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U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Assessment Division
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LIST OF ACRONYMS

AADT	Average Annual 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
DQO	Data Quality Objective(s)
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
F	Fahrenheit
FHWA	Federal Highway Administration
GC/MS-FID	Gas Chromatography/Mass Spectrometry and Flame Ionization Detection
GHG	Greenhouse Gas(es)
GIS	Geographical Information System
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	Method Quality Objective(s)
MRL	Minimal Risk Level
MSA	Metropolitan or Micropolitan Statistical Area(s)
MTBE	Methyl *tert*-butyl ether
NAAQS	National Ambient Air Quality Standard
NATA	National Air Toxics Assessment

LIST OF ACRONYMS (Continued)

NATTS	National Air Toxics Trends Stations
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
PAMS	Photochemical Assessment Monitoring Stations
PAH	Polycyclic Aromatic Hydrocarbon(s)
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)
RFG	Reformulated Gasoline
SATMP	School Air Toxics Monitoring Program
SIM	Selected Ion Monitoring
SIP	State Implementation Plan(s)
SNMOC	Speciated Nonmethane Organic Compound(s)
UATMP	Urban Air Toxics Monitoring Program
VOC	Volatile Organic Compound(s)
TAD	Technical Assistance Document
TNMOC	Total Nonmethane Organic Compound(s)
tpy	Tons per year
TRI	Toxics Release Inventory
TSP	Total Suspended Particulate
TSV	Total Spatial Variance
µg/m^3	Micrograms per cubic meter
µL	Microliter
URE	Unit Risk Estimate(s)
VMT	Vehicle Miles Traveled
WBAN	Weather Bureau/Army/Navy ID

Abstract

This report presents the results and conclusions from the ambient air monitoring conducted as part of the 2011 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 2011 NMP includes data from samples collected at 51 monitoring sites that collected 24-hour air samples, typically on a 1-in-6 or 1-in-12 day schedule. Twenty-four sites sampled for 61 volatile organic compounds (VOC); 31 sites sampled for 14 carbonyl compounds; eight sites sampled for 80 speciated nonmethane organic compounds (SNMOC); 23 sites sampled for 22 polycyclic aromatic hydrocarbons (PAH); 15 sites sampled for 11 metals; and 22 sites sampled for hexavalent chromium. Over 218,900 ambient air concentrations were measured during the 2011 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 2011 NMP serve a wide range of purposes. Not only do these data characterize the nature and extent of air pollution close to the 51 individual monitoring sites participating in these programs, but they also identify trends and patterns that may be common to both 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). This report focuses on the UATMP, NATTS, and CSATAM programs. 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 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 at 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, 2012a). The initial site locations were based on results from preliminary air toxics pilot 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, 2012b).

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).

Many environmental and health agencies have participated in these programs to assess the sources, effects, and changes in air pollution within their jurisdictions. 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 each other.

1.2 The Report

This report summarizes and interprets the 2011 UATMP, NATTS, and CSATAM monitoring efforts of the NMP. Included in this report are data collected at the 51 monitoring sites around the country 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. The 51 sites included in this report are located in or near 33 urban or rural locations in 23 states and the District of Columbia, including 29 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 affect the behavior of air toxics in urban and rural areas most significantly. This report also focuses on data characterizations for each of the 51 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 2011 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, 2012c).

This report is organized into 31 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 2011 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).
2	The 2011 National Monitoring Programs Network	This section provides information on the 2011 NMP and network: • Monitoring locations • Pollutants selected for monitoring • Sampling and analytical methods • Sampling schedules • Completeness of the air monitoring programs.
3	Summary of the 2011 National Monitoring Programs Data Treatments and Methods	This section presents and discusses the data treatments used on the 2011 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 risk.

Table 1-1. Organization of the 2011 National Monitoring Programs Report (Continued)

Report Section	Section Title	Overview of Contents
4	Summary of the 2011 National Monitoring Programs Data	This section presents and discusses the results of the data treatments from the 2011 NMP data.
5	Sites in Arizona	Monitoring results for the sites in the Phoenix-Mesa-Glendale, AZ MSA (PXSS and SPAZ)
6	Sites in California	Monitoring results for the sites in the Los Angeles-Long Beach-Santa Ana, CA MSA (CELA), 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 Garfield County (BMCO, BRCO, PACO, 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-Marietta, GA MSA (SDGA)
11	Sites in Illinois	Monitoring results for the sites in the Chicago-Joliet-Naperville, IL-IN-WI MSA (NBIL and SPIL)
12	Sites in Indiana	Monitoring results for the sites in the Chicago-Joliet-Naperville, IL-IN-WI MSA (INDEM) and the Indianapolis-Carmel, IN MSA (WPIN)
13	Site in Kentucky	Monitoring results for the site in Grayson, KY (GLKY)
14	Site in Massachusetts	Monitoring results for the site in the Boston-Cambridge-Quincy, MA-NH MSA (BOMA)
15	Sites in Michigan	Monitoring results for the sites in the Detroit-Warren-Livonia, MI MSA (DEMI, RRMI, and SWMI)
16	Site in Missouri	Monitoring results for the site in the St. Louis, MO-IL MSA (S4MO)
17	Sites in New Jersey	Monitoring results for the sites in the New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (CHNJ, ELNJ, NBNJ, and PANJ)
18	Sites in New York	Monitoring results for the site in the New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (MONY) and the Rochester, NY MSA (ROCH)
19	Sites in Oklahoma	Monitoring results for the sites in the Tulsa, OK MSA (TOOK and TMOK), the Oklahoma City, OK MSA (MWOK and OCOK), and Pryor Creek, OK (PROK)

Table 1-1. Organization of the 2011 National Monitoring Programs Report (Continued)

Report Section	Section Title	Overview of Contents
20	Site in Rhode Island	Monitoring results for the site in the Providence-New Bedford-Fall River, RI-MA MSA (PRRI)
21	Site in South Carolina	Monitoring results for the site in Chesterfield, SC (CHSC)
22	Sites in South Dakota	Monitoring results for the sites in the Sioux City, IA-NE-SD MSA (UCSD) and the Sioux Falls, SD MSA (SSSD)
23	Sites in Texas	Monitoring results for the sites in the Houston-Sugar Land-Baytown, TX MSA (CAMS 35) and the Marshall, TX MSA (CAMS 85)
24	Site in Utah	Monitoring results for the site in the Ogden-Clearfield, UT MSA (BTUT)
25	Sites in Vermont	Monitoring results for the sites in the Burlington-South Burlington, VT MSA (BURVT and UNVT) and the Rutland, VT MSA (RUVT)
26	Site in Virginia	Monitoring results for the site in the Richmond, VA MSA (RIVA)
27	Site in Washington	Monitoring results for the site in the Seattle-Tacoma-Bellevue, WA MSA (SEWA)
28	Site in Wisconsin	Monitoring results for the site in the Beaver Dam, WI MSA (HOWI)
29	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 2011 NMP ambient air monitoring data.
30	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.
31	References	This section lists the references cited throughout the report.

2.0 The 2011 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 51 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 (EPA-approved method). Section 2.2 provides further details on each of the sampling methodologies used to collect and analyze samples.

Agencies operating these sites 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 laboratories. In these cases, data are generated by sources other than ERG and are 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 2011 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 51 monitoring sites participating in the 2011 programs, which encompass 33 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, 2010). 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, 2012a).

Table 2-1 lists the respective monitoring program and the years of program participation for the 51 monitoring sites. All 51 monitoring sites have been included in previous annual reports, although two sites began sampling again under the NMP in 2011 after nine years. These two sites are highlighted in Table 2-1.

As Figure 2-1 and Table 2-1 show, the 2011 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 two programs. Table 2-2 shows that the locations 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 2011 National Monitoring Programs Monitoring Sites

Table 2-1. 2011 National Monitoring Programs Sites and Past Program Participation

Monitoring Location and Site	Program	2001 and Earlier	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Battlement Mesa, CO (BMCO)	UATMP										✓	✓
Boston, MA ***(BOMA)***	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Bountiful, UT ***(BTUT)***	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Burlington, VT (BURVT)	UATMP									✓	✓	✓
Chester, NJ (CHNJ)	UATMP	2001	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chesterfield, SC ***(CHSC)***	NATTS					✓	✓	✓	✓	✓	✓	✓
Dearborn, MI ***(DEMI)***	NATTS	2001	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Decatur, GA ***(SDGA)***	NATTS					✓	✓	✓	✓	✓	✓	✓
Deer Park, TX ***(CAMS 35)***	NATTS							✓	✓	✓	✓	✓
Detroit, MI (SWMI)	UATMP	2001	✓									✓
Elizabeth, NJ (ELNJ)	UATMP	1999-2001	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
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							✓			✓	✓

Green shading indicates a returning site with past participation under the NMP.
BOLD ITALICS = EPA-designated NATTS site

Table 2-1. 2011 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2001 and Earlier	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Los Angeles, CA (***CELA***)	NATTS							✓	✓	✓	✓	✓
Midwest City, OK (MWOK)	UATMP									✓	✓	✓
New Brunswick, NJ (NBNJ)	UATMP	2001	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
New York, NY (MONY)	NATTS										✓	✓
Northbrook, IL (NBIL)	NATTS			✓	✓	✓	✓	✓	✓	✓	✓	✓
Oklahoma City, OK (OCOK)	UATMP									✓	✓	✓
Orlando, FL (PAFL)	UATMP								✓	✓	✓	✓
Parachute, CO (PACO)	UATMP								✓	✓	✓	✓
Paterson, NJ (PANJ)	CSATAM										✓	✓
Phoenix, AZ (PXSS)	NATTS	2001	✓	✓	✓		✓	✓	✓	✓	✓	✓
Phoenix, AZ (SPAZ)	UATMP	2001						✓	✓	✓	✓	✓
Pinellas Park, FL (SKFL)	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Plant City, FL (SYFL)	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Providence, RI (PRRI)	NATTS					✓	✓	✓	✓	✓	✓	✓
Pryor Creek, OK (PROK)	UATMP								✓	✓	✓	✓
Richmond, VA (RIVA)	NATTS								✓	✓	✓	✓
Rifle, CO (RICO)	UATMP								✓	✓	✓	✓

Green shading indicates a returning site with past participation under the NMP.
BOLD ITALICS = EPA-designated NATTS site

Table 2-1. 2011 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2001 and Earlier	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
River Rouge, MI (RRMI)	UATMP	2001										✓
Rochester, NY (ROCH)	NATTS						✓	✓	✓	✓	✓	✓
Rubidoux, CA (RUCA)	NATTS							✓	✓	✓	✓	✓
Rutland, VT (RUVT)	UATMP	1995-1999	✓							✓	✓	✓
San Jose, CA (SJJCA)	NATTS								✓	✓	✓	✓
Schiller Park, IL (SPIL)	UATMP			✓	✓	✓	✓	✓	✓	✓	✓	✓
Seattle, WA (SEWA)	NATTS					✓	✓	✓	✓	✓	✓	✓
Silt, CO (BRCO)	UATMP								✓	✓	✓	✓
Sioux Falls, SD (SSSD)	UATMP								✓	✓	✓	✓
St. Louis, MO (S4MO)	NATTS		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
St. Petersburg, FL (AZFL)	UATMP	1991-1992, 2001	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tulsa, OK (TMOK)	UATMP									✓	✓	✓
Tulsa, OK (TOOK)	UATMP						✓	✓	✓	✓	✓	✓
Underhill, VT (UNVT)	NATTS		✓			✓	✓	✓	✓	✓	✓	✓
Union County, SD (UCSD)	UATMP									✓	✓	✓
Washington, D.C. (WADC)	NATTS					✓	✓	✓	✓	✓	✓	✓
Winter Park, FL (ORFL)	UATMP	1990-1991		✓	✓	✓	✓	✓	✓	✓	✓	✓

Green shading indicates a returning site with past participation under the NMP.
BOLD ITALICS = EPA-designated NATTS site

Table 2-2. Site Characterizing Information for the 2011 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 from the 2008 NEI[c] (tpy)	County-level Mobile Source HAP Emissions from the 2008 NEI[c] (tpy)
AZFL	12-103-0018	St. Petersburg, FL	Residential	Suburban	917,398	877,075 (2011)	40,500 (2011)	1,381.26	3,808.72
BMCO	NA	Battlement Mesa, CO	Residential	Rural	56,270	72,957 (2010)	2,527 (2002)	1,364.26	353.08
BOMA	25-025-0042	Boston, MA	Commercial	Urban/City Center	730,932	481,199 (2011)	31,400 (2007)	572.38	1,156.01
BRCO	08-045-0009	Silt, CO	Agricultural	Rural	56,270	72,957 (2010)	150 (2002)	1,364.26	353.08
BTUT	49-011-0004	Bountiful, UT	Residential	Suburban	311,811	239,582 (2011)	113,955 (2010)	391.90	1,198.09
BURVT	50-007-0014	Burlington, VT	Commercial	Urban/City Center	157,491	169,767 (2012)	14,000 (2007)	347.53	623.35
CAMS 35	48-201-1039	Deer Park, TX	Residential	Suburban	4,180,894	3,164,173 (2011)	31,043 (2004)	9,322.29	11,313.66
CAMS 85	48-203-0002	Karnack, TX	Agricultural	Rural	66,296	70,858 (2011)	1,250 (2010)	593.11	413.72
CELA	06-037-1103	Los Angeles, CA	Residential	Urban/City Center	9,889,056	7,360,573 (2011)	230,000 (2011)	14,794.19	14,628.66
CHNJ	34-027-3001	Chester, NJ	Agricultural	Rural	494,976	389,359 (2010)[d]	12,917 (2010)	198.46	1,907.47
CHSC	45-025-0001	Chesterfield, SC	Forest	Rural	46,557	40,492 (2011)	550 (2011)	97.19	209.23
DEMI	26-163-0033	Dearborn, MI	Industrial	Suburban	1,802,096	1,334,752 (2011)	92,800 (2011)	7,384.27	7,014.06

BOLD ITALICS = EPA-designated NATTS site

[a] Reference: Census Bureau, 2012b

[b] Individual references provided in each state section.

[c] Reference: EPA, 2012d

[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 2011 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 from the 2008 NEI[c] (tpy)	County-level Mobile Source HAP Emissions from the 2008 NEI[c] (tpy)
ELNJ	34-039-0004	Elizabeth, NJ	Industrial	Suburban	539,494	424,894 (2010)[d]	250,000 (2006)	360.61	1,342.05
GLKY	21-043-0500	Grayson, KY	Residential	Rural	27,586	32,398 (2011)	428 (2009)	55.08	179.45
GPCO[e]	08-077-0017 08-077-0018	Grand Junction, CO	Commercial	Urban/City Center	147,083	178,425 (2010)	11,000 (2011)	532.80	573.11
HOWI	55-027-0001	Horicon, WI	Agricultural	Rural	88,661	100,176 (2011)	5,000 (2008)	531.88	467.91
INDEM	18-089-0022	Gary, IN	Industrial	Urban/City Center	495,558	419,431 (2011)	34,240 (2010)	1,486.55	1,857.03
MONY	36-005-0080	New York, NY	Residential	Urban/City Center	1,392,002	246,748 (2011)	91,465 (2010)	2,171.17	1,217.06
MWOK	40-109-0041	Midwest City, OK	Commercial	Urban/City Center	732,371	832,160 (2011)	40,900 (2011)	1,242.77	3,717.21
NBIL	17-031-4201	Northbrook, IL	Residential	Suburban	5,217,080	2,072,399 (2011)	34,600 (2011)	15,376.26	11,796.13
NBNJ	34-023-0006	New Brunswick, NJ	Agricultural	Rural	814,217	640,893 (2010)[d]	114,322 (2010)	475.76	2,290.35
OCOK	40-109-1037	Oklahoma City, OK	Residential	Suburban	732,371	832,160 (2011)	40,900 (2011)	1,242.77	3,717.21
ORFL	12-095-2002	Winter Park, FL	Commercial	Urban/City Center	1,169,107	1,056,627 (2011)	32,500 (2011)	1,791.25	4,785.53
PACO	08-045-0005	Parachute, CO	Residential	Urban/City Center	56,270	72,957 (2010)	16,000 (2011)	1,364.26	353.08

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[b] Individual references provided in each state section.

[c] Reference: EPA, 2012d

[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 2011 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 from the 2008 NEI[c] (tpy)	County-level Mobile Source HAP Emissions from the 2008 NEI[c] (tpy)
PAFL	12-095-1004	Orlando, FL	Commercial	Suburban	1,169,107	1,056,627 (2011)	46,000 (2011)	1,791.25	4,785.53
PANJ	34-031-0005	Paterson, NJ	Commercial	Urban/City Center	502,007	396,602 (2010)[d]	22,272 (2010)	162.17	1,064.24
PROK	40-097-0187	Pryor Creek, OK	Industrial	Suburban	41,389	39,968 (2011)	15,100 (2011)	329.16	256.05
PRRI	44-007-0022	Providence, RI	Residential	Urban/City Center	626,709	485,837 (2010)[d]	136,800 (2009)	906.46	1,485.96
PXSS	04-013-9997	Phoenix, AZ	Residential	Urban/City Center	3,880,244	3,776,819 (2011)	184,000 (2010)	1,618.22	11,681.75
RICO	08-045-0007	Rifle, CO	Commercial	Urban/City Center	56,270	72,957 (2010)	17,000 (2011)	1,364.26	353.08
RIVA	51-087-0014	Richmond, VA	Residential	Suburban	310,445	354,721 (2011)	73,000 (2011)	740.28	1,020.76
ROCH	36-055-1007	Rochester, NY	Residential	Urban/City Center	745,625	550,992 (2011)	86,198 (2010)	1,809.55	2,250.12
RRMI	26-163-0005	River Rouge, MI	Industrial	Suburban	1,802,096	1,334,752 (2011)	98,500 (2011)	7,384.27	7,014.06
RUCA	06-065-8001	Rubidoux, CA	Residential	Suburban	2,239,620	1,711,492 (2011)	145,000 (2011)	2,552.70	3,490.17
RUVT	50-021-0002	Rutland, VT	Commercial	Urban/City Center	61,289	70,900 (2012)	7,200 (2010)	135.82	308.74
S4MO	29-510-0085	St. Louis, MO	Residential	Urban/City Center	1,316,761	1,114,812 (2011)	79,558 (2011)	1,054.65	1,157.32

BOLD ITALICS = EPA-designated NATTS site

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[b] Individual references provided in each state section.

[c] Reference: EPA, 2012d

[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 2011 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 from the 2008 NEI[c] (tpy)	County-level Mobile Source HAP Emissions from the 2008 NEI[c] (tpy)
SDGA	13-089-0002	Decatur, GA	Residential	Suburban	699,893	472,535 (2011)	140,820 (2011)	779.22	3,044.68
SEWA	53-033-0080	Seattle, WA	Industrial	Suburban	1,969,722	1,783,335 (2011)	226,000 (2011)	3,191.49	9,694.40
SJJCA	06-085-0005	San Jose, CA	Commercial	Urban/City Center	1,809,378	1,517,190 (2011)	104,000 (2011)	3,325.51	2,772.68
SKFL	12-103-0026	Pinellas Park, FL	Residential	Suburban	917,398	877,075 (2011)	47,000 (2011)	1,381.26	3,808.72
SPAZ	04-013-4003	Phoenix, AZ	Residential	Urban/City Center	3,880,244	3,776,819 (2011)	128,000 (2010)	1,618.22	11,681.75
SPIL	17-031-3103	Schiller Park, IL	Mobile	Suburban	5,217,080	2,072,399 (2011)	190,000 (2010)	15,376.26	11,796.13
SSSD	46-099-0008	Sioux Falls, SD	Commercial	Urban/City Center	171,752	210,914 (2011)	18,700 (2011)	382.22	600.33
SWMI	26-163-0015	Detroit, MI	Commercial	Urban/City Center	1,802,096	1,334,752 (2011)	93,000 (2011)	7,384.27	7,014.06
SYFL	12-057-3002	Plant City, FL	Residential	Rural	1,267,775	1,135,945 (2011)	10,600 (2011)	2,633.02	4,579.82
TMOK	40-143-1127	Tulsa, OK	Residential	Urban/City Center	610,599	603,926 (2011)	12,600 (2011)	1,219.02	3,065.07
TOOK	40-143-0235	Tulsa, OK	Industrial	Urban/City Center	610,599	603,926 (2011)	63,000 (2011)	1,219.02	3,065.07
UCSD	46-127-0001	Union County, SD	Agricultural	Rural	14,651	25,419 (2011)	156 (2007)	62.28	122.79

BOLD ITALICS = EPA-designated NATTS site

[a] Reference: Census Bureau, 2012b

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[c] Reference: EPA, 2012d

[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 2011 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 from the 2008 NEI[c] (tpy)	County-level Mobile Source HAP Emissions from the 2008 NEI[c] (tpy)
UNVT	50-007-0007	Underhill, VT	Forest	Rural	157,491	169,767 (2012)	1,100 (2011)	347.53	623.35
WADC	11-001-0043	Washington, D.C.	Commercial	Urban/City Center	617,996	213,232 (2010)	7,700 (2009)	632.23	1,257.69
WPIN	18-097-0078	Indianapolis, IN	Residential	Suburban	911,296	820,767 (2011)	143,970 (2010)	2,965.43	3,380.45

BOLD ITALICS = EPA-designated NATTS site

[a] Reference: Census Bureau, 2012b

[b] Individual references provided in each state section.

[c] Reference: EPA, 2012d

[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

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 roadway to the monitoring site, generally expressed as average annual daily traffic (AADT).
- Stationary and mobile source HAP emissions for the monitoring site's residing county, according to the 2008 National Emissions Inventory (NEI).

This information is discussed in further detail in 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 significantly from monitoring site to monitoring site.

- *Compendium Method TO-15* was used to measure ambient air concentrations of 61 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 14 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.
- *EPA-approved hexavalent chromium method* was used to measure ambient air concentrations of hexavalent chromium.

At each monitoring site, the sample collection equipment 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 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, 2012e) in accordance with the specifications presented in the NATTS Technical Assistance Document (TAD) (EPA, 2009b). This procedure involves analyzing at least seven replicate standards prepared on/in the appropriate sampling media (per analytical method). Instrument-specific detection limits (replicate analysis of standards only) are not determined because sample contamination and preparation variability would not be considered.

For the metals, however, the MDL procedure described by "Appendix D: DQ FAC Single Laboratory Procedure v2.4" (FAC, 2007) was used to determine MDLs for chromium for both quartz and Teflon® filter types, as well as manganese, cobalt, nickel, cadmium, and lead for quartz filters. The method involves analyzing at least seven replicate samples extracted from blank sampling and calculating the MDLs from the results. For all other metals analytes, the MDL procedure described in 40 CFR was used.

Tables 2-3 through 2-8 identify the specific target pollutants for each analytical method and their corresponding MDLs. For the VOC and SNMOC analyses, the experimentally-determined MDLs do not change within a given year unless the sample was diluted. The 2011 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. 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, 2006).

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). 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 61 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. The MDL for every VOC is lower than 0.16 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 0.45 ppbC.

Table 2-3. 2011 VOC Method Detection Limits

Pollutant	2011 MDL (ppbv)	Pollutant	2011 MDL (ppbv)	Pollutant	2011 MDL (ppbv)
Acetonitrile	0.0235	1,2-Dibromoethane	0.0183	Methyl Isobutyl Ketone	0.0223
Acetylene	0.0163	*m*-Dichlorobenzene	0.0342	Methyl Methacrylate	0.0223
Acrolein	0.0501	*o*-Dichlorobenzene	0.0368	Methyl *tert*-Butyl Ether	0.0083
Acrylonitrile	0.0116	*p*-Dichlorobenzene	0.0348	*n*-Octane	0.0149
tert-Amyl Methyl Ether	0.0165	Dichlorodifluoromethane	0.0114	Propylene	0.0393
Benzene	0.0288	1,1-Dichloroethane	0.0084	Styrene	0.0223
Bromochloromethane	0.0083	1,2-Dichloroethane	0.0086	1,1,2,2-Tetrachloroethane	0.0244
Bromodichloromethane	0.0247	1,1-Dichloroethene	0.0088	Tetrachloroethylene	0.0178
Bromoform	0.0250	*cis*-1,2-Dichloroethylene	0.0089	Toluene	0.0162
Bromomethane	0.0091	*trans*-1,2-Dichloroethylene	0.0081	1,2,4-Trichlorobenzene	0.0365
1,3-Butadiene	0.0072	Dichloromethane	0.0100	1,1,1-Trichloroethane	0.0222
Carbon Disulfide	0.0331	1,2-Dichloropropane	0.0227	1,1,2-Trichloroethane	0.0254
Carbon Tetrachloride	0.0237	*cis*-1,3-Dichloropropene	0.0222	Trichloroethylene	0.0254
Chlorobenzene	0.0212	*trans*-1,3-Dichloropropene	0.0246	Trichlorofluoromethane	0.0096
Chloroethane	0.0087	Dichlorotetrafluoroethane	0.0088	Trichlorotrifluoroethane	0.0109
Chloroform	0.0088	Ethyl Acrylate	0.0200	1,2,4-Trimethylbenzene	0.0285
Chloromethane	0.0119	Ethyl *tert*-Butyl Ether	0.0076	1,3,5-Trimethylbenzene	0.0262
Chloromethylbenzene	0.0389	Ethylbenzene	0.0169	Vinyl Chloride	0.0079
Chloroprene	0.0076	Hexachloro-1,3-Butadiene	0.0369	*m,p*-Xylene[1]	0.0336
Dibromochloromethane	0.0207	Methyl Ethyl Ketone	0.1570	*o*-Xylene	0.0180

[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. 2011 SNMOC Method Detection Limits[1]

Pollutant	2011 MDL (ppbC)[1]	Pollutant	2011 MDL (ppbC)[1]	Pollutant	2011 MDL (ppbC)[1]
Acetylene	0.080	1-Heptene	0.440	*n*-Pentane	0.110
Benzene	0.220	*n*-Hexane	0.180	1-Pentene	0.130
1,3-Butadiene	0.190	1-Hexene	0.330	*cis*-2-Pentene	0.180
n-Butane	0.190	*cis*-2-Hexene	0.330	*trans*-2-Pentene	0.140
cis-2-Butene	0.170	*trans*-2-Hexene	0.330	*a*-Pinene	0.200
trans-2-Butene	0.141	Isobutane	0.160	*b*-Pinene	0.200
Cyclohexane	0.189	Isobutene/1-Butene[2]	0.130	Propane	0.100
Cyclopentane	0.124	Isopentane	0.180	*n*-Propylbenzene	0.190
Cyclopentene	0.190	Isoprene	0.190	Propylene	0.090
n-Decane	0.200	Isopropylbenzene	0.200	Propyne	0.100
1-Decene	0.200	2-Methyl-1-Butene	0.190	Styrene	0.260
m-Diethylbenzene	0.200	3-Methyl-1-Butene	0.190	Toluene	0.280
p-Diethylbenzene	0.120	2-Methyl-1-Pentene	0.330	*n*-Tridecane	0.430
2,2-Dimethylbutane	0.140	4-Methyl-1-Pentene	0.330	1-Tridecene	0.430
2,3-Dimethylbutane	0.210	2-Methyl-2-Butene	0.190	1,2,3-Trimethylbenzene	0.150
2,3-Dimethylpentane	0.440	Methylcyclohexane	0.180	1,2,4-Trimethylbenzene	0.180
2,4-Dimethylpentane	0.230	Methylcyclopentane	0.160	1,3,5-Trimethylbenzene	0.190
n-Dodecane	0.430	2-Methylheptane	0.130	2,2,3-Trimethylpentane	0.260
1-Dodecene	0.430	3-Methylheptane	0.160	2,2,4-Trimethylpentane	0.160
Ethane	0.090	2-Methylhexane	0.220	2,3,4-Trimethylpentane	0.150
2-Ethyl-1-butene	0.330	3-Methylhexane	0.140	*n*-Undecane	0.200
Ethylbenzene	0.180	2-Methylpentane	0.150	1-Undecene	0.200
Ethylene	0.290	3-Methylpentane	0.170	*m*-Xylene/*p*-Xylene[2]	0.240
m-Ethyltoluene	0.170	*n*-Nonane	0.210	*o*-Xylene	0.170
o-Ethyltoluene	0.190	1-Nonene	0.250	Sum of Knowns	NA
p-Ethyltoluene	0.250	*n*-Octane	0.230	Sum of Unknowns	NA
n-Heptane	0.190	1-Octene	0.260	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 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 14 carbonyl compounds. 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 for every pollutant is less than 0.01 ppbv.

Table 2-5. 2011 Carbonyl Compound Method Detection Limits

Pollutant	Minimum MDL (ppbv)	Maximum MDL (ppbv)	Average MDL (ppbv)
Acetaldehyde	0.0040	0.0300	0.0068
Acetone	0.0040	0.0300	0.0068
Benzaldehyde	0.0010	0.0100	0.0024
Butyraldehyde	0.0020	0.0140	0.0032
Crotonaldehyde	0.0020	0.0140	0.0032
2,5-Dimethylbenzaldehyde	0.0010	0.0100	0.0024
Formaldehyde	0.0060	0.0840	0.0099
Hexaldehyde	0.0010	0.0090	0.0020
Isovaleraldehyde	0.0009	0.0070	0.0014
Propionaldehyde	0.0020	0.0110	0.0026
Tolualdehydes[1]	0.0020	0.0140	0.0033
Valeraldehyde	0.0010	0.0110	0.0025

[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.

2.2.3 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 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 ranged from 0.032 ng/m^3 (pyrene) to 0.145 ng/m^3 (naphthalene).

Table 2-6. 2011 PAH Method Detection Limits

Pollutant	Minimum MDL (ng/m^3)	Maximum MDL (ng/m^3)	Average MDL (ng/m^3)
Acenaphthene	0.029	0.545	0.051
Acenaphthylene	0.025	0.483	0.045
Anthracene	0.023	0.625	0.057
Benzo(a)anthracene	0.027	0.904	0.083
Benzo(a)pyrene	0.023	0.887	0.081
Benzo(b)fluoranthene	0.025	0.465	0.043
Benzo(e)pyrene	0.024	0.451	0.042
Benzo(g,h,i)perylene	0.016	0.780	0.071
Benzo(k)fluoranthene	0.025	0.640	0.059
Chrysene	0.021	0.416	0.038
Coronene	0.013	0.863	0.079
Cyclopenta[cd]pyrene	0.033	0.718	0.066
Dibenz(a,h)anthracene	0.018	0.800	0.073
Fluoranthene	0.022	0.406	0.038
Fluorene	0.030	0.561	0.052
9-Fluorenone	0.026	0.484	0.045
Indeno(1,2,3-cd)pyrene	0.018	0.754	0.069
Naphthalene	0.067	1.570	0.145
Perylene	0.021	0.865	0.079
Phenanthrene	0.022	0.409	0.038
Pyrene	0.019	0.349	0.032
Retene	0.026	0.481	0.048

2.2.4 Metals Sampling and Analytical Method

Sampling for the determination of metals in or on particulate matter was performed by the sites in accordance with EPA Compendium Method IO-3.5 (EPA, 1999d). 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.

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 inductively coupled plasma mass spectrometry (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 ranged from 0.007 ng/m^3 (mercury) to 2.07 ng/m^3 (chromium) for the quartz filters and from 0.010 ng/m^3 (cadmium) to 8.14 ng/m^3 (chromium) for the Teflon® filters.

Table 2-7. 2011 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	0.007	0.055	0.013	Antimony	0.020	0.060	0.023
Arsenic	0.033	0.389	0.049	Arsenic	0.100	0.220	0.160
Beryllium	0.001	0.059	0.008	Beryllium	0.010	0.020	0.011
Cadmium	0.004	0.079	0.010	Cadmium	0.010	0.020	0.010
Chromium	1.430	3.530	2.072	Chromium	6.080	10.800	8.138
Cobalt	0.015	0.067	0.025	Cobalt	0.020	0.030	0.021
Lead	0.060	19.400	0.132	Lead	0.020	0.080	0.024
Manganese	0.074	23.000	0.163	Manganese	0.200	0.270	0.204
Mercury	0.005	0.565	0.007	Mercury	0.020	0.030	0.022
Nickel	0.230	3.940	0.361	Nickel	0.290	1.500	1.096
Selenium	0.009	0.513	0.021	Selenium	0.060	0.180	0.069

2.2.5 Hexavalent Chromium Sampling and Analytical Method

Hexavalent chromium was measured using an EPA-approved approach. For a detailed description of the method, refer to the "Standard Operating Procedure for the Determination of Hexavalent Chromium in Ambient Air Analyzed by Ion Chromatography (IC)" (EPA, 2006). 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 filters secured in Teflon® cartridges to the monitoring sites prior to each scheduled sample collection event and site operators connected the cartridges 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 detection of these 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, the average detection limit for valid samples reported by the ERG laboratory across the program, which is presented in Table 2-8, is 0.0040 ng/m^3. Raw data for the hexavalent chromium method are presented in Appendix H.

Table 2-8. 2011 Hexavalent Chromium Method Detection Limits

Pollutant	Minimum MDL (ng/m^3)	Maximum MDL (ng/m^3)	Average MDL (ng/m^3)
Hexavalent Chromium	0.0024	0.0081	0.0040

2.3 Sample Collection Schedules

Table 2-9 presents the first and last date on which sample collection occurred for each monitoring site sampling under the NMP in 2011. The first sample date for each site is generally at the beginning of January 2011 and sampling continued through the end of December 2011, although there were a few exceptions:

- The San Jose, CA site (SJJCA) samples PM_{10} metals under the NMP. However, in December 2010, this site changed samplers. This site began sampling PM_{10} metals using a low-volume sampler with Teflon® filters on December 16, 2010 (rather than the previous high-volume sampler with quartz filters). As a result, data from the three December 2010 samples collected with the low-volume sampler have been included with the 2011 data for this site.

- The River Rouge and Detroit, MI sites (RRMI and SWMI) began sampling carbonyl compounds under the NMP at the end of January.

- In May, the Grayson, KY site (GLKY) began sampling PM_{10} metals under the NMP, in addition to VOCs, hexavalent chromium, and PAHs. This site also began sampling carbonyl compounds under the NMP in August.

- The Silt, CO site (BRCO) experienced carbonyl compound sampler problems, delaying sampling until September 2011.

- The Paterson, NJ site (PANJ) stopped sampling under the NMP in May.

- The Midwest City, OK site (MWOK) stopped sampling in November 2011 and the instrumentation was moved to a different location in Oklahoma City. Because less than one month of data was available for 2011 for this new site, data from the new location are not included in the 2011 NMP annual report and will be included in the 2012 NMP report.

According to the NMP schedule, 24-hour integrated samples were to be collected at each monitoring site every 1-in-6 days (or 1-in-12 days, dependent upon location and monitoring objectives) and each sample collection began and ended at midnight, local standard time. However, there were some exceptions:

- The Garfield County, CO sites (BMCO, BRCO, PACO, RICO) collected samples by initiating the samplers manually. For these sites, samples were generally collected from mid-morning of one day to mid-morning of the next. In addition, SNMOC samples were collected on a 1-in-6 day schedule while carbonyl compounds were collected on a 1-in-12 day schedule.

- The South Phoenix, AZ site (SPAZ) collected VOC samples on a 1-in-12 day schedule.

- The Paterson, NJ site (PANJ) 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 Burlington, VT and Rutland, VT sites (BURVT and RUVT) collected VOC samples on a 1-in-12 day schedule.

Table 2-9. 2011 Sampling Schedules and Completeness Rates

Site	Monitoring Period[1]		Carbonyl Compounds			VOC			Hexavalent Chromium			Metals			SNMOC			PAH		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
AZFL	1/3/11	12/31/11	62	61	>100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BMCO	1/3/11	12/29/11	20	30	67[2]	--	--	--	--	--	--	--	--	--	51	61	84	--	--	--
BOMA	1/3/11	12/29/11	--	--	--	--	--	--	61	61	100	60	61	98	--	--	--	61	61	100
BRCO	1/3/11	12/29/11	6	9	67[2]	--	--	--	--	--	--	--	--	--	54	61	89	--	--	--
BTUT	1/3/11	12/29/11	60	61	98	60	61	98	61	61	100	60	61	98	60	61	98	62	61	>100
BURVT[2]	1/9/11	12/23/11	--	--	--	30	30	100	--	--	--	--	--	--	--	--	--	--	--	--
CAMS 35	1/3/11	12/29/11	--	--	--	--	--	--	60	61	98	--	--	--	--	--	--	58	61	95
CAMS 85	1/3/11	12/29/11	--	--	--	--	--	--	61	61	100	--	--	--	--	--	--	--	--	--
CELA	1/3/11	12/29/11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	59	61	97
CHNJ	1/3/11	12/29/11	61	61	100	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
CHSC	1/3/11	12/29/11	--	--	--	--	--	--	60	61	98	--	--	--	--	--	--	60	61	98
DEMI	1/3/11	12/29/11	62	61	>100	61	61	100	61	61	100	--	--	--	--	--	--	60	61	98
ELNJ	1/3/11	12/29/11	61	61	100	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--
GLKY	1/3/11	12/29/11	26	26	100	61	61	100	61	61	100	41	41	100	--	--	--	61	61	100

A = Number of valid samples collected.
B = Number of valid samples that should be collected in 2011 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] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

[3] Includes three samples from December 2010.

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

Table 2-9. 2011 Sampling Schedules and Completeness Rates (Continued)

Site	Monitoring Period[1]		Carbonyl Compounds			VOC			Hexavalent Chromium			Metals			SNMOC			PAH		
	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
GPCO	1/3/11	12/29/11	60	61	98	60	61	98	59	61	97	--	--	--	--	--	--	61	61	100
HOWI	1/3/11	12/29/11	--	--	--	--	--	--	61	61	100	--	--	--	--	--	--	--	--	--
INDEM	1/3/11	12/29/11	57	61	93	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MONY	1/3/11	12/29/11	--	--	--	--	--	--	61	61	100	--	--	--	--	--	--	60	61	98
MWOK	1/3/11	11/29/11	56	56	100	56	56	100	--	--	--	56	56	100	--	--	--	--	--	--
NBIL	1/3/11	12/29/11	62	61	>100	55	61	90	61	61	100	53	61	87	54	61	89	61	61	100
NBNJ	1/3/11	12/29/11	62	61	>100	58	61	95	--	--	--	--	--	--	--	--	--	--	--	--
OCOK	1/3/11	12/29/11	60	61	98	61	61	100	--	--	--	61	61	100	--	--	--	--	--	--
ORFL	1/3/11	12/29/11	60	61	98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PACO	1/3/11	12/29/11	21	30	70[2]	--	--	--	--	--	--	--	--	--	53	61	87	--	--	--
PAFL[2]	1/3/11	12/29/11	--	--	--	--	--	--	--	--	--	31	31	100	--	--	--	--	--	--
PANJ[2]	1/3/11	5/15/11	--	--	--	12	12	100	--	--	--	--	--	--	--	--	--	--	--	--
PROK	1/3/11	12/29/11	58	61	95	56	61	92	--	--	--	56	61	92	--	--	--	--	--	--
PRRI	1/3/11	12/29/11	--	--	--	--	--	--	57	61	93	--	--	--	--	--	--	57	60	95
PXSS	1/3/11	12/29/11	48	61	79	61	61	100	62	61	>100	61	61	100	--	--	--	57	61	93

A = Number of valid samples collected.
B = Number of valid samples that should be collected 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] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.
[3] Includes three samples from December 2010.
BOLD ITALICS = EPA-designated NATTS site.
Shading indicates that completeness is below the MQO of 85%.

Table 2-9. 2011 Sampling Schedules and Completeness Rates (Continued)

	Monitoring Period[1]		Carbonyl Compounds			VOC			Hexavalent Chromium			Metals			SNMOC			PAH		
Site	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
RICO	1/3/11	12/29/11	17	30	57[2]	--	--	--	--	--	--	--	--	--	53	61	87	--	--	--
RIVA	1/3/11	12/29/11	--	--	--	--	--	--	61	61	100	--	--	--	--	--	--	61	61	100
ROCH	1/3/11	12/29/11	--	--	--	--	--	--	56	61	92	--	--	--	--	--	--	58	61	95
RRMI	1/21/11	12/29/11	57	58	98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RUCA	1/3/11	12/29/11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	61	61	100
RUVT[2]	1/9/11	12/23/11	--	--	--	30	30	100	--	--	--	--	--	--	--	--	--	--	--	--
S4MO	1/3/11	12/29/11	59	61	97	57	61	93	61	61	100	59	61	97	--	--	--	61	61	100
SDGA	1/3/11	12/31/11	--	--	--	--	--	--	61	61	100	--	--	--	--	--	--	61	61	100
SEWA	1/3/11	12/29/11	60	61	98	61	61	100	61	61	100	61	61	100	--	--	--	60	61	98
SJJCA[3]	12/16/10	12/29/11	--	--	--	--	--	--	--	--	--	64	64	100	--	--	--	61	61	100
SKFL	1/3/11	12/29/11	61	61	100	--	--	--	62	61	>100	--	--	--	--	--	--	61	61	100
SPAZ[2]	1/6/11	12/29/11	--	--	--	31	31	100	--	--	--	--	--	--	--	--	--	--	--	--
SPIL	1/3/11	12/29/11	62	61	>100	56	61	92	--	--	--	--	--	--	--	--	--	--	--	--
SSSD	1/3/11	12/29/11	59	61	97	60	61	98	--	--	--	--	--	--	60	61	98	--	--	--
SWMI[2]	1/27/11	12/29/11	28	29	97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

A = Number of valid samples collected.
B = Number of valid samples that should be collected 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] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.

[3] Includes three samples from December 2010.

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

Table 2-9. 2011 Sampling Schedules and Completeness Rates (Continued)

	Monitoring Period[1]		Carbonyl Compounds			VOC			Hexavalent Chromium			Metals			SNMOC			PAH		
Site	First Sample	Last Sample	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
SYFL	1/3/11	12/29/11	60	61	98	--	--	--	59	61	97	--	--	--	--	--	--	60	61	98
TMOK	1/3/11	12/29/11	61	61	100	60	61	98	--	--	--	58	61	95	--	--	--	--	--	--
TOOK	1/3/11	12/29/11	56	61	92	57	61	93	--	--	--	56	61	92	--	--	--	--	--	--
UCSD	1/6/11	12/29/11	61	61	100	56	61	92	--	--	--	--	--	--	56	61	92	--	--	--
UNVT	1/3/11	12/29/11	--	--	--	60	61	98	60	61	98	57	61	93	--	--	--	60	61	98
WADC	1/3/11	12/29/11	--	--	--	--	--	--	61	61	100	--	--	--	--	--	--	61	61	100
WPIN	1/3/11	12/29/11	51	61	84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

A = Number of valid samples collected.
B = Number of valid samples that should be collected 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] Sampling schedule was a 1-in-12 day schedule rather than a 1-in-6 schedule.
[3] Includes three samples from December 2010.
BOLD ITALICS = EPA-designated NATTS site.
Shading indicates that completeness is below the MQO of 85%.

Table 2-9 shows the following:

- 24 sites collected VOC samples and 31 sites collected carbonyl compound samples; VOC and carbonyl compound samples were collected concurrently at 19 sites.
- 8 sites collected SNMOC samples.
- 23 sites collected PAH samples.
- 15 sites collected metals samples.
- 22 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. 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, 2011). The data in Table 2-9 show that seven datasets from a total of 123 datasets from the 2011 NMP monitoring sites did not meet this MQO (shaded cells in Table 2-9):

- Four of the seven site-method combinations for which completeness was less than 85 percent were for Garfield County carbonyl compound sites (BRCO, BMCO, PACO, and RICO). These sites tended to experience issues with their carbonyl compound samplers. Prolonged issues resulted in BRCO sampling carbonyl compounds for only four months out of the year.

- Canister issues and several missed sample days led to a completeness less than 85 percent for BMCO SNMOC.

- Maintenance of the primary carbonyl compound sampler at PXSS in 2010 led to a problem with the ozone denuder. As a result, the primary sampling results from mid-February 2010 through March 2011 were invalidated.

- Intermittent sampler issues throughout 2011 resulted in a carbonyl compound completeness less than 85 percent for WPIN.

Although the completeness for S4MO's VOC is 93 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. This is discussed in more detail in the Missouri state section (Section 16).

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 2011 NMP and ranged from 90.37 percent for SNMOC to 98.96 percent for hexavalent chromium.

Table 2-10. Method Completeness Rates for 2011

Method	# of Valid Samples	# of Samples Scheduled	Method Completeness (%)	Minimum Site-Specific Completeness (%)	Maximum Site-Specific Completeness (%)
VOC	1,281	1,318	97.19	90.16 (NBNJ)	100.00 (12 sites)
SNMOC	441	488	90.37	83.60 (BMCO)	98.36 (BTUT)
Carbonyl Compounds	1,594	1,671	95.39	56.67 (RICO)	>100 (5 sites)
PAH	1,382	1,402	98.57	93.44 (PXSS)	>100 (BTUT)
Metals Analysis	834	863	96.64	86.89 (NBIL)	100.00 (7 sites)
Hexavalent Chromium	1,328	1,342	98.96	91.80 (ROCH)	>100 (2 sites)

3.0 Summary of the 2011 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 2011 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 and results from the site-specific data analyses are presented in the individual state sections, Sections 5 through 28.

A total of 218,948 valid air toxics concentrations (including non-detects, duplicate analyses, replicate analyses, and analyses for collocated samples) were produced from 8,835 valid samples collected at 51 monitoring sites during the 2011 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 here.

Table 3-1. Overview and Layout of Data Presented

Pollutant Group	Number of Sites	Appendix	
		Raw Data	Statistical Summary
VOCs	24	C	J
SNMOCs	8	D	K
Carbonyl Compounds	31	E	L
PAHs	23	F	M
Metals	15	G	N
Hexavalent Chromium	22	H	O

3.1 Approach to Data Treatment

This section examines the various statistical tools employed to characterize the data collected during the 2011 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.

For each monitoring site, the primary, duplicate (or collocated), and replicate measurements 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 29).

For the 2011 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, in the 2010 and 2011 NMP reports, 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 the NATTS Network Assessment (EPA, 2012f). The substitution of zeros for non-detects results in lower average concentrations of pollutants that are rarely measured at or above the associated method detection limit 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. As such, 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 site must have a minimum of 75 percent valid samples of the total number of samples possible within a given quarter to have a quarterly average. 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 (2011). Annual average concentrations were calculated for monitoring sites where three quarterly averages could be calculated and where method completeness 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 NMP annual reports prior to

2003, this subset was based on the frequency and magnitude of concentrations (previously called "prevalent compounds"). Since the 2003 NMP annual report, health risk-based calculations have been used to identify "pollutants of interest." For the 2011 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, 2010a). 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, 2012g).

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 that utilizes a risk-based methodology for performing an initial screen of ambient air toxics monitoring datasets (EPA, 2010a). This *preliminary risk-based screening process* provides 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 177 pollutants sampled under the NMP, 81 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 hexachloro-1,3-butadiene 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.

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 analysis

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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, 2012h).

calculations 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.

In addition to the preliminary risk-based screening process described above, the pollutants of interest designation was further refined based on the NATTS TAD (EPA, 2009b). This document 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).

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/EPA

With the exception of acrolein, all of the pollutants listed in Table 3-2 are inherently considered pollutants of interest due to their designation as NATTS MQO Core Analytes. If a pollutant listed in Table 3-2 did not meet the pollutant of interest criteria based on the preliminary risk-based screening approach outlined above, that pollutant was added to the list of program-wide pollutants of interest.

Although it is a NATTS MQO Core Analyte, acrolein was excluded from the preliminary risk-based screening process due to questions about the consistency and reliability of the measurements (EPA, 2010b). 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 (as discussed above).

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 EPA's national contract laboratory 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 benchmarks (ATSDR, 2012a). 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, 2012b). MRLs are intended to be used as screening tools, similar to the preliminary risk-based screening process discussed above, where "exposure to a level above the MRL does not mean that adverse health effects will occur" (ATSDR, 2012b). 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, 2012b). 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 $\mu g/m^3$, 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 expanded upon in the individual state sections.

3.4 Additional Program-Level Analyses of the 2011 National Monitoring Programs Dataset

This section summarizes additional analyses performed on the 2011 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 from motor vehicles contribute significantly to air pollution. “Mobile sources” refer to emitters of air pollutants that move, or can be moved, from place to place and include both on-road and non-road emissions (EPA, 2012i). 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 evaluate the effect of motor vehicle emissions on 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).

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 is 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. 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. 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, 2012j).

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, 2013a). 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 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, 2012j). In the future, additional GHG pollutants 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 28).

3.5.1 Site Characterization

For each site participating in the 2011 NMP, a site characterization was performed. This analysis 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.

Regarding the plotting of emissions sources: for the 2011 (and 2010) NMP report, the locations of point sources located near the monitoring sites were obtained from Version 2 of the 2008 NEI (EPA, 2012d). The 2008 NEI was compiled using a more streamlined approach by EPA from state, local, and tribal agencies, as well as limited emission inventory data from other federal programs, such as EPA's Toxics Release Inventory (TRI). By comparison, the 2008-2009 NMP report used Version 3 of the 2005 NEI, which included additional datasets not available for the 2008 NEI. Thus, the total number of emission sources surrounding the monitoring sites is generally lower in the 2008 NEI vs. the 2005 NEI. When comparing facility maps and emission estimates presented in the 2011 (and 2010) NMP report to those presented in the 2008-2009 NMP report, it should be noted that the emissions inventory used in each report was for different base years and was compiled differently.

3.5.2 Meteorological Analysis

Several site-specific meteorological analyses were performed in order to help readers to 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 2011 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 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, 2010 and 2011). 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 is 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 2011, 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 1 hour to a new point of reference based on the current measured wind speed and direction. At this new point of reference (that is now 1 hour prior to the current observation), the wind speed and direction are used again to determine where the air was 1 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, 2013a). 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 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 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 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 historical wind rose for up to 10 years prior to sampling; second, 2011 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 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 Site-Specific Comparison to Program-level Average Concentrations

To better understand how a site's concentrations compare to the program-level concentrations, 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 selected NATTS MQO Core Analytes listed in Table 3.3. 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 that sampled SNMOCs, benzene and 1,3-butadiene are shown only in comparison to those sites sampling SNMOCs as opposed to sites sampling these pollutants with Method TO-15, 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 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 (μg/m^3) for the purposes of this analysis. These graphs are presented in Sections 5 through 28, 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.

Table 3-3. NATTS MQO Core Analytes Selected for Comparative Analysis

Pollutant	Class/Method
Benzene	VOCs/TO-15
1,3-Butadiene	
Acetaldehyde	Carbonyl Compounds/TO-11A
Formaldehyde	
Benzo(a)pyrene	PAHs/TO-13A
Naphthalene	
Arsenic	Metals/IO-3.5
Manganese	
Lead	
Hexavalent Chromium	Metals/EPA

3.5.4 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 the selected NATTS MQO Core Analytes shown in Table 3-3. Twenty-nine of the 51 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 28).

The trends figures and analyses are presented as 1-year statistical metrics, which is a change from previous reports (where 3-year rolling average concentrations were calculated). 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.
- There must be a minimum of 85 percent completeness for each sampling year, 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).

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 5-18. 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, gray line, or top of the box, respectively); and the average concentration (as denoted by the orange diamond). Each of the five metrics represents all measurements from that 1-year period.

Data used in this analysis were downloaded from EPA's AQS database (EPA, 2012c), 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.

3.5.5 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 risk-related analyses at the site-specific level, as described below:

- 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.

3.5.5.1 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 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.

3.5.5.2 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, 2012h). 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 28).

3.5.5.3 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. For chromium and chromium compounds, trivalent chromium (non-toxic) must be separated from hexavalent chromium (toxic). To do this, apply the chromium speciation profile to extract the hexavalent chromium mass by industry group.

4. 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 3-4 presents the 22 PAHs measured by Method TO-13A and their associated POM Groups. The POM groups are sub-grouped in Table 3-4 because toxicity research has led to the refining of UREs for certain PAHs (EPA, 2012h). 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 3-4 do not have assigned POM Groups.

Table 3-4. 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 2011 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 54 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 method:

- 40.7 percent for VOCs
- 51.1 percent for SNMOCs
- 81.5 percent for carbonyl compounds
- 63.0 percent for PAHs

- 82.6 percent for metals
- 79.4 percent for hexavalent chromium samples.

Some pollutants were always detected 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 (1,594), using the preprocessed daily measurements. These pollutants were reported in every valid carbonyl compound sample collected (1,594). Acetylene, benzene, chloromethane, dichlorodifluoromethane, propylene, toluene, trichlorofluoromethane, and trichlorotrifluoroethane were detected in every valid VOC sample collected (1,281). Eight pollutants, including acetylene, ethylene, ethane, and toluene, were detected in every valid SNMOC sample collected (441). Naphthalene, phenanthrene, fluoranthene, and pyrene were detected in every valid PAH sample collected (1,382). Cadmium, lead, manganese, and nickel were detected in every valid metal sample collected (834). Hexavalent chromium was detected in 1,068 samples (out of 1,328 samples).

Although BTUT and NBIL have the greatest number of measured detections (7,321 for BTUT and 6,995 for NBIL), they were also the only two sites that collected samples for all six analytical methods/pollutant groups. However, the detection rates for these sites (66 and 68 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 99 percent. Conversely, VOCs had the lowest percentage of concentrations greater than the MDLs (40.7 percent). A site measuring only VOCs would be expected to have lower detection rates, such as SPAZ (48.3 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)	Coefficient of Variation
Acetonitrile	1,275	6	0.045	1,030	14.7	0.392	0.206	0.200	1.91	67.0	4.55
Acetylene	1,281	0	0.082	101	0.935	0.598	1.09	0.387	0.970	3.31	3.54
Acrolein	1,254	27	0.078	11.0	0.489	0.370	0	0.215	0.597	0.526	1.08
Acrylonitrile[3]	300	924	0.013	0.778	0.039	0	0	0	0	0.103	2.62
tert-Amyl Methyl Ether	33	1,248	0.004	0.010	0.000	0	0	0	0	0.001	6.36
Benzene	1,281	0	0.053	7.42	0.305	0.218	0.149	0.158	0.325	0.359	1.18
Bromochloromethane	3	1,278	0.009	0.049	0.0001	0	0	0	0	0.001	26.4
Bromodichloromethane	61	1,220	0.012	3.05	0.021	0	0	0	0	0.163	7.90
Bromoform	69	1,212	0.004	0.062	0.001	0	0	0	0	0.004	5.34
Bromomethane	737	544	0.007	0.437	0.010	0.010	0	0	0.014	0.019	1.99
1,3-Butadiene	966	315	0.007	4.29	0.043	0.028	0	0.008	0.050	0.133	3.07
Carbon Disulfide	1,219	62	0.004	22.8	0.925	0.033	0	0.013	0.425	2.60	2.81
Carbon Tetrachloride	1,279	2	0.006	0.260	0.096	0.098	0.098	0.085	0.109	0.022	0.234
Chlorobenzene	20	1,261	0.007	0.084	0.000	0	0	0	0	0.003	10.4
Chloroethane	203	1,078	0.006	8.18	0.011	0	0	0	0	0.229	21.0
Chloroform	756	525	0.003	6.72	0.079	0.018	0	0	0.030	0.427	5.38
Chloromethane	1,281	0	0.133	2.53	0.611	0.600	0.610	0.543	0.663	0.114	0.186
Chloromethylbenzene	9	1,272	0.008	0.124	0.000	0	0	0	0	0.005	18.6
Chloroprene	1	1,280	0.016		NA						
Dibromochloromethane	299	982	0.002	1.13	0.008	0	0	0	0	0.055	6.52
1,2-Dibromoethane	31	1,250	0.005	0.022	0.000	0	0	0	0	0.002	6.82
m-Dichlorobenzene	88	1,193	0.004	0.329	0.001	0	0	0	0	0.012	9.12
o-Dichlorobenzene	108	1,173	0.002	0.083	0.001	0	0	0	0	0.003	4.64
p-Dichlorobenzene	736	545	0.003	0.469	0.013	0.008	0	0	0.017	0.024	1.86
Dichlorodifluoromethane	1,281	0	0.114	1.23	0.554	0.548	0.544	0.526	0.578	0.059	0.106
1,1-Dichloroethane	5	1,276	0.008	0.021	0.0001	0	0	0	0	0.001	17.0

[1] Out of 1,281 valid samples

[2] Excludes zeros for non-detects

[3] Because S4MO invalidated all acrylonitrile data for 2011, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected (1,281).

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)	Coefficient of Variation
1,2-Dichloroethane	320	961	0.011	0.174	0.006	0	0	0	0	0.012	2.04
1,1-Dichloroethene	22	1,259	0.005	0.018	0.0001	0	0	0	0	0.001	8.14
cis-1,2-Dichloroethylene	0	1,281	Not Detected								
trans-1,2-Dichloroethylene	14	1,267	0.006	0.050	0.0002	0	0	0	0	0.002	11.8
Dichloromethane	1,264	17	0.040	349	1.01	0.128	0	0.087	0.230	12.6	12.5
1,2-Dichloropropane	1	1,280	0.012		NA						
cis-1,3-Dichloropropene	11	1,270	0.007	0.088	0.0002	0	0	0	0	0.003	14.6
trans-1,3-Dichloropropene	6	1,275	0.011	0.057	0.0001	0	0	0	0	0.002	17.9
Dichlorotetrafluoroethane	1,241	40	0.004	0.078	0.019	0.018	0.017	0.016	0.020	0.008	0.440
Ethyl Acrylate	4	1,277	0.020	0.078	0.0001	0	0	0	0	0.003	20.7
Ethyl *tert*-Butyl Ether	8	1,273	0.005	0.016	0.0001	0	0	0	0	0.001	13.2
Ethylbenzene	1,277	4	0.004	2.65	0.093	0.064	0.038	0.041	0.101	0.123	1.32
Hexachloro-1,3-butadiene	113	1,168	0.003	0.064	0.001	0	0	0	0	0.004	4.12
Methyl Ethyl Ketone	1,280	1	0.059	34.3	0.541	0.430	0.474	0.285	0.643	1.00	1.85
Methyl Isobutyl Ketone	1,202	79	0.006	2.43	0.043	0.034	0	0.022	0.052	0.074	1.72
Methyl Methacrylate	54	1,227	0.009	0.34	0.002	0	0	0	0	0.014	7.34
Methyl *tert*-Butyl Ether	37	1,244	0.005	0.274	0.001	0	0	0	0	0.012	11.4
n-Octane	1,241	40	0.008	2.62	0.061	0.041	0	0.027	0.065	0.100	1.64
Propylene	1,281	0	0.057	34.1	0.704	0.374	0.348	0.265	0.558	1.85	2.63
Styrene	1,219	62	0.006	3.06	0.059	0.034	0	0.023	0.049	0.156	2.65
1,1,2,2-Tetrachloroethane	55	1,226	0.004	0.048	0.0005	0	0	0	0	0.003	5.50
Tetrachloroethylene	958	323	0.004	1.27	0.023	0.014	0	0	0.027	0.048	2.06
Toluene	1,281	0	0.023	14.9	0.586	0.339	0.288	0.187	0.645	0.959	1.64
1,2,4-Trichlorobenzene	48	1,233	0.004	0.083	0.001	0	0	0	0	0.003	6.82
1,1,1-Trichloroethane	1,096	185	0.002	0.081	0.010	0.010	0	0.008	0.012	0.006	0.570
1,1,2-Trichloroethane	8	1,273	0.008	0.017	0.000	0	0	0	0	0.001	13.0

[1] Out of 1,281 valid samples

[2] Excludes zeros for non-detects

[3] Because S4MO invalidated all acrylonitrile data for 2011, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected (1,281).

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)	Coefficient of Variation
Trichloroethylene	251	1,030	0.004	1.56	0.009	0	0	0	0	0.067	7.57
Trichlorofluoromethane	1,281	0	0.051	1.41	0.280	0.270	0.262	0.255	0.290	0.061	0.219
Trichlorotrifluoroethane	1,281	0	0.023	0.180	0.097	0.096	0.096	0.089	0.104	0.012	0.129
1,2,4-Trimethylbenzene	1,275	6	0.005	1.05	0.088	0.061	0.033	0.039	0.103	0.095	1.07
1,3,5-Trimethylbenzene	1,226	55	0.004	0.386	0.032	0.024	0	0.016	0.037	0.031	0.937
Vinyl chloride	82	1,199	0.003	0.033	0.001	0	0	0	0	0.002	6.21
m,p-Xylene	1,273	8	0.009	6.08	0.243	0.148	0.033	0.078	0.267	0.386	1.11
o-Xylene	1,267	14	0.005	1.99	0.095	0.062	0.023	0.036	0.105	0.127	0.997

[1] Out of 1,281 valid samples

[2] Excludes zeros for non-detects

[3] Because S4MO invalidated all acrylonitrile data for 2011, the number of measured detections plus the number of non-detects does not equal the total number of VOC samples collected (1,281).

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)	Coefficient of Variation
Acetylene	441	0	0.271	237	2.25	1.12	1.10	0.733	1.70	12.4	5.51
Benzene	436	5	0.241	12.9	1.65	1.13	0	0.704	2.25	1.42	0.860
1,3-Butadiene	151	290	0.041	4.24	0.120	0	0	0	0.184	0.285	2.38
n-Butane	361	80	0.339	81.9	11.7	5.70	0	1.53	16.0	15.1	1.29
cis-2-Butene	325	116	0.048	2.36	0.197	0.146	0	0	0.230	0.268	1.36
trans-2-Butene	337	104	0.066	5.54	0.276	0.177	0	0.092	0.297	0.423	1.53
Cyclohexane	425	16	0.101	16.9	1.92	0.954	0	0.240	2.81	2.41	1.25
Cyclopentane	414	27	0.076	21.0	0.615	0.402	0	0.241	0.723	1.14	1.85
Cyclopentene	117	324	0.077	8.21	0.134	0	0	0	0.086	0.488	3.64
n-Decane	405	36	0.073	9.12	0.571	0.383	0	0.170	0.668	0.801	1.40
1-Decene	5	436	0.096	4.27	0.013	0	0	0	0	0.207	16.0
m-Diethylbenzene	401	40	0.075	2.38	0.404	0.350	0	0.239	0.522	0.290	0.717
p-Diethylbenzene	357	84	0.077	1.82	0.269	0.214	0	0.118	0.356	0.272	1.01
2,2-Dimethylbutane	424	17	0.088	2.93	0.555	0.421	0	0.262	0.709	0.453	0.815
2,3-Dimethylbutane	351	90	0.101	3.86	0.730	0.455	0	0.165	1.04	0.802	1.10
2,3-Dimethylpentane	423	18	0.107	4.07	0.611	0.478	0	0.303	0.803	0.482	0.788
2,4-Dimethylpentane	423	18	0.080	2.28	0.406	0.324	0	0.197	0.539	0.311	0.765
n-Dodecane	427	14	0.073	6.60	0.519	0.437	0	0.322	0.628	0.464	0.895
1-Dodecene	355	86	0.071	8.57	0.302	0.201	0	0.112	0.363	0.511	1.69
Ethane	441	0	1.59	1,390	54.9	26.2	100	5.89	69.4	97.1	1.77
2-Ethyl-1-butene	2	439	0.241	0.557	0.002	0	0	0	0	0.029	15.9
Ethylbenzene	433	8	0.086	4.05	0.531	0.341	0	0.232	0.636	0.509	0.959
Ethylene	441	0	0.717	674	4.81	2.09	1.83	1.57	3	35.3	7.33
m-Ethyltoluene	403	38	0.082	2.68	0.328	0.266	0	0.162	0.435	0.275	0.841
o-Ethyltoluene	319	122	0.086	2.71	0.222	0.182	0	0	0.320	0.272	1.23
p-Ethyltoluene	403	38	0.062	1.99	0.246	0.214	0	0.151	0.310	0.187	0.762
n-Heptane	435	6	0.079	11.9	1.65	0.924	0	0.261	2.44	1.88	1.14

[1] Out of 441 valid samples

[2] Excludes zeros for non-detects

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)	Coefficient of Variation
1-Heptene	308	133	0.050	3.87	0.436	0.202	0	0	0.671	0.562	1.29
n-Hexane	439	2	0.137	67.9	3.48	1.72	1.01	0.599	4.29	5.44	1.56
1-Hexene	357	84	0.086	0.566	0.190	0.211	0	0.137	0.263	0.115	0.604
cis-2-Hexene	54	387	0.076	0.404	0.020	0	0	0	0	0.061	3.01
trans-2-Hexene	25	416	0.064	0.543	0.010	0	0	0	0	0.051	5.02
Isobutane	440	1	0.208	129	11.8	5.73	1.14	1.50	15.7	15.5	1.31
Isobutene/1-Butene	181	260	0.107	13.5	0.889	0	0	0	1.52	1.57	1.77
Isopentane	418	23	0.729	110	14.0	10.2	0	4.36	18.9	14.4	1.03
Isoprene	370	71	0.076	7.20	0.406	0.195	0	0.127	0.362	0.671	1.65
Isopropylbenzene	273	168	0.081	0.400	0.094	0.116	0	0	0.155	0.081	0.863
2-Methyl-1-butene	249	192	0.096	2.84	0.220	0.163	0	0	0.312	0.318	1.45
3-Methyl-1-butene	6	435	0.161	2.25	0.010	0	0	0	0	0.121	11.7
2-Methyl-1-pentene	12	429	0.062	0.382	0.005	0	0	0	0	0.033	7.02
4-Methyl-1-pentene	14	427	0.116	0.358	0.006	0	0	0	0	0.035	5.92
2-Methyl-2-butene	287	154	0.087	7.81	0.262	0.191	0	0	0.326	0.505	1.93
Methylcyclohexane	418	23	0.101	33.1	3.58	1.44	0	0.266	5.42	4.76	1.33
Methylcyclopentane	438	3	0.104	21.5	1.85	1.04	2.76	0.384	2.47	2.33	1.26
2-Methylheptane	349	92	0.059	3.15	0.482	0.290	0	0.096	0.761	0.538	1.11
3-Methylheptane	357	84	0.054	2.43	0.386	0.251	0	0.108	0.576	0.406	1.05
2-Methylhexane	427	14	0.168	6.76	1.31	0.930	0	0.549	1.82	1.09	0.834
3-Methylhexane	411	30	0.135	6.66	1.19	0.839	0	0.390	1.71	1.11	0.933
2-Methylpentane	441	0	0.243	28.3	3.46	2.24	1.16	0.967	4.48	3.70	1.07
3-Methylpentane	441	0	0.099	22.1	1.98	1.19	2.49	0.529	2.58	2.34	1.18
n-Nonane	403	38	0.066	11.0	0.668	0.401	0	0.171	0.827	0.938	1.40
1-Nonene	135	306	0.054	3.60	0.090	0	0	0	0.139	0.248	2.75
n-Octane	423	18	0.090	8.94	1.15	0.643	0	0.241	1.60	1.30	1.13
1-Octene	164	277	0.057	0.727	0.078	0	0	0	0.143	0.121	1.56

[1] Out of 441 valid samples

[2] Excludes zeros for non-detects

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)	Coefficient of Variation
n-Pentane	441	0	0.160	199	7.88	3.76	1.94	1.5	8.85	14.1	1.79
1-Pentene	422	19	0.075	17.2	0.425	0.233	0	0.179	0.339	1.12	2.62
cis-2-Pentene	266	175	0.062	121	0.735	0.103	0	0	0.154	7.95	10.8
trans-2-Pentene	363	78	0.064	2.63	0.209	0.158	0	0.107	0.253	0.255	1.22
a-Pinene	122	319	0.071	1.70	0.106	0	0	0	0.142	0.220	2.08
b-Pinene	46	395	0.094	2.00	0.067	0	0	0	0	0.237	3.55
Propane	441	0	1.41	376	34.5	18.0	126	6.15	43.6	43.2	1.25
n-Propylbenzene	347	94	0.075	1.24	0.155	0.148	0	0.103	0.207	0.133	0.863
Propylene	438	3	0.294	46.4	1.19	0.836	1.03	0.640	1.16	2.51	2.11
Propyne	9	432	0.101	0.225	0.003	0	0	0	0	0.024	7.18
Styrene	83	358	0.052	5.06	0.104	0	0	0	0	0.424	4.07
Toluene	441	0	0.248	174	4.60	2.29	2.72	1.14	4.24	14.2	3.08
n-Tridecane	41	400	0.061	2.45	0.024	0	0	0	0	0.141	5.85
1-Tridecene	14	427	0.073	0.377	0.005	0	0	0	0	0.028	6.24
1,2,3-Trimethylbenzene	359	82	0.074	1.33	0.166	0.155	0	0.108	0.215	0.140	0.844
1,2,4-Trimethylbenzene	430	11	0.108	10.2	0.557	0.417	0	0.278	0.661	0.653	1.17
1,3,5-Trimethylbenzene	254	187	0.059	2.01	0.210	0.134	0	0	0.324	0.267	1.27
2,2,3-Trimethylpentane	108	333	0.074	0.707	0.062	0	0	0	0	0.124	2.00
2,2,4-Trimethylpentane	332	109	0.084	4.26	0.404	0.235	0	0.086	0.503	0.549	1.36
2,3,4-Trimethylpentane	383	58	0.056	1.48	0.212	0.174	0	0.120	0.249	0.192	0.909
n-Undecane	401	40	0.078	13.1	0.429	0.287	0	0.150	0.493	0.765	1.78
1-Undecene	57	384	0.053	2.72	0.055	0	0	0	0	0.258	4.70
m-Xylene/*p*-Xylene	246	195	0.076	13.7	1.13	0.360	0	0	1.75	1.78	1.57
o-Xylene	426	15	0.097	4.97	0.539	0.396	0	0.231	0.649	0.555	1.03
SNMOC (Sum of Knowns)	441	NA	15.9	2,740	192	116	250	49.1	250	234	1.22
Sum of Unknowns	441	NA	11.2	5,510	88.6	47.0	29.5	28.5	76.4	281	3.18
TNMOC	441	NA	30.1	5,660	280	195	245	101	328	366	1.31

[1] Out of 441 valid samples

[2] Excludes zeros for non-detects

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)	Coefficient of Variation
Acetaldehyde	1,594	0	0.023	8.05	1.11	0.928	1.07	0.636	1.38	0.719	0.647
Acetone	1,594	0	0.031	6.48	1.08	0.881	1.21	0.580	1.37	0.771	0.716
Benzaldehyde	1,572	22	0.004	0.359	0.032	0.024	0.017	0.016	0.035	0.030	0.956
Butyraldehyde	1,591	3	0.008	0.924	0.103	0.084	0.065	0.058	0.121	0.079	0.770
Crotonaldehyde	1,570	24	0.005	2.19	0.108	0.040	0.016	0.022	0.123	0.163	1.51
2,5-Dimethylbenzaldehyde	0	1,594	Not Detected								
Formaldehyde	1,594	0	0.026	22.5	2.33	1.82	1.79	1.22	2.76	1.89	0.813
Hexaldehyde	1,562	32	0.004	1.29	0.039	0.024	0.012	0.015	0.039	0.086	2.20
Isovaleraldehyde	3	1,591	0.014	0.028	0.00004	0	0	0	0	0.001	23.9
Propionaldehyde	1,588	6	0.008	0.604	0.132	0.110	0.081	0.078	0.165	0.084	0.633
Tolualdehydes	1,364	230	0.005	0.256	0.030	0.024	0	0.014	0.038	0.029	0.947
Valeraldehyde	1,563	31	0.005	0.550	0.030	0.022	0.011	0.014	0.035	0.041	1.35

[1] Out of 1,594 valid samples
[2] Excludes zeros for non-detects

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)	Coefficient of Variation
Acenaphthene	1,366	16	0.0793	111	4.64	2.16	0	0.986	4.55	8.09	1.74
Acenaphthylene	634	748	0.0428	17.6	0.666	0	0	0	0.587	1.54	2.31
Anthracene	1,015	367	0.0229	17.1	0.369	0.171	0	0	0.411	0.826	2.24
Benzo(a)anthracene	968	414	0.015	2.4	0.088	0.043	0	0	0.111	0.158	1.80
Benzo(a)pyrene	844	538	0.0175	1.99	0.084	0.038	0	0	0.109	0.149	1.76
Benzo(b)fluoranthene	1,275	107	0.0194	2.80	0.219	0.117	0	0.054	0.276	0.284	1.30
Benzo(e)pyrene	1,131	251	0.0147	1.87	0.112	0.064	0	0.030	0.145	0.145	1.29
Benzo(g,h,i)perylene	1,225	157	0.0115	1.55	0.126	0.069	0	0.034	0.150	0.168	1.33
Benzo(k)fluoranthene	817	565	0.00906	0.861	0.056	0.030	0	0	0.076	0.086	1.53
Chrysene	1,321	61	0.0204	3.04	0.218	0.134	0	0.070	0.293	0.252	1.15
Coronene	852	530	0.0127	0.705	0.051	0.030	0	0	0.061	0.079	1.55
Cyclopenta[cd]pyrene	250	1,132	0.0147	1.13	0.023	0	0	0	0	0.080	3.50
Dibenz(a,h)anthracene	287	1,095	0.0158	0.276	0.009	0	0	0	0	0.023	2.47
Fluoranthene	1,382	0	0.0925	39.5	2.42	1.27	1.51	0.690	2.51	3.76	1.55
Fluorene	1,376	6	0.365	70.5	4.98	3.03	1.91	1.69	5.16	6.98	1.40
9-Fluorenone	1,379	3	0.101	15.4	1.46	1.03	1.04	0.589	1.77	1.49	1.02
Indeno(1,2,3-cd)pyrene	1,074	308	0.0175	1.34	0.110	0.061	0	0.025	0.138	0.150	1.37
Naphthalene	1,382	0	2.27	779	81.7	62.8	102	32.8	108	73.3	0.898
Perylene	423	959	0.00889	0.398	0.016	0	0	0	0.029	0.033	2.01
Phenanthrene	1,382	0	0.387	178	9.92	5.43	11	2.87	10.1	15.8	1.59
Pyrene	1,382	0	0.0408	19.0	1.40	0.770	1.29	0.419	1.47	1.95	1.39
Retene	1,363	19	0.0204	10.6	0.410	0.203	0	0.117	0.410	0.662	1.61

[1] Out of 1,382 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)	Coefficient of Variation
Antimony (PM_{10})	546	1	0.020	8.87	1.27	0.830	0.190	0.478	1.43	1.44	1.13
Arsenic (PM_{10})	541	6	0.004	4.27	0.587	0.436	0.090	0.258	0.761	0.525	0.894
Beryllium (PM_{10})	517	30	0.0003	0.27	0.012	0.006	0.002	0.002	0.010	0.028	2.25
Cadmium (PM_{10})	547	0	0.006	2.23	0.155	0.083	0.040	0.050	0.153	0.226	1.46
Chromium (PM_{10})	526	21	0.004	11	2.68	2.49	0	1.89	3.25	1.44	0.536
Cobalt (PM_{10})	536	11	0.002	2.96	0.179	0.095	0.040	0.050	0.180	0.303	1.69
Lead (PM_{10})	547	0	0.320	30.9	3.82	2.50	2.47	1.57	4.42	4.00	1.05
Manganese (PM_{10})	547	0	0.403	395	8.81	4.48	13.8	2.36	9.86	20.6	2.34
Mercury (PM_{10})	516	31	0.0005	0.526	0.019	0.010	0.01	0.007	0.020	0.032	1.70
Nickel (PM_{10})	547	0	0.073	7.97	1.27	0.980	1.18	0.629	1.43	1.13	0.890
Selenium (PM_{10})	490	57	0.0001	3.24	0.440	0.300	0	0.140	0.540	0.488	1.11
Antimony (TSP)	287	0	0.063	4.12	0.565	0.432	0.395	0.289	0.696	0.489	0.865
Arsenic (TSP)	287	0	0.099	1.76	0.559	0.519	0.247	0.349	0.704	0.288	0.515
Beryllium (TSP)	287	0	0.003	0.108	0.022	0.018	0.009	0.010	0.029	0.016	0.723
Cadmium (TSP)	287	0	0.025	1.50	0.185	0.145	0.131	0.090	0.218	0.175	0.944
Chromium (TSP)	287	0	0.850	9.06	1.85	1.70	1.45	1.43	2.09	0.719	0.389
Cobalt (TSP)	287	0	0.065	12.3	0.708	0.370	0.368	0.227	0.663	1.30	1.83
Lead (TSP)	287	0	0.571	19.0	3.70	3.12	2.30	2.25	4.36	2.41	0.652
Manganese (TSP)	287	0	2.07	104	17.8	14.4	21.8	9.32	23.1	12.8	0.719
Mercury (TSP)	287	0	0.005	0.089	0.013	0.012	0.012	0.009	0.016	0.007	0.530
Nickel (TSP)	287	0	0.271	5.44	1.20	1.01	1.28	0.690	1.50	0.706	0.589
Selenium (TSP)	287	0	0.052	2.57	0.715	0.690	1.01	0.399	0.951	0.396	0.554

[1] For PM_{10}, out of 548 valid samples
[2] For TSP, out of 287 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)	Coefficient of Variation
Hexavalent Chromium	1,068	260	0.001	0.268	0.024	0.018	0	0.009	0.031	0.026	1.08

[1] Out of 1,328 valid samples

[2] Excludes zeros for non-detects

4.1.2 Concentration Range and Data Distribution

The concentrations measured during the 2011 NMP show 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 (0.045 ppbv to 1,030 ppbv)
- For SNMOCs, ethane (1.59 ppbC to 1,390 ppbC)
- For carbonyl compounds, formaldehyde (0.026 ppbv to 22.5 ppbv)
- For PAHs, naphthalene (2.27 ng/m^3 to 779 ng/m^3)
- For metals, both size fractions, manganese (0.403 ng/m^3 to 395 ng/m^3 for PM_{10} and 2.07 ng/m^3 to 104 ng/m^3 for TSP)
- For hexavalent chromium, 0.001 ng/m^3 to 0.268 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, standard deviation, and coefficient of variation) for each of the pollutants sampled during the 2011 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 (14.7 ± 3.67 ppbv)
- dichloromethane (1.01 ± 0.693 ppbv)
- acetylene (0.934 ± 0.182 ppbv).

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

- ethane (54.9 ± 9.09 ppbC)
- propane (34.5 ± 4.04 ppbC)
- isopentane (14.0 ± 1.34 ppbC).

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

- formaldehyde (2.33 ± 0.09 ppbv)
- acetaldehyde (1.11 ± 0.04 ppbv)
- acetone (1.08 ± 0.04 ppbv).

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

- naphthalene (81.7 ± 3.87 ng/m^3)
- phenanthrene (9.92 ± 0.83 ng/m^3)
- fluorene (4.98 ± 0.37 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} = 8.81 ± 1.73 ng/m^3, TSP = 17.80 ± 1.49 ng/m^3)
- lead (PM_{10} = 3.82 ± 0.34 ng/m^3, TSP = 3.70 ± 0.28 ng/m^3)
- total chromium (PM_{10} = 2.68 ± 0.12 ng/m^3, TSP = 1.85 ± 0.08 ng/m^3).

The average mass concentration of hexavalent chromium, as presented in Table 4-6, is 0.024 ± 0.001 ng/m^3.

Appendices J through O present similar statistical calculations on a site-specific basis.

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.

The results in Table 4-7 are listed in descending order by number of screens failed. Table 4-7 shows that formaldehyde failed the highest number of screens (1,592), although acetaldehyde and benzene were not far behind (1,570 and 1,488, respectively). These three pollutants were also among those with the highest number of measured detections. Conversely, four pollutants (chloroprene, *cis*-1,3-dichloropropene, tetrachloroethylene, and *trans*-1,3-dichloropropene) failed only one screen each. The number of measured detections for these four pollutants varied significantly. Tetrachloroethylene was detected in 958 samples while chloroprene was detected only once (both out of 1,281 valid samples).

While seven pollutants exhibited a failure rate of 100 percent, most of them were infrequently detected. Of these seven, benzene was detected in all 1,488 samples (both SNMOC and Method TO-15), while the other pollutants were detected less frequently. 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. Other pollutants with relatively high failure rates include acetaldehyde, acrylonitrile, carbon tetrachloride, 1,2-dichloroethane, 1,2-dibromoethane, formaldehyde, and 1,1,2,2-tetrachloroethane. While each of these pollutants failed more than 98 percent of screens, four of them (acrylonitrile, 1,2-dichloroethane, 1,2-dibromoethane, and 1,1,2,2-tetrachloroethane) were detected in fewer than 25 percent of samples collected.

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

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Failed Screens	% of Total Failures	Cumulative % Contribution
Formaldehyde	0.077	1,592	1,594	99.87	13.93	13.93
Acetaldehyde	0.45	1,570	1,594	98.49	13.74	27.67
Benzene	0.13	1,488	1,488	100.00	13.02	40.69
Carbon Tetrachloride	0.17	1,261	1,279	98.59	11.03	51.72
Naphthalene	0.029	1,074	1,382	77.71	9.40	61.12
1,3-Butadiene	0.03	995	1,045	95.22	8.71	69.82
Arsenic	0.00023	694	828	83.82	6.07	75.89
Manganese	0.005	518	834	62.11	4.53	80.43
Ethylbenzene	0.4	401	1,487	26.97	3.51	83.94
p-Dichlorobenzene	0.091	351	736	47.69	3.07	87.01
1,2-Dichloroethane	0.038	320	320	100.00	2.80	89.81
Acrylonitrile	0.015	300	300	100.00	2.62	92.43
Acenaphthene	0.011	132	1,366	9.66	1.15	93.59
Fluorene	0.011	117	1,376	8.50	1.02	94.61
Hexachloro-1,3-butadiene	0.045	105	113	92.92	0.92	95.53
Nickel	0.0021	97	834	11.63	0.85	96.38
1,1,2,2-Tetrachloroethane	0.017	55	55	100.00	0.48	96.86
Propionaldehyde	0.8	49	1,588	3.09	0.43	97.29
Fluoranthene	0.011	43	1,382	3.11	0.38	97.66
Hexavalent Chromium	0.000083	40	1,068	3.75	0.35	98.01
Cadmium	0.00056	36	834	4.32	0.31	98.33
Trichloroethylene	0.2	35	251	13.94	0.31	98.64
Dichloromethane	7.7	34	1,264	2.69	0.30	98.93
1,2-Dibromoethane	0.0017	31	31	100.00	0.27	99.20
Benzo(a)pyrene	0.00057	19	844	2.25	0.17	99.37
Lead	0.015	17	834	2.04	0.15	99.52
Chloroform	9.8	14	756	1.85	0.12	99.64
Xylenes	10	12	1,484	0.81	0.10	99.75
Chloromethylbenzene	0.02	9	9	100.00	0.08	99.83
Acenaphthylene	0.011	4	634	0.63	0.03	99.86
Bromomethane	0.5	4	737	0.54	0.03	99.90
1,1,2-Trichloroethane	0.0625	4	8	50.00	0.03	99.93
Carbon Disulfide	70	2	1,219	0.16	0.02	99.95
Cobalt	0.01	2	823	0.24	0.02	99.97
Chloroprene	0.0021	1	1	100.00	0.01	99.97
cis-1,3-Dichloropropene	0.25	1	11	9.09	0.01	99.98
trans-1,3-Dichloropropene	0.25	1	6	16.67	0.01	99.99
Tetrachloroethylene	3.8	1	958	0.10	0.01	100.00
Total		11,429	31,373	36.43		

BOLD = EPA MQO NATTS Core Analyte

The 18 NATTS MQO Core Analytes (excluding acrolein) are bolded in Table 4-7. Several NATTS MQO Core Analytes failed screens, but did not contribute to the top 95 percent of failed screens (such as hexavalent chromium). However, as described in Section 3.2, all NATTS MQO Core Analytes are inherently designated as program-wide pollutants of interest. Two pollutants, beryllium and vinyl chloride, were added as pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens. These two pollutants are not shown in Table 4-7. Note that seven of the 15 pollutants contributing to the top 95 percent of failed screens (ethylbenzene, *p*-dichlorobenzene, 1,2-dichloroethane, acrylonitrile, acenaphthene, fluorene, and hexachloro-1,3-butadiene) are not NATTS MQO Core Analytes.

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

- Acenaphthene
- Acetaldehyde
- Acrylonitrile
- Arsenic
- Benzene
- Benzo(a)pyrene
- Beryllium
- 1,3-Butadiene
- Cadmium
- Carbon Tetrachloride
- Chloroform
- *p*-Dichlorobenzene
- 1,2-Dichloroethane
- Ethylbenzene
- Fluorene
- Formaldehyde
- Hexachloro-1,3-butadiene
- Hexavalent Chromium
- Lead
- Manganese
- Naphthalene
- Nickel
- Tetrachloroethylene
- Trichloroethylene
- Vinyl Chloride

The list of pollutants of interest identified via the preliminary risk-based screening approach for 2011 is similar to the list of pollutants of interest for 2010. There is, however, one exception. Hexachloro-1,3-butadiene was not identified as a pollutant of interest for 2010, although it did fail screens. This pollutant was detected in 10 times as many samples in 2011 compared to 2010 and failed roughly 10 times more screens in 2011 than in 2010.

Of the 81 pollutants sampled for under the NMP that have corresponding screening values, concentrations of 38 pollutants failed at least one screen (or roughly 48 percent of pollutants). Of these, a total of 11,429 out of 31,373 concentrations (or 36.4 percent) failed screens. If the measured detections for vinyl chloride and beryllium (the two NATTS MQO Core Analytes that did not fail any screens) are included in the total number of concentrations (32,259), the percentage of failed screens is 35.4 percent. 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 (11,429 of 53,222, or 21.5 percent).

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 (602), followed by PXSS (589) and NBIL (556). 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.

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	602	2,724	22.10	5
PXSS	589	2,584	22.79	5
NBIL	556	2,662	20.89	6
TOOK	521	1,701	30.63	3
TMOK	511	1,769	28.89	3
BTUT	510	2,473	20.62	6
GPCO	498	2,076	23.99	4
SEWA	482	2,531	19.04	5
DEMI	468	2,112	22.16	4
OCOK	457	1,776	25.73	3
PROK	422	1,640	25.73	3
MWOK	417	1,654	25.21	3
ELNJ	406	1,319	30.78	2
SPIL	405	1,236	32.77	2
NBNJ	364	1,266	28.75	2
CHNJ	345	1,244	27.73	2
SSSD	319	1,251	25.50	3
GLKY	303	2,142	14.15	5
UCSD	300	1,143	26.25	3
UNVT	179	1,884	9.50	4
SKFL	176	964	18.26	3
SYFL	156	814	19.16	3
SPAZ	154	549	28.05	1
SJJCA	143	1,243	11.50	2
RICO	142	414	34.30	2
PACO	125	395	31.65	2
AZFL	123	186	66.13	1
BURVT	123	533	23.08	1
BOMA	122	1,471	8.29	3
ORFL	120	180	66.67	1
INDEM	115	171	67.25	1
MONY	115	893	12.88	2
RRMI	110	169	65.09	1
BMCO	102	367	27.79	2
WPIN	102	153	66.67	1
ROCH	97	735	13.20	2
RUVT	96	472	20.34	1
CAMS 35	75	629	11.92	2
BRCO	70	331	21.15	2
PRRI	66	798	8.27	2
CELA	64	691	9.26	1

[1] Total number of measured detections for all pollutants with screening values, not just those failing screens.

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
PANJ	63	237	26.58	1
WADC	61	731	8.34	2
RIVA	57	681	8.37	2
SWMI	57	84	67.86	1
SDGA	56	668	8.38	2
RUCA	54	625	8.64	1
PAFL	28	308	9.09	1
CHSC	3	452	0.66	2
CAMS 85	0	50	0.00	1
HOWI	0	41	0.00	1

[1] Total number of measured detections for all pollutants with screening values, not just those failing screens.

BOLD ITALICS = EPA-designated NATTS Site

The total number of screens and the number of pollutant groups measured by each site must also be considered when interpreting the results in Table 4-8. For example, sites sampling three, four, or five pollutant groups tended to have a higher number of failed screens. Although WPIN, ORFL, INDEM, and SWMI have the highest failure rates (67-68 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, BTUT, and SEWA. These sites each sampled five or six pollutant groups and have a failure rate around 20 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 only on those pollutants designated as program-level pollutants of interest.

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 considered valid 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 µg/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	Acrylonitrile (µg/m^3)	Benzene (µg/m^3)	1,3-Butadiene (µg/m^3)	Carbon Tetrachloride (µg/m^3)	Chloroform (µg/m^3)	*p*-Dichlorobenzene (µg/m^3)
1	SPIL 0.77 ± 0.11	TOOK 3.59 ± 0.98	SPAZ 0.29 ± 0.10	***DEMI*** 0.65 ± 0.02	***NBIL*** 6.06 ± 2.17	SPAZ 0.26 ± 0.07
2	UCSD 0.17 ± 0.04	SPAZ 1.65 ± 0.45	***PXSS*** 0.23 ± 0.06	***SEWA*** 0.65 ± 0.03	***DEMI*** 0.82 ± 0.14	***S4MO*** 0.21 ± 0.11
3	***GLKY*** 0.16 ± 0.07	PACO 1.45 ± 0.21	OCOK 0.20 ± 0.31	***NBIL*** 0.64 ± 0.03	***PXSS*** 0.37 ± 0.07	PROK 0.20 ± 0.07
4	***NBIL*** 0.13 ± 0.03	TMOK 1.35 ± 0.18	RICO 0.18 ± 0.04	***PXSS*** 0.63 ± 0.03	***S4MO*** 0.35 ± 0.40	***PXSS*** 0.20 ± 0.04
5	CHNJ 0.10 ± 0.05	***PXSS*** 1.34 ± 0.22	SPIL 0.16 ± 0.03	SPAZ 0.63 ± 0.07	SPAZ 0.18 ± 0.04	TOOK 0.15 ± 0.03
6	NBNJ 0.09 ± 0.05	***GPCO*** 1.34 ± 0.35	ELNJ 0.14 ± 0.02	TOOK 0.63 ± 0.05	ELNJ 0.14 ± 0.03	ELNJ 0.10 ± 0.02
7	TMOK 0.08 ± 0.07	RICO 1.27 ± 0.18	***GPCO*** 0.13 ± 0.02	***GLKY*** 0.63 ± 0.03	NBNJ 0.13 ± 0.02	MWOK 0.09 ± 0.01
8	OCOK 0.07 ± 0.05	***BTUT*** 1.14 ± 0.15	***NBIL*** 0.12 ± 0.10	CHNJ 0.62 ± 0.03	***SEWA*** 0.12 ± 0.01	TMOK 0.08 ± 0.02
9	***GPCO*** 0.06 ± 0.03	ELNJ 1.03 ± 0.13	TMOK 0.10 ± 0.02	PROK 0.62 ± 0.03	CHNJ 0.10 ± 0.03	SPIL 0.07 ± 0.03
10	ELNJ 0.04 ± 0.03	RUVT 0.89 ± 0.16	***BTUT*** 0.10 ± 0.02	***S4MO*** 0.61 ± 0.04	SPIL 0.09 ± 0.02	BURVT 0.07 ± 0.01

BOLD ITALICS = EPA-designated NATTS Site

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

Rank	1,2-Dichloroethane ($\mu g/m^3$)	Ethylbenzene ($\mu g/m^3$)	Hexachloro-1,3-Butadiene ($\mu g/m^3$)	Tetrachloroethylene ($\mu g/m^3$)	Trichloroethylene ($\mu g/m^3$)	Vinyl Chloride ($\mu g/m^3$)
1	CHNJ 0.034 ± 0.019	SPAZ 1.06 ± 0.28	***S4MO*** 0.023 ± 0.014	***PXSS*** 0.55 ± 0.28	SPIL 0.64 ± 0.41	***NBIL*** 0.003 ± 0.002
2	***S4MO*** 0.032 ± 0.013	***PXSS*** 0.82 ± 0.13	BURVT 0.019 ± 0.015	SPAZ 0.41 ± 0.16	ELNJ 0.09 ± 0.09	NBNJ 0.003 ± 0.002
3	OCOK 0.031 ± 0.024	TOOK 0.68 ± 0.13	MWOK 0.017 ± 0.023	***NBIL*** 0.35 ± 0.13	SPAZ 0.05 ± 0.03	SPIL 0.003 ± 0.003
4	NBNJ 0.030 ± 0.012	***GPCO*** 0.62 ± 0.11	SPIL 0.016 ± 0.025	SPIL 0.31 ± 0.08	CHNJ 0.05 ± 0.09	***S4MO*** 0.003 ± 0.002
5	ELNJ 0.028 ± 0.014	***DEMI*** 0.61 ± 0.13	NBNJ 0.015 ± 0.01	***GPCO*** 0.26 ± 0.05	***NBIL*** 0.04 ± 0.02	***DEMI*** 0.003 ± 0.002
6	PROK 0.028 ± 0.012	TMOK 0.55 ± 0.09	***GPCO*** 0.014 ± 0.01	ELNJ 0.20 ± 0.05	***GPCO*** 0.04 ± 0.02	CHNJ 0.002 ± 0.002
7	***GLKY*** 0.028 ± 0.01	ELNJ 0.51 ± 0.16	***GLKY*** 0.014 ± 0.009	***DEMI*** 0.18 ± 0.03	***S4MO*** 0.03 ± 0.01	***GPCO*** 0.002 ± 0.002
8	***BTUT*** 0.028 ± 0.013	NBNJ 0.49 ± 0.39	UCSD 0.013 ± 0.011	***S4MO*** 0.18 ± 0.04	NBNJ 0.02 ± 0.01	OCOK 0.001 ± 0.002
9	***GPCO*** 0.027 ± 0.012	***BTUT*** 0.47 ± 0.13	CHNJ 0.011 ± 0.009	MWOK 0.15 ± 0.06	***PXSS*** 0.02 ± 0.01	***PXSS*** 0.001 ± 0.001
10	UCSD 0.026 ± 0.011	***S4MO*** 0.38 ± 0.04	***BTUT*** 0.010 ± 0.008	NBNJ 0.13 ± 0.02	UCSD 0.02 ± 0.02	UCSD 0.001 ± 0.001

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	ELNJ 3.24 ± 0.39	***BTUT*** 4.49 ± 1.15
2	SPIL 2.94 ± 0.61	***S4MO*** 4.25 ± 0.92
3	***S4MO*** 2.75 ± 0.43	OCOK 4.06 ± 0.80
4	TOOK 2.75 ± 0.41	MWOK 4.05 ± 0.53
5	NBNJ 2.49 ± 0.27	TMOK 3.93 ± 0.62
6	***GPCO*** 2.43 ± 0.29	PROK 3.84 ± 0.67
7	OCOK 2.41 ± 0.33	TOOK 3.74 ± 0.57
8	TMOK 2.40 ± 0.34	ELNJ 3.45 ± 0.44
9	UCSD 2.33 ± 0.40	SPIL 3.29 ± 0.46
10	***BTUT*** 2.19 ± 0.35	RRMI 3.23 ± 0.47

BOLD ITALICS = EPA-designated NATTS Site

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

Rank	Acenaphthene (ng/m^3)	Benzo(a)pyrene (ng/m^3)	Fluorene (ng/m^3)	Naphthalene (ng/m^3)
1	***DEMI*** 13.42 ± 5.17	***GPCO*** 0.20 ± 0.08	***NBIL*** 13.46 ± 4.25	***GPCO*** 155.52 ± 29.71
2	***NBIL*** 13.14 ± 4.14	***MONY*** 0.20 ± 0.04	***DEMI*** 11.19 ± 3.84	***DEMI*** 143.35 ± 23.07
3	***ROCH*** 12.29 ± 3.55	***DEMI*** 0.19 ± 0.07	***ROCH*** 9.92 ± 2.81	***MONY*** 135.66 ± 15.50
4	***GPCO*** 10.54 ± 2.17	***PRRI*** 0.16 ± 0.03	***MONY*** 9.47 ± 1.55	***CELA*** 131.96 ± 21.23
5	***MONY*** 8.99 ± 1.80	***NBIL*** 0.15 ± 0.03	***CAMS 35*** 7.84 ± 2.85	***WADC*** 102.71 ± 20.46
6	***CAMS 35*** 6.58 ± 2.30	***S4MO*** 0.13 ± 0.03	***GPCO*** 7.68 ± 0.98	***NBIL*** 99.39 ± 29.75
7	***S4MO*** 5.41 ± 1.45	***BOMA*** 0.11 ± 0.02	***S4MO*** 6.08 ± 1.40	***CAMS 35*** 94.14 ± 18.02
8	***CELA*** 4.92 ± 0.76	***PXSS*** 0.10 ± 0.04	***CELA*** 5.62 ± 0.70	***PRRI*** 91.41 ± 14.27
9	***PRRI*** 3.65 ± 0.83	***ROCH*** 0.09 ± 0.03	***PRRI*** 4.97 ± 0.96	***RUCA*** 91.18 ± 17.14
10	***RIVA*** 3.13 ± 0.64	***SEWA*** 0.08 ± 0.05	***RUCA*** 4.09 ± 0.56	***SDGA*** 90.82 ± 15.61

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)	Beryllium (PM_{10}) (ng/m^3)	Beryllium (TSP) (ng/m^3)	Cadmium (PM_{10}) (ng/m^3)	Cadmium (TSP) (ng/m^3)	Hexavalent Chromium (ng/m^3)
1	***S4MO*** 0.87 ± 0.14	TOOK 0.76 ± 0.08	***PXSS*** 0.047 ± 0.016	PROK 0.029 ± 0.006	***S4MO*** 0.56 ± 0.12	TOOK 0.31 ± 0.08	***PXSS*** 0.065 ± 0.012
2	***PXSS*** 0.77 ± 0.16	TMOK 0.63 ± 0.08	***BTUT*** 0.013 ± 0.004	TOOK 0.026 ± 0.004	***NBIL*** 0.14 ± 0.03	TMOK 0.22 ± 0.03	***CAMS 35*** 0.050 ± 0.007
3	***NBIL*** 0.73 ± 0.15	PROK 0.54 ± 0.07	***BOMA*** 0.010 ± 0.007	MWOK 0.019 ± 0.003	***BTUT*** 0.14 ± 0.05	PROK 0.16 ± 0.02	***DEMI*** 0.047 ± 0.009
4	***SEWA*** 0.66 ± 0.12	OCOK 0.47 ± 0.07	***S4MO*** 0.008 ± 0.002	OCOK 0.018 ± 0.003	***PXSS*** 0.14 ± 0.03	OCOK 0.13 ± 0.03	***MONY*** 0.041 ± 0.005
5	PAFL 0.62 ± 0.17	MWOK 0.40 ± 0.04	***NBIL*** 0.007 ± 0.004	TMOK 0.018 ± 0.003	***BOMA*** 0.13 ± 0.01	MWOK 0.12 ± 0.02	***SEWA*** 0.033 ± 0.007
6	***BTUT*** 0.59 ± 0.19		***SJJCA*** 0.007 ± 0.001		***SEWA*** 0.10 ± 0.03		***S4MO*** 0.033 ± 0.006
7	***BOMA*** 0.43 ± 0.07		***SEWA*** 0.006 ± 0.005		***SJJCA*** 0.07 ± 0.02		***BOMA*** 0.026 ± 0.006
8	***SJJCA*** 0.39 ± 0.07		***UNVT*** 0.006 ± 0.002		***UNVT*** 0.07 ± 0.01		***SKFL*** 0.023 ± 0.005
9	***UNVT*** 0.25 ± 0.06		PAFL 0.004 ± 0.001		PAFL 0.06 ± 0.01		***PRRI*** 0.022 ± 0.006
10							***CAMS 85*** 0.022 ± 0.003

BOLD ITALICS = EPA-designated NATTS Site

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

Rank	Lead (PM_{10}) (ng/m^3)	Lead (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	***S4MO*** 10.42 ± 1.72	TOOK 5.87 ± 0.87	***PXSS*** 22.82 ± 6.79	TOOK 30.09 ± 4.58	***SEWA*** 1.90 ± 0.46	TOOK 1.75 ± 0.19
2	***NBIL*** 4.16 ± 1.07	TMOK 4.91 ± 0.64	***S4MO*** 18.42 ± 13.18	TMOK 20.52 ± 3.06	***PXSS*** 1.74 ± 0.33	TMOK 1.42 ± 0.19
3	***PXSS*** 4.06 ± 0.64	PROK 2.69 ± 0.3	***NBIL*** 8.30 ± 2.29	OCOK 14.04 ± 2.01	***BTUT*** 1.73 ± 0.35	MWOK 1.20 ± 0.21
4	***BTUT*** 3.51 ± 0.98	OCOK 2.61 ± 0.26	***SEWA*** 8.17 ± 2.57	MWOK 13.26 ± 1.94	***BOMA*** 1.38 ± 0.17	OCOK 0.84 ± 0.08
5	***BOM***A 3.07 ± 0.44	MWOK 2.48 ± 0.22	***BTUT*** 7.58 ± 1.27	PROK 11.31 ± 1.88	***NBIL*** 1.27 ± 0.21	PROK 0.79 ± 0.09
6	***SJJCA*** 3.02 ± 0.56		***SJJCA*** 6.62 ± 1.14		***SJJCA*** 1.27 ± 0.17	
7	***SEWA*** 2.89 ± 0.44		***BOMA*** 3.48 ± 0.44		***S4MO*** 1.20 ± 0.26	
8	PAFL 2.13 ± 0.47		PAFL 2.23 ± 0.35		PAFL 0.72 ± 0.10	
9	***UNVT*** 1.46 ± 0.29		***UNVT*** 1.84 ± 0.32		***UNVT*** 0.53 ± 0.10	
10						

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 chloroform for NBIL (6.06 ± 2.17 µg/m^3). As shown in Table 4-9, this annual average concentration is more than seven times the next highest concentration of chloroform (DEMI, 0.82 ± 0.14 µg/m^3). The relatively large confidence interval associated with this annual average indicates a wide range of concentrations are factored into this average. Twenty-five of the 26 highest chloroform concentrations measured program-wide, ranging from 2.61 µg/m^3 to 32.9 µg/m^3, were measured at NBIL. NBIL also had the highest annual average chloroform concentration among sites sampling this pollutant in 2010.

