEM and WPIN; propionaldehyde also failed a single screen for WPIN.

- Formaldehyde had the highest annual average concentration for both sites, although concentrations were higher at WPIN than INDEM. WPIN’s annual average concentration of formaldehyde is the second highest annual average for this pollutant among NMP sites sampling carbonyl compounds.

- Sampling for the site-specific pollutants of interest has occurred at WPIN and INDEM for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. The most significant changes shown are for INDEM. Both acetaldehyde and formaldehyde decreased dramatically at INDEM between 2008 and 2009, with little change since. These changes appear to be related to a sampler contamination issue that was subsequently corrected.

- The cancer risk approximations for formaldehyde were an order of magnitude greater than the cancer risk approximations for acetaldehyde for both sites. WPIN's cancer risk approximation for formaldehyde is the second highest cancer risk approximation calculated across the program.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in both Marion and Lake Counties. Coke oven emissions (PM) had the highest cancer toxicity-weighted emissions for Lake County while formaldehyde had the highest cancer toxicity-weighted emissions for Marion County.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in both Lake and Marion Counties while acrolein had the highest noncancer toxicity-weighted emissions for both counties.

Kentucky.

- Three Kentucky monitoring sites are located in northeast Kentucky, two in Ashland (ASKY and ASKY-M) and one near Grayson Lake (GLKY). The Grayson Lake monitoring site is a NATTS site. One monitoring site is located south of Evansville, Indiana (BAKY). Five monitoring sites are located in or near the Calvert City area (ATKY, CCKY, BLKY, LAKY, and TVKY). The final monitoring site is located in Lexington, in north-central Kentucky (LEKY).

- Four monitoring sites (ASKY-M, BAKY, CCKY, and LEKY) began sampling PM_{10} metals under the NMP in March 2012. Two monitoring sites (ASKY and LEKY) began sampling carbonyl compounds in July. Seven monitoring sites also began sampling VOCs in July. GLKY sampled VOCs, PAHs, carbonyl compounds, PM_{10} metals and hexavalent chromium year-round.

- The number of pollutants failing screens for the Kentucky sites varies from three (BAKY) to 15 (LEKY).

- Because the start dates for sampling were staggered, annual average concentrations could only be calculated for GLKY and those Kentucky sites sampling PM_{10} metals.

- The annual average concentrations for arsenic, manganese, lead, and nickel calculated for ASKY-M were the highest annual averages among NMP sites sampling PM_{10} metals. The Kentucky sites have five of the 10 highest annual average concentrations of arsenic among NMP sites; four of the highest annual average concentrations of manganese; and two of the highest annual average concentrations of nickel.

- The Calvert city sites measured some of the highest concentrations of the VOCs, particularly vinyl chloride, 1,2-dichloroethane, and carbon tetrachloride.

- The highest cancer risk approximation (among the pollutants of interest for which cancer risk approximations could be calculated) was calculated for formaldehyde for GLKY. None of the pollutants of interest for which noncancer hazard approximations could be calculated were greater than 1.0. The noncancer hazard approximation for manganese for ASKY-M was the second highest noncancer hazard approximation calculated across the program.

- Benzene and formaldehyde were the highest emitted pollutants with cancer toxicity factors in all Kentucky counties with NMP sites, except Marshall County. Benzene and ethylbenzene were the highest emitted pollutants with cancer toxicity factors in Marshall County. Coke oven emissions and emissions of formaldehyde, benzene, and POM Group 1a were among the pollutants with the highest cancer toxicity-weighted emissions for the Kentucky counties with monitoring sites. Toluene was the highest emitted pollutant with a noncancer toxicity factor in all Kentucky counties with NMP sites, except Marshall County, where methanol emissions were higher than toluene emissions. Acrolein had the highest noncancer toxicity-weighted emissions in four of the Kentucky counties, but ranked second in Boyd County (behind manganese) and Marshall County (behind chlorine).

Massachusetts.

- The Massachusetts monitoring site (BOMA) is a NATTS site located in Boston.

- BOMA sampled for metals (PM_{10}), PAHs, and hexavalent chromium.

- Nine pollutants failed screens for BOMA. Arsenic and naphthalene each accounted for roughly 40 percent of the site's failed screens.

- Of the pollutants of interest, naphthalene had the highest annual average concentration.

- BOMA had the fifth highest annual average concentration of nickel among NMP sites sampling PM_{10} metals.

- Sampling for the site-specific pollutants of interest has occurred at BOMA for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of nickel have an overall decreasing trend at BOMA over the years of sampling.

- The only pollutants of interest with cancer risk approximations greater than 1.0 in-a-million were arsenic and naphthalene. None of the pollutants of interest for BOMA had noncancer hazard approximations greater than 1.0.

- Formaldehyde was the highest emitted pollutant with a cancer toxicity factor in Suffolk County and had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor in Suffolk County, while acrolein had the highest noncancer toxicity-weighted emissions.

Michigan.