- Behind NBIL's chloroform concentration, the next four highest annual average concentrations were calculated for formaldehyde, ranging from 4.05 ± 2.17 µg/m^3 (MWOK) to 4.49 ± 2.17 µg/m^3 (BTUT). All other annual average concentrations were less than 4.0 µg/m^3. Formaldehyde and acetaldehyde account for 30 of the 32 annual average concentrations greater than 2.0 µg/m^3 in Tables 4-9 through 4-12 (the two exceptions being for NBIL's chloroform and TOOK's benzene).

- Among the VOCs, the annual average concentrations of benzene are the only annual averages consistently greater than 1 µg/m^3. TOOK's annual average benzene concentration (3.59 ± 0.98 µg/m^3) is significantly higher than the next highest annual average benzene concentration (1.65 ± 0.45 µg/m^3 for SPAZ), which is similar to the 2010 NMP report. Across the program, four of the five benzene measurements greater than 10 µg/m^3 (and 11 of the 15 benzene concentrations greater than 5 µg/m^3) were measured at TOOK. Three of the five Colorado sites have one of the top 10 annual average benzene concentrations and both Tulsa, Oklahoma sites appear in Table 4-9 for benzene.

- The difference between the highest and tenth highest annual average concentration of carbon tetrachloride is only 0.04 µg/m^3. The difference between the highest and lowest annual average concentration of this pollutant among all NMP sites is 0.12 µg/m^3, indicating the relative uniformity in concentrations of this pollutant in ambient air.

- The annual average concentration of acrylonitrile for SPIL (0.77 ± 0.11 µg/m^3) is more than four times higher than the next highest annual average concentration of this pollutant (0.17 ± 0.04 µg/m^3 for UCSD). Thirty-one of the 38 highest concentrations of acrylonitrile (those greater than 0.75 µg/m^3) were measured at SPIL and of the 24 measurements greater than 1.0 µg/m^3 program-wide, 19 were measured at SPIL. However, the highest concentration of acrylonitrile (1.69 µg/m^3) was not measured at SPIL; it was measured at TMOK.

- The only other VOC for which an annual average concentration was greater than 1.0 µg/m^3 was calculated for ethylbenzene (SPAZ, 1.06 ± 0.28 µg/m^3). SPAZ had the second highest number of ethylbenzene concentrations greater than 1 µg/m^3 (12), behind only PXSS (20), which had the second highest annual average concentration of ethylbenzene (0.82 ± 0.13 µg/m^3).

- The annual average concentration of trichloroethylene for SPIL (0.64 ± 0.41 µg/m^3) is seven times higher than the next highest annual average (ELNJ, 0.09 ± 0.09 µg/m^3). Of the 13 concentrations of trichloroethylene measured across the program that are greater than 0.75 µg/m^3, 10 were measured at SPIL (and two were measured at ELNJ). Similar trends in SPIL's trichloroethylene concentrations were seen in the 2008-2009 and 2010 NMP reports. The confidence intervals shown for both sites indicate a relatively high-level of variability in the measurements. Note that trichloroethylene was detected in 75 percent of samples at SPIL and 40 percent of samples at ELNJ.

- Although BTUT has the highest annual average concentration of formaldehyde (4.49 ± 1.15 µg/m^3), the maximum concentration was not measured at this site. However, nine of the 26 concentrations greater than 10 µg/m^3 were measured at BTUT. While just greater than 0.50 µg/m^3 separates the annual averages for the top five sites, the confidence interval for BTUT's annual average suggests a slightly higher level of variability in the measurements than the other sites. The site with the maximum formaldehyde measurement (2.71 ± 1.10 µg/m^3) is NBNJ, who's annual average formaldehyde concentration ranked 13th.

- Although ELNJ has the highest annual average concentration of acetaldehyde (3.24 ± 0.39 µg/m^3), the maximum concentration was measured at SPIL (14.5 µg/m^3), which has the second highest annual average concentration (2.94 ± 0.61 µg/m^3) among sites sampling carbonyl compounds. These two sites account for 18 of the 51 acetaldehyde measurements greater than 5 µg/m^3 (10 for ELNJ and eight for SPIL).

- Although GPCO has the highest annual average concentration of naphthalene (155.52 ± 29.71 ng/m^3), the highest measurement of this pollutant was not measured at this site. NBIL has the maximum measurement among all sites sampling naphthalene (799 ng/m^3), although its annual average concentration ranked sixth (99.39 ± 29.75 ng/m^3). GPCO has the highest number of naphthalene measurements greater than 300 ng/m^3 (five) among sites sampling this pollutant.

- S4MO has the highest annual average concentration of three of the six PM_{10} metals: arsenic, cadmium, and lead. In addition, S4MO's annual average manganese concentration ranks second highest. Several of S4MO's annual averages, such as lead, are significantly higher than the other annual averages listed. The two maximum concentrations of lead across the program were measured at S4MO (30.9 ng/m^3 and 27.5 ng/m^3). Additionally, 22 of the 32 highest lead concentrations (those greater than 10 ng/m^3) were measured at S4MO. The maximum manganese concentration among all sites sampling PM_{10} metals was measured at S4MO (395 ng/m^3) and is more than twice the next highest manganese concentration (130 ng/m^3, measured at PXSS). The maximum concentration of cadmium was also measured at S4MO, while the second highest concentration of arsenic was measured at S4MO (behind only BTUT).

- TOOK has the highest annual average concentration of five of the six TSP metals: arsenic, cadmium, lead, manganese, nickel. TOOK's annual average beryllium concentration ranked second, behind PROK. Note that only Oklahoma sites sampled TSP metals.

- S4MO was on the top 10 list for 21 of the 25 program-level pollutants of interest; PXSS and NBIL were both on the top 10 list for 17 of the 25 program-level pollutants of interest. GPCO appears in Tables 4-9 through 4-12 a total of 14 times. Conversely, 12 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 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, 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 μg/m^3 and the maximum concentration measured was nearly 24 μg/m^3. Conversely, the acute MRL for acetone is 60,000 μg/m^3 while the maximum concentration measured was 15.4 μg/m^3.

The pollutant with the concentration closest to the acute MRL is benzene (the acute MRL is 30 μg/m^3 and the maximum benzene measurement is 23.8 μg/m^3). The pollutant with the quarterly average concentration closest to the intermediate MRL is also benzene (the intermediate MRL is 20 μg/m^3 and the maximum quarterly average is 4.39 μg/m^3). The pollutant with the annual average concentration closest to the chronic MRL is manganese (the chronic MRL is 0.04 μg/m^3 and the maximum annual average is 0.03 μg/m^3).

Because none of the preprocessed daily measurements are greater than associated acute MRLs, the emission tracer analysis described in Section 3.5.5.1 was not performed.

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

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)
Acetone	60,000	15.40	30,000	9.67	30,000	4.92
Acrylonitrile	200	1.69	--	--	--	--
Benzene	30	23.80	20	4.39	10	3.59
Bromomethane	200	1.70	200	0.20	20	0.07
1,3-Butadiene	200	9.51	--	--	--	--
Cadmium	0.03	<0.01	--	--	0.01	<0.01
Carbon Disulfide	--	--	--	--	900	29.46
Carbon Tetrachloride	--	--	200	0.72	200	0.65
Chloroethane	40,000	21.60	--	--	--	--
Chloroform	500	32.90	200	12.41	100	6.06
Chloromethane	1,000	5.24	400	1.55	100	1.42
Chromium	--	--	0.3	<0.01	--	--
Cobalt	--	--	--	--	0.1	<0.01
p-Dichlorobenzene	10,000	2.83	1,000	0.54	60	0.26
1,2-Dichloroethane	--	--	--	--	2,000	0.03
1,1-Dichloroethene	--	--	80	<0.01	--	--
trans-1,2-Dichloroethylene	800	0.20	800	0.03	--	--
Dichloromethane	2,000	1,214.00	1,000	156.90	1,000	53.90
1,2-Dichloropropane	200	0.06	30	<0.01	--	
cis-1,3-Dichloropropene	--	--	40	0.03	30	0.01
trans-1,3-Dichloropropene	--	--	40	0.02	30	<0.01
Ethylbenzene	20,000	11.50	9,000	1.65	300	1.06
Formaldehyde	50	27.70	40	8.37	10	4.49
n-Hexane	--	--	--	--	2,000	4.41
Hexavalent Chromium	--	--	0.3	<0.01	-- --	--
Manganese	--	--	--	--	0.04	0.03
Mercury	--	--	--	--	0.2	<0.01
Methyl *tert*-Butyl Ether	7,000	0.99	3,000	0.08	3,000	0.02

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

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)
Naphthalene	--	--	--	--	4	0.16
Nickel	--	--	0.2	<0.01	0.09	<0.01
Styrene	20,000	13.10	--	--	900	1.45
Tetrachloroethylene	1,000	8.63	--	--	300	0.55
Toluene	4,000	93.90	--	--	300	6.41
1,1,1-Trichloroethane	10,000	0.44	4,000	0.10	--	--
Trichloroethylene	10,000	8.40	500	1.28	--	--
Vinyl Chloride	1,000	0.08	80	0.01	--	--
Xylenes	9,000	34.76	3,000	6.45	200	4.06

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

4.3 The Impact of Mobile Sources

Ambient air is significantly impacted by mobile sources, as discussed in Section 3.4.1. Table 4-14 contains several parameters that are used to assess mobile source impacts on 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 account for nearly half of 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 construction vehicles that use roadways; non-road emissions come from the remaining mobile sources such as locomotives, lawn mowers, and boats (EPA, 2012i). Table 4-14 contains county-level on-road and non-road HAP emissions from the 2008 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 is located), followed by Harris County, TX (where CAMS 35 is located), and Maricopa County, AZ (where PXSS and SPAZ are located) while estimated on-road emissions were lowest in Chesterfield County, SC and Union County, SD (where CHSC and UCSD are located, respectively). Estimated non-road county emissions were also highest in Los Angeles County, CA, followed by Cook County, IL (where NBIL and SPIL are located) and Maricopa County, AZ. Estimated non-road county emissions were lowest in Union County, SD and Carter County, KY (where GLKY is located).

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

Site	County-level Motor Vehicle Registration[1] (# of Vehicles)	Estimated 10-Mile Vehicle Ownership[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)
AZFL	877,075	555,080	40,500	21,395,381	2,650.97	1,157.75	NA
BMCO	72,957	7,703	2,527	1,901,434	260.03	93.05	NA
BOMA	481,199	1,100,560	31,400	10,695,874	715.05	440.97	NA
BRCO	72,957	33,018	150	1,901,434	260.03	93.05	NA
BTUT	239,582	206,495	113,955	6,866,779	861.85	336.23	3.75
BURVT	169,767	130,202	14,000	4,027,945	371.91	251.44	2.42
CAMS 35	3,164,173	528,398	31,043	56,650,489	8,521.88	2,791.78	NA
CAMS 85	70,585	2,410	1,250	2,578,700	284.17	129.54	NA
CELA	7,360,573	2,647,604	230,000	214,458,140	9,556.40	5,072.27	NA
CHNJ	389,359	187,012	12,917	14,256,044	1,202.20	705.27	1.81
CHSC	40,792	4,852	550	1,276,517	128.86	80.37	NA
DEMI	1,334,752	775,162	92,800	42,804,737	5,900.70	1,113.36	3.27
ELNJ	424,894	1,724,607	250,000	12,485,902	951.86	390.19	4.48
GLKY	32,398	17,159	428	1,084,000	163.87	15.58	1.30
GPCO	178,425	145,607	11,000	2,031,327	392.28	180.83	4.67
HOWI	100,176	24,846	5,000	2,626,054	247.41	220.50	NA
INDEM	419,431	348,652	34,240	16,226,000	1,222.76	634.27	NA
MONY	246,748	1,007,684	91,465	9,698,000	825.34	391.72	NA
MWOK	832,160	427,423	40,900	27,190,328	2,900.47	816.74	1.90
NBIL	2,072,399	353,553	34,600	86,863,779	7,721.47	4,074.66	5.71
NBNJ	640,893	637,915	114,322	20,415,685	1,617.22	673.13	2.66
OCOK	832,160	429,679	40,900	27,190,328	2,900.47	816.74	2.42
ORFL	1,056,627	907,230	32,500	33,325,315	3,198.03	1,587.50	NA
PACO	72,957	7,703	16,000	1,901,434	260.03	93.05	NA
PAFL	1,056,627	795,455	46,000	33,325,315	3,198.03	1,587.50	NA

[1] Individual references provided in each state section.

[2] Reference: EPA, 2012d

[3] This parameter is only available for monitoring sites sampling VOCs.

BOLD ITALICS = EPA-designated NATTS Site

NA = Data not available

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

Site	County-level Motor Vehicle Registration[1] (# of Vehicles)	Estimated 10-Mile Vehicle Ownership[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)
PANJ	396,602	1,071,818	22,272	8,178,167	616.98	447.26	4.57
PROK	39,968	29,285	15,100	1,656,458	172.07	83.98	2.02
PRRI	485,837	509,773	136,800	NA	1,104.51	381.46	NA
PXSS	3,776,819	1,314,732	184,000	89,448,000	7,862.48	3,819.27	5.16
RICO	72,957	23,530	17,000	1,901,434	260.03	93.05	NA
RIVA	354,721	544,138	73,000	8,246,774	831.85	188.91	NA
ROCH	550,992	480,772	86,198	17,772,000	1,566.25	683.88	NA
RRMI	1,334,752	572,987	98,500	42,804,737	5,900.70	1,113.36	NA
RUCA	1,711,492	784,472	145,000	55,717,760	2,486.42	1,003.76	NA
RUVT	70,900	40,098	7,200	1,766,027	158.14	150.60	2.47
S4MO	1,114,812	673,974	79,558	19,896,584	974.72	182.60	2.65
SDGA	472,535	492,952	140,820	20,187,000	2,272.55	772.13	NA
SEWA	1,783,335	890,137	226,000	23,282,703	6,932.11	2,762.29	2.37
SJJCA	1,517,190	1,242,743	104,000	41,250,490	1,960.08	812.60	NA
SKFL	877,075	674,583	47,000	21,395,381	2,650.97	1,157.75	NA
SPAZ	3,776,819	826,196	128,000	89,448,000	7,862.48	3,819.27	6.74
SPIL	2,072,399	805,601	190,000	86,863,779	7,721.47	4,074.66	2.86
SSSD	210,914	229,582	18,700	3,751,886	467.40	132.93	1.75
SWMI	1,334,752	721,842	93,000	42,804,737	5,900.70	1,113.36	NA
SYFL	1,135,945	288,235	10,600	34,351,899	3,252.93	1,326.89	NA
TMOK	603,926	323,647	12,600	20,348,926	2,197.21	867.85	3.89
TOOK	603,926	448,957	63,000	20,348,926	2,197.21	867.85	9.15
UCSD	25,419	9,676	156	808,049	91.81	30.98	0.98
UNVT	169,767	36,243	1,100	4,027,945	371.91	251.44	0.94
WADC	213,232	666,556	7,700	9,775,000	929.71	327.98	NA
WPIN	820,767	718,087	143,970	32,005,000	2,664.97	715.48	NA

[1] Individual references provided in each state section.

[2] Reference: EPA, 2012d

[3] This parameter is only available for monitoring sites sampling VOCs.

BOLD ITALICS = EPA-designated NATTS Site

NA = Data not available

4.3.2 Hydrocarbon Concentrations

Hydrocarbons are organic compounds that contain only carbon and hydrogen. Hydrocarbons are derived mostly 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, SPAZ, and NBIL have the highest hydrocarbon averages among the sites monitoring VOCs. Each of these sites is located in a highly populated urban area and in relatively close proximity to heavily traveled roadways. For example, TOOK is located near Exit 3A of I-244 in Tulsa, Oklahoma. The sites with the lowest hydrocarbon averages are GLKY, UCSD, and UNVT. All three of these sites are located in rural areas. 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, 2011). 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, SPAZ, and NBIL have the highest average summed hydrocarbon concentrations, respectively, while GLKY and UCSD 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 PROK, GLKY, and UCSD have the lowest. The Pearson correlation coefficient calculated between these two datasets is 0.46. Although this correlation falls just below the "strong" classification, it does indicate a positive correlation between hydrocarbon concentrations and vehicle registration. CELA, which has the highest county-level vehicle ownership of all NMP sites, did not sample VOCs under the NMP.

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. Therefore, a vehicle registration-to-population ratio was developed for each county with a monitoring site. Each ratio was then applied to the 10-mile population surrounding the sites (provided in the individual state sections) to estimate a 10-mile vehicle ownership, which is also presented in Table 4-14. Table 4-14 shows that ELNJ, PXSS, and PANJ have the highest 10-mile estimated vehicle ownership of the sites sampling VOCs, while PROK, GLKY, and UCSD have the lowest. The Pearson correlation coefficient calculated between the average summed hydrocarbon calculations and the 10-mile vehicle registration estimates is 0.41. While this correlation also falls below the "strong" classification, it does indicate a positive correlation between hydrocarbon concentrations and the estimated vehicle registration within a 10-mile radius. CELA, which had the highest 10-mile estimated vehicle ownership of all NMP sites, did not sample VOCs under the NMP.

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 total volume of traffic on a highway segment for 1 year, divided by the number of days in the year," and incorporates both directions of traffic (FL DOT, 2007). AADT counts obtained were based on data from 2002 to 2011, primarily 2009 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 in 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 28).

Table 4-14 shows that ELNJ, SEWA, and SPIL have the highest daily traffic volumes of the sites sampling VOCs, while UNVT, GLKY, and UCSD have the lowest. For all monitoring sites (not just those sampling VOCs), the highest daily traffic volume occurs near ELNJ, CELA, and SEWA. ELNJ is located near Exit 13 on I-95; CELA is located in downtown Los Angeles; and SEWA is located in Seattle near the intersection of I-5 and I-9. ELNJ has the highest traffic volume and the seventh highest hydrocarbon average, but SEWA, SPIL, and PXSS, which have the second, third, and fourth highest traffic volumes, have the 17th, 11th, and 4th highest hydrocarbon averages, respectively. Again, CELA did not measure VOCs under the NMP. A Pearson correlation coefficient calculated between the average hydrocarbon calculations and the traffic counts is 0.28. While this correlation is not a "strong" correlation, it does indicate a positive correlation between hydrocarbon concentrations and traffic volumes.

4.3.5 Vehicle Miles Traveled

Another approach to determine how mobile sources affect urban air quality is to review VMT. VMT is "the sum of distances traveled by all motor vehicles in a specified system of highways for a given period of time" (OR DOT, 2012). Thus, VMT values tend to be large (in the millions). In past NMP reports, daily VMT data from the Federal Highway Administration (FHWA) were obtained. However, VMT was only available by urban area; thus, no VMT was available for sites located in rural areas. Beginning with the 2010 NMP, county-level VMT was obtained 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.

The sites with the highest county-level VMT, where available, are CELA (Los Angeles County, CA), PXSS and SPAZ (Maricopa County, AZ), and SPIL and NBIL (Cook County, IL). The sites with the lowest county-level VMT, where available, are CHSC (Chesterfield County, SC), GLKY (Carter County, KY), and UCSD (Union County, SD). A Pearson correlation coefficient calculated between the average summed hydrocarbon concentrations and VMT, where available, is 0.46, indicating a positive 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, RUCA, CAMS 35, and SJJCA). In addition, county-level VMT were 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 4-25a are graphical displays of site-specific CVs (standard deviation vs. annual average concentration) for the program-level pollutants of interest. Figures 4-1b through 4-25b are bar graphs depicting the site-specific annual averages overlain on the program-level averages, as discussed 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 tend to 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 4-10a 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 4-10a 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 4-10b supports what is shown in Figure 4-10a. The inter-site variability is relatively low, with the annual average concentrations of carbon tetrachloride ranging from 0.53 $\mu g/m^3$ for GPCO to 0.65 $\mu g/m^3$ for SEWA and DEMI. Further, the confidence intervals for all sites shown are less than ± 0.07 $\mu g/m^3$.

Figure 4-13a shows that 1,2-dichloroethane also appears to exhibit clustering. However, it should be noted that the y-axis scale for the standard deviation is three times larger than the x-axis scale for the annual average concentration. This indicates that there is a relatively high-level of variability in the individual concentrations, as supported in Figure 4-13b by the relatively large confidence intervals shown for every site. In addition, this pollutant was detected infrequently (only 25 percent of samples) and therefore has many zero substitutions factored into each annual average, which contributes to both the low range of annual average concentrations (all less than 0.035 µg/m^3) and the large confidence intervals.

Other pollutants, such as hexchloro-1,3-butadiene and vinyl chloride, exhibit the same large confidence intervals on the inter-site variability graphs as 1,2-dichloroethane due to a large number of non-detects and the associate zero substitutions. Hexchloro-1,3-butadiene was detected in fewer than 10 percent of samples, resulting in a large number of zero substitutions. With the exception of the sites that did not detect this pollutant, the standard deviations are all greater than the annual average for each site in Figure 4-17a, as shown by the values along the x- and y-axes. Further, nearly every site has a relatively large confidence interval shown in Figure 4-17b. The largest confidence intervals were calculated for SPIL and MWOK; although these two sites measured the two greatest concentrations of hexachloro-1,3-butadiene (0.684 µg/m^3 for SPIL and 0.631 µg/m^3 for MWOK), this pollutant was detected only three times at SPIL and four times at MWOK.

Similarly, vinyl chloride is another infrequently detected pollutant (less than a 7 percent detection rate) for which the annual averages have large standard deviations in Figure 4-25a (note how many of the standard deviations are more than twice the corresponding annual averages) and large confidence intervals in Figure 4-25b. Although the concentrations of vinyl chloride were at least an order of magnitude less than the concentrations of hexchloro-1,3-butadiene, nearly half of the vinyl chloride measurements were greater than the MDL while only two (the high concentrations for MWOK and SPIL) were greater than the MDL for hexachloro-1,3-butadiene.

Several CVs for the program-level pollutants of interest follow a linear trend line. Examples of pollutants whose annual average concentrations exhibit this trend include acenaphthalene, acetaldehyde, benzene, fluorene, hexavalent chromium, lead, naphthalene, and tetrachloroethylene. 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 wider 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 4-1a and 4-1b for acenaphthalene and Figures 4-15a and 4-15b for fluorene are good examples of this trend. The higher annual averages for sites such as DEMI, NBIL and ROCH 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 acenaphthene for DEMI was 0.698 ng/m^3 to 111 ng/m^3 while the range of measurements for GLKY was 0.0793 ng/m^3 to 1.02 ng/m^3. DEMI's 111 ng/m^3 measurement of acenaphthene was the highest measurement of acenaphthene measured across the program.

Some of the pollutants' annual averages follow a linear pattern, but one of the annual average concentrations is significantly higher than other annual average concentrations of the other sites, one of the standard deviations is significantly higher than other sites, or both (such as benzene, beryllium, and tetrachloroethylene). Figures 4-5a and 4-5b show that the annual average benzene concentration for TOOK is more than twice the next highest annual average concentration for this pollutant. A review of TOOK's benzene data shows that all but seven of TOOK's preprocessed daily measurements (out of 57) were greater than the program-level average concentration of 0.98 µg/m^3. Thus, concentrations of benzene at TOOK tend to run higher than at other sites. Figure 4-23a shows that the magnitude of the standard deviation axis is more than twice the annual average axis for tetrachloroethylene. Figure 4-23b shows that this is the result of the PXSS data. The maximum concentration measured at PXSS (8.63 µg/m^3) is more than three times higher than the next highest tetrachloroethylene measurement (2.42 µg/m^3, measured at NBIL) and nearly five times higher than the next highest tetrachloroethylene measurement at PXSS (1.74 μg/m^3). Thus, the annual average concentration of tetrachloroethylene for PXSS is reflecting the influence of the outlying concentration.

Although many of the other pollutants of interest do not exhibit easily classifiable clustering or appear to follow a linear pattern, some of them are influenced by one or more data points that do not fall in line with the others. For example, the larger standard deviation (1.20 μg/m^3) exhibited for 1,3-butadiene in Figure 4-8a indicates that this particular annual average is likely influenced by outlier(s). Figure 4-8b shows that this data point represents OCOK's annual average. Excluding this data point would allow the rest to follow a more linear trend line. Although this site did not have the highest annual average concentration of 1,3-butadiene, the highest individual measurement of this pollutant across the program was measured at OCOK (9.51 μg/m^3). The next highest measurement of 1,3-butadiene at OCOK was considerably less (approximately 0.25 μg/m^3). The next highest measurement at the program level was 2.68 μg/m^3, measured at NBIL.

If the data point that represents SPIL's annual average and standard deviation was removed and the scales adjusted, the trichloroethylene concentrations would appear to exhibit a more linear trend, although some clustering would still be shown among the sites with the lowest annual averages. The annual average trichloroethylene concentration for SPIL (0.64 ± 0.41 μg/m^3) is more than seven times the annual average trichloroethylene concentration for any other site, as shown in both Figures 4-23a and 4-23b. If the two highest concentrations measured at SPIL (those greater than 3 μg/m^3) were removed from the calculation, SPIL's annual average would still be more than four times the next highest annual average (as calculated for ELNJ). SPIL's annual average trichloroethylene concentration is discussed in more detail in Section 4.2.1.

Acrylonitrile appears to exhibit clustering in Figure 4-3a with the exception of the annual average concentration for SPIL. The annual average concentration of acrylonitrile for SPIL (0.77 μg/m^3) is nearly five times greater than the next highest concentration, as shown in Table 4-9 and Figure 4-3b. Without this data point, the annual average concentrations of acrylonitrile range from 0.01 μg/m^3 to 0.17 μg/m^3. However, this pollutant was detected in fewer than 25 percent of samples, resulting in a large number of zero substitutions; thus the standard deviations for this pollutant tended to be rather large, as compared to the annual averages themselves. This is evident by the number of sites whose standard deviations are larger than their corresponding annual averages in Figure 4-3a.

Chloroform appears to exhibit clustering in Figure 4-11a. However, chloroform was detected in fewer than 60 percent of samples. This can yield relatively low annual averages and standard deviations, due in part to the substitution of zeros for many non-detects. If the data point that represents NBIL's annual average, which is more than seven times greater than the next highest annual average, was removed from Figure 4-11a and the scales adjusted, most of the chloroform concentrations still exhibit clustering. However, the three sites (DEMI, PXSS, and S4MO) with annual averages just above and just below the program-level average concentration of chloroform (0.39 $\mu g/m^3$) stand out more, as they do in Figure 4-11b. While S4MO's annual average concentration is less than the annual averages for DEMI and PXSS, S4MO's standard deviation (1.50 $\mu g/m^3$) is relatively large compared to its annual average concentration (0.35 ± 0.40 $\mu g/m^3$). This is due to one particularly high measurement (11.5 $\mu g/m^3$), skewing the data. This is illustrated not only by the confidence intervals shown in Figure 4-11b but also by the site-specific annual average concentration comparison for chloroform shown in Table 4-9.

Figure 4-1a. Coefficient of Variation Analysis of Acenaphthene Across 23 Sites

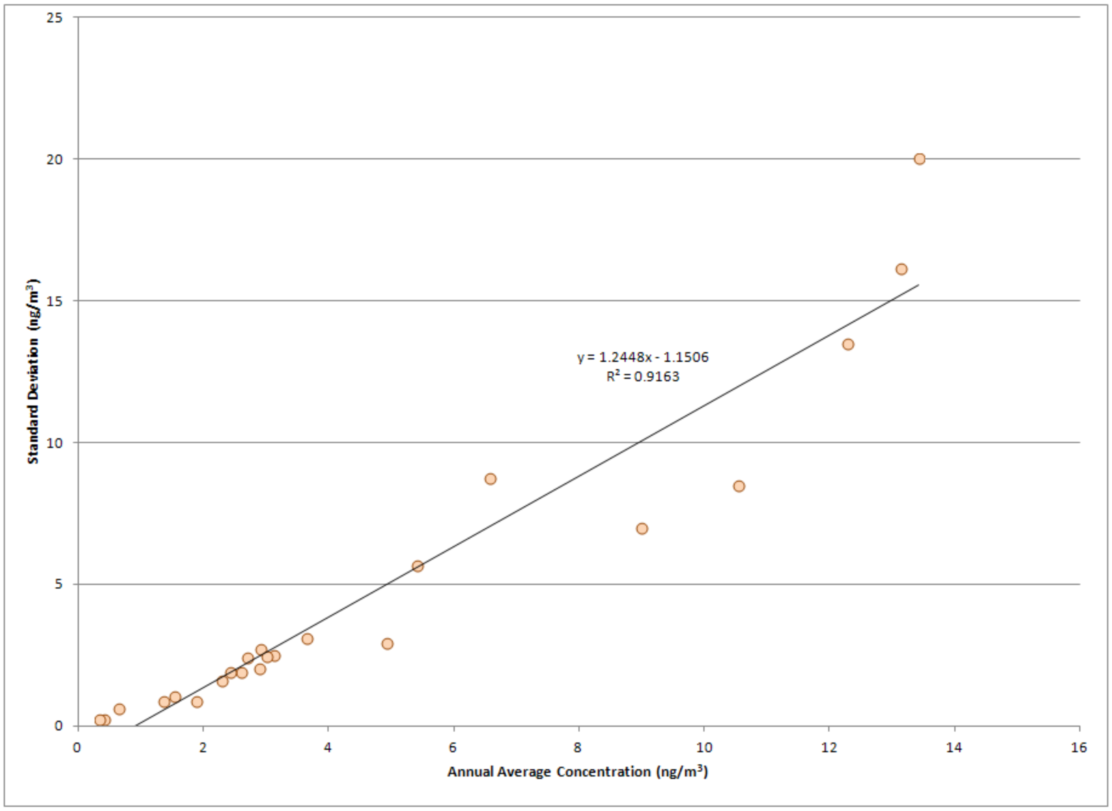


Figure 4-1b. Inter-Site Variability for Acenaphthene

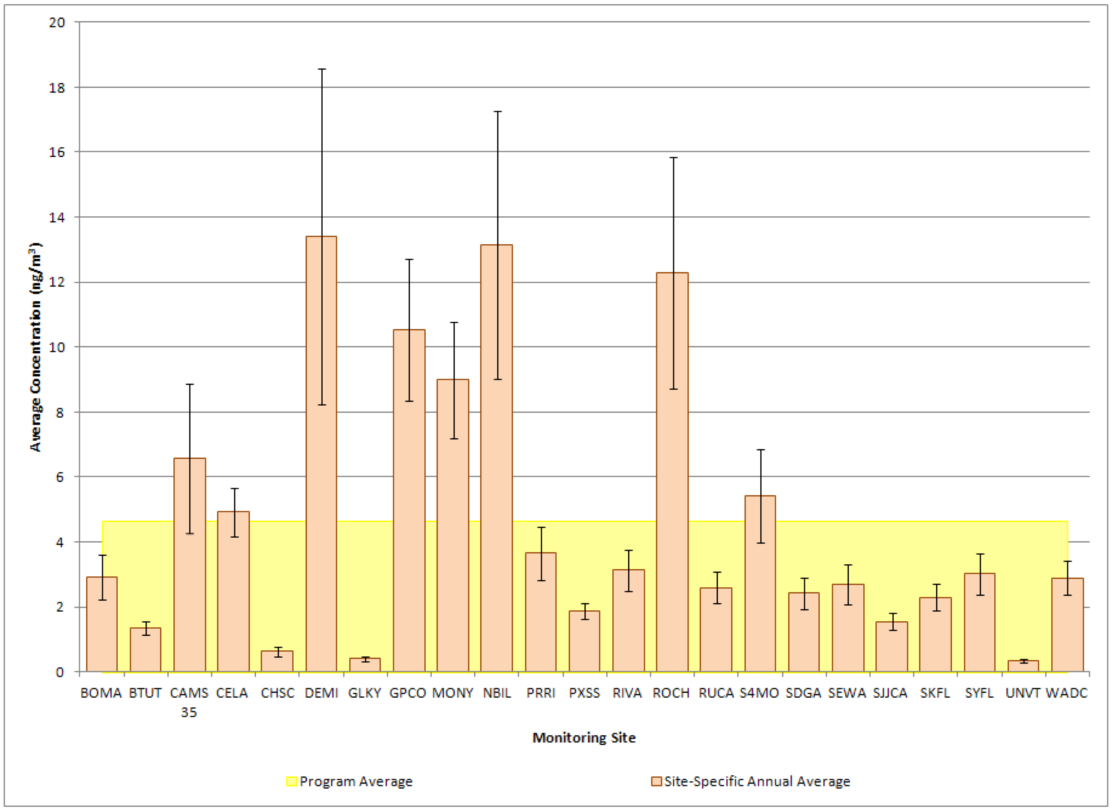


Figure 4-2a. Coefficient of Variation Analysis of Acetaldehyde Across 24 Sites

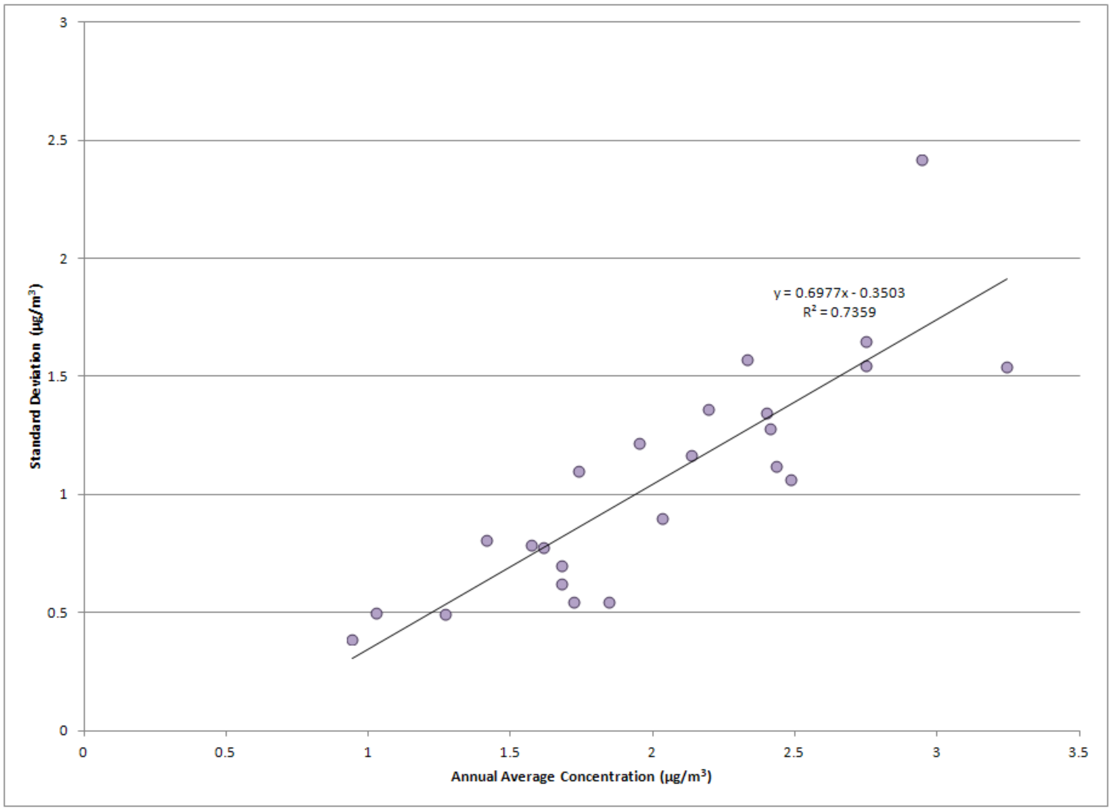


Figure 4-2b. Inter-Site Variability for Acetaldehyde

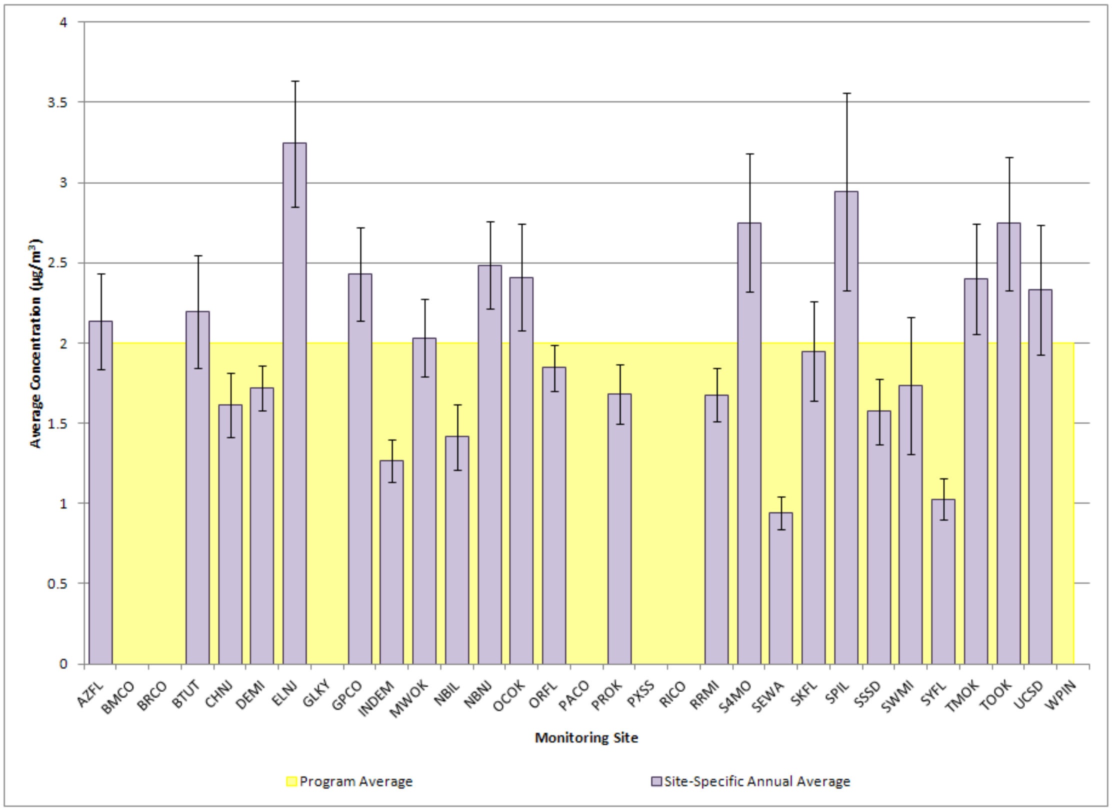


Figure 4-3a. Coefficient of Variation Analysis of Acrylonitrile Across 22 Sites

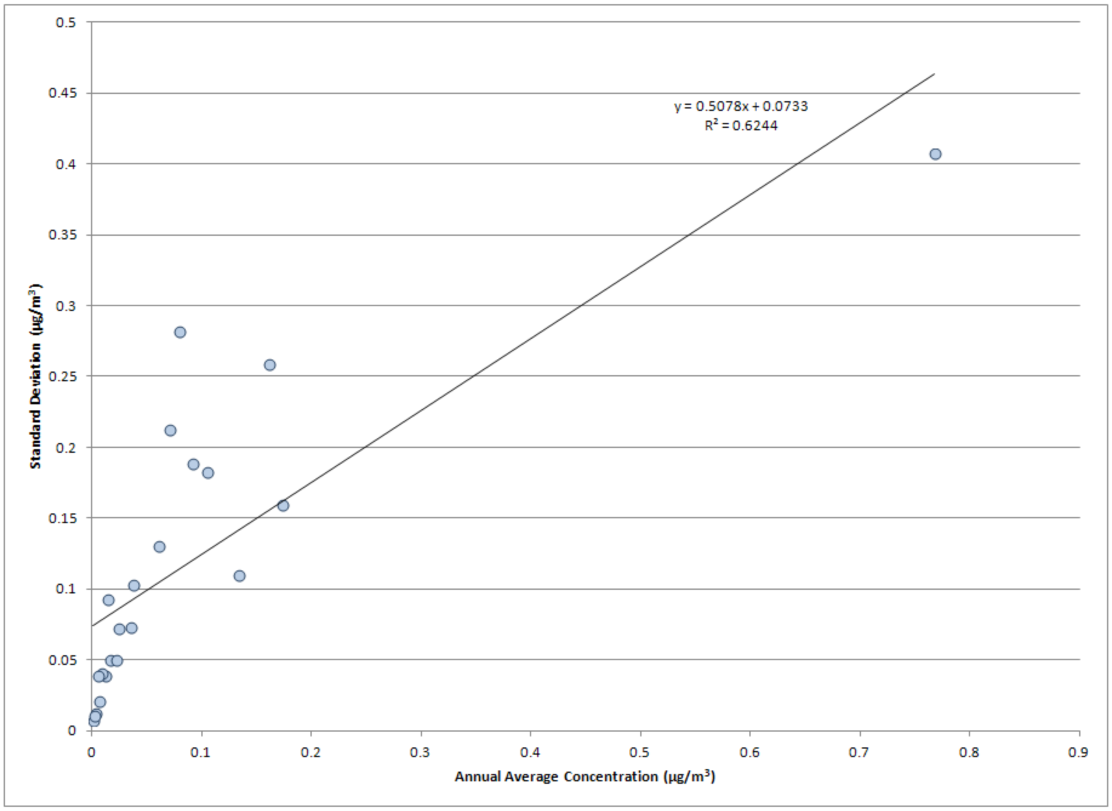


Figure 4-3b. Inter-Site Variability for Acrylonitrile

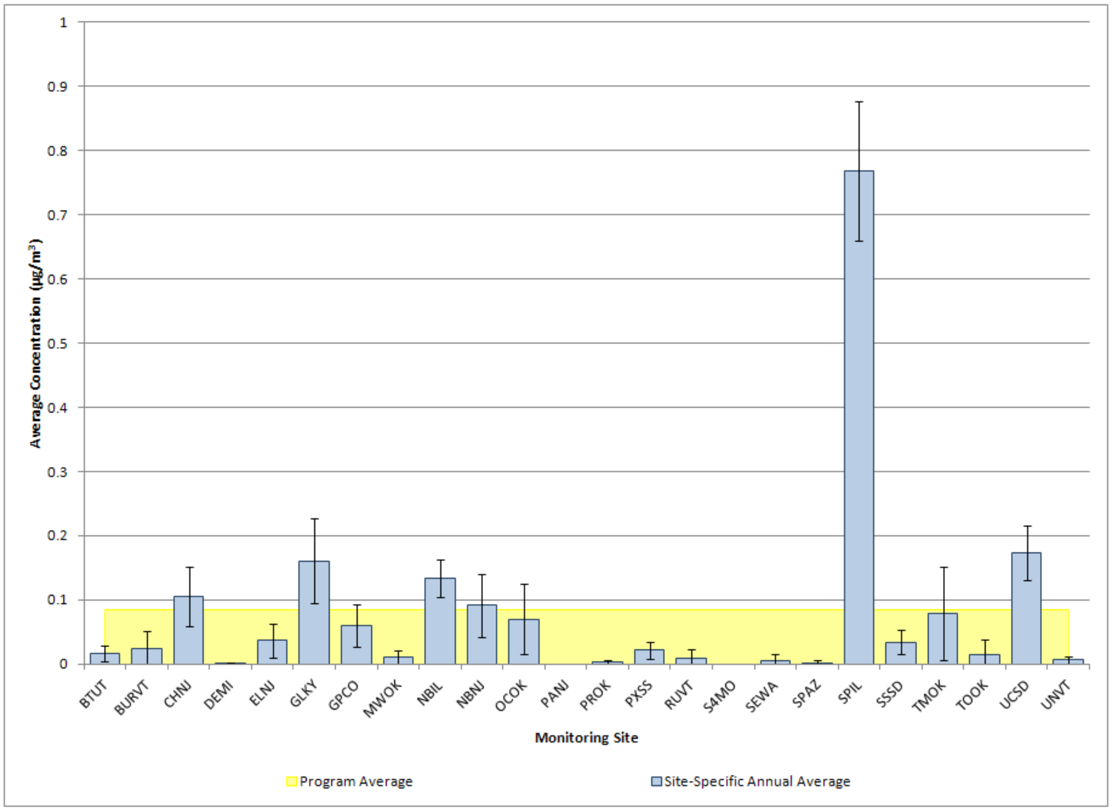


Figure 4-4a. Coefficient of Variation Analysis of Arsenic Across 14 Sites

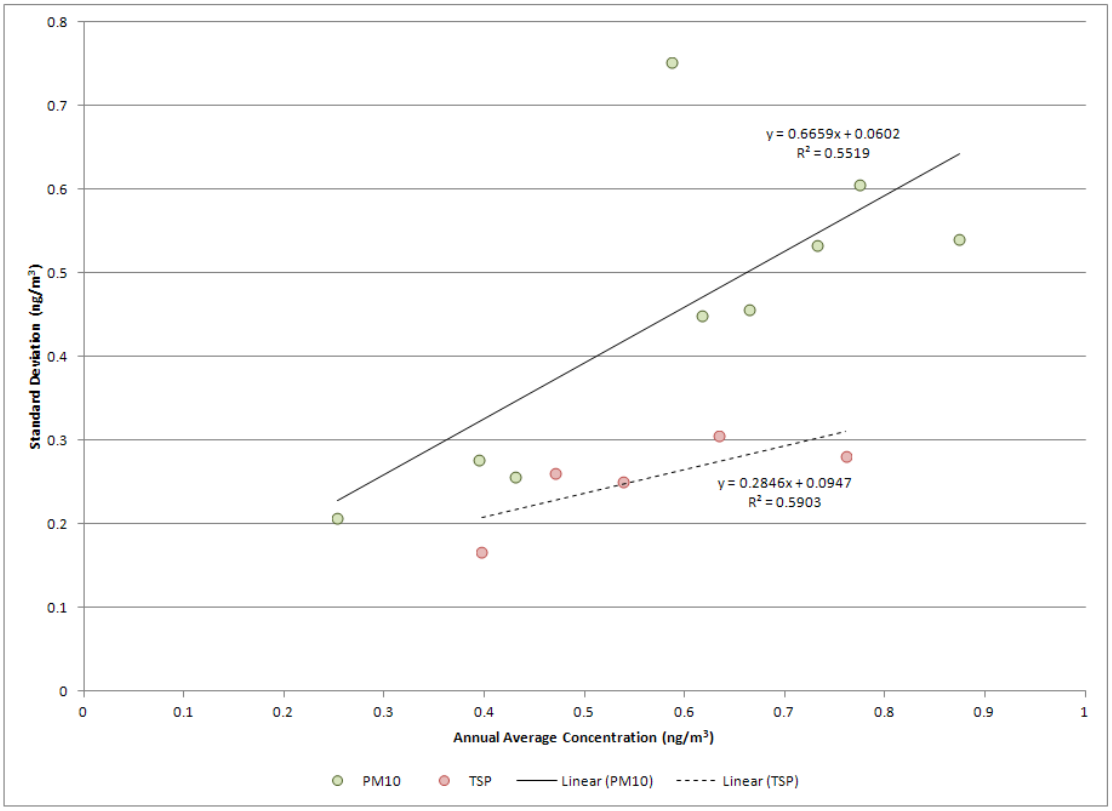


Figure 4-4b. Inter-Site Variability for Arsenic

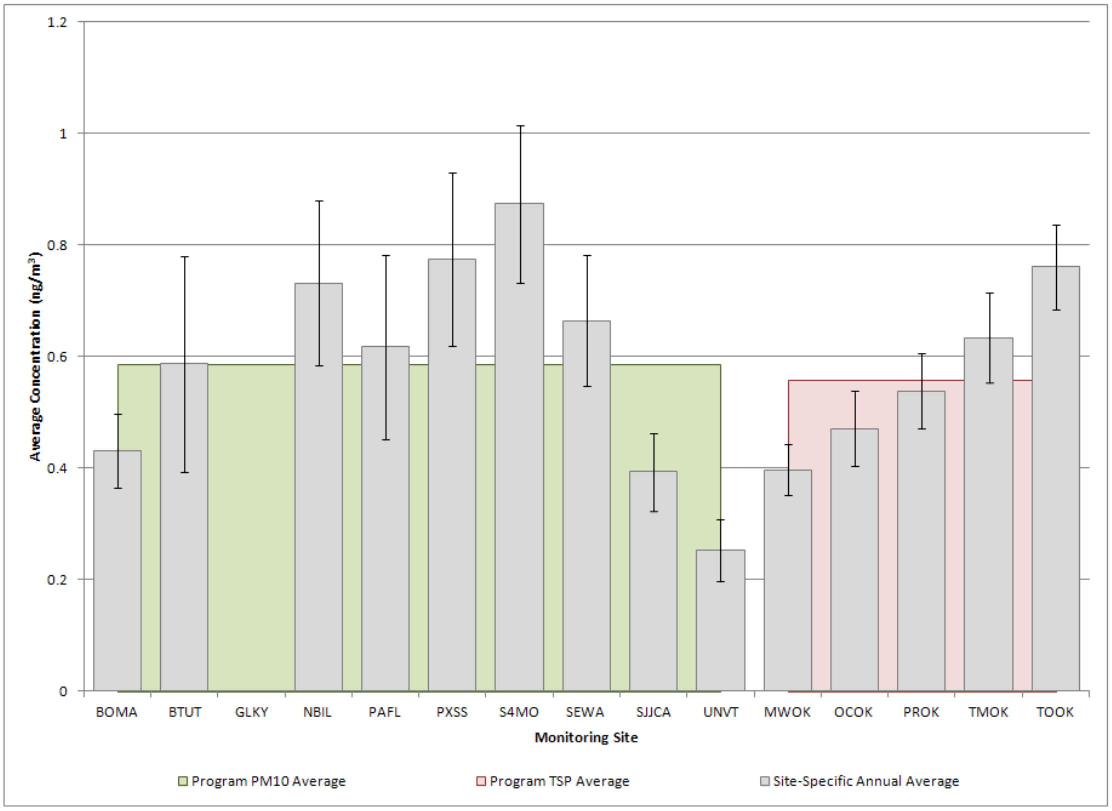


Figure 4-5a. Coefficient of Variation Analysis of Benzene Across 23 Sites

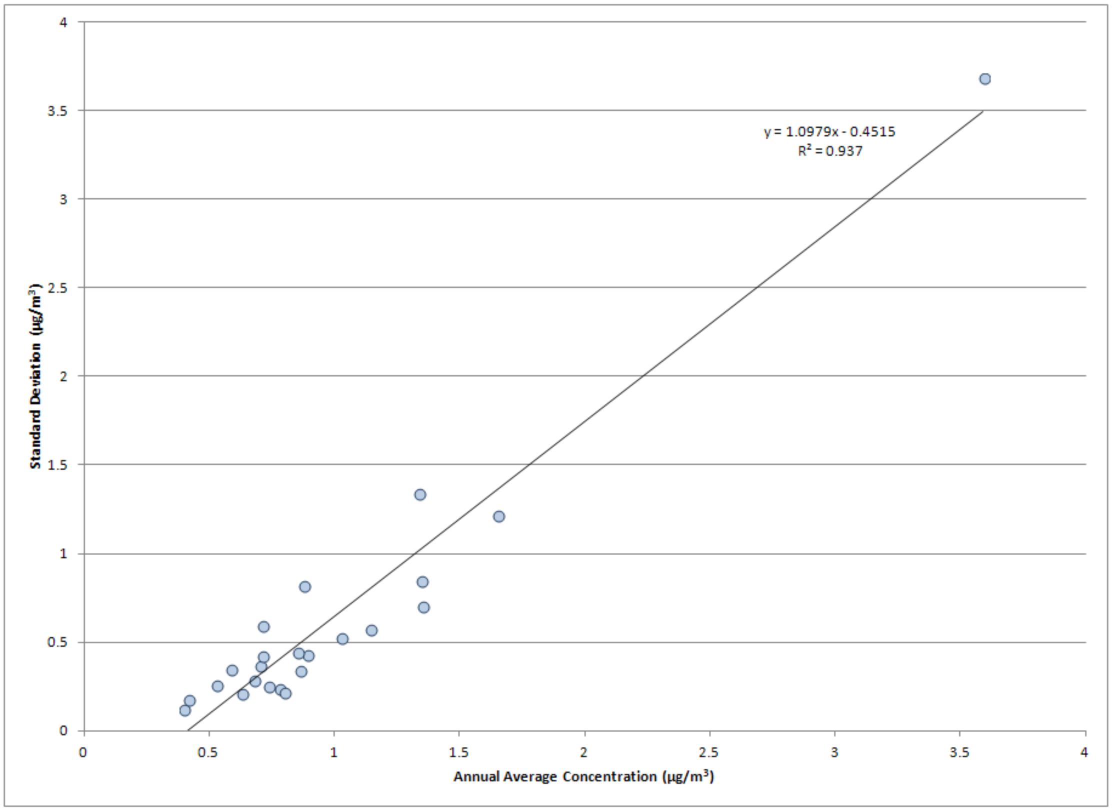


Figure 4-5b. Inter-Site Variability for Benzene

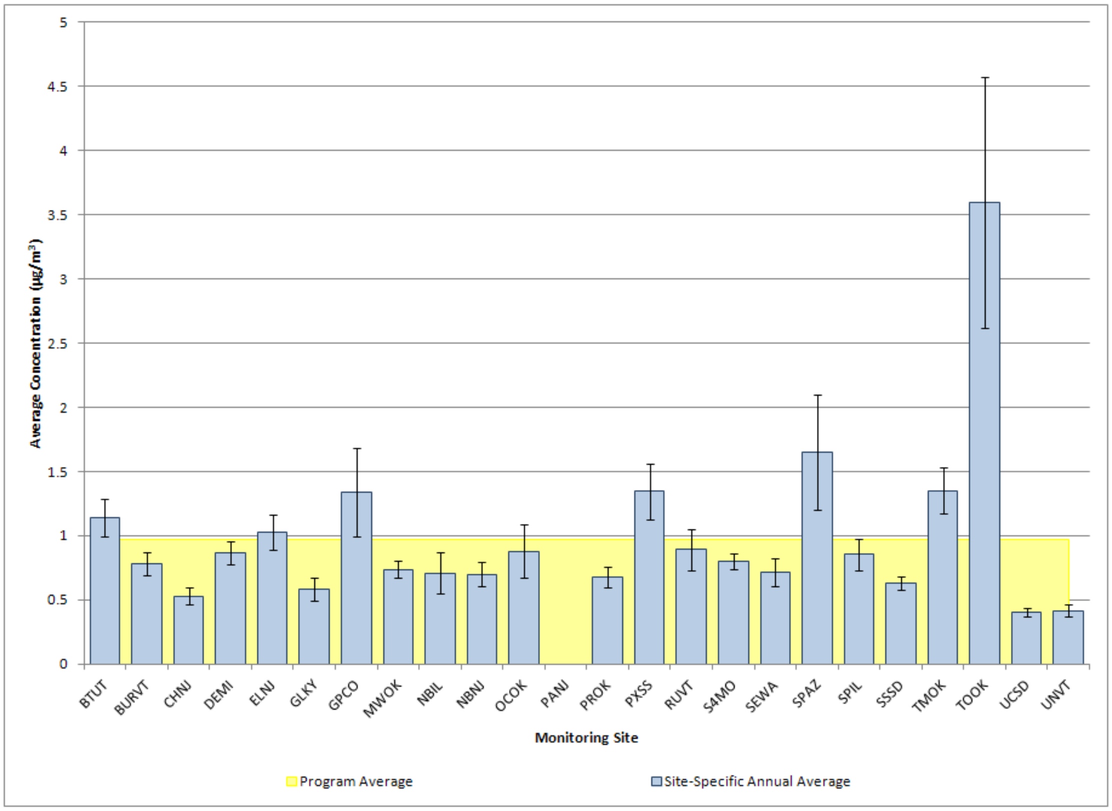


Figure 4-6a. Coefficient of Variation Analysis of Benzo(a)pyrene Across 23 Sites

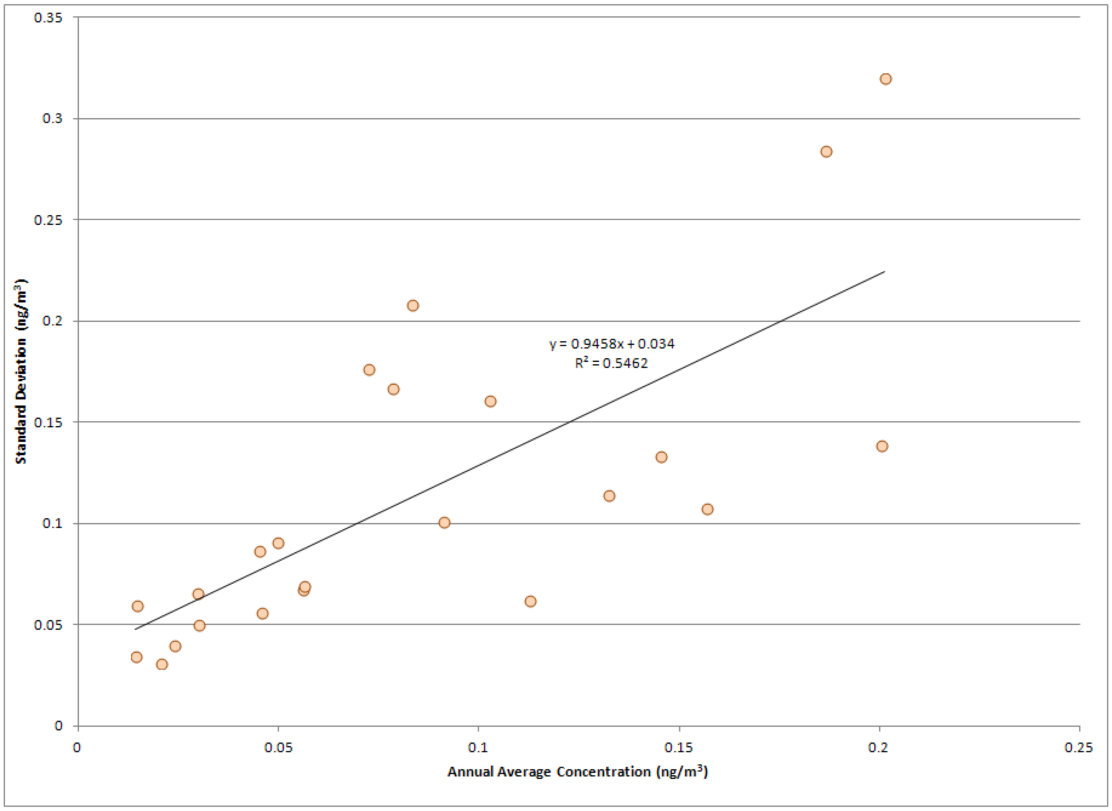


Figure 4-6b. Inter-Site Variability for Benzo(a)pyrene

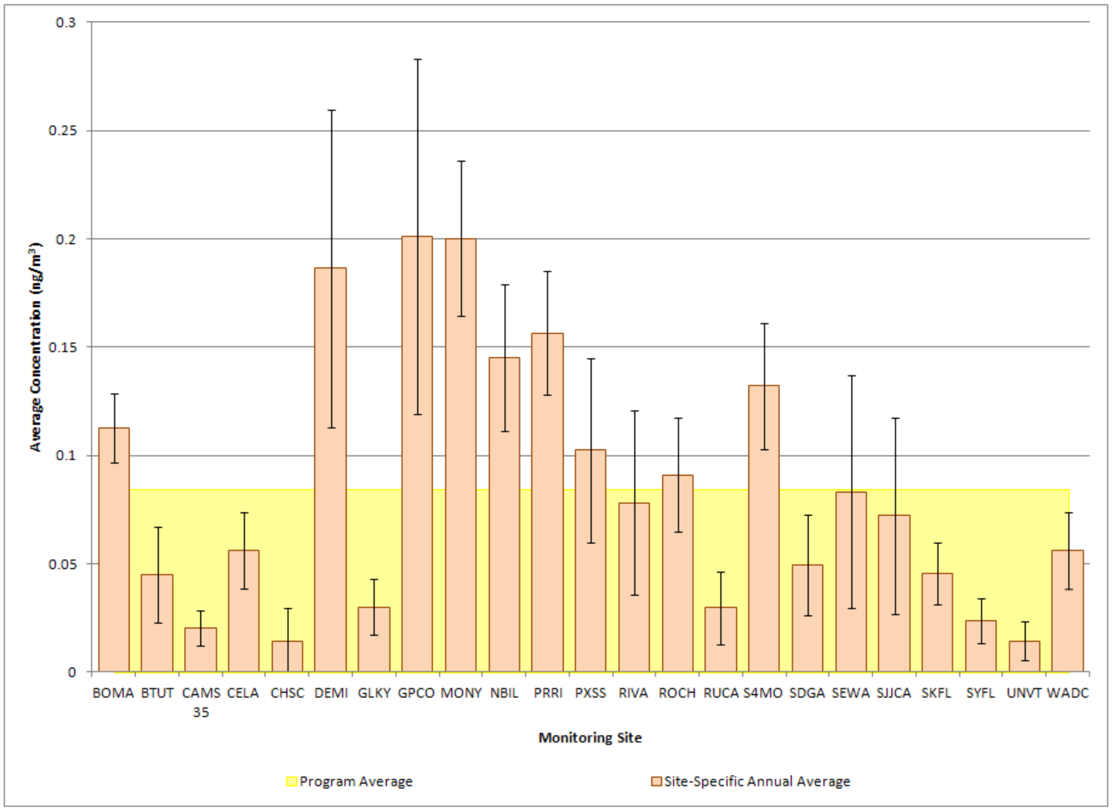


Figure 4-7a. Coefficient of Variation Analysis of Beryllium Across 14 Sites

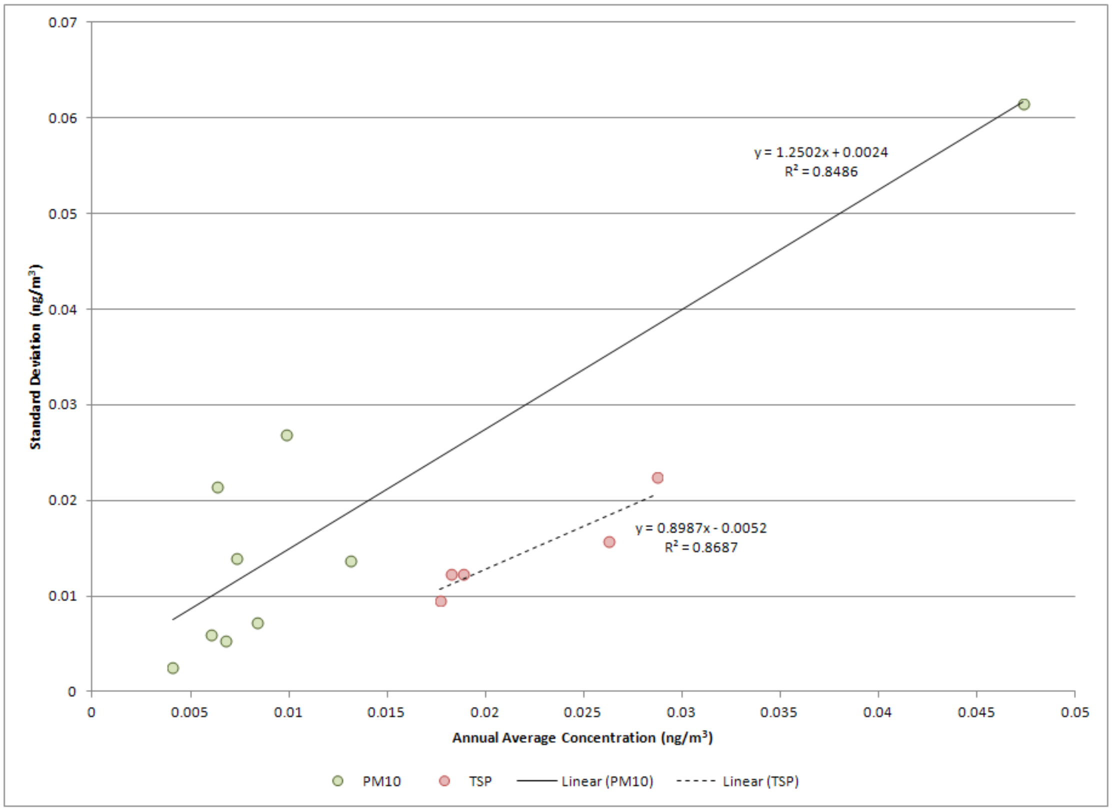


Figure 4-7b. Inter-Site Variability for Beryllium

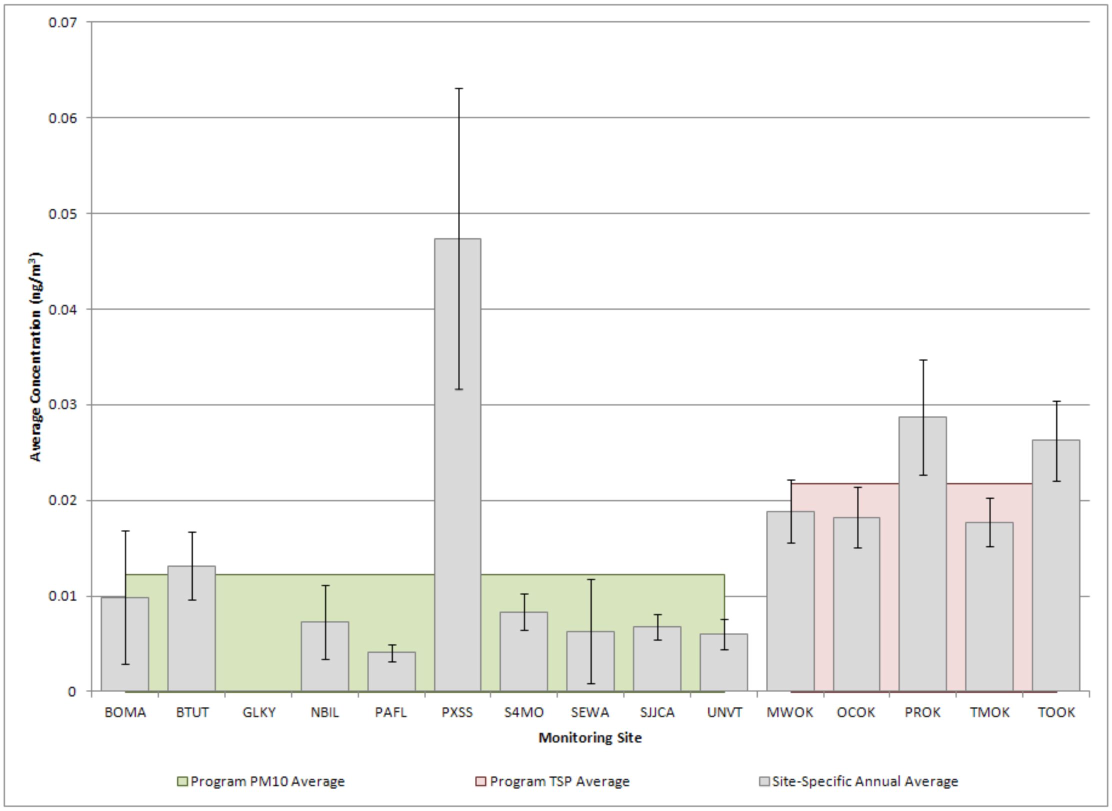


Figure 4-8a. Coefficient of Variation Analysis of 1,3-Butadiene Across 23 Sites

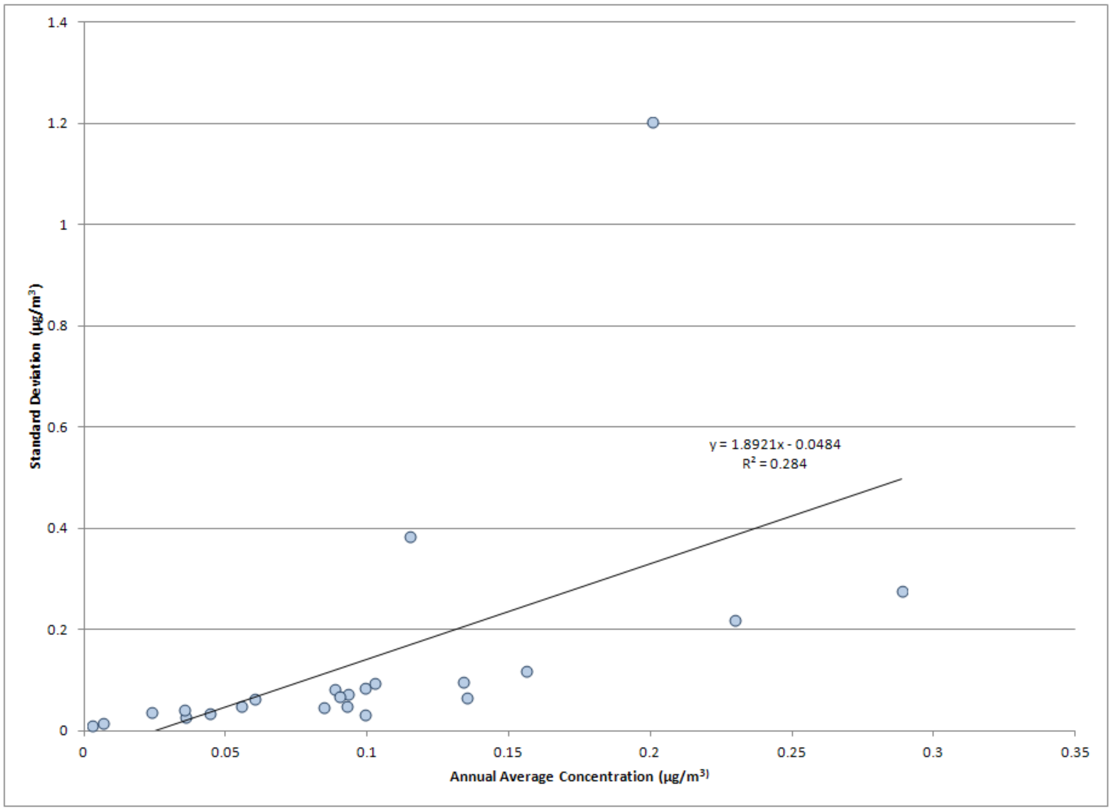


Figure 4-8b. Inter-Site Variability for 1,3-Butadiene

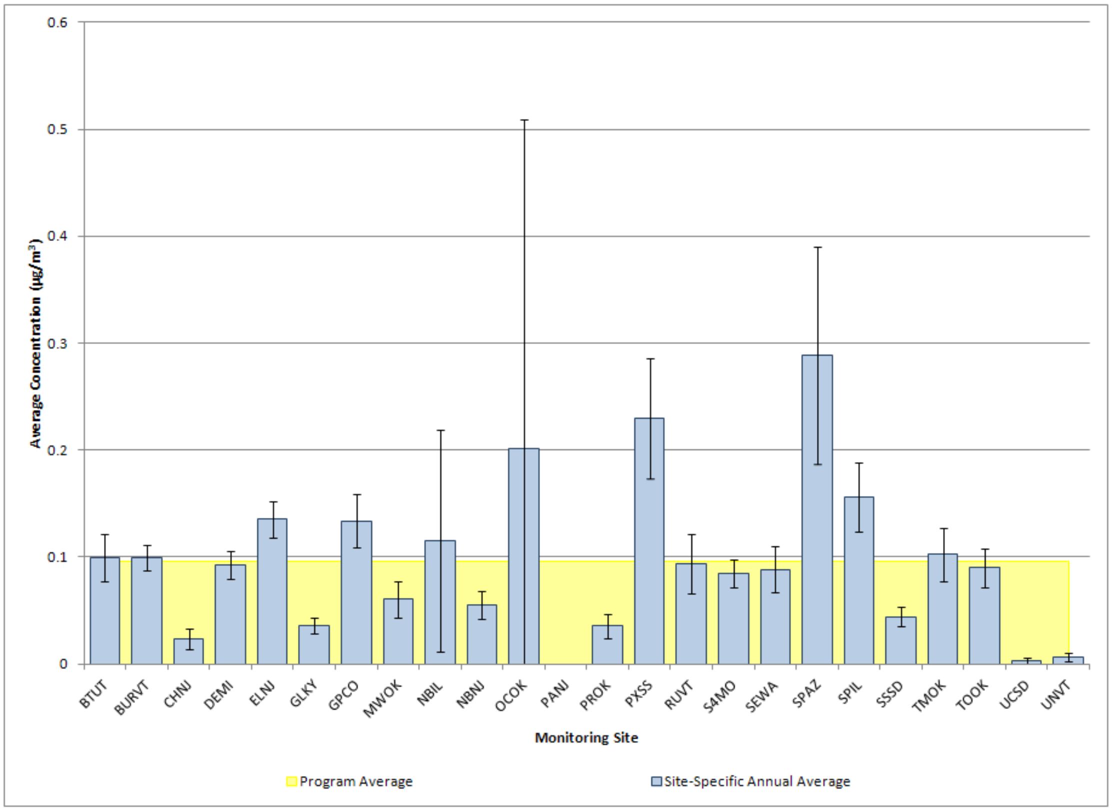


Figure 4-9a. Coefficient of Variation Analysis of Cadmium Across 14 Sites

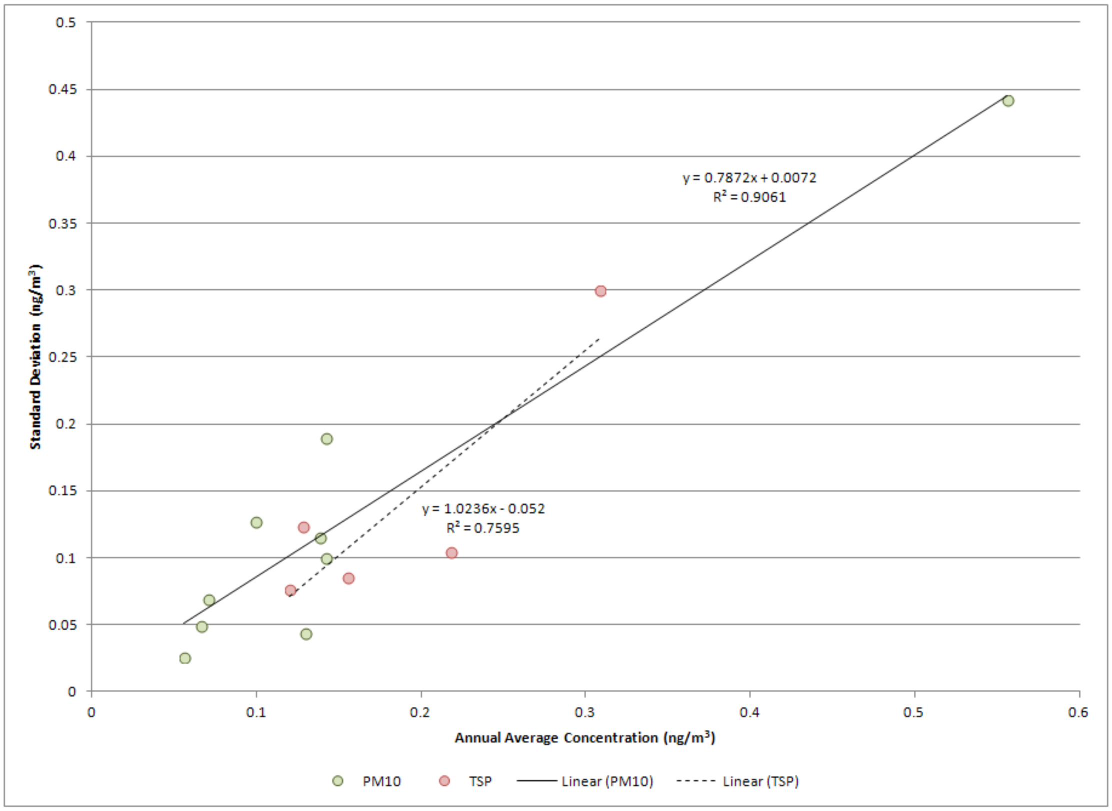


Figure 4-9b. Inter-Site Variability for Cadmium

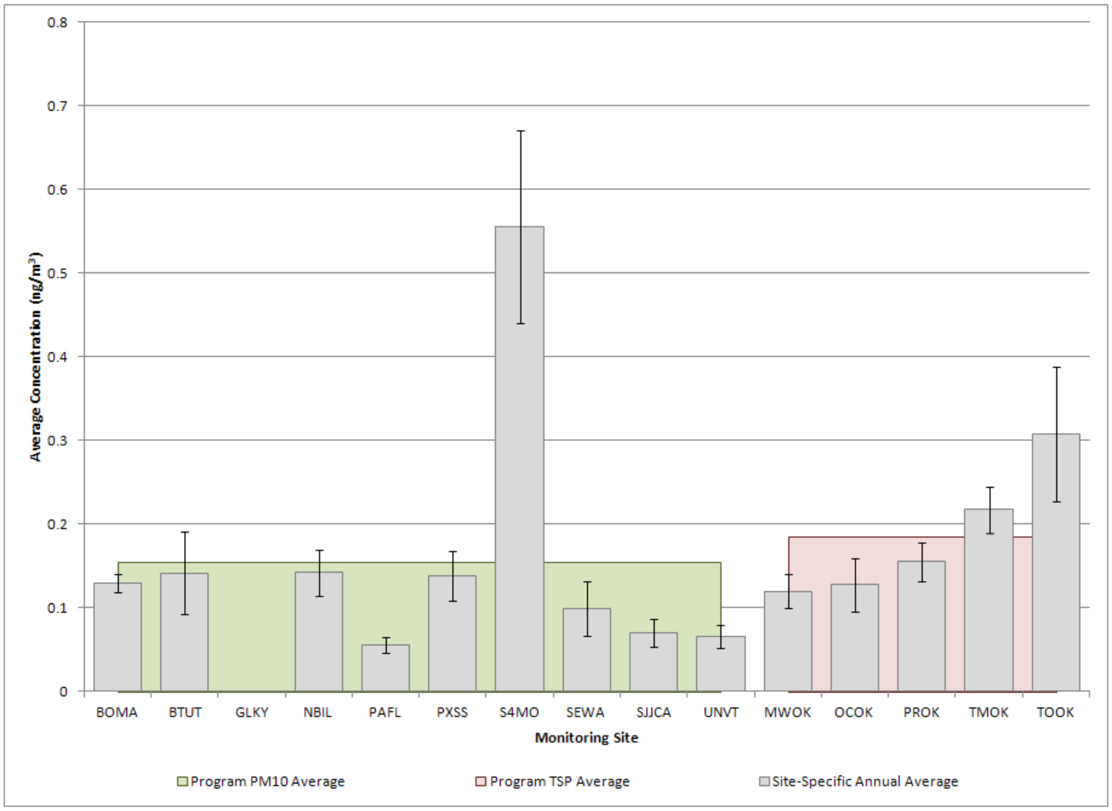


Figure 4-10a. Coefficient of Variation Analysis of Carbon Tetrachloride Across 23 Sites

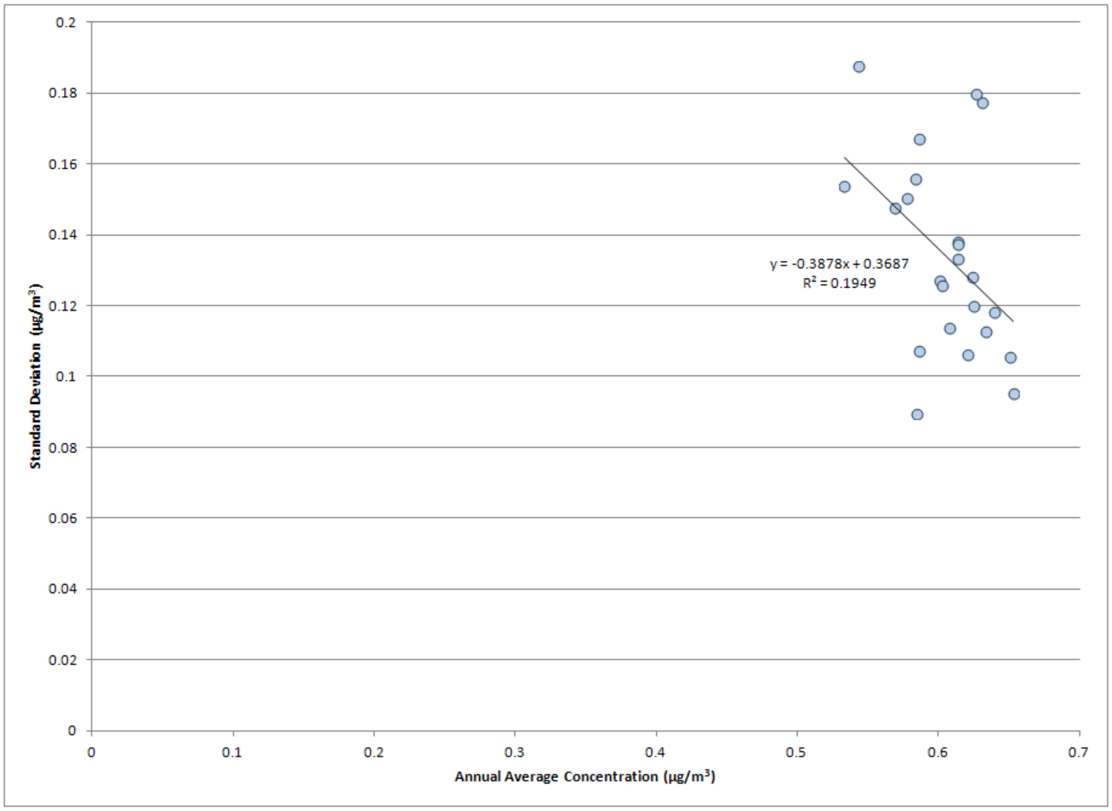


Figure 4-10b. Inter-Site Variability for Carbon Tetrachloride

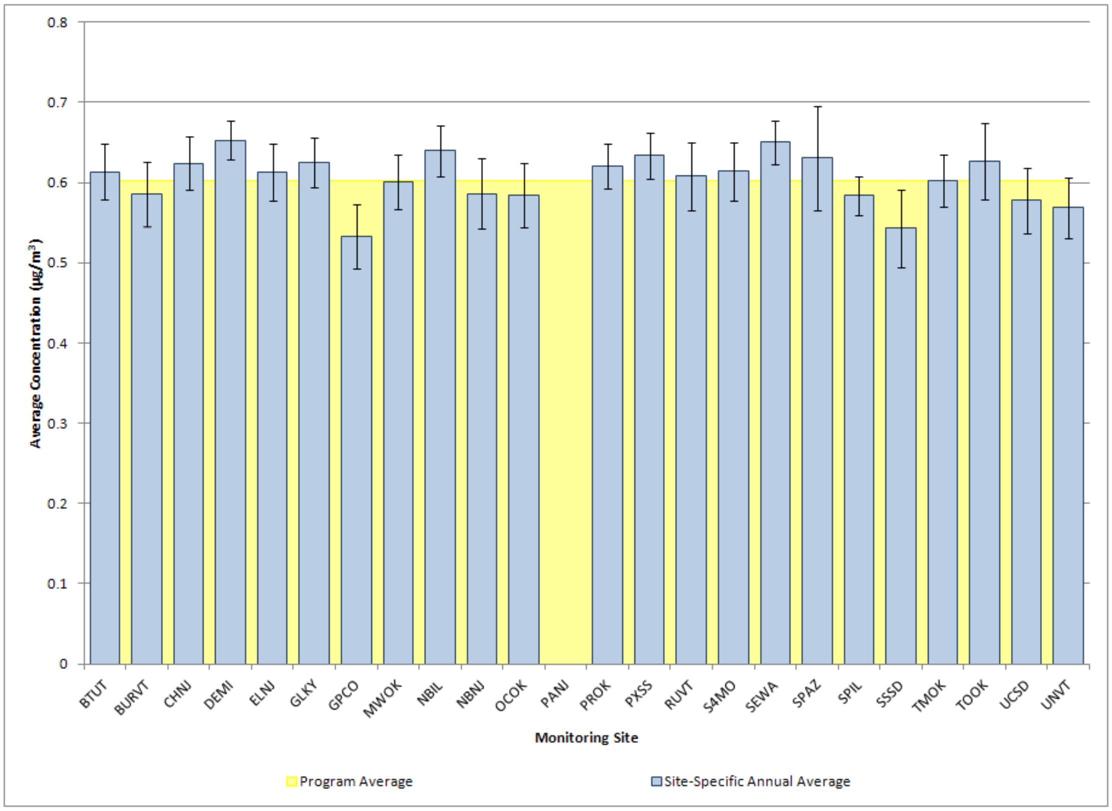


Figure 4-11a. Coefficient of Variation Analysis of Chloroform Across 23 Sites

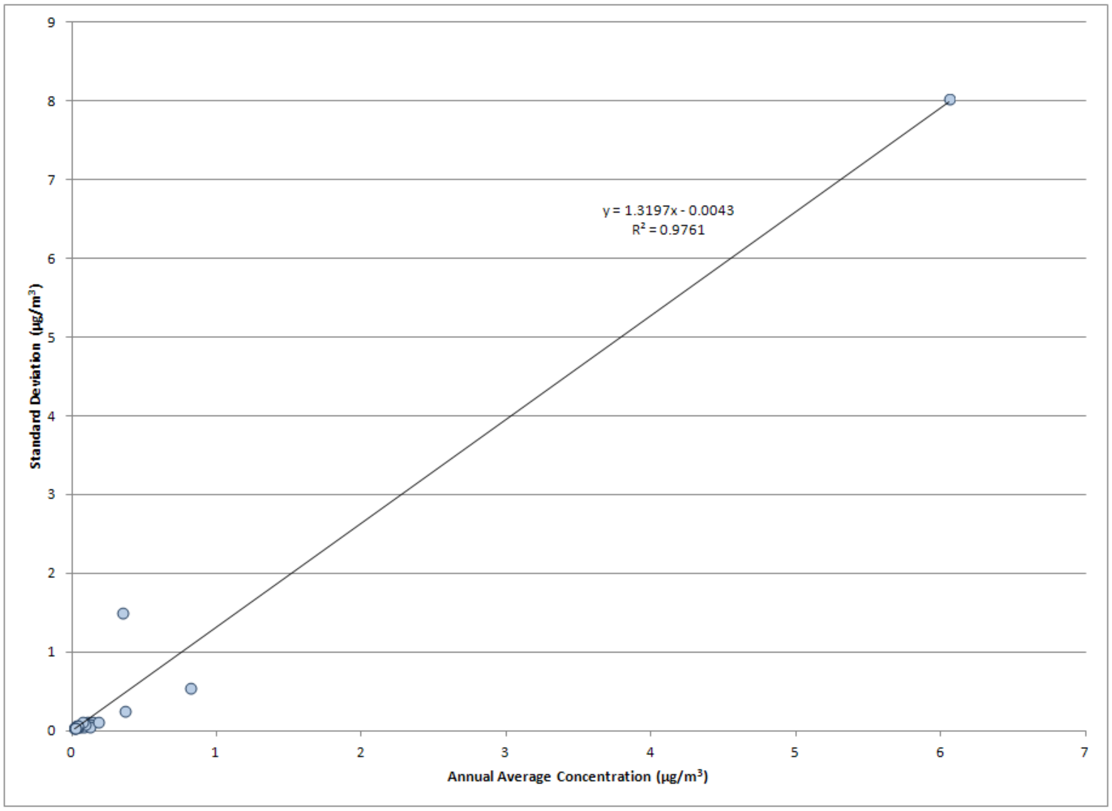


Figure 4-11b. Inter-Site Variability for Chloroform

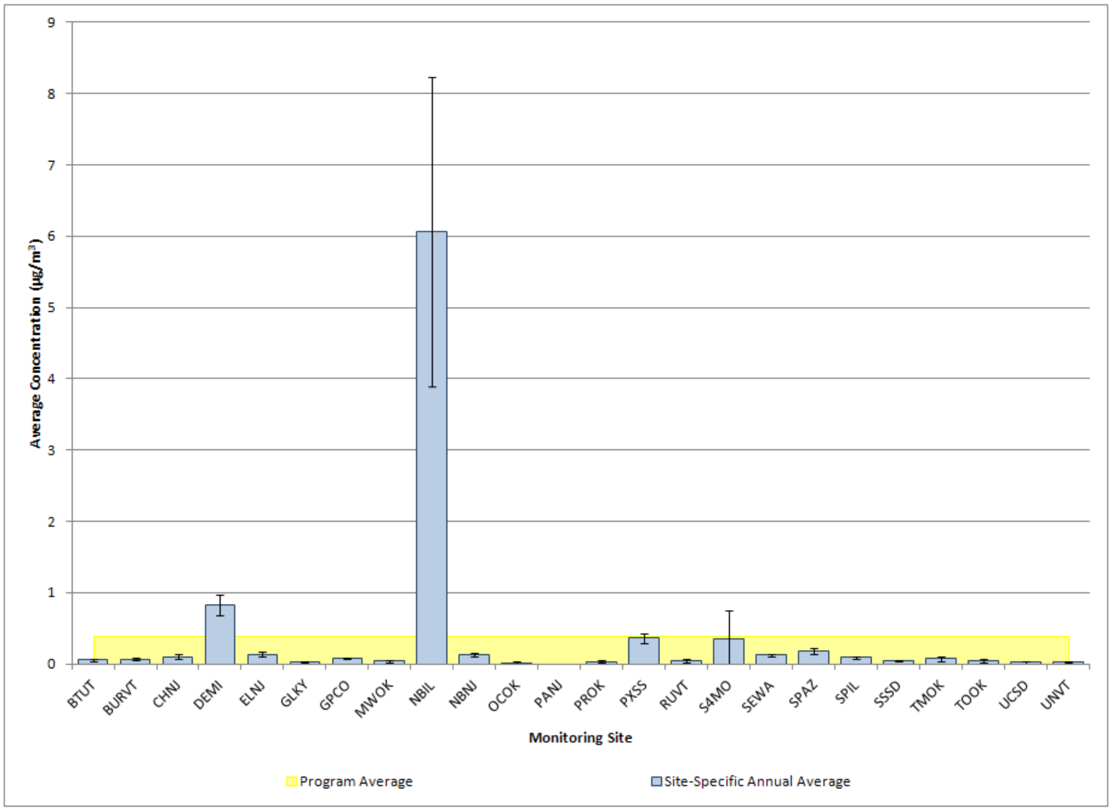


Figure 4-12a. Coefficient of Variation Analysis of *p*-Dichlorobenzene Across 23 Sites

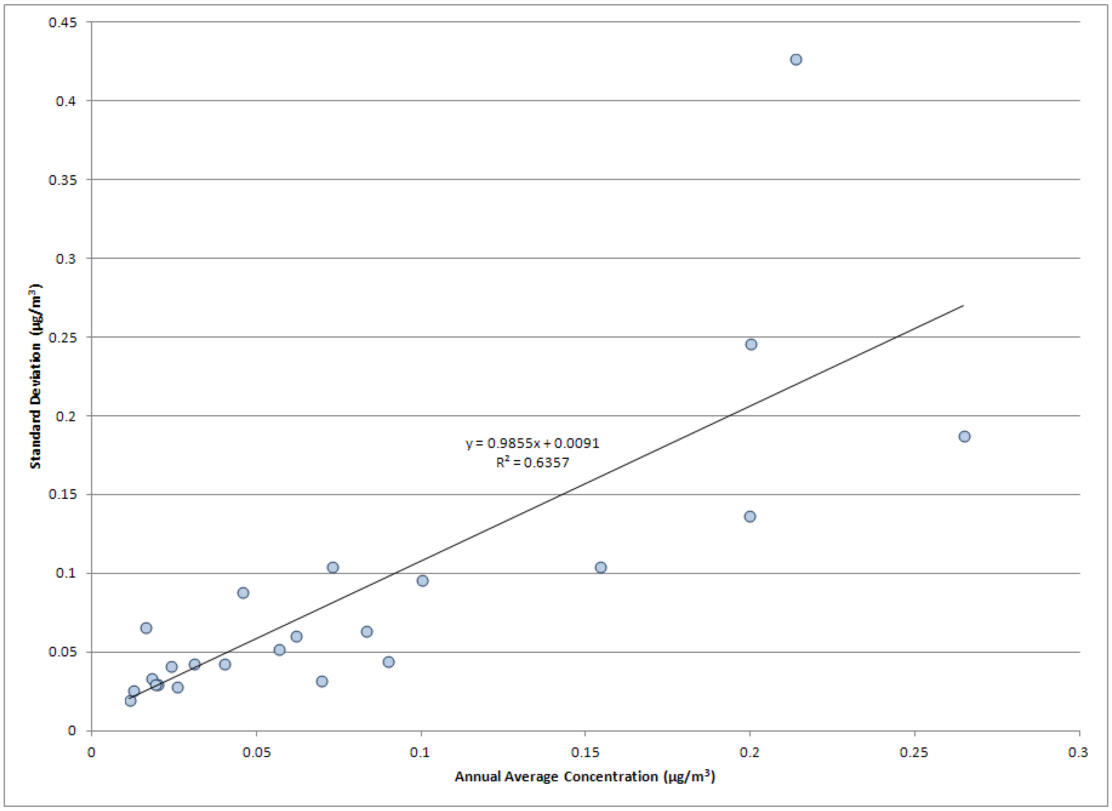


Figure 4-12b. Inter-Site Variability for *p*-Dichlorobenzene

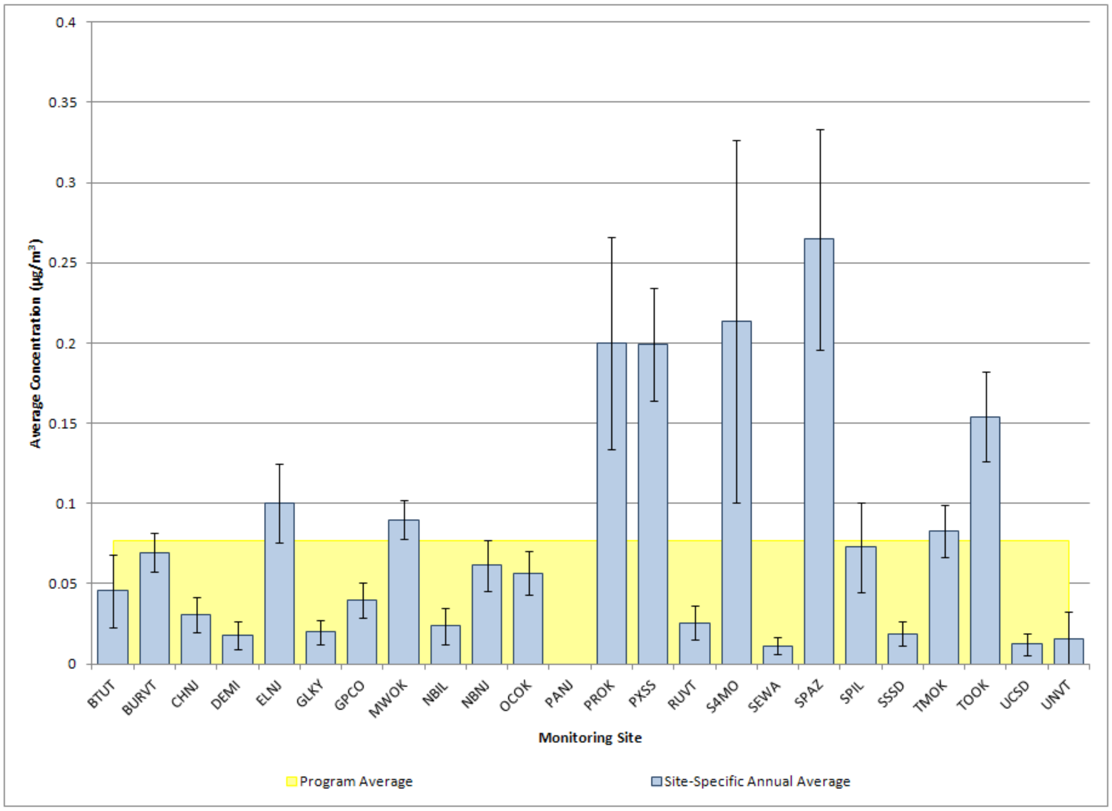


Figure 4-13a. Coefficient of Variation Analysis of 1,2-Dichloroethane Across 23 Sites

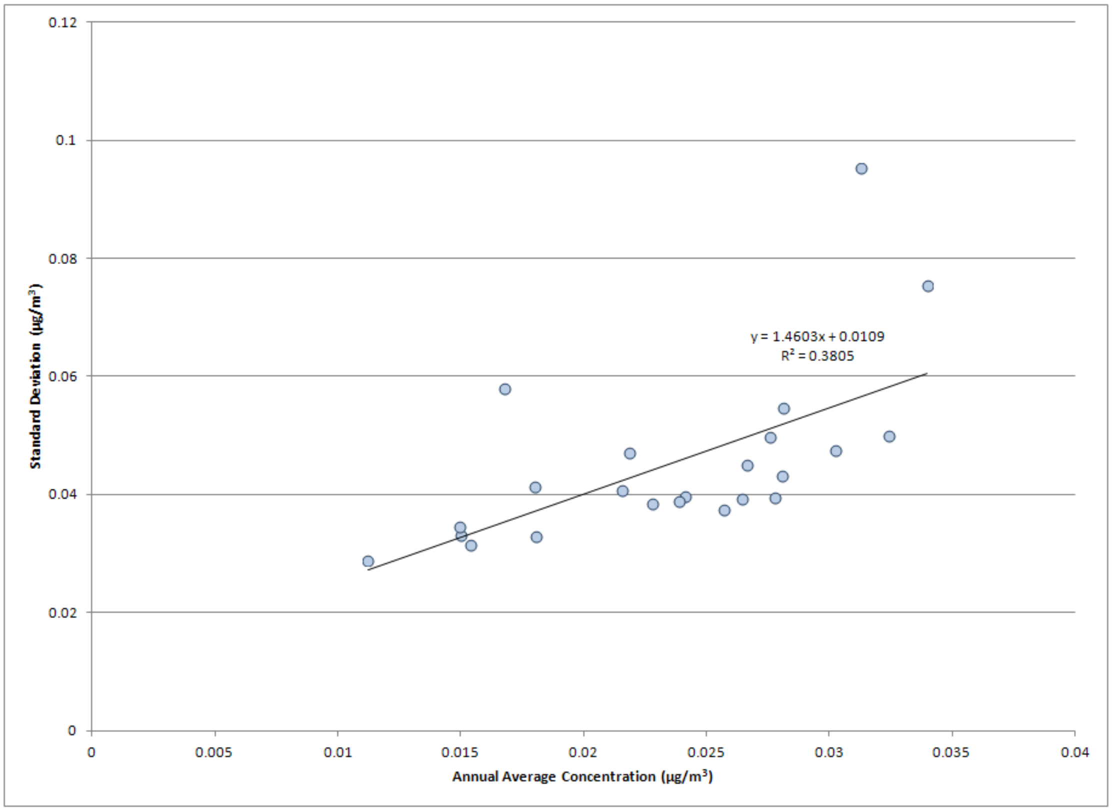


Figure 4-13b. Inter-Site Variability for 1,2-Dichloroethane

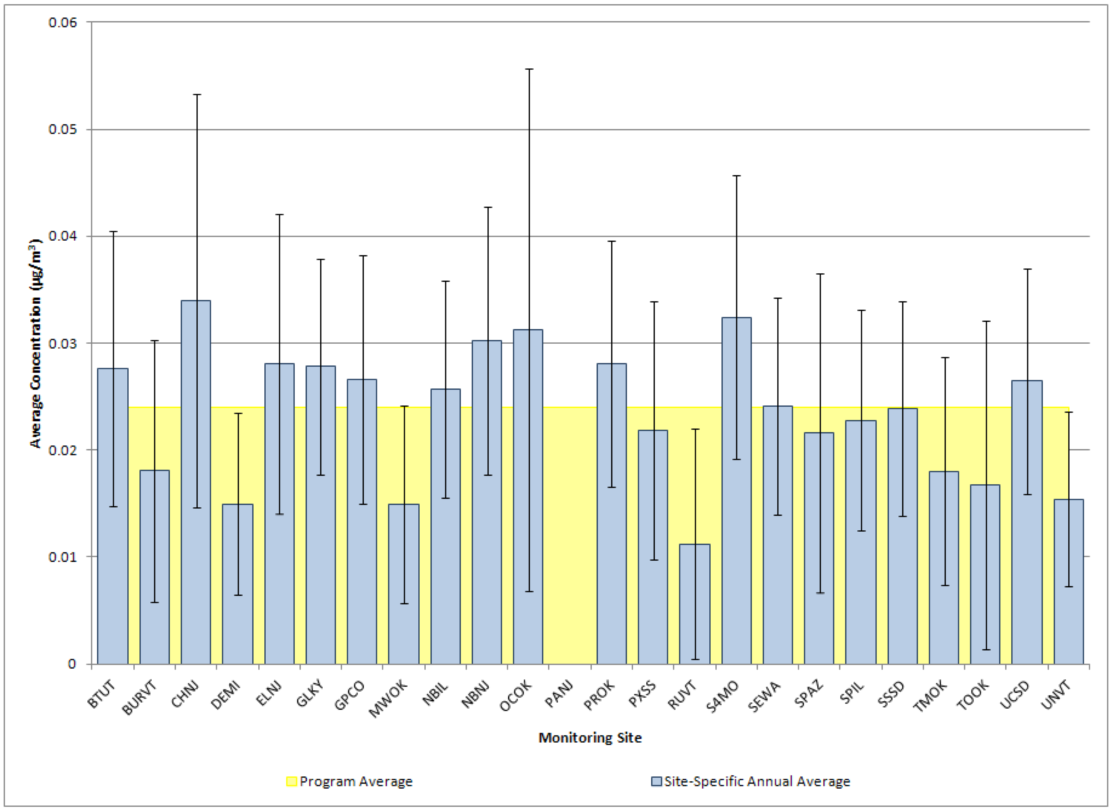


Figure 4-14a. Coefficient of Variation Analysis of Ethylbenzene Across 23 Sites

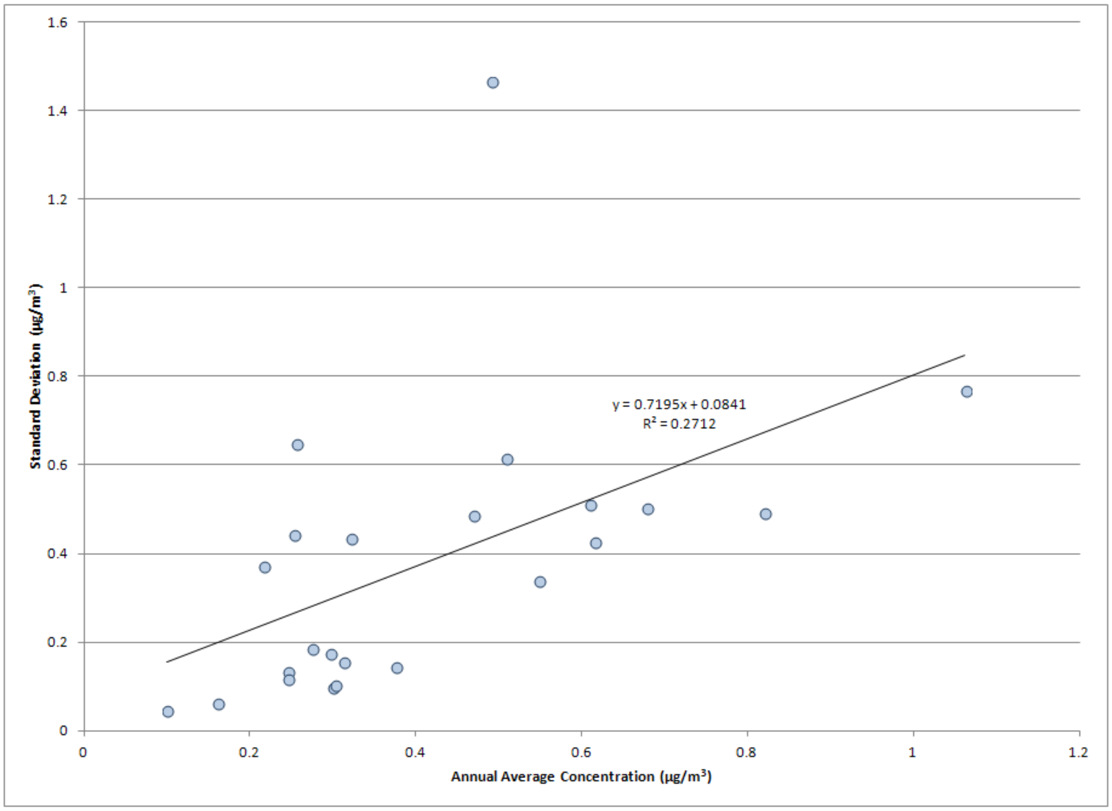


Figure 4-14b. Inter-Site Variability for Ethylbenzene

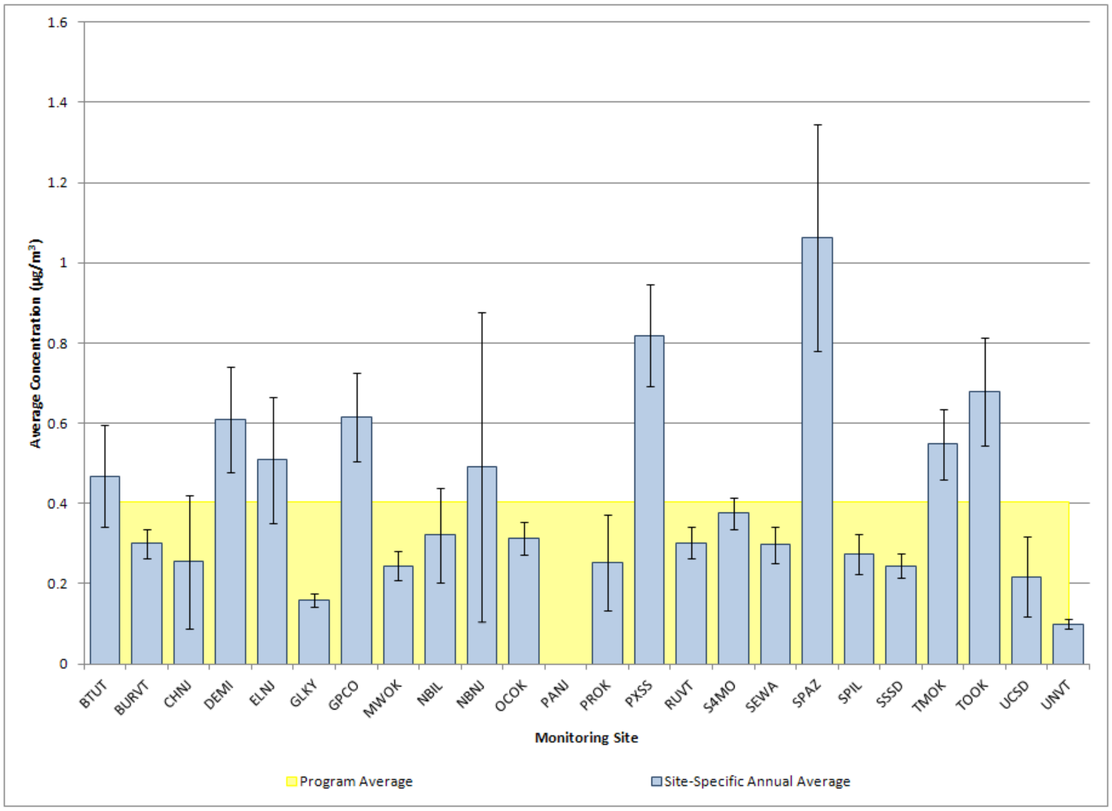


Figure 4-15a. Coefficient of Variation Analysis of Fluorene Across 23 Sites

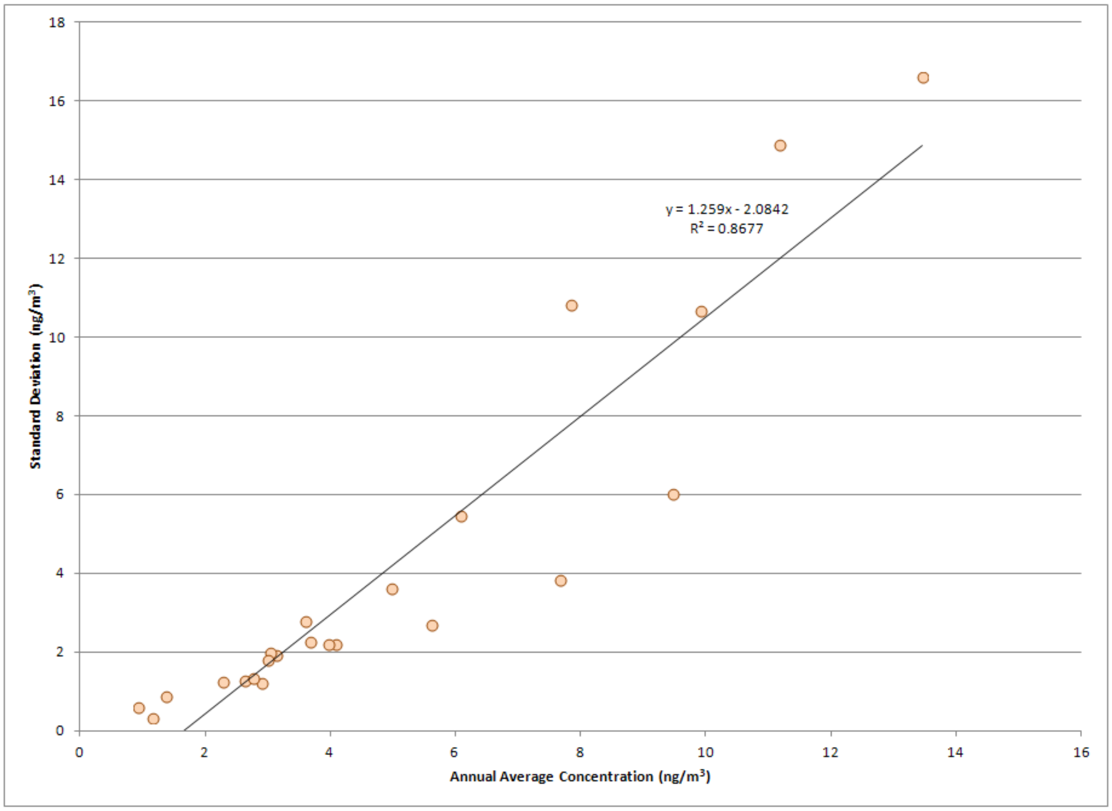


Figure 4-15b. Inter-Site Variability for Fluorene

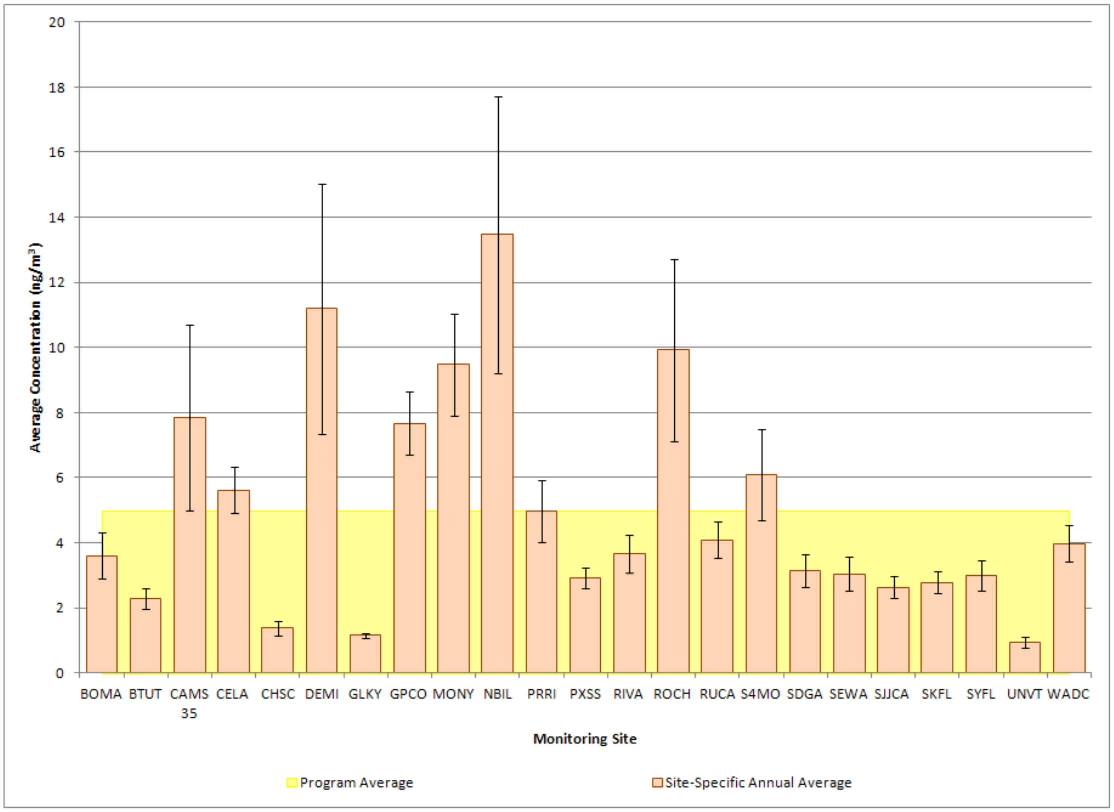


Figure 4-16a. Coefficient of Variation Analysis of Formaldehyde Across 24 Sites

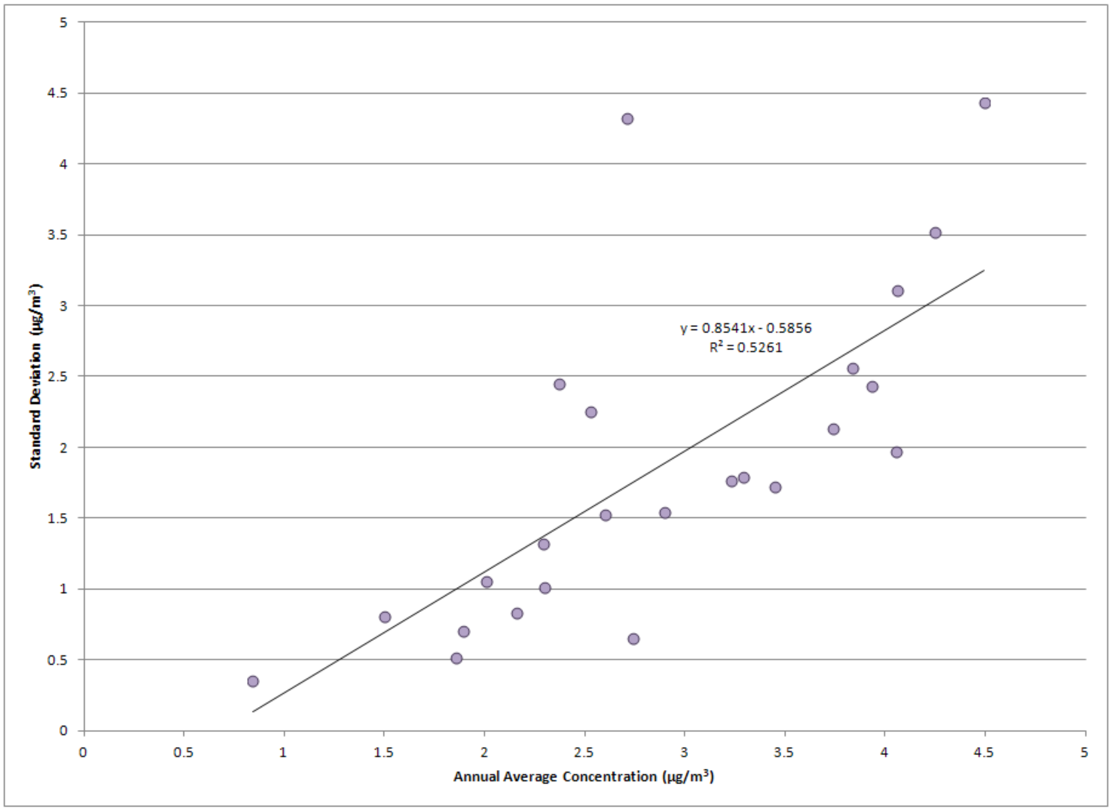


Figure 4-16b. Inter-Site Variability for Formaldehyde

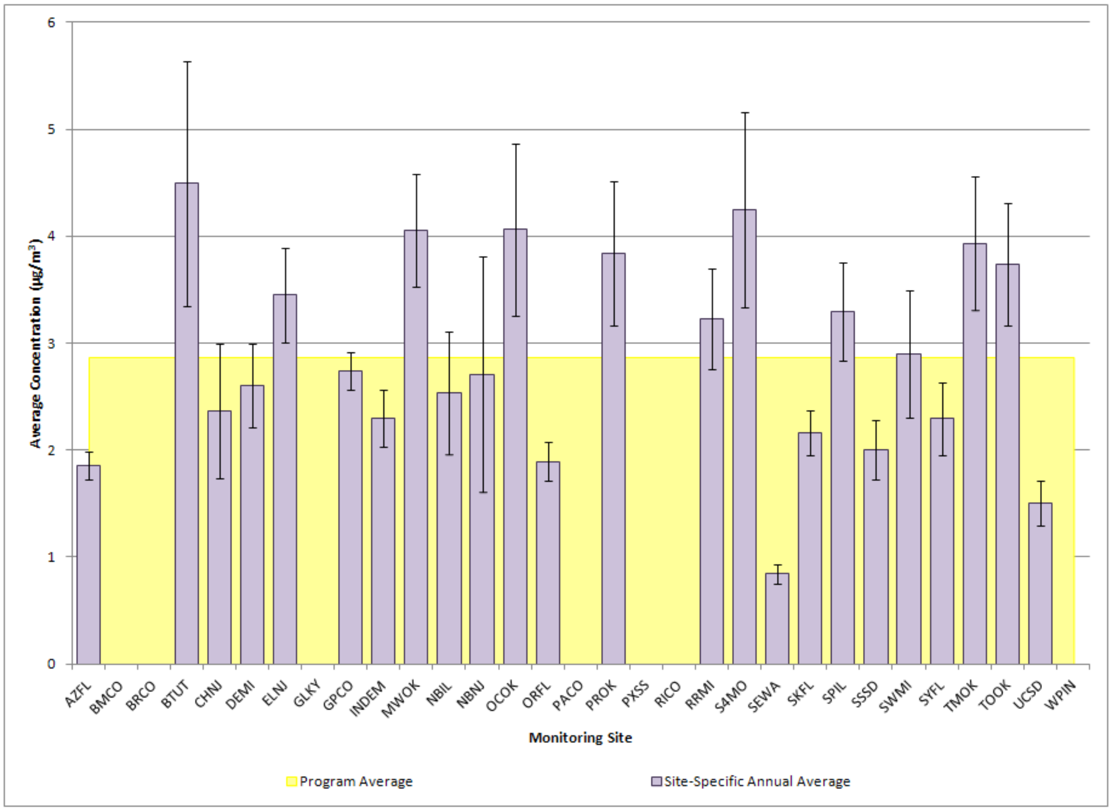


Figure 4-17a. Coefficient of Variation Analysis of Hexachloro-1,3-butadiene Across 23 Sites

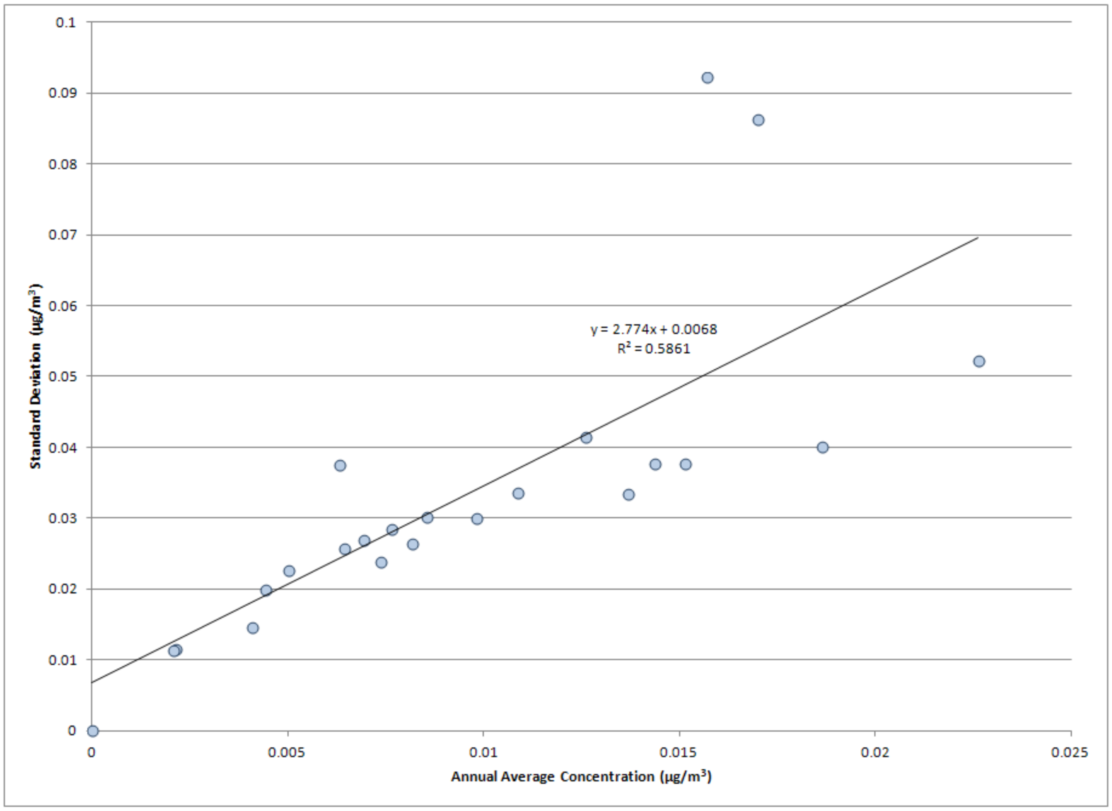


Figure 4-17b. Inter-Site Variability for Hexachloro-1,3-butadiene

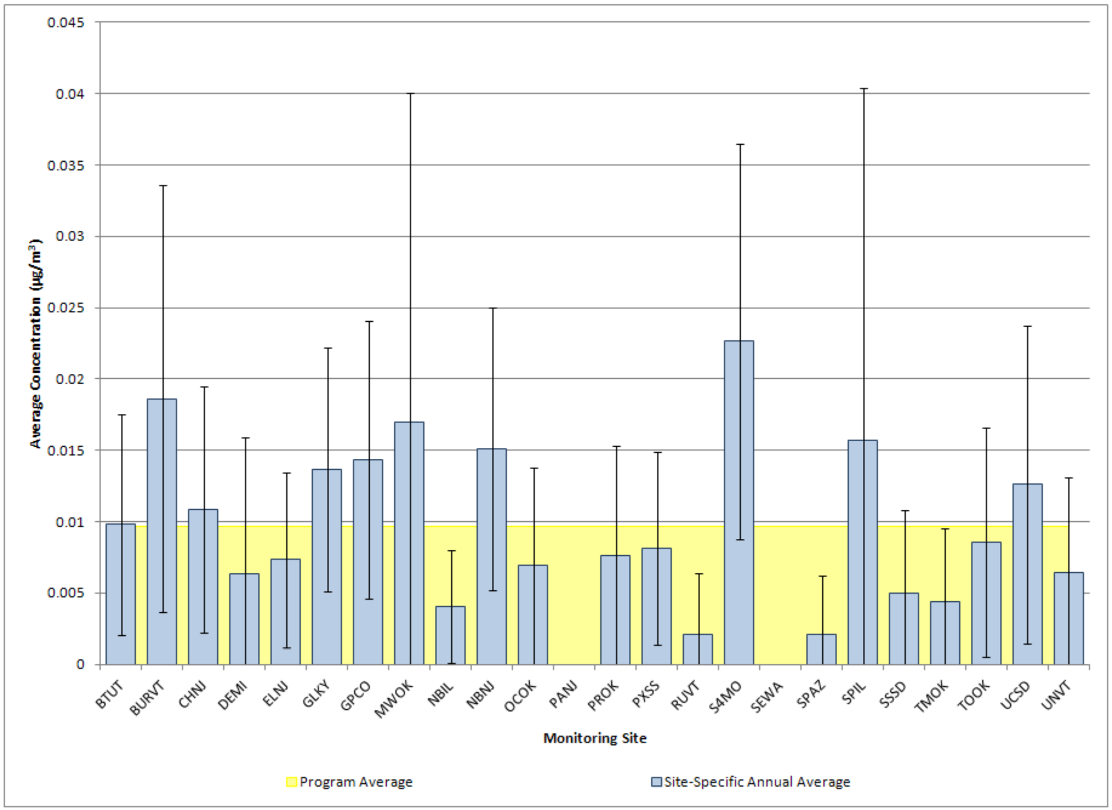


Figure 4-18a. Coefficient of Variation Analysis of Hexavalent Chromium Across 22 Sites

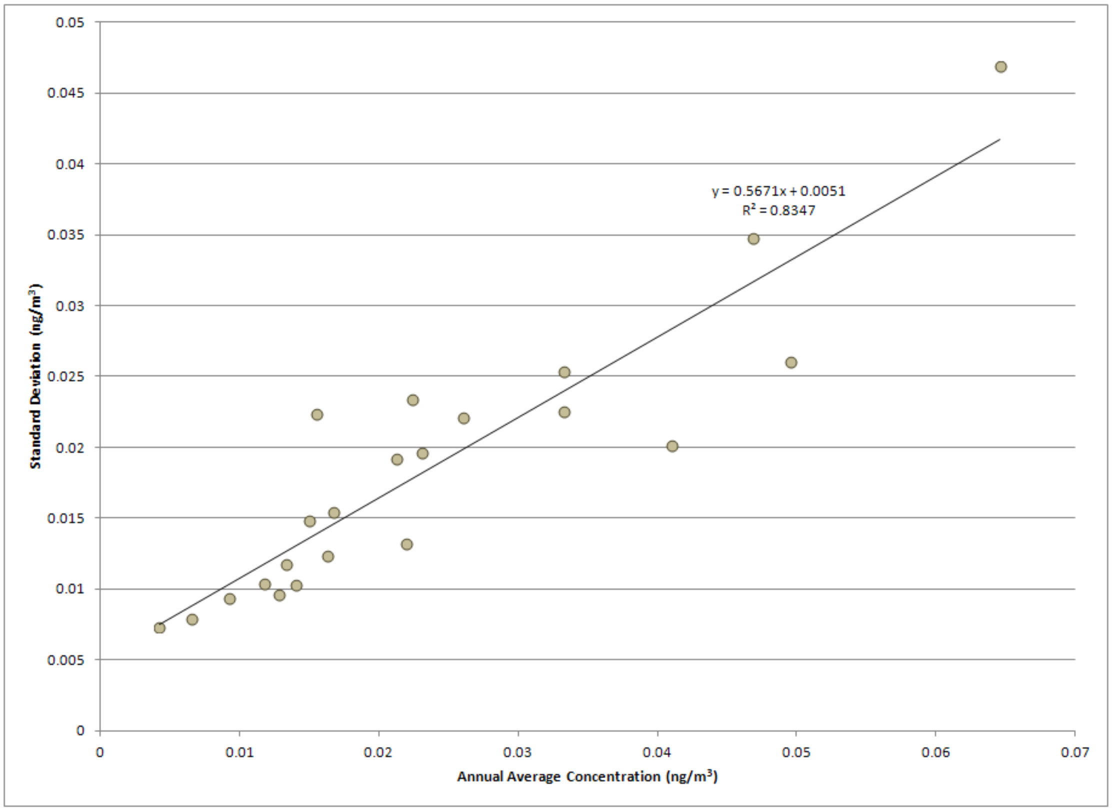


Figure 4-18b. Inter-Site Variability for Hexavalent Chromium

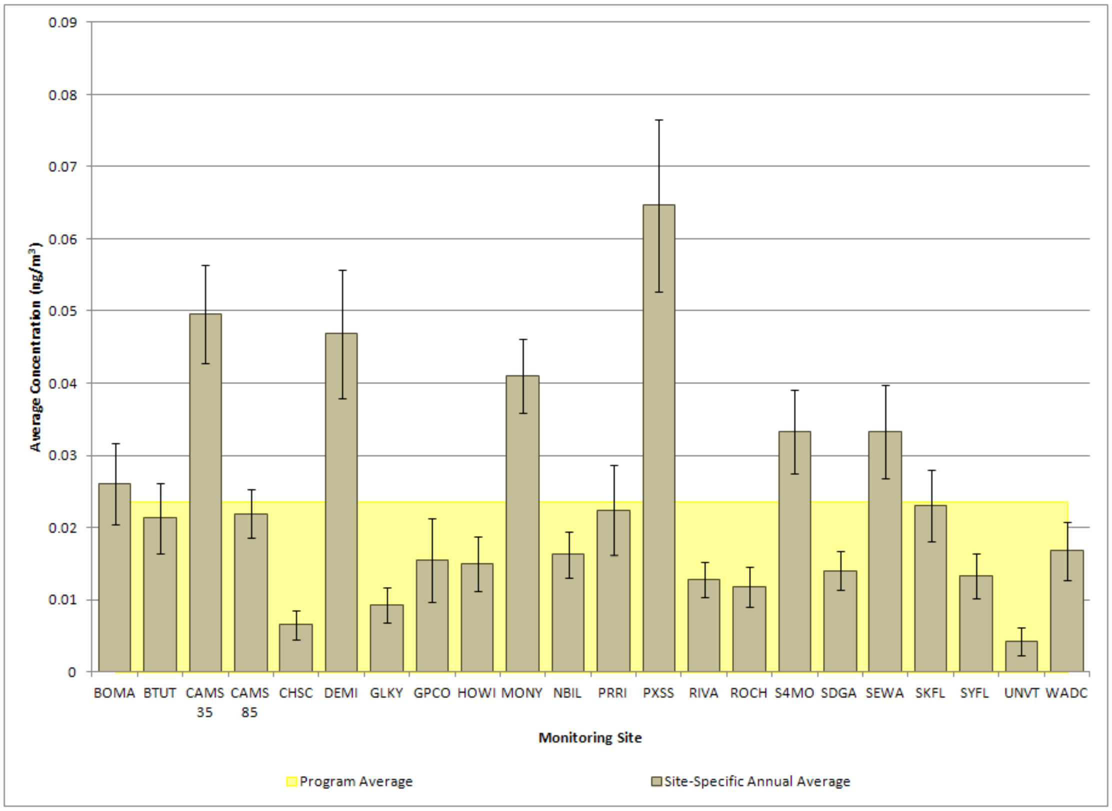


Figure 4-19a. Coefficient of Variation Analysis of Lead Across 14 Sites

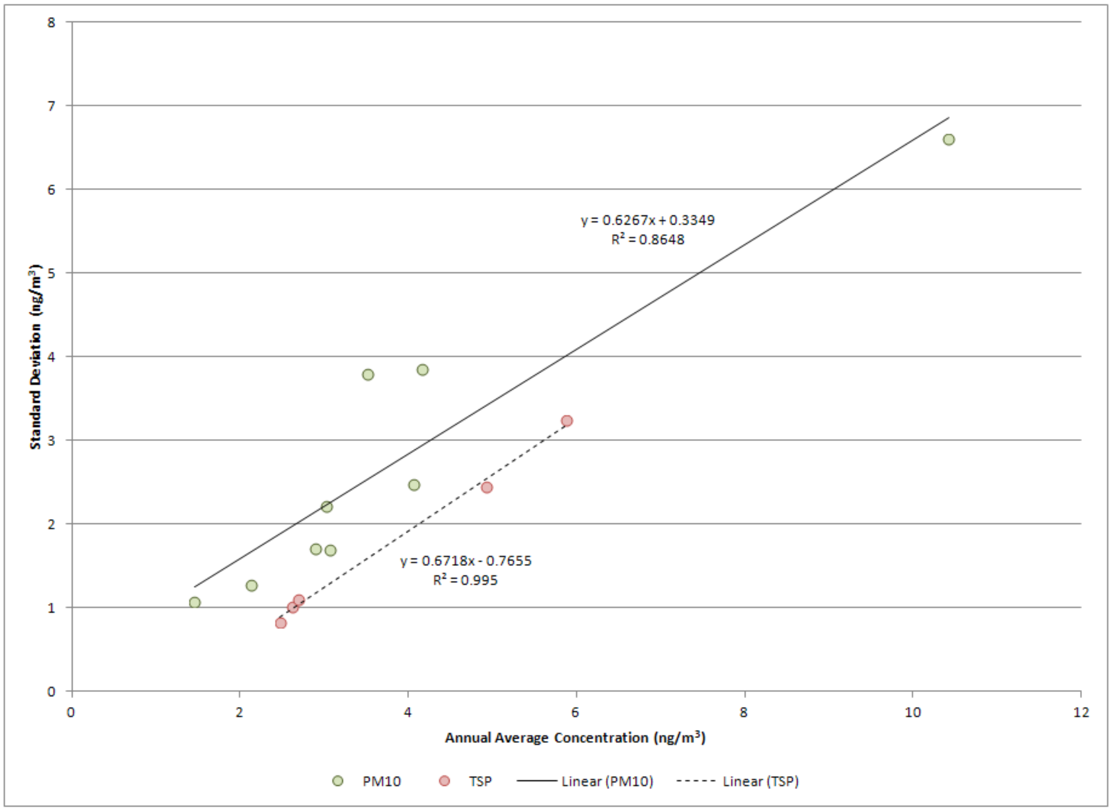


Figure 4-19b. Inter-Site Variability for Lead

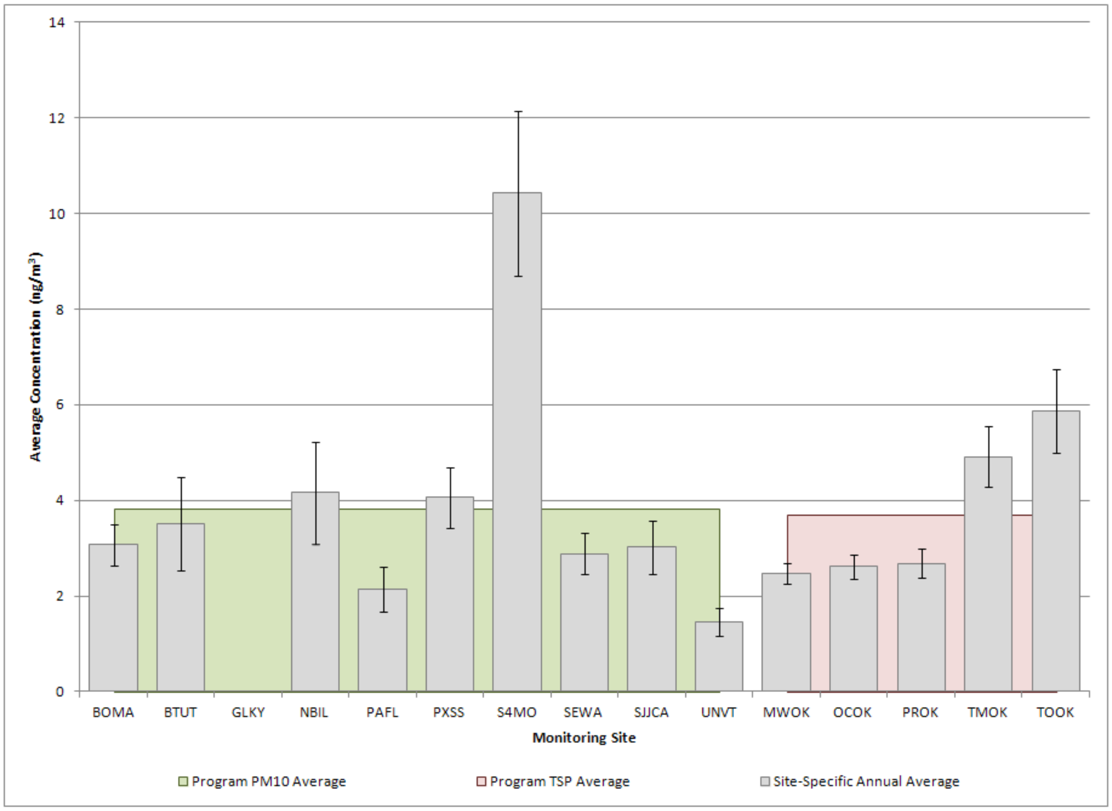


Figure 4-20a. Coefficient of Variation Analysis of Manganese Across 14 Sites

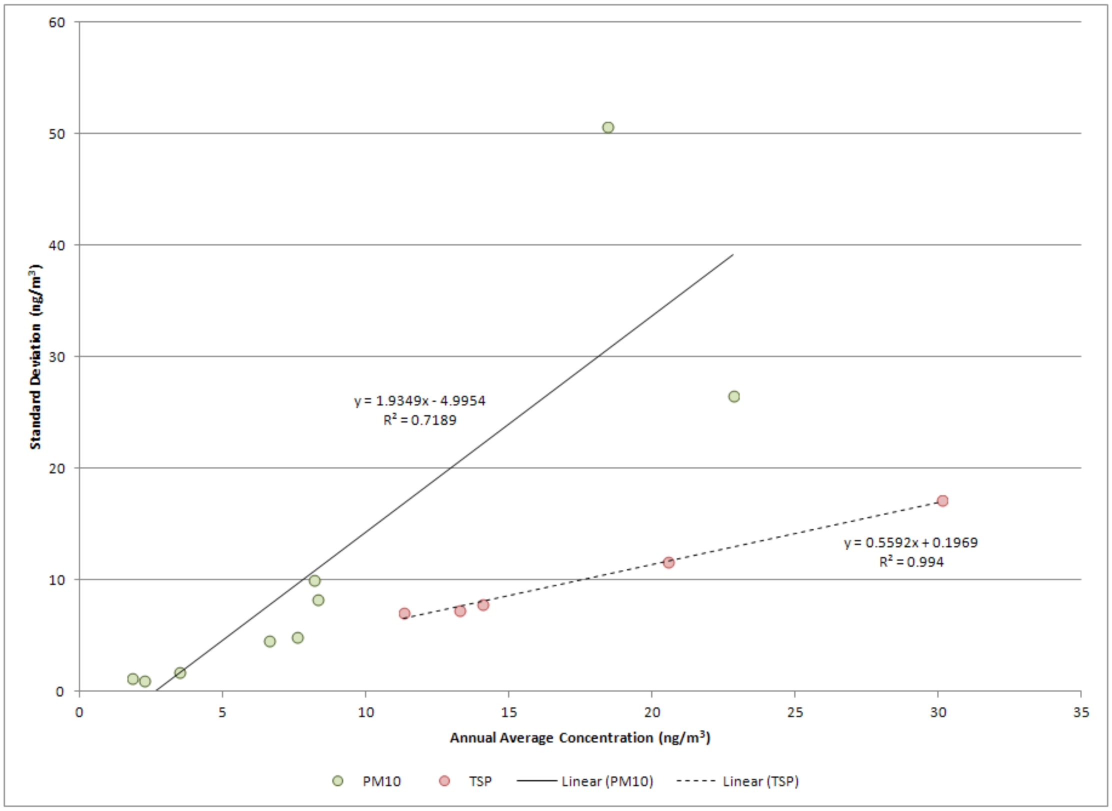


Figure 4-20b. Inter-Site Variability for Manganese

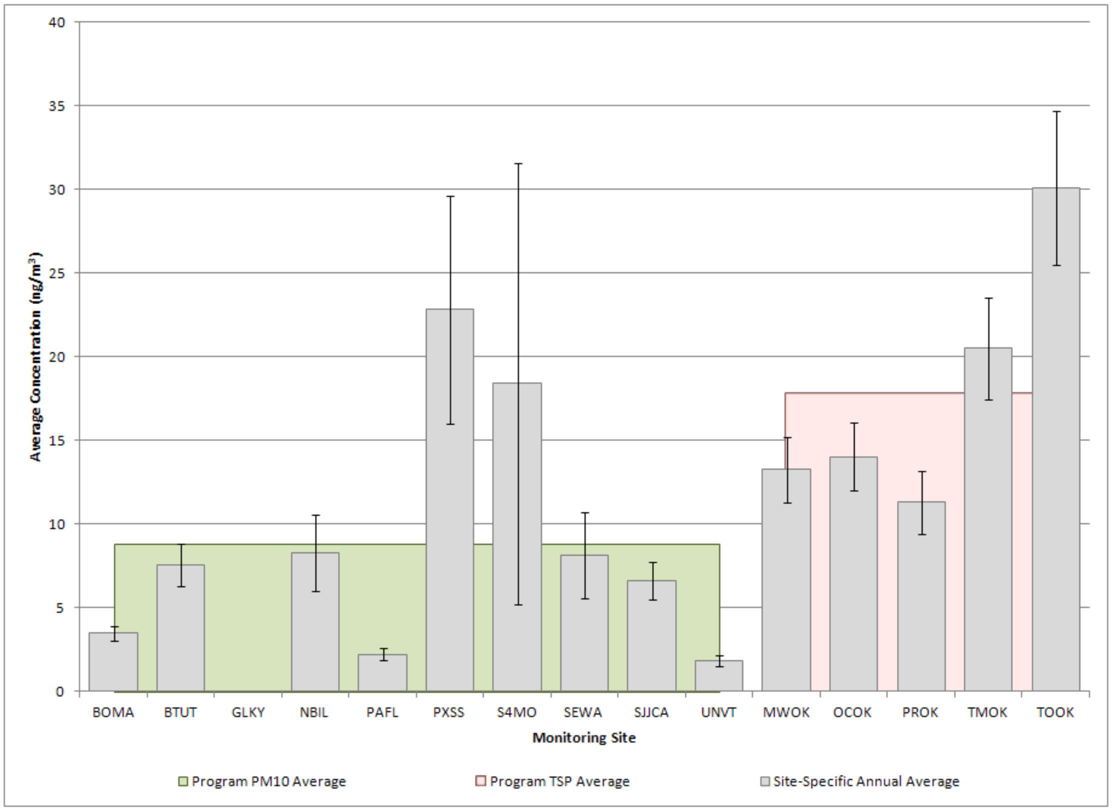


Figure 4-21a. Coefficient of Variation Analysis of Naphthalene Across 23 Sites

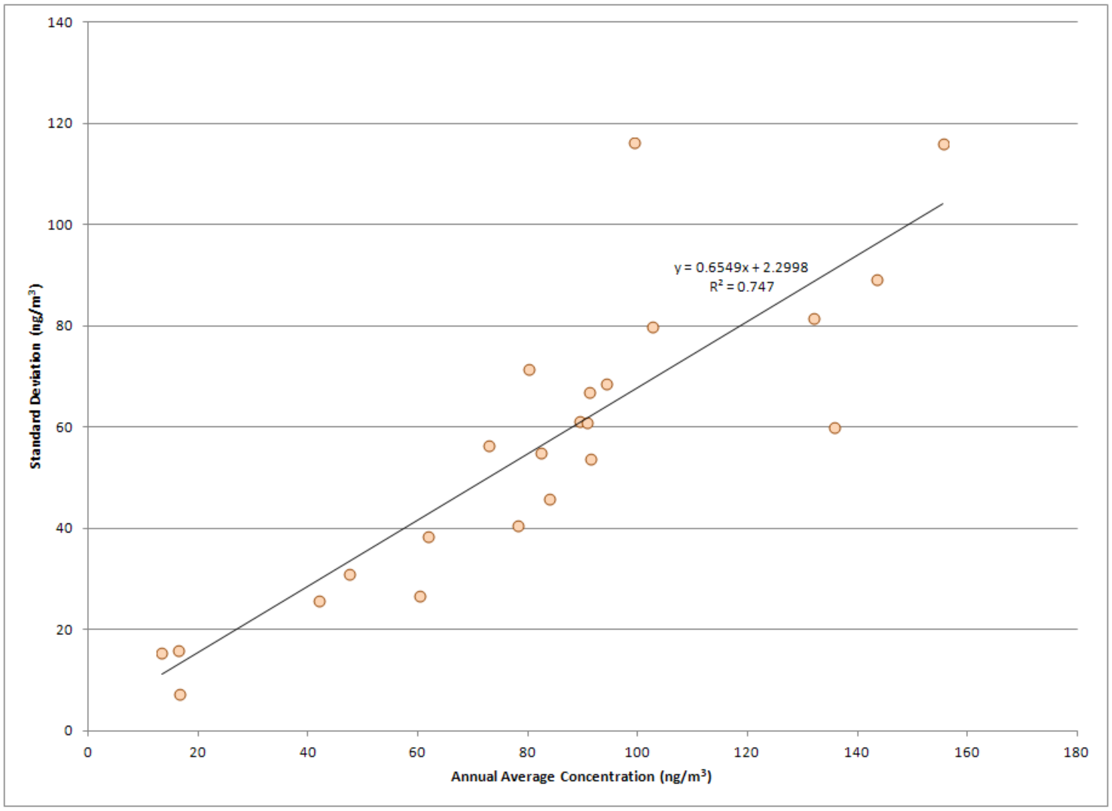


Figure 4-21b. Inter-Site Variability for Naphthalene

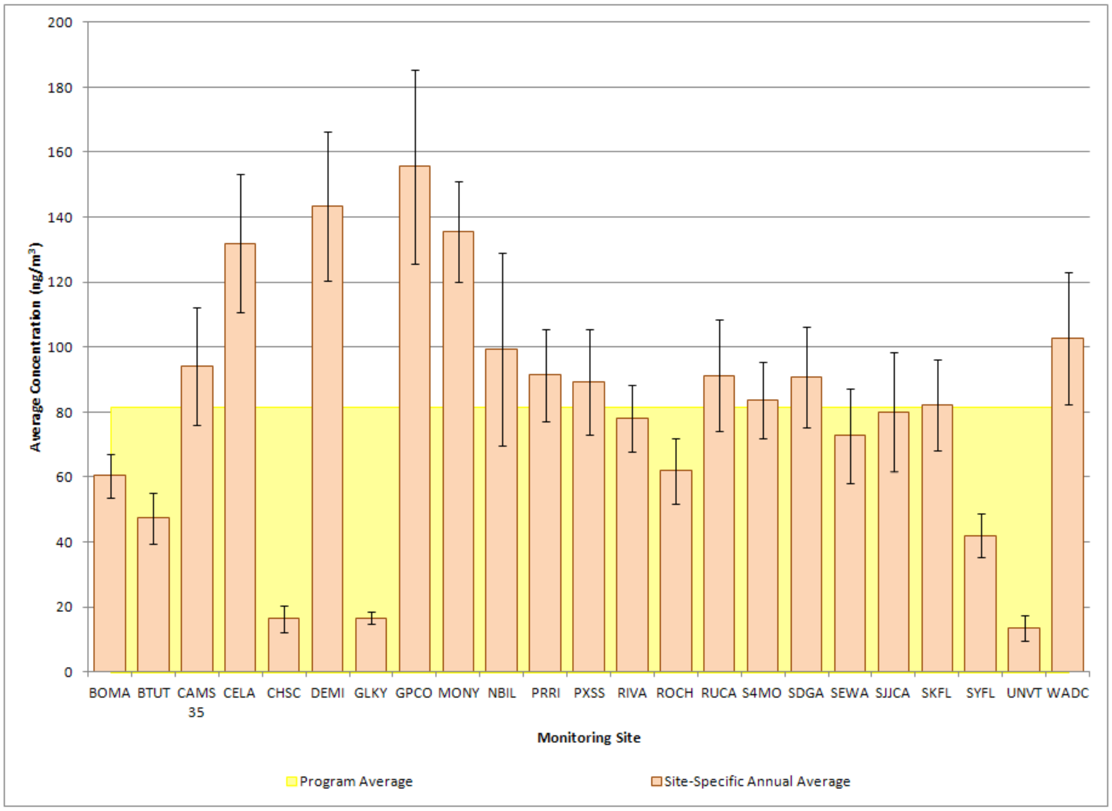


Figure 4-22a. Coefficient of Variation Analysis of Nickel Across 14 Sites

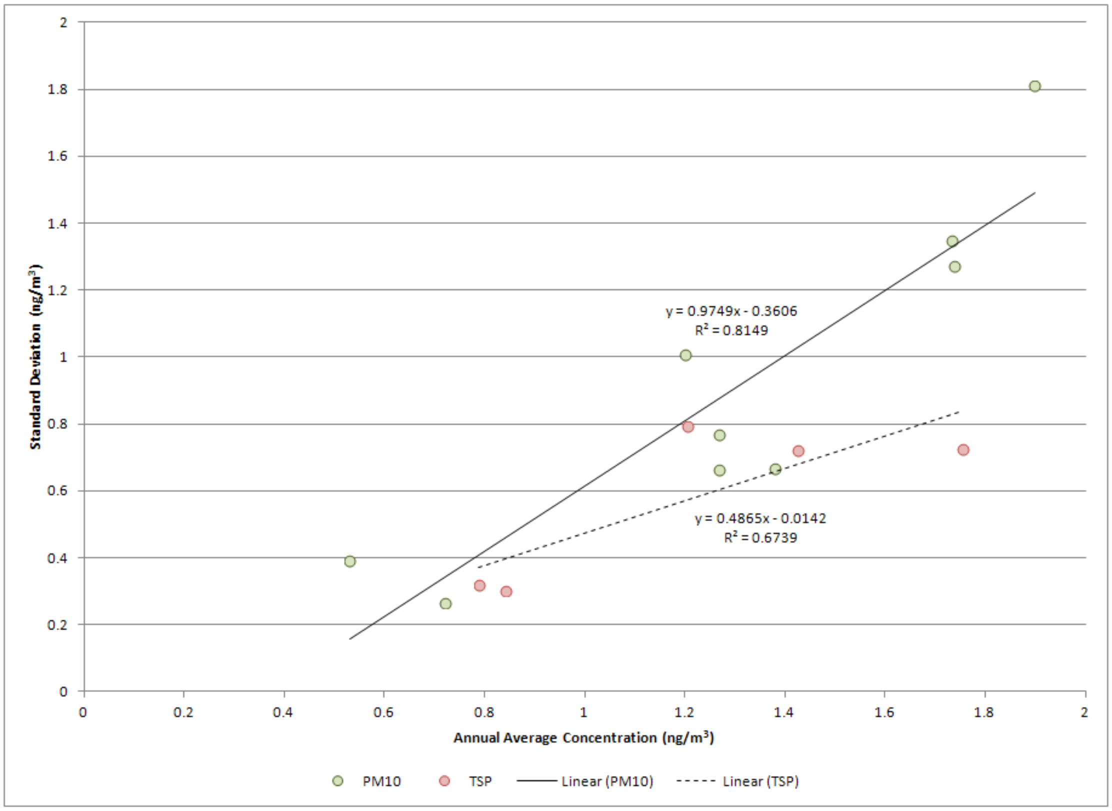


Figure 4-22b. Inter-Site Variability for Nickel

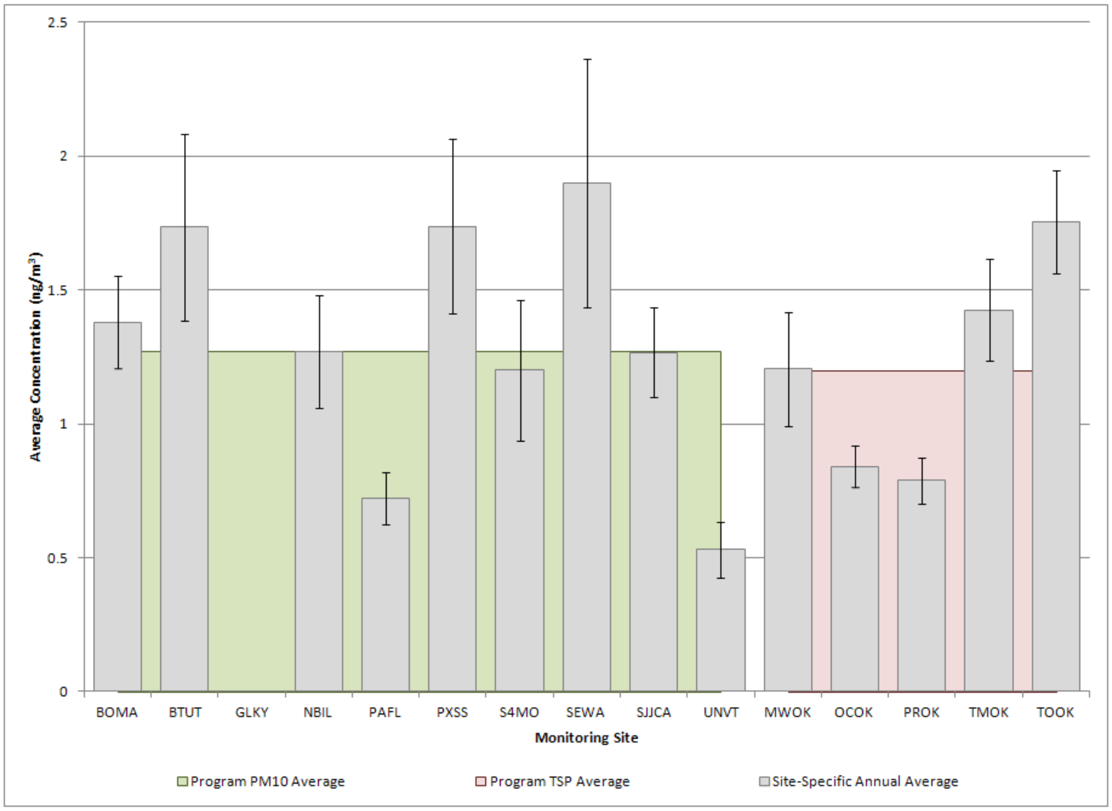


Figure 4-23a. Coefficient of Variation Analysis of Tetrachloroethylene Across 23 Sites

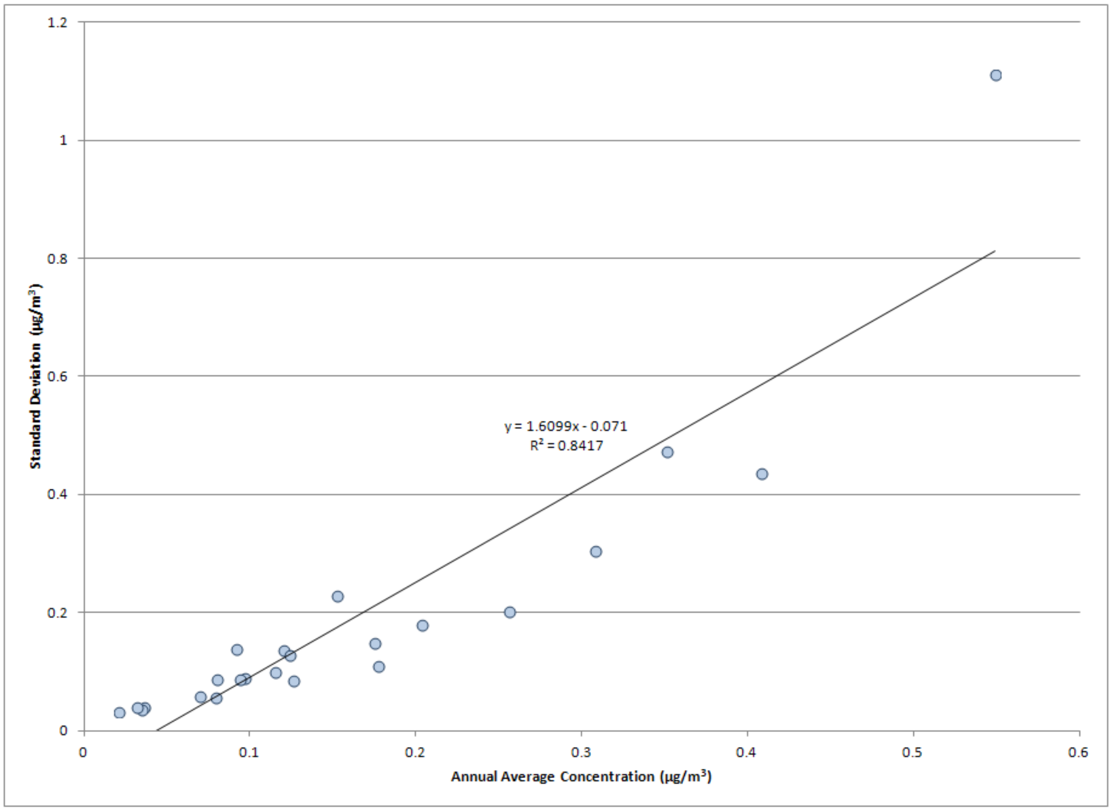


Figure 4-23b. Inter-Site Variability for Tetrachloroethylene

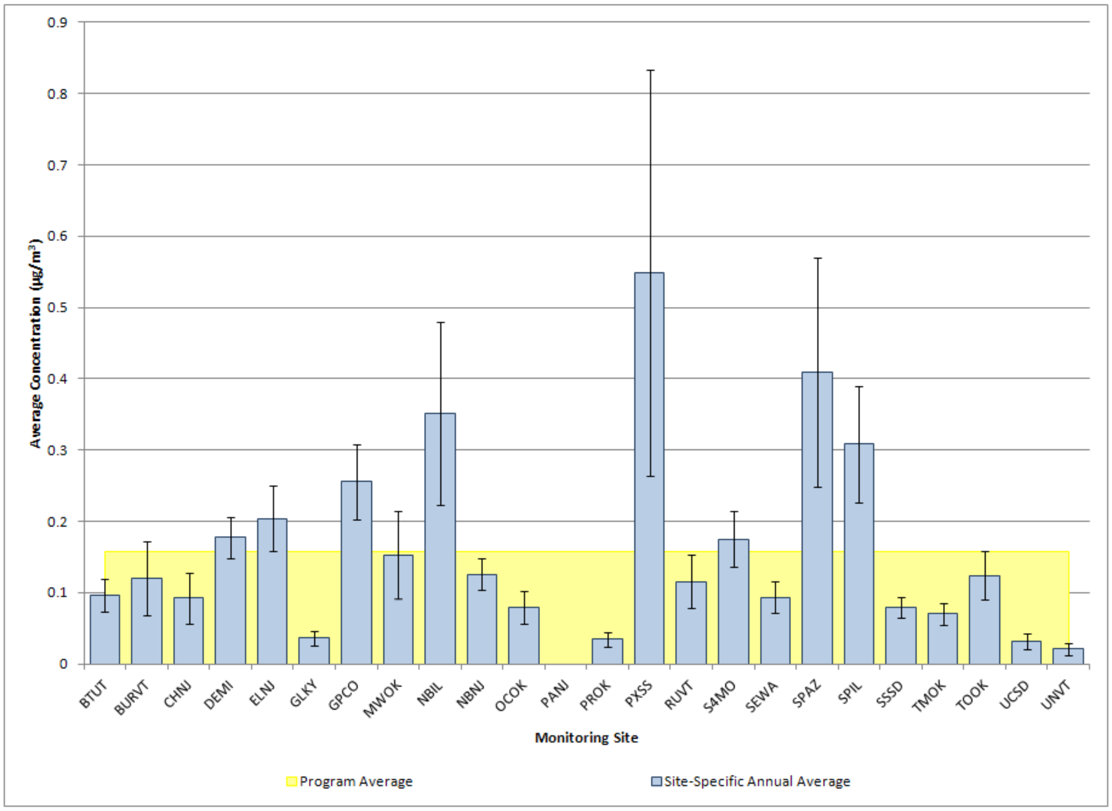


Figure 4-24a. Coefficient of Variation Analysis of Trichloroethylene Across 23 Sites

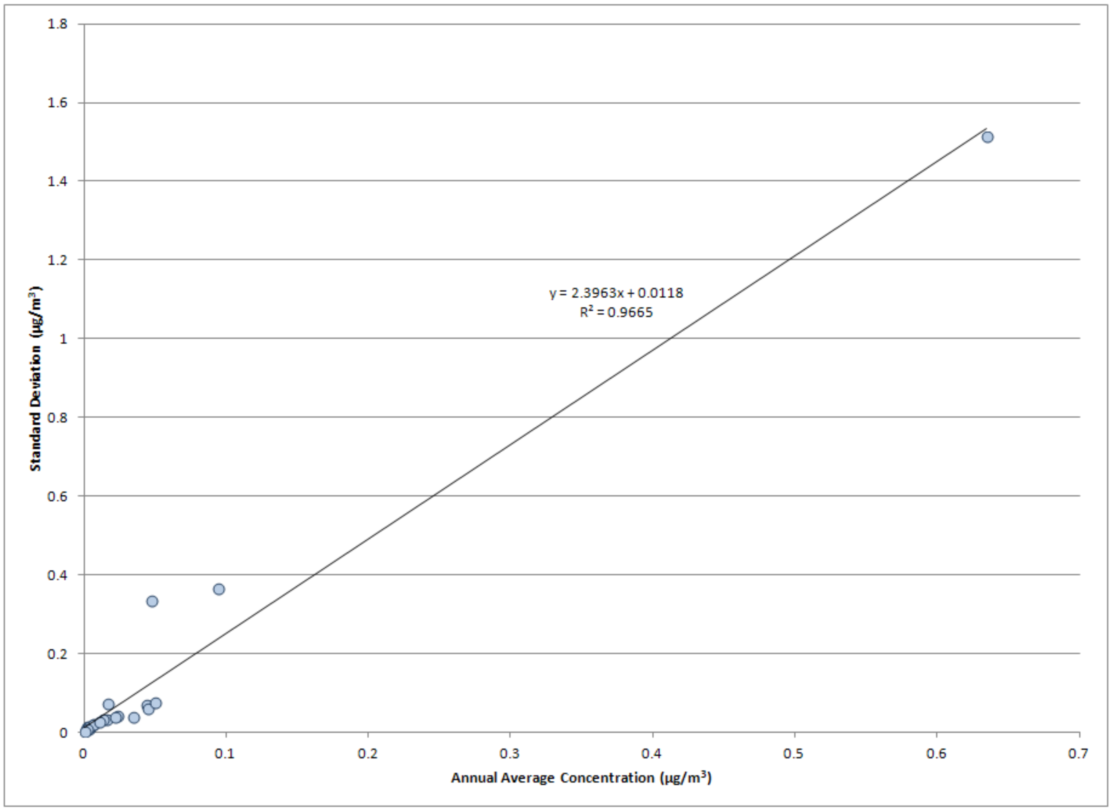


Figure 4-24b. Inter-Site Variability for Trichloroethylene

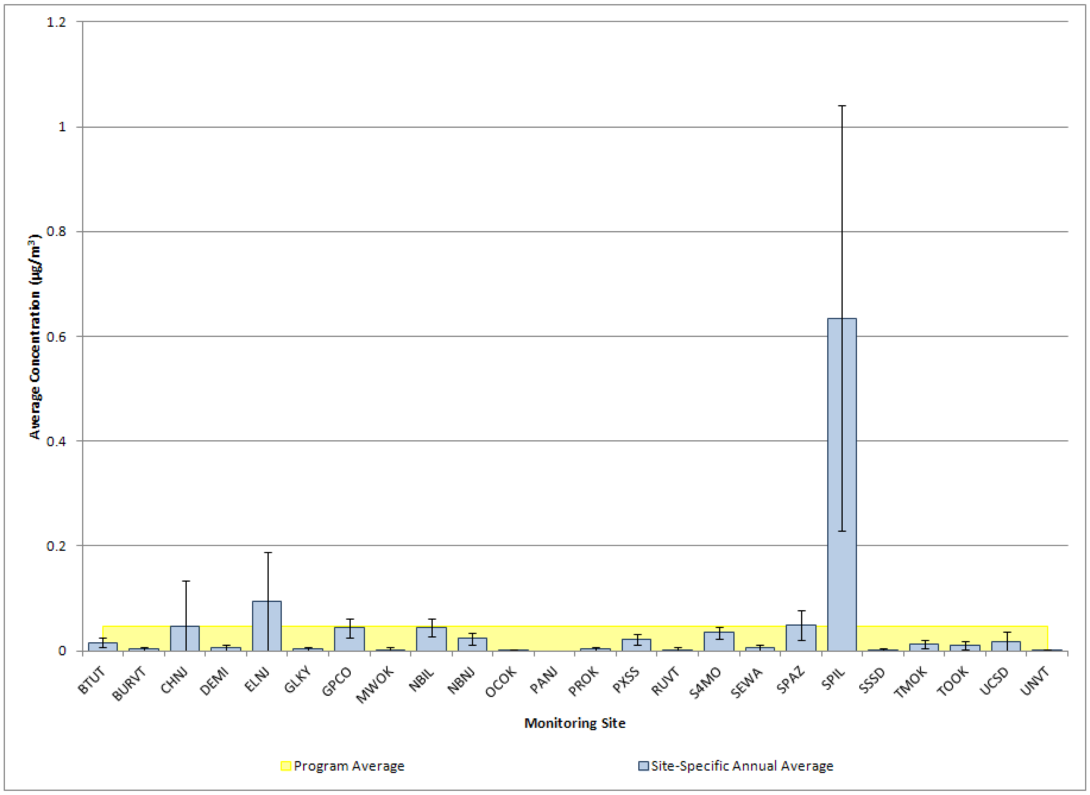


Figure 4-25a. Coefficient of Variation Analysis of Vinyl Chloride Across 23 Sites

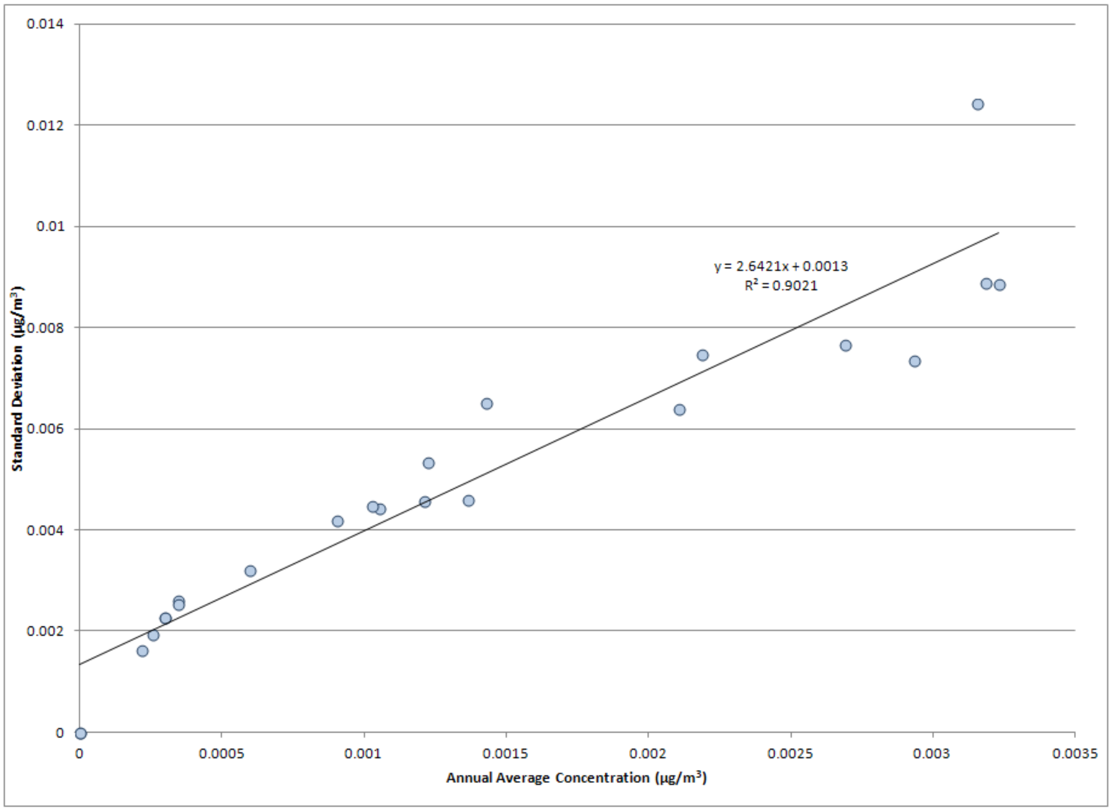
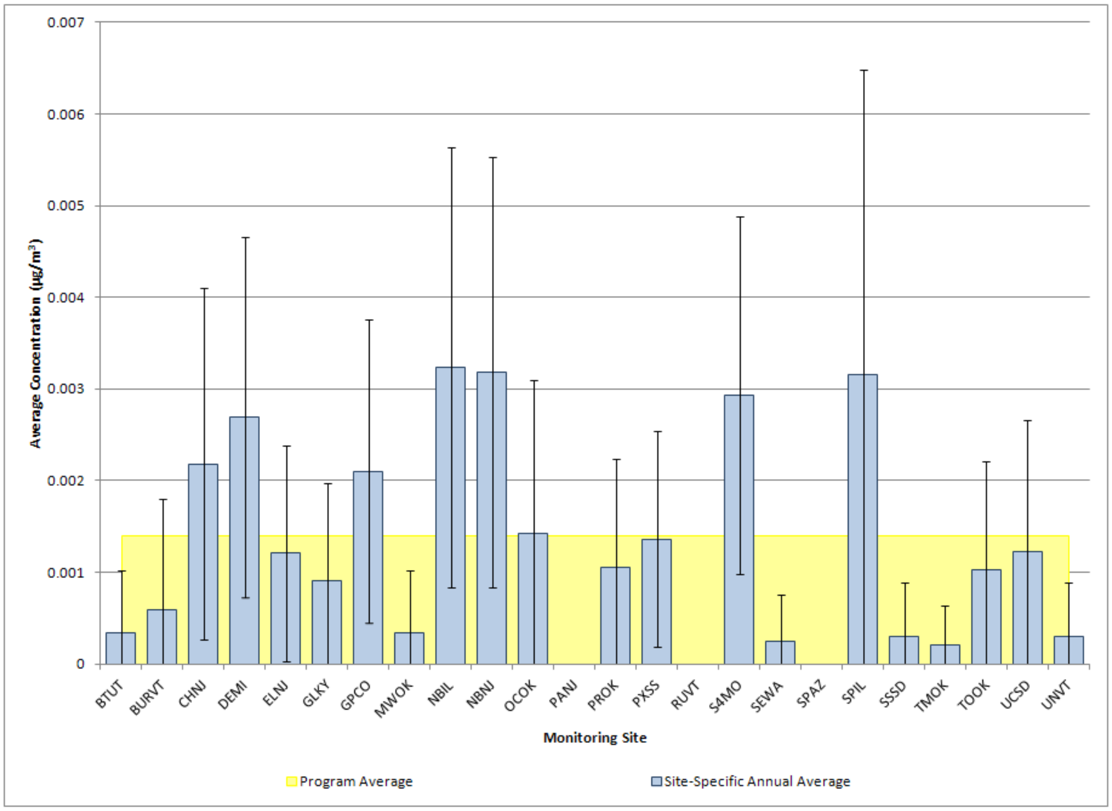


Figure 4-25b. Inter-Site Variability for Vinyl Chloride



4.4.2 Quarterly Variability Analysis

Figures 4-26 through 4-50 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. The National Ambient Air Quality Standard (NAAQS) for lead (TSP) is a 3-month standard. Because this time period aligns well with the quarterly averages presented in this section, the NAAQS for lead (TSP) is also provided in Figure 4-44a and 4-44b. 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 two 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 4-28 for acrylonitrile. This pollutant was infrequently detected (300 measured detections out of 1,281 valid samples); of the 85 possible quarterly averages of this pollutant, 22 of them are zero. Thus, few quarterly averages appear in Figure 4-28. Further, most of the remaining quarterly averages have relatively few measurements and include many zero substitutions for non-detects, resulting in relatively low quarterly averages. (Although this pollutant was detected in only 23 percent of VOC samples collected, its risk screening value is relatively low; thus, all 300 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 4-30 are primarily due to sampling duration. PANJ stopped sampling VOCs in May 2011; thus, the third and fourth quarterly averages are blank. Because the criteria in Section 3.1 require a site to have 75 percent of the possible samples within a quarter (12 for a site sampling on a 1-in-6 day schedule), PAJN could not get a quarterly average for the second quarter because it did not sample long enough within that quarter. Therefore, the only quarterly average that could be calculated for PANJ was for the first quarter.

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 trend for these pollutants. For example, formaldehyde averages tended to be highest in the third quarter, as shown in Figure 4-41, with 18 of the 30 sites sampling formaldehyde (and have quarterly averages) exhibiting the highest quarterly average during July through September. Thus, it appears that formaldehyde concentrations tend to be highest during the summer months. Conversely, benzene averages tended to be higher during the first quarter followed by the fourth quarter, or the colder months, as shown in Figure 4-30. The seasonal behavior of benzene and formaldehyde suggests the influence of reformulated gasoline (RFG) because the benzene content is typically lowered during warmer periods (i.e., summer and spring). Refineries typically begin production of RFG during the spring and end in the autumn. Additionally, methyl *tert*-butyl ether (MTBE) is often used as an RFG additive in fuels to replace the lowered benzene content. Research has shown that the combustion of fuels containing MTBE leads to the secondary production of formaldehyde. Thus, while benzene concentrations decrease during the summer months, formaldehyde concentrations may increase if MTBE is used in the gasoline blend.

Other notable trends include benzo(a)pyrene and 1,3-butaidene with higher concentrations in the first and fourth quarters; acenaphthene and fluorene with higher concentrations in the third quarter; and 1,2-dichloroethane with higher concentrations in the second and fourth quarters. Arsenic tended to be highest during the fourth quarter for eight of the nine sites sampling PM_{10} metals year-round and four of the five sites sampling TSP metals (a fourth quarter average could not be calculated for MWOK because it did not meet the completeness criteria).

Other notable trends may also be revealed in these graphs. Figure 4-38 for 1,2-dichlorethane shows that most of the measured detections of this pollutant were measured during the second and fourth quarter averages of 2011, as indicated by the red (second quarter) and purple (fourth quarter) bars. Over 50 percent of the measured detections were measured during the fourth quarter and another 28 percent were measured during the second quarter. Figure 4-50 for vinyl chloride shows that this pollutant was infrequently detected, as many sites have fewer than four quarterly averages shown, even though they sampled year-round and met the completeness criteria. Note that BTUT, RUVT, and SPAZ did not detect this pollutant at all.

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 4-28, 4-30, 4-32a, 4-33, 4-36, and 4-49 for acrylonitrile, benzene, beryllium, 1,3-butadiene, chloroform, and trichloroethylene, respectively, to name a few. For example, Figure 4-36 shows that the quarterly averages of chloroform for NBIL are significantly higher than for other sites sampling VOCs, as most of the other bars are barely visible on the graph. Figure 4-49 shows that the quarterly averages of trichloroethylene for SPIL are significantly higher than for other sites sampling VOCs. Figure 4-32a and 4-32b show that PXSS's third quarter average concentration of beryllium is significantly higher than this site's other the quarterly averages as well as all other sites sampling speciated metals (both PM_{10} and TSP). Conversely, these graphs may also reveal when there is very little variability in the quarterly averages across other sites. Figure 4-35 for carbon tetrachloride shows that the quarterly averages of this pollutant did not vary significantly across the sites. Other pollutants may not exhibit such trends.

These graphs also show that only 10 of the 25 program-level pollutants of interest have ATSDR Intermediate MRLs. For the 10 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 10 cases, the scale on the graph is well below the ATSDR Intermediate MRL.