- The three Michigan monitoring sites are located in the Detroit area. DEMI is a NATTS site located in Dearborn. RRMI and SWMI are UATMP sites located in River Rouge and Detroit, respectively.

- All three Michigan sites sampled carbonyl compounds; DEMI also sampled VOCs, PAHs, and hexavalent chromium.

- Twenty-two pollutants failed screens for DEMI. Acetaldehyde and formaldehyde both failed screens for RRMI and SWMI, contributing equally to the total number of failed screens for each site.

- Formaldehyde had the highest annual average concentration for DEMI and SWMI. Annual average concentrations could not be calculated for RRMI due to a collection error that lead to the invalidation of 3 months of data.

- Compared to other NMP sites, DEMI had the highest annual average concentration of carbon tetrachloride among sites sampling VOCs. DEMI also had the second highest annual average concentration of acenaphthene and third highest annual averages of fluorene and naphthalene among NMP sites sampling PAHs.

- Sampling for the site-specific pollutants of interest has occurred at DEMI for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. The most notable trend is for benzene. Benzene concentrations exhibit a steady decreasing trend although concentrations have leveled out in recent years. In addition, the detection rate of 1,2-dichloroethane at DEMI has been increasing steadily over the last few years of sampling, particularly for 2012.

- Formaldehyde had the highest cancer risk approximation for DEMI and SWMI. None of the pollutants of interest for the Michigan sites had a noncancer hazard approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Wayne County, while coke oven emissions had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor in Wayne County, while acrolein had the highest noncancer toxicity-weighted emissions.

Minnesota.

- The UATMP site in Minnesota (STMN) is located in St. Cloud.

- STMN sampled only hexavalent chromium.

- Hexavalent chromium failed six screens for STMN.

- Measured detections of hexavalent chromium span three orders of magnitude, ranging from 0.0044 ng/m^3 to 8.51 ng/m^3, including 15 non-detects.

- The maximum hexavalent chromium concentration measured at STMN is the single highest concentration measured under the NMP since this method was added to the program in 2005.

- The cancer risk approximation for STMN for hexavalent chromium was the highest cancer risk approximation calculated for this pollutant among NMP sites sampling hexavalent chromium. The noncancer hazard approximation for hexavalent chromium for STMN was still considerably less than 1.0.

- Bis(2-ethylhexyl)phthalate (DEHP), gas was the highest emitted pollutant with a cancer toxicity factor in Stearns County, while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor in Stearns County, while acrolein had the highest noncancer toxicity-weighted emissions.

Missouri.

- The NATTS site in Missouri (S4MO) is located in St. Louis.

- S4MO sampled for VOCs, carbonyl compounds, PAHs, metals (PM_{10}), and hexavalent chromium.

- Twenty-four pollutants failed at least one screen for S4MO, 17 of which contributed to 95 percent of failed screens. S4MO failed the greatest number of screens among NMP sites.

- Of the pollutants of interest for S4MO, formaldehyde and acetaldehyde had the highest annual average concentrations and were the only pollutants with annual average concentrations greater than 1 µg/m^3.

- S4MO had the highest annual average concentration of 1,2-dichloroethane, the second highest annual average concentrations of hexachloro-1,3-butadiene and arsenic, and the third highest annual average concentrations of *p*-dichlorobenzene and manganese among NMP sites sampling these pollutants.

- Sampling for the site-specific pollutants of interest has occurred at S4MO for at least 5 consecutive years; thus, a trends analysis was conducted for each of the site-specific pollutants of interest. The most significant changes in recent years are in the acetaldehyde concentrations, which have decreased significantly since 2010. The detection rate of 1,2-dichloroethane has been steadily increasing over the years, with a significant increase for 2012.

- Formaldehyde had the highest cancer risk approximation for S4MO. None of the pollutants of interest for S4MO had a noncancer hazard approximation greater than 1.0.

- Formaldehyde was the highest emitted pollutant with a cancer toxicity factor in St. Louis (city) and had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor, while acrolein had the highest noncancer toxicity-weighted emissions in St. Louis (city).

New Jersey.

- The three UATMP sites in New Jersey are located in Chester (CHNJ), Elizabeth (ELNJ), and North Brunswick (NBNJ).

- CHNJ, ELNJ, and NBNJ sampled for VOCs and carbonyl compounds.

- Thirteen pollutants failed at least one screen for CHNJ; 14 pollutants failed at least one screen for ELNJ; and 12 pollutants failed screens for NBNJ.

- Of the site-specific pollutants of interest, formaldehyde had the highest annual average concentration for CHNJ, ELNJ, and NBNJ.

- NBNJ had the highest annual average concentration of hexachloro-1,3-butadiene among NMP sites sampling VOCs. ELNJ had the fourth highest annual average concentration of formaldehyde and fifth highest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds.

- Sampling for the site-specific pollutants of interest has occurred at each of the New Jersey for at least 5 consecutive years; specifically, ELNJ is the longest running NMP site still participating in the program. As such, a trends analysis was conducted for the site-specific pollutants of interest. The most notable trend is for propionaldehyde at ELNJ. Concentrations of propionaldehyde measured at ELNJ have a steady increasing trend at this site. In addition, the detection rate of 1,2-dichloroethane at all three New Jersey sites has been increasing steadily over the last few years of sampling, particularly for 2012.