Figure 4-26. Comparison of Average Quarterly Acenaphthene Concentrations

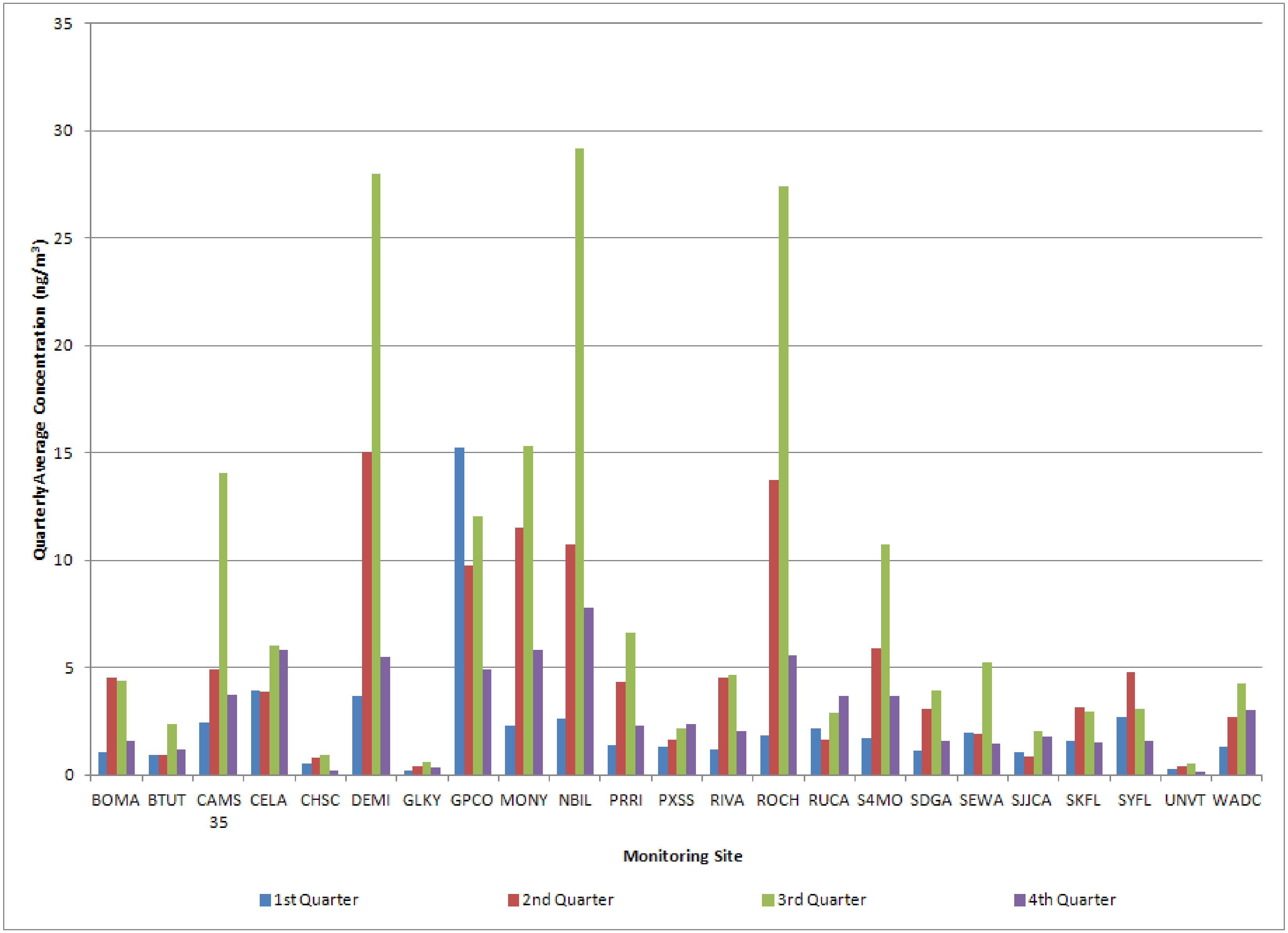


Figure 4-27. Comparison of Average Quarterly Acetaldehyde Concentrations

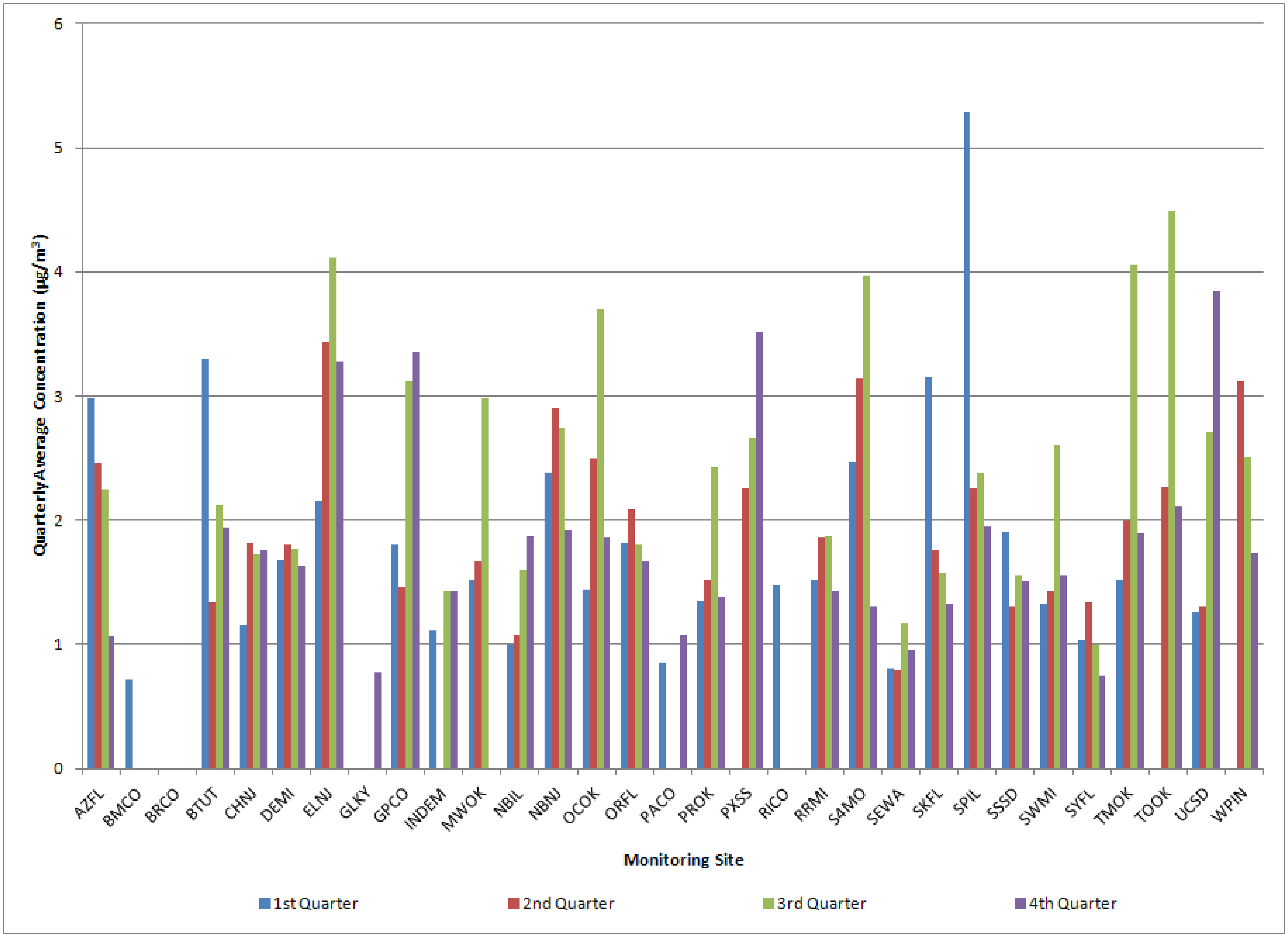


Figure 4-28. Comparison of Average Quarterly Acrylonitrile Concentrations

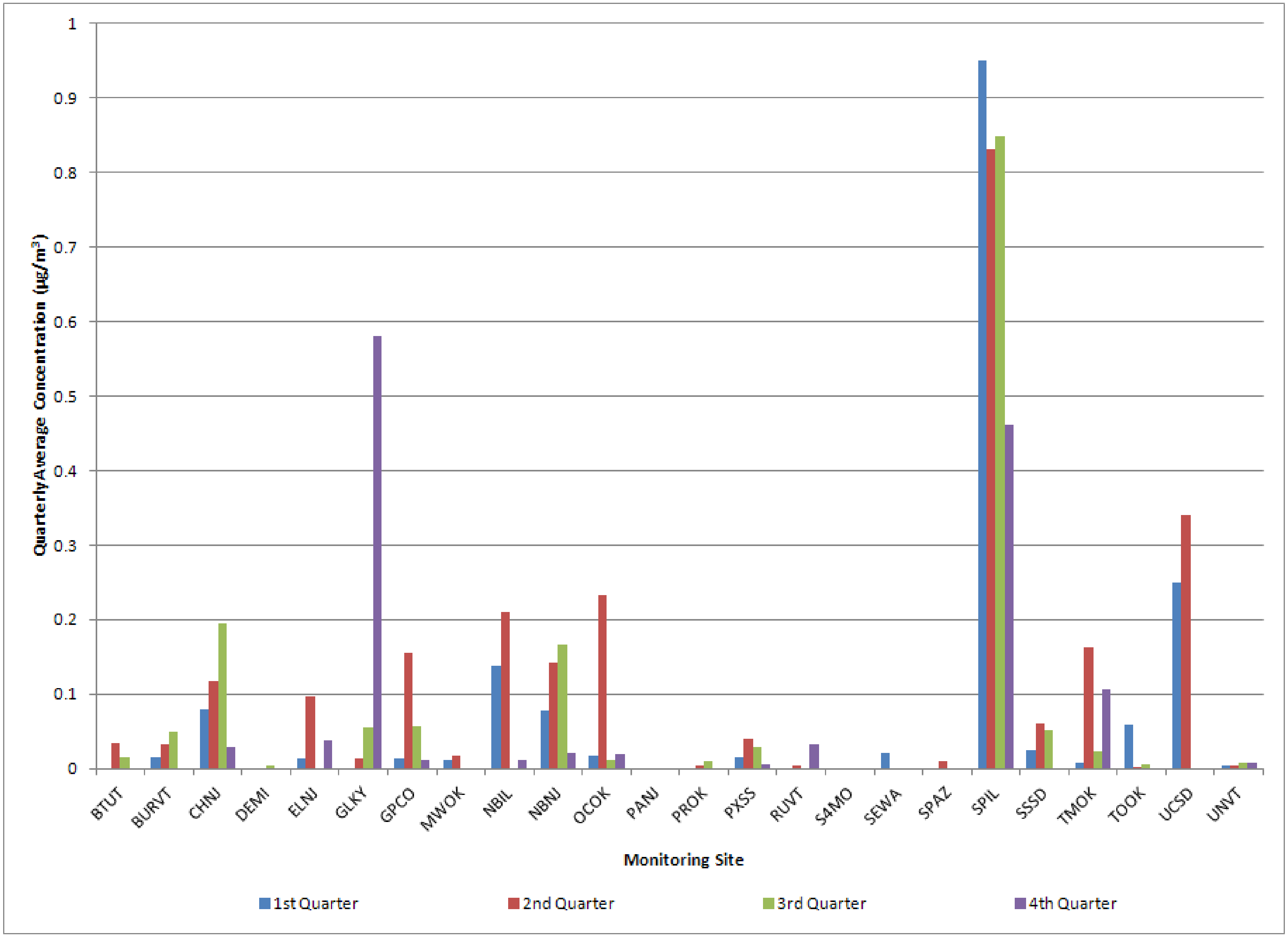


Figure 4-29a. Comparison of Average Quarterly Arsenic (PM_{10}) Concentrations

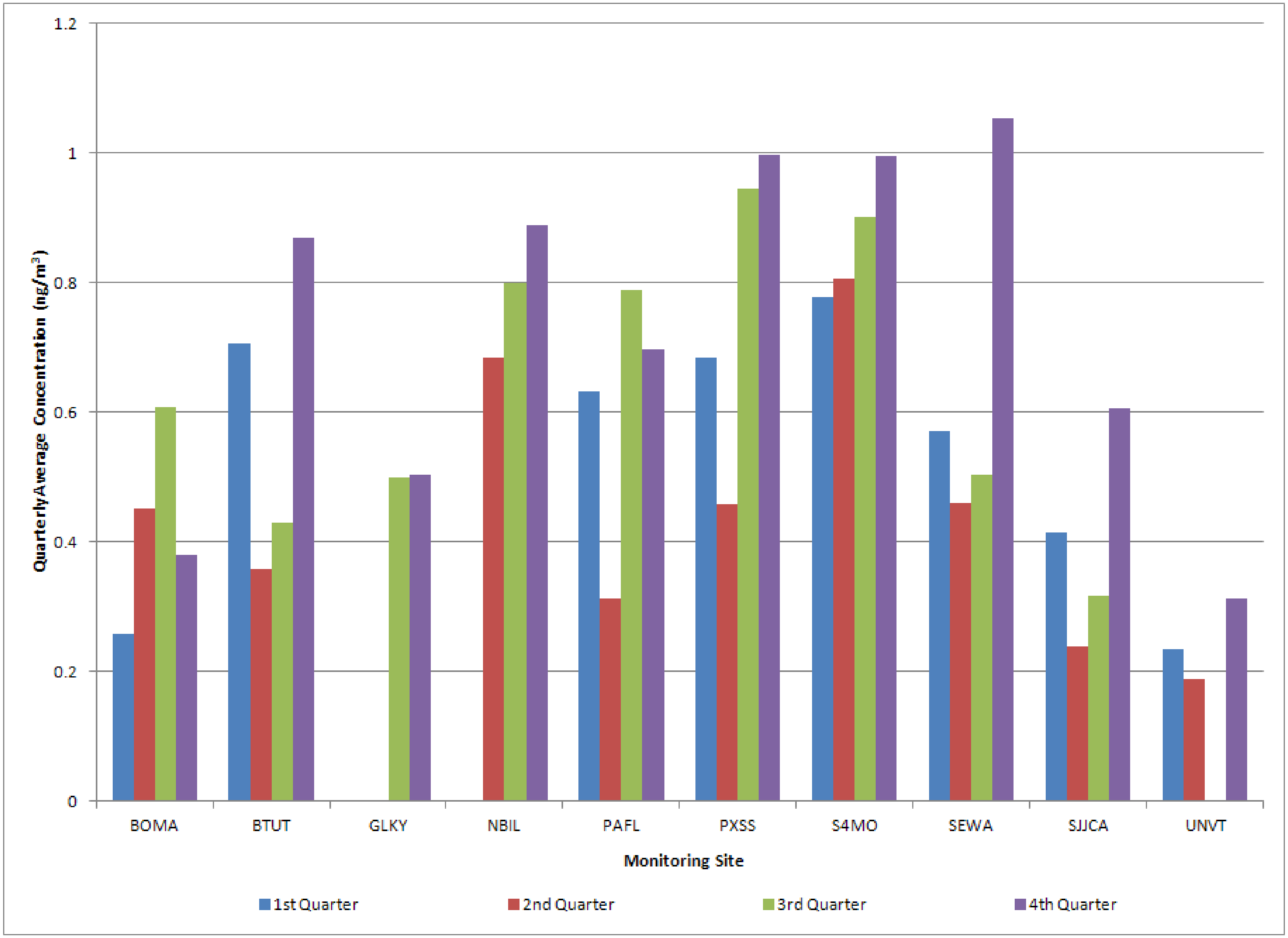


Figure 4-29b. Comparison of Average Quarterly Arsenic (TSP) Concentrations

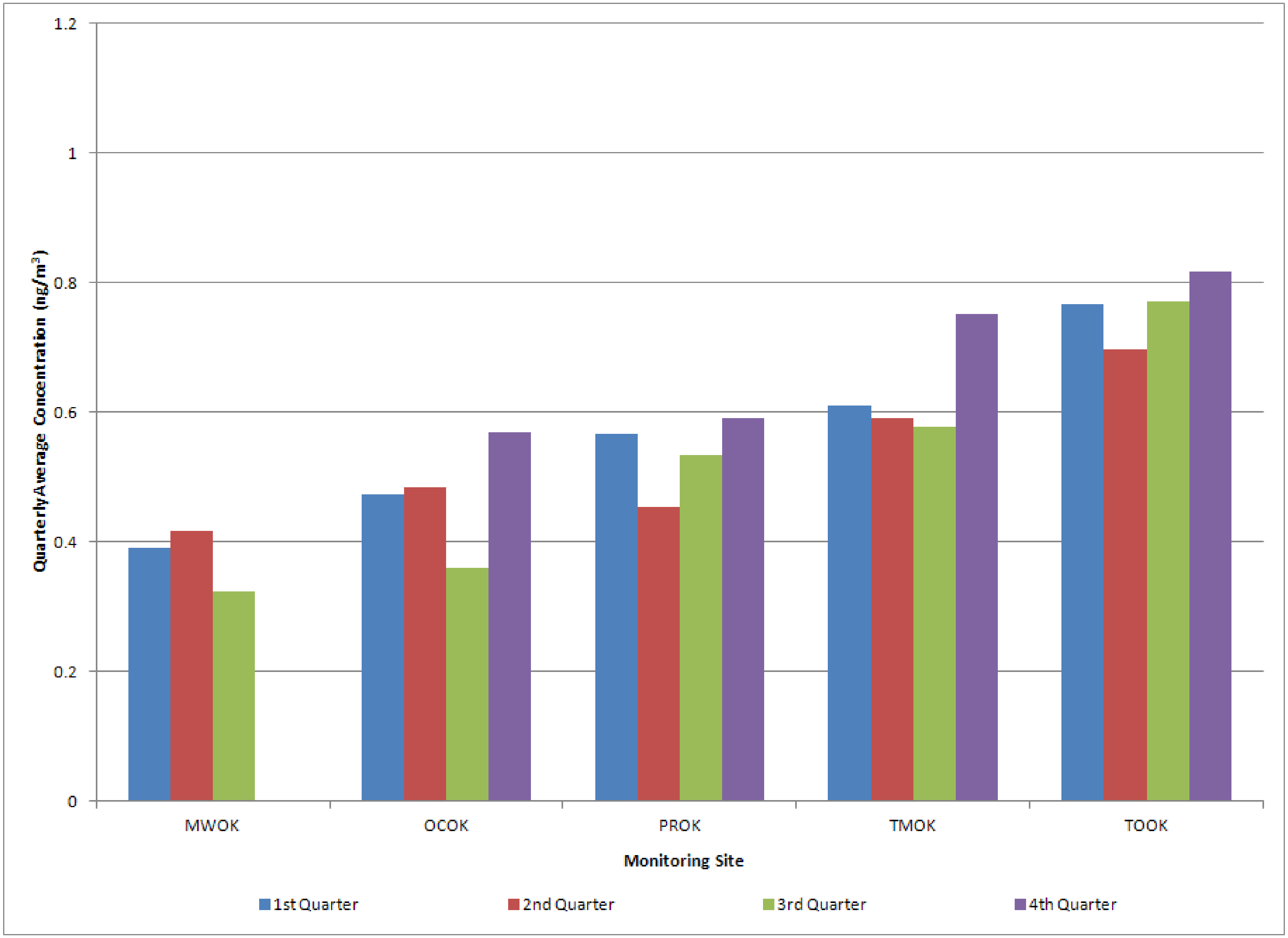


Figure 4-30. Comparison of Average Quarterly Benzene Concentrations

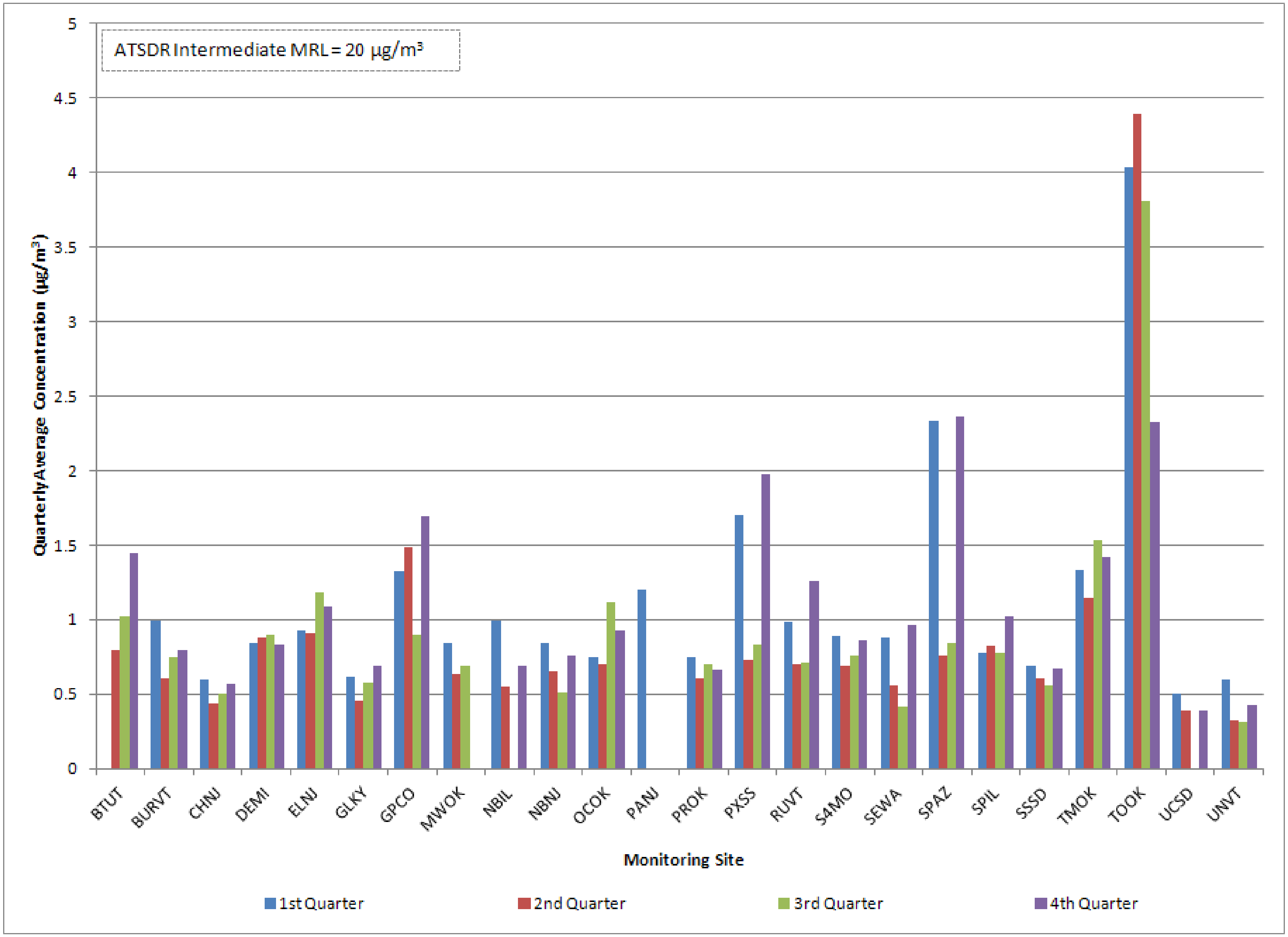


Figure 4-31. Comparison of Average Quarterly Benzo(a)pyrene Concentrations

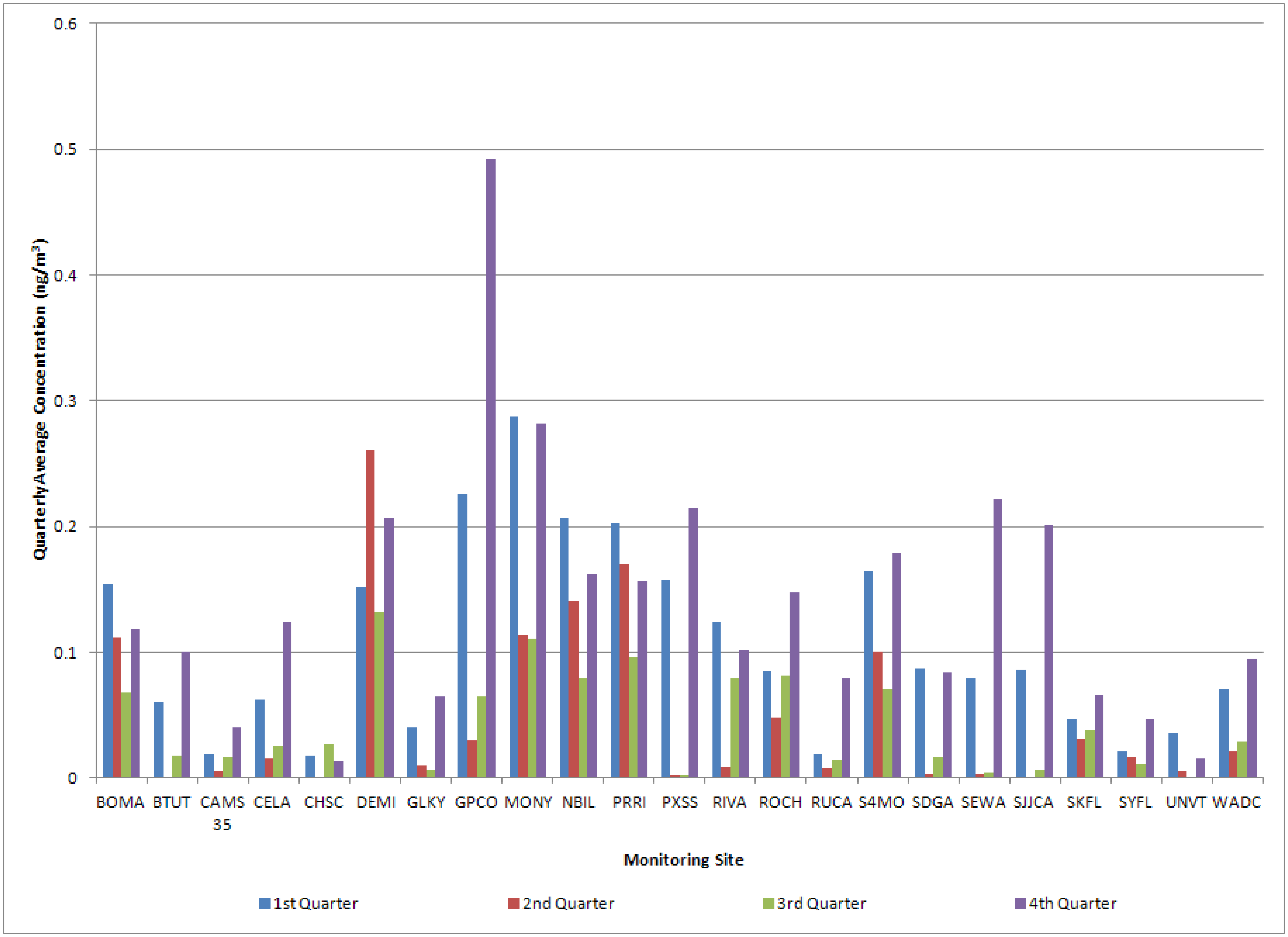


Figure 4-32a. Comparison of Average Quarterly Beryllium (PM_{10}) Concentrations

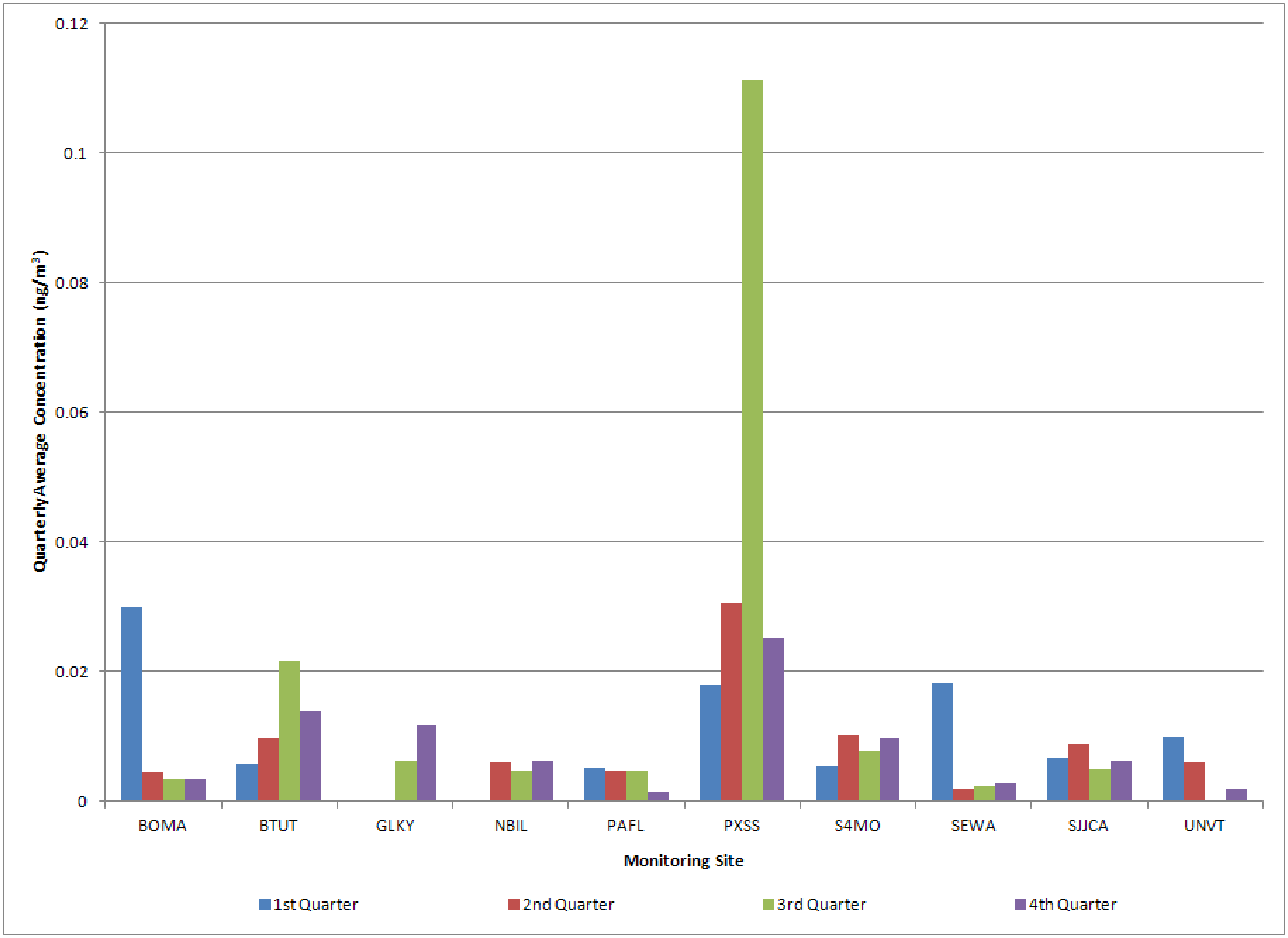


Figure 4-32b. Comparison of Average Quarterly Beryllium (TSP) Concentrations

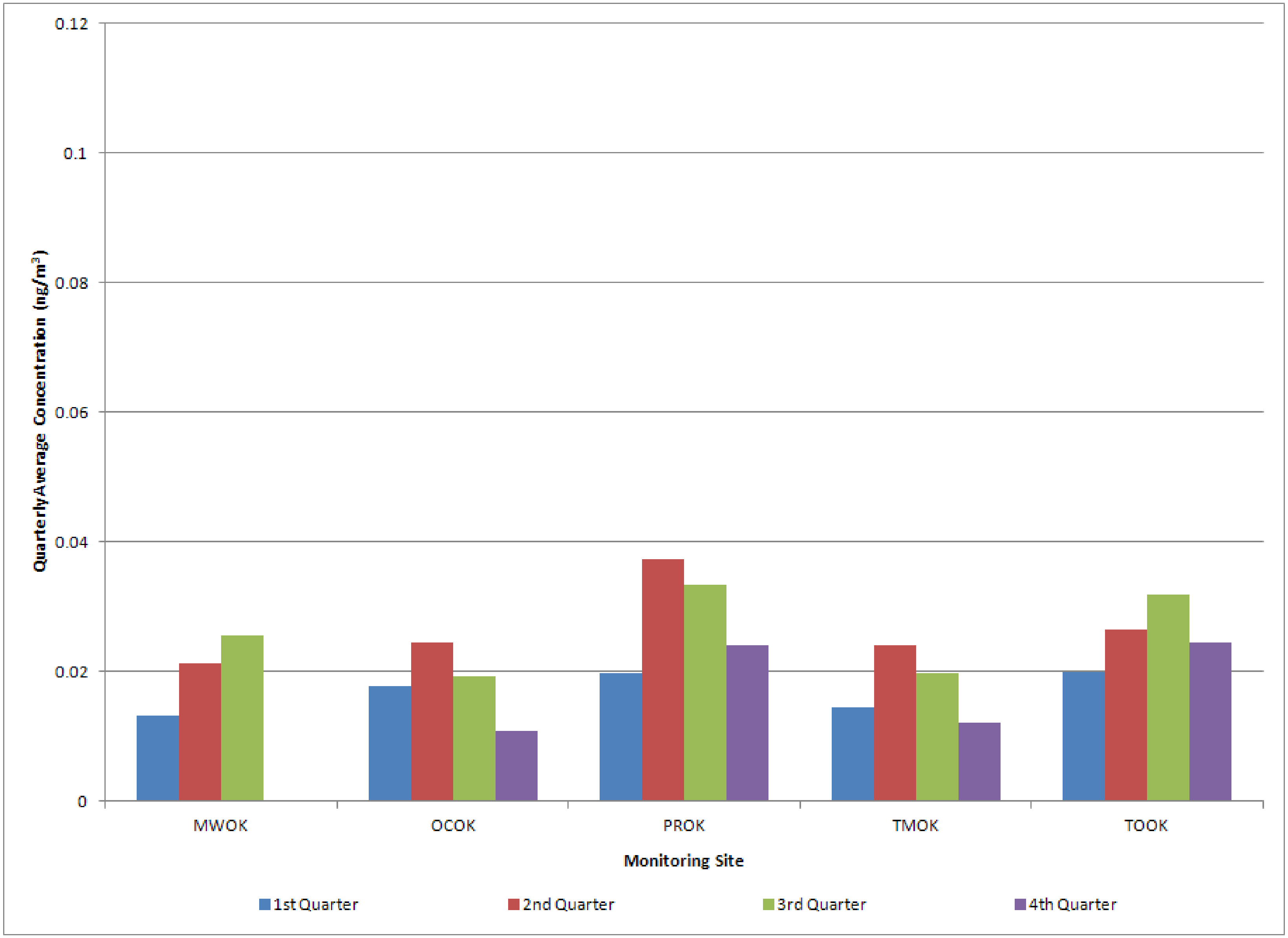


Figure 4-33. Comparison of Average Quarterly 1,3-Butadiene Concentrations

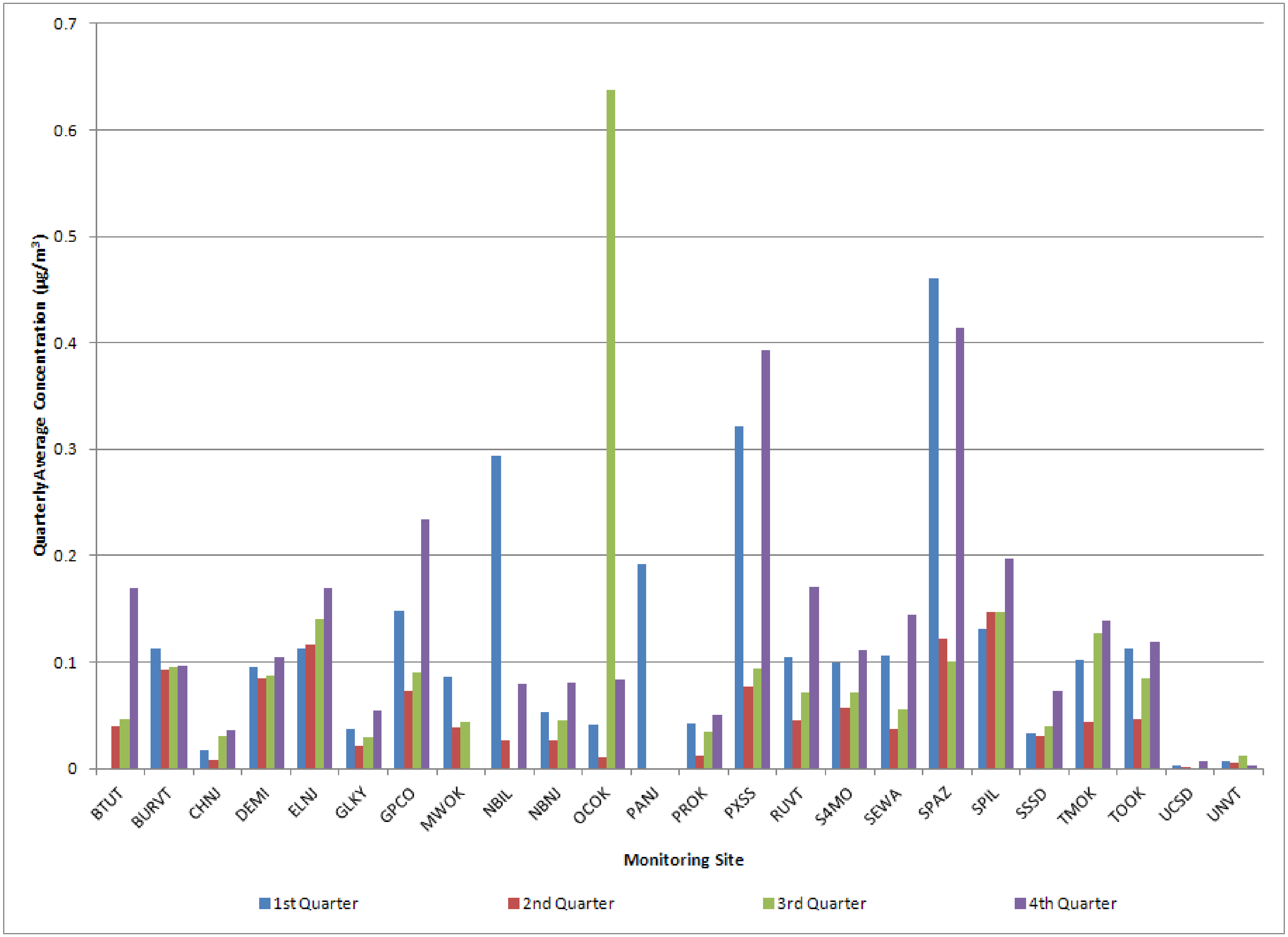


Figure 4-34a. Comparison of Average Quarterly Cadmium (PM_{10}) Concentrations

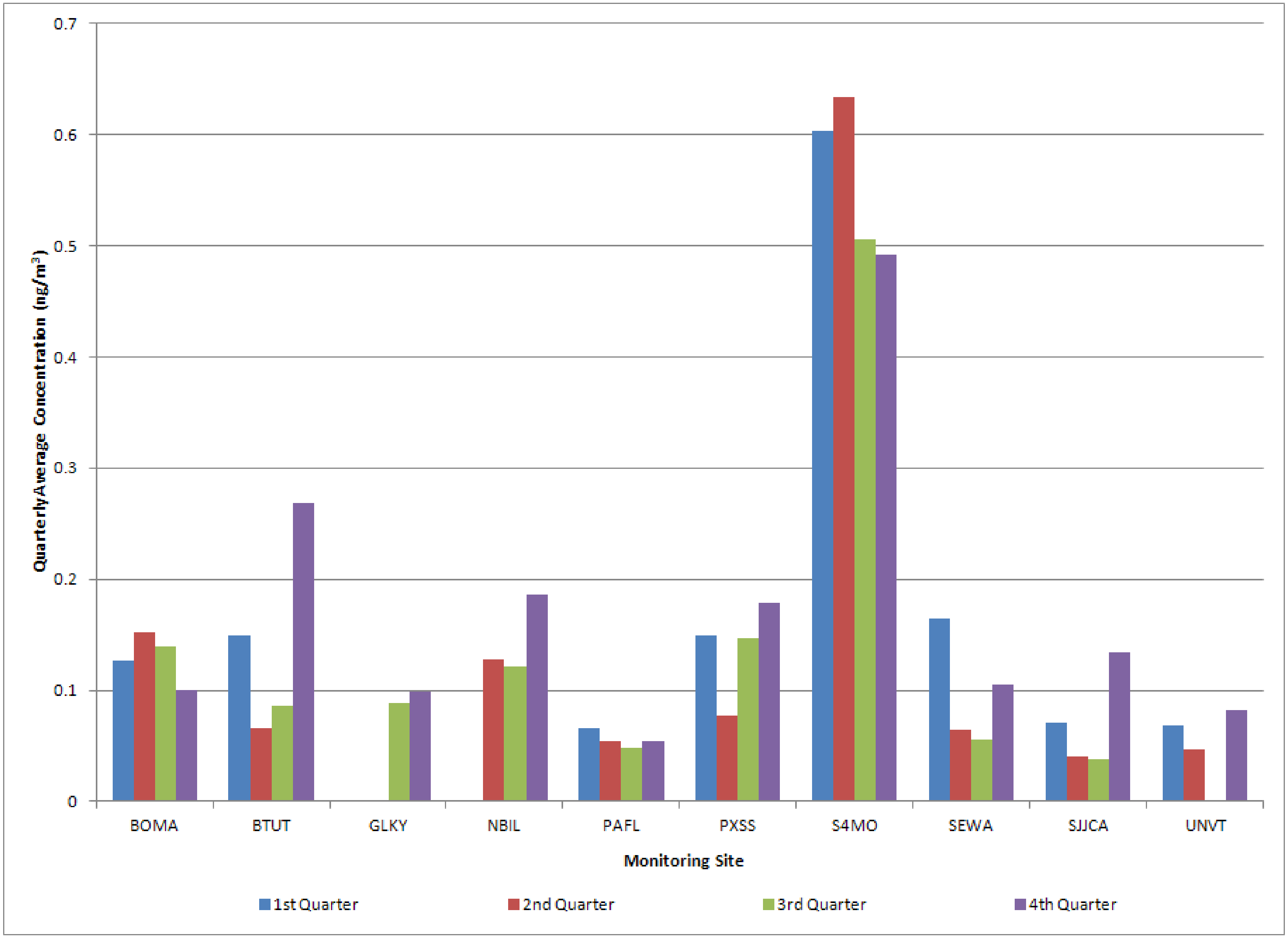


Figure 4-34b. Comparison of Average Quarterly Cadmium (TSP) Concentrations

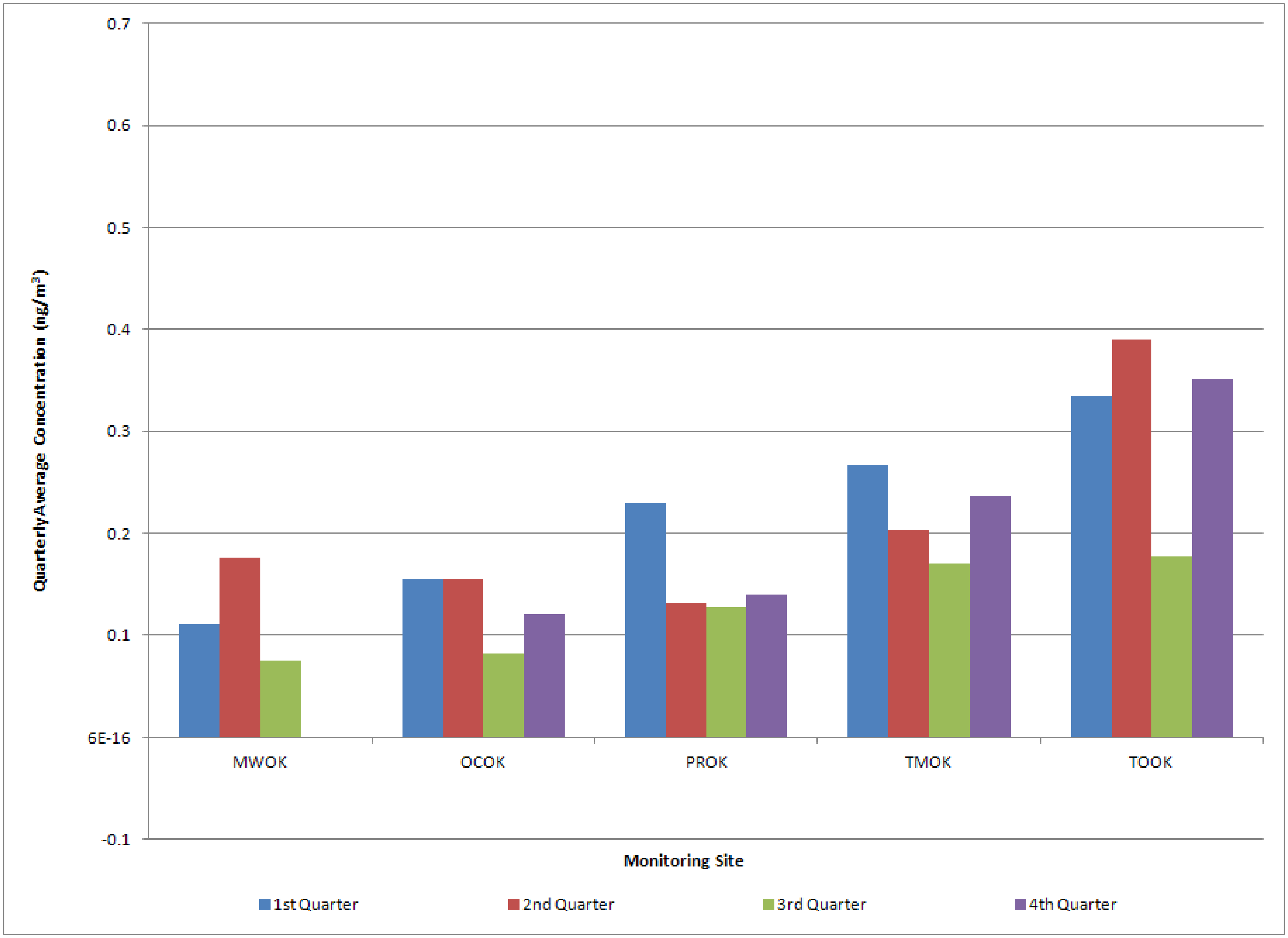
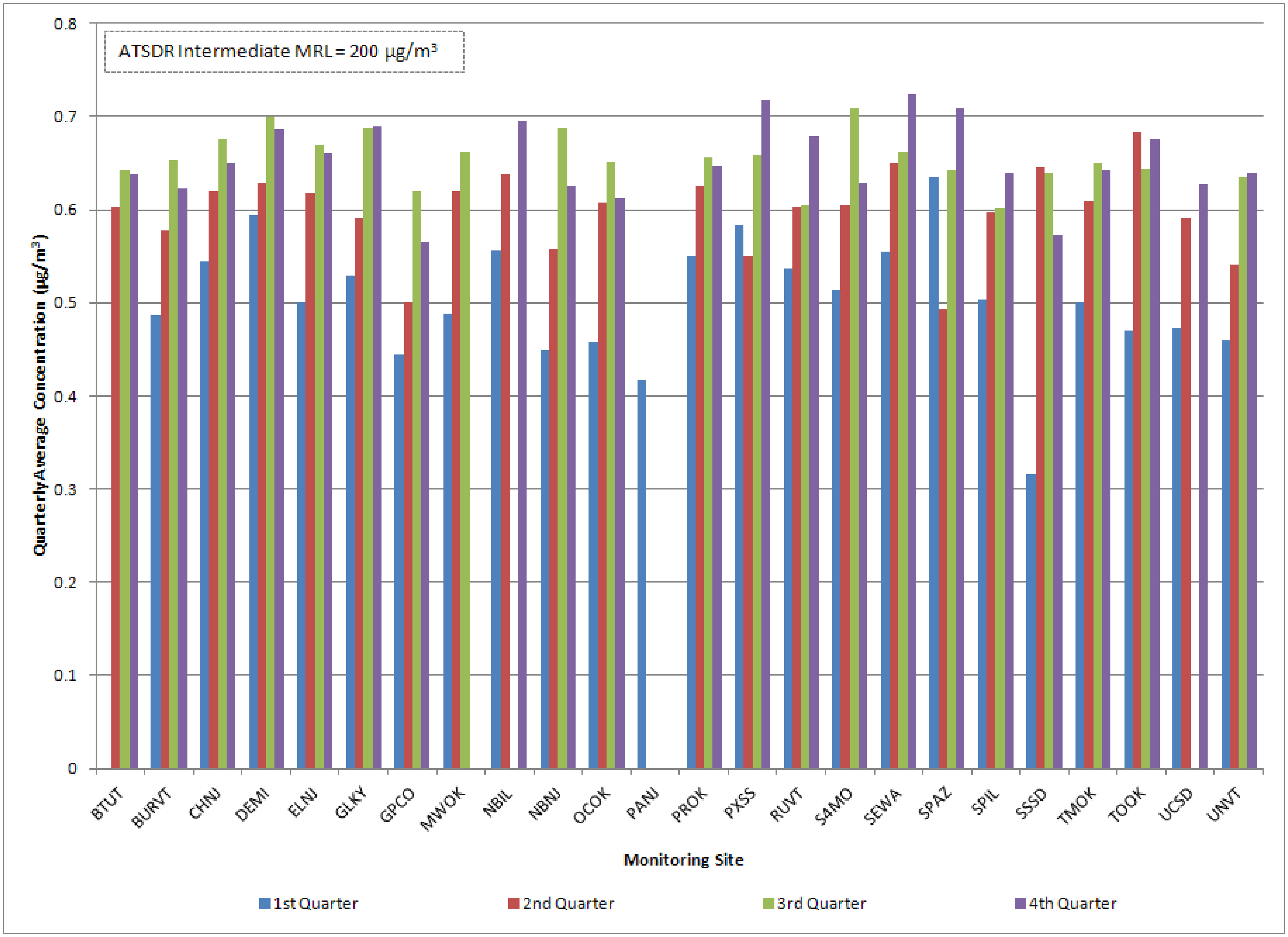


Figure 4-35. Comparison of Average Quarterly Carbon Tetrachloride Concentrations



ATSDR Intermediate MRL = 200 µg/m³

Figure 4-36. Comparison of Average Quarterly Chloroform Concentrations

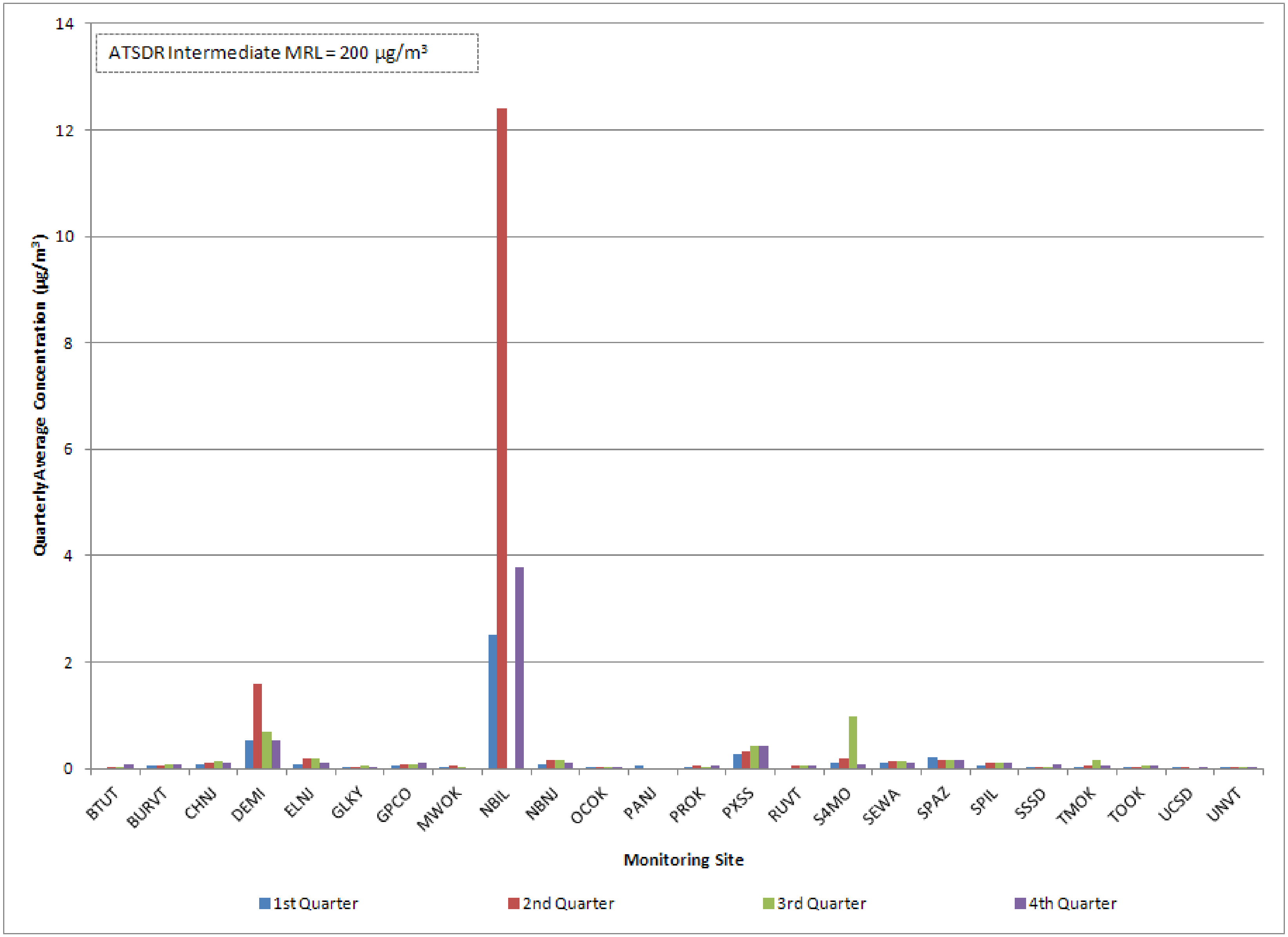


Figure 4-37. Comparison of Average Quarterly *p*-Dichlorobenzene Concentrations

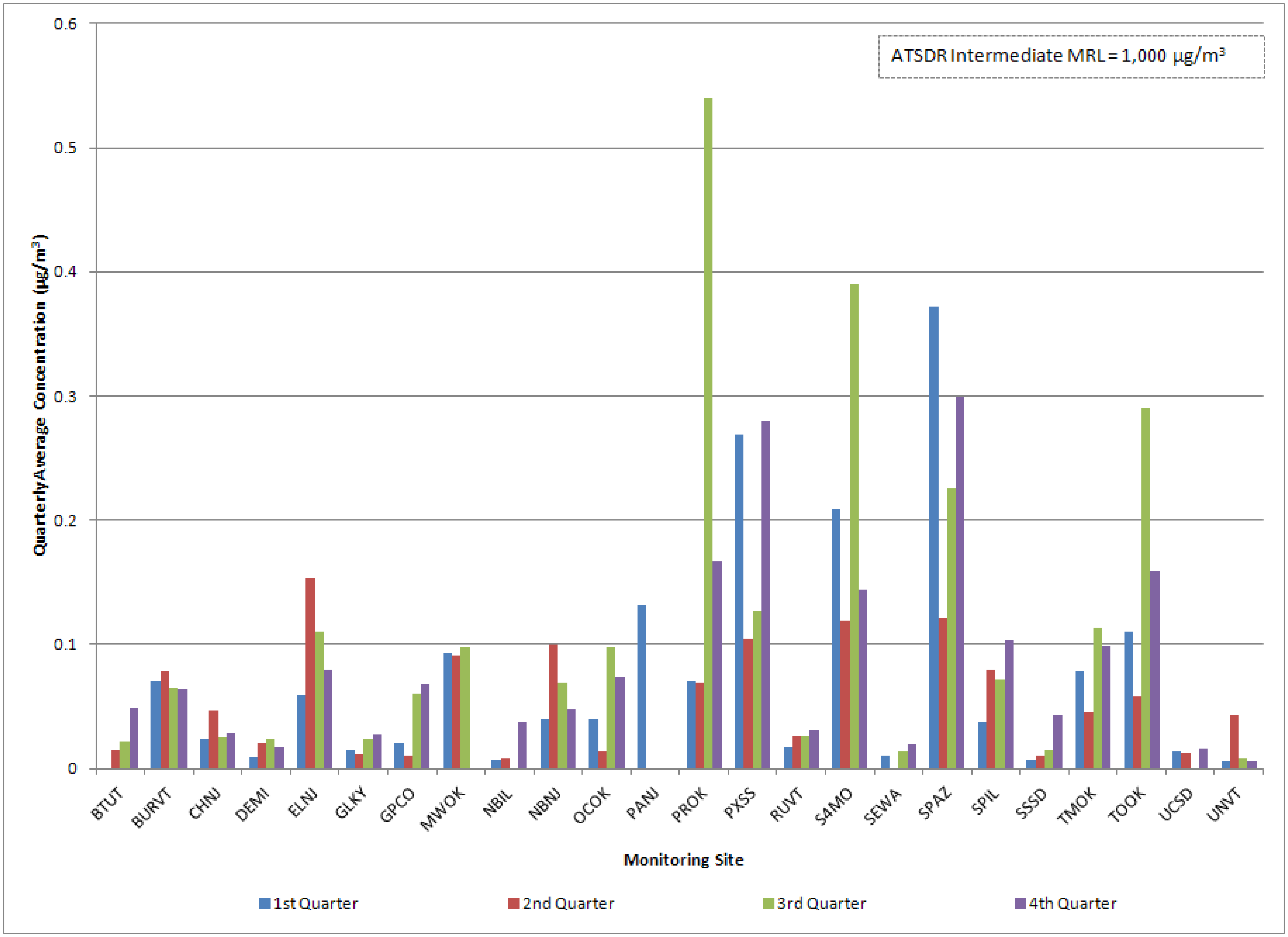


Figure 4-38. Comparison of Average Quarterly 1,2-Dichloroethane Concentrations

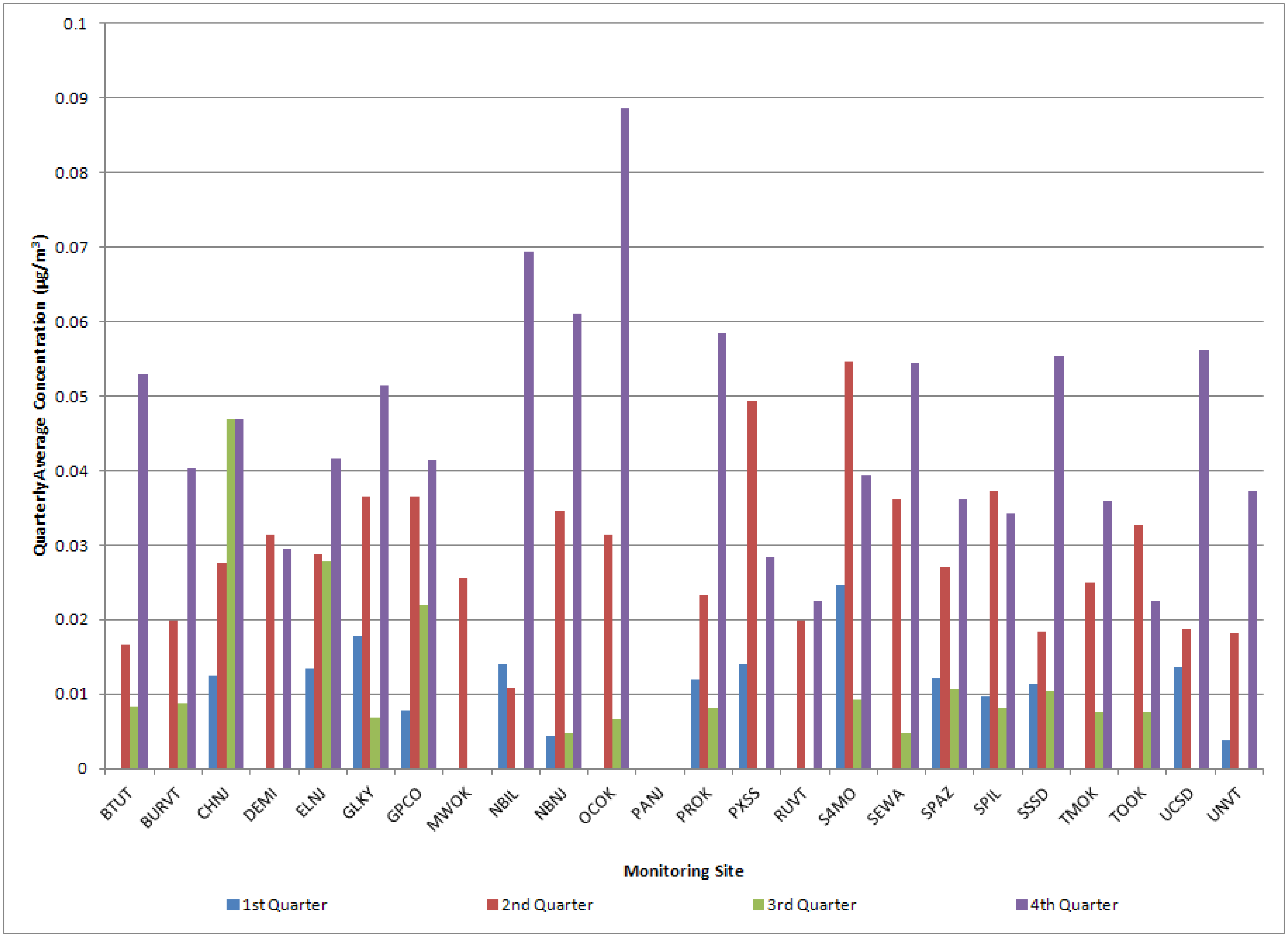


Figure 4-39. Comparison of Average Quarterly Ethylbenzene Concentrations

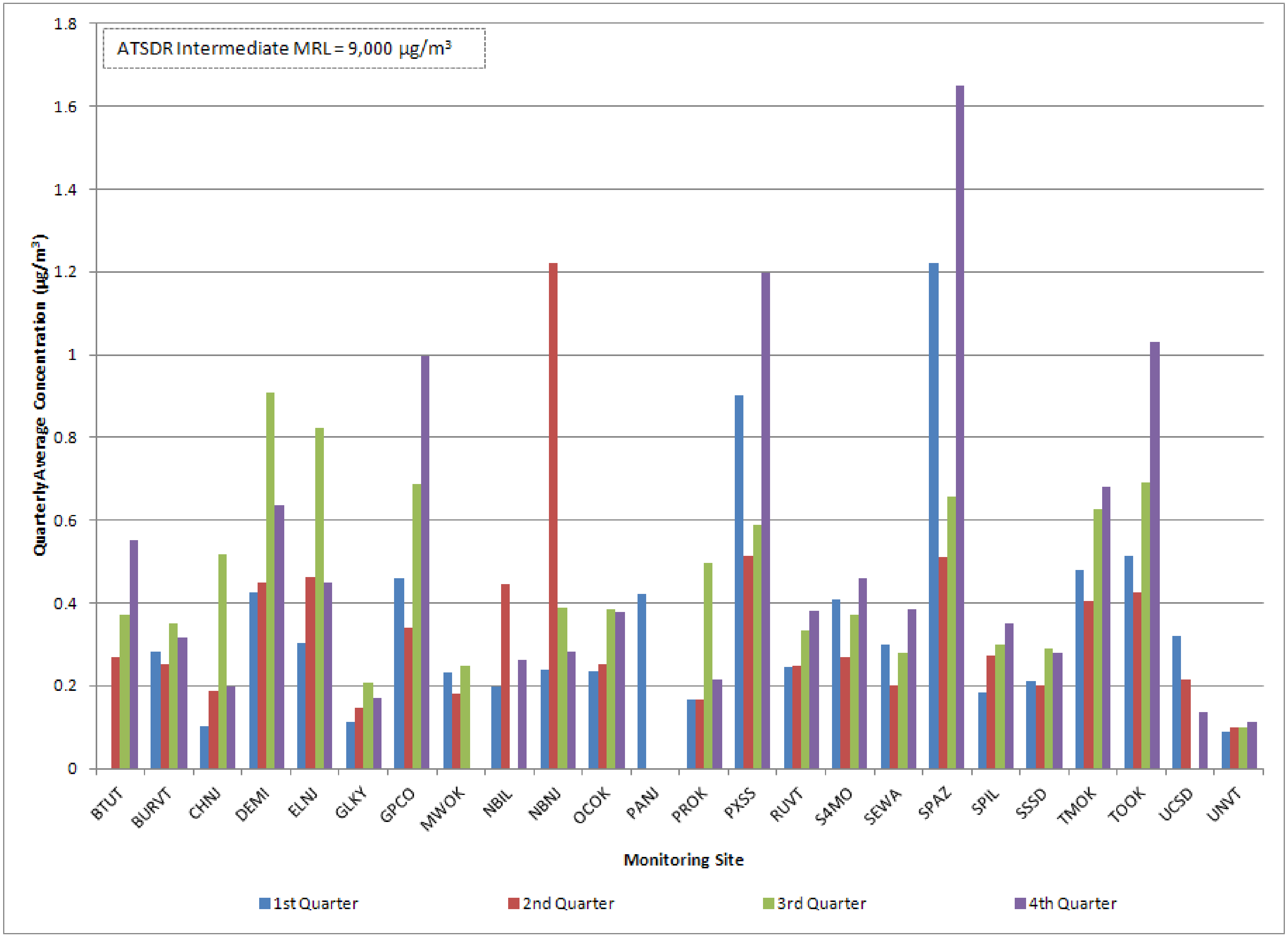


Figure 4-40. Comparison of Average Quarterly Fluorene Concentrations

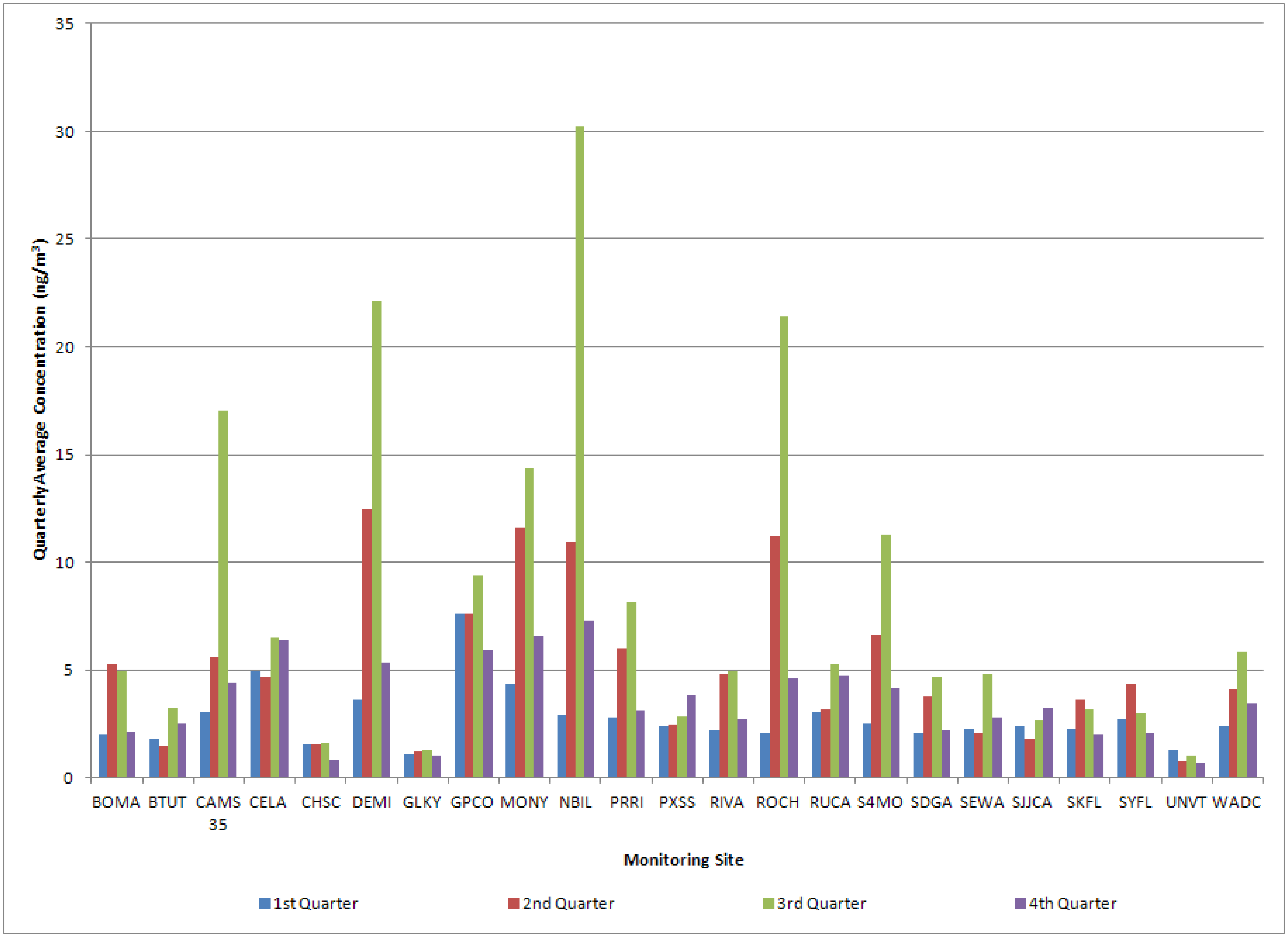


Figure 4-41. Comparison of Average Quarterly Formaldehyde Concentrations

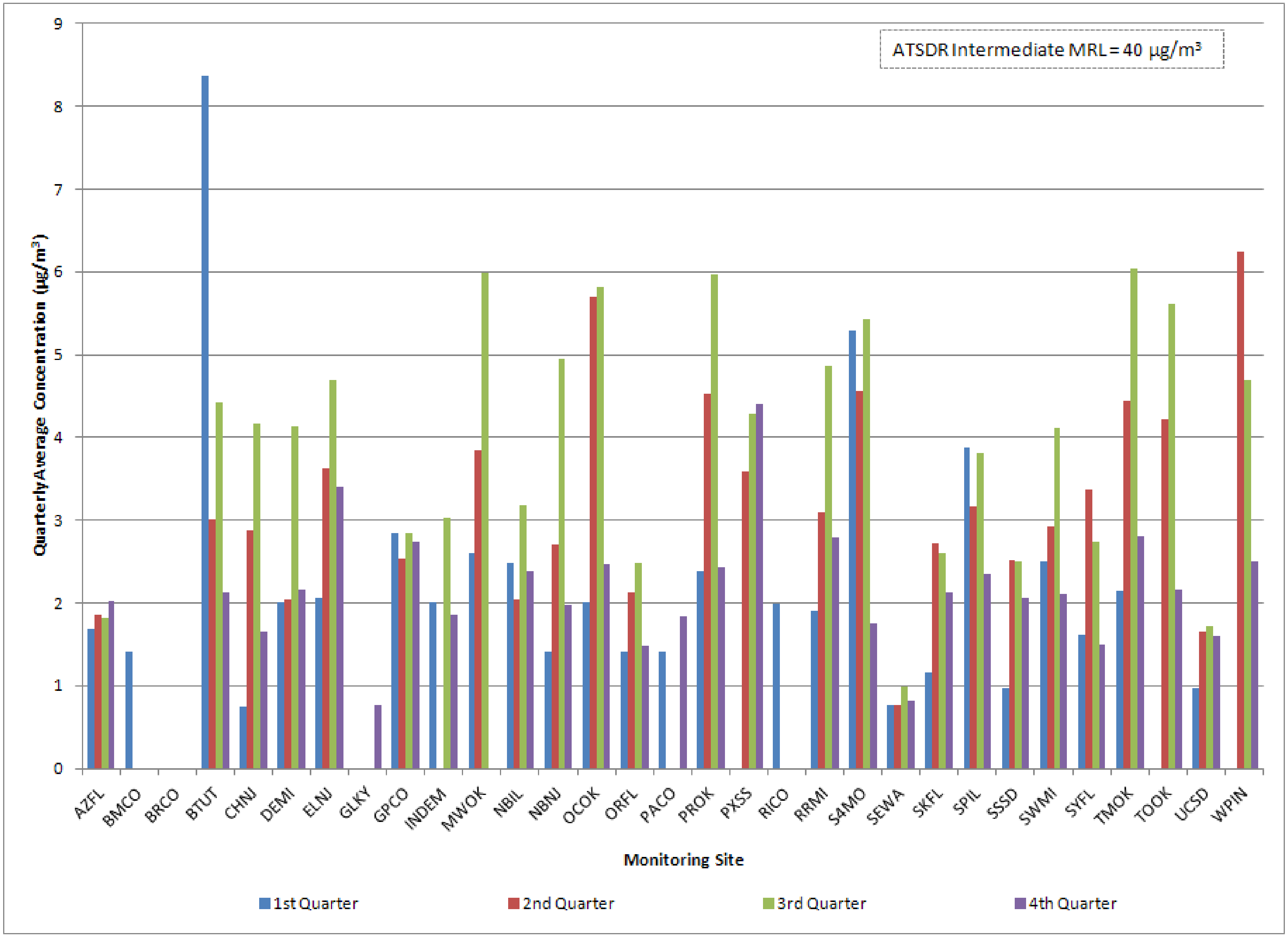


Figure 4-42. Comparison of Average Quarterly Hexachloro-1,3-butadiene Concentrations

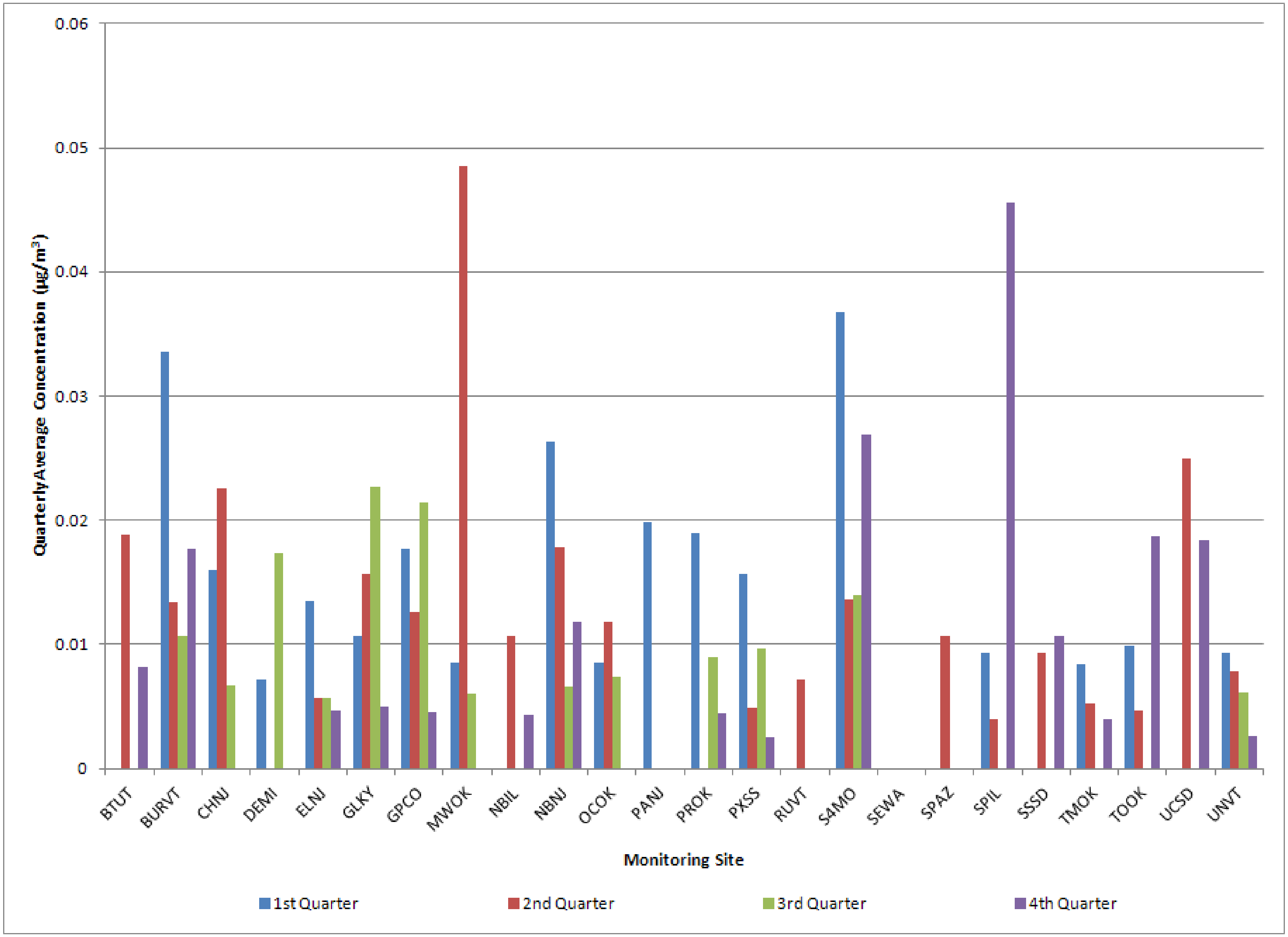


Figure 4-43. Comparison of Average Quarterly Hexavalent Chromium Concentrations

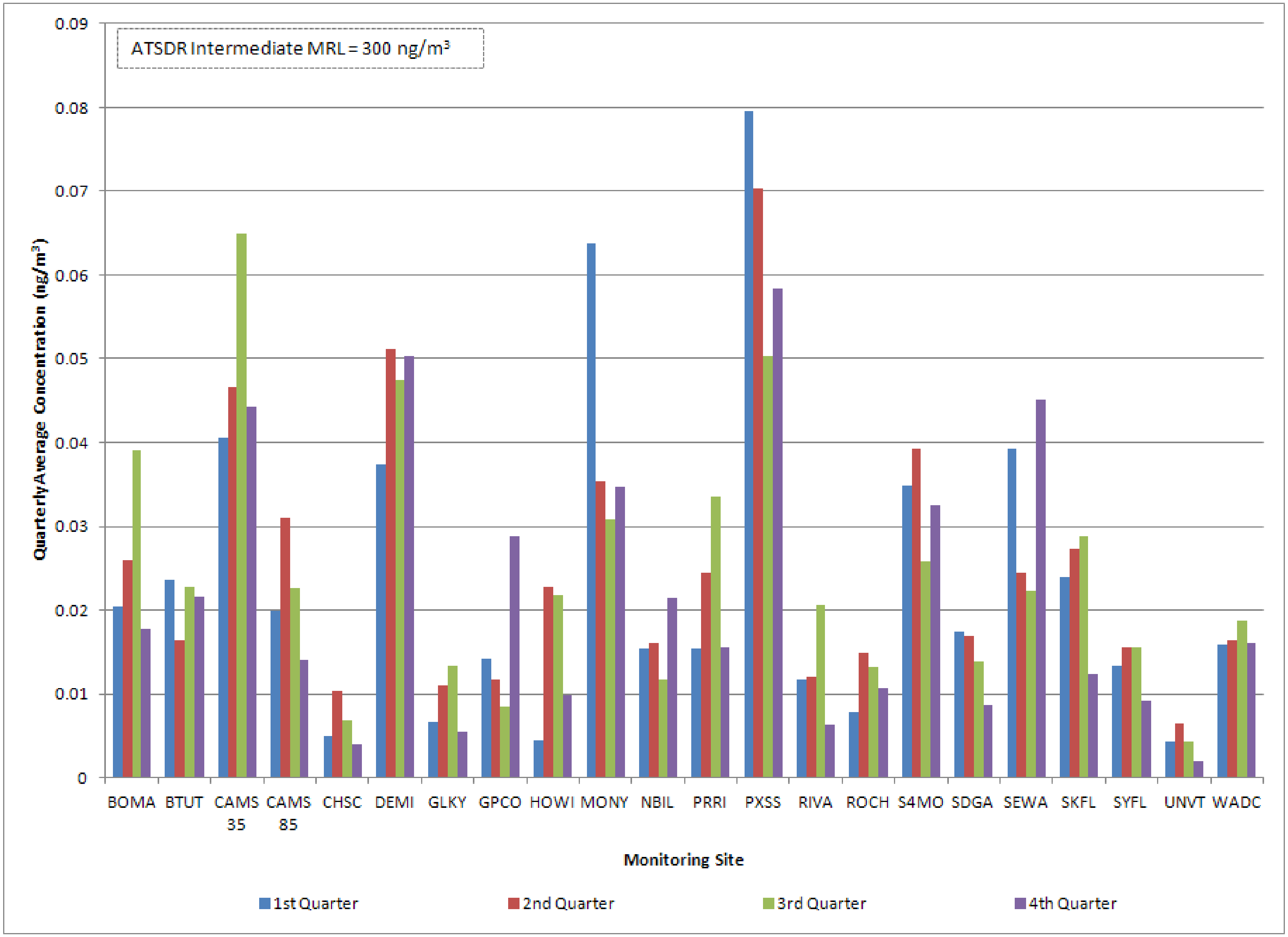


Figure 4-44a. Comparison of Average Quarterly Lead (PM_{10}) Concentrations

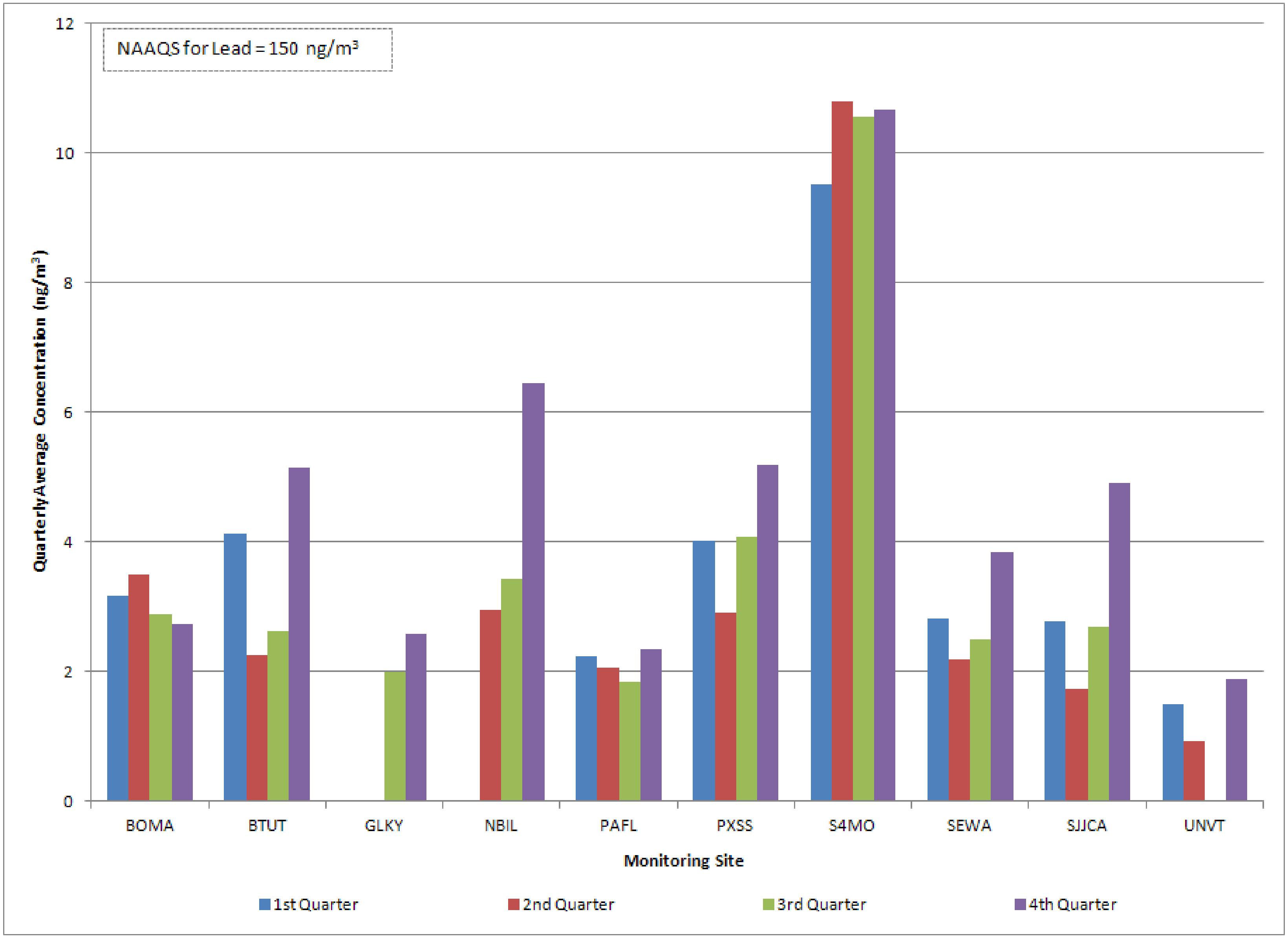


Figure 4-44b. Comparison of Average Quarterly Lead (TSP) Concentrations

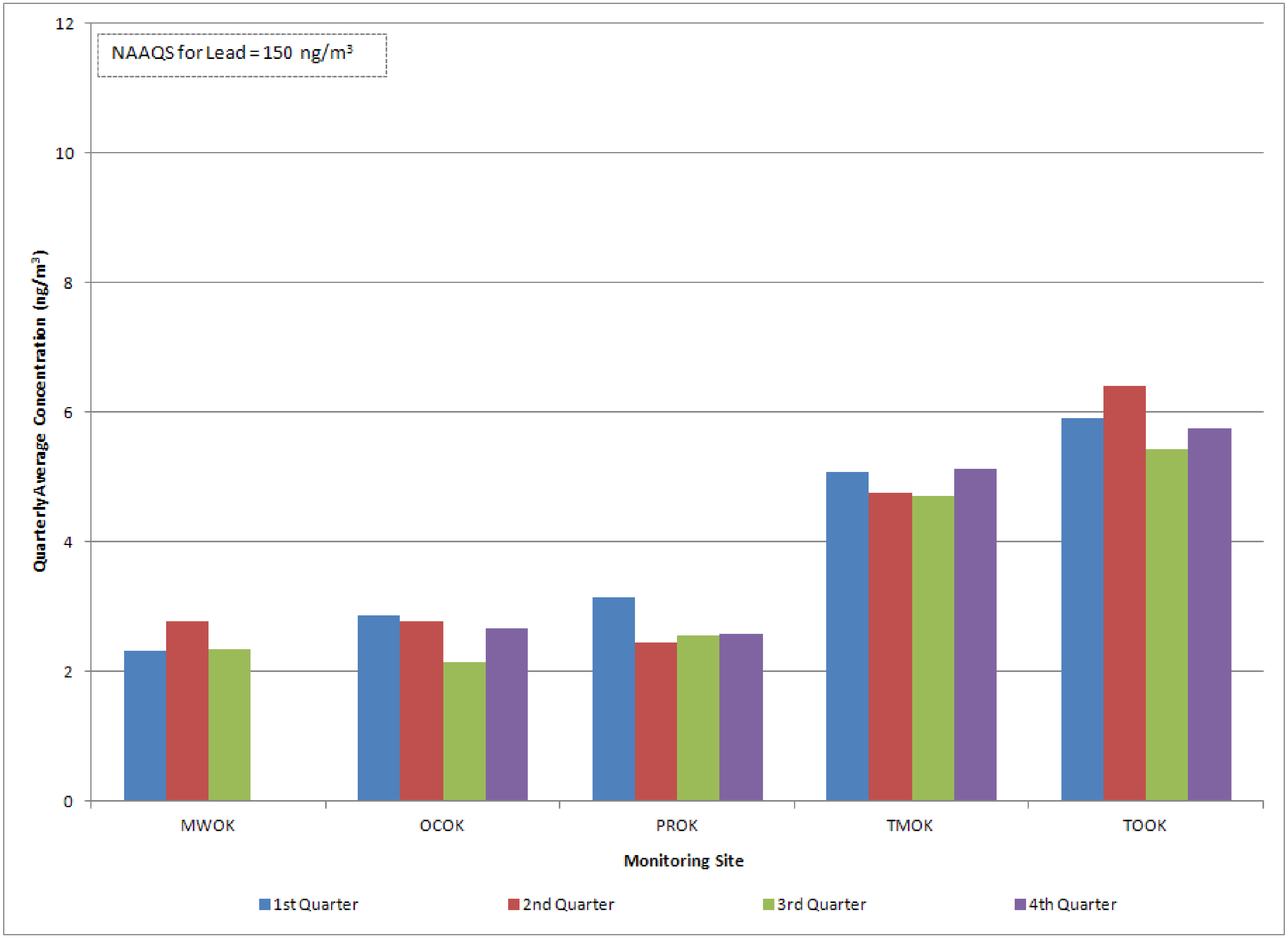


Figure 4-45a. Comparison of Average Quarterly Manganese (PM_{10}) Concentrations

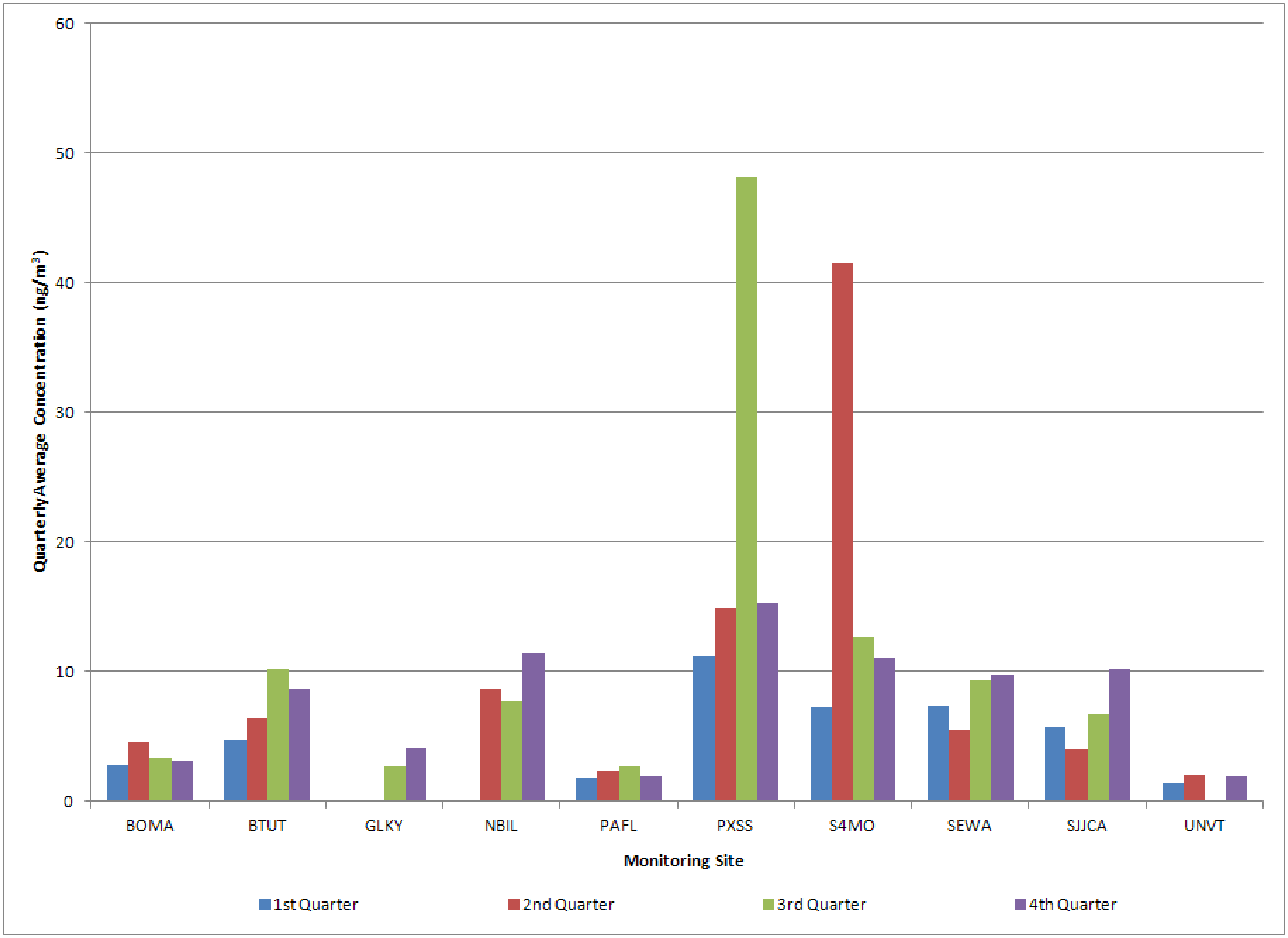


Figure 4-45b. Comparison of Average Quarterly Manganese (TSP) Concentrations

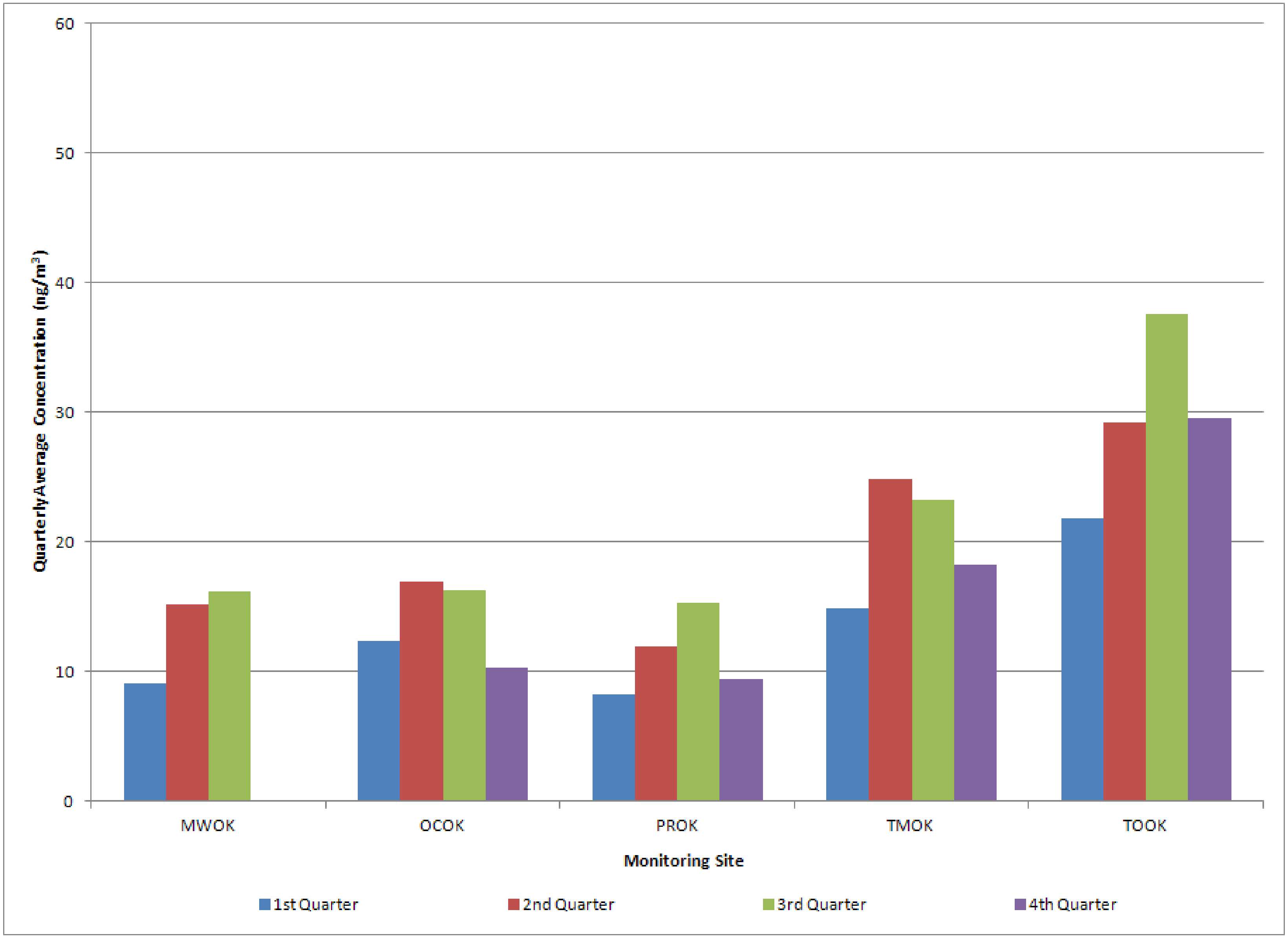


Figure 4-46. Comparison of Average Quarterly Naphthalene Concentrations

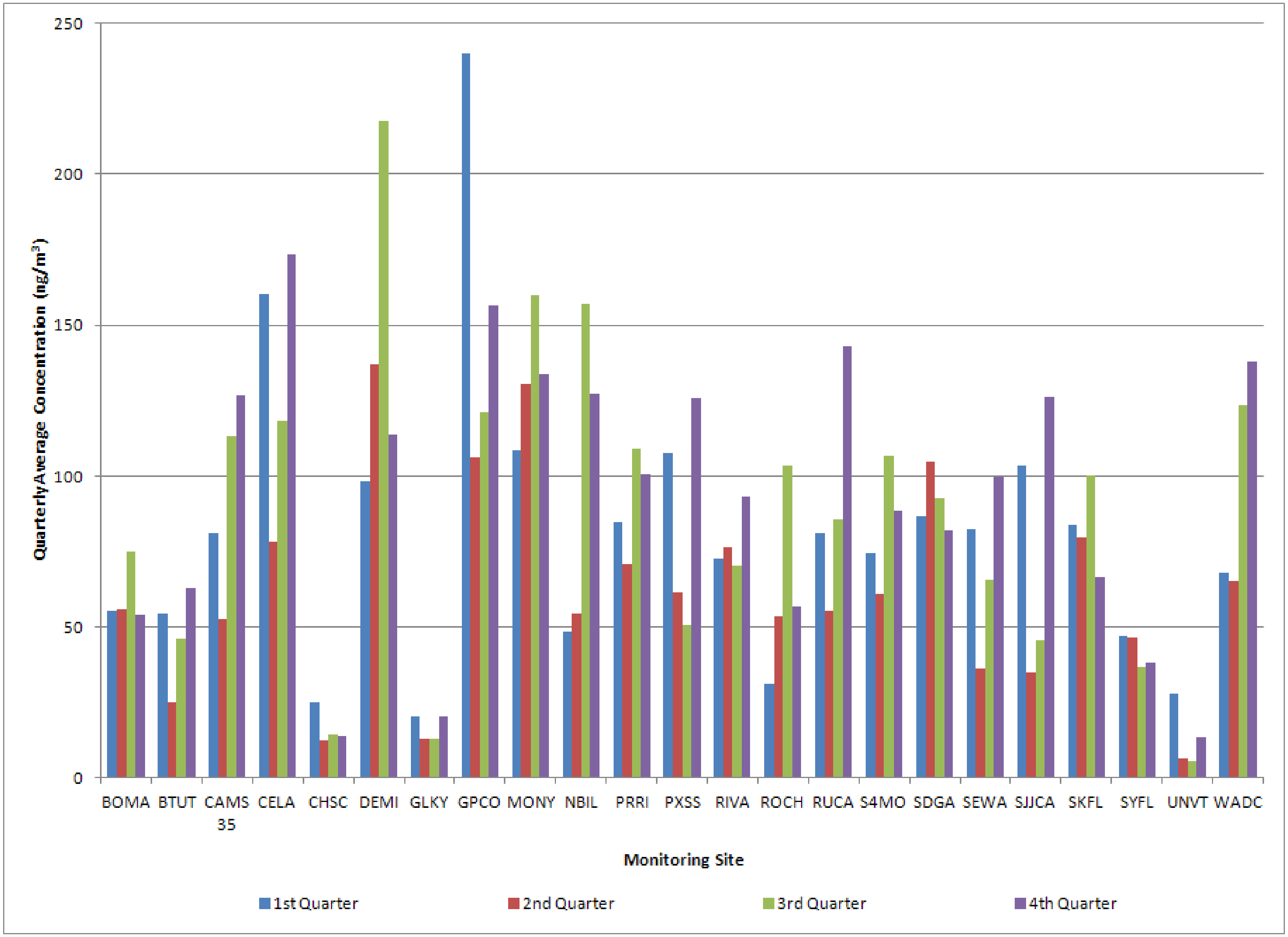


Figure 4-47a. Comparison of Average Quarterly Nickel (PM_{10}) Concentrations

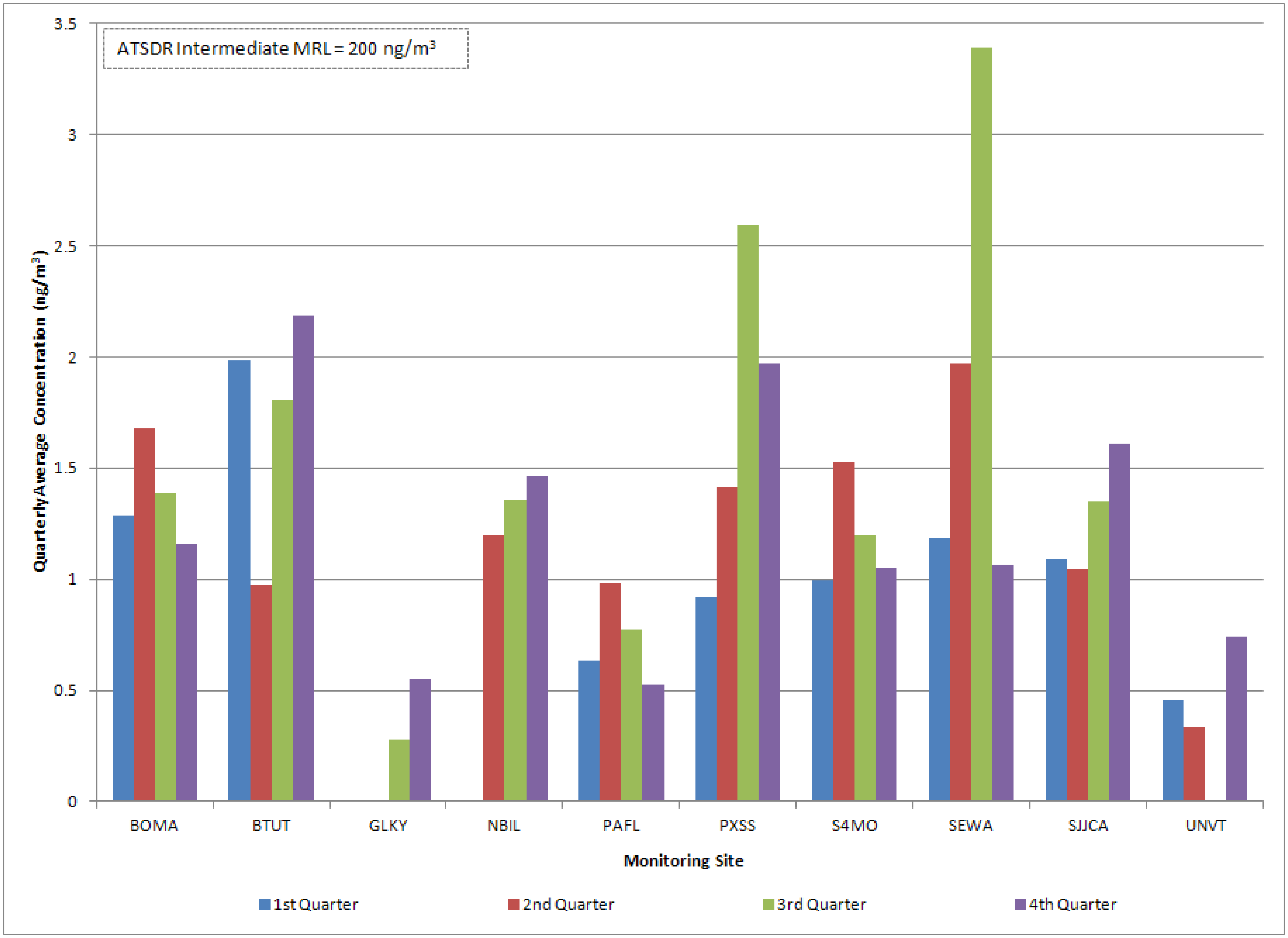


Figure 4-47b. Comparison of Average Quarterly Nickel (TSP) Concentrations

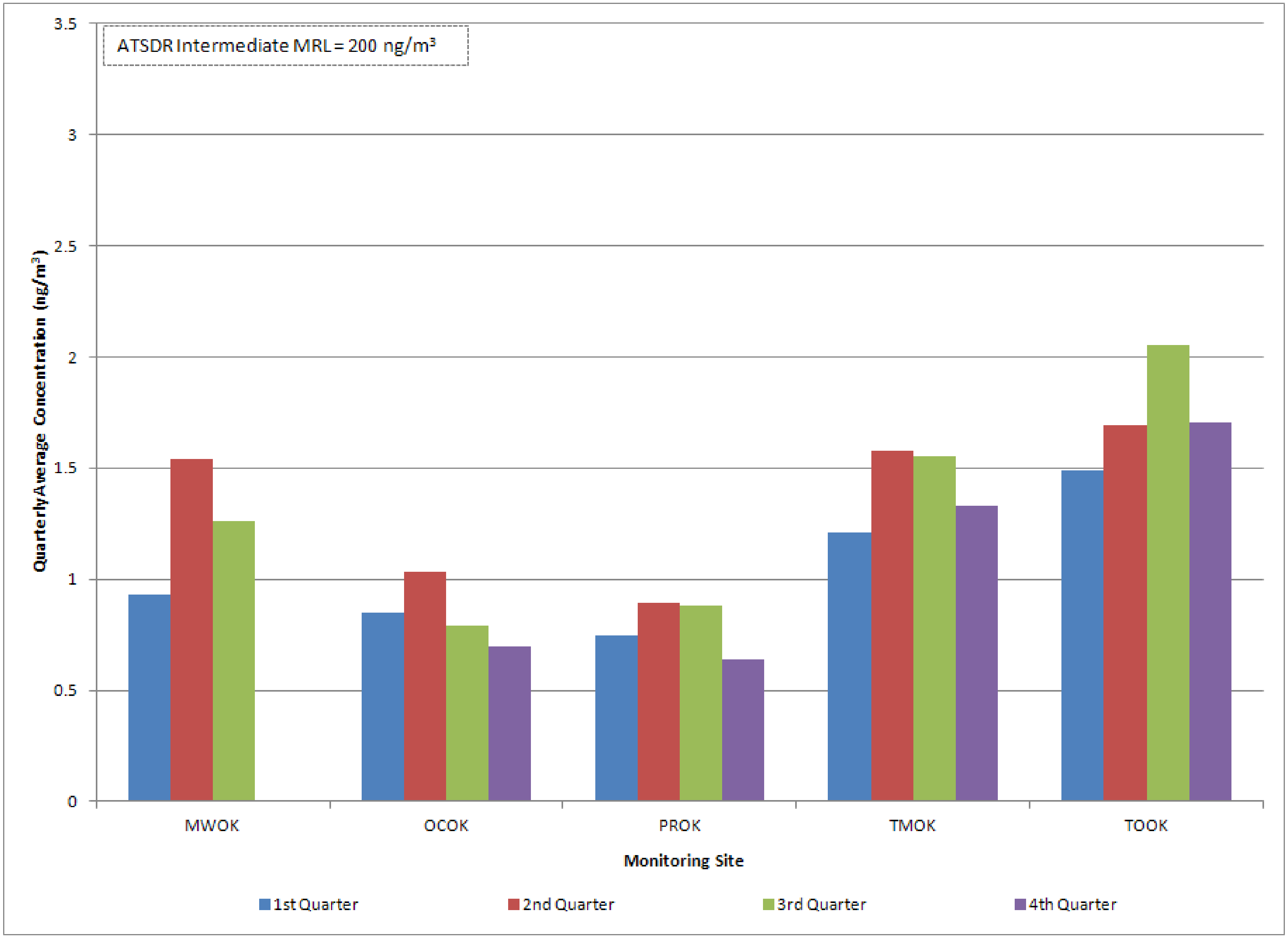


Figure 4-48. Comparison of Average Quarterly Tetrachloroethylene Concentrations

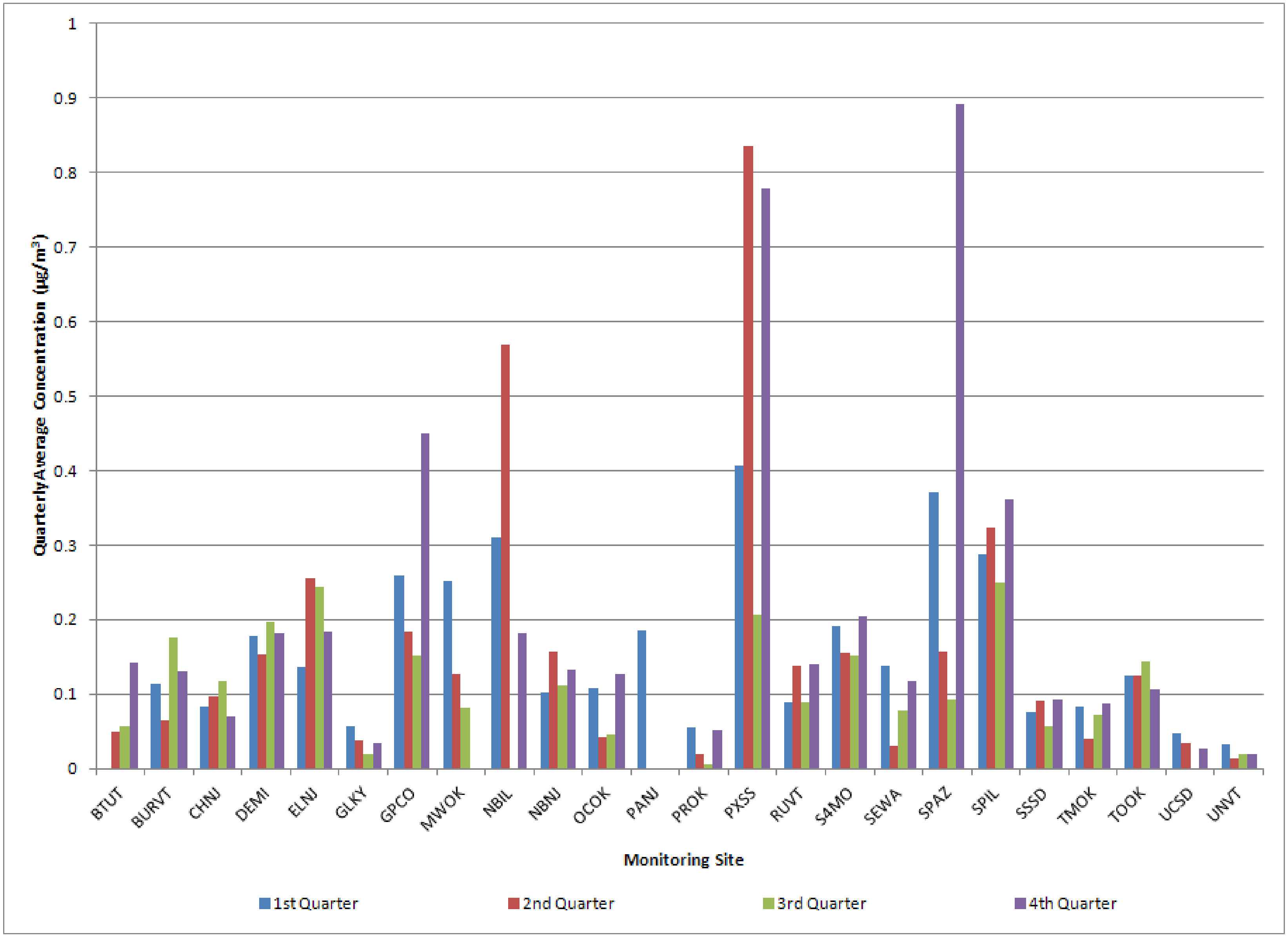


Figure 4-49. Comparison of Average Quarterly Trichloroethylene Concentrations

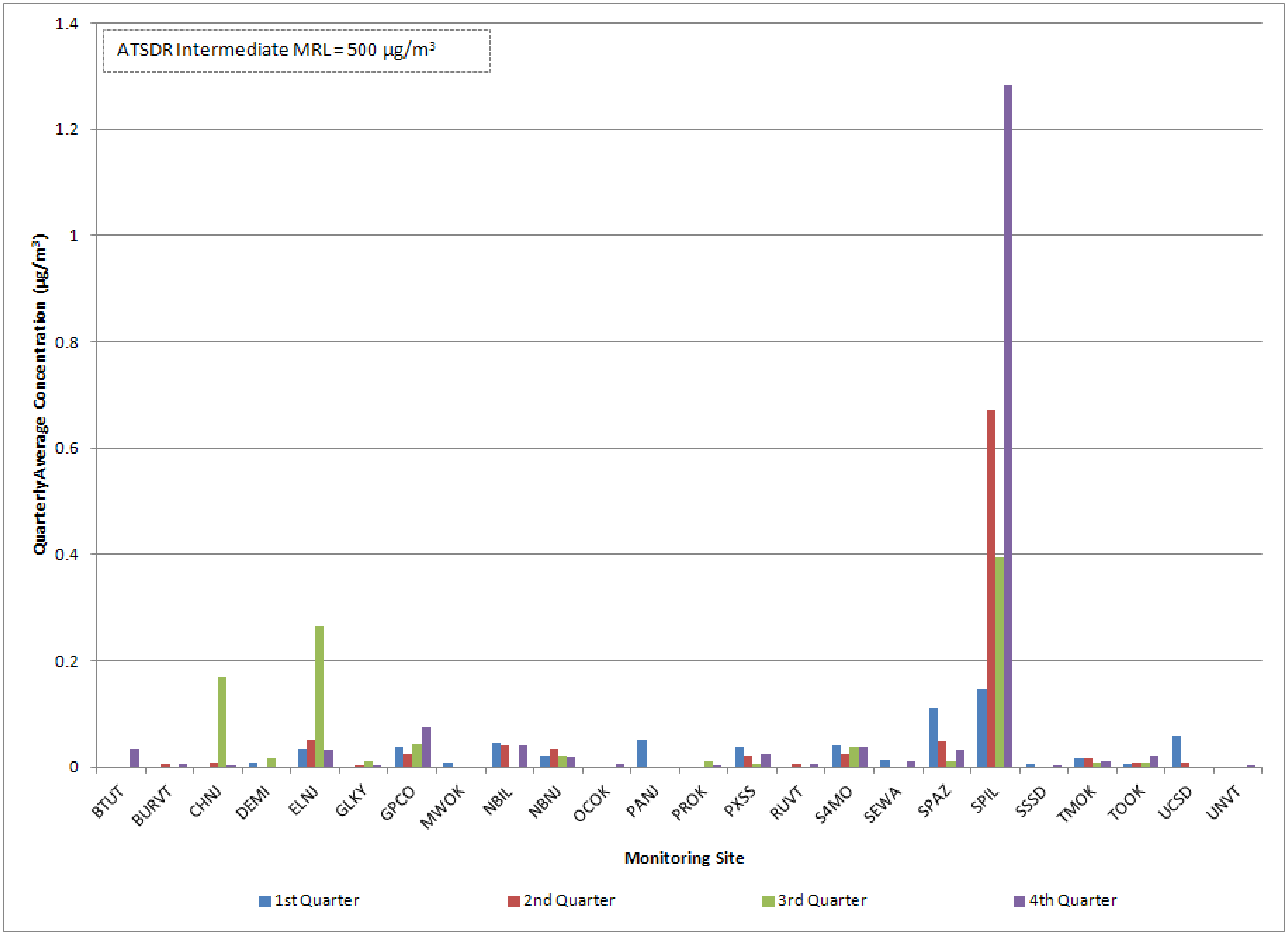
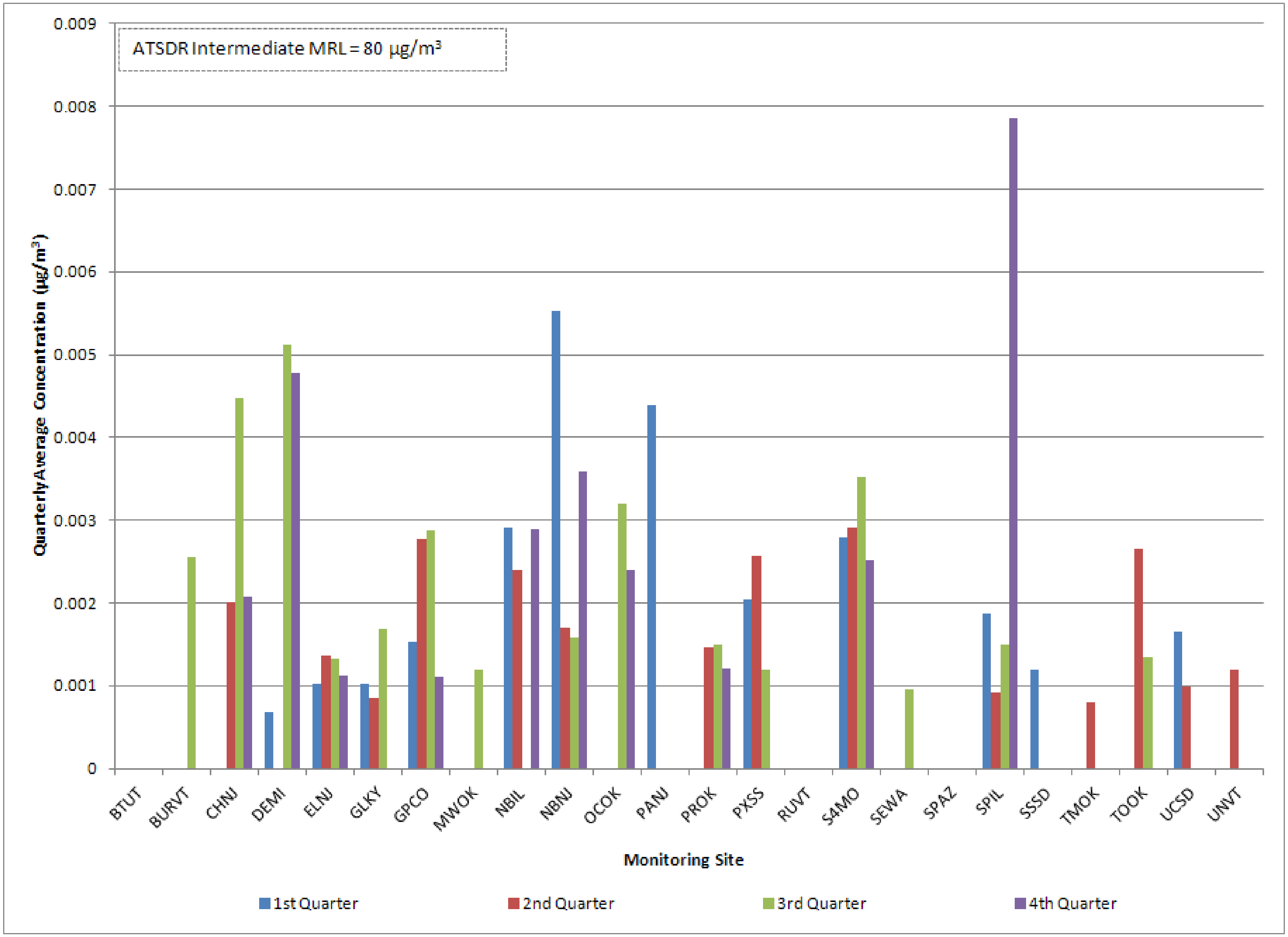


Figure 4-50. Comparison of Average Quarterly Vinyl Chloride Concentrations



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 1,281 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 8.7, respectively). Dichloromethane has the highest program-level average concentration among the GHGs measured, although the associated confidence interval indicates that this concentration is likely influenced by outliers. A review of the data shows that a single site contributed to this high average concentration. Three concentrations of this pollutant greater than 100 µg/m^3 were measured at BTUT (ranging from 175 µg/m^3 to 349 µg/m^3). An additional three concentrations greater than 20 µg/m^3 were measured at BTUT (ranging from 22.4 µg/m^3 to 70 µg/m^3). Besides dichloromethane, only three additional GHGs shown in Table 4-15 have program-level average concentrations greater than 1 µg/m^3: dichlorodifluoromethane, trichlorofluoromethane, and chloromethane.

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

Pollutant	Global Warming Potential[1] (100 yrs)	Total # of Measured Detections	2011 Program Average (µg/m^3)
Dichlorodifluoromethane	10,900	1,281	2.75 ± 0.02
Dichlorotetrafluoroethane	10,000	1,241	0.13 ± <0.01
Trichlorotrifluoroethane	6,130	1,281	0.74 ± 0.01
Trichlorofluoromethane	4,750	1,281	1.58 ± 0.02
Carbon Tetrachloride	1,400	1,279	0.60 ± 0.01
1,1,1-Trichloroethane	146	1,096	0.05 ± <0.01
Chloroform	31	756	0.39 ± 0.11
Chloromethane	13	1,281	1.26 ± 0.01
Dichloromethane	8.7	1,264	3.51 ± 2.41
Bromomethane	5	737	0.04 ± <0.01

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

5.0 Sites in Arizona

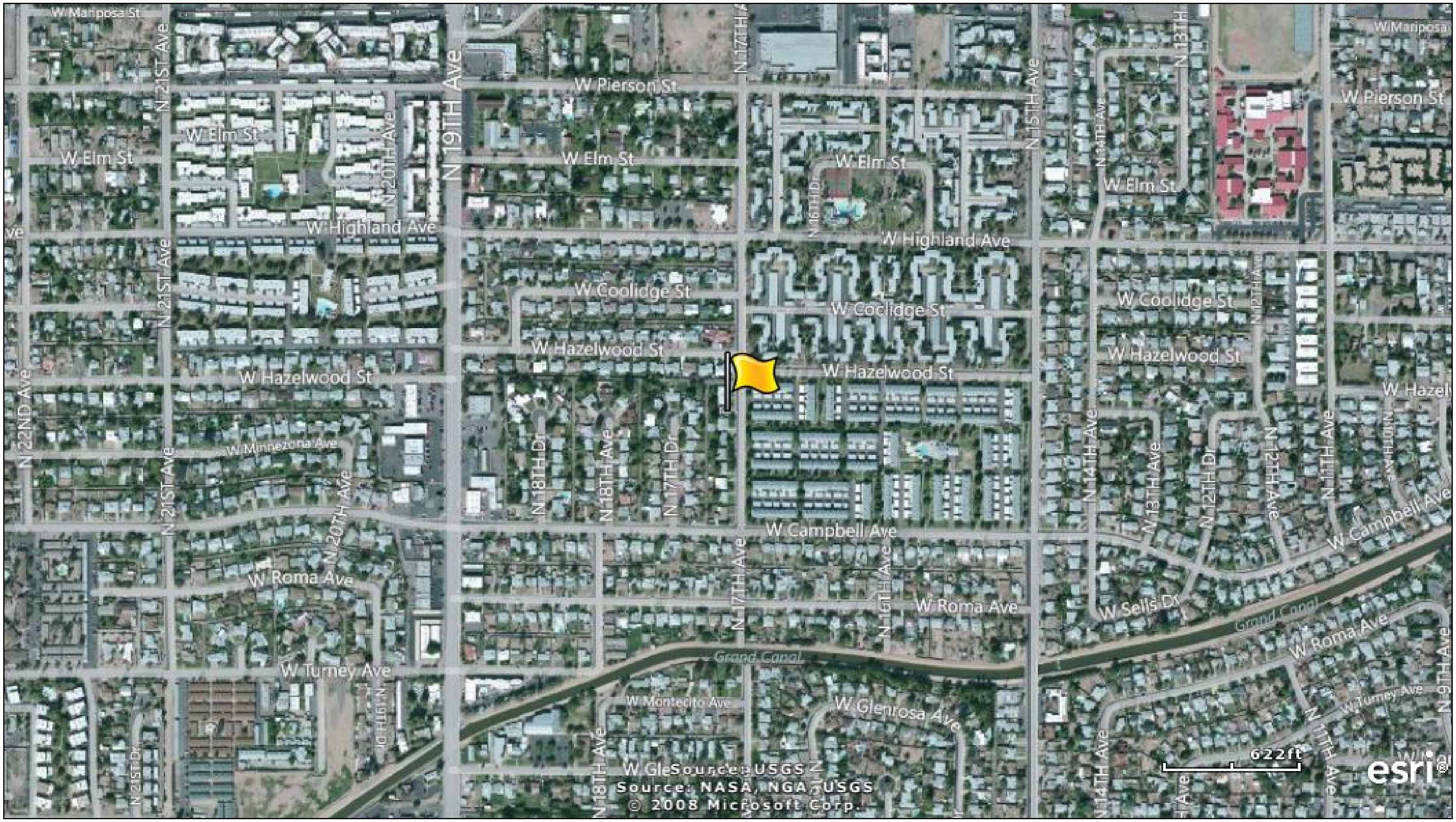
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Arizona, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included 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 in their urban locations. Figure 5-3 identifies nearby point source emissions locations by source category, as reported in the 2008 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.

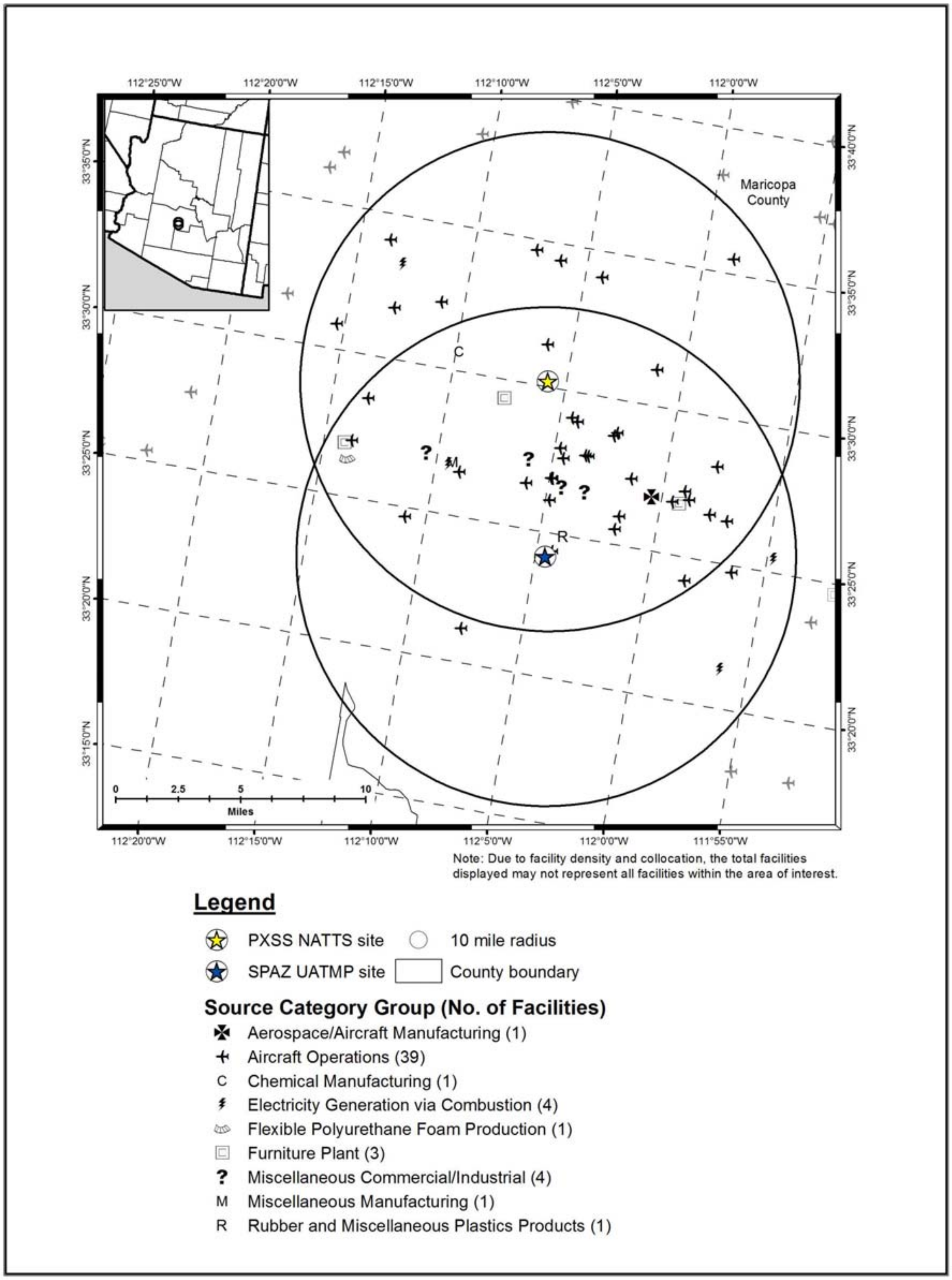
Figure 5-1. Phoenix, Arizona (PXSS) Monitoring Site



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

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

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



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

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-Glendale, AZ MSA	33.503731, -112.095809	Residential	Urban/City Center	Haze, CO, SO_2, NO, NO_2, NO_x, PAMS, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, PM Coarse, $PM_{2.5}$ Speciation.
SPAZ	04-013-4003	Phoenix	Maricopa	Phoenix-Mesa-Glendale, AZ MSA	33.40316, -112.07533	Residential	Urban/City Center	CO, PAMS, O_3, Meteorological parameters, $PM_{2.5}$, $PM_{10,}$ PM Coarse.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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 three-quarters of a mile east of I-17 and 2 miles north of I-10. Figure 5-2 shows that SPAZ is located near the intersection of West Tamarisk Avenue and South Central Avenue in South Phoenix. SPAZ is bounded on the west side by residential properties and commercial properties on the east side. SPAZ is located approximately 1 mile south of I-17.

SPAZ and PXSS are located approximately 7 miles apart. 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 aircraft operations source category, which includes airports as well as small runways, heliports, or landing pads. The emissions source nearest PXSS is a landing strip at a hospital while the source nearest SPAZ is a landing strip 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 county-level population and vehicle registration information. Table 5-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 5-2 also contains traffic volume information for each site. Finally, 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]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
PXSS	3,880,244	3,776,819	0.97	1,350,735	1,314,732	184,000	89,448,000
SPAZ				848,821	826,196	128,000	

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Arizona DOT (AZ DOT, 2011a)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2010 data from the Arizona DOT (AZ DOT, 2010)
[5] County-level VMT reflects 2010 data for all public roads from the Arizona DOT (AZ DOT, 2011b)
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.

- The vehicle-per-person ratio is just less than one vehicle per person. This ratio falls within the top third compared to other NMP sites.

- The 10-mile population and estimated vehicle ownership are higher near PXSS than SPAZ.

- PXSS experiences a higher traffic volume compared to SPAZ, based on locations along I-17 (between exits 195B and 196 for PXSS and between exits 202 and 203 for SPAZ). The traffic volume near PXSS is the fifth highest compared to traffic volumes near other NMP sites, with the traffic volume near SPAZ ranking tenth.

- 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

The Phoenix area 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 storms originating off the Pacific Ocean bring rain in the winter and early spring. Winds are generally light (Bair, 1992, and WRCC, 2013).

5.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest these sites were retrieved for 2011 (NCDC, 2011). The closest weather station to PXSS and SPAZ is located at Phoenix Sky Harbor International Airport (WBAN 23183). Additional information about the 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 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 for 2011. 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 throughout the year. The greatest difference between the full-year averages and sample day averages is for the maximum and average temperatures for PXSS. This may be due to make-up samples; thirteen of the nineteen make-up samples were collected between May and October 2011, during the warmer months of the year. Table 5-3 also shows that these sites experienced the lowest relative humidity levels among NMP sites.

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

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)
Phoenix, Arizona - PXSS									
Phoenix Sky Harbor Intl. Airport 23183 (33.44, -111.99)	7.19 miles 136° (SE)	Sample Day	87.5 ± 4.0	76.6 ± 3.8	35.6 ± 3.1	55.5 ± 2.3	28.6 ± 3.7	1010.8 ± 1.2	5.5 ± 0.5
		2011	86.2 ± 1.7	75.3 ± 1.7	34.8 ± 1.5	54.7 ± 1.0	28.8 ± 1.6	1011.3 ± 0.6	5.3 ± 0.2
South Phoenix, Arizona - SPAZ									
Phoenix Sky Harbor Intl. Airport 23183 (33.44, -111.99)	5.46 miles 70° (ENE)	Sample Day	86.2 ± 6.0	75.2 ± 5.8	35.1 ± 4.7	54.8 ± 3.4	30.0 ± 6.1	1011.4 ± 1.9	5.6 ± 0.7
		2011	86.2 ± 1.7	75.3 ± 1.7	34.8 ± 1.5	54.7 ± 1.0	28.8 ± 1.6	1011.3 ± 0.6	5.3 ± 0.2

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

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 in 2011. 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.

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

- The 24-hour air shed domain for PXSS is the smallest in size, based on average back trajectory length, compared to other NMP sites. The farthest away a back trajectory originated from PXSS was over northern Utah, or just greater than 500 miles away. However, most trajectories (89 percent) originated less than 300 miles from PXSS and the average trajectory length was approximately 166 miles.

- Back trajectories originated from a variety of directions at PXSS, although many trajectories originated from the southwest and west. A secondary group of trajectories originated from the north to northeast of the site. Back trajectories also originated from the east of the site.

- The cluster analysis map supports the observations above regarding the direction of trajectory origin as well as the observations about trajectory distances. Nearly half (43 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 (40 percent) represents back trajectories originating from nearly all directions, but generally less than 200 miles in length.

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 a result, fewer trajectories are shown in Figure 5-6 than Figure 5-4.

- The composite trajectory map for SPAZ has a trajectory distribution pattern similar to PXSS. The cluster analysis maps are also similar to each other. One difference, however, is that for SPAZ, the shorter trajectories of varying directions are included with the back trajectories originating from the north and east (as represented by the 42 percent cluster), while they are represented by a separate cluster trajectory for PXSS.

Figure 5-4. 2011 Composite Back Trajectory Map for PXSS

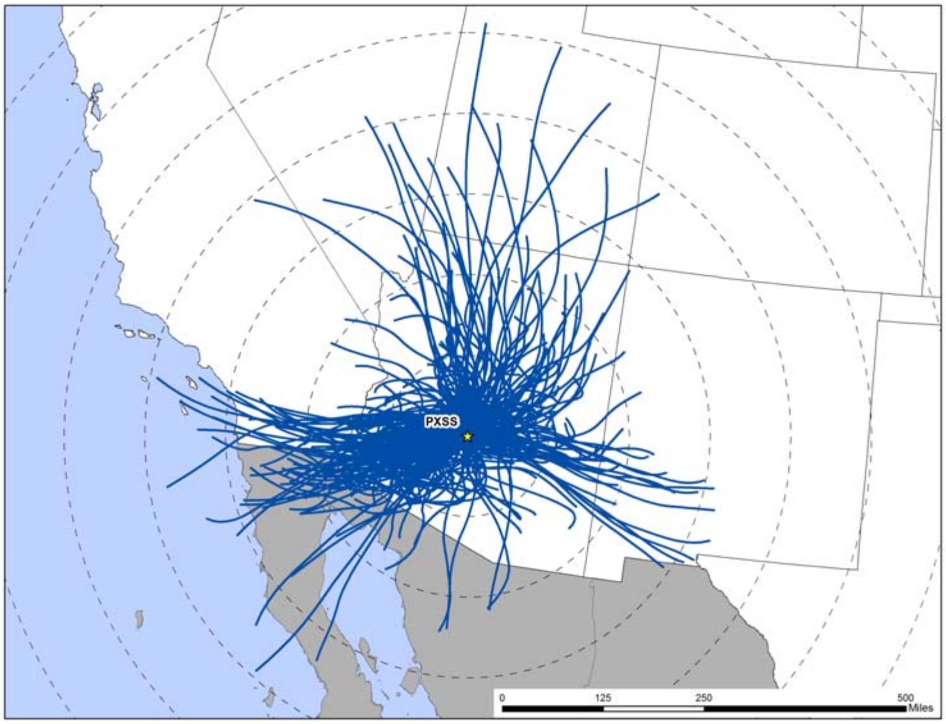


Figure 5-5. Back Trajectory Cluster Map for PXSS

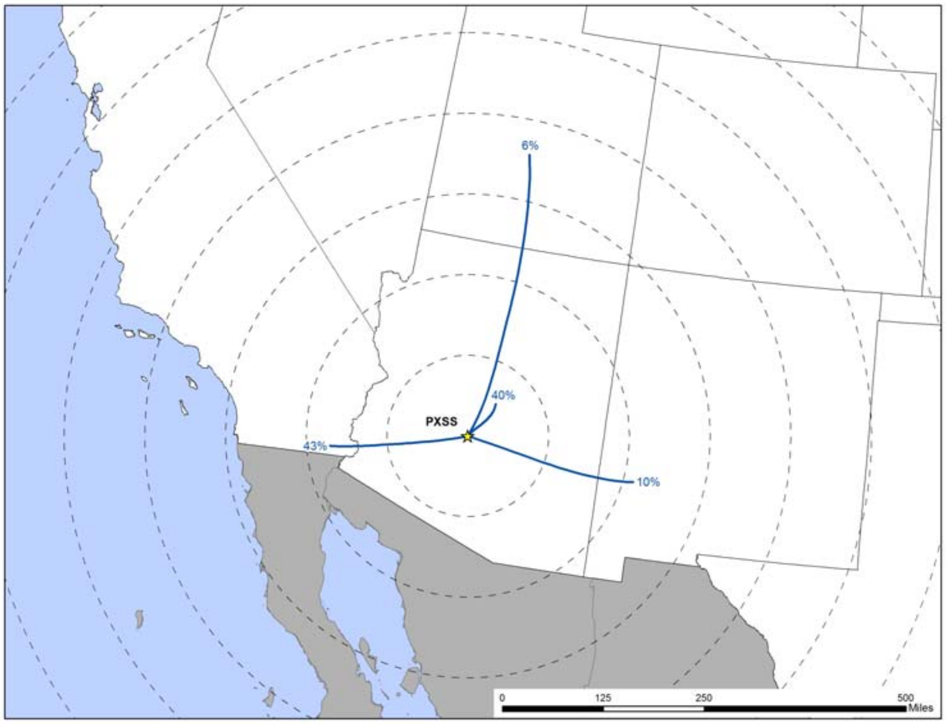


Figure 5-6. 2011 Composite Back Trajectory Map for SPAZ

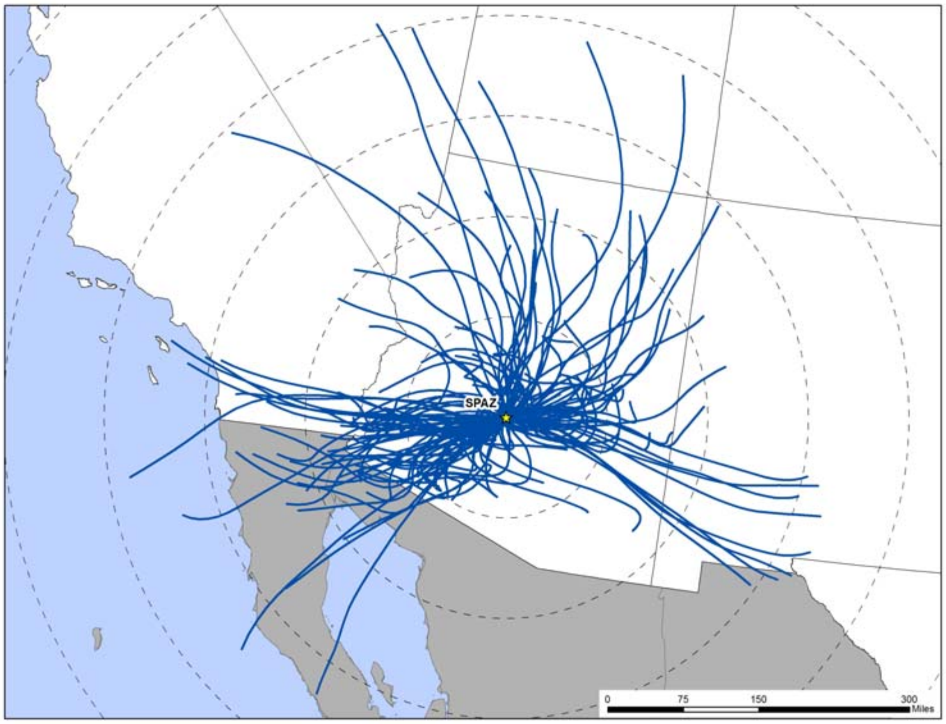
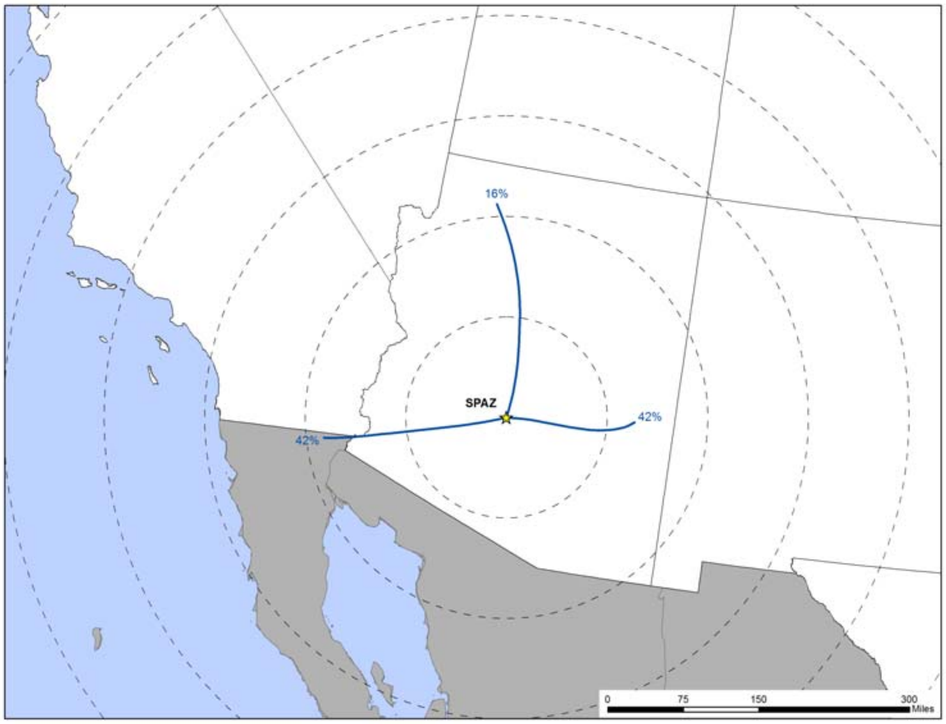


Figure 5-7. Back Trajectory Cluster Map for SPAZ

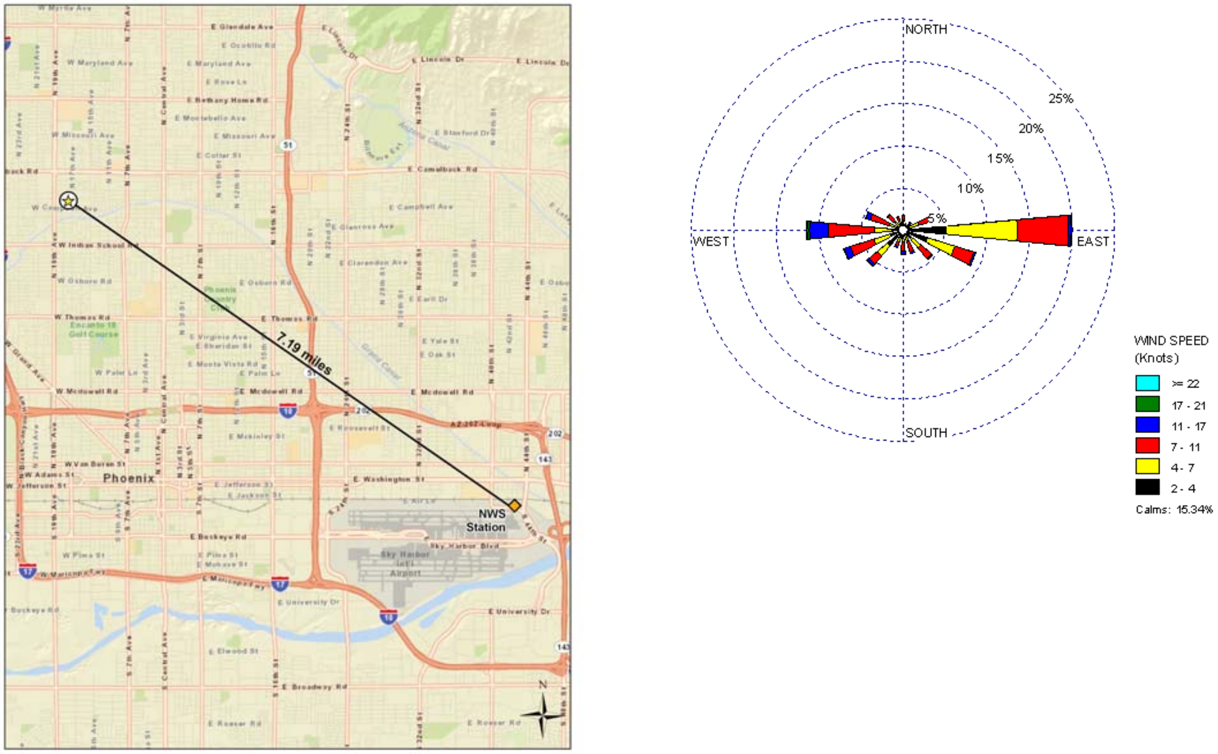


5.2.4 Wind Rose Comparison

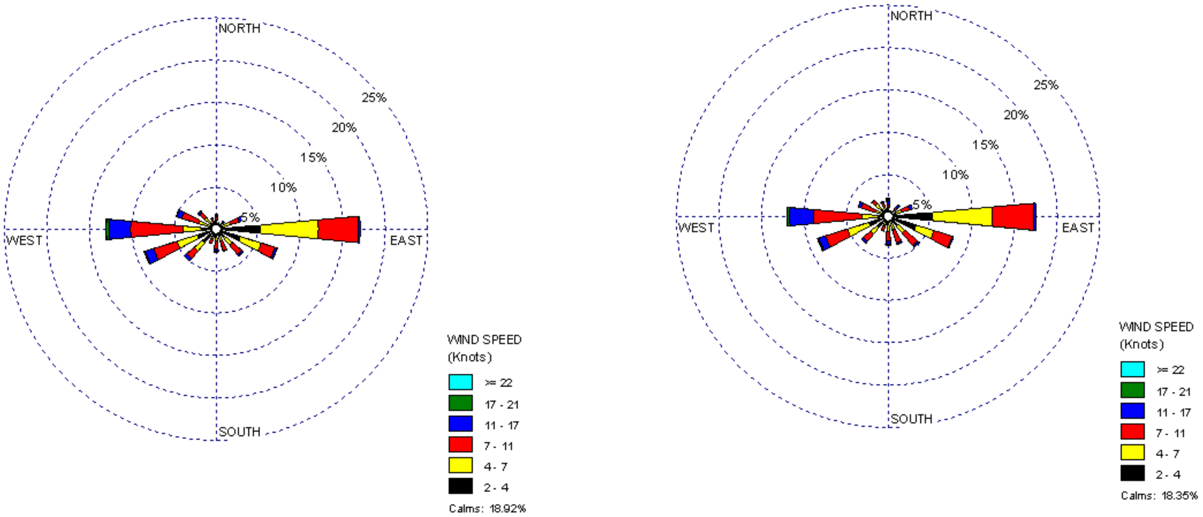
Hourly surface wind data from the NWS weather station at Phoenix Sky Harbor International Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point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

Figure 5-8 presents a map showing the distance between the NWS 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 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind observations for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and 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.

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

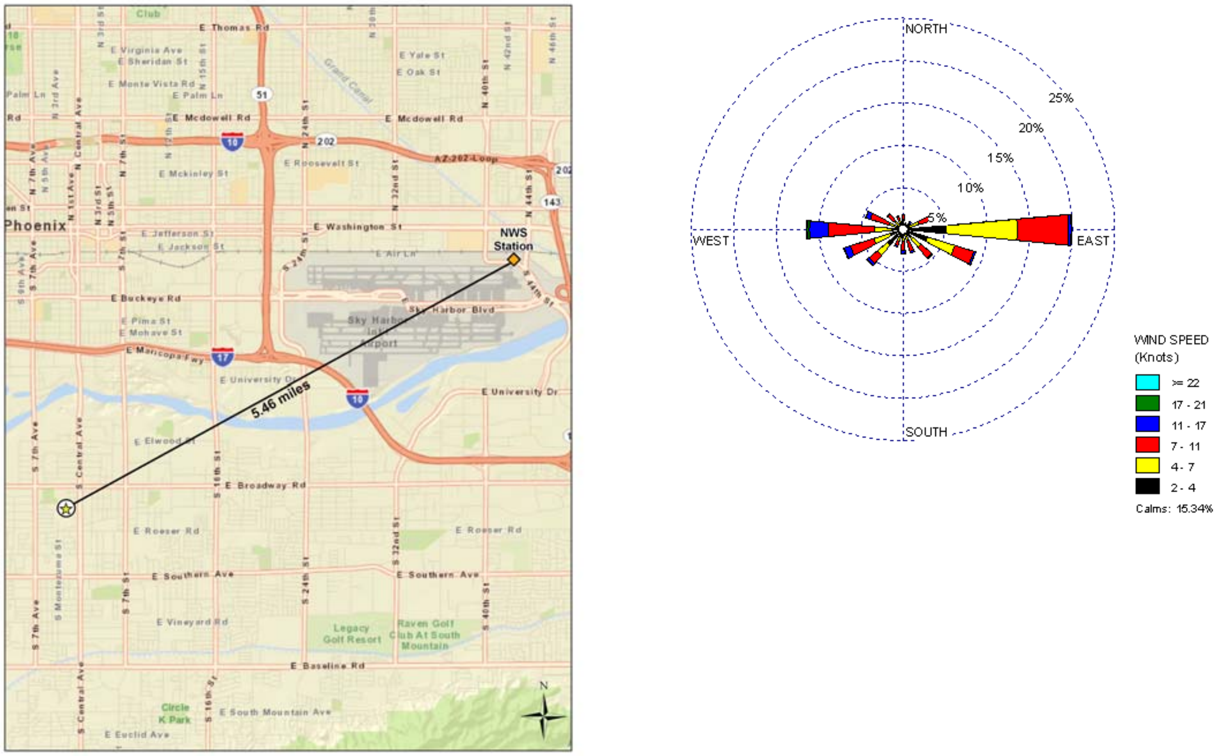

Distance between PXSS and NWS Station

2001-2010 Historical Wind Rose


2011 Wind Rose

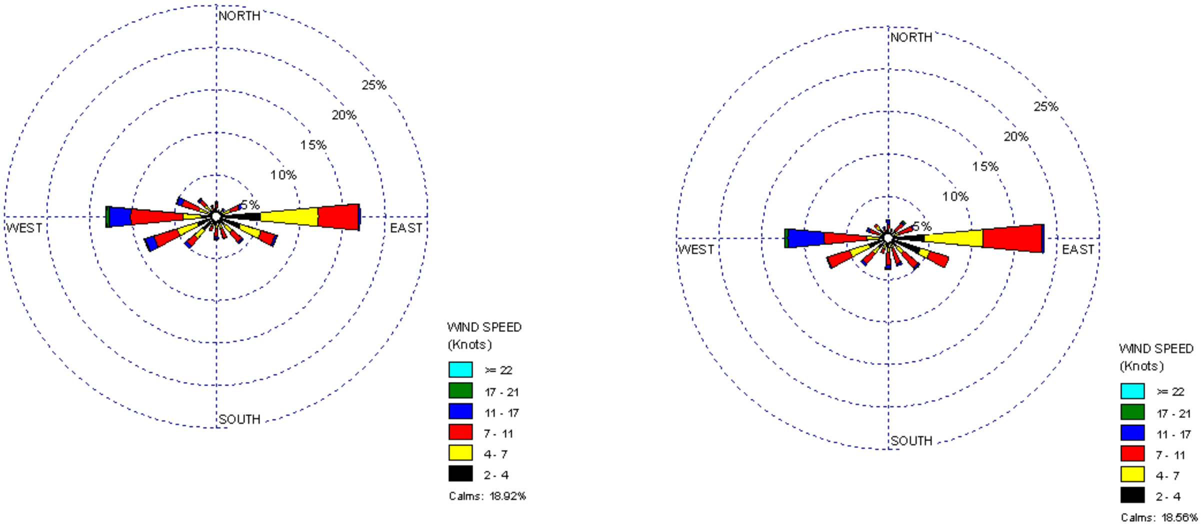
Sample Day Wind Rose

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



Distance between SPAZ and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

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

- The NWS 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 approximately 7.2 miles southeast of PXSS and 5.5 miles east-northeast of SPAZ.
- Because the Phoenix Sky Harbor weather station is the closest weather station to both sites, the historical and 2011 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 20 percent of observations), followed by westerly and east-southeasterly winds. Winds from the northwest, north, and northeast were infrequently observed, as were winds from the south. Calm winds (≤ 2 knots) account for 15 percent of the hourly wind measurements from 2001 to 2010.
- The 2011 wind patterns are similar to the historical wind patterns, with just slightly more calm wind observations (nearly 19 percent). Further, the sample day wind patterns for each site resemble the historical and 2011 wind patterns, indicating that wind conditions on sample days were representative of those experienced over the entire year and historically.

5.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Arizona monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 5-4 presents the results of the preliminary risk-based screening process for PXSS and SPAZ. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded.

Thus, pollutants of interest are shaded and/or bolded. 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						
Benzene	0.13	61	61	100.00	10.36	10.36
Carbon Tetrachloride	0.17	61	61	100.00	10.36	20.71
1,3-Butadiene	0.03	56	56	100.00	9.51	30.22
Manganese (PM$_{10}$)	0.005	55	61	90.16	9.34	39.56
Arsenic (PM$_{10}$)	0.00023	53	61	86.89	9.00	48.56
Naphthalene	0.029	50	57	87.72	8.49	57.05
Acetaldehyde	0.45	48	48	100.00	8.15	65.20
p-Dichlorobenzene	0.091	48	55	87.27	8.15	73.34
Formaldehyde	0.077	48	48	100.00	8.15	81.49
Ethylbenzene	0.4	44	61	72.13	7.47	88.96
Hexavalent Chromium	0.000083	14	62	22.58	2.38	91.34
1,2-Dichloroethane	0.038	12	12	100.00	2.04	93.38
Nickel (PM$_{10}$)	0.0021	12	61	19.67	2.04	95.42
Acrylonitrile	0.015	11	11	100.00	1.87	97.28
Hexachloro-1,3-butadiene	0.045	5	6	83.33	0.85	98.13
1,1,2,2-Tetrachloroethane	0.017	3	3	100.00	0.51	98.64
Chloromethylbenzene	0.02	2	2	100.00	0.34	98.98
Benzo(a)pyrene	0.00057	1	30	3.33	0.17	99.15
Cadmium (PM$_{10}$)	0.00056	1	61	1.64	0.17	99.32
1,2-Dibromoethane	0.0017	1	1	100.00	0.17	99.49
Dichloromethane	7.7	1	61	1.64	0.17	99.66
Propionaldehyde	0.8	1	48	2.08	0.17	99.83
Tetrachloroethylene	3.8	1	56	1.79	0.17	100.00
Total		589	983	59.92		
South Phoenix, Arizona - SPAZ						
Benzene	0.13	31	31	100.00	20.13	20.13
1,3-Butadiene	0.03	30	30	100.00	19.48	39.61
Carbon Tetrachloride	0.17	30	30	100.00	19.48	59.09
p-Dichlorobenzene	0.091	24	29	82.76	15.58	74.68
Ethylbenzene	0.4	24	31	77.42	15.58	90.26
1,2-Dichloroethane	0.038	7	7	100.00	4.55	94.81
Trichloroethylene	0.2	3	12	25.00	1.95	96.75
Xylenes	10	3	31	9.68	1.95	98.70
Acrylonitrile	0.015	1	1	100.00	0.65	99.35
Hexachloro-1,3-butadiene	0.045	1	1	100.00	0.65	100.00
Total		154	203	75.86		

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 different pollutants measured at each site.

- Twenty-three pollutants failed at least one screen for PXSS, of which 13 are NATTS MQO Core Analytes.

- Thirteen pollutants, of which 10 are NATTS MQO Core Analytes, were initially identified as pollutants of interest for PXSS. Benzo(a)pyrene, cadmium, and tetrachloroethylene were added to the pollutants of interest for PXSS because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of the total failed screens. Five additional NATTS MQO Core Analytes were added to the pollutants of interest for PXSS, even though their concentrations did not fail any screens: beryllium, chloroform, lead, trichloroethylene, and vinyl chloride. These five pollutants are not shown in Table 5-4 but are shown in subsequent tables in the sections that follow.

- For PXSS, approximately 60 percent of the measured detections failed screens (of those pollutants failing at least one screen).

- PXSS failed the second highest number of screens (589) among all NMP sites, behind only S4MO with 602 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 23 percent. This is due primarily to the relatively high number of pollutants sampled at this site, as discussed in Section 4.2.

- Ten pollutants failed screens for SPAZ, of which four are NATTS MQO Core Analytes. Eight pollutants were initially identified as pollutants of interest for SPAZ. Chloroform and tetrachloroethylene were added to the pollutants of interest for SPAZ because they are NATTS MQO Core Analytes, even though their concentrations did not fail any screens. These two pollutants are not shown in Table 5-4 but are shown in subsequent tables in the sections that follow. While vinyl chloride is also a NATTS MQO Core Analyte, it was not detected at SPAZ, and therefore not added to the list of pollutants of interest.

- For SPAZ, nearly 76 percent of the measured detections failed screens (of the pollutants failing at least one screen).

- Of the VOCs, which were measured by Method TO-15 at both sites, the following pollutants of interest failed 100 percent of screens for both sites: acrylonitrile, benzene, 1,3-butadiene, carbon tetrachloride, and 1,2-dichloroethane. Hexachloro-1,3-butadiene also failed 100 percent of screens for SPAZ. Acetaldehyde, chloromethylbenzene, 1,2-dibromoethane, formaldehyde, and 1,1,2,2-tetrachloroethane failed 100 percent of screens at PXSS. However, many of these pollutants were detected infrequently.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Arizona monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for PXSS and SPAZ are provided in Appendices J, L, M, N, and O.

5.4.1 2011 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Arizona 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 of 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	48/48	NA	2.26 ± 0.60	2.66 ± 0.53	3.52 ± 0.80	NA
Benzene	61/61	1.70 ± 0.38	0.73 ± 0.16	0.83 ± 0.20	1.98 ± 0.49	1.34 ± 0.22
1,3-Butadiene	56/61	0.32 ± 0.10	0.08 ± 0.03	0.09 ± 0.04	0.39 ± 0.13	0.23 ± 0.06
Carbon Tetrachloride	61/61	0.58 ± 0.02	0.55 ± 0.07	0.66 ± 0.05	0.72 ± 0.05	0.63 ± 0.03
Chloroform	57/61	0.28 ± 0.06	0.31 ± 0.16	0.43 ± 0.17	0.43 ± 0.13	0.37 ± 0.07
p-Dichlorobenzene	55/61	0.27 ± 0.06	0.10 ± 0.04	0.13 ± 0.05	0.28 ± 0.08	0.20 ± 0.04
1,2-Dichloroethane	12/61	0.01 ± 0.02	0.05 ± 0.04	0	0.03 ± 0.02	0.02 ± 0.01
Ethylbenzene	61/61	0.90 ± 0.23	0.51 ± 0.17	0.59 ± 0.13	1.20 ± 0.29	0.82 ± 0.13
Formaldehyde	48/48	NA	3.58 ± 0.73	4.29 ± 0.41	4.41 ± 0.77	NA
Tetrachloroethylene	56/61	0.41 ± 0.10	0.83 ± 1.35	0.21 ± 0.07	0.78 ± 0.26	0.55 ± 0.28
Trichloroethylene	16/61	0.04 ± 0.02	0.02 ± 0.02	0.01 ± 0.01	0.02 ± 0.02	0.02 ± 0.01
Vinyl Chloride	5/61	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	0	<0.01 ± <0.01
Arsenic (PM$_{10}$)[a]	61/61	0.68 ± 0.33	0.46 ± 0.21	0.95 ± 0.37	1.00 ± 0.30	0.77 ± 0.16
Benzo(a)pyrene[a]	30/57	0.16 ± 0.09	<0.01 ± <0.01	<0.01 ± <0.01	0.21 ± 0.10	0.10 ± 0.04
Cadmium (PM$_{10}$)[a]	61/61	0.15 ± 0.07	0.08 ± 0.02	0.15 ± 0.07	0.18 ± 0.06	0.14 ± 0.03
Beryllium (PM$_{10}$)[a]	61/61	0.02 ± 0.01	0.03 ± 0.01	0.11 ± 0.05	0.03 ± 0.01	0.05 ± 0.02
Hexavalent Chromium[a]	62/62	0.08 ± 0.02	0.07 ± 0.03	0.05 ± 0.02	0.06 ± 0.02	0.06 ± 0.01
Lead (PM$_{10}$)[a]	61/61	4.02 ± 1.30	2.92 ± 1.14	4.09 ± 1.00	5.19 ± 1.64	4.06 ± 0.64
Manganese (PM$_{10}$)[a]	61/61	11.21 ± 2.96	14.89 ± 3.21	48.14 ± 21.67	15.37 ± 4.79	22.82 ± 6.79
Naphthalene[a]	57/57	107.68 ± 27.68	61.28 ± 38.49	50.61 ± 16.97	125.83 ± 29.09	89.36 ± 16.23
Nickel (PM$_{10}$)[a]	61/61	0.92 ± 0.19	1.42 ± 0.29	2.59 ± 0.84	1.97 ± 0.75	1.74 ± 0.33

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

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
South Phoenix, Arizona - SPAZ						
Benzene	31/31	2.33 ± 1.26	0.76 ± 0.30	0.84 ± 0.29	2.36 ± 0.68	1.65 ± 0.45
1,3-Butadiene	30/31	0.46 ± 0.32	0.12 ± 0.06	0.10 ± 0.05	0.41 ± 0.13	0.29 ± 0.10
Carbon Tetrachloride	30/31	0.64 ± 0.14	0.49 ± 0.24	0.64 ± 0.09	0.71 ± 0.10	0.63 ± 0.07
Chloroform	26/31	0.22 ± 0.06	0.18 ± 0.06	0.17 ± 0.13	0.16 ± 0.08	0.18 ± 0.04
1,2-Dichloroethane	7/31	0.01 ± 0.03	0.03 ± 0.04	0.01 ± 0.02	0.04 ± 0.04	0.02 ± 0.01
Ethylbenzene	31/31	1.22 ± 0.69	0.51 ± 0.23	0.66 ± 0.23	1.65 ± 0.57	1.06 ± 0.28
p-Dichlorobenzene	29/31	0.37 ± 0.16	0.12 ± 0.07	0.23 ± 0.18	0.03 ± 0.09	0.26 ± 0.07
Tetrachloroethylene	28/31	0.37 ± 0.16	0.16 ± 0.06	0.09 ± 0.07	0.89 ± 0.38	0.41 ± 0.16
Trichloroethylene	12/31	0.11 ± 0.08	0.05 ± 0.08	0.01 ± 0.02	0.03 ± 0.04	0.05 ± 0.03
Xylenes	31/31	4.76 ± 2.72	1.86 ± 0.89	2.33 ± 0.94	6.45 ± 2.38	4.06 ± 1.14

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/m³ for ease of viewing.

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

- The pollutant with the highest annual average concentration by mass is benzene. This is the only pollutant with an annual average concentration greater than 1 µg/m³ (1.34 ± 0.22 µg/m³). The quarterly average concentrations of benzene exhibit a seasonal trend, with higher quarterly averages for the colder months of the year.

- Similarly, concentrations of benzo(a)pyrene, 1,3-butadiene, and *p*-dichlorobenzene are also higher during the colder months of the year. Ethylbenzene and naphthalene also appear to exhibit this trend, but the difference in the quarterly average concentrations is not statistically significant for these pollutants.

- The confidence interval for the second quarter average concentration of tetrachloroethylene is higher than the average itself, indicating the likely influence of outliers. The highest concentration of this pollutant was measured at PXSS on May 9, 2011 (8.63 µg/m³) and is nearly five times greater than the next highest concentration of this pollutant measured at PXSS (1.74 µg/m³) and more than three times the next highest concentration measured among NMP sites sampling VOCs (2.42 µg/m³, measured at NBIL).

- The third quarter average concentration of manganese is three times higher than the other quarterly averages and has a relatively large confidence interval associated with it. Three of the five concentrations of manganese greater than 100 ng/m^3 measured across the program were measured at PXSS. All three of these measurements were measured during the third quarter of 2011, one in each month and ranged from 111 ng/m^3 to 130 ng/m^3.

- Regarding hexavalent chromium measurements at PXSS: stainless steel filter holders used in the hexavalent chromium sampler at PXSS may have contaminated the samples collected at this site. The filter holder was exchanged with a Teflon® filter holder at the end of February 2011. Although the first quarter average is the highest quarterly average for 2011, the difference is not statistically significant and the maximum concentration of hexavalent chromium was not measured during the first quarter. Of the nine concentrations greater than 0.1 ng/m^3, four were measured during the first quarter, two in the second, one in the third, and two in the fourth.

- Note that neither acetaldehyde nor formaldehyde have first quarter or annual average concentrations presented in Table 5-5. This is because maintenance of the primary carbonyl compound sampler at PXSS led to a problem with the ozone denuder, resulting in the invalidation of the sampling results through the end of March 2011. However, Appendix L provides the pollutant-specific average concentrations for all valid samples collected over the entire sample period for each site.

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

- The pollutant with the highest annual average concentration by mass for SPAZ is xylenes (4.06 ± 1.14 µg/m^3), which is more than twice the next highest annual average for benzene (1.65 ± 0.45 µg/m^3). Ethylbenzene is the only other pollutant of interest with an annual average greater than 1 µg/m^3 (1.06 ± 0.28 µg/m^3).

- The first and fourth quarterly averages of xylene are more than twice the quarterly averages for the second and third quarters and have relatively large confidence intervals associated with them. Xylenes were detected in all 31 valid VOC samples collected at SPAZ and ranged from 0.879 µg/m^3 to 11.93 µg/m^3. Of these 31, the eight highest concentrations (those greater than 5 µg/m^3) were all measured in the first and fourth quarters; conversely, the four lowest concentrations (those less than 1 µg/m^3) were measured during the second and third quarters. SPAZ is the only site for which xylenes is a pollutant of interest.

- Similar to PXSS, the quarterly average concentrations of several of the VOCs exhibit a seasonal trend, with the averages being higher during the colder months of year. However, the confidence intervals indicate that the differences in the quarterly averages are not statistically significant for SPAZ.

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 25 times.
- SPAZ has the highest annual average concentration of 1,3-butadiene, *p*-dichlorobenzene, and ethylbenzene among all NMP sites sampling VOCs, and the second highest annual averages of benzene and tetrachloroethylene. PXSS has the highest annual average concentration of tetrachloroethylene and the second highest annual average concentrations of 1,3-butadiene and ethylbenzene among sites sampling VOCs.
- PXSS has the highest annual average concentration of hexavalent chromium among all NMP sites sampling this pollutant. However, the annual average for 2011 is half of what it was in 2010 (0.13 ± 0.03 ng/m^3).
- PXSS also has the highest annual average concentrations of beryllium and manganese, the second highest annual averages of arsenic and nickel, and the third highest annual average concentration of lead, 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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzene and 1,3-butadiene were created for both PXSS and SPAZ. Box plots were also created for arsenic, benzo(a)pyrene, hexavalent chromium, lead, manganese, and naphthalene for PXSS. Figures 5-10 through 5-17 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.

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

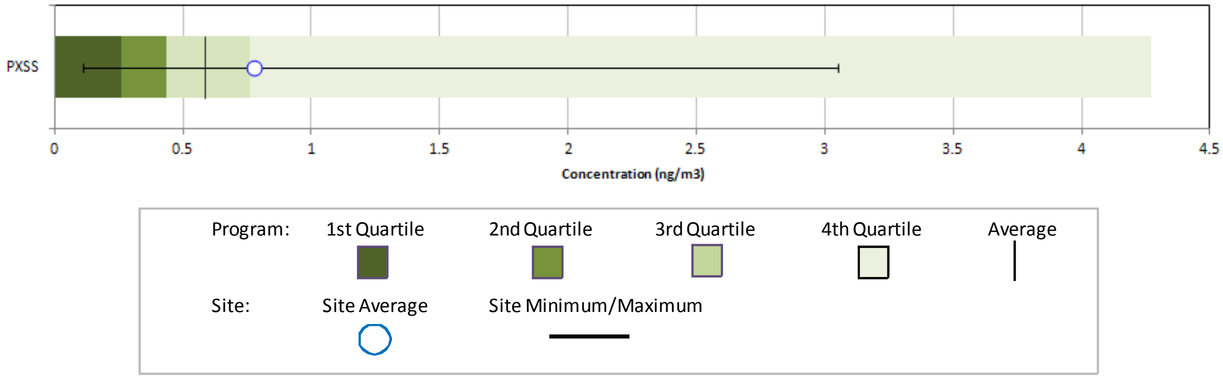


Figure 5-11. Program vs. Site-Specific Average Benzene Concentrations

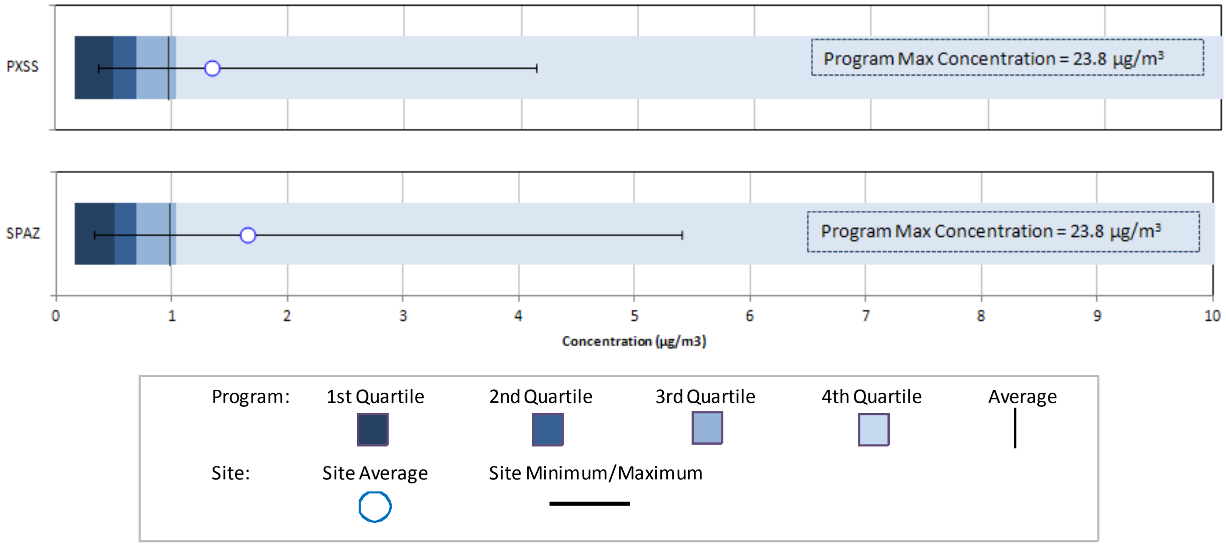


Figure 5-12. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

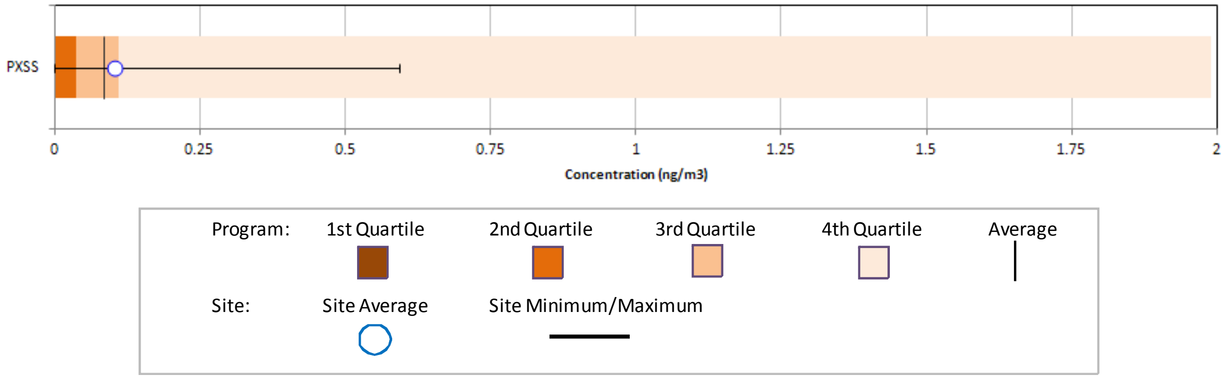


Figure 5-13. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

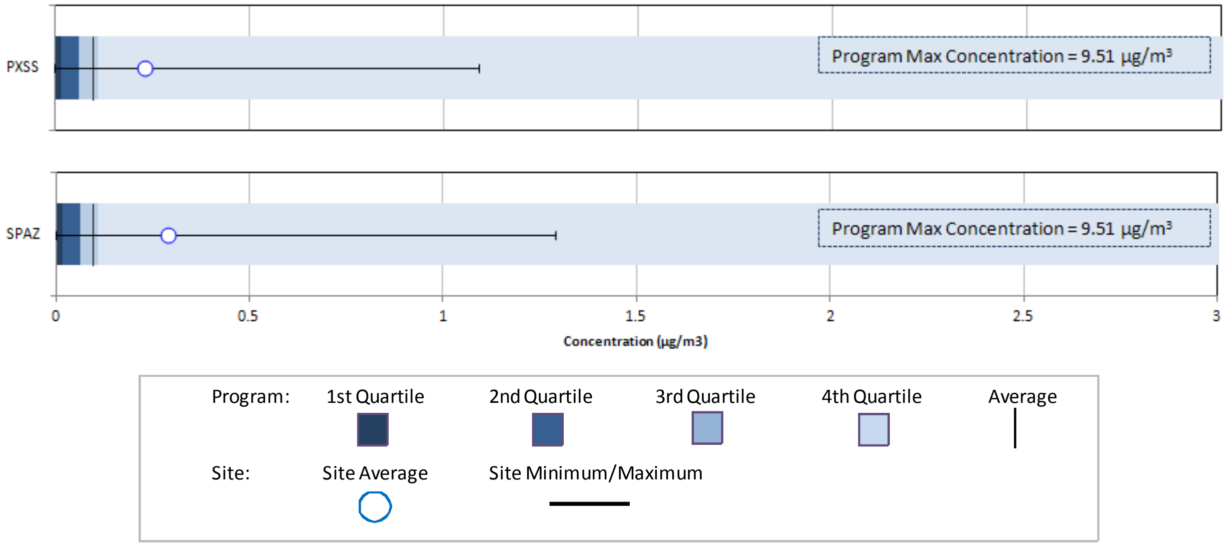


Figure 5-14. Program vs. Site-Specific Average Hexavalent Chromium Concentration

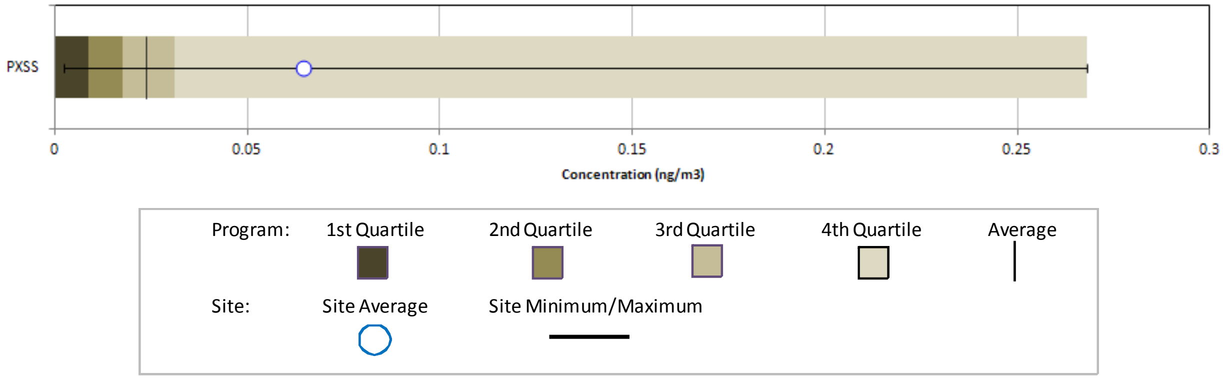


Figure 5-15. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

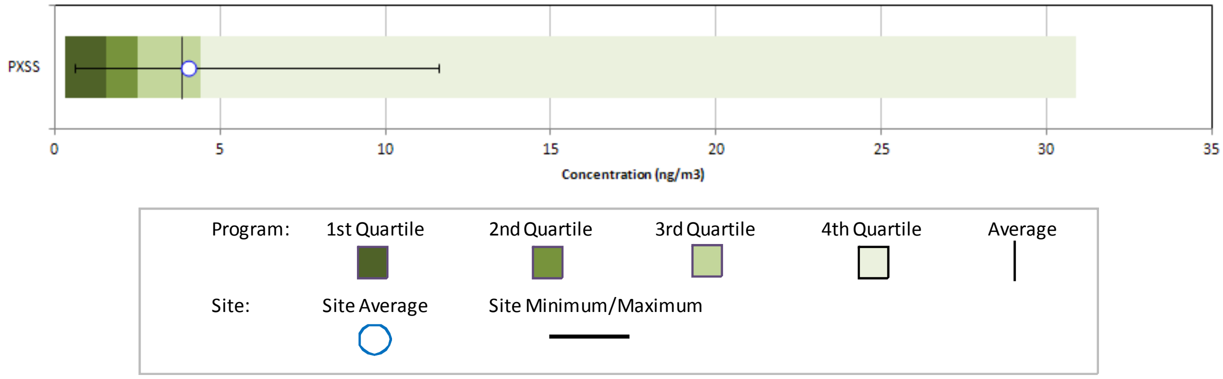


Figure 5-16. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

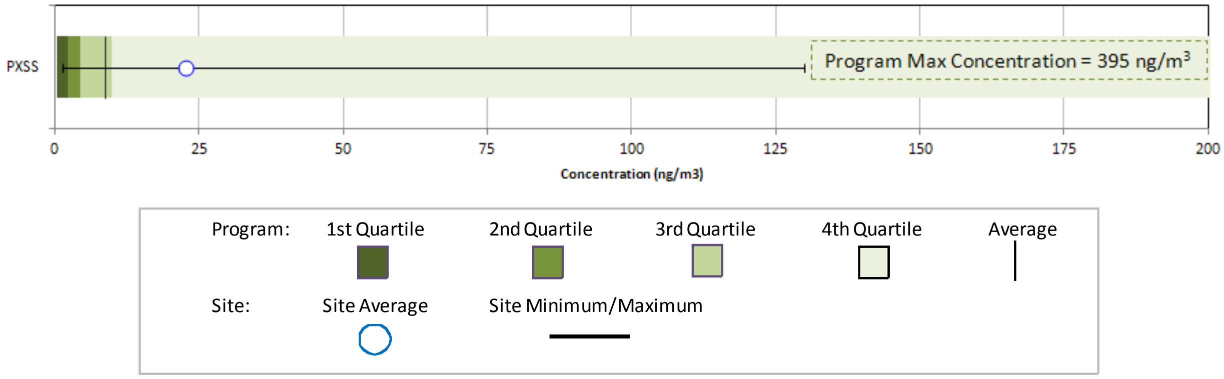
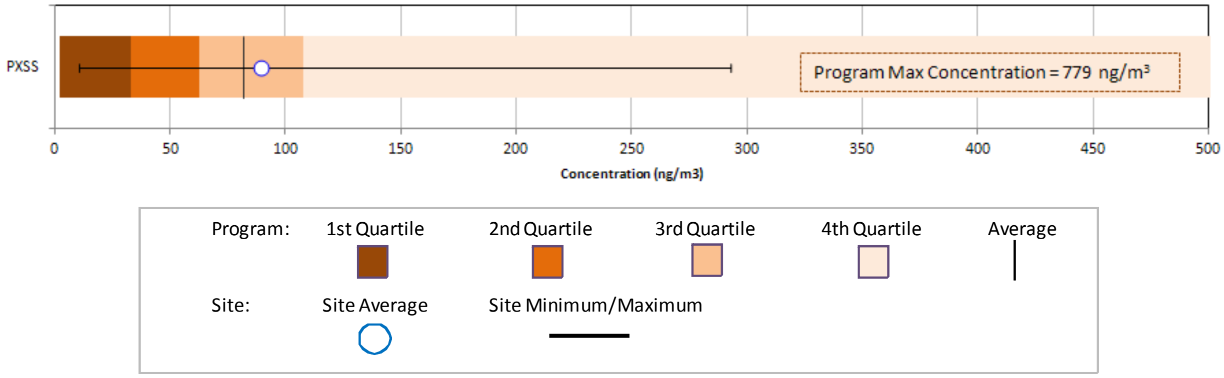


Figure 5-17. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 5-10 through 5-17 include the following:

- Figure 5-10 shows that the annual average arsenic (PM_{10}) concentration for PXSS is greater than the program-level average for arsenic (PM_{10}). Although the maximum concentration of arsenic measured across the program was not measured at PXSS, the maximum concentration measured at PXSS (3.05 ng/m^3) was among the higher arsenic measurements. There were no non-detects of arsenic measured at PXSS.

- Figure 5-11 for benzene shows both sites, as both SPAZ and PXSS sampled VOCs. Note that the program-level maximum concentration (23.8 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 10 µg/m^3. 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. SPAZ has the second highest annual average concentration of benzene among NMP sites sampling this pollutant, as discussed above. There were no non-detects of benzene measured at either site (or among sites sampling VOCs).

- Figure 5-12 is the box plot for benzo(a)pyrene for PXSS. Note that the program-level first quartile for this pollutant is zero and is not visible on this box plot. The box plot shows that the annual average concentration for PXSS is just greater than the program-level average concentration and just less than the program-level third quartile. Figure 5-12 also shows that the maximum concentration measured at PXSS is considerably less than the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at PXSS.

- Figure 5-13 for 1,3-butadiene also shows both sites. Similar to the box plots for benzene, the program-level maximum 1,3-butadiene concentration (9.51 $\mu g/m^3$) is not shown directly on the box plots as the scale has been reduced to 3 $\mu g/m^3$ in order to allow for the observation of data points at the lower end of the concentration range. 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 1,3-butadiene annual average concentration for SPAZ slightly higher than the annual average concentration for PXSS. There were five non-detects of 1,3-butadiene measured at PXSS and one non-detect measured at SPAZ.

- Figure 5-14 is the box plot for hexavalent chromium for PXSS. Figure 5-14 shows that the maximum concentration of this pollutant across the program (0.268 ng/m^3) was measured at PXSS. The box plot also shows that this site's annual average concentration of hexavalent chromium (0.065 ng/m^3) is nearly three times greater than the program-level average concentration (0.024 ng/m^3). As discussed above, PXSS has the highest annual average concentration of hexavalent chromium among NMP sites sampling hexavalent chromium. There were no non-detects of hexavalent chromium measured at PXSS.

- Figure 5-15 shows that the annual average concentration of lead (PM_{10}) for PXSS is just greater than the program-level average concentration. While the maximum concentration measured at PXSS is considerably less than the program maximum concentration, PXSS has the third highest annual average concentration of lead among the NMP sites, behind only S4MO and NBIL. There were no non-detects of lead measured at PXSS (or among sites sampling PM_{10} metals).

- Figure 5-16 is the box plot for manganese (PM_{10}) for PXSS. Note that the program-level maximum concentration (395 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 200 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. Figure 5-16 shows the annual average concentration of manganese for PXSS (22.82 ng/m^3) is greater than the program-level average concentration (8.81 ng/m^3), nearly two and a half times as high). PXSS has the highest annual average concentration of manganese among NMP sites sampling PM_{10} metals, as discussed above. While the maximum concentration measured at PXSS (130 ng/m^3) is considerably less than the program-level maximum concentration, this is the second highest measurement of manganese measured among the NMP sites sampling PM_{10}

metals. There were no non-detects of manganese measured at PXSS (or among sites sampling PM_{10} metals).

- Figure 5-17 is the box plot for naphthalene. Note that the program-level maximum concentration (779 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. Figure 5-17 shows that the annual average naphthalene concentration for PXSS (89.36 ng/m^3) is greater than the program-level average concentration (81.68 ng/m^3). The maximum naphthalene concentration measured at PXSS (293 ng/m^3) is considerably less than the program-level maximum concentration. There were no non-detects of naphthalene measured at PXSS (or among sites sampling PAHs).

- Recall that annual averages could not be calculated for formaldehyde and acetaldehyde, as discussed in Section 5.4.1.

5.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. PXSS has sampled PM_{10} metals and hexavalent chromium under the NMP since 2006; thus, Figures 5-18 through 5-21 present the annual statistical metrics for arsenic, hexavalent chromium, lead, and manganese, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

SPAZ began sampling VOCs and PXSS began sampling VOCs, carbonyl compounds, and PAHs under the NMP in 2007. However, they did not begin sampling until halfway through the year; therefore, annual statistical metrics could not be calculated for 2007. Thus, the trends analysis was not conducted for the pollutants for these methods for PXSS and SPAZ.

Figure 5-18. Annual Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at PXSS

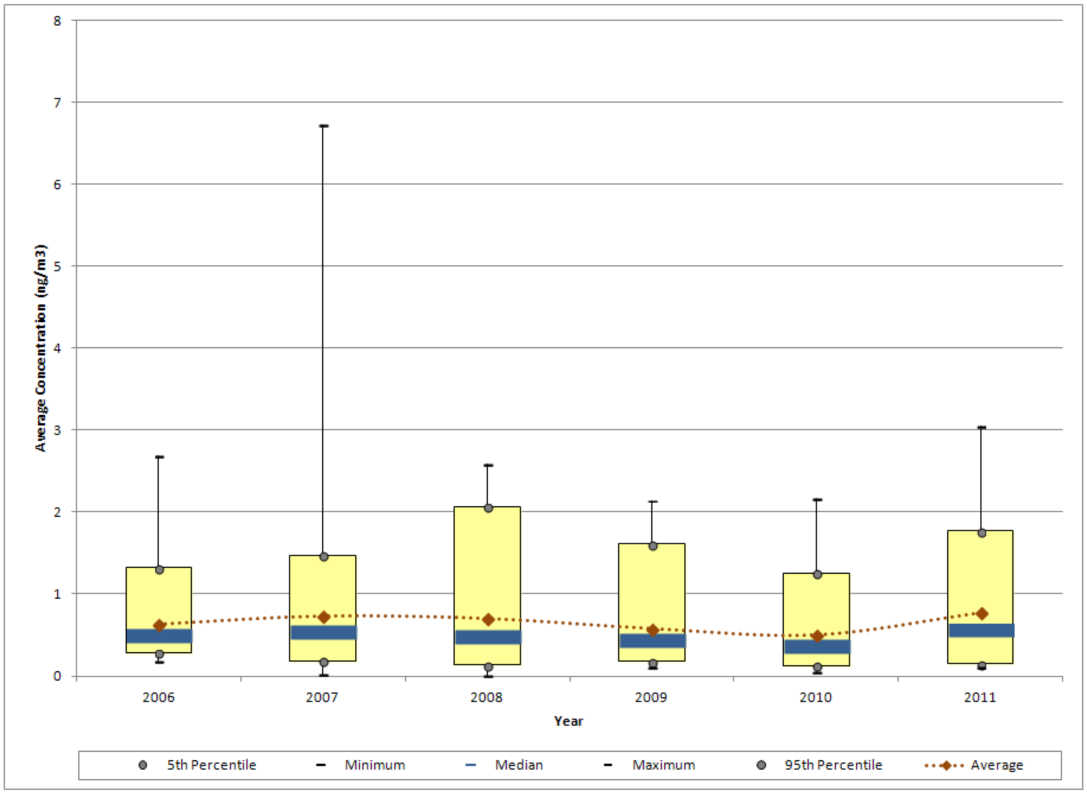


Figure 5-19. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at PXSS

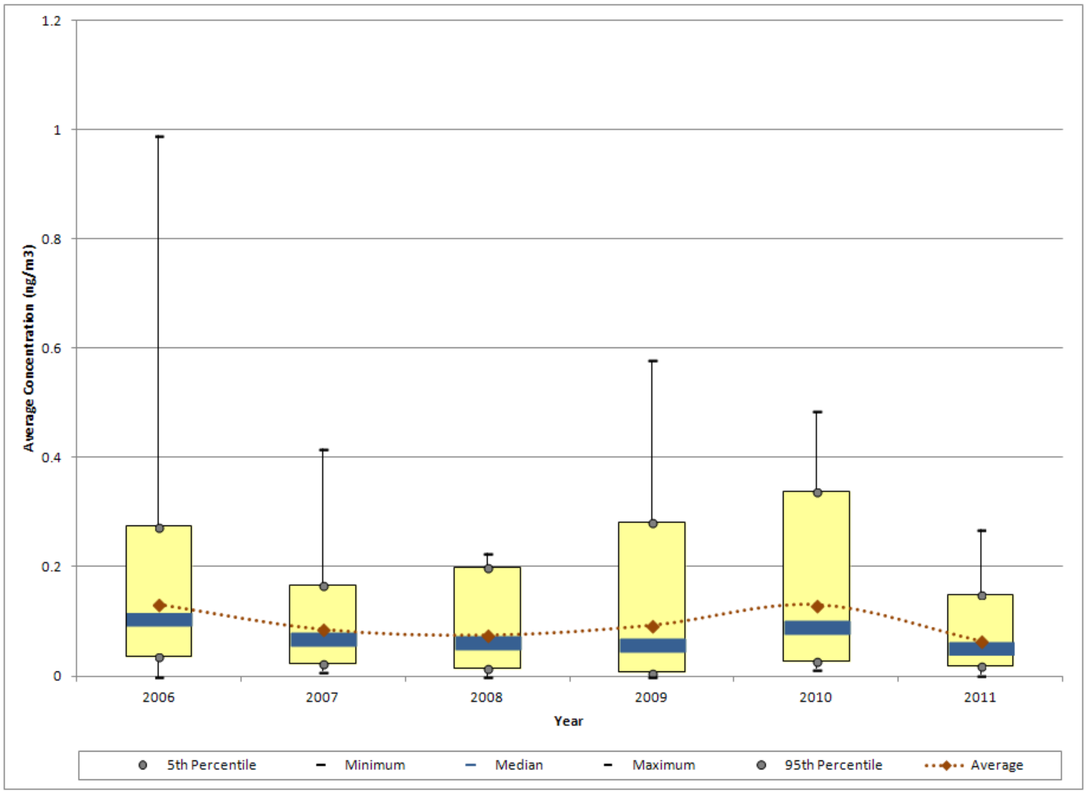


Figure 5-20. Annual Statistical Metrics for Lead (PM_{10}) Concentrations Measured at PXSS

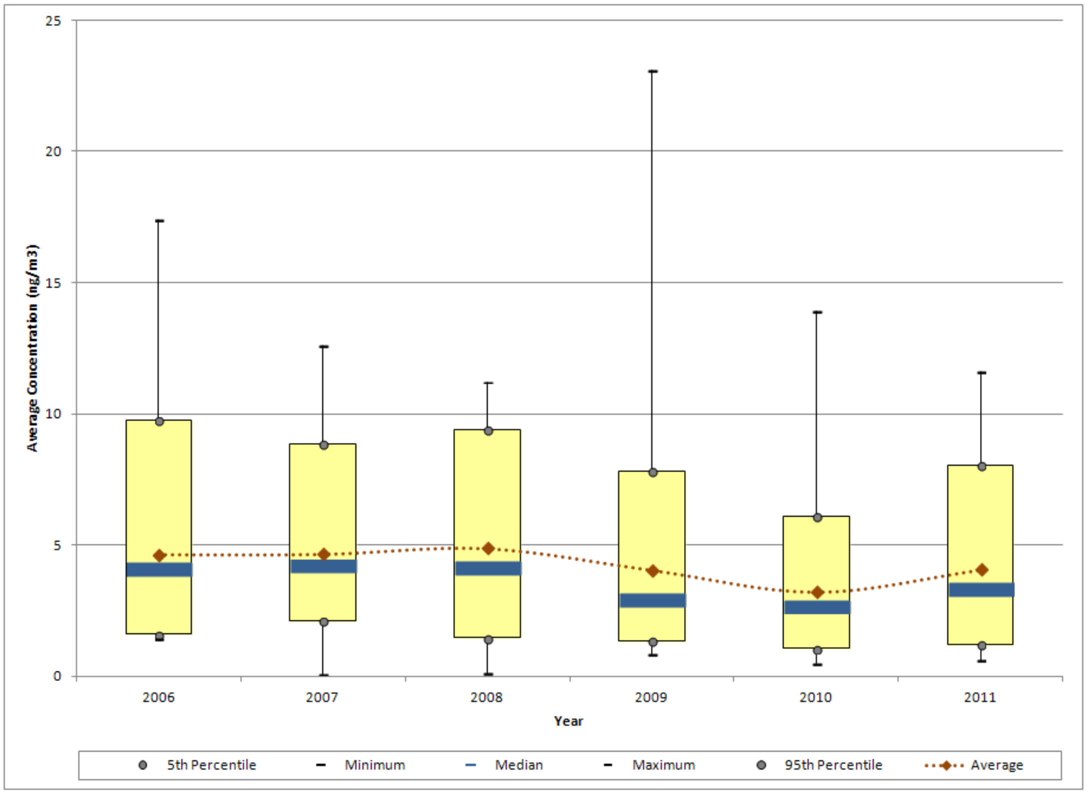
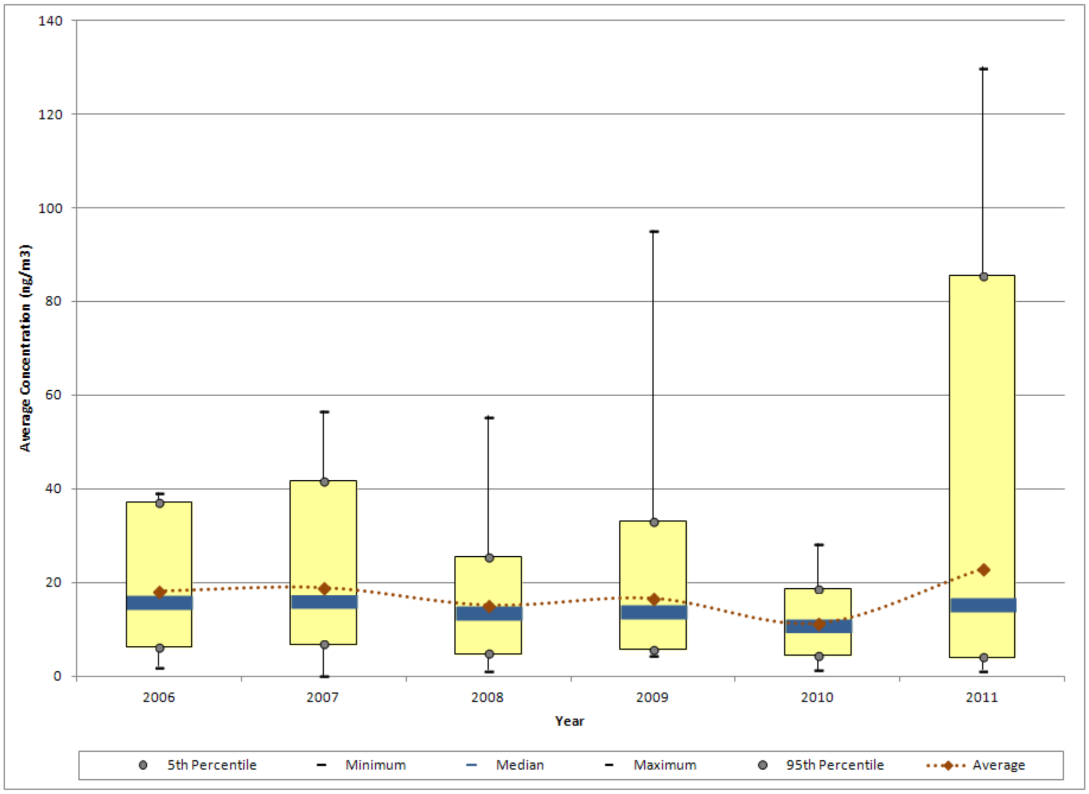


Figure 5-21. Annual Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at PXSS



Observations from Figure 5-18 for arsenic measurements 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 average concentration increased from 2010 to 2011 after several years of slight decreasing, although the changes across the years of sampling are not statistically significant. The averages range from 0.51 ng/m^3 in 2010 to 0.77 ng/m^3 in 2011.

Observations from Figure 5-19 for hexavalent chromium measurements at PXSS include the following:

- PXSS began sampling hexavalent chromium in January 2006.

- The maximum hexavalent chromium concentration shown was measured on July 10, 2006 (0.989 ng/m^3). The second highest concentration was also measured in 2006 (0.737 ng/m^3).

- There is little statistical difference in the average concentrations, which range from 0.06 ng/m^3 in 2011 to 0.13 ng/m^3 in 2006 and 2010.

- For 2011, the difference between the average and the median concentrations is at a minimum, indicating decreasing variability in the concentrations measured.

Observations from Figure 5-20 for lead measurements at PXSS include the following:

- The maximum lead concentration (23.1 ng/m^3) was measured on January 1, 2009. The second highest concentration (17.4 ng/m^3) was measured on December 31, 2006.

- Similar to arsenic, the average lead concentrations exhibit an increase for 2011 after a decreasing trend between 2008 and 2010.

- There have been no non-detects reported for lead since the onset of lead sampling at PXSS. The minimum concentrations for 2007 and 2008 are considerably less than the others, but are still numerical measurements.

Observations from Figure 5-21 for manganese measurements at PXSS include the following:

- Three manganese concentrations greater than 100 ng/m^3 have been measured at PXSS since 2006; all three were measured in 2011. Of the nine concentrations greater than 50 ng/m^3, five were measured during 2011.

- The annual average concentration of manganese for 2011 is twice the average for 2010 and represents a significant increase between the two years. Over the course of sampling, the measurements from 2011 exhibit the highest variability while the measurements from 2010 exhibit the least. Regardless, this site still has some of the highest levels of manganese among sites sampling PM_{10} metals; PXSS had the second highest annual average concentration of manganese for 2010 and the highest annual average across the program for 2011.

- The 95th percentile for 2011 is significantly higher than for the previous years of sampling, indicating that a greater number of concentrations were on the higher side for 2011.

- The widening difference between the median and the annual average concentration for 2011 is a further indication of the increasing variability of the 2011 manganese measurements, whereas for 2010, the median and average concentrations were less than 0.30 ng/m^3 apart.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 with the highest annual average concentrations by mass are benzene, ethylbenzene, and carbon tetrachloride, with only benzene having an annual average concentration greater than 1 $\mu g/m^3$.

- Based on the annual averages and cancer UREs, benzene, 1,3-butadiene, and carbon tetrachloride have the three highest cancer risk approximations. An additional four pollutants have cancer risk approximations greater than 1.0 in-a-million.

- 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 (0.46).

- The noncancer hazard approximation for PXSS for manganese is the third highest noncancer hazard approximation calculated across the program and the second highest for this pollutant (second only to TOOK).

- Annual averages (and therefore cancer risk and noncancer hazard approximations) could not be calculated for acetaldehyde and formaldehyde, as discussed in Section 5.4.1.

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

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 Hazard Approximation (HQ)
Phoenix, Arizona - PXSS						
Acetaldehyde	0.0000022	0.009	48/48	NA	NA	NA
Arsenic (PM$_{10}$)[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	3.33	0.05
Benzene	0.0000078	0.03	61/61	1.34 ± 0.22	10.48	0.04
Benzo(a)pyrene[a]	0.00176	--	30/57	<0.01 ± <0.01	0.18	--
Beryllium (PM$_{10}$)[a]	0.0024	0.00002	61/61	<0.01 ± <0.01	0.11	<0.01
1,3-Butadiene	0.00003	0.002	56/61	0.23 ± 0.06	6.89	0.11
Cadmium (PM$_{10}$)[a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.25	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.63 ± 0.03	3.80	0.01
Chloroform	--	0.098	57/61	0.37 ± 0.07	--	<0.01
p-Dichlorobenzene	0.000011	0.8	55/61	0.20 ± 0.04	2.19	<0.01
1,2-Dichloroethane	0.000026	2.4	12/61	0.02 ± 0.01	0.57	<0.01
Ethylbenzene	0.0000025	1	61/61	0.82 ± 0.13	2.05	<0.01
Formaldehyde	0.000013	0.0098	48/48	NA	NA	NA
Hexavalent Chromium[a]	0.012	0.0001	62/62	<0.01 ± <0.01	0.78	<0.01
Lead (PM$_{10}$)[a]	--	0.00015	61/61	<0.01 ± <0.01	--	0.03
Manganese (PM$_{10}$)[a]	--	0.00005	61/61	0.02 ± 0.01	--	0.46
Naphthalene[a]	0.000034	0.003	57/57	0.09 ± 0.02	3.04	0.03
Nickel (PM$_{10}$)[a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.83	0.02
Tetrachloroethylene	0.00000026	0.04	56/61	0.55 ± 0.28	0.14	0.01
Trichloroethylene	0.0000048	0.002	16/61	0.02 ± 0.01	0.10	0.01
Vinyl Chloride	0.0000088	0.1	5/61	<0.01 ± <0.01	0.01	<0.01

-- = 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 5-5.

Table 5-6. Risk Approximations for the Arizona 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 Hazard Approximation (HQ)
South Phoenix, Arizona - SPAZ						
Benzene	0.0000078	0.03	31/31	1.65 ± 0.45	12.88	0.06
1,3-Butadiene	0.00003	0.002	30/31	0.29 ± 0.10	8.66	0.14
Carbon Tetrachloride	0.000006	0.1	30/31	0.63 ± 0.07	3.79	0.01
Chloroform	--	0.098	26/31	0.18 ± 0.04	--	<0.01
1,2-Dichloroethane	0.000026	2.4	7/31	0.02 ± 0.01	0.56	<0.01
Ethylbenzene	0.0000025	1	31/31	1.06 ± 0.28	2.66	<0.01
p-Dichlorobenzene	0.000011	0.8	29/31	0.26 ± 0.07	2.91	<0.01
Tetrachloroethylene	0.00000026	0.04	28/31	0.41 ± 0.16	0.11	0.01
Trichloroethylene	0.0000048	0.002	12/31	0.05 ± 0.03	0.24	0.02
Xylenes	--	0.1	31/31	4.06 ± 1.14	--	0.04

-- = 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 5-5.

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

- The pollutants with the highest annual average concentrations by mass are xylenes, benzene, and ethylbenzene. These three pollutants are the only ones with an annual average concentration greater than 1 $\mu g/m^3$.

- Based on the annual averages and cancer UREs, benzene, 1,3-butadiene, and carbon tetrachloride have the three highest cancer risk approximations. Two additional pollutants have cancer risk approximations greater than 1.0 in-a-million.

- The cancer risk approximation for SPAZ for benzene (12.88 in-a-million) is the second highest cancer risk approximation calculated for this pollutant across the program (second only to TOOK). The cancer risk approximation for PXSS for benzene (10.48 in-a-million) ranks fifth.

- 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 (0.14).

5.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 5-7 and 5-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 5-6. Table 5-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 5-6.

The pollutants listed in Table 5-7 and 5-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 5.3, PXSS sampled for VOCs, carbonyl compounds, PAHs, metals (PM_{10}), and hexavalent chromium; SPAZ sampled for VOCs only. 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, cancer risk and noncancer hazard approximations were not calculated for formaldehyde and acetaldehyde. A more in-depth discussion of this analysis is provided in Section 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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	1,256.37	Formaldehyde	1.26E-02	Benzene	10.48
Formaldehyde	969.28	Benzene	9.80E-03	1,3-Butadiene	6.89
Ethylbenzene	766.10	1,3-Butadiene	5.38E-03	Carbon Tetrachloride	3.80
Acetaldehyde	487.50	Naphthalene	3.08E-03	Arsenic	3.33
1,3-Butadiene	179.20	Ethylbenzene	1.92E-03	Naphthalene	3.04
Naphthalene	90.54	Hexavalent Chromium, PM	1.70E-03	*p*-Dichlorobenzene	2.19
Dichloromethane	28.45	POM, Group 2b	1.29E-03	Ethylbenzene	2.05
POM, Group 2b	14.68	Acetaldehyde	1.07E-03	Nickel	0.83
POM, Group 1a	2.61	Arsenic, PM	7.14E-04	Hexavalent Chromium	0.78
Propylene oxide	1.66	POM, Group 5a	3.83E-04	1,2-Dichloroethane	0.57
South Phoenix, Arizona (Maricopa County) – SPAZ					
Benzene	1,256.37	Formaldehyde	1.26E-02	Benzene	12.88
Formaldehyde	969.28	Benzene	9.80E-03	1,3-Butadiene	8.66
Ethylbenzene	766.10	1,3-Butadiene	5.38E-03	Carbon Tetrachloride	3.79
Acetaldehyde	487.50	Naphthalene	3.08E-03	*p*-Dichlorobenzene	2.91
1,3-Butadiene	179.20	Ethylbenzene	1.92E-03	Ethylbenzene	2.66
Naphthalene	90.54	Hexavalent Chromium, PM	1.70E-03	1,2-Dichloroethane	0.56
Dichloromethane	28.45	POM, Group 2b	1.29E-03	Trichloroethylene	0.24
POM, Group 2b	14.68	Acetaldehyde	1.07E-03	Tetrachloroethylene	0.11
POM, Group 1a	2.61	Arsenic, PM	7.14E-04		
Propylene oxide	1.66	POM, Group 5a	3.83E-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	3,931.16	Acrolein	2,430,403.47	Manganese	0.46
Xylenes	2,893.73	Formaldehyde	98,905.78	1,3-Butadiene	0.11
Benzene	1,256.37	1,3-Butadiene	89,599.85	Arsenic	0.05
Formaldehyde	969.28	Acetaldehyde	54,166.44	Benzene	0.04
Hexane	963.82	Lead, PM	42,964.38	Naphthalene	0.03
Ethylbenzene	766.10	Benzene	41,879.01	Lead	0.03
Acetaldehyde	487.50	Naphthalene	30,178.52	Nickel	0.02
Ethylene glycol	240.60	Xylenes	28,937.26	Cadmium	0.01
1,3-Butadiene	179.20	Arsenic, PM	11,077.09	Tetrachloroethylene	0.01
Glycol ethers, gas	98.40	Propionaldehyde	8,611.73	Trichloroethylene	0.01
South Phoenix, Arizona (Maricopa County) – SPAZ					
Toluene	3,931.16	Acrolein	2,430,403.47	1,3-Butadiene	0.14
Xylenes	2,893.73	Formaldehyde	98,905.78	Benzene	0.06
Benzene	1,256.37	1,3-Butadiene	89,599.85	Xylenes	0.04
Formaldehyde	969.28	Acetaldehyde	54,166.44	Trichloroethylene	0.02
Hexane	963.82	Lead, PM	42,964.38	Tetrachloroethylene	0.01
Ethylbenzene	766.10	Benzene	41,879.01	Carbon Tetrachloride	0.01
Acetaldehyde	487.50	Naphthalene	30,178.52	Chloroform	<0.01
Ethylene glycol	240.60	Xylenes	28,937.26	Ethylbenzene	<0.01
1,3-Butadiene	179.20	Arsenic, PM	11,077.09	*p*-Dichlorobenzene	<0.01
Glycol ethers, gas	98.40	Propionaldehyde	8,611.73	1,2-Dichloroethane	<0.01

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.

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

- Benzene, 1,3-butadiene, and carbon tetrachloride have highest cancer risk approximations for both PXSS and SPAZ. While benzene and 1,3-butadiene both appear among the pollutants with the 10 highest emissions and 10 highest toxicity-weighted emissions for Maricopa County, carbon tetrachloride does not appear on either list. In addition to benzene and 1,3-butadiene, ethylbenzene also appears on all three lists for both sites. Naphthalene also appears on all three lists for PXSS.

- POM, Group 2b is the eighth highest emitted "pollutant" in Maricopa County and ranks seventh for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at PXSS including acenaphthene, benzo(e)pyrene, fluoranthene, and perylene. None of the PAHs included in POM, Group 2b were identified as pollutants of interest for PXSS.

- POM, Group 5a is the pollutant with the tenth highest toxicity-weighted emissions for Maricopa County. Benzo(a)pyrene is part of POM, Group 5a.

Observations from Table 5-8 include the following:

- Toluene, xylenes, and benzene 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.

- 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.

- Manganese has the highest noncancer hazard approximation for PXSS (although considerably less than an HQ of 1.0), followed by 1,3-butadiene. 1,3-Butadiene has the highest noncancer hazard approximation for SPAZ. In addition to 1,3-butadiene, benzene and xylenes all appear on all three lists for both sites.

- Five metals appear among the 10 pollutants with highest noncancer hazard approximations for PXSS. Two of these (arsenic and lead) are among those with the highest toxicity-weighted emissions while none appear among the highest emitted pollutants in Maricopa County.