- Formaldehyde had the highest cancer risk approximation for CHNJ, ELNJ, and NBNJ. None of the pollutants of interest for any of the New Jersey sites had noncancer hazard approximations greater than 1.0.

- Tetrachloroethylene was the highest emitted pollutant with a cancer URE in Union, Middlesex, and Morris Counties. Formaldehyde also had the highest toxicity-weighted emissions for Union and Middlesex Counties while benzene had the highest toxicity-weighted emissions for Morris County.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in Morris County, while tetrachloroethylene was the highest emitted pollutant with a noncancer toxicity factor in Union and Middlesex Counties. Acrolein had the highest noncancer toxicity-weighted emissions for each New Jersey county.

New York.

- The New York City monitoring sites are located in New York City (BXNY and MONY) and Rochester (ROCH). All are NATTS monitoring sites.

- The instrumentation at BXNY were relocated to MONY due to roofing construction in 2010. At the end of June 2012, the instrumentation was returned to the BXNY site and sampling resumed at this location in July 2012. Thus, this report includes the final 6 months of sampling at MONY and the initial 6 months of sampling after the relocation back to BXNY.

- PAHs and hexavalent chromium were sampled at all three New York monitoring sites.

- Five pollutants failed screens for BXNY, five pollutants failed screens for MONY, and four pollutants failed screens for ROCH. Naphthalene failed the majority of screens for all three sites.

- Naphthalene had the highest annual average concentration for ROCH. Sampling at MONY ended in June, and sampling BXNY began in July. As a result, annual average concentrations were not calculated for these two sites.

- ROCH has the third highest annual average concentration of acenaphthene and fourth highest annual average of fluorene among NMP sites sampling PAHs.

- Cancer risk and noncancer hazard approximations could only be calculated for ROCH. Naphthalene had the highest cancer risk approximation among the pollutants of interest for ROCH. None of the pollutants of interest for ROCH had noncancer hazard approximations greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor for Bronx and Monroe Counties while formaldehyde had the highest cancer toxicity-weighted emissions for both counties.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in Bronx and Monroe Counties. Acrolein had the highest noncancer toxicity-weighted emissions for both counties.

Oklahoma.

- There are five UATMP sites in Oklahoma: two located in Tulsa (TOOK and TMOK), one in Pryor Creek (PROK), and two in Oklahoma City (ADOK and OCOK).

- Each of the Oklahoma sites sampled for VOCs, carbonyls compounds, and metals (TSP). Sampling at PROK was discontinued at the end of October 2012.

- Twenty-one pollutants failed screens for TOOK; 19 failed screens for TMOK; 18 failed screens for PROK; 17 failed screens for ADOK; and 17 failed screens for OCOK.

- Of the site-specific pollutants of interest, formaldehyde had the highest annual average concentration for each Oklahoma site.

- TOOK had the highest annual average concentrations of acetaldehyde, benzene, and ethylbenzene among NMP sites sampling these pollutants. TOOK has the highest annual average concentration among NMP sites sampling manganese (PM_{10} or TSP).

- Sampling for the site-specific pollutants of interest has occurred at TOOK for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of ethylbenzene, manganese, and nickel exhibit increasing trends at TOOK. In addition, the detection rate of 1,2-dichloroethane at TOOK has been increasing steadily over the last few years of sampling, particularly for 2012.

- Formaldehyde and benzene had the highest cancer risk approximations for all of the Oklahoma monitoring sites. The benzene cancer risk approximation for TOOK is the highest benzene cancer risk approximation program-wide. Arsenic had the highest cancer risk approximations among the metals. None of the pollutants of interest for the Oklahoma sites had a noncancer hazard approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Mayes, Oklahoma, and Tulsa Counties. POM, Group 1a had the highest cancer toxicity-weighted emissions for Oklahoma and Tulsa Counties while hexavalent chromium had the highest cancer toxicity-weighted emissions for Mayes Counties.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in all three counties, while acrolein had the highest noncancer toxicity-weighted emissions for all three counties.

Rhode Island.

- The Rhode Island monitoring site (PRRI) is located in Providence and is a NATTS site.

- PRRI sampled for PAHs and hexavalent chromium.

- Three pollutants failed screens for PRRI, although 95 percent of failed screens were attributable to naphthalene.

- Naphthalene had the highest annual average concentration among the other pollutants of interest for PRRI.

- Sampling for the site-specific pollutants of interest has occurred at PRRI for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of naphthalene exhibit little change over the years. The range of hexavalent chromium concentrations has an increasing trend over the last 4 years of sampling.

- The cancer risk approximation for naphthalene was considerably higher than the cancer risk approximation for hexavalent chromium. All of the noncancer hazard approximations for PRRI were less than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Providence County, while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor, while acrolein had the highest noncancer toxicity-weighted emissions for Providence County.

South Carolina.

- The South Carolina monitoring site (CHSC) is located near Chesterfield and is a NATTS site.

- CHSC sampled for hexavalent chromium and PAHs.

- Naphthalene was the only pollutant to fail screens for CHSC. Naphthalene failed 13 percent of screens for CHSC.

- Naphthalene concentrations measured at CHSC span an order of magnitude, ranging from 5.61 ng/m^3 to 58.3 ng/m^3. Compared to other NMP sites sampling this pollutant, CHSC had one of the lowest annual average concentrations of naphthalene.

- Sampling for the site-specific pollutants of interest has occurred at CHSC for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutant of interest. Concentrations of naphthalene exhibit little change over the years.

- The cancer risk approximation for naphthalene for CHSC was one of the lowest among NMP sites sampling this pollutant; naphthalene's noncancer hazard approximation for CHSC was considerably less than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Chesterfield County while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor, while acrolein had the highest noncancer toxicity-weighted emissions.

South Dakota.

- The UATMP site in South Dakota is located in Sioux Falls (SSSD).

- VOCs, SNMOCs, and carbonyl compounds were sampled for at SSSD.

- Eleven pollutants failed screens for SSSD, with six contributing to 95 percent of failed screens for this site.

- Formaldehyde and acetaldehyde had the highest annual average concentrations for SSSD and are the only two pollutants with annual averages greater than 1.0 $\mu g/m^3$.

- Sampling for the site-specific pollutants of interest has occurred at SSSD for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of 1,3-butadiene increased significantly from 2011 to 2012 at SSSD. Conversely, formaldehyde concentrations measured at SSSD exhibit a steady decreasing trend across the years, although the most significant decreases were realized during the early years of sampling. In addition, the detection rate of 1,2-dichloroethane at SSSD has been increasing steadily over the last few years of sampling, particularly for 2012.

- Formaldehyde had the highest cancer risk approximation for SSSD. None of the pollutants of interest for SSSD had a noncancer hazard approximation greater than 1.0.

- Formaldehyde was the highest emitted pollutant with a cancer toxicity factor in Minnehaha County and had the highest toxicity-weighted emissions for this county.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in Minnehaha County, while acrolein had the highest noncancer toxicity-weighted emissions for this county.

Texas.

- There are two NATTS sites in Texas: one in Deer Park (CAMS 35) and one in Karnack (CAMS 85).

- The CAMS 35 site sampled for PAHs and hexavalent chromium, although sampling for PAHs was discontinued in February 2012. CAMS 85 sampled for hexavalent chromium only.

- Two pollutants failed screens for CAMS 35, naphthalene and hexavalent chromium. Hexavalent chromium did not fail any screens for CAMS 85.

- Concentrations of hexavalent chromium measured at CAMS 35 ranged from 0.0044 ng/m^3 to 0.195 ng/m^3, including a single non-detect. The annual average concentration for CAMS 35 is among the higher annual averages, ranking fifth among the 22 NMP sites sampling hexavalent chromium. Because sampling for PAHs was discontinued in February 2012, no quarterly or annual averages could be calculated for naphthalene.

- The cancer risk approximation for hexavalent chromium for CAMS 35 is less than 1 in-a-million. The noncancer hazard approximation for hexavalent chromium for CAMS 35 is considerably less than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Harris County, while 1,3-butadiene had the highest cancer toxicity-weighted emissions. Formaldehyde was the highest emitted pollutant with a cancer toxicity factor in Harrison County and had the highest cancer toxicity-weighted emissions.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in both counties, while acrolein had the highest noncancer toxicity-weighted emissions.

Utah.

- The NATTS site in Utah (BTUT) is located in Bountiful, north of Salt Lake City.

- BTUT sampled for VOCs, carbonyl compounds, SNMOCs, PAHs, metals (PM$_{10}$), and hexavalent chromium and is one of two NMP sites sampling all six pollutant groups.

- Twenty-one pollutants failed screens for BTUT, 13 of which contributed to 95 percent of this site's failed screens.

- Of the site-specific pollutants of interest, dichloromethane had the highest annual average concentration for BTUT, similar to 2011. BTUT had the highest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds, for the second year in a row.

- Sampling for the site-specific pollutants of interest has occurred at BTUT for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. The most notable trend is for benzene. Concentrations of benzene have an overall decreasing trend at BTUT. The 1-year average concentration for 2012 is the lowest 1-year average concentration of benzene calculated since the onset of sampling at BTUT. In addition, the detection rate of 1,2-dichloroethane at BTUT has been increasing steadily over the last few years of sampling, particularly for 2012.

- The pollutant with the highest cancer risk approximation for BTUT is formaldehyde; this is the highest cancer risk approximation calculated across the program. None of the pollutants of interest had noncancer hazard approximations greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Davis County while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor, while acrolein had the highest noncancer toxicity-weighted emissions for Davis County.

Vermont.