5.6 Summary of the 2011 Monitoring Data for PXSS and SPAZ

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

- *Twenty-three pollutants failed screens for PXSS; 14 of these are NATTS MQO Core Analytes. Ten pollutants failed screens for SPAZ, of which four are NATTS MQO Core Analytes.*

- *Of the site-specific pollutants of interest for PXSS, benzene had the highest annual average concentration and was the only pollutant with an annual average greater than 1 µg/m*^{3}*. For SPAZ, xylenes 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 slightly higher during the colder months of the year.*

- *PXSS has the highest annual average concentration of tetrachloroethylene, hexavalent chromium, beryllium (*PM_{10}*), and manganese (*PM_{10}*) among all NMP sites sampling these pollutants; SPAZ has the highest annual average concentration of 1,3-butadiene, p-dichlorobenzene, and ethylbenzene among all NMP sites sampling VOCs.*

6.0 Sites in California

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at three NATTS sites 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, Rubidoux, and San Jose. Figures 6-1, 6-3, and 6-5 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban locations. Figures 6-2, 6-4, and 6-6 identify nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figures 6-2, 6-4, and 6-6. 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 maps, but have been grayed out in order to show emissions sources just outside the boundary. 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

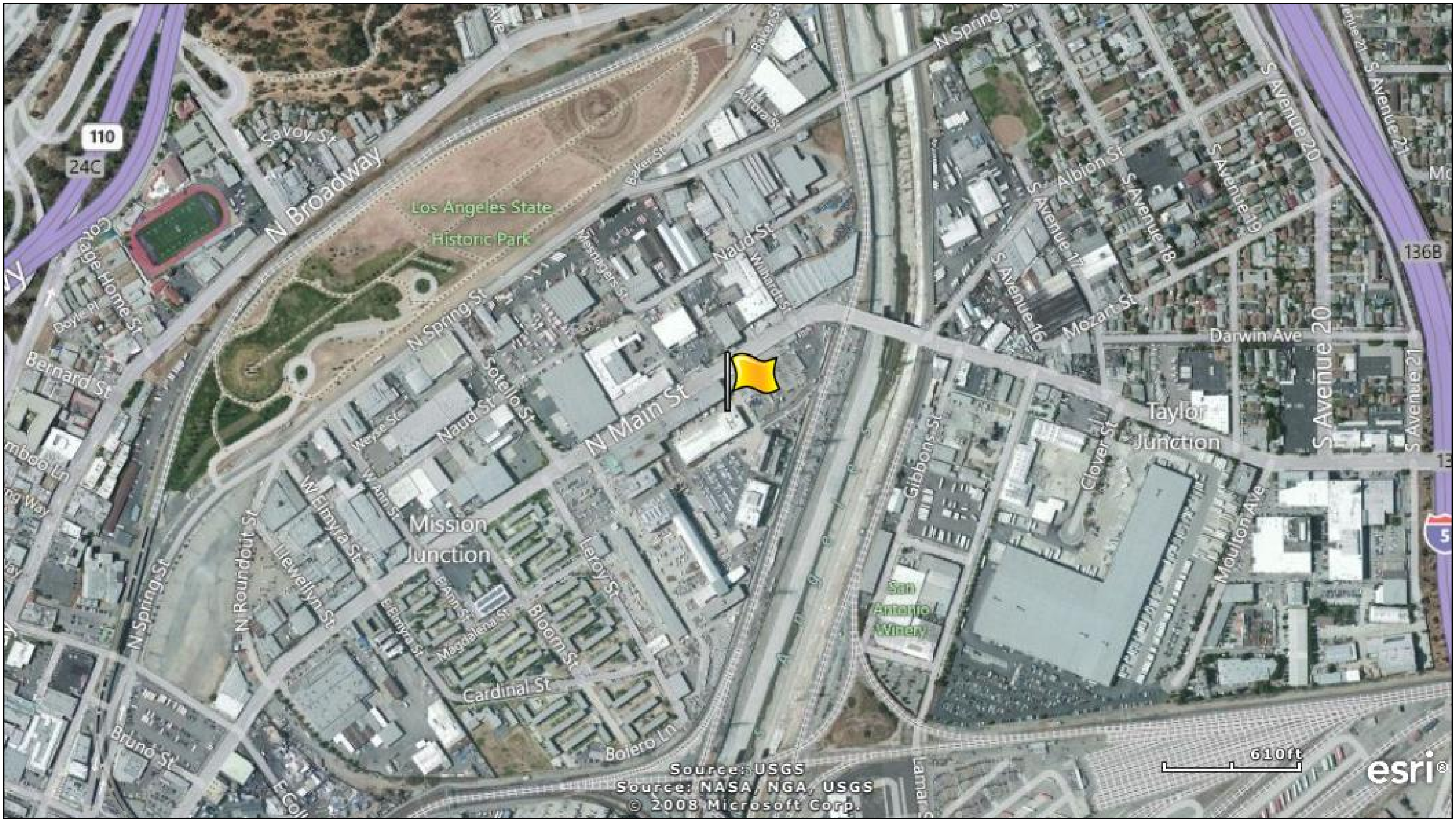
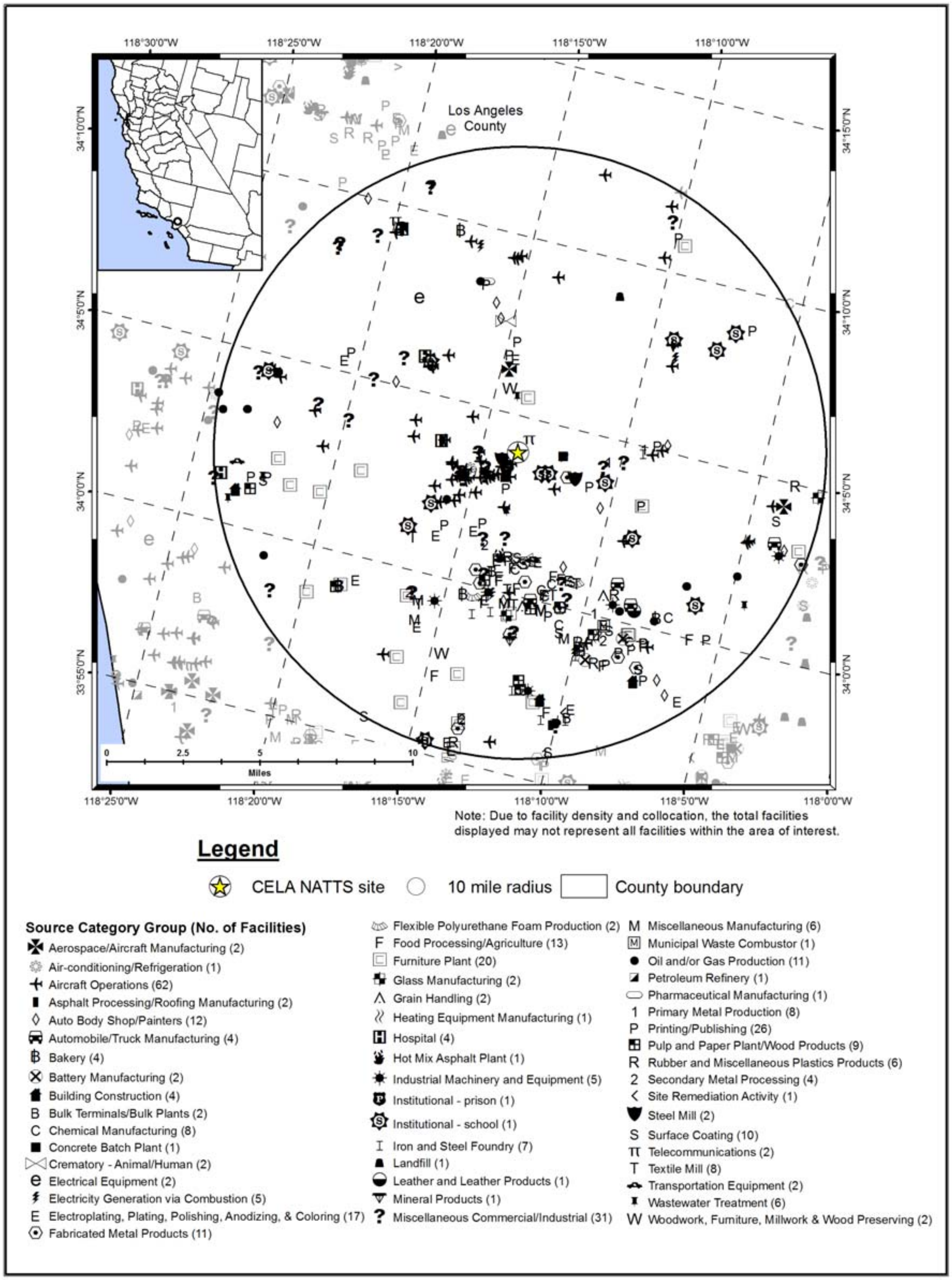
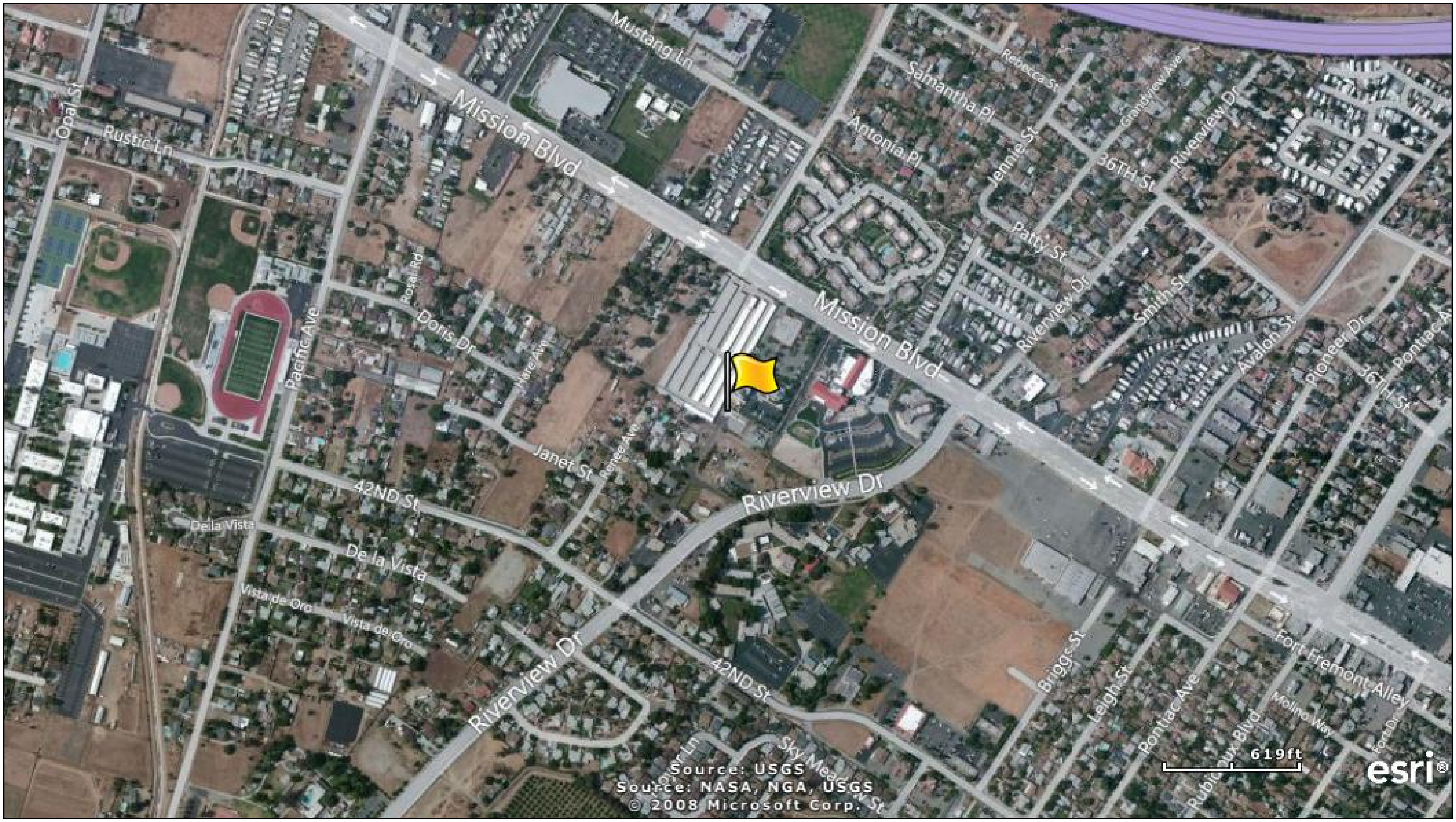


Figure 6-2. NEI Point Sources Located Within 10 Miles of CELA



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

Figure 6-3. Rubidoux, California (RUCA) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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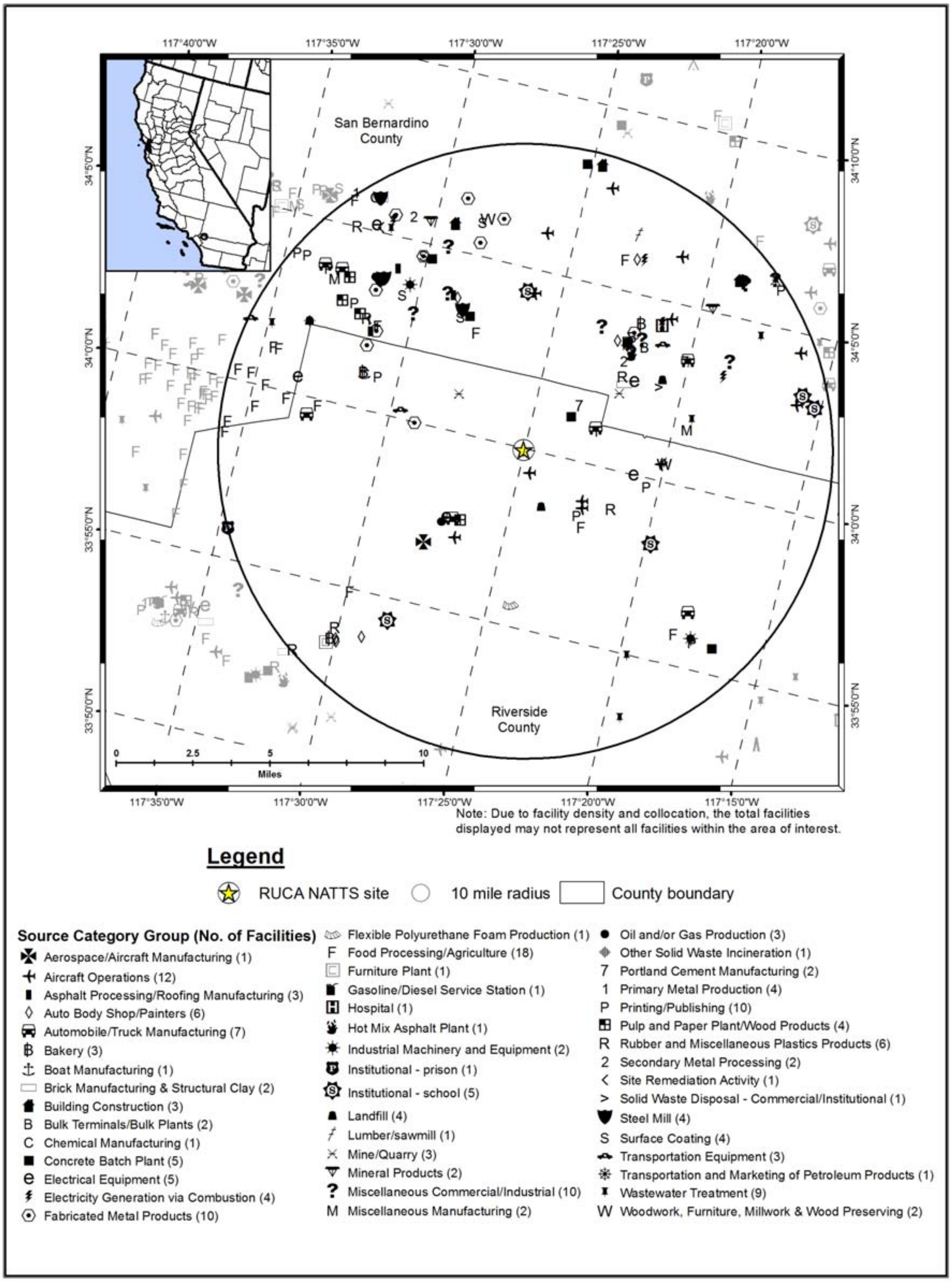
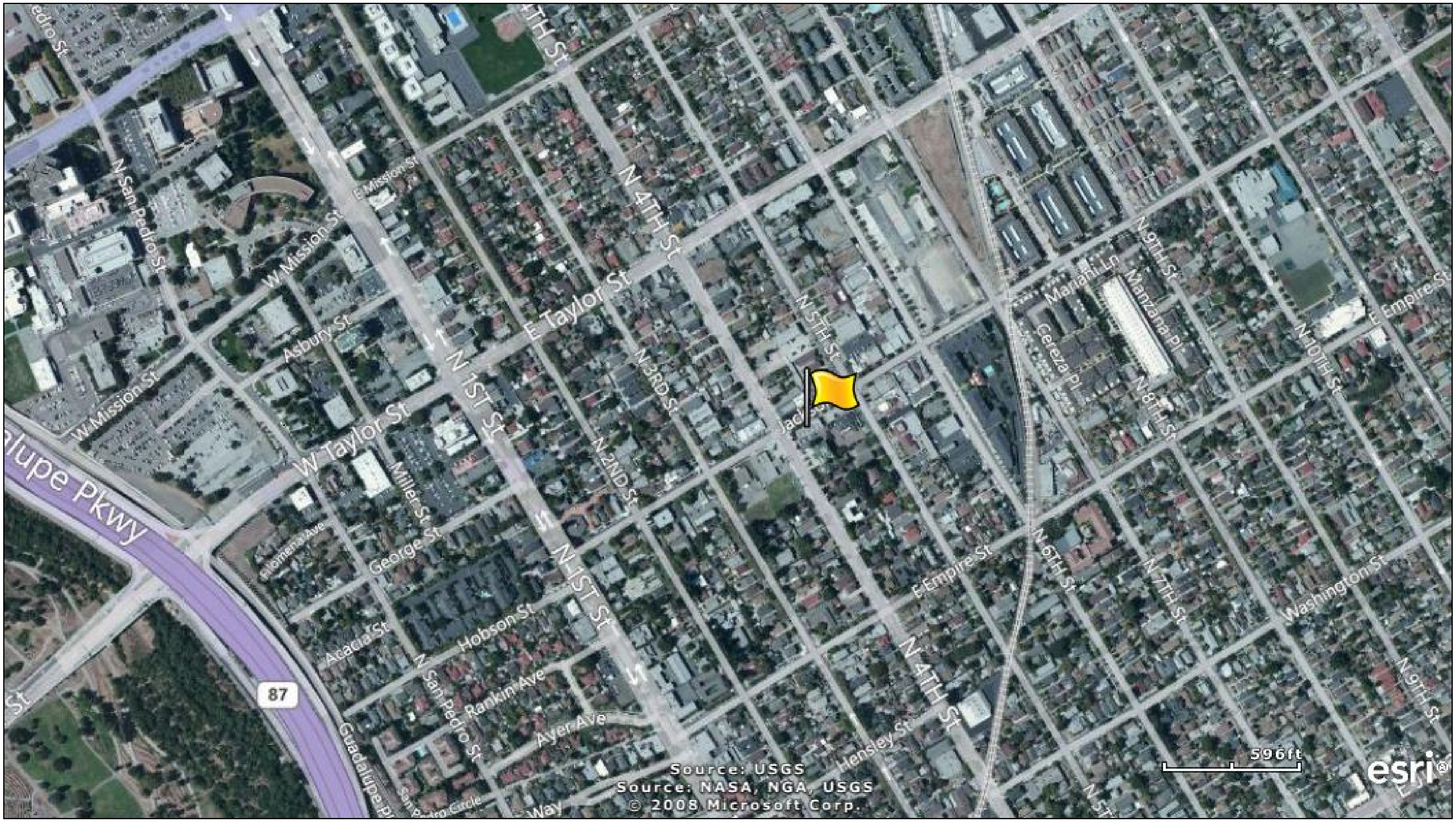
Figure 6-4. NEI Point Sources Located Within 10 Miles of RUCA



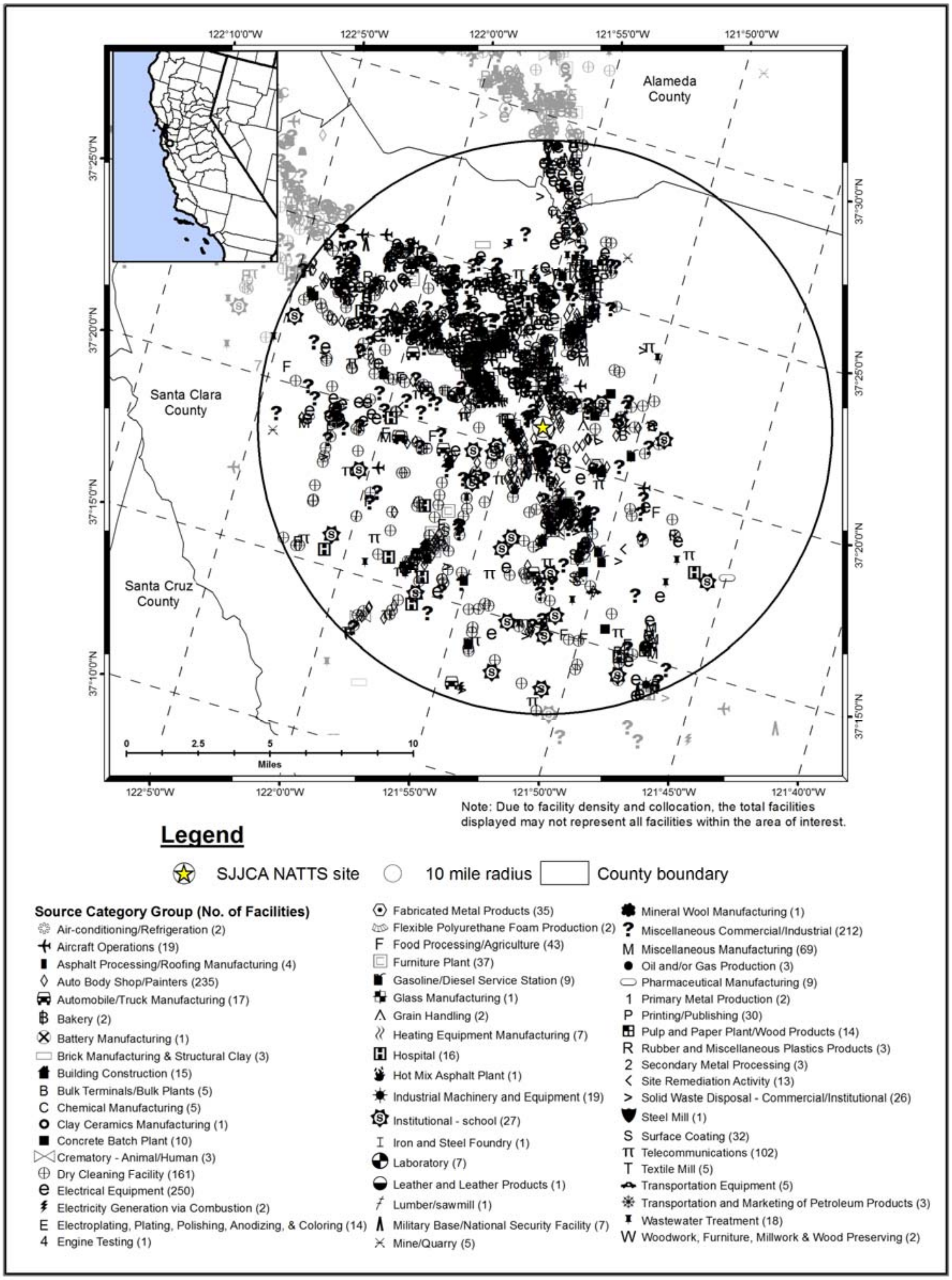
Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 6-5. San Jose, California (SJJCA) Monitoring Site



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

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



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

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-Santa Ana, 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, $PM_{2.5}$, $PM_{2.5}$ Speciation.
RUCA	06-065-8001	Rubidoux	Riverside	Riverside-San Bernardino-Ontario, CA MSA	33.99958, -117.41601	Residential	Suburban	Haze, TSP Speciation, Hexavalent chromium, CO, SO_2, NO, NO_2, NO_x, PAMS, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, PM coarse, $PM_{2.5}$, $PM_{2.5}$ Speciation.
SJJCA	06-085-0005	San Jose	Santa Clara	San Jose-Sunnyvale-Santa Clara, CA MSA	37.3485, -121.895	Commercial	Urban/City Center	TSP Speciation, Hexavalent chromium, CO, SO_2, NO, NO_2, NO_x, VOCs, Carbonyl compounds, O_3, NMOC, Meteorological parameters, PM_{10}, PM_{10} Speciation, Black carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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. As Figure 6-2 shows, CELA is situated among numerous point sources. There is a cluster of emissions sources located just to the southwest of CELA. A large number of emissions sources within 10 miles of CELA are involved in aircraft operations, which include airports as well as small runways, heliports, or landing pads; furniture products; electroplating, plating, polishing, anodizing, and coloring; and printing or publishing.

RUCA is located just outside of Riverside, in a residential area of the suburban town of Rubidoux. 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. Figure 6-3 shows that RUCA is adjacent to a power substation near the intersection of Mission Boulevard and Riverview Drive. RUCA and CELA are located less than 45 miles apart. Figure 6-4 shows that fewer emissions sources surround RUCA than CELA. 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. The emissions source categories with the highest number of sources near RUCA include food processing, aircraft operations, printing and publishing, and fabricated metals products.

SJJCA is located in central San Jose. Figure 6-5 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 6-5. Guadalupe Parkway, which can be seen on the bottom left of Figure 6-5, 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. Figure 6-6 shows that the density of point sources is significantly higher near SJJCA than CELA and RUCA. The emissions source categories with the highest number of sources are electrical equipment; auto body/paint shops; dry cleaning; and telecommunications.

Table 6-2 presents additional site-characterizing information, including indicators of mobile source activity, for the California monitoring sites. Table 6-2 includes county-level population and vehicle registration information. Table 6-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 6-2 also contains traffic volume information for each site. Finally, 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]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
CELA	9,889,056	7,360,573	0.74	3,557,102	2,647,604	230,000	214,458,140
RUCA	2,239,620	1,711,492	0.76	1,026,542	784,472	145,000	55,717,760
SJJCA	1,809,378	1,517,190	0.84	1,482,077	1,242,743	104,000	41,250,490

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the California DMV (CA DMV, 2011)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data from the California DOT (CA DOT, 2011)
[5] County-level VMT reflects 2011 data from the California DOT (CA DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 6-2 include the following:

- Los Angeles County (CELA) has the highest county-level population and vehicle registration compared to all counties with NMP sites. CELA also has the highest 10-mile estimated vehicle ownership. However, the 10-mile population near this site ranks second behind MONY, which is located in Bronx County and part of New York City.

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

- Among the California sites, the vehicle-per-person ratio is lowest for the most populous area (CELA) and highest for the least populated area (SJJCA), based on county population, although all three sites are located in highly populated areas. In general, this trend is also true among all NMP sites.

- CELA experiences the second highest annual average daily traffic among NMP sites, and has a substantially higher traffic volume than both RUCA and SJJCA (although all three rank in the top third among NMP sites). The traffic count for CELA is based on data from I-5 near Exit 136A at Main Street. The traffic count for RUCA is based on data from Mission Boulevard at Rubidoux Boulevard. The traffic count for SJJCA is based on the intersection of Guadalupe Parkway at West Taylor Street.

- 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).

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. 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 (Bair, 1992 and 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 (Bair, 1992 and NOAA, 1999).

6.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2010 and 2011 (NCDC, 2010 and 2011). The weather station nearest CELA is located at Downtown Los Angeles/USC Campus; the nearest NWS weather station to RUCA is located at Riverside Municipal Airport; and the nearest NWS station to SJJCA is located at San Jose International (WBAN 93134, 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 the entire year for 2011. For SJJCA, meteorological data for the additional days from 2010, as discussed in Section 2.3, have been included in the averages presented in Table 6-3. 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 these sites were representative of average weather conditions throughout the year. The most significant difference in the table is for average relative humidity for RUCA. Table 6-3 shows a marked wind speed difference between CELA and RUCA (which are located 45 miles apart), as alluded to in Section 6.2.1, although wind speeds for both sites are very light. As expected, conditions tended to be cooler near SJJCA than near CELA and RUCA.

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

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)
Los Angeles, California - CELA									
Downtown L.A./USC Campus Airport 93134 (34.03, -118.30)	4.57 miles 248° (WSW)	Sample Day	72.8 ± 2.4	62.7 ± 1.8	47.8 ± 2.5	55.0 ± 1.7	62.7 ± 3.6	1015.0 ± 1.0	1.0 ± 0.2
		2011	72.2 ± 0.9	62.6 ± 0.7	48.2 ± 1.0	55.1 ± 0.7	63.7 ± 1.4	1015.1 ± 0.4	1.2 ± 0.1
Rubidoux, California - RUCA									
Riverside Municipal Airport 03171 (33.95, -117.44)	3.49 miles 214° (SW)	Sample Day	78.3 ± 3.5	64.8 ± 2.6	42.3 ± 3.6	53.6 ± 2.1	51.5 ± 4.4	1014.0 ± 1.1	3.8 ± 0.4
		2011	77.9 ± 1.3	64.3 ± 1.0	43.8 ± 1.3	53.8 ± 0.8	54.2 ± 1.7	1014.1 ± 0.4	3.8 ± 0.2
San Jose, California - SJJCA									
San Jose Intl. Airport 23293 (37.36, -121.93)	1.90 miles 316° (NW)	Sample Day	69.4 ± 2.3	58.6 ± 1.7	46.5 ± 2.1	52.4 ± 1.6	67.9 ± 2.9	1016.8 ± 1.1	4.9 ± 0.5
		Dec 2010-2011	68.7 ± 1.0	58.2 ± 0.8	46.5 ± 0.9	52.2 ± 0.7	68.6 ± 1.2	1016.8 ± 0.5	5.3 ± 0.2

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

6.2.3 Back Trajectory Analysis

Figure 6-7 is the composite back trajectory map for days on which samples were collected at the CELA monitoring site in 2011. Included in Figure 6-7 are four back trajectories per sample day. Figure 6-8 is the corresponding cluster analysis. Similarly, Figures 6-9 and 6-11 are the composite back trajectory maps for days on which samples were collected at RUCA and SJJCA and Figures 6-10 and 6-12 are the corresponding cluster analyses, respectively. 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 6-7 through 6-12 represents 100 miles.

Observations from Figures 6-7 and 6-8 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 trajectories. Although the farthest away a trajectory originated was over southwest Montana, or greater than 800 miles away, most trajectories (83 percent) originated within 300 miles of CELA (and only eight back trajectories originated greater than 500 miles away).

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

- The cluster analysis shows that roughly 70 percent of trajectories originated from the northwest and/or offshore, although of varying distances. The shorter cluster trajectory (19 percent) includes back trajectories originating to the northwest of Los Angeles as well as shorter trajectories originating just offshore. The cluster analysis also shows that 25 percent of trajectories originated from the northeast quadrant (including northerly and easterly directions). The long cluster (3 percent) originating over Idaho represents the longer trajectories originating over northeast Utah, Idaho, and Montana.

Figure 6-7. 2011 Composite Back Trajectory Map for CELA

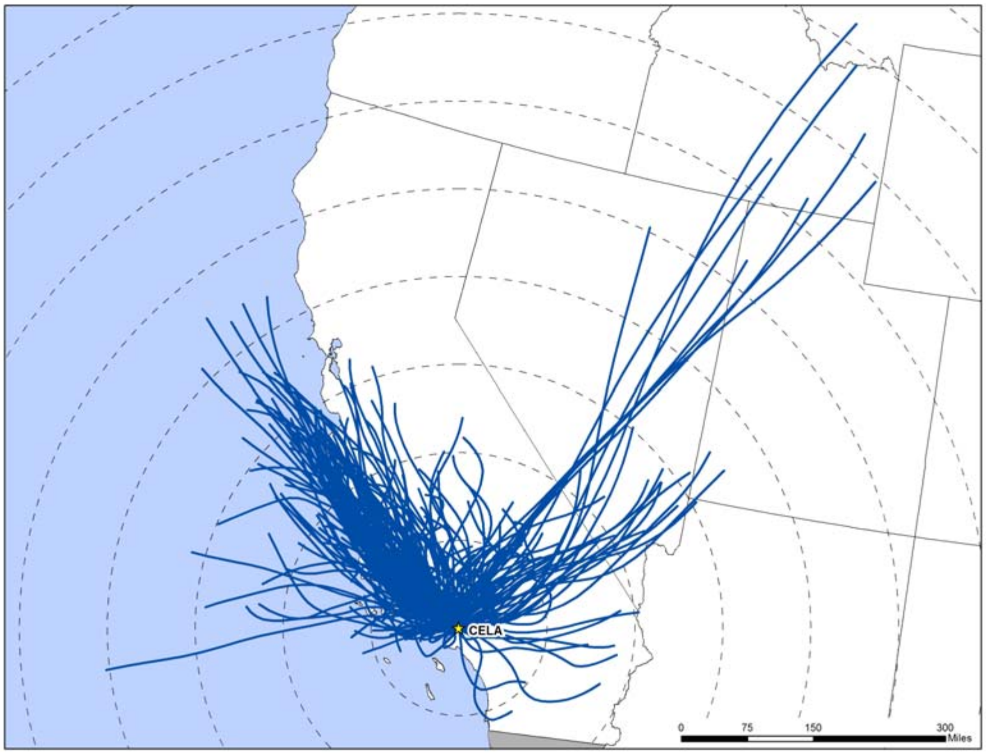


Figure 6-8. Back Trajectory Cluster Map for CELA

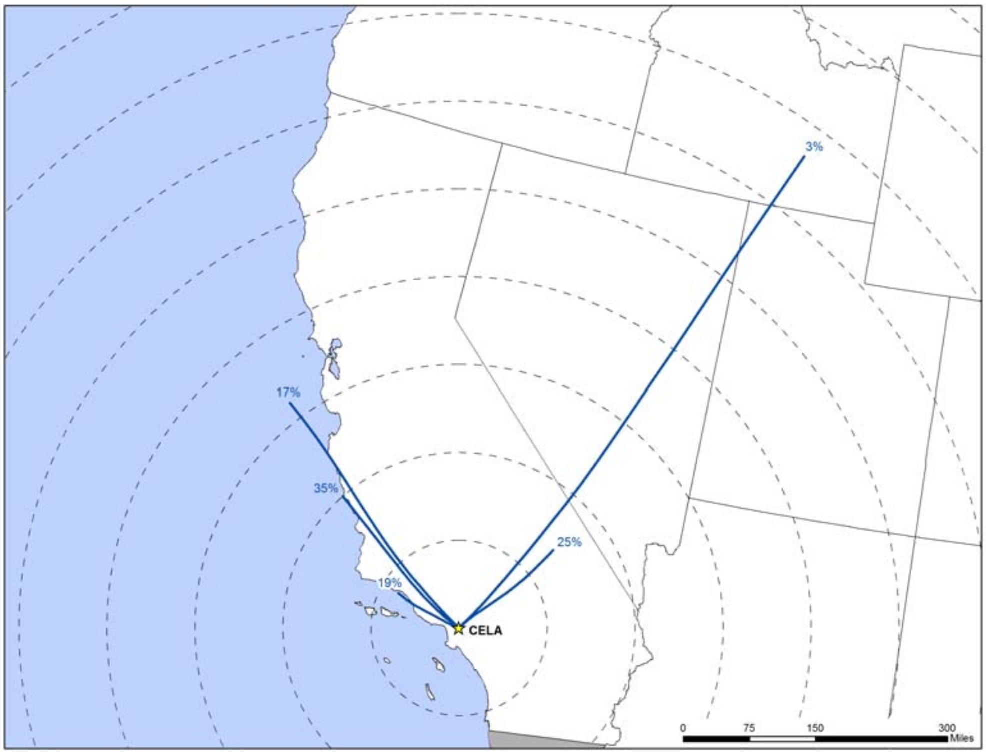


Figure 6-9. 2011 Composite Back Trajectory Map for RUCA

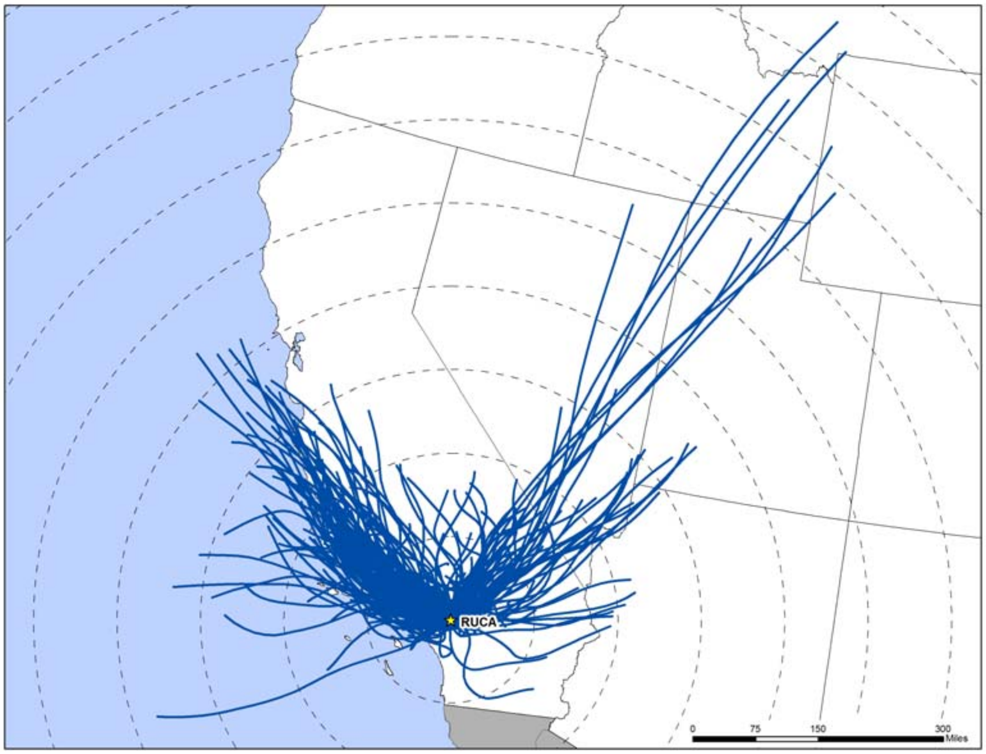


Figure 6-10. Back Trajectory Cluster Map for RUCA

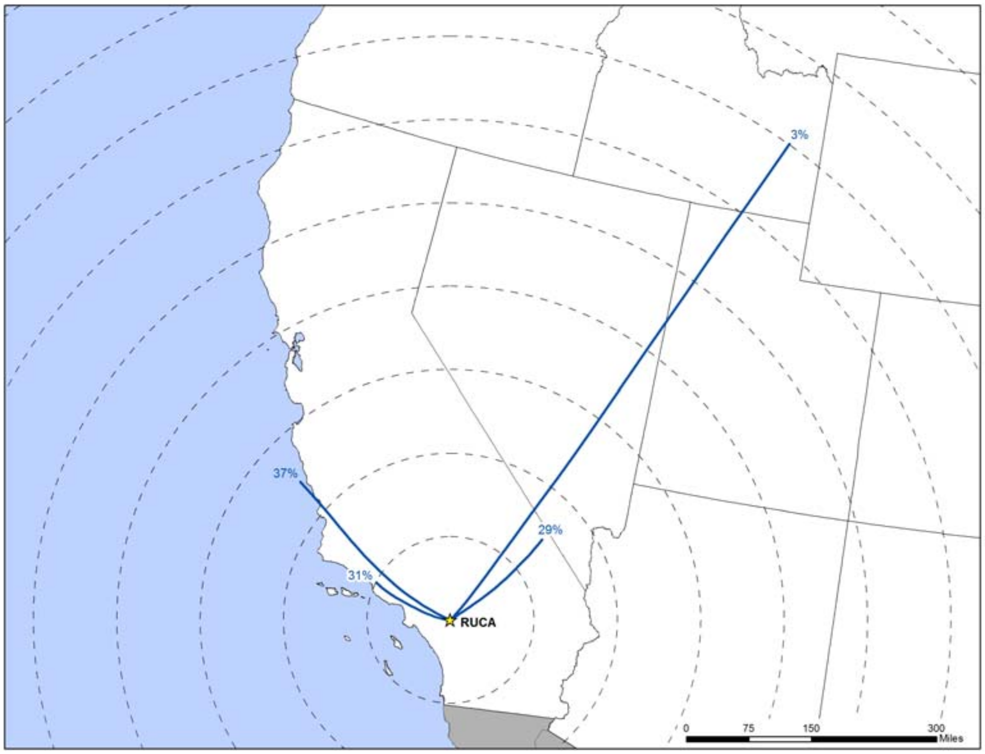


Figure 6-11. 2011 Composite Back Trajectory Map for SJJCA

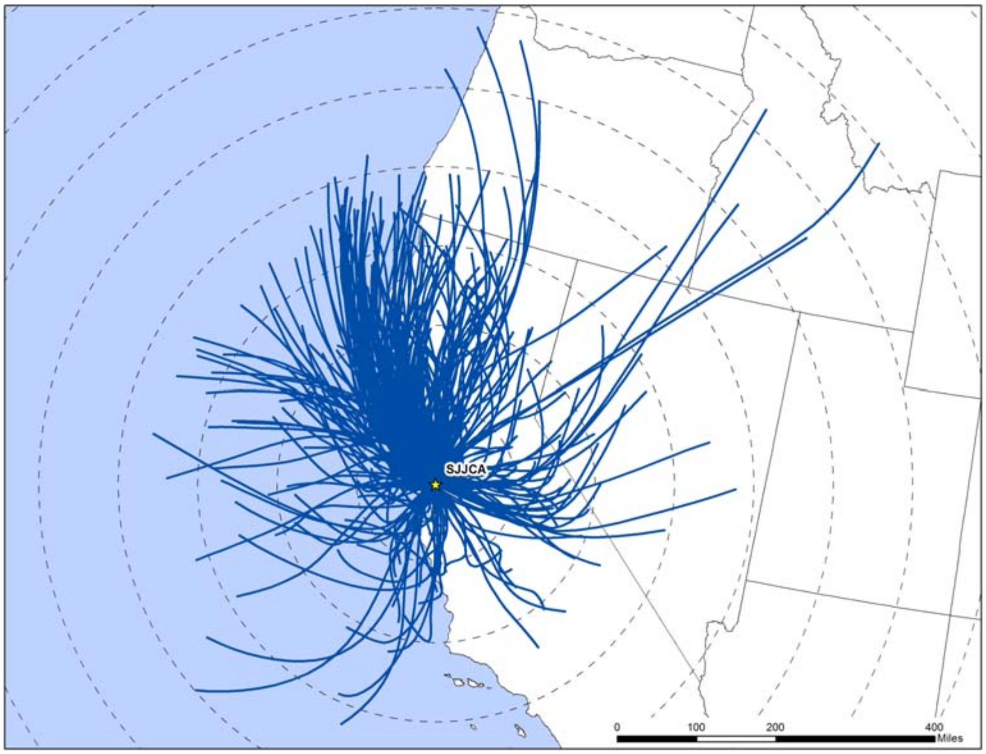
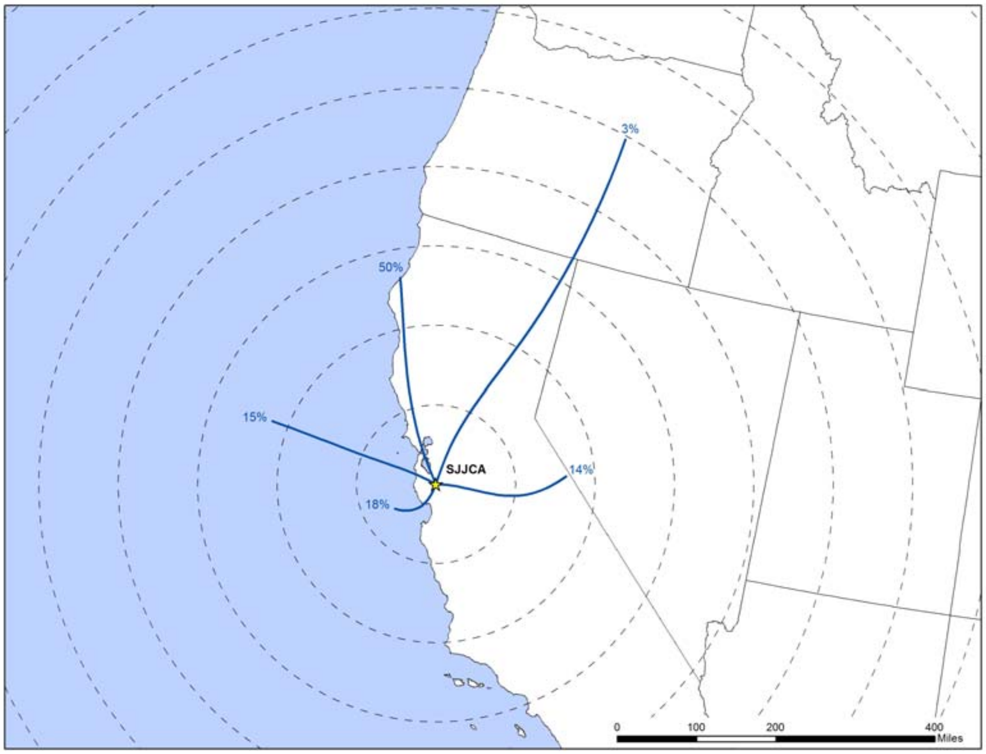


Figure 6-12. Back Trajectory Cluster Map for SJJCA



Observations from Figures 6-9 and 6-10 for RUCA include the following:

- The composite back trajectory map for RUCA resembles the one for CELA, which is not surprising given their relatively close proximity. The 24-hour air shed domain for RUCA is similar in size to CELA. The farthest away a trajectory originated was also over western Montana, or greater than 850 miles away. Most trajectories (86 percent) originated within 300 miles of RUCA and only eight trajectories originated farther than 500 miles away.

- Back trajectories originated from a variety of directions at RUCA. A large cluster of trajectories originated from the northwest of the site and a secondary cluster originated from the northeast. Few trajectories originated from the east, southeast, or south. The longest back trajectories originated to the northeast of the site.

- The cluster analysis for RUCA is similar to the cluster analysis for CELA. Figure 6-10 shows that nearly 70 percent of trajectories originated from the northwest of the site. However, the shorter trajectory (31 percent) includes some back trajectories originating from the northwest along the coastline and offshore as well as shorter trajectories originating from the west (either offshore or inland, as the clustering program uses both direction and distance to determine clusters). Another cluster (29 percent) represents those trajectories originating from the north, northeast, and east over southern California, southern Nevada, northwest Arizona, and southwest Utah. The long cluster trajectory marked with 3 percent represents the eight back trajectories originating over the inter-mountain west.

Observations from Figures 6-11 and 6-12 for SJJCA include the following:

- Based on the average length of the back trajectories, the 24-hour air shed domain for SJJCA is somewhat larger than the air shed domains for the other two California sites. The farthest away a back trajectory originated was also over western Montana or just greater than 700 miles away, which is shorter than the longest back trajectories for CELA and RUCA. Only 71 percent of back trajectories originated within 300 miles of SJJCA, while greater than 80 percent originated within 300 miles of CELA and RUCA. Eight back trajectories originated farther than 500 miles away from the site. Recall from Section 2.3, that three additional sample days from December 2010 are included in the composite back trajectory map for SJJCA.

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

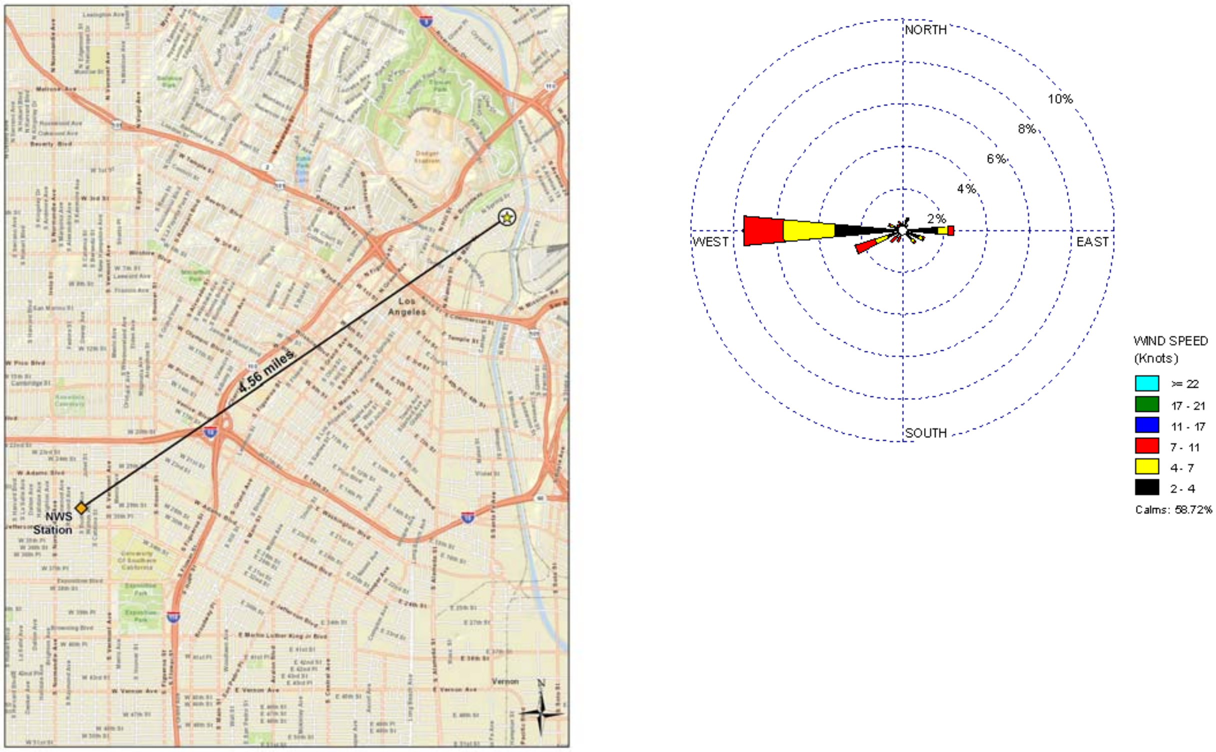
- The cluster analysis shows that 50 percent of trajectories originated from the northwest to northeast, with the cluster program grouping those from the northwest, north, and northeast together. Back trajectories originating from the northeast to east to southeast are represented by the cluster trajectory originating to the east (14 percent). The short cluster (18 percent) originating just offshore includes back trajectories less than 200 miles in length from a variety of directions as well as those longer trajectories originating from the south. Fifteen percent of back trajectories originated farther offshore. The longest trajectory (3 percent) includes the eleven trajectories originating over the Pacific Northwest and Idaho.

6.2.4 Wind Rose Comparison

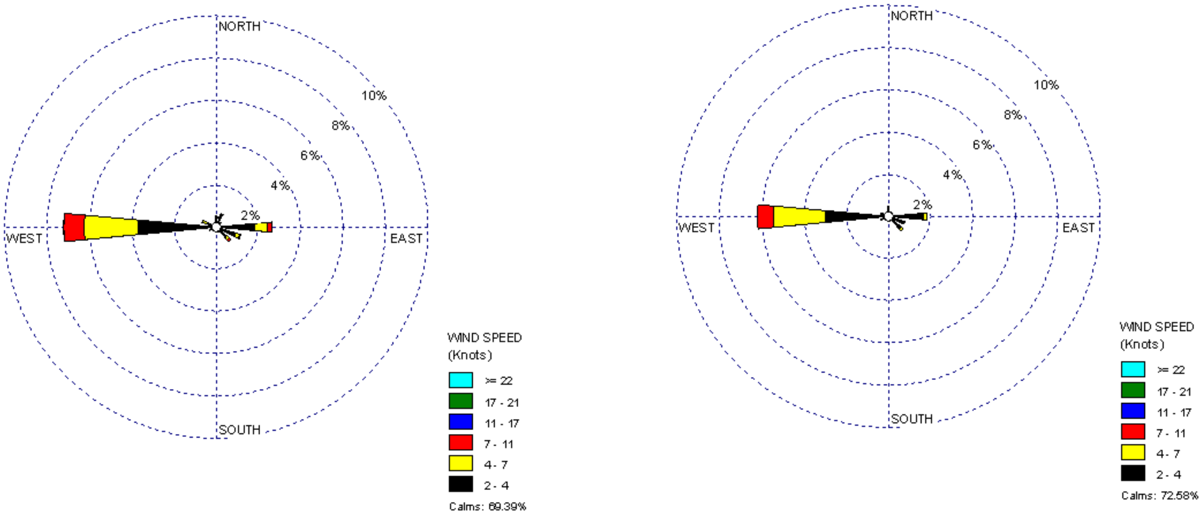
Hourly surface wind data from the NWS weather stations at the Downtown Los Angeles/USC Campus (for CELA), Riverside Municipal Airport (for RUCA), and San Jose International Airport (for SJJCA) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. 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 6-13 presents a map showing the distance between the NWS station and CELA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 6-13 also presents three different wind roses for the CELA monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 6-14 and 6-15 present the distance maps and wind roses for RUCA and SJJCA, respectively.

Figure 6-13. Wind Roses for the Downtown Los Angeles/USC Campus Weather Station near CELA


Distance between CELA and NWS Station

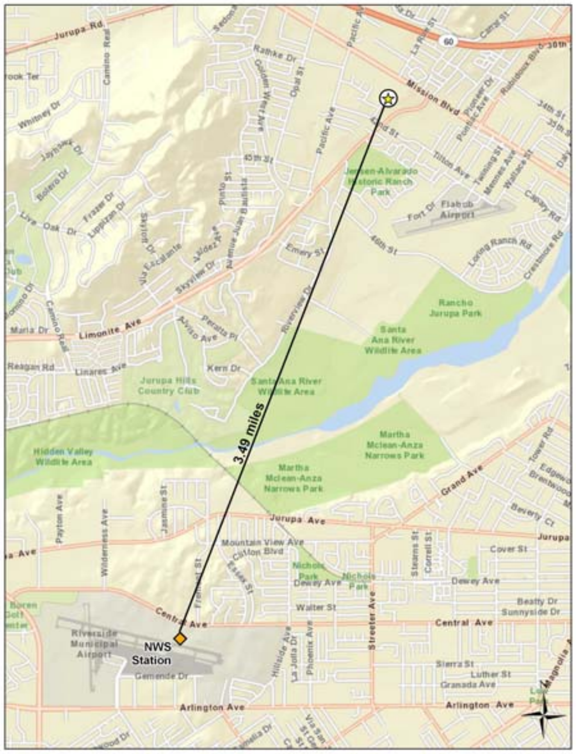
2001-2010 Historical Wind Rose


2011 Wind Rose

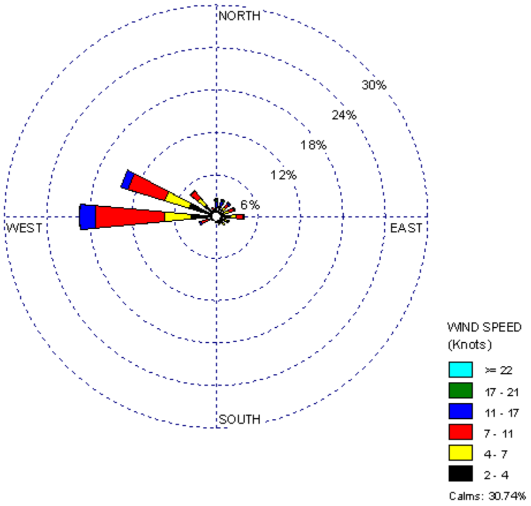
Sample Day Wind Rose

Figure 6-14. Wind Roses for the Riverside Municipal Airport Weather Station near RUCA

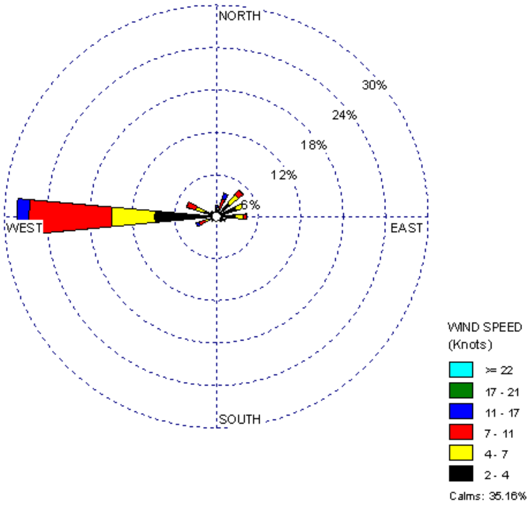
Distance between RUCA and NWS Station



2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

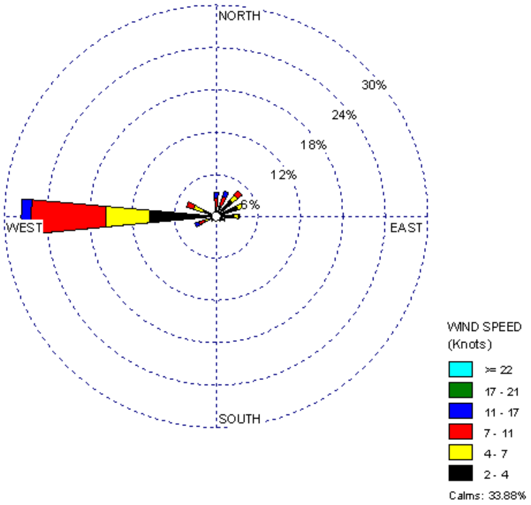
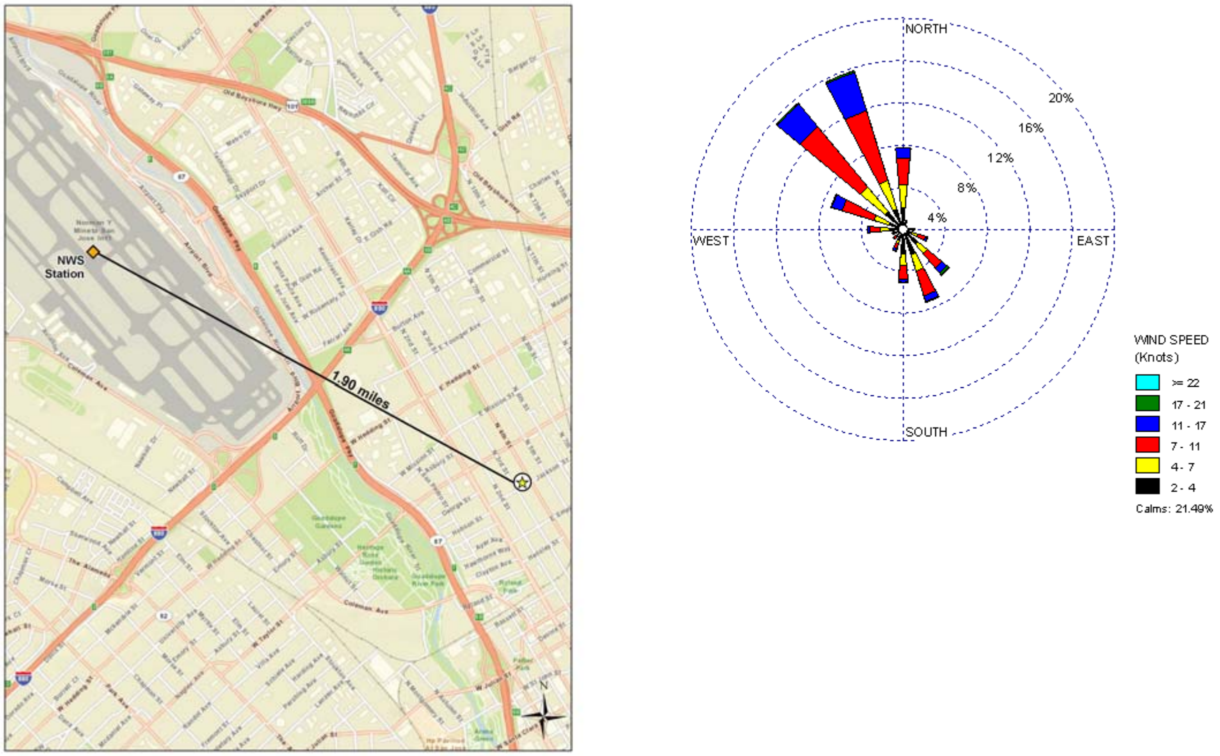


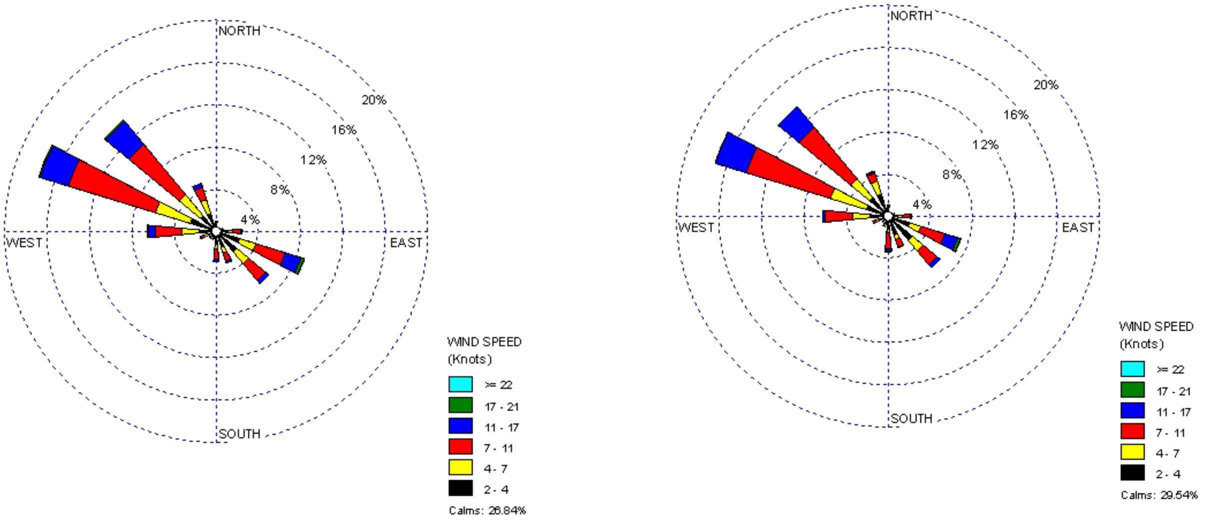
Figure 6-15. Wind Roses for the San Jose International Airport Weather Station near SJJCA


Distance between SJJCA and NWS Station

2001-2010 Historical Wind Rose

2011 Wind Rose

Sample Day Wind Rose



Observations from Figure 6-13 for CELA include the following:

- The NWS 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 nearly 60 percent of the wind observations. For wind speeds greater than 2 knots, westerly winds were most common, followed by west-southwesterly and easterly winds. Wind speeds greater than 11 knots were not measured at this weather station.

- The 2011 full-year and sample day wind roses are similar to the historical wind rose in that calm winds make up the bulk of the observations and that westerly winds were prominent. The wind patterns shown on the full-year and sample day wind roses generally resemble the historical wind patterns, indicating that conditions in 2011 and on sample days were representative of those experienced historically. However, west-southwesterly winds were rarely observed in 2011.

Observations from Figure 6-14 for RUCA include the following:

- The NWS weather station at the Riverside Municipal Airport is located across 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, based on the historical wind rose.

- The 2011 wind rose exhibits a slightly higher percentage of calm winds compared to the historical wind rose. Westerly winds make up almost the same percentage of wind observations in 2011 as both westerly and west-northwesterly winds on the historical wind rose, as west-northwesterly winds were observed less frequently in 2011 than historically.

- 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 were representative of those experienced over the entire year.

Observations from Figure 6-15 for SJJCA include the following:

- The NWS weather station at the San Jose International Airport is located approximately 2 miles northwest of SJJCA, across I-880, the Guadalupe Parkway, and the Guadalupe River.

- Between 2001 and 2010, approximately 47 percent of winds were from the west-northwest to north. Another 20 percent of winds were from the east-southeast to south. Winds from the northeastern and southwestern quadrants were rarely observed. Approximately one-fifth of the winds were calm.

- The additional days from December 2010 have been included in the 2011 full-year and sample day wind roses, as discussed in Section 2.3.

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

- 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 were representative of those experienced over the entire year.

6.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the California monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 6-4 presents the results of the preliminary risk-based screening process for CELA, RUCA, and SJJCA. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. CELA and RUCA sampled for PAHs only, while SJJCA sampled for metals (PM_{10}) and PAHs.

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

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Los Angeles, California - CELA						
Naphthalene	0.029	58	59	98.31	90.63	90.63
Acenaphthene	0.011	3	59	5.08	4.69	95.31
Fluorene	0.011	3	59	5.08	4.69	100.00
Total		64	177	36.16		
Rubidoux, California - RUCA						
Naphthalene	0.029	54	61	88.52	100.00	100.00
Total		54	61	88.52		
San Jose, California - SJJCA						
Naphthalene	0.029	52	61	85.25	36.36	36.36
Arsenic (PM_{10})	0.00023	43	63	68.25	30.07	66.43
Manganese (PM_{10})	0.005	35	64	54.69	24.48	90.91
Nickel (PM_{10})	0.0021	8	64	12.50	5.59	96.50
Benzo(a)pyrene	0.00057	3	19	15.79	2.10	98.60
Acenaphthylene	0.011	2	27	7.41	1.40	100.00
Total		143	298	47.99		

Observations from Table 6-4 include the following:

- Naphthalene failed the majority of screens for all three California monitoring sites, with its site-specific contribution to the total failed screens ranging from 36 percent (SJJCA) to 100 percent (RUCA).

- Three pollutants failed screens for CELA, including one NATTS MQO Core Analyte (naphthalene). Benzo(a)pyrene was added to the pollutants of interest for CELA because it is a NATTS MQO Core Analyte, even though it did not fail any screens. Benzo(a)pyrene is not shown in Table 6-4 but is shown in subsequent tables in the sections that follow.

- Naphthalene was the only pollutant to fail screens for RUCA. Similar to CELA, benzo(a)pyrene was added to RUCA's pollutants of interest because it is a NATTS MQO Core Analyte, even though it did not fail any screens. Benzo(a)pyrene is not shown in Table 6-4 but is shown in subsequent tables in the sections that follow.

- Six pollutants failed screens for SJJCA, of which five are NATTS MQO Core Analytes. Four of these were initially identified as pollutants of interest for SJJCA. Benzo(a)pyrene was added as a pollutant of interest, even though it did not contribute to 95 percent of SJJCA's total failed screens, because it is a NATTS MQO Core Analyte. Three additional NATTS MQO Core Analytes were added to the pollutants of interest for SJJCA, even though their concentrations did not fail any screens: beryllium, cadmium, and lead. These three pollutants are not shown in Table 6-4, but are shown in subsequent tables in the sections that follow.

- The instrumentation at SJJCA for sampling metals was changed in mid-December 2010 and the site began sampling metals on Teflon® filters rather than quartz filters. In light of this change, the three samples from 2010 on the new instrumentation were included in all data analyses contained in this report.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the California monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for CELA, RUCA, and SJJCA are provided in Appendices M and N.

6.4.1 2011 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 of 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. Note also that the three December 2010 metals samples for SJJCA have been included in the first quarter averages shown in Table 6-5.

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						
Acenaphthene	59/59	3.96 ± 1.25	3.89 ± 1.11	6.06 ± 1.39	5.83 ± 2.18	4.92 ± 0.76
Benzo(a)pyrene	41/59	0.06 ± 0.02	0.02 ± 0.01	0.03 ± 0.01	0.12 ± 0.05	0.06 ± 0.02
Fluorene	59/59	4.92 ± 1.25	4.69 ± 1.22	6.54 ± 1.42	6.37 ± 1.78	5.62 ± 0.70
Naphthalene	59/59	160.49 ± 50.18	78.35 ± 22.87	118.30 ± 30.47	173.46 ± 51.51	131.96 ± 21.23
Rubidoux, California - RUCA						
Benzo(a)pyrene	25/61	0.02 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.08 ± 0.06	0.03 ± 0.02
Naphthalene	61/61	80.99 ± 26.99	55.39 ± 17.96	85.68 ± 24.06	143.05 ± 50.61	91.18 ± 17.14
San Jose, California - SJJCA						
Arsenic (PM$_{10}$)	63/64	0.41 ± 0.17	0.24 ± 0.07	0.32 ± 0.09	0.61 ± 0.14	0.39 ± 0.07
Benzo(a)pyrene	19/61	0.09 ± 0.05	0	0.01 ± 0.01	0.20 ± 0.17	0.07 ± 0.05
Beryllium (PM$_{10}$)	55/64	0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01
Cadmium (PM$_{10}$)	64/64	0.07 ± 0.03	0.04 ± 0.01	0.04 ± 0.01	0.13 ± 0.05	0.07 ± 0.02
Lead (PM$_{10}$)	64/64	2.78 ± 1.19	1.73 ± 0.43	2.70 ± 1.09	4.92 ± 1.07	3.02 ± 0.56
Manganese (PM$_{10}$)	64/64	5.78 ± 2.19	4.00 ± 0.95	6.70 ± 1.55	10.19 ± 3.12	6.62 ± 1.14
Naphthalene	61/61	103.53 ± 44.91	34.63 ± 8.01	45.44 ± 10.88	138.94 ± 42.95	80.06 ± 18.30
Nickel (PM$_{10}$)	64/64	1.09 ± 0.36	1.05 ± 0.27	1.35 ± 0.29	1.61 ± 0.38	1.27 ± 0.17

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

- Naphthalene and benzo(a)pyrene are pollutants of interest for each site.

- The pollutant with the maximum annual average concentration for each site is naphthalene, which ranged from 80.06 ± 18.30 ng/m^3 for SJJCA to 131.96 ± 21.23 ng/m^3 for CELA. The naphthalene concentrations for SJJCA exhibit a seasonal trend, with higher concentrations measured during the colder months of the year (first and fourth quarters). Naphthalene concentrations for CELA appear to exhibit this trend too, although the difference in the quarterly averages is not statistically significant. Naphthalene concentrations for RUCA appear highest during the fourth quarter, but the relatively high confidence interval associated with this average indicates the possible influence of outliers.

- Benzo(a)pyrene concentrations also appear to be higher during the colder months of the year, particularly for SJJCA. However, this pollutant was detected in just over one-quarter of the samples collected at SJJCA. Benzo(a)pyrene was not detected at all during the second quarter at SJJCA and was detected only twice during the third quarter of 2011.

- Manganese has the highest annual average concentration (6.62 ± 1.14 ng/m^3) of the PM_{10} metals measured at SJJCA. The quarterly averages for manganese show that the highest concentrations were measured during the fourth quarter of 2011. A review of the data shows that of the 11 concentrations of manganese greater than 10 ng/m^3 measured at this site, seven were measured during the fourth quarter of 2011, including the two highest concentrations (25.4 ng/m^3 measured on November 2, 2011 and 18.1 ng/m^3 measured on October 27, 2011).

- The highest quarterly average concentration was calculated for the fourth quarter of 2011 for most of the PM_{10} metals.

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 appears in Table 4-11 for PAHs three times. CELA has the fourth highest annual average concentration naphthalene among NMP sites sampling PAHs, behind GPCO, DEMI, and MONY. This site also ranks eighth for acenaphthene and fluorene, but does not appear in Table 4-11 for benzo(a)pyrene (it ranks 14th). RUCA has the ninth highest annual average concentration of naphthalene and tenth highest annual average concentration of fluorene. SJJCA does not appear in Table 4-11.

- Because only nine sites sampled PM_{10} metals, SJJCA appears in Table 4-12 for every program-level metal pollutant of interest. However, this site was not in the top five for any of the speciated 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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzo(a)pyrene and naphthalene were created for all three California sites. Box plots were also created for arsenic, lead, and manganese for SJJCA. Figures 6-16 through 6-20 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.

Figure 6-16. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

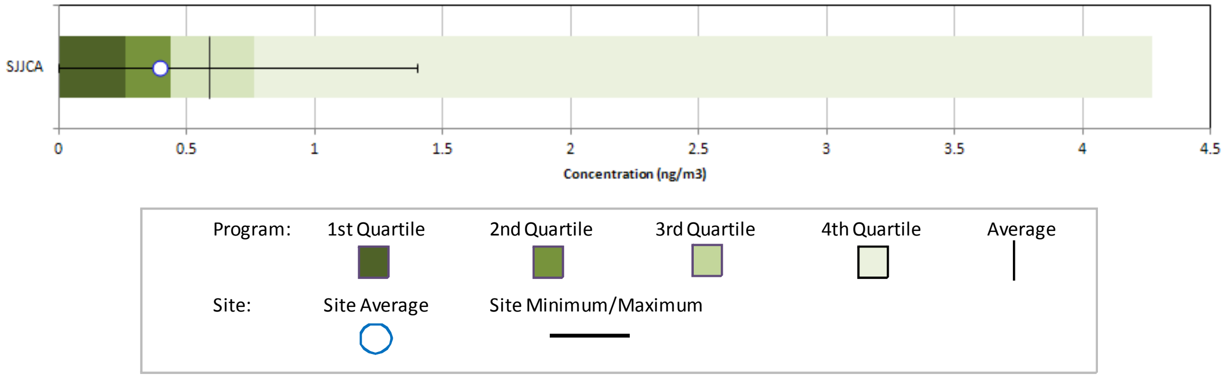


Figure 6-17. Program vs. Site-Specific Average Benzo(a)pyrene Concentrations

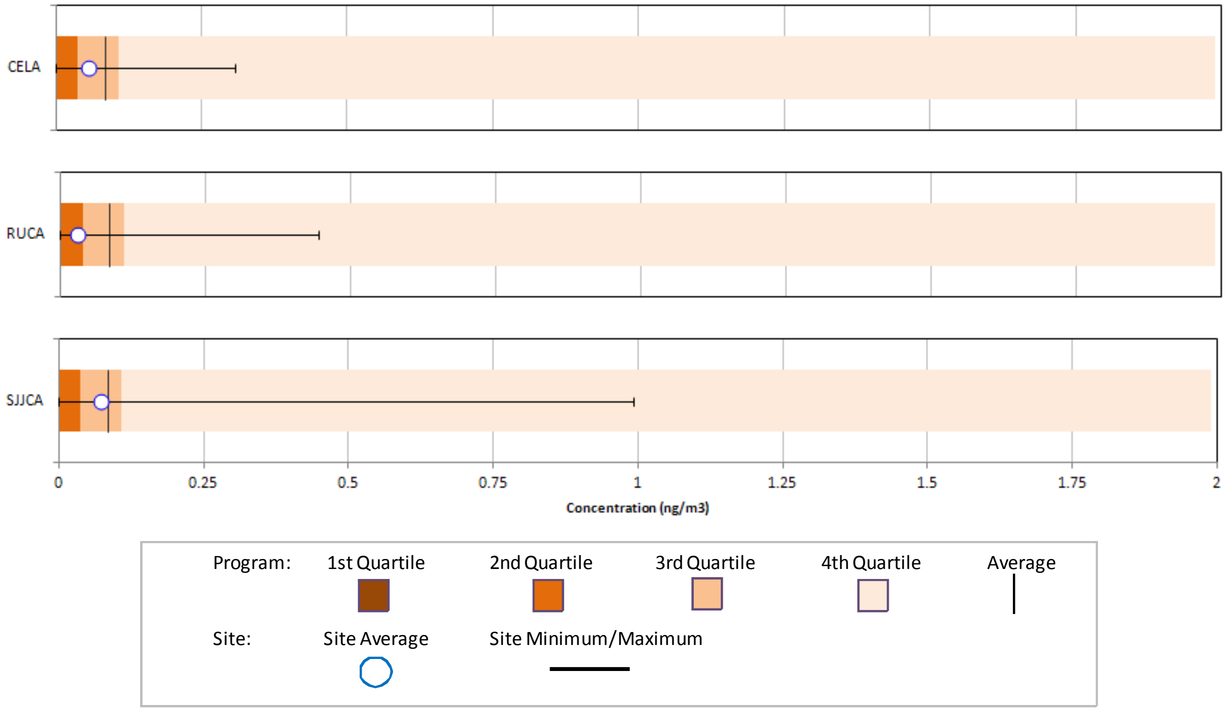


Figure 6-18. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

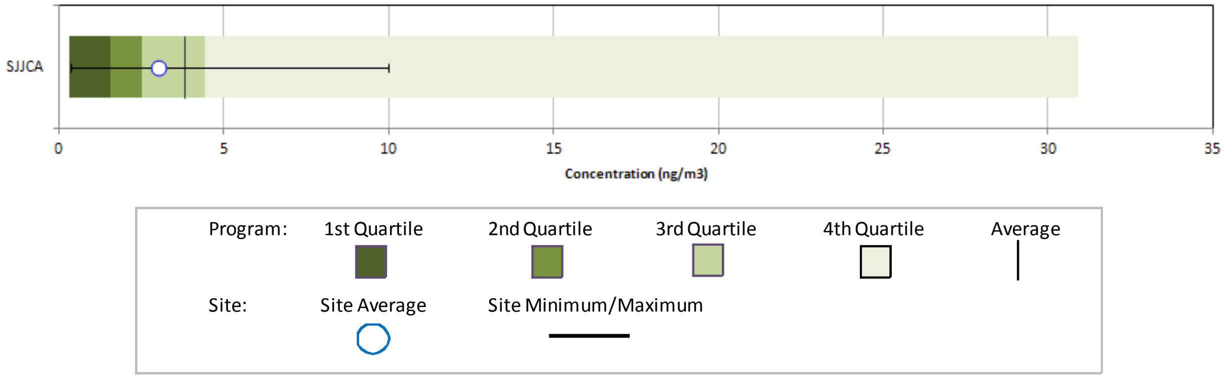


Figure 6-19. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

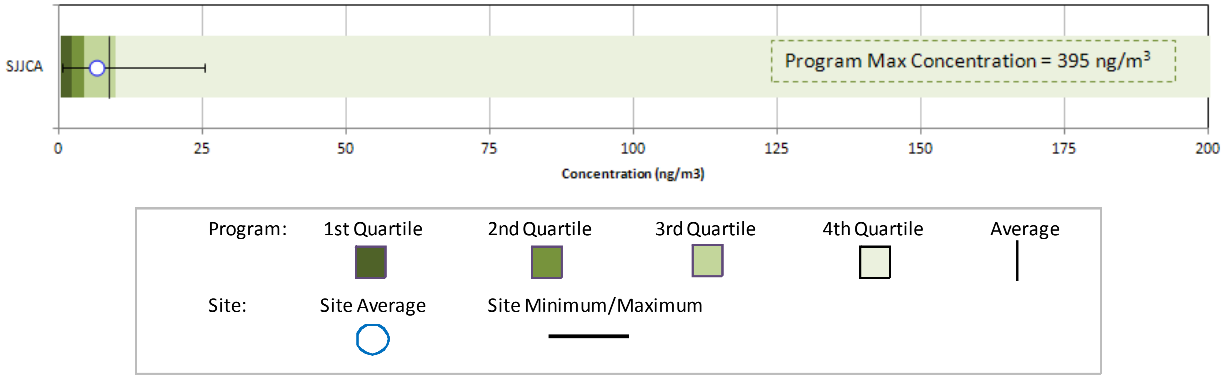
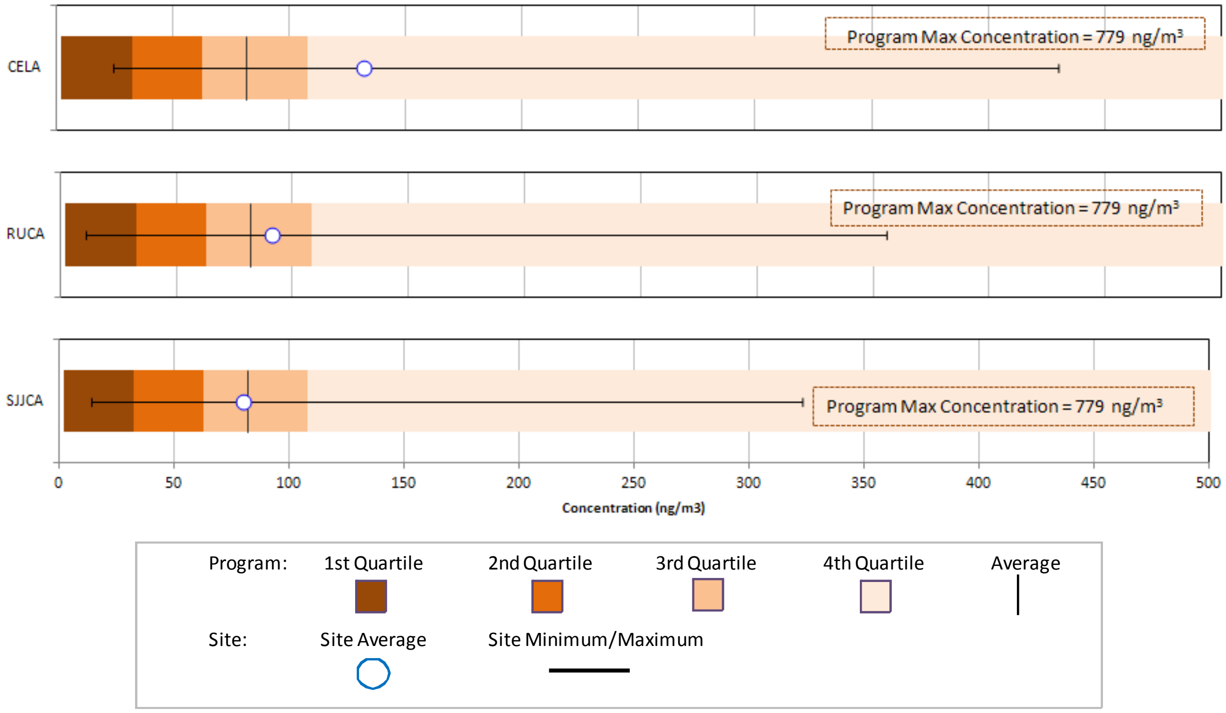


Figure 6-20. Program vs. Site-Specific Average Naphthalene Concentrations



Observations from Figures 6-16 through 6-20 include the following:

- Figure 6-16 shows that the annual average arsenic (PM_{10}) concentration for SJJCA is less than the program-level average and median concentrations of arsenic (PM_{10}). A single non-detect of arsenic was measured at SJJCA.

- Figure 6-17 for benzo(a)pyrene shows all three sites. Note that the program-level first quartile for this pollutant is zero and is not visible on the box plots. Each of the annual average concentrations of benzo(a)pyrene for the California sites is less than the program-level average concentration. Figure 6-17 also shows that while the maximum benzo(a)pyrene concentration measured at each California site is less than the maximum concentration measured across the program, the maximum concentration measured at SJJCA is more than twice the maximum concentration measured at RUCA and three times the maximum concentration measured at CELA. Non-detects of benzo(a)pyrene were reported for each of these three sites.

- Figure 6-18 shows that the annual average concentration of lead (PM_{10}) for SJJCA is less than the program-level average and but greater than the program-level median concentration. The maximum lead concentration measured at SJJCA is less than the maximum concentration measured across the program. There were no non-detects of lead measured at SJJCA or across the program.

- Figure 6-19 is the box plot for manganese (PM_{10}). Note that the program-level maximum concentration (395 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 200 ng/m^3. Figure 6-19 shows that the annual average concentration of manganese (PM_{10}) for SJJCA is also less than the program-level average concentration. The maximum manganese concentration measured at SJJCA is considerably less than the maximum concentration measured across the program. There were no non-detects of manganese measured at SJJCA or across the program.

- Figure 6-20 for naphthalene also shows all three sites. Note that the program-level maximum concentration (779 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 ng/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 6-20 shows that the annual average concentrations for CELA and RUCA are greater than the program-level average concentration, while the annual average concentration for SJJCA is just less than the program-level average. Figure 6-20 also shows that the maximum concentrations for all three sites are less than the maximum concentration measured across the program. However, CELA's maximum concentration (430 ng/m^3) is the fifth highest concentration measured among sites sampling PAHs. There were no non-detects of naphthalene measured at CELA, RUCA, or 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 selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. Although both CELA and RUCA began sampling PAHs in 2007, they did not begin until April and May, respectively, and therefore average concentrations could not be calculated for 2007. SJJCA did not begin sampling under the NMP until 2008. Therefore, the trends analysis was not conducted for the California sites.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

6.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the California 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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. # Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Los Angeles, California - CELA						
Acenaphthene	0.000088	--	59/59	4.92 ± 0.76	0.43	--
Benzo(a)pyrene	0.00176	--	41/59	0.06 ± 0.02	0.10	--
Fluorene	0.000088	--	59/59	5.62 ± 0.70	0.49	--
Naphthalene	0.000034	0.003	59/59	131.96 ± 21.23	4.49	0.04
Rubidoux, California - RUCA						
Benzo(a)pyrene	0.00176	--	25/61	0.03 ± 0.02	0.05	--
Naphthalene	0.000034	0.003	61/61	91.18 ± 17.14	3.10	0.03
San Jose, California - SJJCA						
Arsenic (PM_{10})	0.0043	0.000015	63/64	0.39 ± 0.07	1.69	0.03
Benzo(a)pyrene	0.00176	--	19/61	0.07 ± 0.05	0.13	--
Beryllium (PM_{10})	0.0024	0.00002	55/64	0.01 ± <0.01	0.02	0
Cadmium (PM_{10})	0.0018	0.00001	64/64	0.07 ± 0.02	0.13	0.01
Lead (PM_{10})	--	0.00015	64/64	3.02 ± 0.56	--	0.02
Manganese (PM_{10})	--	0.00005	64/64	6.62 ± 1.14	--	0.13
Naphthalene	0.000034	0.003	61/61	80.06 ± 18.30	2.72	0.03
Nickel (PM_{10})	0.00048	0.00009	64/64	1.27 ± 0.17	0.61	0.01

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

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

- Naphthalene has the highest annual average concentration for each of the California sites, as discussed in the previous section.

- Naphthalene also has the highest cancer risk approximation among the pollutants of interest for all three California monitoring sites. The cancer risk approximations range from 2.72 in-a-million for SJJCA to 4.49 in-a-million for CELA.

- Of the metals sampled at SJJCA, arsenic has the highest cancer risk approximation and is the only metal for which a cancer risk approximation is greater than 1.0 in-a-million (1.69 in-a-million).

- 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.

6.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 6-7 and 6-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages and provided in Table 6-6. Table 6-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 6-6.

The pollutants listed in Tables 6-7 and 6-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, 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, all three California monitoring sites sampled for PAHs and SJJCA also sampled PM_{10} metals. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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	3,019.71	Formaldehyde	3.93E-02	Naphthalene	4.49
Benzene	1,847.23	Hexavalent Chromium, PM	2.57E-02	Fluorene	0.49
Dichloromethane	1,347.58	Benzene	1.44E-02	Acenaphthene	0.43
Acetaldehyde	1,236.99	1,3-Butadiene	1.07E-02	Benzo(a)pyrene	0.10
Ethylbenzene	959.04	Naphthalene	7.07E-03		
1,3-Butadiene	358.22	Arsenic, PM	5.28E-03		
Naphthalene	207.88	Nickel, PM	5.01E-03		
p-Dichlorobenzene	144.14	Acetaldehyde	2.72E-03		
Tetrachloroethylene	105.99	Ethylbenzene	2.40E-03		
Trichloroethylene	50.40	POM, Group 1a	1.99E-03		
Rubidoux, California (Riverside County) - RUCA					
Formaldehyde	793.92	Hexavalent Chromium, PM	2.13E-02	Naphthalene	3.10
Benzene	409.04	Formaldehyde	1.03E-02	Benzo(a)pyrene	0.05
Acetaldehyde	353.08	Benzene	3.19E-03		
Ethylbenzene	207.95	1,3-Butadiene	2.44E-03		
Tetrachloroethylene	163.53	Naphthalene	1.89E-03		
Dichloromethane	150.35	Arsenic, PM	1.82E-03		
1,3-Butadiene	81.30	Acetaldehyde	7.77E-04		
Naphthalene	55.49	POM, Group 1a	5.85E-04		
1,3-Dichloropropene	37.72	Ethylbenzene	5.20E-04		
p-Dichlorobenzene	28.62	Nickel, PM	4.85E-04		

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)**
San Jose, California (Santa Clara County) - SJJCA					
Formaldehyde	577.88	Formaldehyde	7.51E-03	Naphthalene	2.72
Benzene	353.73	Hexavalent Chromium, PM	7.13E-03	Arsenic	1.69
Acetaldehyde	254.78	Benzene	2.76E-03	Nickel	0.61
Ethylbenzene	201.33	1,3-Butadiene	2.24E-03	Benzo(a)pyrene	0.13
Dichloromethane	102.75	POM, Group 1a	1.70E-03	Cadmium	0.13
Tetrachloroethylene	97.93	Naphthalene	1.34E-03	Beryllium	0.02
1,3-Butadiene	74.71	Arsenic, PM	9.76E-04		
Naphthalene	39.30	Acetaldehyde	5.61E-04		
p-Dichlorobenzene	25.48	Ethylbenzene	5.03E-04		
POM, Group 1a	19.28	Nickel, PM	2.82E-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					
1,1,1-Trichloroethane	7,345.47	Acrolein	8,698,970.49	Naphthalene	0.04
Toluene	5,503.09	Chlorine	367,827.04		
Formaldehyde	3,019.71	Formaldehyde	308,133.92		
Benzene	1,847.23	1,3-Butadiene	179,110.50		
Dichloromethane	1,347.58	Acetaldehyde	137,443.72		
Hexane	1,286.59	Nickel, PM	115,985.91		
Acetaldehyde	1,236.99	Arsenic, PM	81,886.64		
Ethylbenzene	959.04	Hexamethylene-1,6-diisocyanate, gas	78,379.05		
Xylenes	873.15	Naphthalene	69,291.67		
Ethylene glycol	655.71	Benzene	61,574.38		
Rubidoux, California (Riverside County) - RUCA					
Toluene	1,289.54	Acrolein	1,964,801.08	Naphthalene	0.03
1,1,1-Trichloroethane	807.28	Chlorine	87,536.25		
Formaldehyde	793.92	Formaldehyde	81,012.73		
Benzene	409.04	1,3-Butadiene	40,650.19		
Acetaldehyde	353.08	Acetaldehyde	39,230.78		
Hexane	300.78	Arsenic, PM	28,239.83		
Ethylbenzene	207.95	Naphthalene	18,496.03		
Xylenes	178.62	Hexavalent Chromium, PM	17,714.98		
Tetrachloroethylene	163.53	Bromomethane	16,899.96		
Dichloromethane	150.35	Benzene	13,634.82		

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)**
San Jose, California (Santa Clara County) - SJJCA					
Toluene	1,394.35	Acrolein	1,999,590.36	Manganese	0.13
1,1,1-Trichloroethane	1,290.78	Chlorine	109,927.46	Arsenic	0.03
Formaldehyde	577.88	Formaldehyde	58,967.45	Naphthalene	0.03
Benzene	353.73	1,3-Butadiene	37,354.73	Lead	0.02
Hexane	265.48	Acetaldehyde	28,308.52	Nickel	0.01
Acetaldehyde	254.78	Arsenic, PM	15,130.81	Cadmium	0.01
Ethylbenzene	201.33	Propionaldehyde	14,149.25	Beryllium	<0.01
Xylenes	176.68	Naphthalene	13,100.12		
Ethylene glycol	120.59	Benzene	11,790.92		
Propionaldehyde	113.19	Lead, PM	10,622.90		

Observations from Table 6-7 include the following:

- Formaldehyde and benzene are the two highest emitted pollutants with cancer UREs in all three California counties. The quantity emitted is greater for Los Angeles County than Riverside and Santa Clara Counties.

- Formaldehyde and hexavalent chromium are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Los Angeles and Santa Clara Counties, while the order is reversed for Riverside County.

- Six of the highest emitted pollutants also have the highest toxicity-weighted emissions for Los Angeles and Riverside Counties, while there are seven in common for Santa Clara County. While hexavalent chromium is at or near the top in toxicity-weighted emissions for all three counties, this pollutant is not among the 10 highest emitted pollutants in these counties. Hexavalent chromium emissions rank between 13th highest for RUCA to 18th highest for SJJCA.

- Naphthalene has the highest cancer risk approximation for all three sites. Naphthalene is the only pollutant to appear on all three lists for all three counties.

- Arsenic and nickel, which have the second and third highest cancer risk approximations for SJJCA, respectively, have the seventh and tenth highest toxicity-weighted emissions for Santa Clara County, but are not among the 10 highest emitted pollutants for this county. These are the only pollutants sampled by SJJCA, other than naphthalene, to appear on either emissions-based list.

Observations from Table 6-8 include the following:

- Toluene, 1,1,1-trichloroethane, formaldehyde, and benzene are the highest emitted pollutants with noncancer RfCs in all three California counties (although not necessarily in that order). Consistent with pollutants having cancer UREs, emissions are greater in Los Angeles County than Riverside and Santa Clara Counties.

- 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 third highest emissions for each county.

- Three of the highest emitted pollutants also have the highest toxicity-weighted emissions for Los Angeles and Riverside Counties, while four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Santa Clara County.

- Naphthalene, the only pollutant for which a noncancer hazard approximation could be calculated for CELA and RUCA, has one of the 10 highest toxicity-weighted emissions for these sites' respective counties, but does not appear on the list of the 10 highest total emissions for either county (of pollutants with noncancer RfCs). This is also true for Santa Clara County.

- Besides naphthalene, arsenic and lead are the only two pollutants for which noncancer hazard approximations could be calculated for SJJCA and that also appear on the list of 10 highest toxicity-weighted emissions. Manganese, which has the highest noncancer hazard approximation for SJJCA, appears on neither emissions-based list. None of the metals appear among the pollutants with the highest total emissions.