- Two Vermont monitoring sites are located in or near Burlington (BURVT and UNVT); a third monitoring site is located in Rutland (RUVT). UNVT is a NATTS monitoring site, while the remaining sites are UATMP sites.

- UNVT sampled year-round for VOCs, hexavalent chromium, PAHs, and metals (PM_{10}) while BURVT and RUVT sampled year-round for VOCs only. All three sites began sampling carbonyl compounds under the NMP in July 2012.

- Eleven pollutants failed screens for BURVT; 12 pollutants failed screens for RUVT; and 13 pollutants failed screens for UNVT.

- Benzene had the highest annual average concentrations for BURVT and RUVT, while carbon tetrachloride had the highest annual average concentration for UNVT. Annual averages for the carbonyl compounds could not be calculated due to the short sampling duration.

- Annual average concentrations of the pollutants of interest for UNVT were among the lowest compared to NMP sites sampling the same pollutants.

- Sampling for few of the site-specific pollutants of interest has occurred at UNVT for at least 5 consecutive years; thus, a trends analysis was conducted for arsenic. Little change is shown in the concentrations of arsenic since sampling under the NMP began.

- Benzene and carbon tetrachloride have the highest cancer risk approximations for the Vermont monitoring sites (although not necessarily in that order). None of the noncancer hazard approximations for these sites were greater than an HQ of 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Chittenden and Rutland Counties. Benzene also had the highest cancer toxicity-weighted emissions for Rutland County while formaldehyde had the highest cancer toxicity-weighted emissions for Chittenden County.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in both counties, while acrolein had the highest noncancer toxicity-weighted emissions.

Virginia.

- The NATTS site in Virginia is located near Richmond (RIVA).

- RIVA sampled for PAHs and hexavalent chromium.

- Four PAHs failed screens for RIVA, although naphthalene contributed to nearly 95 percent of the total failed screens. Hexavalent chromium did not fail any screens.

- Of the site-specific pollutants of interest, naphthalene had the highest annual average concentration.

- Naphthalene had the highest cancer risk approximation for RIVA. None of the pollutants of interest for RIVA had a noncancer hazard approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Henrico County, while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor in Henrico County, while acrolein had the highest noncancer toxicity-weighted emissions.

Washington.

- The NATTS site in Washington is located in Seattle (SEWA).

- SEWA sampled for VOCs, carbonyl compounds, PAHs, metals (PM_{10}), and hexavalent chromium.

- Fifteen pollutants failed screens for SEWA, of which 10 were identified as pollutants of interest for this site.

- Of the site-specific pollutants of interest for SEWA, acetaldehyde and carbon tetrachloride had the highest annual average concentrations. The annual average concentration of formaldehyde for SEWA is the lowest among NMP sites sampling this pollutant.

- SEWA had the second highest annual average concentration of nickel among NMP sites sampling metals (PM_{10}). This site had the highest annual average nickel concentration for 2010 and 2011.

- Sampling for the site-specific pollutants of interest has occurred at SEWA for at least 5 consecutive years; thus, a trends analysis was conducted for the site-specific pollutants of interest. Concentrations of carbon tetrachloride exhibit a decreasing trend over most of the sampling period, although this trend did not continue into 2012. In addition, the detection rate of 1,2-dichloroethane SEWA has been increasing steadily over the last few years of sampling, particularly for 2012.

- Formaldehyde had the highest cancer risk approximation for SEWA, although it is the lowest cancer risk approximation for formaldehyde among NMP sites. All of the noncancer hazard approximations for the pollutants of interest for SEWA sites were less than an HQ of 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in King County while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer toxicity factor in King County, while acrolein had the highest noncancer toxicity-weighted emissions.

Wisconsin.

- One Wisconsin monitoring site is located in Horicon (HOWI) and is a NATTS site. The second site (MIWI) is located in Milwaukee and is a UATMP site.

- Both HOWI and MIWI sampled for hexavalent chromium only.

- Hexavalent chromium was detected in greater than half of samples collected at HOWI but did not fail any screens. Hexavalent chromium was detected in nearly 80 percent of samples collected at MIWI and failed nearly one-third of screens.

- Concentrations of hexavalent chromium measured at MIWI spanned three orders of magnitude, ranging from 0.0045 ng/m^3 to 2.30 ng/m^3 (as well as 11 non-detects). MIWI is one of only two NMP sites at which concentrations of hexavalent chromium greater than 1 ng/m^3 were measured.

- The cancer risk approximation for hexavalent chromium for MIWI is one of only two cancer risk approximations for this pollutant greater than 1 in-a-million program-wide. The noncancer hazard approximation for hexavalent chromium is considerably less than an HQ of 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Dodge County and had the highest cancer toxicity-weighted emissions. Benzene was also the highest emitted pollutant with a cancer toxicity factor in Milwaukee County, although POM, Group 1a had the highest cancer toxicity-weighted emissions.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in Dodge and Milwaukee Counties, while acrolein had the highest noncancer toxicity-weighted emissions for each county.

31.1.3 Composite Site-level Results Summary

- Twenty-eight pollutants were identified as site-specific pollutants of interest, based on the risk-based screening process. Acetaldehyde and formaldehyde were the two most common pollutants of interest among the monitoring sites. Acetaldehyde and formaldehyde were identified as pollutants of interest for all 37 sites that sampled carbonyl compounds. Benzene, 1,3-butadiene, and carbon tetrachloride were the most common VOC pollutants of interest. Benzene was identified as a pollutant of interest for all 35 sites that sampled VOCs and/or SNMOCs. Twenty-three of the 25 sites that sampled PAHs had naphthalene as a pollutant of interest (based on the risk-based screening process). Arsenic was identified as a pollutant of interest for all 19 sites that sampled metals. Hexavalent chromium was identified as a pollutant of interest for seven of the 25 sites that sampled this pollutant.

- Concentrations from two sites, CAMS 85 and HOWI, did not fail any screens. However, only hexavalent chromium was sampled at these two sites.

- Formaldehyde frequently had the highest site-specific annual average concentration among the site-specific pollutants of interest; formaldehyde had the highest annual average concentration for 25 sites. Naphthalene had the next highest at nine.

- Formaldehyde tended to have the highest cancer risk approximations on a site-specific basis. The cancer risk approximation calculated for BTUT (57.62 in-a-million) from the annual average concentration of formaldehyde is the highest of all annual average-based cancer risk approximations. Three other sites exhibited cancer risk approximations greater than 50 in-a-million for formaldehyde (WPIN, PXSS, and ELNJ). Benzene is the only other pollutant for which a cancer risk approximation greater than 10 in-a-million was calculated (TOOK, SPAZ, and PXSS).

- Carbon tetrachloride often had relatively high cancer risk approximations (based on annual average concentrations) compared to other pollutants of interest among the monitoring sites, ranging between 3.5 in-a-million and 4.5 in-a-million, but tended to have relatively low emissions and toxicity-weighted emissions according to the NEI. This pollutant appears only once in the emissions-based tables for counties with NMP sites (Marshall County, Kentucky).

- None of the noncancer hazard approximations were greater than 1.0. The noncancer hazard approximation calculated for TOOK's annual average concentration of manganese (an HQ of 0.77) was the highest of all annual average-based noncancer hazard approximations. Formaldehyde and naphthalene along with manganese tended to have the highest noncancer hazard approximations on a site-specific basis.

- Of those pollutants with cancer UREs, benzene, formaldehyde, ethylbenzene, and acetaldehyde often had the highest county-level emissions for participating counties. Benzene, formaldehyde, and 1,3-butadiene typically had the highest toxicity-weighted emissions (of those with a cancer URE).

- Of those pollutants with a noncancer RfC, toluene, xylenes, and ethylene glycol were often the highest emitted pollutants, although they rarely had the highest toxicity-weighted emissions. Acrolein tended to have the highest toxicity-weighted emissions of pollutants with noncancer RfCs, although acrolein emissions were generally low when compared to other pollutants. Acrolein appears only once among the highest emitted pollutants for counties with NMP sites (Garfield County, Colorado). However, due to the high toxicity of this pollutant, even low emissions translated into high noncancer toxicity-weighted emissions; the toxicity-weighted value was often several orders of magnitude higher than other pollutants. Acrolein is a national noncancer risk driver according to NATA. Besides acrolein, formaldehyde and 1,3-butadiene tended to have the highest toxicity-weighted emissions among the pollutants with noncancer RfCs.

- For the 2012 NMP report, ethylene glycol emissions rank higher than they did for the 2011 NMP report. Emissions data provided in the 2012 NMP report are from version 1 of the 2011 NEI while emissions data for the 2011 NMP report were from the 2008 NEI. The movement in the ranking of ethylene glycol emissions may be attributable to differences in the way these emissions were reported between the different versions of the inventory.

- Although production of carbon tetrachloride has declined sharply over the last 30 years due to its role as an ozone depleting substance, it has a relatively long atmospheric lifetime and thus, is present at similar levels at nearly any given location. NMP sites are located in a variety of locations across the county with different purposes behind the monitoring at each site. In most cases, the concentrations of carbon tetrachloride measured across the program confirm the ubiquitous nature of this pollutant. However, carbon tetrachloride measurements collected at the Calvert City, Kentucky sites were often higher than levels of this pollutant collected elsewhere. Vinyl chloride is an industrial-marker and is rarely measured at detectable levels (this pollutant has a 10 percent detection rate across the program). The five Calvert City, Kentucky sites account for nearly half of the measured detections of vinyl chloride for 2012 yet sampling did not begin at these sites until July. The only other monitoring site with a similar statistic is DEMI. The Calvert City sites also account for the 50 highest concentrations of 1,2-dichloroethane measured across the program. These ambient air measurements agree with corresponding emissions data in the NEI. These three pollutants appear among the highest emitted pollutants in Marshall County, Kentucky (among those with a cancer URE) but are not one of the highest emitted pollutants for any other county with an NMP site. From a quantitative standpoint, the emissions of carbon tetrachloride and vinyl chloride in Marshall County are higher than their emissions for any other county with an NMP site. The emissions of 1,2-dichloroethane for Marshall County rank second highest (behind only Harris County, Texas).