6.6 Summary of the 2011 Monitoring Data for CELA, RUCA, and SJJCA

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

- *Three PAHs, including naphthalene, failed screens for CELA, while only naphthalene failed screens for RUCA. Three PAHs and three PM_{10} metals failed screens for SJJCA.*

- *Naphthalene had the highest annual average concentration among all the pollutants of interest for the California sites. Among the metals sampled at SJJCA, manganese had the highest annual average concentration.*

- *Concentrations of naphthalene and benzo(a)pyrene exhibit a seasonal trend at SJJCA, with higher concentrations during the first and fourth quarters (or the colder months) of 2011.*

7.0 Sites in Colorado

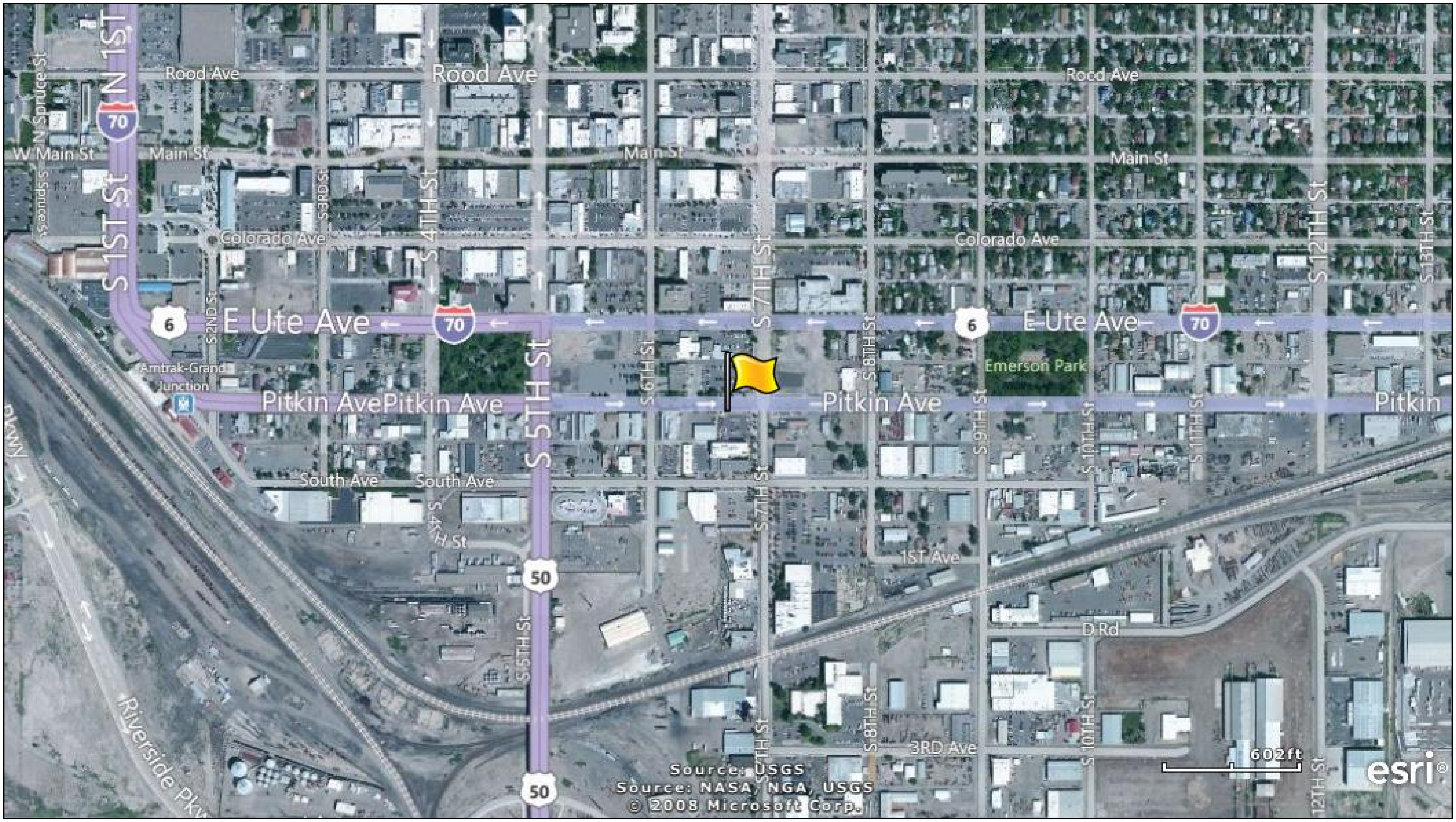
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and UATMP sites in Colorado, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included 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 is located in Grand Junction (GPCO) and the other four sites are located in Garfield County, between 35 and 55 miles northeast of Grand Junction, in the towns of Battlement Mesa (BMCO), Silt (BRCO), Parachute (PACO), and Rifle (RICO). Figure 7-1 for GPCO and Figures 7-3 through 7-6 for the Garfield County sites are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 7-2 and 7-7 identify nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of each site are included in the facility counts provided in Figures 7-2 and 7-7. 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 maps, but have been grayed out in order to show emissions sources just outside the boundary. 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



Source: USGS
Source: NASA, NGA, USGS
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Figure 7-2. NEI Point Sources Located Within 10 Miles of GPCO

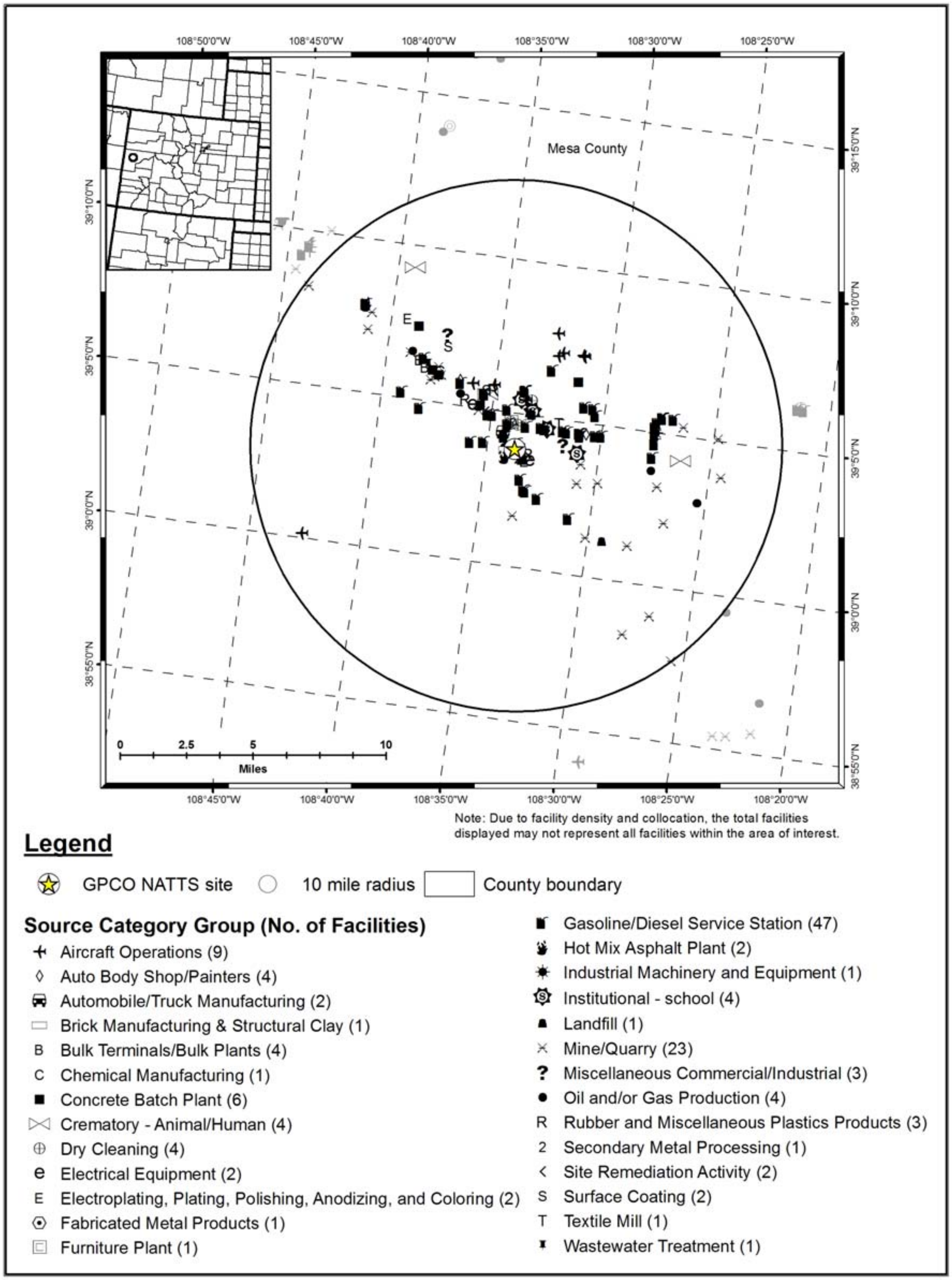
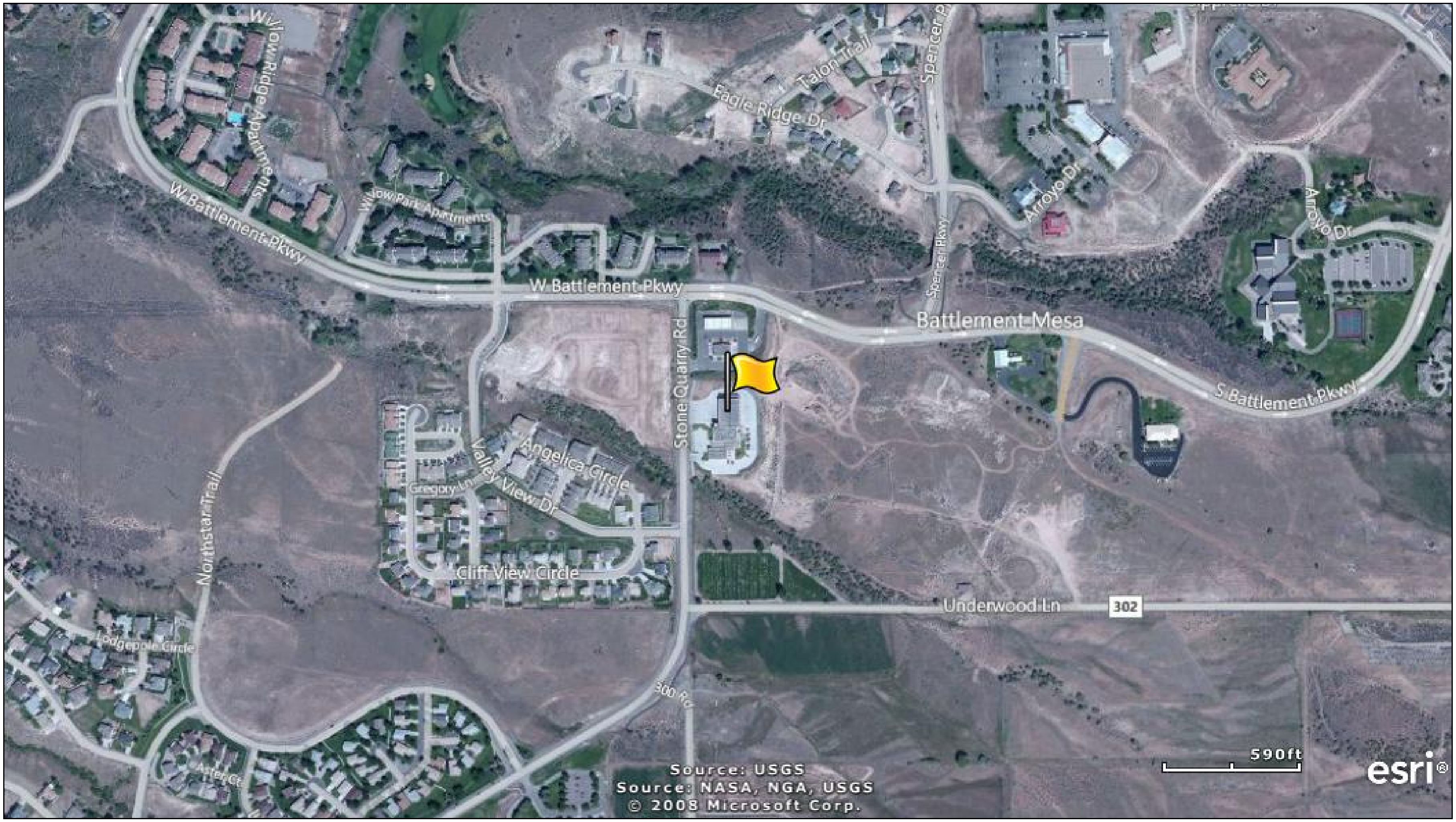


Figure 7-3. Battlement Mesa, Colorado (BMCO) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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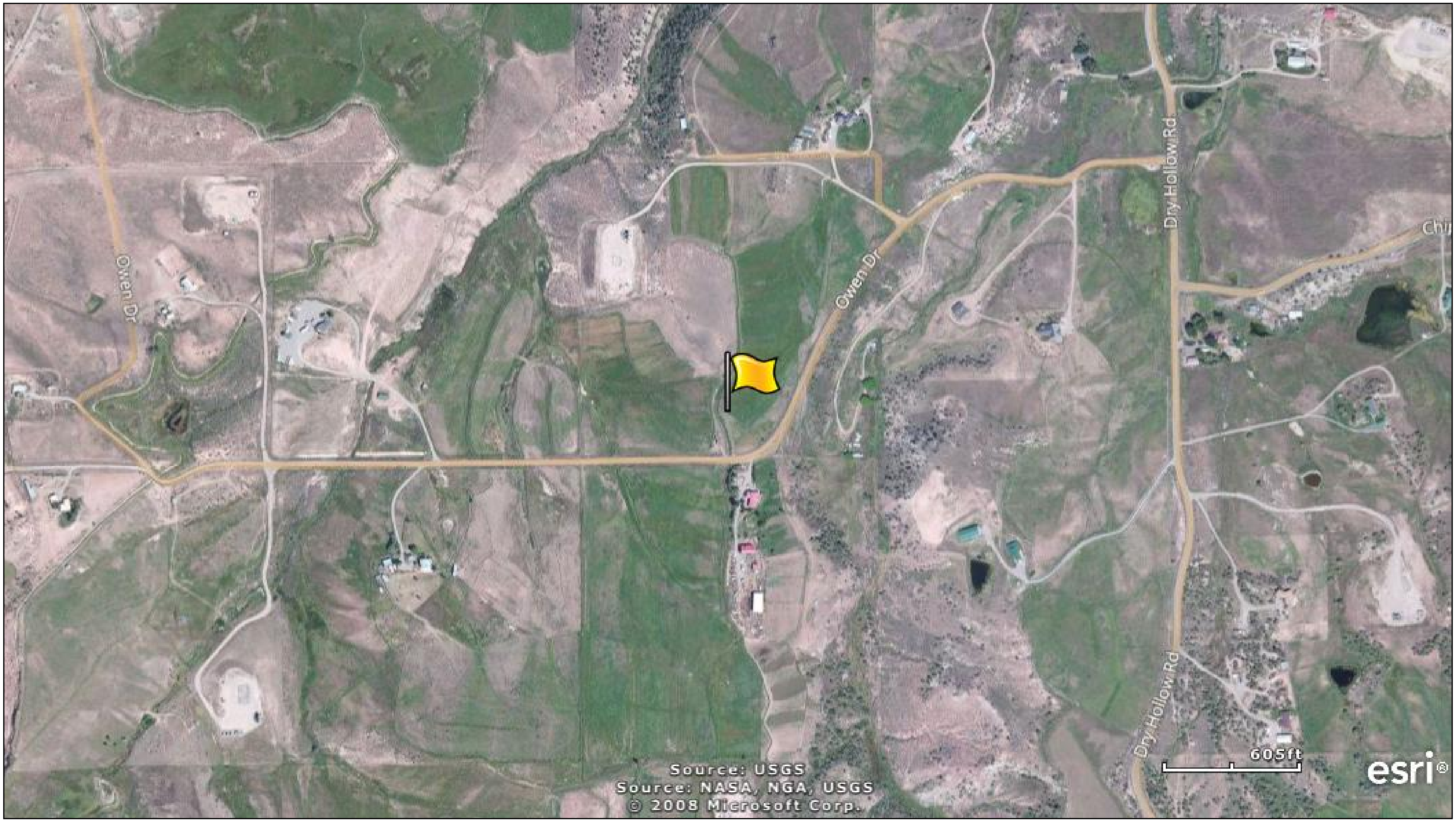
Figure 7-4. Silt, Colorado (BRCO) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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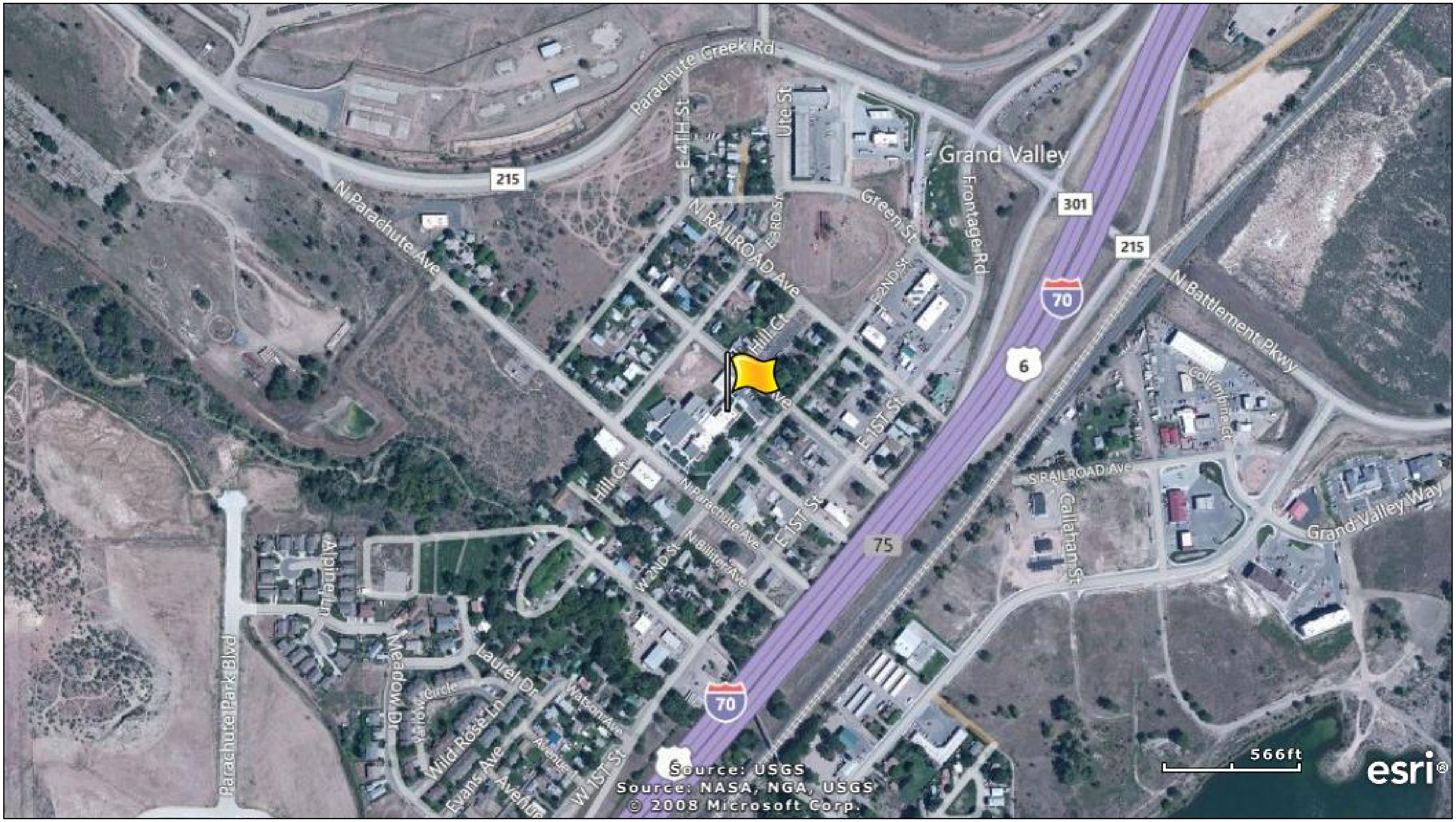
Figure 7-5. Parachute, Colorado (PACO) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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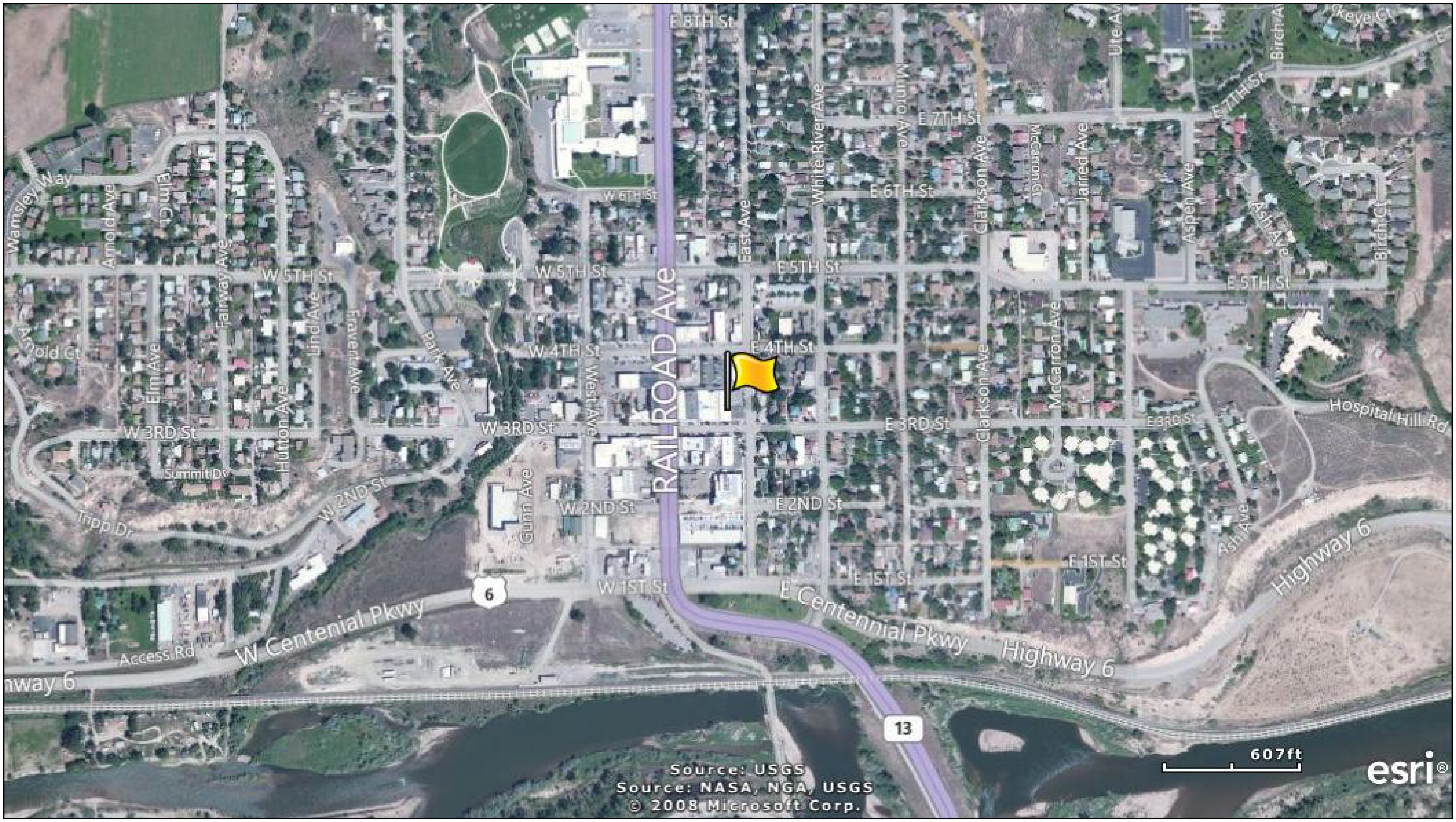
Figure 7-6. Rifle, Colorado (RICO) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 7-7. NEI Point Sources Located Within 10 Miles of BMCO, BRCO, PACO, and RICO

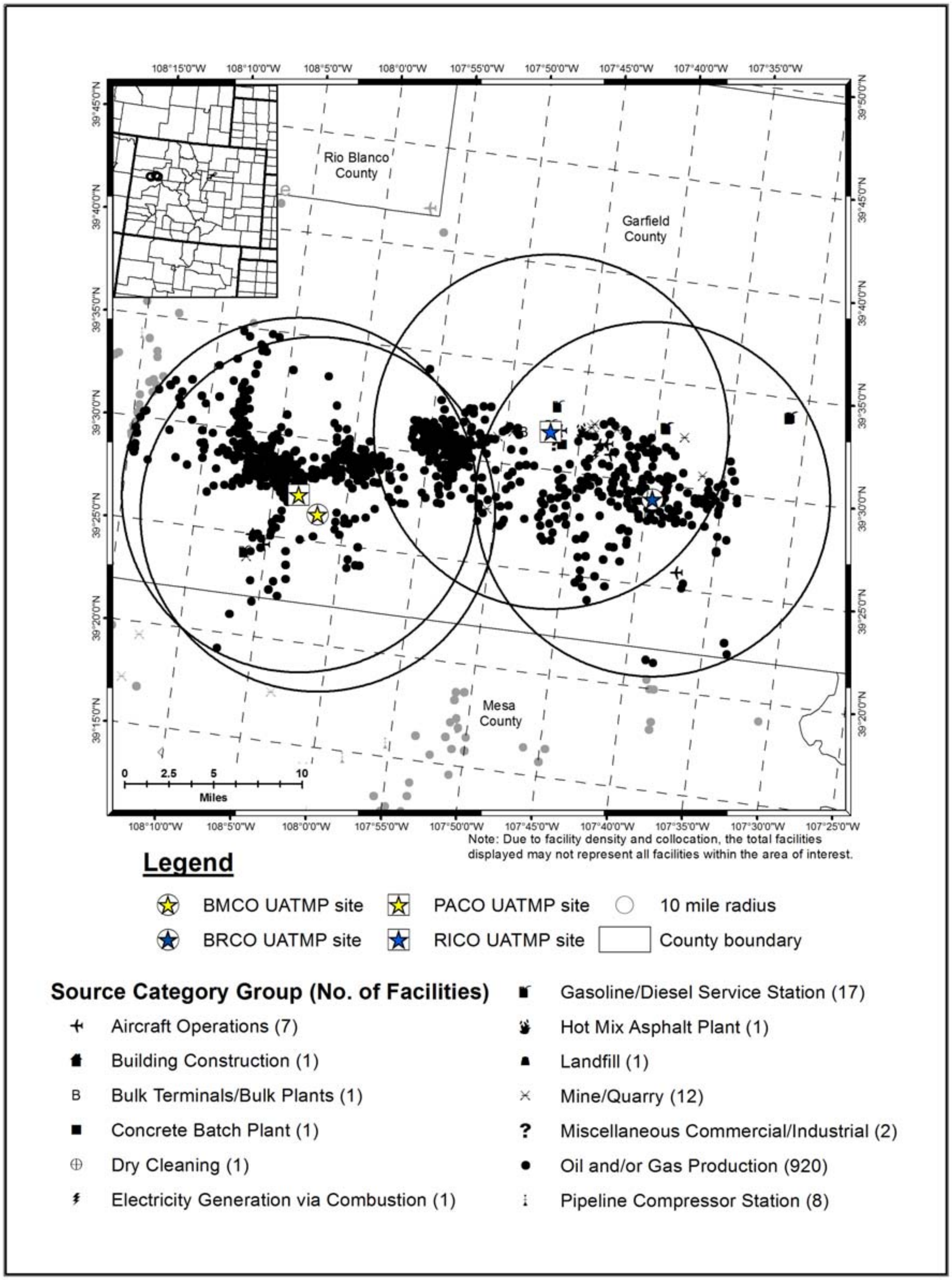


Table 7-1. Geographical Information for the Colorado Monitoring Sites

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, $PM_{2.5}$, and $PM_{2.5}$ Speciation.
BMCO	None	Battlement Mesa	Garfield	Not in an MSA	39.4399898, -108.029769	Residential	Rural	No AQS entry.
BRCO	08-045-0009	Silt	Garfield	Not in an MSA	39.487755, -107.659685	Agricultural	Rural	None.
PACO	08-045-0005	Parachute	Garfield	Not in an MSA	39.453654, -108.053259	Residential	Urban/City Center	PM_{10}, PM_{10} Speciation.
RICO	08-045-0007	Rifle	Garfield	Not in an MSA	39.531813, -107.782298	Commercial	Urban/City Center	PM_{10}, PM_{10} Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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. Many of the point sources near GPCO fall into the gasoline/diesel service station and mine/quarry source categories. The sources closest to GPCO are a bulk terminal/bulk plant, an automobile/truck manufacturer, and a gasoline/diesel service station.

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.

The 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 900 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, 2010).

Table 7-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Colorado monitoring sites. Table 7-2 includes county-level population and vehicle registration information. Table 7-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 7-2 also contains traffic volume information for each site. Finally, 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 other state sections.

Observations from Table 7-2 include the following:

- Mesa County's population and vehicle ownership are considerably higher than those for Garfield County. This is also true for 10-mile population and vehicle ownership. However, both counties rank in the bottom-third compared to other counties with NMP sites.
- The vehicle-per-person ratios for the Colorado sites are among the highest for all NMP sites, with the Garfield County sites' ranking second behind only UCSD, and GPCO ranking fourth.
- The traffic volumes near PACO, RICO, and GPCO are considerably higher than the traffic volumes near the other Colorado monitoring sites. The lowest traffic volume

among all NMP sites is for BRCO. The traffic estimate provided for GPCO is based on Business-70 near 7th Street; from South Battlement Parkway for BMCO; from the junction of County Roads 331 and 326 for BRCO; from I-70 near exit 75 for PACO; and from Highway 13 between Highway 6 and I-70 for RICO.

- 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.

Table 7-2. Population, Motor Vehicle, and Traffic Information for the Colorado Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
GPCO	147,083	178,425	1.21	120,030	145,607	11,000	2,031,327
BMCO	56,270	72,957	1.30	5,941	7,703	2,527	1,901,434
BRCO				25,466	33,018	150	
PACO				5,941	7,703	16,000	
RICO				18,148	23,530	17,000	

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)

[2] County-level vehicle registration reflects 2010 data from the Colorado DOR (CO DOR, 2011)

[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)

[4] AADT reflects 2002 data for BMCO and BRCO from Garfield County (GCRBD, 2002) and 2011 data for GPCO, PACO, and RICO from the Colorado DOT (CO DOT, 2011a)

[5] County-level VMT reflects 2011 data for state highways only from the Colorado DOT (CO DOT, 2011b)

BOLD ITALICS = EPA-designated NATTS Site

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 valley location of the city helps protect it from dramatic weather changes. The area tends to be fairly dry and winds tend to flow out of the east-southeast on average, due to the valley breeze effect (Bair, 1992). 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. 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 valley breezes (GCPH, 2010 and WRCC, 2013).

7.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). The weather station nearest GPCO is located at Walker Field Airport (WBAN 23066); the closest weather station to the four Garfield County sites is located at Garfield County Regional Airport (WBAN 03016). 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 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 for 2011. 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 GPCO were representative of average weather conditions throughout the year. Temperatures on sample days near the Garfield County sites appear slightly cooler than over the course of the year. This may be attributable to a few missed sample days in May and September for each site.

Table 7-3. Average Meteorological Conditions near the Colorado Monitoring Sites

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)
Grand Junction, Colorado - GPCO									
Walker Field Airport 23066 (39.13, -108.54)	4.96 miles 22° (NNE)	Sample Day	63.8 ± 5.2	51.5 ± 4.8	28.2 ± 3.5	40.5 ± 3.4	48.9 ± 4.6	1014.7 ± 2.2	6.3 ± 0.7
		2011	64.5 ± 2.2	52.3 ± 2.0	28.5 ± 1.4	40.9 ± 1.4	47.7 ± 1.9	1014.9 ± 0.9	6.2 ± 0.3
Battlement Mesa, Colorado - BMCO									
Garfield Co. Regional Airport 03016 (39.53, -107.73)	16.41 miles 76° (ENE)	Sample Day	59.4 ± 5.6	45.5 ± 5.1	27.3 ± 4.2	37.2 ± 4.0	56.6 ± 4.3	1016.4 ± 2.6	5.1 ± 0.8
		2011	61.4 ± 2.2	47.2 ± 1.9	28.1 ± 1.4	38.2 ± 1.5	55.2 ± 1.7	1016.7 ± 0.9	4.5 ± 0.3
Silt, Colorado - BRCO									
Garfield Co. Regional Airport 03016 (39.53, -107.73)	4.23 miles 316° (NW)	Sample Day	59.5 ± 5.8	45.3 ± 5.3	26.6 ± 4.2	36.7 ± 4.2	55.9 ± 4.3	1016.2 ± 2.7	5.1 ± 0.8
		2011	61.4 ± 2.2	47.2 ± 1.9	28.1 ± 1.4	38.2 ± 1.5	55.2 ± 1.7	1016.7 ± 0.9	4.5 ± 0.3
Parachute, Colorado - PACO									
Garfield Co. Regional Airport 03016 (39.53, -107.73)	17.22 miles 81° (E)	Sample Day	59.4 ± 5.6	45.5 ± 5.1	27.3 ± 4.2	37.1 ± 4.0	56.8 ± 4.3	1016.5 ± 2.6	5.0 ± 0.8
		2011	61.4 ± 2.2	47.2 ± 1.9	28.1 ± 1.4	38.2 ± 1.5	55.2 ± 1.7	1016.7 ± 0.9	4.5 ± 0.3

[1] Sample day averages are highlighted 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 Co. Regional Airport 03016 (39.53, -107.73)	2.89 miles 105° (ESE)	Sample Day	59.8 ± 5.7	45.7 ± 5.2	26.9 ± 4.0	37.1 ± 4.0	55.7 ± 4.3	1016.3 ± 2.6	5.2 ± 0.8
		2011	61.4 ± 2.2	47.2 ± 1.9	28.1 ± 1.4	38.2 ± 1.5	55.2 ± 1.7	1016.7 ± 0.9	4.5 ± 0.3

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

7.2.3 Back Trajectory Analysis

Figure 7-8 is the composite back trajectory map for days on which samples were collected at the GPCO monitoring site in 2011. Included in Figure 7-8 are four back trajectories per sample day. Figure 7-9 is the corresponding cluster analysis. Similarly, Figures 7-10 through 7-17 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 7-8 through 7-17 represents 100 miles.

Observations for GPCO from Figures 7-8 and 7-9 include the following:

- The 24-hour air shed domain for GPCO is one of the smallest in size, based on average back trajectory length, compared to other NMP monitoring sites. The farthest away a back trajectory originated was over southwest Arizona, or just greater than 450 miles away. However, most trajectories (88 percent) originated within 300 miles of GPCO and the average trajectory length was approximately 169 miles.

- Back trajectories originated from a variety of directions at GPCO, although a large cluster of trajectories originated to the southwest of GPCO and the majority of the trajectories had a westerly component.

- The cluster analysis shows that back trajectories frequently originated from the southwest, accounting for roughly 37 percent of back trajectories. Another 27 percent of trajectories originated from the northwest and west of GPCO. Shorter back trajectories originating over southeast Utah and southwest Colorado are represented by the short cluster labeled 24 percent and originating to the south of GPCO. The cluster originating to the east of GPCO represents back trajectories originating from the northeast, east, and southeast of the site (12 percent). Thus, air moving towards GPCO is generally originating in Colorado, Utah, and Arizona.

Figure 7-8. 2011 Composite Back Trajectory Map for GPCO

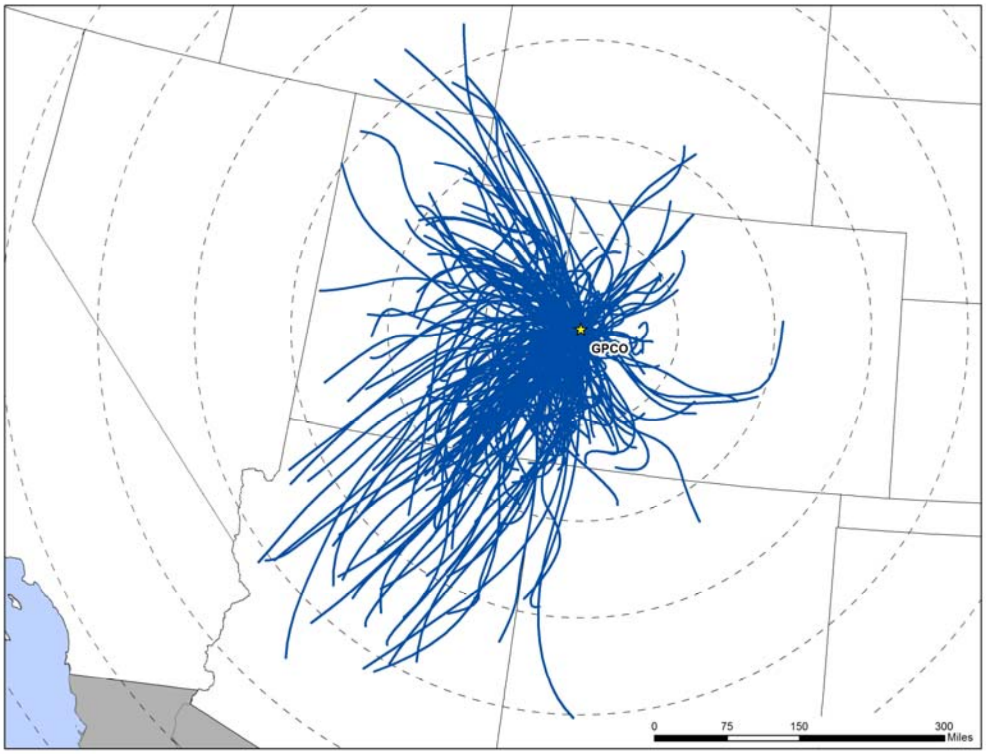


Figure 7-9. Back Trajectory Cluster Map for GPCO

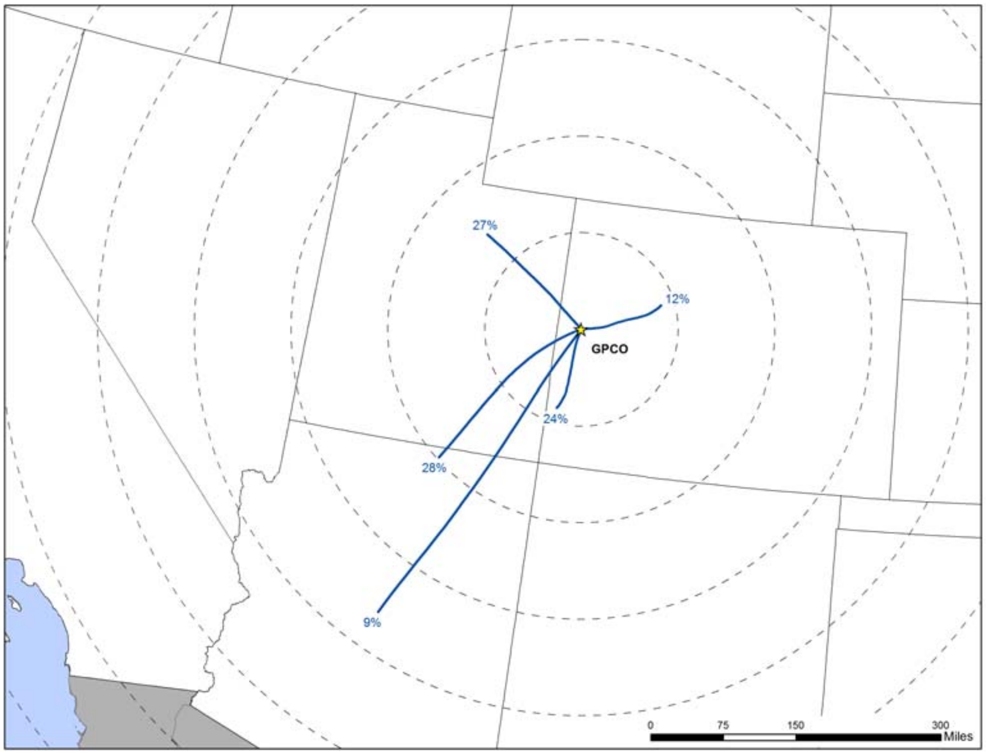


Figure 7-10. 2011 Composite Back Trajectory Map for BMCO

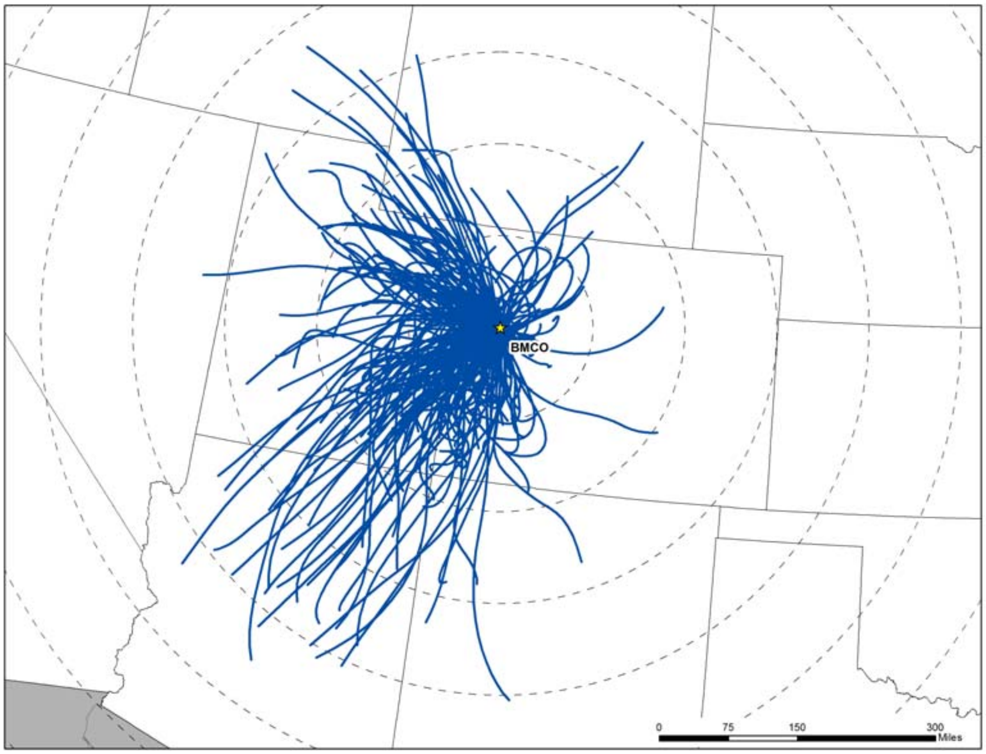


Figure 7-11. Back Trajectory Cluster Map for BMCO

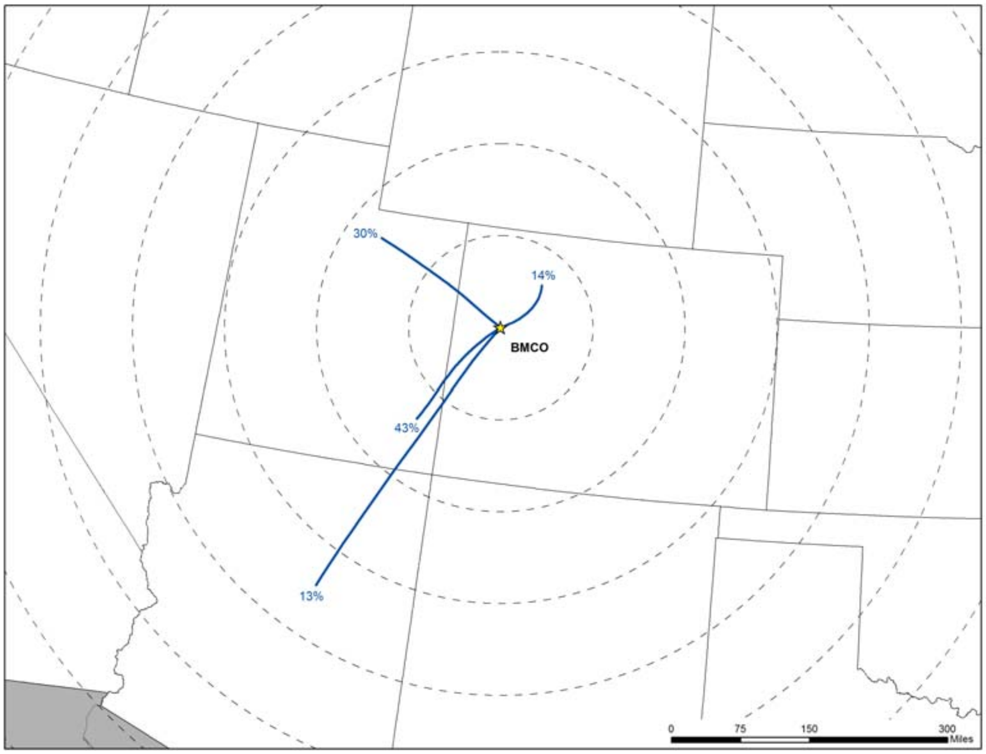


Figure 7-12. 2011 Composite Back Trajectory Map for BRCO

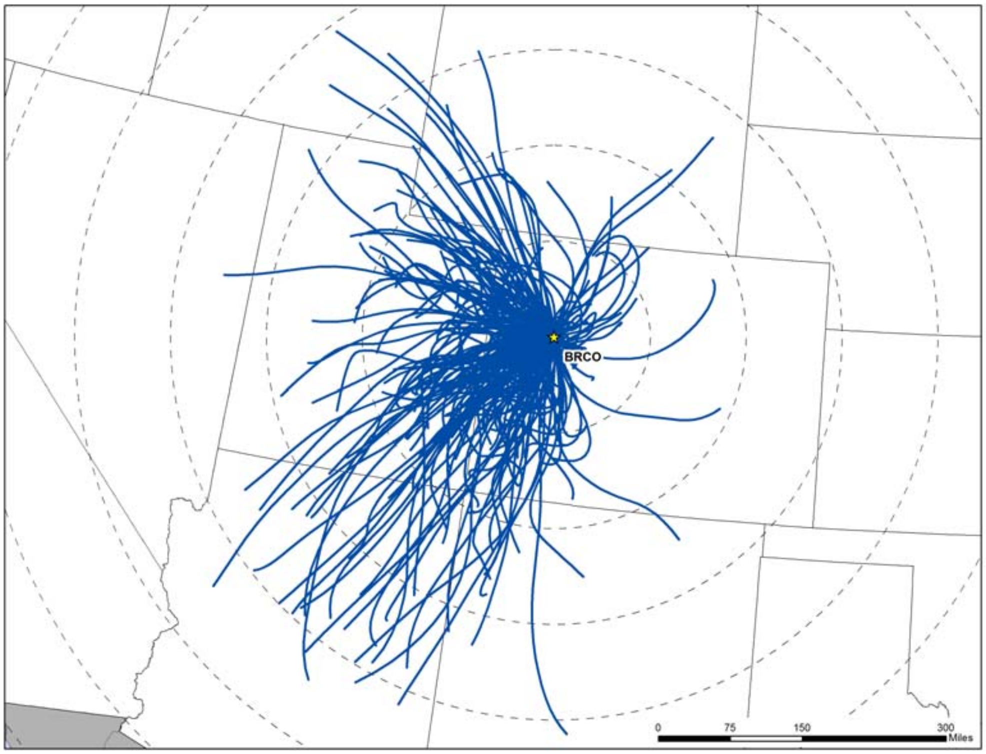


Figure 7-13. Back Trajectory Cluster Map for BRCO

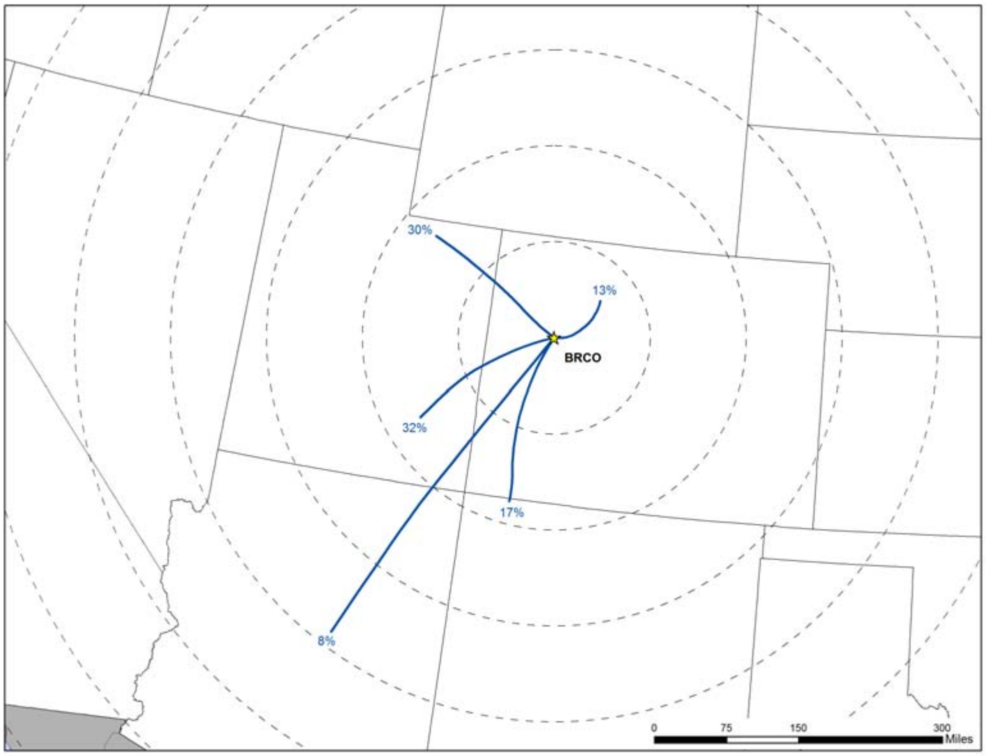


Figure 7-14. 2011 Composite Back Trajectory Map for PACO

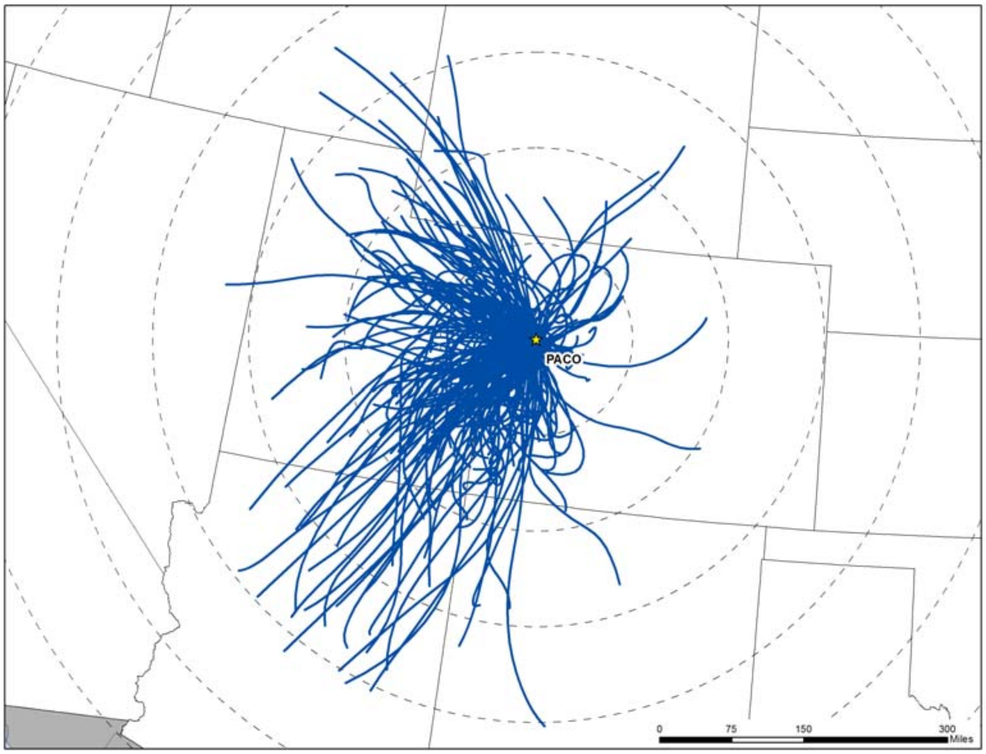


Figure 7-15. Back Trajectory Cluster Map for PACO

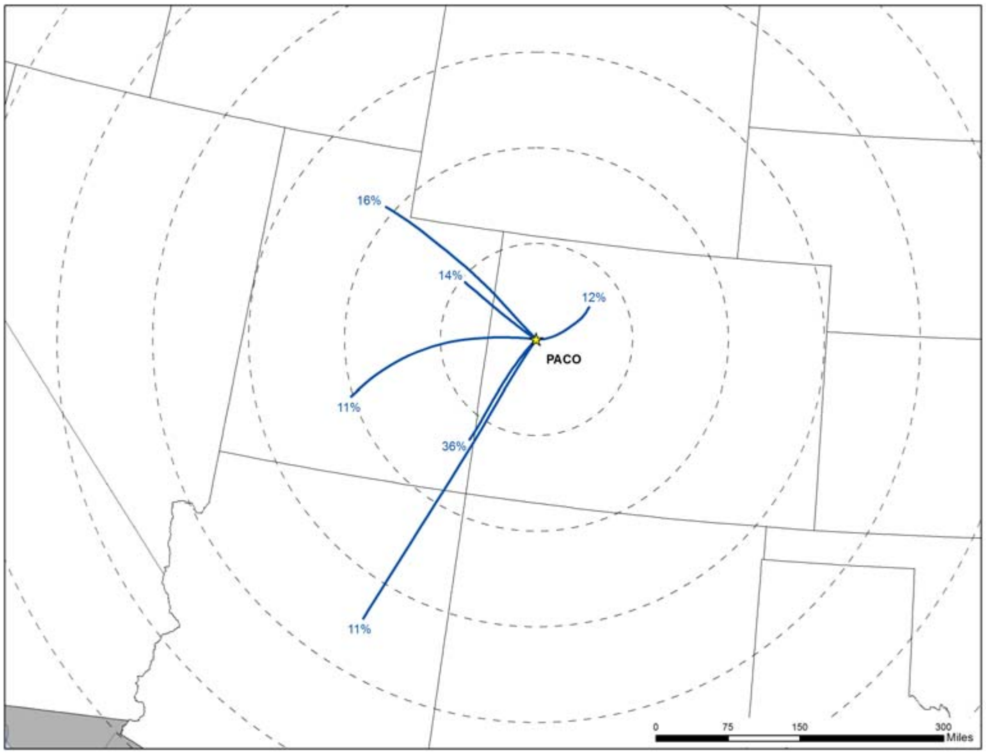


Figure 7-16. 2011 Composite Back Trajectory Map for RICO

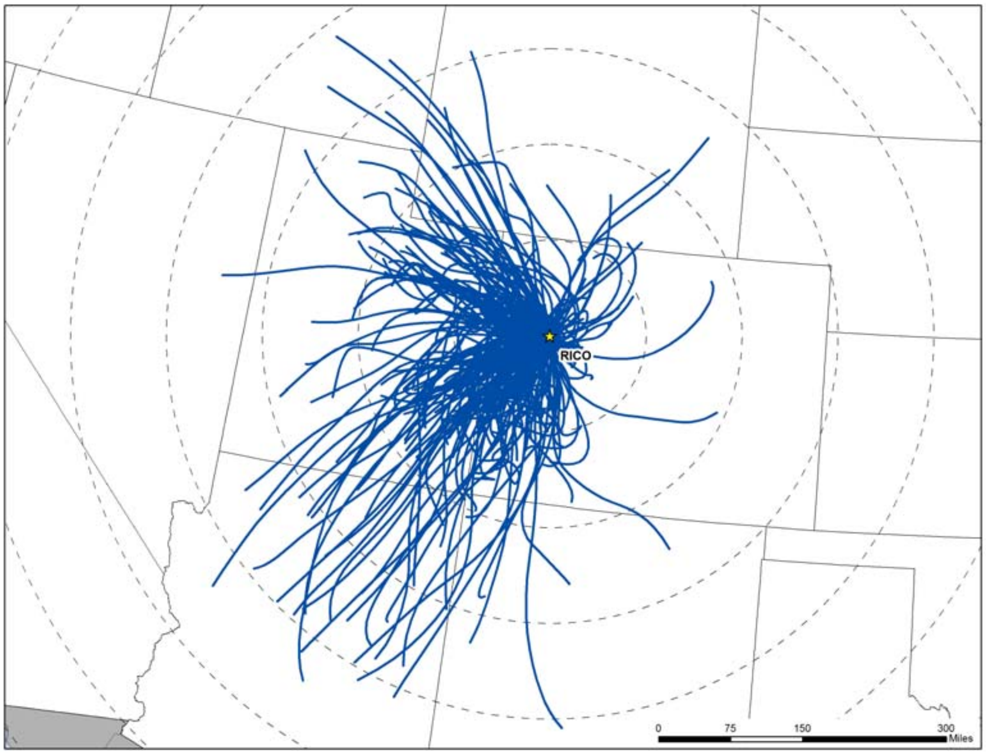
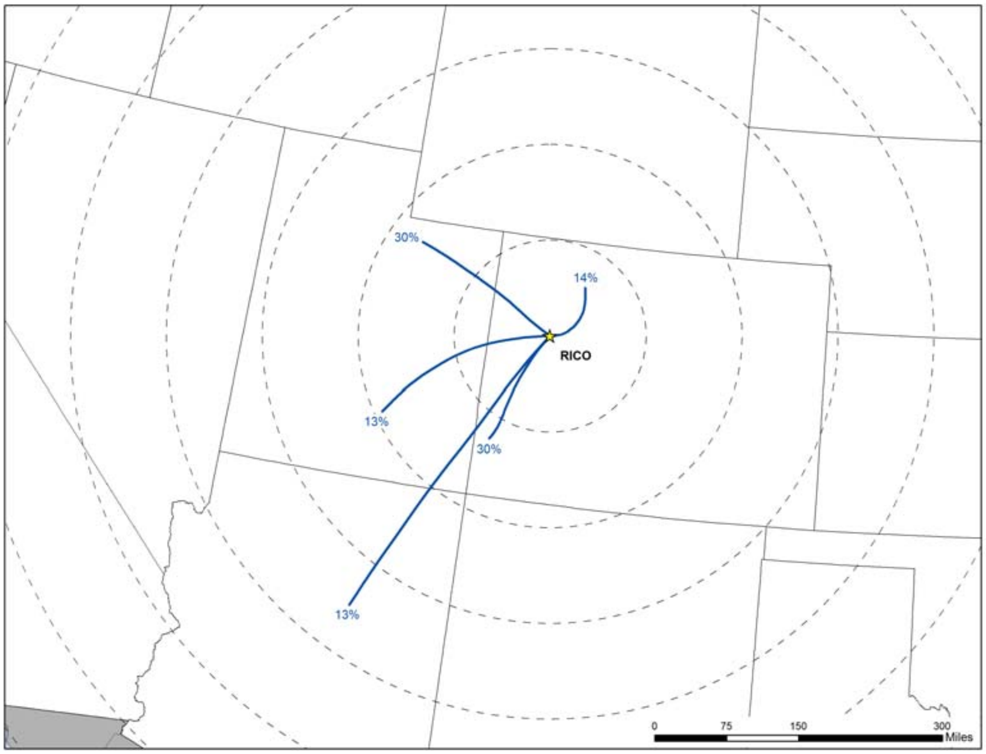


Figure 7-17. Back Trajectory Cluster Map for RICO



Observations from Figures 7-10 through 7-17 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' close proximity to GPCO (and to each other).

- The 24-hour air shed domains for the Garfield County sites were similar in size to GPCO, with the average trajectory length ranging from 171 miles for PACO to 181 miles for BRCO. The longest trajectories for these sites originated over central Arizona. For each Garfield County site, approximately 85 percent of back trajectories originated within 300 miles of the site.

- The cluster maps for the Garfield County sites resemble the cluster map for GPCO, with most of the trajectories having a southwesterly or northwesterly component.

7.2.4 Wind Rose Comparison

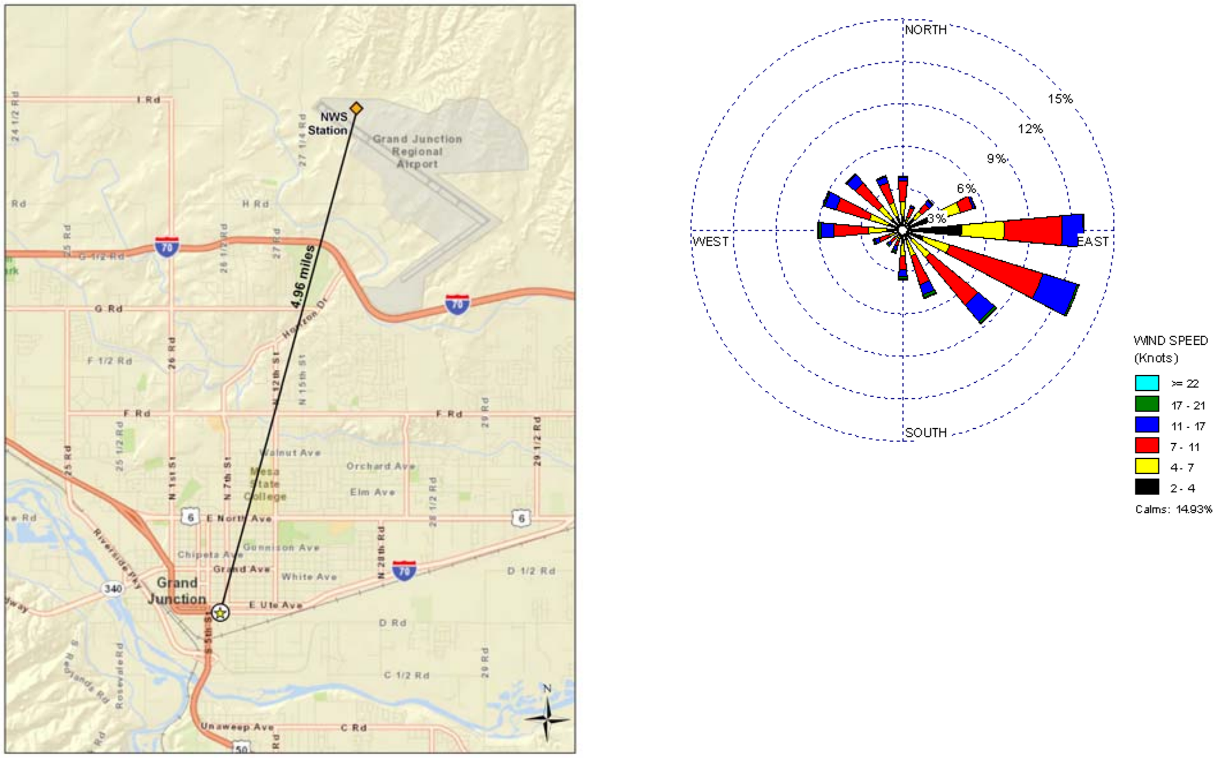
Hourly surface wind data from the NWS weather stations at the Walker Field Airport (for GPCO) and Garfield County Regional Airport (for BMCO, BRCO, PACO, and RICO) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using "petals" positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 7-18 presents a map showing the distance between the NWS station and GPCO, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 7-18 also presents three different wind roses for the GPCO monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 7-19 through 7-22 present the distance maps and wind roses for the four Garfield County sites.

Figure 7-18. Wind Roses for the Walker Field Airport Weather Station near GPCO

Distance between GPCO and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

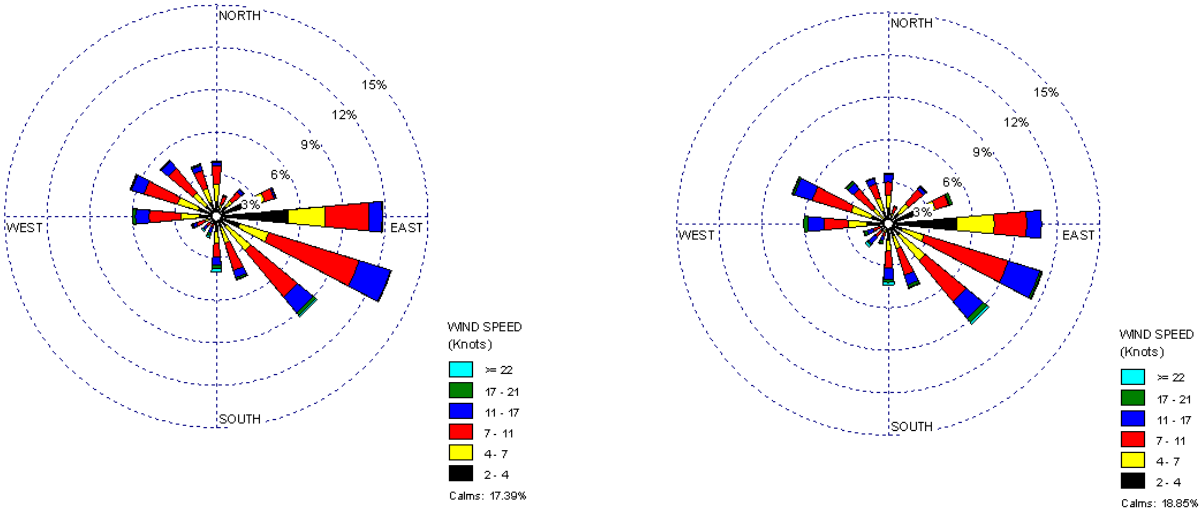
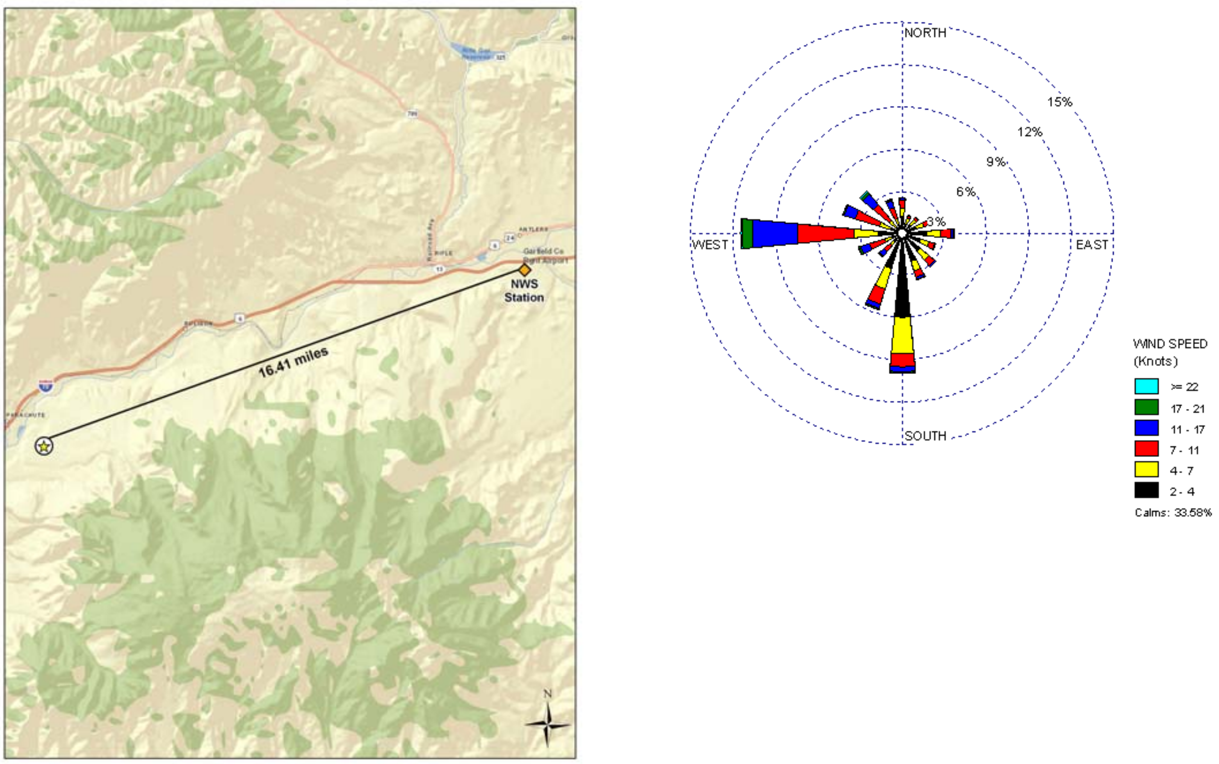


Figure 7-19. Wind Roses for the Garfield County Regional Airport near BMCO

Distance between BMCO and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

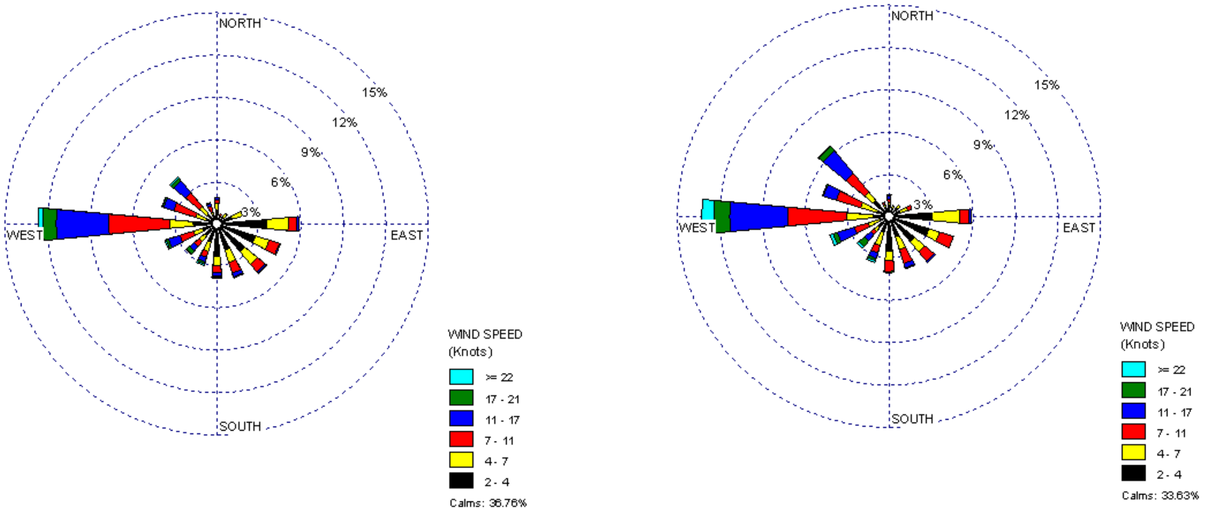
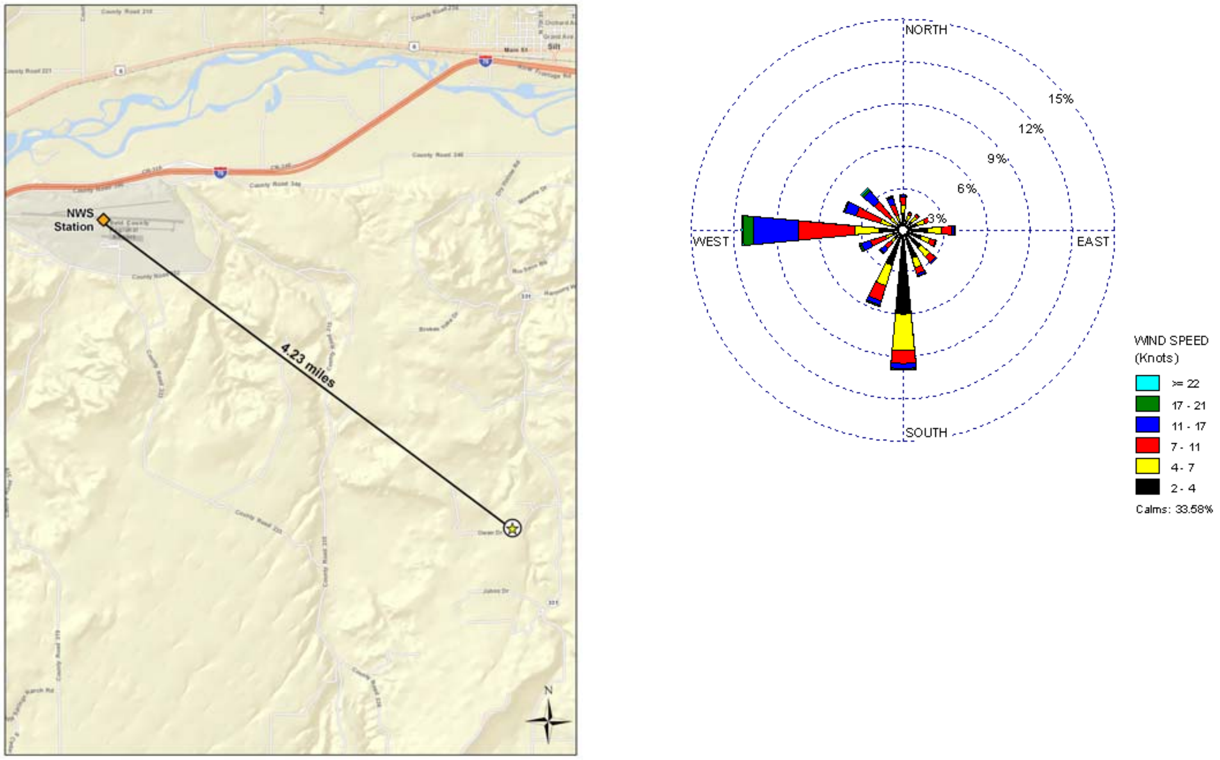


Figure 7-20. Wind Roses for the Garfield County Regional Airport near BRCO

Distance between BRCO and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

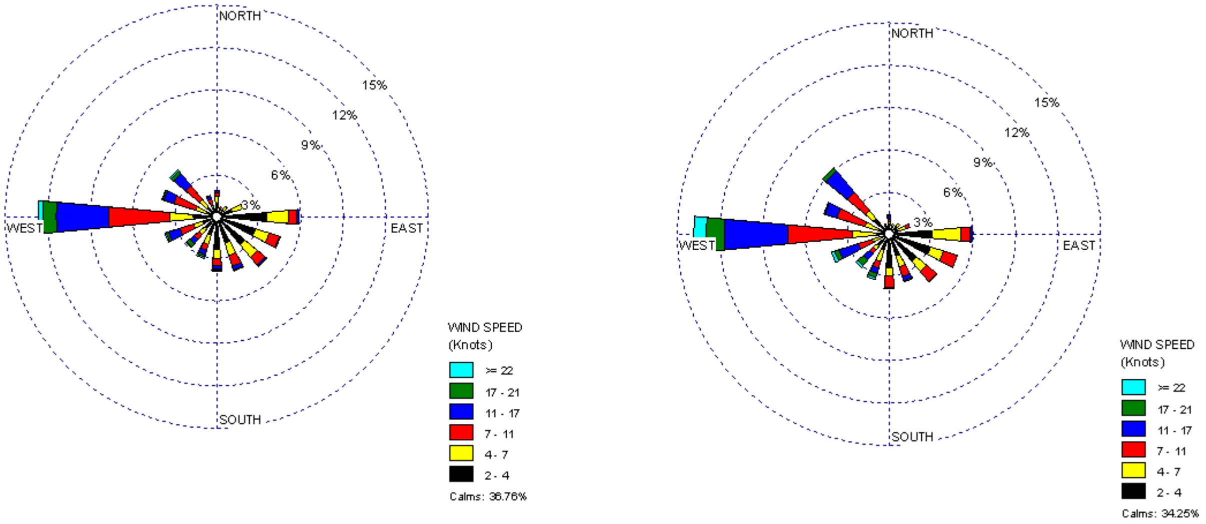
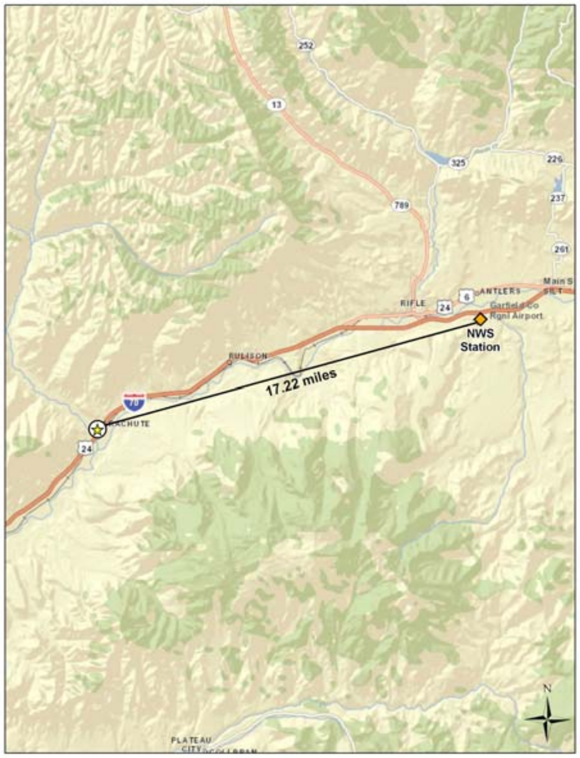
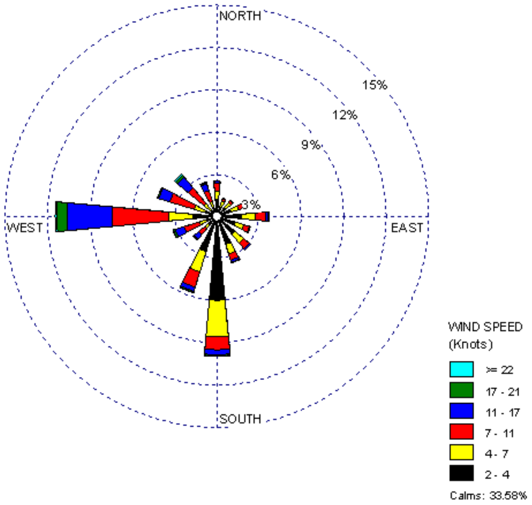


Figure 7-21. Wind Roses for the Garfield County Regional Airport near PACO

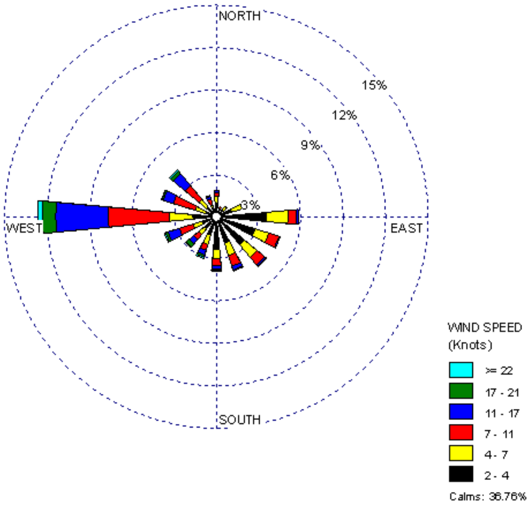
Distance between PACO and NWS Station



2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

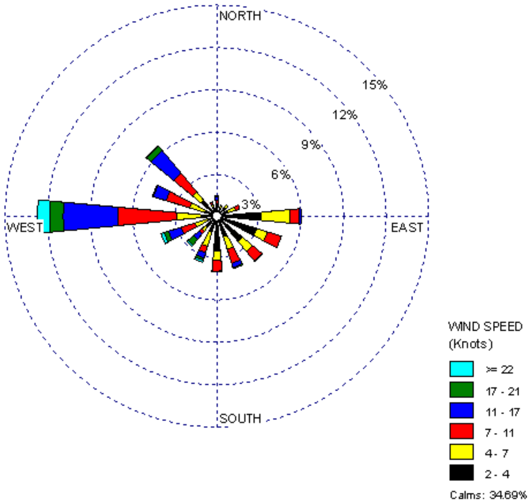
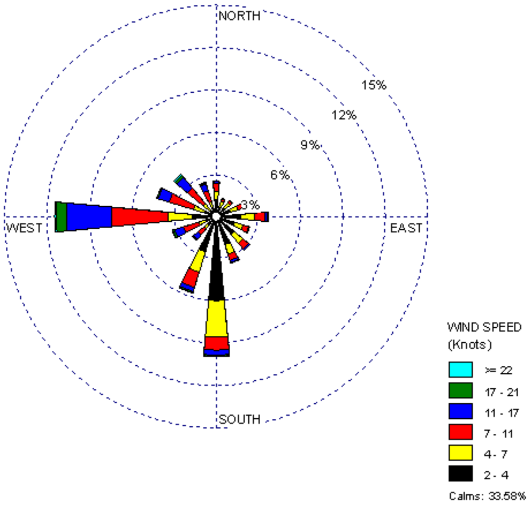


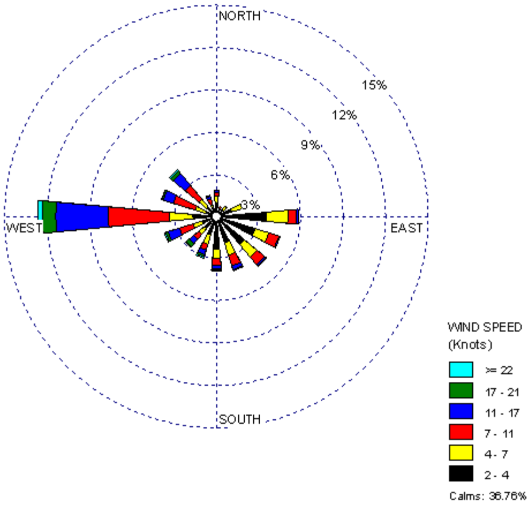
Figure 7-22. Wind Roses for the Garfield County Regional Airport near RICO

Distance between RICO and NWS Station

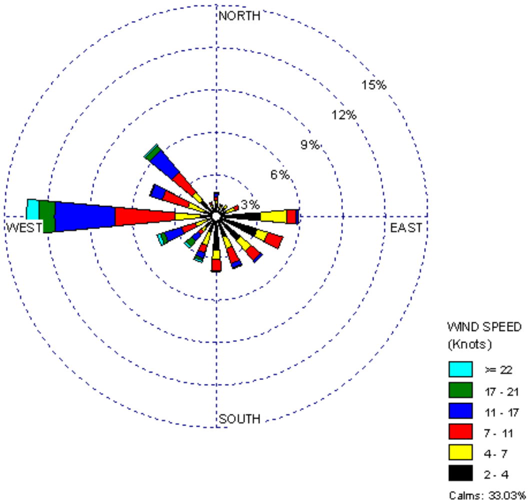
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



Observations from Figure 7-18 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 weather station.

- The historical wind rose shows that easterly, east-southeasterly, and southeasterly winds were prevalent near GPCO. Calm winds ($\leq$ 2 knots) were observed for less than 15 percent of the hourly wind measurements.

- The 2011 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 7-19 through 7-22 for the Garfield County sites include the following:

- The NWS weather station at Garfield County Regional Airport is the closest weather station to all four monitoring sites in Garfield County. The weather station is located just east of Rifle. The distances from the weather station to the sites varies from less than 3 miles (RICO) to just over 17 miles (PACO).

- The historical and 2011 wind roses for the Garfield County sites are identical to each other. This is because the wind observations come from the same NWS 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.

- Calm winds were observed for greater than one third of the wind observations in 2011. The 2011 wind roses exhibit a higher percentage of westerly winds and a significantly lower percentage of southerly and south-southwesterly winds than the historical wind rose.

- The sample day wind patterns for each site resemble the full-year wind patterns, but with a higher percentage of northwesterly winds. This resemblance indicates that conditions on sample days were representative of those experienced over the entire year.

7.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Colorado monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 7-4 presents the results of the preliminary risk-based screening process for each Colorado monitoring site. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. 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						
Naphthalene	0.029	61	61	100.00	12.25	12.25
Acetaldehyde	0.45	60	60	100.00	12.05	24.30
Benzene	0.13	60	60	100.00	12.05	36.35
Formaldehyde	0.077	60	60	100.00	12.05	48.39
Carbon Tetrachloride	0.17	58	60	96.67	11.65	60.04
1,3-Butadiene	0.03	53	53	100.00	10.64	70.68
Ethylbenzene	0.4	36	60	60.00	7.23	77.91
Acenaphthene	0.011	21	61	34.43	4.22	82.13
Acrylonitrile	0.015	17	17	100.00	3.41	85.54
1,2-Dichloroethane	0.038	16	16	100.00	3.21	88.76
Fluorene	0.011	11	61	18.03	2.21	90.96
p-Dichlorobenzene	0.091	9	32	28.13	1.81	92.77
Hexachloro-1,3-butadiene	0.045	8	8	100.00	1.61	94.38
Benzo(a)pyrene	0.00057	7	44	15.91	1.41	95.78

Table 7-4. Risk-Based Screening Results for the Colorado Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
1,1,2,2-Tetrachloroethane	0.017	7	7	100.00	1.41	97.19
Trichloroethylene	0.2	4	22	18.18	0.80	97.99
1,2-Dibromoethane	0.0017	3	3	100.00	0.60	98.59
Dichloromethane	7.7	2	60	3.33	0.40	99.00
Acenaphthylene	0.011	1	41	2.44	0.20	99.20
Hexavalent Chromium	0.000083	1	42	2.38	0.20	99.40
Propionaldehyde	0.8	1	60	1.67	0.20	99.60
1,1,2-Trichloroethane	0.0625	1	1	100.00	0.20	99.80
Xylenes	10	1	60	1.67	0.20	100.00
Total		498	949	52.48		
Battlement Mesa, Colorado - BMCO						
Benzene	0.13	51	51	100.00	50.00	50.00
Formaldehyde	0.077	20	20	100.00	19.61	69.61
Acetaldehyde	0.45	14	20	70.00	13.73	83.33
Ethylbenzene	0.4	9	51	17.65	8.82	92.16
1,3-Butadiene	0.03	8	8	100.00	7.84	100.00
Total		102	150	68.00		
Silt, Colorado - BRCO						
Benzene	0.13	53	53	100.00	75.71	75.71
1,3-Butadiene	0.03	6	7	85.71	8.57	84.29
Formaldehyde	0.077	6	6	100.00	8.57	92.86
Acetaldehyde	0.45	5	6	83.33	7.14	100.00
Total		70	72	97.22		
Parachute, Colorado - PACO						
Benzene	0.13	52	52	100.00	41.60	41.60
1,3-Butadiene	0.03	21	22	95.45	16.80	58.40
Formaldehyde	0.077	21	21	100.00	16.80	75.20
Acetaldehyde	0.45	19	21	90.48	15.20	90.40
Ethylbenzene	0.4	12	53	22.64	9.60	100.00
Total		125	169	73.96		
Rifle, Colorado - RICO						
Benzene	0.13	51	51	100.00	35.92	35.92
1,3-Butadiene	0.03	42	42	100.00	29.58	65.49
Acetaldehyde	0.45	17	17	100.00	11.97	77.46
Formaldehyde	0.077	17	17	100.00	11.97	89.44
Ethylbenzene	0.4	15	53	28.30	10.56	100.00
Total		142	180	78.89		

Observations from Table 7-4 include the following:

- Twenty-three pollutants failed at least one screen for GPCO, of which eight are NATTS MQO Core Analytes.

- Fourteen pollutants were initially identified as pollutants of interest for GPCO based on the risk-based screening process, of which seven are NATTS MQO Core Analytes. Trichloroethylene and hexavalent chromium were added to GPCO's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of GPCO's total failed screens. Three additional NATTS MQO Core Analytes were also added to GPCO's pollutants of interest even though their concentrations did not fail any screens: chloroform, tetrachloroethylene, and vinyl chloride. These three pollutants are not shown in Table 7-4 but are shown in subsequent tables in the sections that follow.

- 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 four sites. Ethylbenzene also failed screens for three of the four Garfield County sites (BRCO being the exception), and was identified as a pollutant of interest for BMCO, PACO, and RICO.

- Note that carbonyl compound samples were collected on a 1-in-12 day sampling schedule at the Garfield County sites, while SNMOCs were collected on a 1-in-6 day sampling schedule; thus, the number of carbonyl compounds samples collected at these sites were often less than half the number of SNMOC samples.

- Benzene and formaldehyde failed 100 percent of screens for all five Colorado sites.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Colorado monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for the five Colorado sites are provided in Appendices J through M and Appendix O.

7.4.1 2011 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Colorado 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 of 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 and hexavalent chromium 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	60/60	1.81 ± 0.34	1.47 ± 0.24	3.12 ± 0.45	3.36 ± 0.62	2.43 ± 0.29
Acrylonitrile	17/60	0.01 ± 0.03	0.15 ± 0.11	0.06 ± 0.04	0.01 ± 0.02	0.06 ± 0.03
Benzene	60/60	1.32 ± 0.29	1.49 ± 1.35	0.90 ± 0.14	1.69 ± 0.40	1.34 ± 0.35
1,3-Butadiene	53/60	0.15 ± 0.04	0.07 ± 0.03	0.09 ± 0.02	0.23 ± 0.06	0.13 ± 0.02
Carbon Tetrachloride	60/60	0.44 ± 0.08	0.50 ± 0.08	0.62 ± 0.08	0.57 ± 0.06	0.53 ± 0.04
Chloroform	42/60	0.07 ± 0.02	0.08 ± 0.03	0.07 ± 0.04	0.11 ± 0.03	0.08 ± 0.02
p-Dichlorobenzene	32/60	0.02 ± 0.02	0.01 ± 0.02	0.06 ± 0.02	0.07 ± 0.02	0.04 ± 0.01
1,2-Dichloroethane	16/60	0.01 ± 0.02	0.04 ± 0.03	0.02 ± 0.02	0.04 ± 0.03	0.03 ± 0.01
Ethylbenzene	60/60	0.46 ± 0.13	0.34 ± 0.06	0.69 ± 0.18	1.00 ± 0.33	0.62 ± 0.11
Formaldehyde	60/60	2.84 ± 0.37	2.53 ± 0.27	2.84 ± 0.37	2.74 ± 0.41	2.74 ± 0.17
Hexachloro-1,3-butadiene	8/60	0.02 ± 0.02	0.01 ± 0.02	0.02 ± 0.02	<0.01 ± 0.01	0.01 ± 0.01
1,1,2,2-Tetrachloroethane	7/60	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.02	<0.01 ± 0.01	0.01 ± 0.01
Tetrachloroethylene	53/60	0.26 ± 0.07	0.18 ± 0.08	0.15 ± 0.05	0.45 ± 0.15	0.26 ± 0.05
Trichloroethylene	22/60	0.04 ± 0.02	0.02 ± 0.03	0.04 ± 0.04	0.07 ± 0.06	0.04 ± 0.02
Vinyl Chloride	6/60	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Acenaphthene[a]	61/61	15.27 ± 6.69	9.75 ± 4.24	12.07 ± 2.27	4.95 ± 1.72	10.54 ± 2.17
Benzo(a)pyrene[a]	44/61	0.23 ± 0.11	0.03 ± 0.02	0.06 ± 0.07	0.49 ± 0.26	0.20 ± 0.08
Fluorene[a]	61/61	7.65 ± 2.43	7.65 ± 2.26	9.39 ± 1.47	5.90 ± 1.66	7.68 ± 0.98
Hexavalent Chromium[a]	42/59	0.01 ± 0.01	0.01 ± <0.01	0.01 ± <0.01	0.03 ± 0.02	0.02 ± 0.01
Naphthalene[a]	61/61	240.29 ± 96.22	106.40 ± 36.96	121.08 ± 19.58	156.63 ± 47.25	155.52 ± 29.71

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)
Battlement Mesa, Colorado - BMCO						
Acetaldehyde	20/20	0.71 ± 0.29	NA	NA	NA	NA
Benzene	51/51	1.37 ± 0.36	NA	2.65 ± 1.04	1.22 ± 0.36	NA
1,3-Butadiene	8/51	0.02 ± 0.03	NA	0	0.05 ± 0.03	NA
Ethylbenzene	51/51	0.24 ± 0.04	NA	0.65 ± 0.36	0.28 ± 0.14	NA
Formaldehyde	20/20	1.42 ± 0.57	NA	NA	NA	NA
Silt, Colorado - BRCO						
Acetaldehyde	6/6	NA	NA	NA	NA	NA
Benzene	53/54	1.06 ± 0.29	0.48 ± 0.12	NA	0.85 ± 0.15	0.86 ± 0.13
1,3-Butadiene	7/54	0.02 ± 0.02	0	NA	0.02 ± 0.02	0.01 ± 0.01
Formaldehyde	6/6	NA	NA	NA	NA	NA
Parachute, Colorado - PACO						
Acetaldehyde	21/21	0.85 ± 0.33	NA	NA	1.07 ± 0.29	NA
Benzene	52/53	1.61 ± 0.47	NA	1.61 ± 0.46	1.56 ± 0.35	1.45 ± 0.21
1,3-Butadiene	22/53	0.13 ± 0.06	NA	0	0.11 ± 0.05	0.07 ± 0.03
Ethylbenzene	53/53	0.25 ± 0.07	NA	0.59 ± 0.27	0.27 ± 0.06	0.32 ± 0.07
Formaldehyde	21/21	1.41 ± 0.33	NA	NA	1.83 ± 0.39	NA
Rifle, Colorado - RICO						
Acetaldehyde	17/17	1.47 ± 0.58	NA	NA	NA	NA
Benzene	51/53	1.48 ± 0.36	0.64 ± 0.14	NA	1.75 ± 0.32	1.27 ± 0.18
1,3-Butadiene	42/53	0.27 ± 0.09	0.09 ± 0.04	NA	0.28 ± 0.08	0.18 ± 0.04
Ethylbenzene	53/53	0.34 ± 0.06	0.22 ± 0.03	NA	0.47 ± 0.11	0.35 ± 0.04
Formaldehyde	17/17	1.99 ± 0.84	NA	NA	NA	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.

Observations for GPCO from Table 7-5 include the following:

- The pollutants with the highest annual average concentrations by mass are formaldehyde (2.74 ± 0.17 µg/m^3), acetaldehyde (2.43 ± 0.29 µg/m^3), and benzene (1.34 ± 0.35 µg/m^3). These are also the only pollutants with annual average concentrations greater than 1 µg/m^3.

- The confidence intervals associated with the quarterly average concentrations of acrylonitrile are relatively high and in some case greater than the quarterly averages themselves. This pollutant was detected 17 times in 2011 and its measurements ranged from 0.0739 µg/m^3 to 0.757 µg/m^3. Thus, a large number of zeros (43) were substituted into the calculations, leading to the appearance of a higher level of variability within the average concentrations, which is reflected in the confidence intervals. Nine of the 17 measured detections were measured during the second quarter. The minimum and maximum acrylonitrile concentrations were measured during this quarter.

- Acetaldehyde concentrations were highest during third and fourth quarters of the year. This trend is not reflected in the formaldehyde concentrations.

- Benzene's second quarter confidence interval is nearly as great as the quarterly average concentration, indicating the likely influence of outliers. The maximum concentration of benzene was measured at GPCO on June 8, 2011 (10.6 µg/m^3). This concentration is more than twice the next highest measurement (3.55 µg/m^3 measured on November 29, 2011) and more than seven times the next highest concentration measured in that quarter (1.49 µg/m^3 measured on April 27, 2011). The June 8th concentration is also the fourth highest benzene concentration measured across the program.

- For many VOCs, the fourth quarter averages were greater than the other quarterly averages, particularly for 1,3-butadiene, ethylbenzene, and tetrachloroethylene. However, the differences across the averages are not statistically significant.

- The first quarter average concentration of naphthalene is the highest of the quarterly averages and has a relatively large confidence interval associated with it. A review of the data shows that concentrations of naphthalene range from 38.1 ng/m^3 to 650 ng/m^3, with three of the highest measurements of naphthalene (those greater than 400 ng/m^3) measured in January and February of 2011. GPCO has three of six highest naphthalene concentrations measured across the program

- Average benzo(a)pyrene concentrations for the first and fourth quarters of 2011 are significantly higher than the average concentrations for the other two quarters. A review of the data shows that 22 of the 25 concentrations of this pollutant greater than 0.01 ng/m^3 were measured during the first and fourth quarters of 2011. Conversely, 14 of the 16 non-detects were measured during the second and third quarters of 2011. Three measurements of benzo(a)pyrene greater than 1 ng/m^3 were measured during a 1-month period between November and December 2011; these measurements account for three of the seven measurements of benzo(a)pyrene greater than 1 ng/m^3 measured across the program for all NMP sites sampling PAHs.

Observations for the Garfield County sites from Table 7-5 include the following:

- Of the SNMOCs, benzene has the highest annual average concentration by mass for each of the Garfield County sites. Annual average concentrations of benzene ranged from 0.86 ± 0.13 µg/m^3 for BRCO to 1.45 ± 0.21 µg/m^3 for PACO. While PACO's benzene concentrations were steady across 2011, the quarterly average concentrations of benzene for the other sites exhibit more variability.

- The annual average concentrations of 1,3-butadiene varied significantly across the Garfield County sites, ranging from 0.01 ± 0.0.1 µg/m^3 for BRCO to 0.18 ± 0.04 µg/m^3 for RICO. A comparison of the Garfield County sites shows that the 10 highest concentrations of 1,3-butadiene were measured at RICO, all of which were measured during the first and fourth quarters of 2011. Note that this pollutant was not detected during the second quarter at BRCO nor at BMCO and PACO during the third quarter of 2011. However, the lack of quarterly averages across all sites and all quarters makes a seasonal trend difficult to determine.

- Annual average concentrations for the carbonyl compound pollutants of interest could not be calculated for any of the Garfield County sites because these sites did not meet the quarterly completeness criteria specified above. However, Appendix L provides the pollutant-specific average concentrations for all valid samples collected over the entire sample period for each site.

- Annual average concentrations for the SNMOC pollutants of interest could not be calculated for BMCO because the overall method completeness criterion was not met. Appendix K also provides the pollutant-specific average concentrations for all valid SNMOC samples collected over the entire sample period.

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 14 times.

- GPCO appears frequently in Table 4-9 for VOCs, although its highest ranking is fourth (ethylbenzene). PACO's annual average benzene concentration ranked third among all sites sampling this pollutant, with GPCO and RICO ranking sixth and seventh, respectively. RICO and GPCO rank fourth and seventh for 1,3-butadiene, respectively.

- GPCO's annual average acetaldehyde concentration ranked sixth highest among NMP sites sampling carbonyl compounds, as shown in Table 4-10. GPCO's formaldehyde concentration does not appear in this table (it ranked 12th).

- As shown in Table 4-11 for the PAHs, GPCO has the highest annual concentration of naphthalene and benzo(a)pyrene among all NMP sites sampling PAHs. This site also has the fourth highest annual average of acenaphthene and the sixth highest annual average of fluorene.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzene and 1,3-butadiene were created for each of the Colorado sites. Note that these box plots are 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). Box plots for acetaldehyde and formaldehyde were created for GPCO (the only site for which annual averages for these pollutants could be calculated). Box plots were also created for benzo(a)pyrene, hexavalent chromium, and naphthalene for GPCO. Figures 7-23 through 7-29 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.