- For every NMP site for which 1,2-dichloroethane was a pollutant of interest (14 sites), and where a trends analysis could be conducted for this pollutant, a dramatic increase in the number of measured detections is shown, particularly for 2012. This pollutant was detected in less than 10 percent of samples at most sites participating in the NMP prior to 2010 (and still participating now); the rate increased significantly since, with a detection rate between 80 percent and 95 percent for most sites for 2012.

31.1.4 Data Quality Results Summary

Completeness, precision, and accuracy were assessed for the 2012 monitoring effort. The quality assessments presented in this report show that the 2012 monitoring data are of a known and high quality, based on the attainment of the established MQOs.

To the largest extent, ambient air concentration data sets met MQO for completeness. Only five out of 144 site- and method-specific data sets failed to comply with the MQO of 85 percent completeness while 71 data sets achieved 100 percent completeness.

Method (sampling and analytical) precision and analytical precision were determined for the 2012 NMP monitoring efforts using CV calculations based on duplicate, collocated, and replicate samples. The precision for each analytical method utilized during the 2012 NMP was within the MQO of 15 percent CV. The method precision presented in this report is based on analytical results greater than or equal to the sample- and pollutant-specific MDL.

Analytical method accuracy is ensured by using proven methods, as demonstrated by third-party analysis of proficiency test audit samples, and following strict quality control and quality assurance guidelines. Most of the pollutants for which audit samples were analyzed met the MQO for accuracy. Of the 90 pollutants analyzed for via audit samples, only two exceeded the MQO of ± 25 percent.

31.2 Conclusions

Conclusions resulting from the data analyses of the data generated from the 2012 NMP monitoring efforts are presented below.

- There are a large number of concentrations that are greater than their respective risk screening values, particularly for many of the NATTS MQO Core Analytes. However, there were no instances where the preprocessed daily measurements or time-period average concentrations were greater than the ATSDR MRL noncancer health risk benchmarks.

- For those pollutants for which annual averages could be calculated and have available cancer UREs, none of the cancer risk approximations were greater than 100 in-a-million; 30 were greater than 10 in-a-million (27 for formaldehyde and three for benzene); and roughly 80 percent were greater than 1.0 in-a-million.

- For those pollutants for which annual averages could be calculated and have available noncancer RfCs, none of the noncancer hazard approximations were greater than 1.0.

- When comparing the highest emitted pollutants for a specific county to the pollutants with the highest toxicity-weighted emissions, the listed pollutants were more similar for the pollutants with cancer UREs than for pollutants with noncancer RfCs. This indicates that pollutants with cancer UREs that are emitted in higher quantities are often more toxic than pollutants emitted in lower quantities; conversely, the highest emitted pollutants with noncancer RfCs are not necessarily the most toxic. For example, toluene is the noncancer pollutant that was emitted in the highest quantities for many NMP counties, but was not one of the pollutants with highest toxicity-weighted emissions for any listed county. Conversely, while acrolein had the highest noncancer toxicity-weighted emissions for most NMP counties, it was among the highest emitted pollutants for only one county.

- The number of states and sites participating in the NMP changes from year to year. The number of sites participating in the 2012 NMP increased rather significantly, from 51 in 2011 to 64 for 2012. Yet, many of the data analyses utilized in this report require data from year-round (or nearly year-round) sampling. Of the 64 sites whose data are included in the 2012 report, 18 sites sampled for an abbreviated duration (due to site initialization and/or site closure/relocation). Of the 144 site-method combinations, 32 site-method combinations did not cover the entire year. As a result, the number of time-period averages and subsequent risk-based analyses that could not be calculated increased for 2012 compared to 2011. Fewer data gaps allow for more complete results and inter-site comparisons. However, most of these abbreviated durations are due to site initialization rather than site closure.

- Of the 64 monitoring sites participating in the 2012 NMP, only two sampled for all six available pollutant groups under the national program (BTUT and NBIL). Another five sites sampled all five pollutant groups required for NATTS sites (GLKY, PXSS, S4MO, SEWA, and UNVT). The wide range of pollutant groups sampled among the sites, which is often a result of different purposes behind the monitoring at the sites, makes it difficult to draw definitive conclusions regarding air toxics in ambient air in a global manner.

- This report strives to represent the best laboratory practices and utilize the best data analysis techniques available. Examples for 2012 include the improvement of MDLs and the incorporation of updated values for various toxicity factors. This can lead to adjusting the focus of the report to concentrate on the air quality issues of highest concern. Thus, the NMP report is dynamic in nature and scope; yet this approach may prevent the direct comparison of the current report to past reports. The major difference between 2012 report and other reports in recent years is the determination of the pollutants of interest. The NATTS MQO Core Analytes were not automatically included as pollutants of interest for each site for 2012, allowing the data generated for each site to be the primary driver of each site's pollutants of interest. These site-specific pollutants of interest were then the same pollutants for which the trends analysis and program vs. site-specific concentration comparisons were performed.

31.3 Recommendations

Based on the conclusions from the 2012 NMP, a number of recommendations for future ambient air monitoring efforts are presented below.

- *Continue participation in the National Monitoring Programs.* Ongoing ambient air monitoring at fixed locations can provide insight into long-term trends in air quality and the potential for air pollution to cause adverse health effects among the general population. Therefore, state and local agencies should be encouraged to either 1) develop and implement their own ambient air monitoring programs based on proven, consistent sampling and analysis methods and EPA technical and quality assurance guidance, or 2) consider long-term participation in the NMP.

- *Participate in the National Monitoring Programs year-round.* Many of the analyses presented in the 2012 report require a full year of data to be most useful and representative of conditions experienced at each specified location. Therefore, state and local agencies should be encouraged to implement year-long ambient air monitoring programs in addition to participating in future monitoring efforts.

- *Monitor for additional pollutant groups based on the results of data analyses in the annual report.* The risk-based analysis where county-level emissions are weighted based on toxicity identifies those pollutants whose emissions may result in adverse health effects in a specific area. If a site is not sampling for a pollutant or pollutant group identified as particularly hazardous for a given area, the agency responsible for that site should consider sampling for those compounds.

- *Strive to develop standard conventions for interpreting air monitoring data.* The lack of consistent approaches to present and summarize ambient air monitoring data complicates direct comparisons between different studies. Thought should be given to the feasibility of establishing standard approaches for analyzing and reporting air monitoring data for programs with similar objectives.

- *Continue to identify and implement improvements to the sampling and analytical methods.* Two analytical methods were accepted by governing bodies as approved method with which to analyze specific pollutants. ERG's hexavalent chromium method was approved as an ASTM method and ERG's inorganic method for both TSP and PM_{10} was accepted as a FEM for lead (NAAQS). These approvals were obtained after various method enhancements that improve the detection and recovery of these pollutants. Further research is encouraged to identify other method improvements that would allow for the characterization of an even wider range of components in air pollution and enhance the ability of the methods to quantify all cancer and noncancer pollutants to at least their levels of concern (risk screening concentrations).

- *Revise the pollutants targeted for sampling based on lessons learned in the field, in the laboratory, and/or from the annual report.* In conjunction with method improvements, the analytes targeted for monitoring should/need to be reviewed and revised periodically based experience with the collection and analysis methods and based on the findings in the annual report. Pollutants initially targeted for ambient monitoring may no longer be considered problematic based on monitoring results and could be discontinued. Other pollutants may prove problematic from a sampling and/or analytical stand point and can be removed from the target analyte list due to uncertainties associated with its analytical results. In addition, studies may indicate that one analytical method is better than another at providing accurate results for a given pollutant. All of these factors should be considered when determining the pollutants for which to monitor.

- *Require consistency in sampling and analytical methods.* The development of the NATTS program has shown that there are inconsistencies in collection and analytical methods that make data comparison difficult across agencies. Requiring agencies to use specified and accepted measurement methods, consistent with the guidelines presented in the most recent version of the NATTS TAD, is integral to the identification of trends and measuring the effectiveness of regulation.

- *Perform case studies based on findings from the annual report.* Often, the annual report identifies an interesting tendency or trend, or highlights an event at a particular site(s). For example, dichloromethane concentrations have been highest at BTUT and GPCO for multiple years. Tetrachloride concentrations have been highest at SPIL for multiple years. Further examination of the data in conjunction with meteorological phenomena and potential emissions events or incidents, or further site characterization may help identify state and local agencies pinpoint issues affecting air quality in their area.

- *Consider more rigorous study of the effect of automobile emissions on ambient air quality using multiple years of data.* Because many NMP sites have generated years of continuous data, a real opportunity exists to evaluate the importance and impact of automobile emissions on ambient air quality. Suggested areas of study include additional signature compound assessments and parking lot characterizations.

- *Develop and/or verify HAP and VOC emissions inventories.* State/local/tribal agencies should use the data collected from NMP sites to develop and validate emissions inventories, or at the very least, identify and/or verify emissions sources of concern. Ideally, state/local/tribal agencies would compare the ambient monitoring results with an emissions inventory for source category completeness. The emissions inventory could then be used to develop modeled concentrations useful to compare against ambient monitoring data.

- *Promulgate ambient air standards for HAPs.* Concentrations of several pollutants sampled during the 2012 program year were greater than risk screening values developed by various government agencies. One way to reduce the risk to human health would be to develop standards similar to the NAAQS for pollutants that frequently exceed published risk screening levels.

- *Incorporate/Update Risk in State Implementation Plans (SIPs).* Use risk calculations to design State Implementation Plans to implement policies that reduce the potential for human health risk. This would be easier to enforce if ambient standards for certain HAPs were developed (refer to above recommendation).

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