Figure 7-23. Program vs. Site-Specific Average Acetaldehyde Concentration

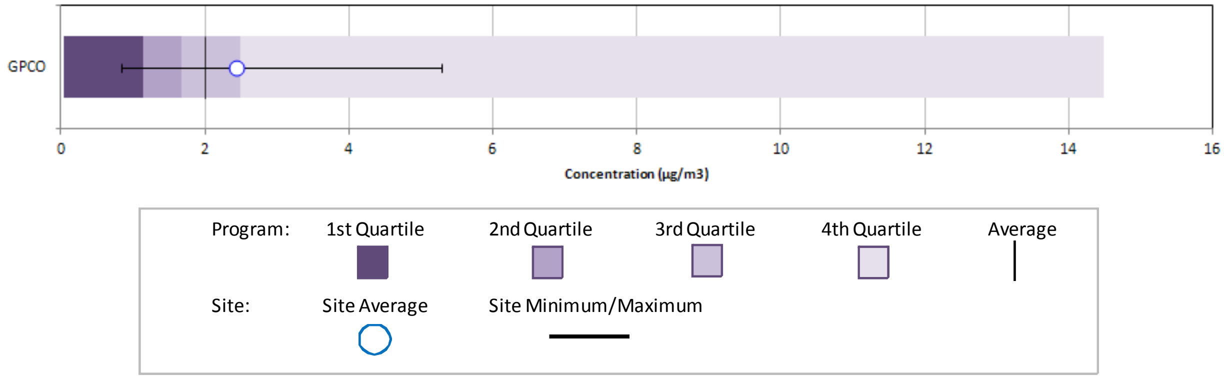
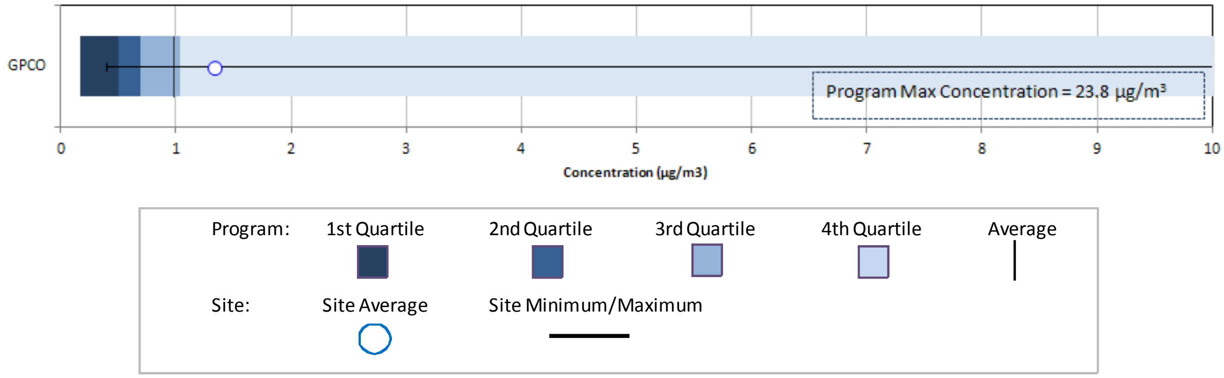


Figure 7-24a. Program vs. Site-Specific Average Benzene (Method TO-15) Concentration



Program Max Concentration = 23.8 µg/m³

Figure 7-24b. Program vs. Site-Specific Average Benzene (SNMOC) Concentrations

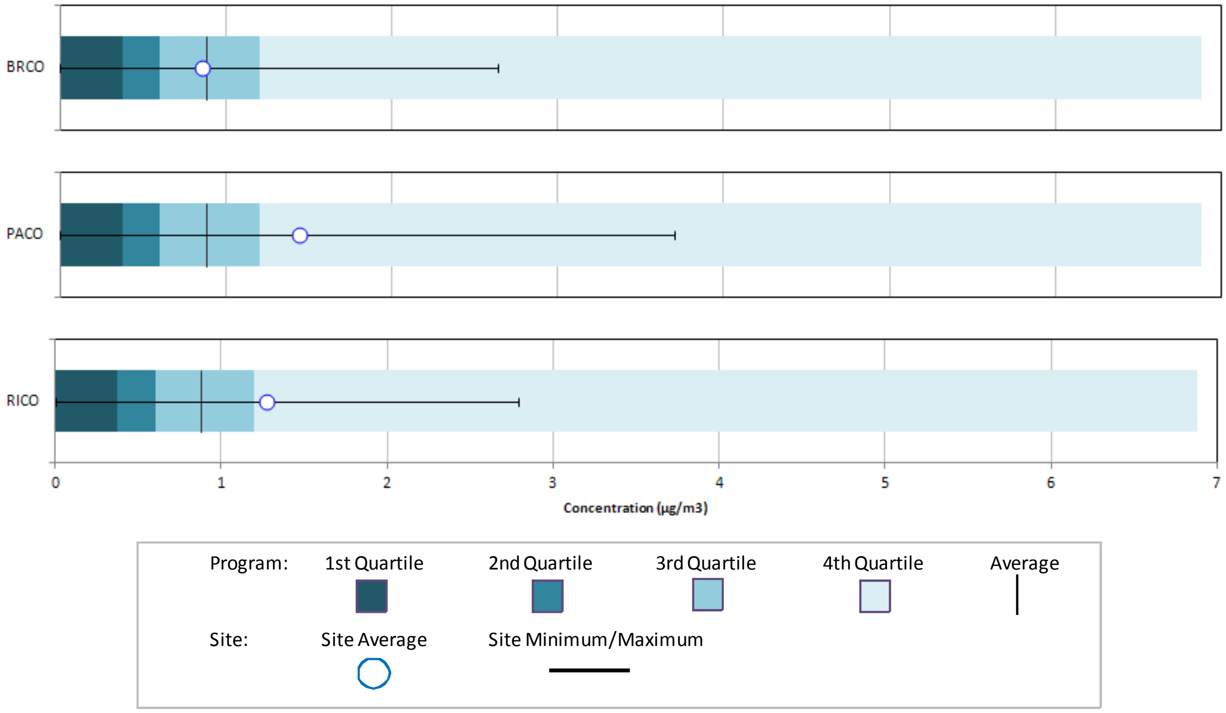


Figure 7-25. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

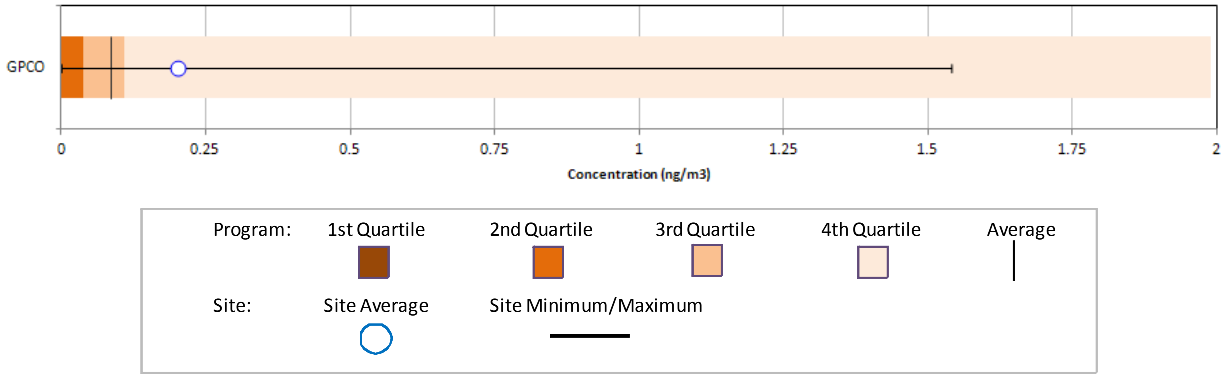


Figure 7-26a. Program vs. Site-Specific Average 1,3-Butadiene (Method TO-15) Concentration

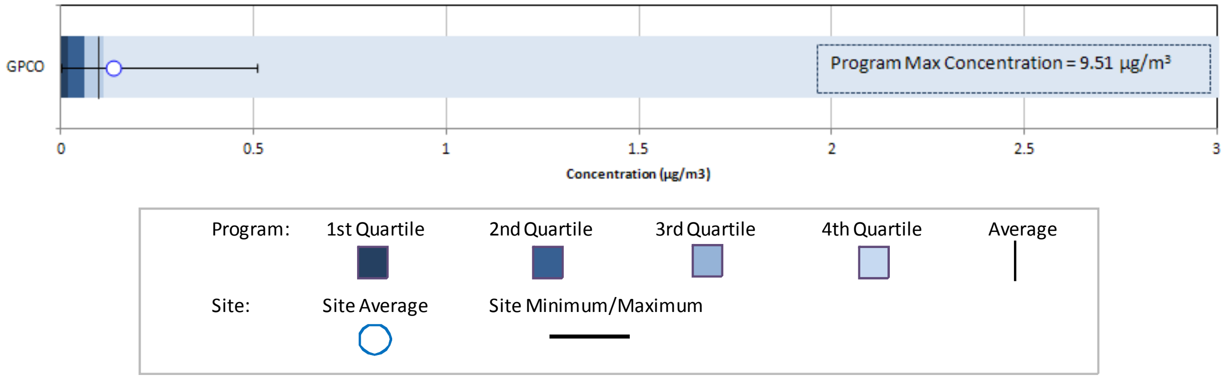


Figure 7-26b. Program vs. Site-Specific Average 1,3-Butadiene (SNMOC) Concentrations

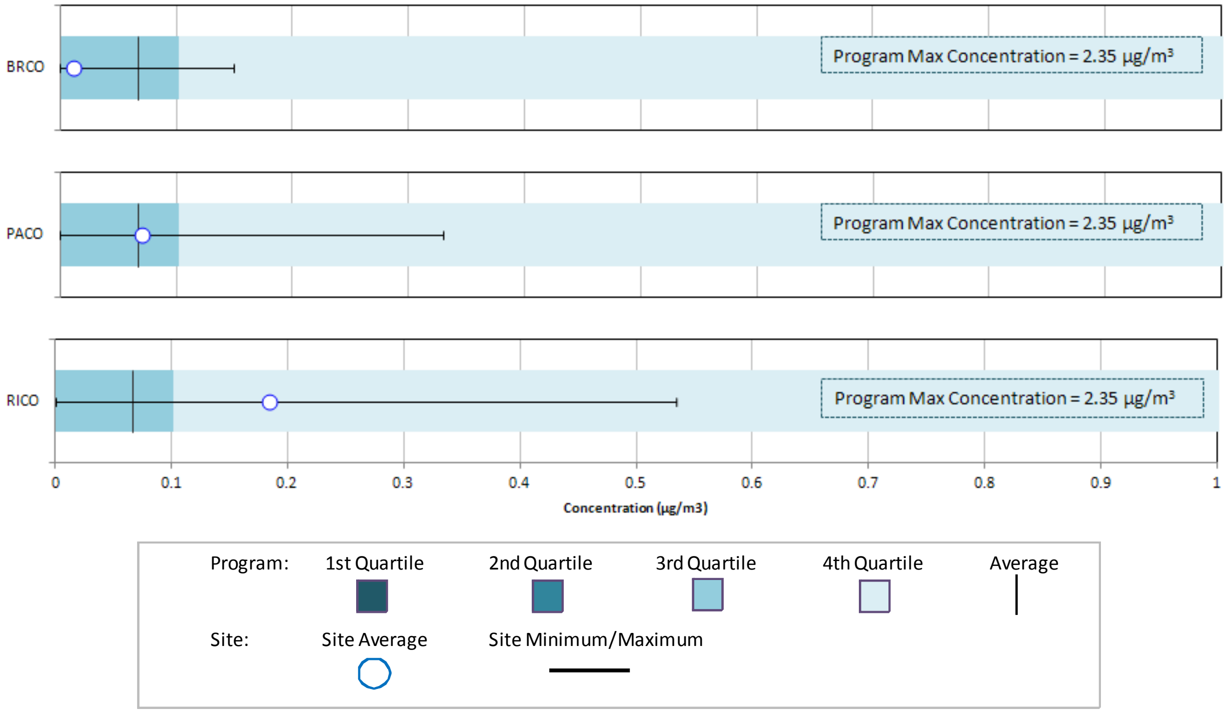


Figure 7-27. Program vs. Site-Specific Average Formaldehyde Concentration

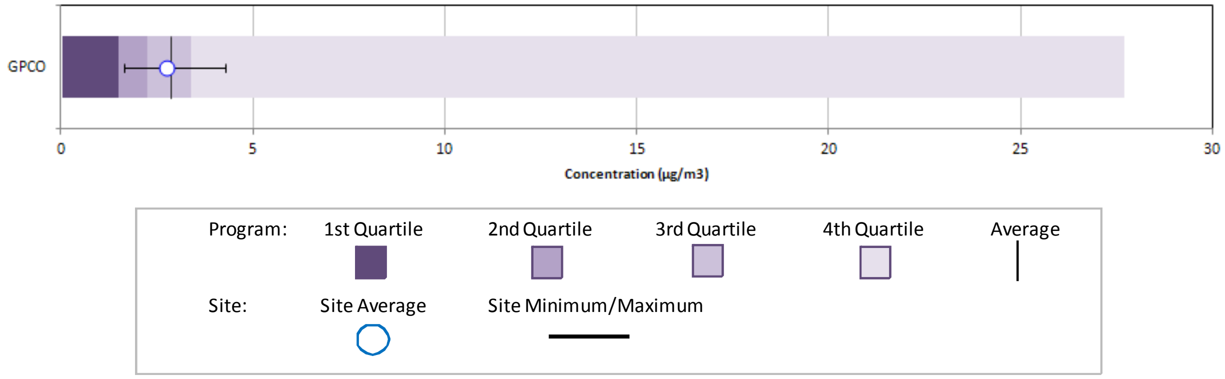


Figure 7-28. Program vs. Site-Specific Average Hexavalent Chromium Concentration

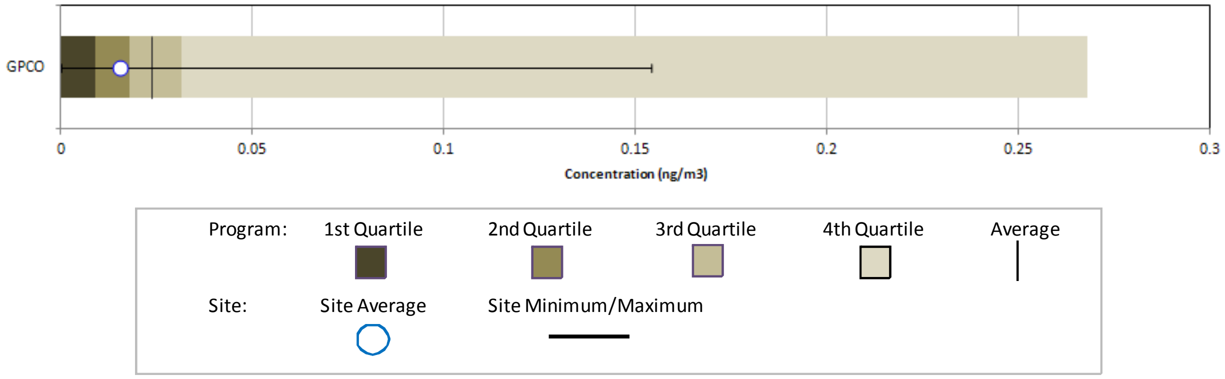
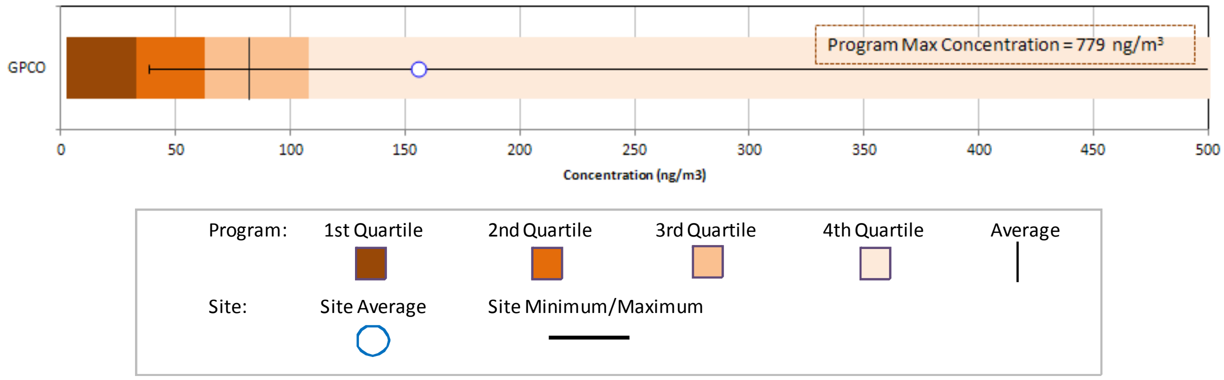


Figure 7-29. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 7-23 through 7-29 include the following:

- Figure 7-23 shows that GPCO's annual average acetaldehyde concentration is greater than the program-level average concentration and just less than the program-level third quartile (or 75th percentile). The maximum acetaldehyde concentration measured at GPCO is less than the maximum concentration measured across the program.

- Figure 7-24a presents the benzene concentrations for GPCO compared to the benzene concentrations measured across the program for NMP sites sampling VOCs with Method TO-15; Figure 7-24b 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.

- Figure 7-24a is the box plot for benzene for GPCO. The program-level maximum concentration (23.8 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 10 µg/m^3. The box plot 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. While the maximum benzene concentration measured at GPCO is less than the maximum measured across the program, it is greater than the scale on the graph (10.6 µg/m^3).

- The annual average benzene concentrations for PACO and RICO are greater than the program-level average concentration while the annual average concentration for BRCO is just less than the program-level average, as shown in Figure 7-24b. The annual averages for PACO and RICO are also greater than the program-level third quartile. The maximum benzene concentration measured by sites sampling SNMOCs was not measured at the Garfield County sites.

- Figure 7-25 is the box plot for benzo(a)pyrene for GPCO. Note that the program-level first quartile for this pollutant is zero and is not visible on this box plot. The box plot shows that the annual average concentration for GPCO is greater than the program-level average concentration as well as the program-level third quartile. Recall from the previous section that GPCO has the highest annual average benzo(a)pyrene concentration among all sites sampling PAHs. Figure 7-25 also shows that while the maximum benzo(a)pyrene concentration measured at GPCO (1.54 ng/m^3) is not the maximum concentration measured across the program (1.99 ng/m^3), it was the second highest. The third highest concentration measured across the program was also measured at GPCO. Several non-detects of benzo(a)pyrene were measured at GPCO.

- Similar to the box plots for benzene, Figure 7-26a 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 7-26b 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. Note that the program-level maximum concentrations are not shown directly on either box plot as the scale has been reduced to allow for the observation of data points at the lower end of the concentration range.

- Figure 7-26a shows that, similar to benzene, GPCO’s annual average 1,3-butadiene concentration is greater than the program-level average concentration and greater than the third quartile for the program. However, the maximum concentration measured at GPCO is considerably less than the maximum concentration measured across the program. A few non-detects of 1,3-butadiene were measured at GPCO.

- The first and second quartiles (and median concentration) at the program-level are zero, and thus, not shown in Figure 7-26b, indicating that at least half of the 1,3-butadiene concentrations measured by sites sampling SNMOCs were non-detects. Figure 7-26b shows that, of the Garfield County sites for which annual average concentrations could be calculated, RICO’s annual average 1,3-butadiene concentration is the highest and BRCO’s annual average the lowest. This figure also shows that the annual average concentration for BRCO is less than the program-level average, the annual average concentration for PACO is similar to the program-level average, and the annual average concentration for RICO is more than twice the program-level average concentration.

- Figure 7-27 shows that GPCO’s annual average formaldehyde concentration is just less than the program-level average concentration. The range of formaldehyde concentrations measured at GPCO appears rather small, ranging from 1.65 µg/m^3 to 4.28 µg/m^3. Note that the minimum formaldehyde concentration measured at GPCO is greater than the program-level first quartile.

- Figure 7-28 is the box plot for hexavalent chromium for GPCO. The figure shows that the annual average concentration for GPCO is less than both the program-level average and median concentrations. Although the maximum concentration measured at GPCO is less than the maximum concentration measured across the program, GPCO’s maximum concentration is the seventh highest measurement of this pollutant among sites sampling hexavalent chromium. Several non-detects of hexavalent chromium were measured at GPCO.

- Figure 7-29 is the box plot for naphthalene. Note that the program-level maximum concentration (779 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 ng/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 7-29 shows that the annual average naphthalene concentration for GPCO is greater than the program-level average concentration as well as 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 maximum naphthalene concentration measured at GPCO (650 ng/m^3) is the second highest measurement across the program. The minimum concentration of naphthalene measured at GPCO (38.1 ng/m^3) is greater than the program-level first quartile (32.8 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 selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. GPCO has sampled carbonyl compounds and VOCs since 2004 and hexavalent chromium since 2005. Thus, Figures 7-30 through 7-35 present the annual statistical metrics for acetaldehyde, benzene, 1,3-butadiene, formaldehyde, and hexavalent chromium for GPCO, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

GPCO began sampling PAHs and BRCO, PACO, and RICO began sampling SNMOCs and carbonyl compounds under the NMP in 2008; because this is fewer than 5 consecutive years of sampling, the trends analysis was not conducted for the listed pollutants for these methods. BMCO began sampling SNMOCs and carbonyl compounds under the NMP at the end of 2010; thus, the trends analysis was not conducted for this site either.

Figure 7-30. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at GPCO

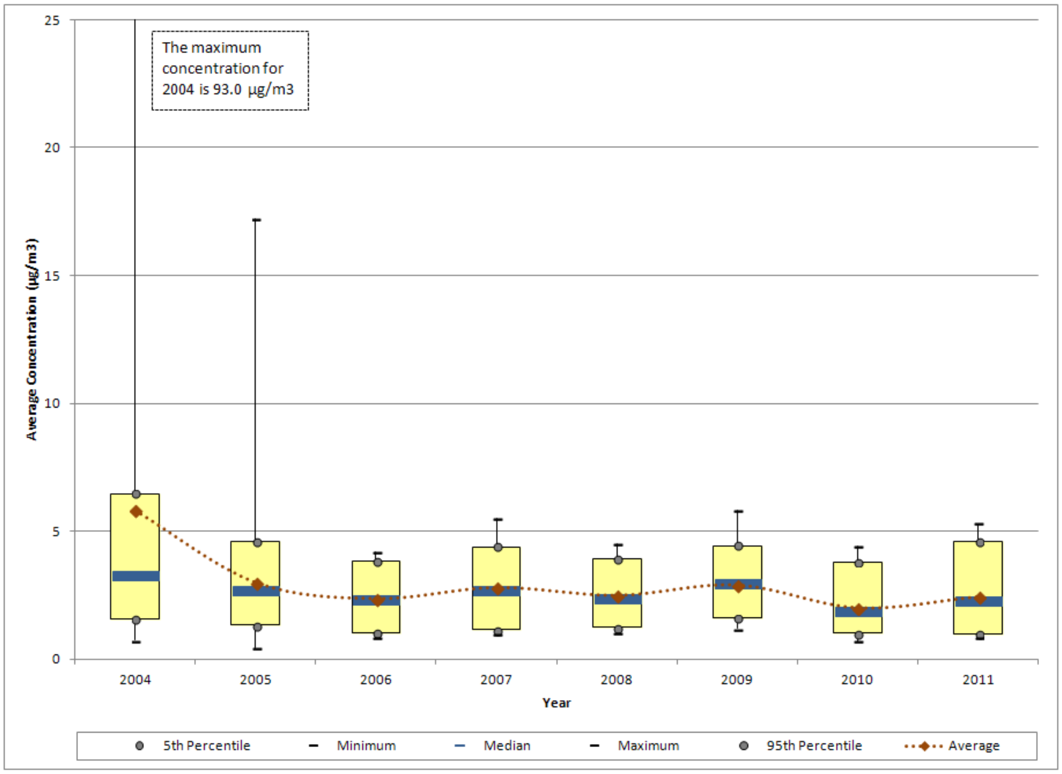


Figure 7-31. Annual Statistical Metrics for Benzene Concentrations Measured at GPCO

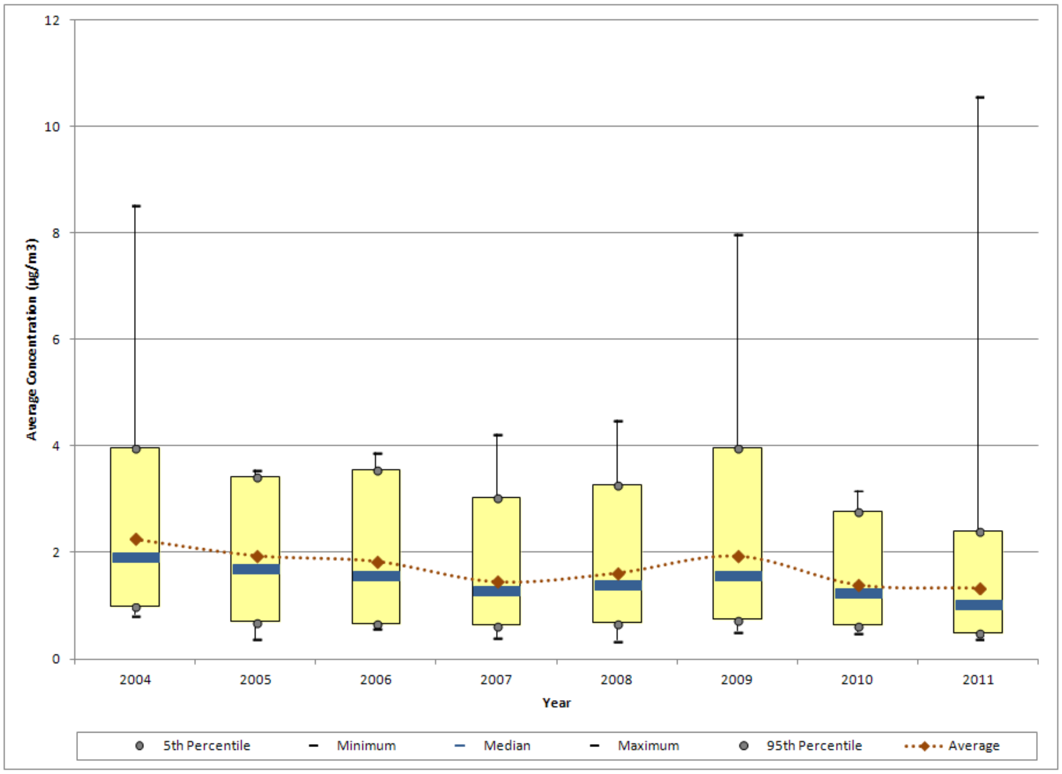


Figure 7-32. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at GPCO

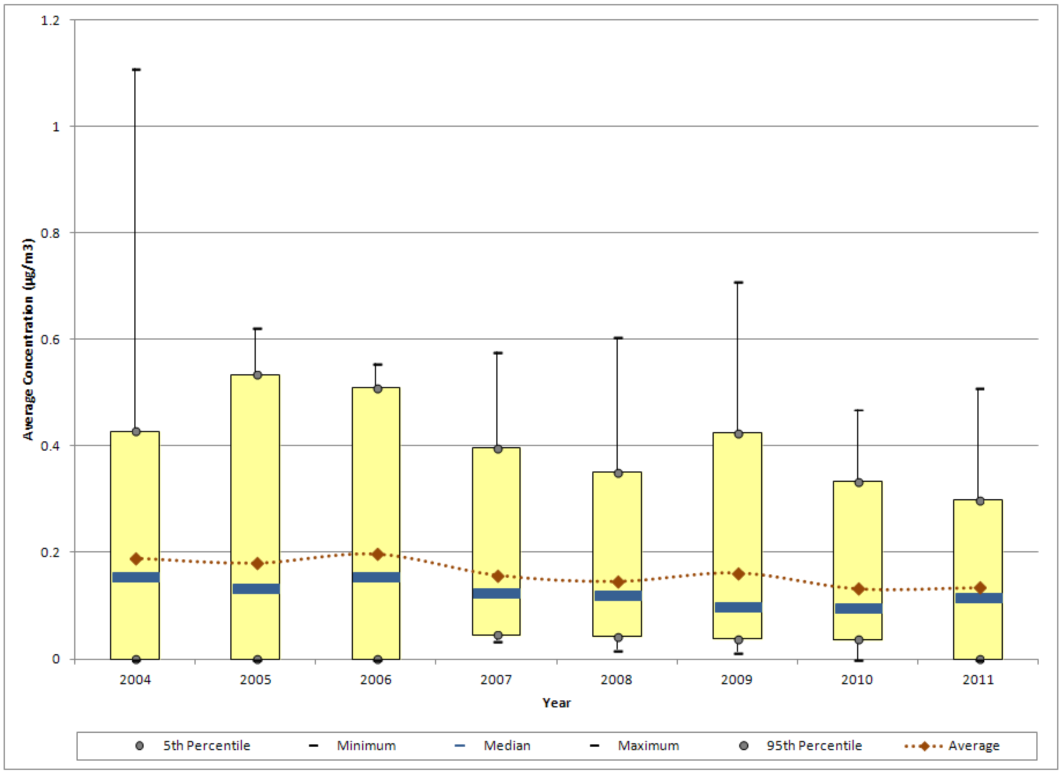


Figure 7-33. Annual Statistical Metrics for Formaldehyde Concentrations Measured at GPCO

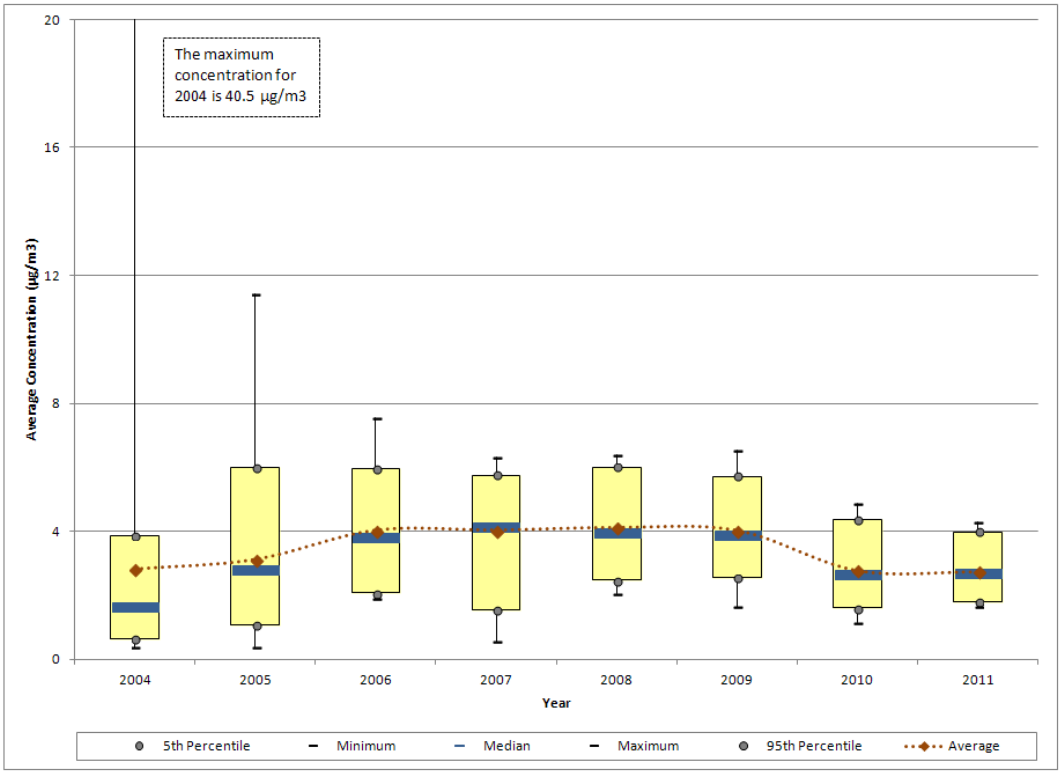
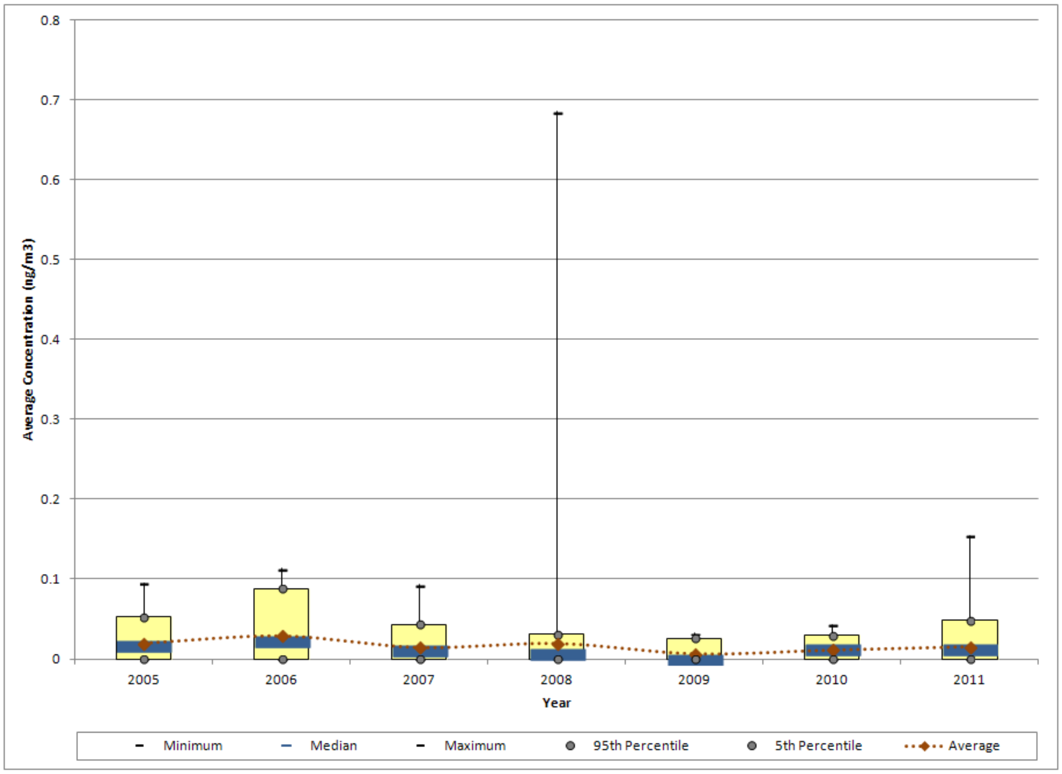


Figure 7-34. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at GPCO



Observations from Figure 7-30 for acetaldehyde measurements at GPCO include the following:

- The maximum acetaldehyde concentration was measured during 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 measured in 2004 and the six highest acetaldehyde concentrations (ranging from 6.35 µg/m^3 to 93.0 µg/m^3) were all measured in 2004 and 2005.

- After the first two years of sampling, the median and average concentrations fluctuate only slightly from year to year. The average concentration ranged from 2.00 µg/m^3 for 2010 to 2.90 µg/m^3 for 2009 for the period from 2006 to 2011.

- Although difficult to discern in Figure 7-30, the average and median concentrations differ less than 0.15 µg/m^3 for each year after 2005, indicating relatively little variability in the central tendency of acetaldehyde concentrations measured over the periods shown.

Observations from Figure 7-31 for benzene measurements 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.

- Even with the maximum concentration, most of the statistical metrics for 2011 decreased from 2010 to 2011.

- Although there have been fluctuations, both the average and median concentrations of benzene have decreased slightly over time.

- There have been no non-detects of benzene reported over the period of sampling.

Observations from Figure 7-32 for 1,3-butadiene measurements 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 average concentrations appear to have a slight decreasing trend; however, confidence intervals calculated from the individual concentrations show that this decrease is not statistically significant.

- The difference between the average and the median concentrations is at a minimum for 2011, which can be an indication of decreasing variability in the measurements.

- The number of non-detects, and subsequently zeros substituted for non-detects, decreased from approximately 30 percent in 2004 and 2005, to eight percent in 2006, to none in 2007, 2008, and 2009. The number of non-detects began to increase slightly after 2009, up to three percent in 2010 and nearly 12 percent in 2011.

Observations from Figure 7-33 for formaldehyde measurements at GPCO include the following:

- The trends graph for formaldehyde resembles the trends graph for acetaldehyde in that the maximum formaldehyde concentration was measured in 2004 and is significantly higher than the maximum concentrations measured in subsequent years. The three highest concentrations of formaldehyde were measured on the same days as the three highest acetaldehyde concentrations.

- Even with decreasing maximum concentrations, the average formaldehyde concentrations (as well as several other statistical parameters) have a slight increasing trend through 2006. Between 2006 and 2009, the average concentration was approximately 4 µg/m^3. A significant decrease in all of the statistical metrics is shown for 2010, with little change for 2011.

- The difference between the 5th and 95th percentiles has been decreasing since 2007, and is at a minimum for 2011, which indicates a smaller range in the majority of the concentrations measured. The decreasing difference between the median and average concentrations is a further indicator of the decreasing variability in the formaldehyde measurements at GPCO.

Observations from Figure 7-34 for hexavalent chromium measurements at GPCO include the following:

- The maximum hexavalent chromium concentration was measured on July 5, 2008 (0.685 ng/m^3). Only two additional hexavalent chromium concentrations measured at GPCO are greater than 0.1 ng/m^3, one measured on December 29, 2011 (0.154 ng/m^3) and the other on August 9, 2006 (0.113 ng/m^3).

- The average concentration of hexavalent chromium for 2008 is being driven by the outlier measured that year. If that measurement was removed from the calculation, concentrations of hexavalent chromium would exhibit a steady decreasing trend between 2006 and 2009, followed by an increasing trend for 2010 and 2011.

- Both the minimum concentration and 5th percentile for all years of sampling are zero, indicating the presence of non-detects. For 2009, the median (or 50th percentile) is also zero indicating that at least half of the measurements were non-detects. The percentage of non-detects has ranged from 18 percent in 2006 to 60 percent in 2009.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

7.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Colorado 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 Hazard Approximation (HQ)
Grand Junction, Colorado - GPCO						
Acenaphthene[a]	0.000088	--	61/61	0.01 ± <0.01	0.93	--
Acetaldehyde	0.0000022	0.009	60/60	2.43 ± 0.29	5.35	0.27
Acrylonitrile	0.000068	0.002	17/60	0.06 ± 0.03	4.07	0.03
Benzene	0.0000078	0.03	60/60	1.34 ± 0.35	10.42	0.04
Benzo(a)pyrene[a]	0.00176	--	44/61	<0.01 ± <0.01	0.35	--
1,3-Butadiene	0.00003	0.002	53/60	0.13 ± 0.02	4.01	0.07
Carbon Tetrachloride	0.000006	0.1	60/60	0.53 ± 0.04	3.20	0.01
Chloroform	--	0.098	42/60	0.08 ± 0.02	--	<0.01

-- = 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 Hazard Approximation (HQ)
p-Dichlorobenzene	0.000011	0.8	32/60	0.04 ± 0.01	0.44	<0.01
1,2-Dichloroethane	0.000026	2.4	16/60	0.03 ± 0.01	0.69	<0.01
Ethylbenzene	0.0000025	1	60/60	0.62 ± 0.11	1.54	<0.01
Fluorene[a]	0.000088	--	61/61	0.01 ± <0.01	0.68	--
Formaldehyde	0.000013	0.0098	60/60	2.74 ± 0.17	35.60	0.28
Hexachloro-1,3-butadiene	0.000022	0.09	8/60	0.01 ± 0.01	0.32	<0.01
Hexavalent Chromium[a]	0.012	0.0001	42/59	<0.01 ± <0.01	0.19	<0.01
Naphthalene[a]	0.000034	0.003	61/61	0.16 ± 0.03	5.29	0.05
1,1,2,2-Tetrachloroethane	0.000058	--	7/60	0.01 ± 0.01	0.56	--
Tetrachloroethylene	0.00000026	0.04	53/60	0.26 ± 0.05	0.07	0.01
Trichloroethylene	0.0000048	0.002	22/60	0.04 ± 0.02	0.21	0.02
Vinyl Chloride	0.0000088	0.1	6/60	<0.01 ± <0.01	0.02	<0.01
Battlement Mesa, Colorado - BMCO						
Acetaldehyde	0.0000022	0.009	20/20	NA	NA	NA
Benzene	0.0000078	0.03	51/51	NA	NA	NA
1,3-Butadiene	0.00003	0.002	8/51	NA	NA	NA
Ethylbenzene	0.0000025	1	51/51	NA	NA	NA
Formaldehyde	0.000013	0.0098	20/20	NA	NA	NA
Silt, Colorado - BRCO						
Acetaldehyde	0.0000022	0.009	6/6	NA	NA	NA
Benzene	0.0000078	0.03	53/54	0.86 ± 0.13	6.71	0.03
1,3-Butadiene	0.00003	0.002	7/54	0.01 ± 0.01	0.34	0.01
Formaldehyde	0.000013	0.0098	6/6	NA	NA	NA

-- = 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 $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Hazard Approximation (HQ)
Parachute, Colorado - PACO						
Acetaldehyde	0.0000022	0.009	21/21	NA	NA	NA
Benzene	0.0000078	0.03	52/53	1.45 ± 0.21	11.27	0.05
1,3-Butadiene	0.00003	0.002	22/53	0.07 ± 0.03	2.10	0.04
Ethylbenzene	0.0000025	1	53/53	0.32 ± 0.07	0.79	<0.01
Formaldehyde	0.000013	0.0098	21/21	NA	NA	NA
Rifle, Colorado - RICO						
Acetaldehyde	0.0000022	0.009	17/17	NA	NA	NA
Benzene	0.0000078	0.03	51/53	1.27 ± 0.18	9.93	0.04
1,3-Butadiene	0.00003	0.002	42/53	0.18 ± 0.04	5.53	0.09
Ethylbenzene	0.0000025	1	53/53	0.35 ± 0.04	0.87	<0.01
Formaldehyde	0.000013	0.0098	17/17	NA	NA	NA

-- = 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:

- Formaldehyde, acetaldehyde, and benzene have the highest annual average concentrations for GPCO.

- Formaldehyde also has the highest cancer risk approximation (35.60 in-a-million) for this site. Benzene has the second highest cancer risk approximation (10.42 in-a-million) and acetaldehyde has the third highest cancer risk approximation (5.35 in-a-million), with naphthalene a close fourth (5.29 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. Formaldehyde has the highest noncancer hazard approximation (0.28) among the pollutants of interest for GPCO.

Observations for the Garfield County sites from Table 7-6 include the following:

- Benzene's cancer risk approximation is the highest among each site's pollutants of interest, where risk approximations could be calculated. Benzene's cancer risk approximations range from 6.71 in-a-million for BRCO to 11.27 in-a-million for PACO. PACO's benzene cancer risk approximation is the third highest benzene cancer risk approximation compared to other NMP sites.

- 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 1,3-butadiene for RICO (0.09).

- Annual averages, and thus cancer risk and noncancer hazard approximations, could not be calculated for acetaldehyde and formaldehyde for any of the Garfield County sites because the completeness criteria were not met, as discussed in Section 7.4.1.

- Annual averages, and thus cancer risk and noncancer hazard approximations, could not be calculated for the SNMOCs for BMCO due to completeness issues, as discussed in Section 7.4.1.

7.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 7-7 and 7-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 7-6. Table 7-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 7-6.

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	140.94	Formaldehyde	1.46E-03	Formaldehyde	35.60
Formaldehyde	112.12	Benzene	1.10E-03	Benzene	10.42
Acetaldehyde	45.52	1,3-Butadiene	4.25E-04	Acetaldehyde	5.35
Ethylbenzene	41.56	POM, Group 3	3.93E-04	Naphthalene	5.29
1,3-Butadiene	14.18	Naphthalene	2.59E-04	Acrylonitrile	4.07
Naphthalene	7.63	POM, Group 2b	1.78E-04	1,3-Butadiene	4.01
Dichloromethane	6.38	Arsenic, PM	1.58E-04	Carbon Tetrachloride	3.20
POM, Group 2b	2.02	Hexavalent Chromium, PM	1.37E-04	Ethylbenzene	1.54
Tetrachloroethylene	1.20	Ethylbenzene	1.04E-04	Acenaphthene	0.93
POM, Group 6	0.20	Acetaldehyde	1.00E-04	1,2-Dichloroethane	0.69
Battlement Mesa, Colorado (Garfield County) - BMCO					
Formaldehyde	324.22	Formaldehyde	4.21E-03		
Benzene	269.17	Benzene	2.10E-03		
Acetaldehyde	79.93	POM, Group 3	8.97E-04		
Ethylbenzene	27.66	1,3-Butadiene	4.81E-04		
1,3-Butadiene	16.04	POM, Group 2b	2.37E-04		
Naphthalene	6.02	Naphthalene	2.05E-04		
POM, Group 2b	2.69	Acetaldehyde	1.76E-04		
Tetrachloroethylene	1.34	POM, Group 5a	1.00E-04		
Dichloromethane	0.74	Ethylbenzene	6.92E-05		
POM, Group 6	0.32	POM, Group 6	5.61E-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	324.22	Formaldehyde	4.21E-03	Benzene	6.71
Benzene	269.17	Benzene	2.10E-03	1,3-Butadiene	0.34
Acetaldehyde	79.93	POM, Group 3	8.97E-04		
Ethylbenzene	27.66	1,3-Butadiene	4.81E-04		
1,3-Butadiene	16.04	POM, Group 2b	2.37E-04		
Naphthalene	6.02	Naphthalene	2.05E-04		
POM, Group 2b	2.69	Acetaldehyde	1.76E-04		
Tetrachloroethylene	1.34	POM, Group 5a	1.00E-04		
Dichloromethane	0.74	Ethylbenzene	6.92E-05		
POM, Group 6	0.32	POM, Group 6	5.61E-05		
Parachute, Colorado (Garfield County) - PACO					
Formaldehyde	324.22	Formaldehyde	4.21E-03	Benzene	11.27
Benzene	269.17	Benzene	2.10E-03	1,3-Butadiene	2.10
Acetaldehyde	79.93	POM, Group 3	8.97E-04	Ethylbenzene	0.79
Ethylbenzene	27.66	1,3-Butadiene	4.81E-04		
1,3-Butadiene	16.04	POM, Group 2b	2.37E-04		
Naphthalene	6.02	Naphthalene	2.05E-04		
POM, Group 2b	2.69	Acetaldehyde	1.76E-04		
Tetrachloroethylene	1.34	POM, Group 5a	1.00E-04		
Dichloromethane	0.74	Ethylbenzene	6.92E-05		
POM, Group 6	0.32	POM, Group 6	5.61E-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)**
Rifle, Colorado (Garfield County) - RICO					
Formaldehyde	324.22	Formaldehyde	4.21E-03	Benzene	9.93
Benzene	269.17	Benzene	2.10E-03	1,3-Butadiene	5.53
Acetaldehyde	79.93	POM, Group 3	8.97E-04	Ethylbenzene	0.87
Ethylbenzene	27.66	1,3-Butadiene	4.81E-04		
1,3-Butadiene	16.04	POM, Group 2b	2.37E-04		
Naphthalene	6.02	Naphthalene	2.05E-04		
POM, Group 2b	2.69	Acetaldehyde	1.76E-04		
Tetrachloroethylene	1.34	POM, Group 5a	1.00E-04		
Dichloromethane	0.74	Ethylbenzene	6.92E-05		
POM, Group 6	0.32	POM, Group 6	5.61E-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	240.58	Acrolein	553,576.79	Formaldehyde	0.28
Xylenes	188.54	Formaldehyde	11,440.45	Acetaldehyde	0.27
Benzene	140.94	1,3-Butadiene	7,087.62	1,3-Butadiene	0.07
Formaldehyde	112.12	Acetaldehyde	5,058.01	Naphthalene	0.05
Methanol	88.05	Benzene	4,698.01	Benzene	0.04
Hexane	50.96	Naphthalene	2,543.73	Acrylonitrile	0.03
Acetaldehyde	45.52	Arsenic, PM	2,443.88	Trichloroethylene	0.02
Ethylbenzene	41.56	Xylenes	1,885.37	Tetrachloroethylene	0.01
Hydrochloric acid	27.54	Hydrochloric acid	1,376.84	Carbon Tetrachloride	0.01
1,3-Butadiene	14.18	Manganese, PM	1,158.03	Chloroform	<0.01
Battlement Mesa, Colorado (Garfield County) - BMCO					
Toluene	419.91	Acrolein	2,021,060.94		
Formaldehyde	324.22	Formaldehyde	33,083.40		
Xylenes	321.33	Benzene	8,972.23		
Benzene	269.17	Acetaldehyde	8,880.90		
Hexane	82.14	1,3-Butadiene	8,021.37		
Acetaldehyde	79.93	Xylenes	3,213.31		
Methanol	60.71	Naphthalene	2,008.12		
Acrolein	40.42	Cyanide Compounds, gas	988.69		
Ethylbenzene	27.66	Lead, PM	430.70		
1,3-Butadiene	16.04	Arsenic, PM	233.88		

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	419.91	Acrolein	2,021,060.94	Benzene	0.03
Formaldehyde	324.22	Formaldehyde	33,083.40	1,3-Butadiene	0.01
Xylenes	321.33	Benzene	8,972.23		
Benzene	269.17	Acetaldehyde	8,880.90		
Hexane	82.14	1,3-Butadiene	8,021.37		
Acetaldehyde	79.93	Xylenes	3,213.31		
Methanol	60.71	Naphthalene	2,008.12		
Acrolein	40.42	Cyanide Compounds, gas	988.69		
Ethylbenzene	27.66	Lead, PM	430.70		
1,3-Butadiene	16.04	Arsenic, PM	233.88		
Parachute, Colorado (Garfield County) - PACO					
Toluene	419.91	Acrolein	2,021,060.94	Benzene	0.05
Formaldehyde	324.22	Formaldehyde	33,083.40	1,3-Butadiene	0.04
Xylenes	321.33	Benzene	8,972.23	Ethylbenzene	<0.01
Benzene	269.17	Acetaldehyde	8,880.90		
Hexane	82.14	1,3-Butadiene	8,021.37		
Acetaldehyde	79.93	Xylenes	3,213.31		
Methanol	60.71	Naphthalene	2,008.12		
Acrolein	40.42	Cyanide Compounds, gas	988.69		
Ethylbenzene	27.66	Lead, PM	430.70		
1,3-Butadiene	16.04	Arsenic, PM	233.88		

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)**
Rifle, Colorado (Garfield County) - RICO					
Toluene	419.91	Acrolein	2,021,060.94	1,3-Butadiene	0.09
Formaldehyde	324.22	Formaldehyde	33,083.40	Benzene	0.04
Xylenes	321.33	Benzene	8,972.23	Ethylbenzene	<0.01
Benzene	269.17	Acetaldehyde	8,880.90		
Hexane	82.14	1,3-Butadiene	8,021.37		
Acetaldehyde	79.93	Xylenes	3,213.31		
Methanol	60.71	Naphthalene	2,008.12		
Acrolein	40.42	Cyanide Compounds, gas	988.69		
Ethylbenzene	27.66	Lead, PM	430.70		
1,3-Butadiene	16.04	Arsenic, PM	233.88		

The pollutants listed in Tables 7-7 and 7-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, the cancer risk and noncancer hazard approximations based on each site's annual averages are limited to those pollutants for which each respective monitoring site sampled. As discussed in Section 7.3, GPCO sampled for VOCs, carbonyl compounds, PAHs, and hexavalent chromium; the Garfield County sites sampled for SNMOCs and carbonyl compounds only. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 7-7 include the following:

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in Mesa County. These same pollutants also topped the list for Garfield County, although not in the same order. Note that the quantity emitted for each pollutant was roughly twice as high in 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.

- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions in Mesa County while eight of the highest emitted pollutants also have the highest toxicity-weighted emissions in Mesa County.

- For GPCO, six of the 10 pollutants with the highest cancer risk approximations also appear on both emissions-based lists for Mesa County. In addition, POM, Group 2b is the eighth 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.

- Where cancer risk approximations could be calculated for the Garfield County sites, all of the pollutants of interest listed appear on both emissions-based lists.

- POM, Groups 2b, 3, 5a, and 6 appear on Garfield County's emissions-based lists. PAHs were not sampled at the Garfield County sites.

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 two pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties are acrolein and formaldehyde. 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.

- Six of the 10 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. This is the only county for which acrolein appears among the highest emitted pollutants.

- Formaldehyde, acetaldehyde, benzene, and 1,3-butadiene appear on all three lists for GPCO. Additionally, naphthalene appears among the pollutants with the highest noncancer hazard approximations and highest toxicity-weighted emissions, but is not among the highest emitted pollutants with a noncancer RfC in Mesa County.

- Benzene and 1,3-butadiene appear on all three lists for the Garfield County sites. Ethylbenzene, a pollutant of interest for PACO and RICO but not BRCO, is one of the highest emitted pollutants in Garfield County, but is not among the most toxic.

7.6 Summary of the 2011 Monitoring Data for the Colorado Monitoring Sites

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

- ❖ *Twenty-three pollutants failed screens for GPCO. The number of pollutants failing screens for the Garfield County sites ranged from four to five.*

- ❖ *The pollutants with the highest annual average concentrations for GPCO were formaldehyde, acetaldehyde, and benzene. These were also the only pollutants with annual average concentrations greater than 1 µg/m^3. Benzene had the highest annual average concentration for each of the Garfield County sites.*

- ❖ *GPCO has the highest annual average concentrations of naphthalene and benzo(a)pyrene among all NMP sites sampling PAHs.*

- ❖ *Benzene concentrations at GPCO have an overall decreasing trend. In recent years, concentrations of hexavalent chromium have increased at GPCO while concentrations of formaldehyde have decreased.*

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 in its urban location. Figure 8-2 identifies nearby point source emissions locations by source category, as reported in the 2008 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

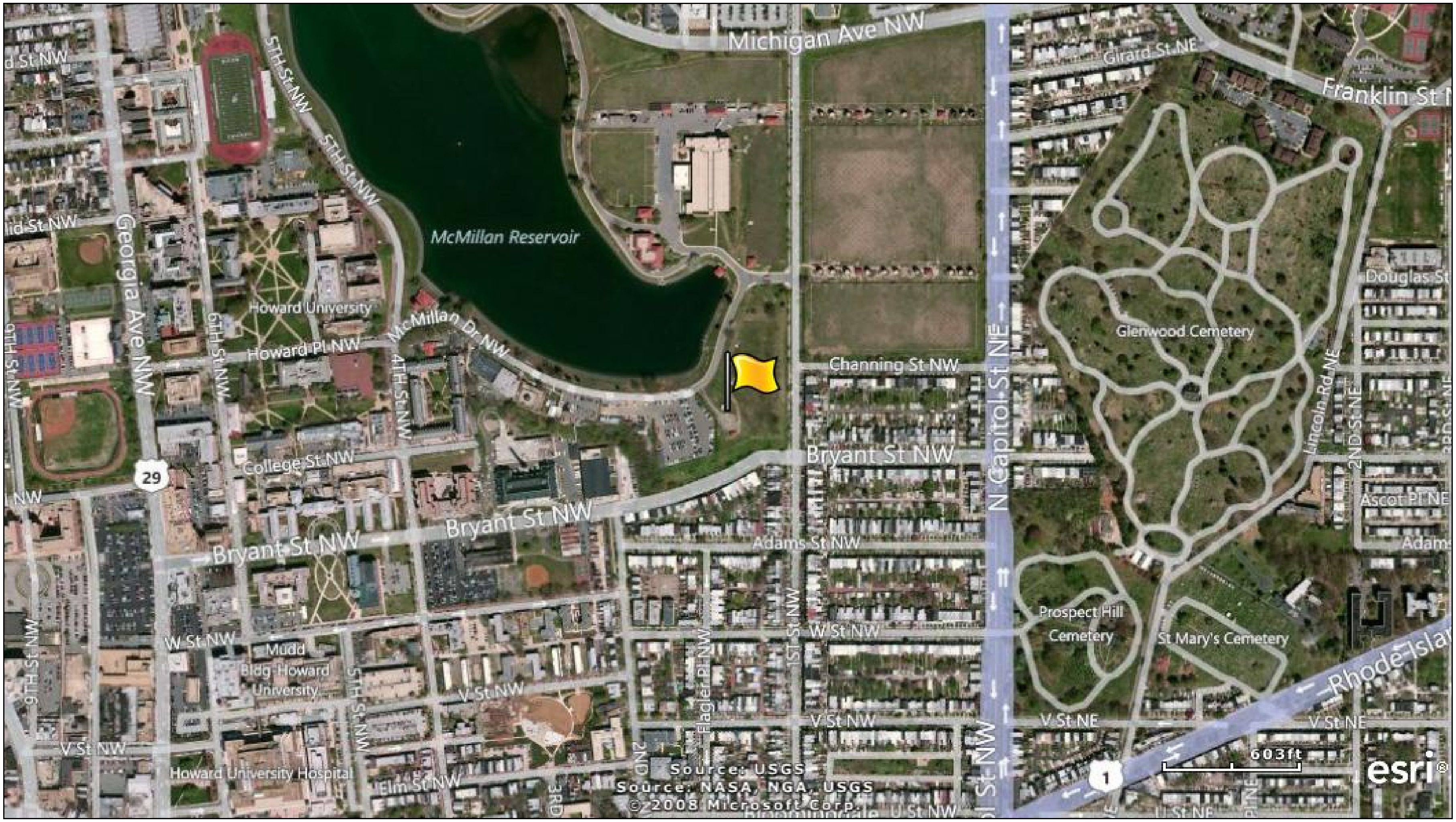
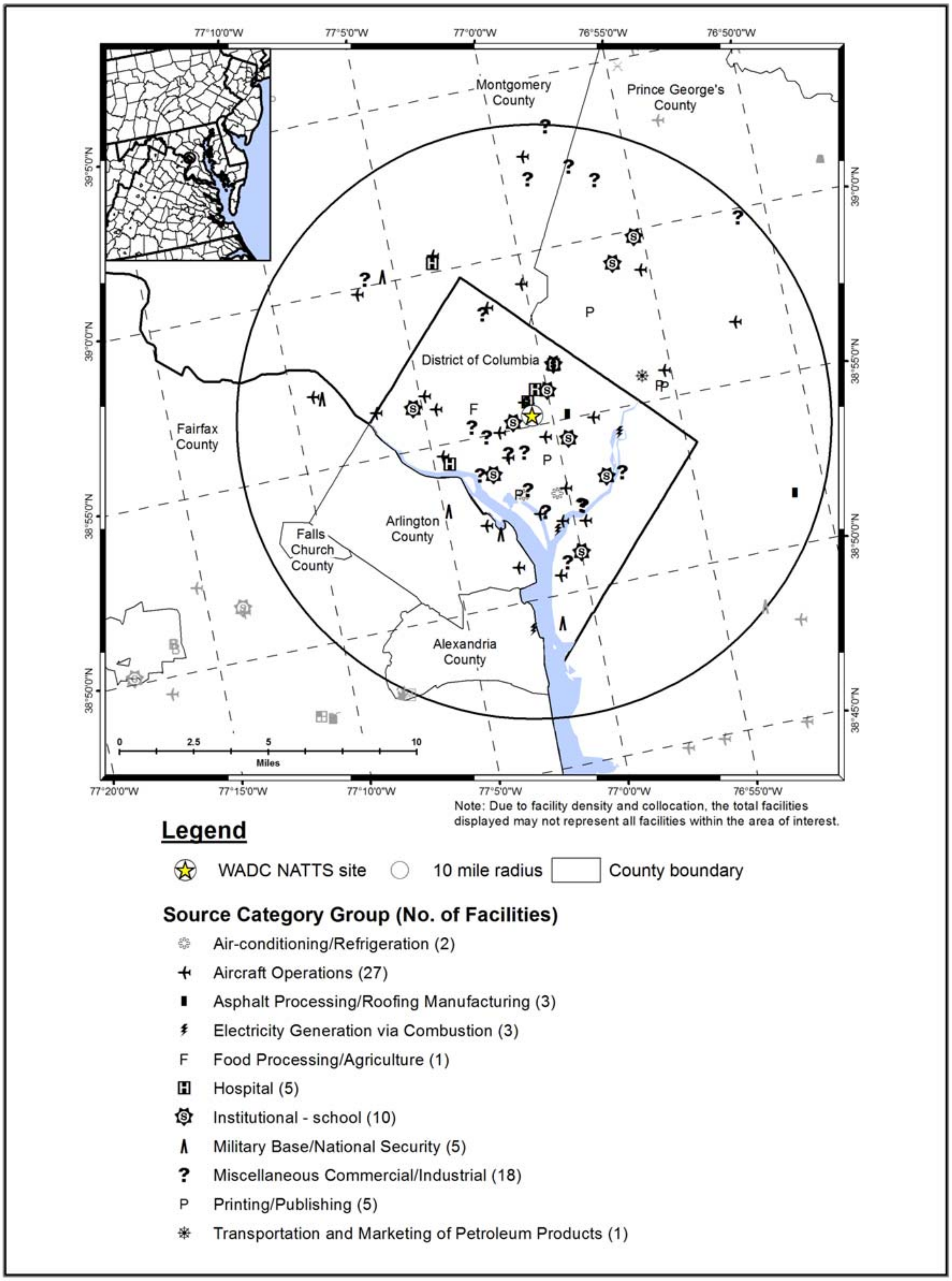


Figure 8-2. NEI Point Sources Located Within 10 Miles of WADC



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

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, CO, VOCs, SO_2, NO_y, NO, NO_2, NO_x, PAMS, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, PM_{10} Speciation, Black carbon, PM Coarse, $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for WADC (EPA, 2012c); 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 of 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 predominantly by sources in the aircraft operations source category. This category includes airports as well as small runways, heliports, or landing pads. Aside from aircraft operations, the source category with the highest number of sources within 10 miles of the WADC monitoring site is schools. The closest sources to WADC are 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 county-level population and vehicle registration information. Table 8-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the District of Columbia. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 8-2 also contains traffic volume information for WADC. Finally, Table 8-2 presents the county-level 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]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10 mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
WADC	617,996	213,232	0.35	1,931,834	666,556	7,700	9,775,000

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2010 data from the Federal Highway Administration (FHWA, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2009 data from the District DOT (DC DOT, 2011)
[5] County-level VMT reflects 2011 data from the District DOT (DC DOT, 2012)
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. Its 10-mile population however, ranks fifth highest and is three times higher than its county-level population.
- The District-level vehicle registration is in the bottom third compared to other counties with NMP sites, while its 10-mile ownership is in the middle of the range.
- The vehicle-per-person ratio is among the lowest compared to other 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 the intersection of Bryant Street and First Street.
- 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 enjoys all four seasons, although its weather is somewhat variable. Summers are warm and often humid, where southerly winds prevail, which 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. Precipitation is evenly distributed across the seasons (Bair, 1992).

8.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2011 (NCDC, 2011). The closest weather station to WADC is located at Ronald Reagan Washington National Airport (WBAN 13743). Additional information about the 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. Average Meteorological Conditions near the Washington, D.C. Monitoring Site

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)
Washington, D.C. - WADC									
Ronald Reagan Washington National Airport 13743 (38.87, -77.03)	4.07 miles 183° (S)	Sample Day	66.4 ± 4.3	58.7 ± 4.0	44.9 ± 4.5	51.9 ± 3.7	63.5 ± 3.7	1017.0 ± 1.7	7.5 ± 0.8
		2011	67.7 ± 1.9	59.6 ± 1.8	46.4 ± 1.9	52.9 ± 1.6	64.9 ± 1.5	1016.5 ± 0.7	7.0 ± 0.3

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

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 the entire year for 2011. 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 generally representative of average weather conditions throughout the year. The largest differences were calculated for dew point temperature and relative humidity, although the differences were slight. These differences may result from make-up samples collected in November and December 2011.

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 in 2011. 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.

Figure 8-3. 2011 Composite Back Trajectory Map for WADC

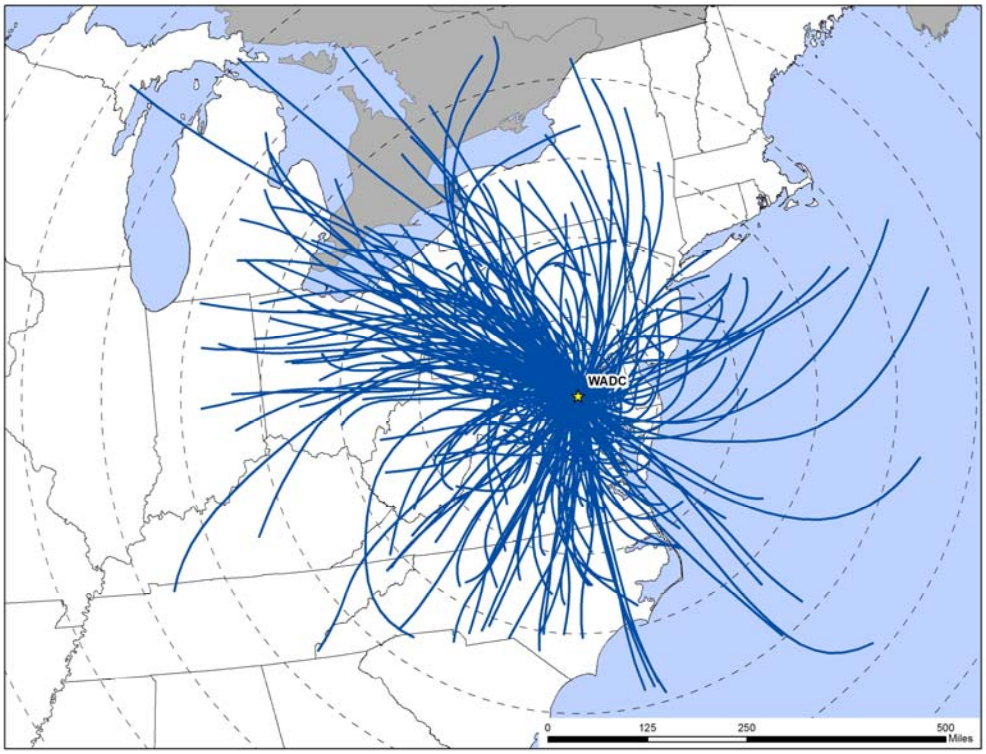


Figure 8-4. Back Trajectory Cluster Map for WADC

Observations from Figures 8-3 and 8-4 include the following:

- Back trajectories originated from a variety of directions at WADC. The most common direction of trajectory origin appears to be from the northwest.

- The 24-hour air shed domain for WADC was comparable in size to many other NMP monitoring sites. The farthest away a back trajectory originated was over the Upper Peninsula of Michigan, or nearly than 700 miles away. However, the average trajectory length was 239 miles and 88 percent of back trajectories originated within 400 miles of the site.

- The cluster analysis confirms that back trajectories originating from the northwest were most common (26 percent). The cluster trajectory originating from the west of WADC (16 percent) represents back trajectories originating over Virginia and West Virginia and generally less than 200 miles in length. Twelve percent of trajectories originated to the north of WADC, another 10 percent originated to the south over North Carolina, and another 7 percent originated from the east and offshore. The short cluster (28 percent) represents trajectories originating within 200 miles of the site and of varying direction, but most often to the south of the site as well as longer trajectories originating off the coast of North Carolina and Virginia.

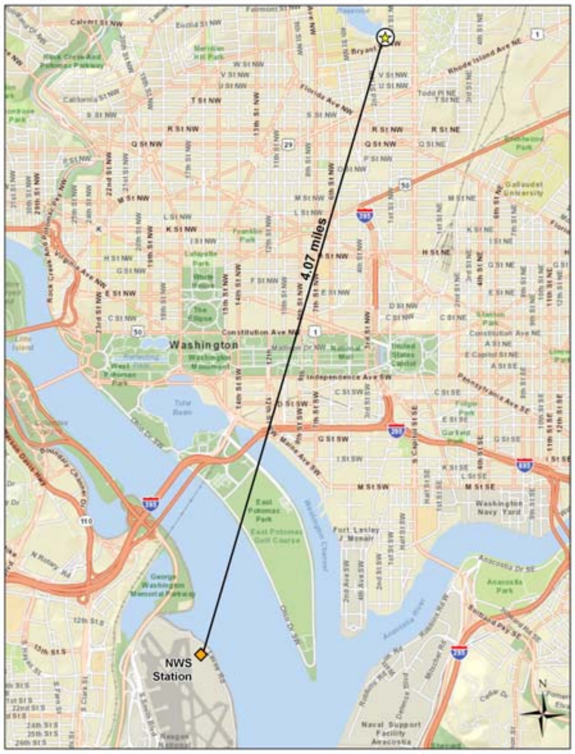
8.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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.

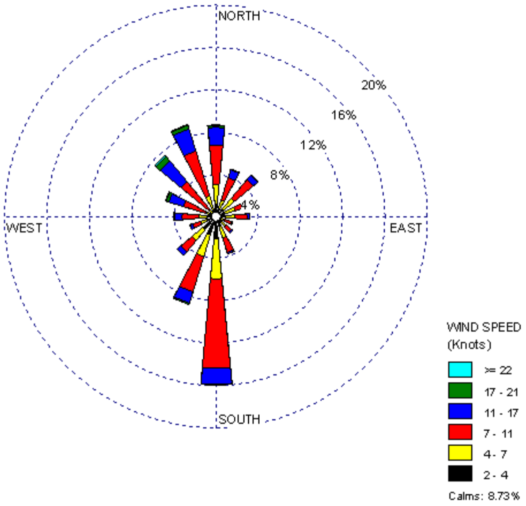
Figure 8-5 presents a map showing the distance between the NWS station and WADC, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 8-5 also presents three different wind roses for the WADC monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 8-5. Wind Roses for the Ronald Reagan Washington National Airport Weather Station near WADC

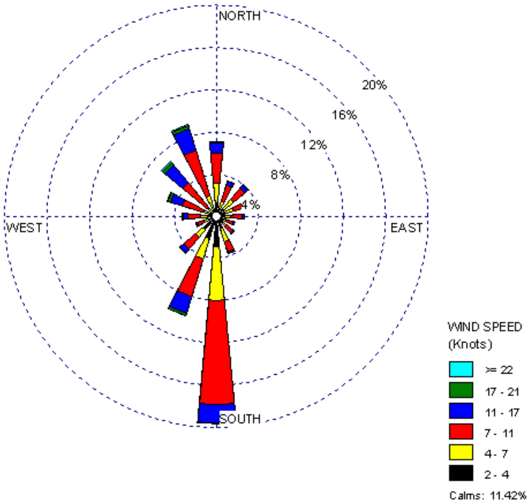
Distance between WADC and NWS Station



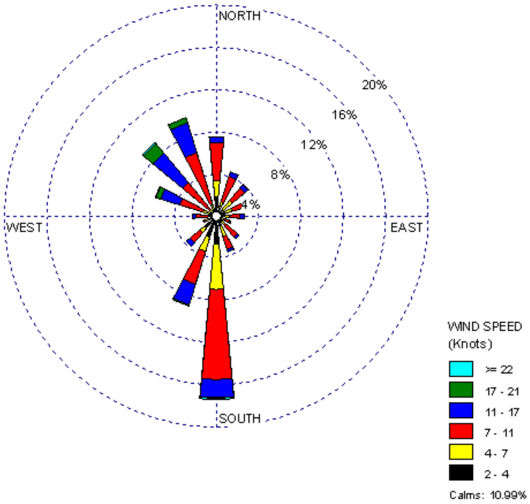
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



Observations from Figure 8-5 for WADC include the following:

- The NWS weather station at Washington National Airport is located approximately 4.1 miles to the south of WADC. Note that 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 both the full-year and sample day wind roses are similar to the wind patterns shown on the historical wind rose, although southerly winds accounted for a slightly higher percentage of wind observations in 2011. The similarities in the wind roses indicate that wind patterns in 2011 were similar to what is expected climatologically near this site.

8.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Washington, D.C. monitoring site in order to allow 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." 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 8-4 presents the results of the preliminary risk-based screening process. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for the WADC monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. WADC sampled for hexavalent chromium and PAHs.

Table 8-4. Risk-Based Screening Results for the Washington, D.C. Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# 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	100.00	100.00
Total		61	61	100.00		

Observations from Table 8-4 include the following:

- Naphthalene is the only pollutant to failed screens for WADC. Naphthalene failed 100 percent of its screens.
- Benzo(a)pyrene and hexavalent chromium were added as pollutants of interest for WADC because they are the other NATTS MQO Core Analytes measured by this site. These two pollutants are not shown in Table 8-4 but are shown in subsequent tables in the sections that follow.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for WADC are provided in Appendices M and O.

8.4.1 2011 Concentration Averages

Quarterly and annual concentration averages 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 of 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						
Benzo(a)pyrene	37/61	0.07 ± 0.04	0.02 ± 0.02	0.03 ± 0.02	0.09 ± 0.04	0.06 ± 0.02
Hexavalent Chromium	49/61	0.02 ± 0.01	0.02 ± <0.01	0.02 ± 0.01	0.02 ± 0.01	0.02 ± <0.01
Naphthalene	61/61	67.83 ± 17.12	65.20 ± 12.60	123.41 ± 50.74	137.87 ± 46.65	102.71 ± 20.46

Observations for WADC from Table 8-5 include the following:

- Naphthalene was detected in every PAH sample collected at WADC while benzo(a)pyrene was detected in approximately 60 percent of the PAH samples collected. Hexavalent chromium was detected in 80 percent of the samples collected.

- The annual average concentration of naphthalene is significantly higher than the annual average concentrations of benzo(a)pyrene and hexavalent chromium.

- Benzo(a)pyrene concentrations appear higher during the colder months of the year, as indicated by the quarterly averages. Of the 14 measurements of benzo(a)pyrene greater than or equal to 0.1 ng/m^3, eight were measured during the fourth quarter and four during the first quarter (and one each in the second and third quarters). In all, there were eight measured detections of this pollutant during the first quarter of 2011, five during the second quarter, eight during the third quarter, and 16 during the fourth quarter. The number of non-detects was highest during the warmer quarters of the year (five, nine, seven, and three, respectively).

- Concentrations of hexavalent chromium were relatively consistent across the year.

- The third and fourth quarterly average concentrations of naphthalene are twice as high as the first and second quarterly average concentrations. The maximum naphthalene concentration was measured at WADC on August 31, 2011 (416 ng/m^3). Of the 19 naphthalene concentrations greater than 100 ng/m^3 measured at WADC, 15 were measured during the third and fourth quarters; conversely, of the 15 naphthalene concentrations less than 50 ng/m^3 measured at WADC, 10 were measured during the first and second quarters. However, both relatively high and low naphthalene concentrations were measured in each quarter of 2011.

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 selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzo(a)pyrene, hexavalent chromium, and naphthalene were created for WADC. Figures 8-6 through 8-8 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 8-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

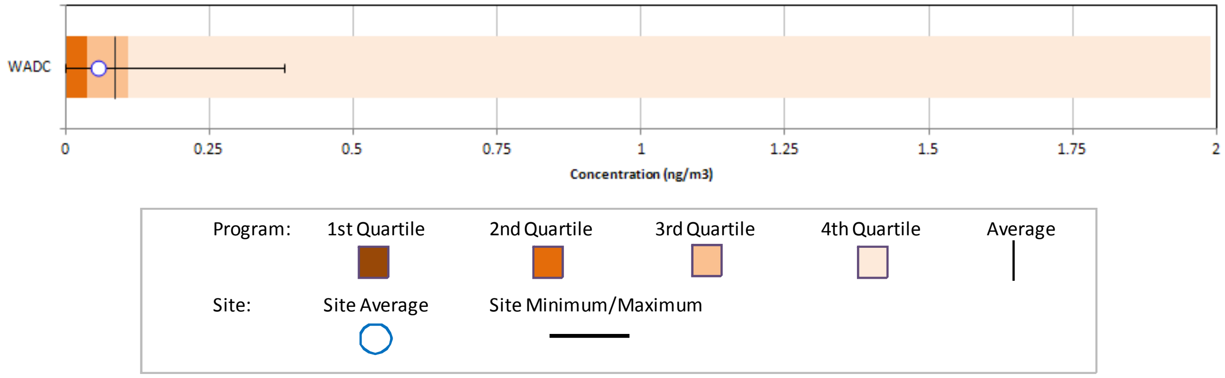


Figure 8-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

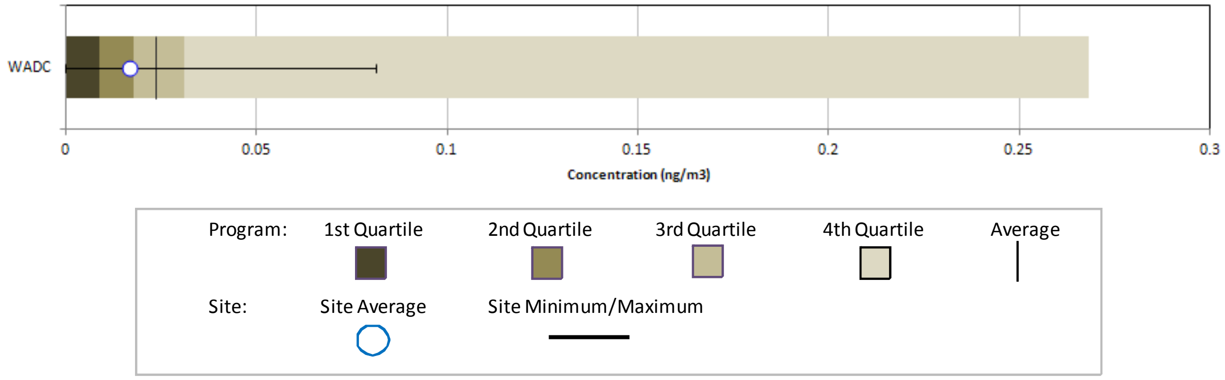
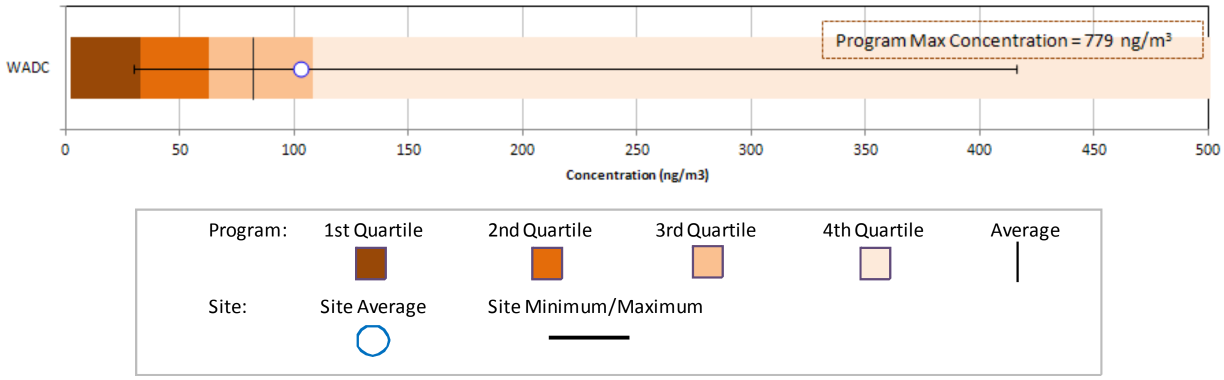


Figure 8-8. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 8-6 through 8-8 include the following:

- Figure 8-6 is the box plot for benzo(a)pyrene. Note that the program-level first quartile for this pollutant is zero and is not visible on this box plot. The box plot shows that the annual average concentration for WADC is less than the program-level average concentration but greater than the program-level median concentration. Figure 8-6 also shows that the maximum concentration measured at WADC is considerably less than the maximum concentration measured across the program. There were several non-detects of benzo(a)pyrene measured at WADC.

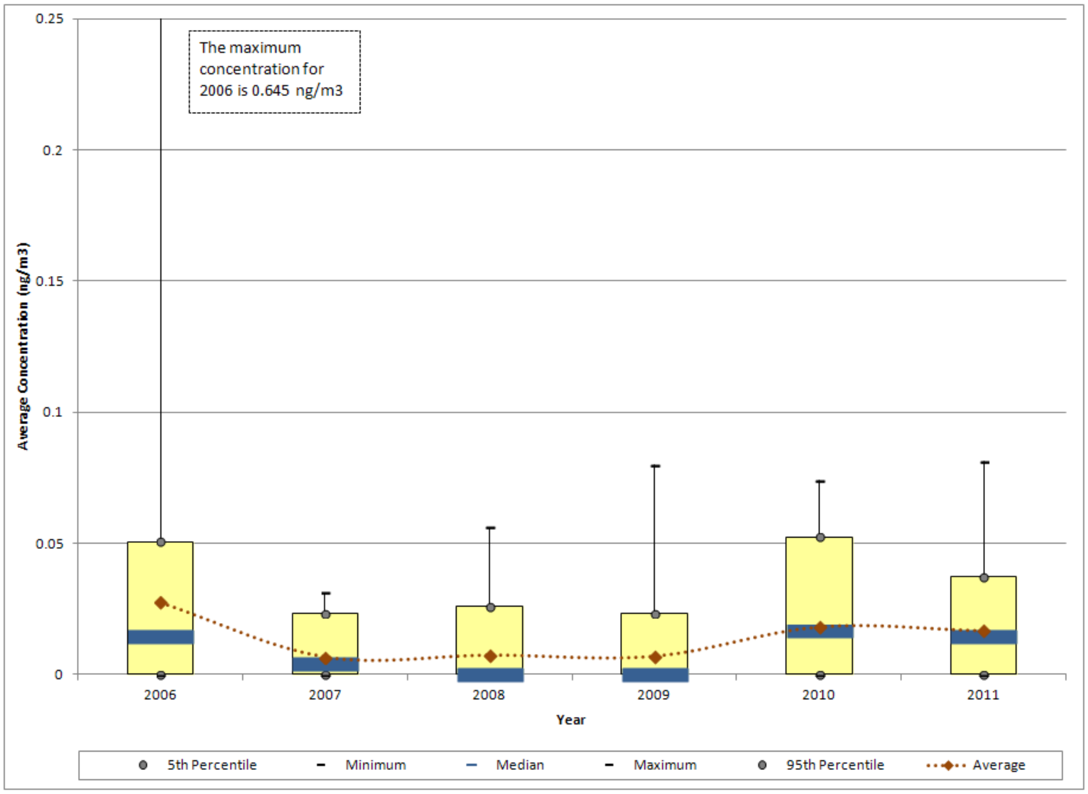
- Figure 8-7 is the box plot for hexavalent chromium. Figure 8-7 shows that WADC's annual average concentration (0.0167 ng/m^3) is less than the program-level average (0.0237 ng/m^3) and just less than the program-level median concentration (0.0178 ng/m^3). The maximum concentration measured at WADC is less than the program-level maximum concentration. There were several non-detects of hexavalent chromium measured at WADC.

- Figure 8-8 is the box plot for naphthalene. Note that the program-level maximum concentration (779 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 500 ng/m^3. Figure 8-8 shows that the annual naphthalene average for WADC is greater than the program-level average concentration and just less than the program-level third quartile. The annual average concentration of naphthalene for WADC ranked 12th compared to other NMP sites sampling PAHs. The maximum naphthalene concentration measured at WADC is less than the program-level maximum concentration. The minimum concentration measured at WADC is just less than the program-level first quartile. There were no non-detects of naphthalene measured at WADC or across the program.

8.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. WADC has sampled hexavalent chromium under the NMP since 2005. Thus, Figure 8-9 presents the annual statistical metrics for hexavalent chromium for WADC. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. WADC did not begin sampling PAHs until 2008; thus, the trends analysis was not conducted for the pollutants for these methods.

Figure 8-9. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at WADC



The maximum concentration for 2006 is 0.645 ng/m3

Observations from Figure 8-9 for hexavalent chromium measurements at WADC include the following:

- Sampling for hexavalent chromium began in March 2005 but because fewer than 85 percent of possible samples were collected, Figure 8-9 excludes 2005 data and begins with 2006.

- The maximum hexavalent chromium concentration shown was measured on July 4, 2006 (0.645 ng/m^3).

- The average hexavalent chromium concentration decreased significantly from 2006 to 2007 and remained steady through 2009. During this time, the median decreased to zero for 2008 and 2009, indicating that at least 50 percent of the measurements were non-detects. The percentage of non-detects increased from 32 percent in 2006 to a maximum of 72 percent in 2009. The substitution of zeros for these non-detects is the likely reason for this decrease in these statistical parameters. The number of non-detects decreased in 2010 (33 percent) and again in 2011 (20 percent); accordingly, with fewer zero substitutions for non-detects, the median and average concentrations increased.

- The maximum concentrations are roughly the same across the last three years of sampling (approximately 0.08 ng/m^3). However, the 95th percentile exhibits more fluctuations, indicating more variability among the majority of measurements.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 (µg/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 Hazard Approximation (HQ)**
Washington, D.C. - WADC						
Benzo(a)pyrene	0.00176	--	37/61	0.06 ± 0.02	0.10	--
Hexavalent Chromium	0.012	0.0001	49/61	0.02 ± <0.01	0.20	<0.01
Naphthalene	0.000034	0.003	61/61	102.71 ± 20.46	3.49	0.03

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

Observations for WADC from Table 8-6 include the following:

- As discussed in Section 8.4.1, naphthalene's annual average concentration is four orders of magnitude higher than the annual average concentrations for the other two pollutants of interest.
- Naphthalene's cancer risk approximation is greater than 1.0 in-a-million (3.49 in-a-million). Its noncancer hazard approximation is significantly less than 1.0 (0.03), indicating no adverse health effects are expected from this pollutant.
- The cancer risk approximation for benzo(a)pyrene is considerably less than the cancer risk approximation for naphthalene (0.10 in-a-million). A noncancer RfC is not available for benzo(a)pyrene; thus, a noncancer hazard approximation could not be calculated.

- The cancer surrogate risk approximation based on hexavalent chromium's annual average concentration is less than 1.0 in-a-million (0.20 in-a-million). The noncancer hazard approximation is also low (<0.01).

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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 8-6. Table 8-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 8-6.

The pollutants listed in Tables 8-7 and 8-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, 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 8.3, WADC sampled for PAHs and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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	149.75	Formaldehyde	1.82E-03	Naphthalene	3.49
Formaldehyde	139.99	Benzene	1.17E-03	Hexavalent Chromium	0.20
Acetaldehyde	83.08	1,3-Butadiene	7.48E-04	Benzo(a)pyrene	0.10
Ethylbenzene	76.80	POM, Group 3	6.38E-04		
1,3-Butadiene	24.93	Naphthalene	4.90E-04		
Naphthalene	14.40	POM, Group 2b	3.13E-04		
Dichloromethane	4.38	Hexavalent Chromium, PM	2.01E-04		
POM, Group 2b	3.56	Ethylbenzene	1.92E-04		
POM, Group 1a	0.39	Acetaldehyde	1.83E-04		
POM, Group 6	0.35	POM, Group 5a	1.32E-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	433.60	Acrolein	361,586.14	Naphthalene	0.03
Methanol	342.72	Formaldehyde	14,284.26	Hexavalent Chromium	<0.01
Xylenes	309.21	1,3-Butadiene	12,467.17		
Benzene	149.75	Acetaldehyde	9,231.05		
Formaldehyde	139.99	Benzene	4,991.64		
Hexane	93.23	Naphthalene	4,799.27		
Acetaldehyde	83.08	Xylenes	3,092.12		
Ethylbenzene	76.80	Nickel, PM	1,910.51		
Ethylene glycol	36.01	Arsenic, PM	1,536.26		
1,3-Butadiene	24.93	Propionaldehyde	966.01		

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).

- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions.

- Naphthalene is the only pollutant sampled for at WADC that appears on both emissions-based lists. Naphthalene is the sixth 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).

- While hexavalent chromium is not one of the 10 highest emitted pollutants in the District, its toxicity-weighted emissions ranked seventh highest (of the pollutants with cancer UREs).

- Several POM Groups are among the highest emitted "pollutants" in the District and/or rank among the highest toxicity-weighted emissions. POM, Group 5a, which includes benzo(a)pyrene, appears on both emissions-based lists for the District. POM, Group 2b includes several PAHs sampled for at WADC including acenaphthylene, fluoranthene, fluorene, and perylene. POM, Group 6 includes benzo(a)anthracene and indeno(1,2,3-cd)pyrene. None of the PAHs included in POM, Groups 2b or 6 were identified as pollutants of interest for WADC.

Observations from Table 8-8 include the following:

- Toluene, methanol, and xylenes 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 highest noncancer hazard approximation for WADC (albeit low). Naphthalene has the sixth highest toxicity-weighted emissions but is not one of the 10 highest emitted pollutants (of the pollutants with noncancer RfCs).

- Hexavalent chromium, the only other pollutant of interest for which a noncancer RfC is available, does not appear on either emissions-based list.

8.6 Summary of the 2011 Monitoring Data for WADC

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

- *Naphthalene was the only pollutant to fail screens for WADC. While naphthalene was the only pollutant of interest identified via the risk screening process, benzo(a)pyrene and hexavalent chromium were added to WADC's pollutants of interest because they are NATTS MQO Core Analytes.*

- *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for WADC. Naphthalene concentrations were highest during the second half of the year.*

- *The number of non-detects of hexavalent chromium measured at WADC has been decreasing over recent years of sampling.*

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, FL MSA. Figures 9-1 through 9-3 are composite satellite images retrieved from ArcGIS Explorer showing the Tampa/St. Petersburg monitoring sites in their urban and rural locations. Figure 9-4 identifies nearby point source emissions locations that surround these three sites by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 9-4. 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. Figures 9-5 and 9-6 are the composite satellite images for the two sites in the Orlando area and Figure 9-7 is the emissions sources map for these sites. 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

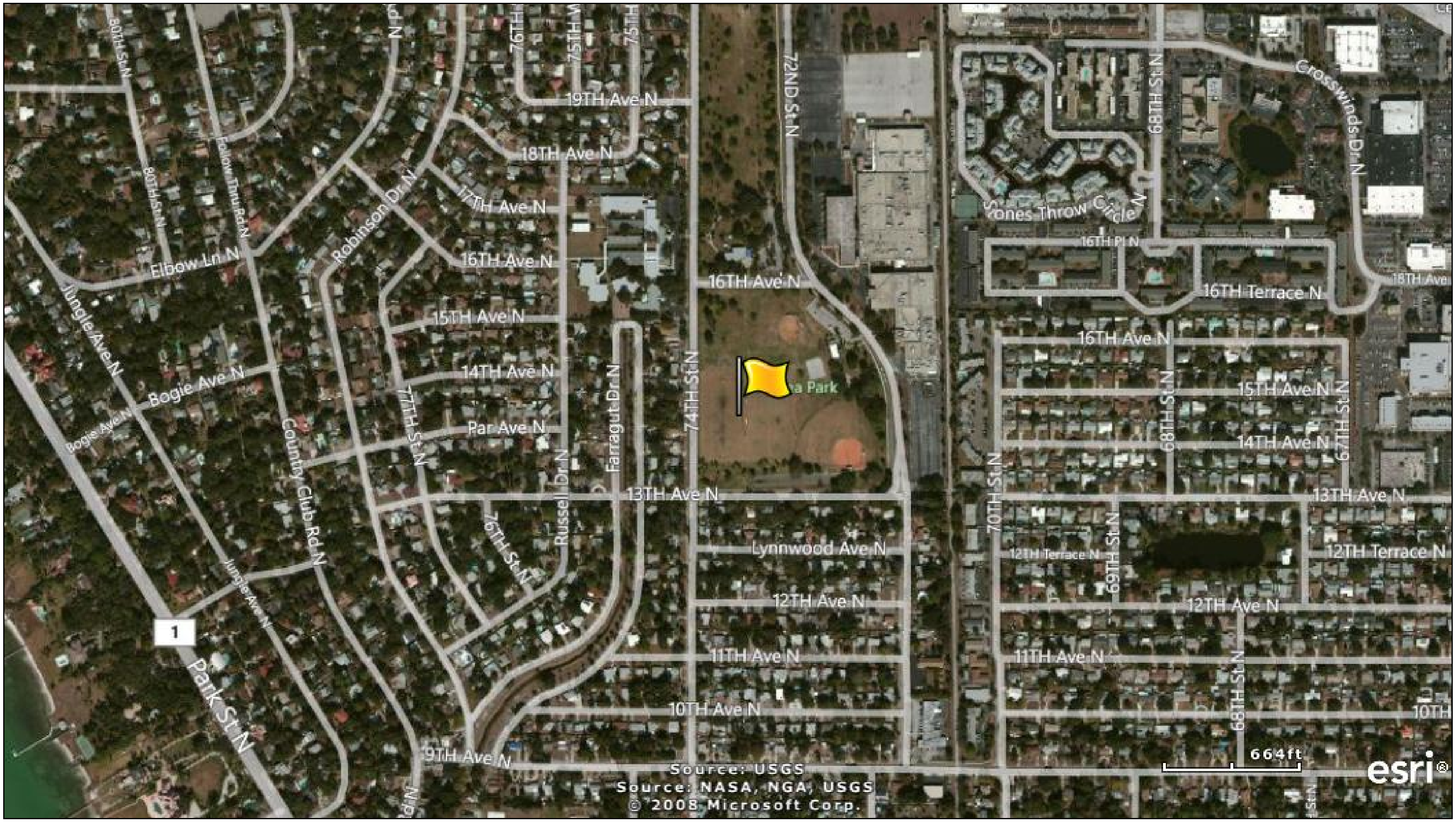
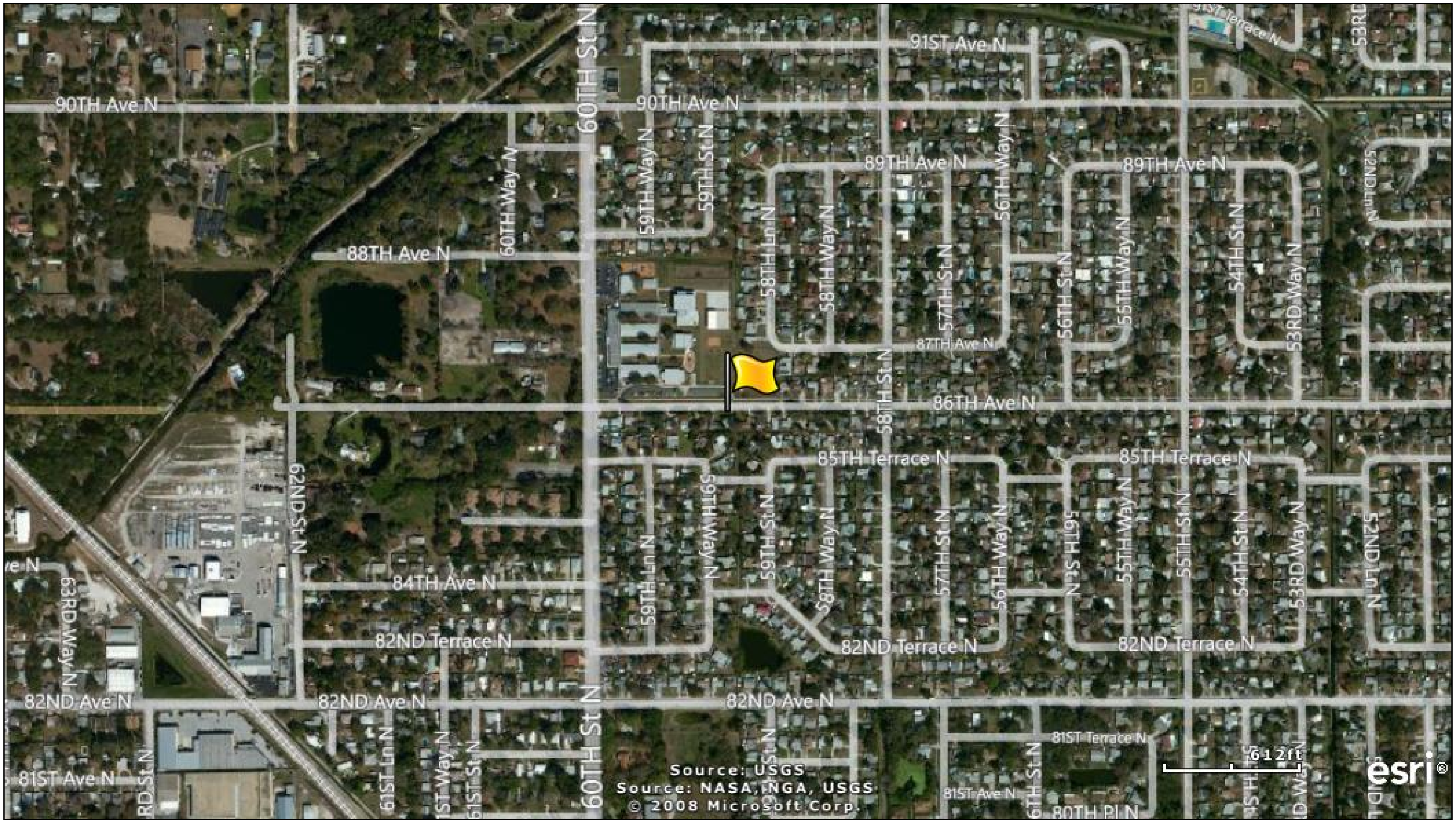


Figure 9-2. Pinellas Park, Florida (SKFL) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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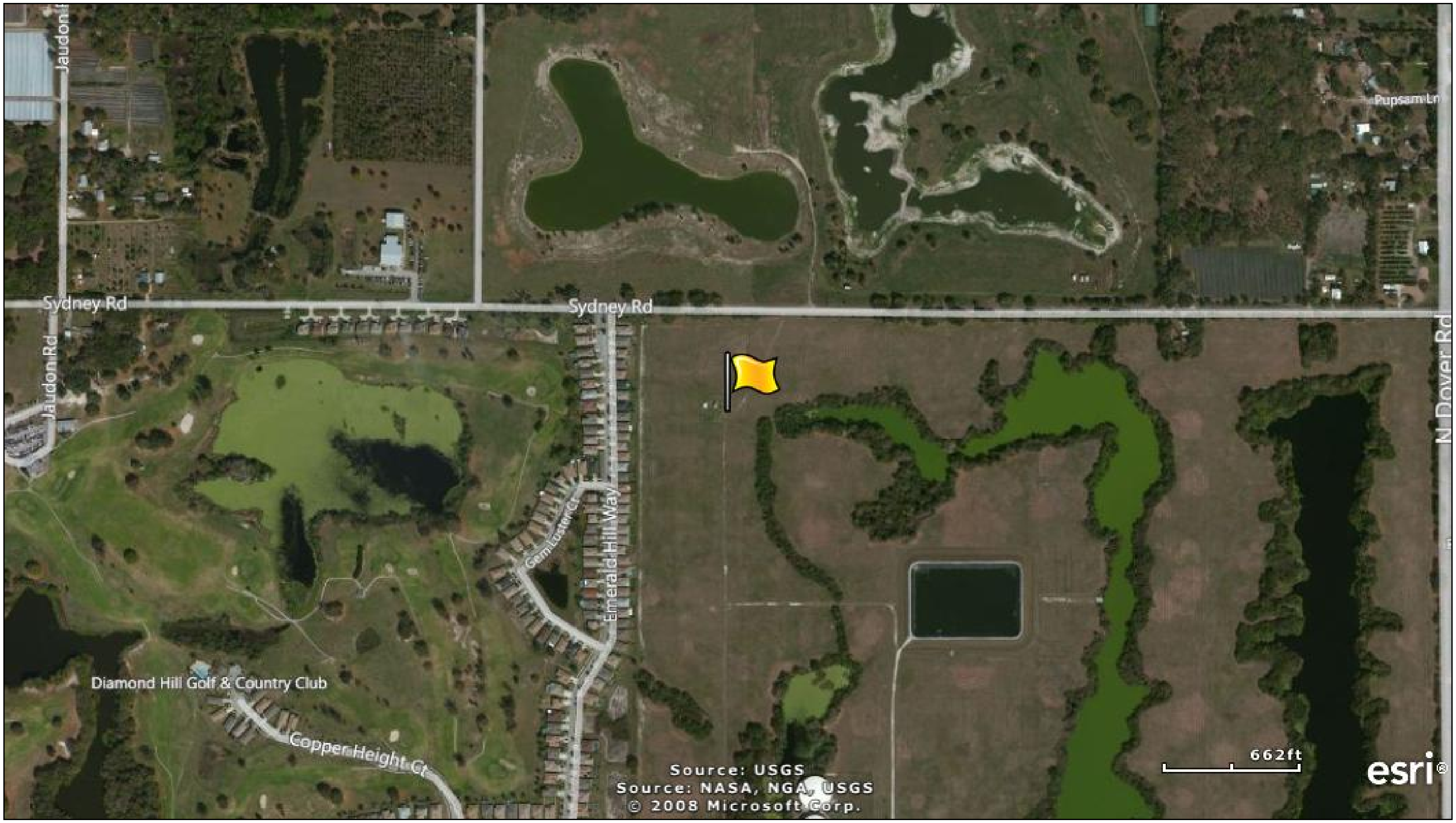
Figure 9-3. Plant City, Florida (SYFL) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 9-4. NEI Point Sources Located Within 10 Miles of the Tampa/St. Petersburg, Florida Monitoring Sites

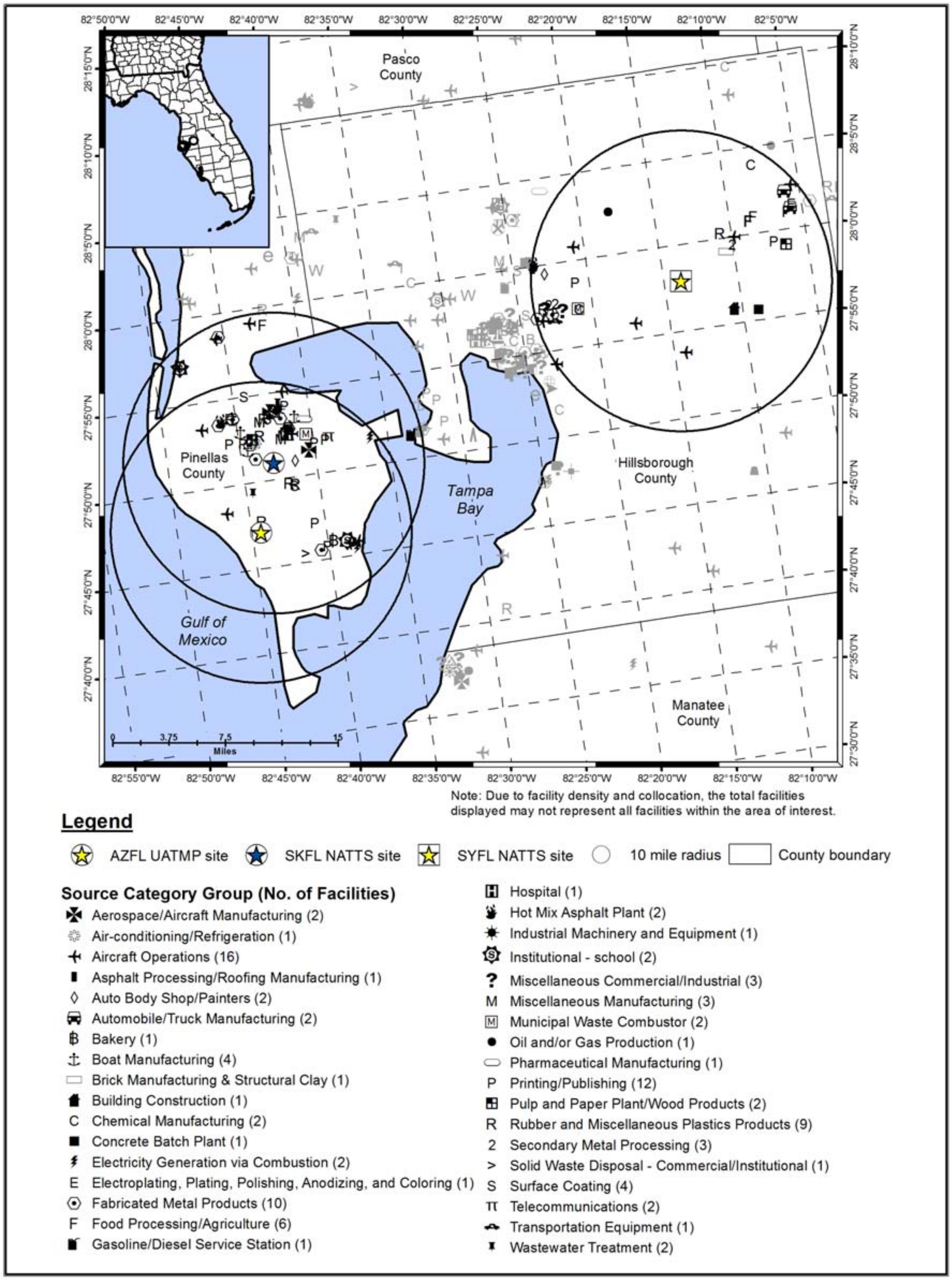
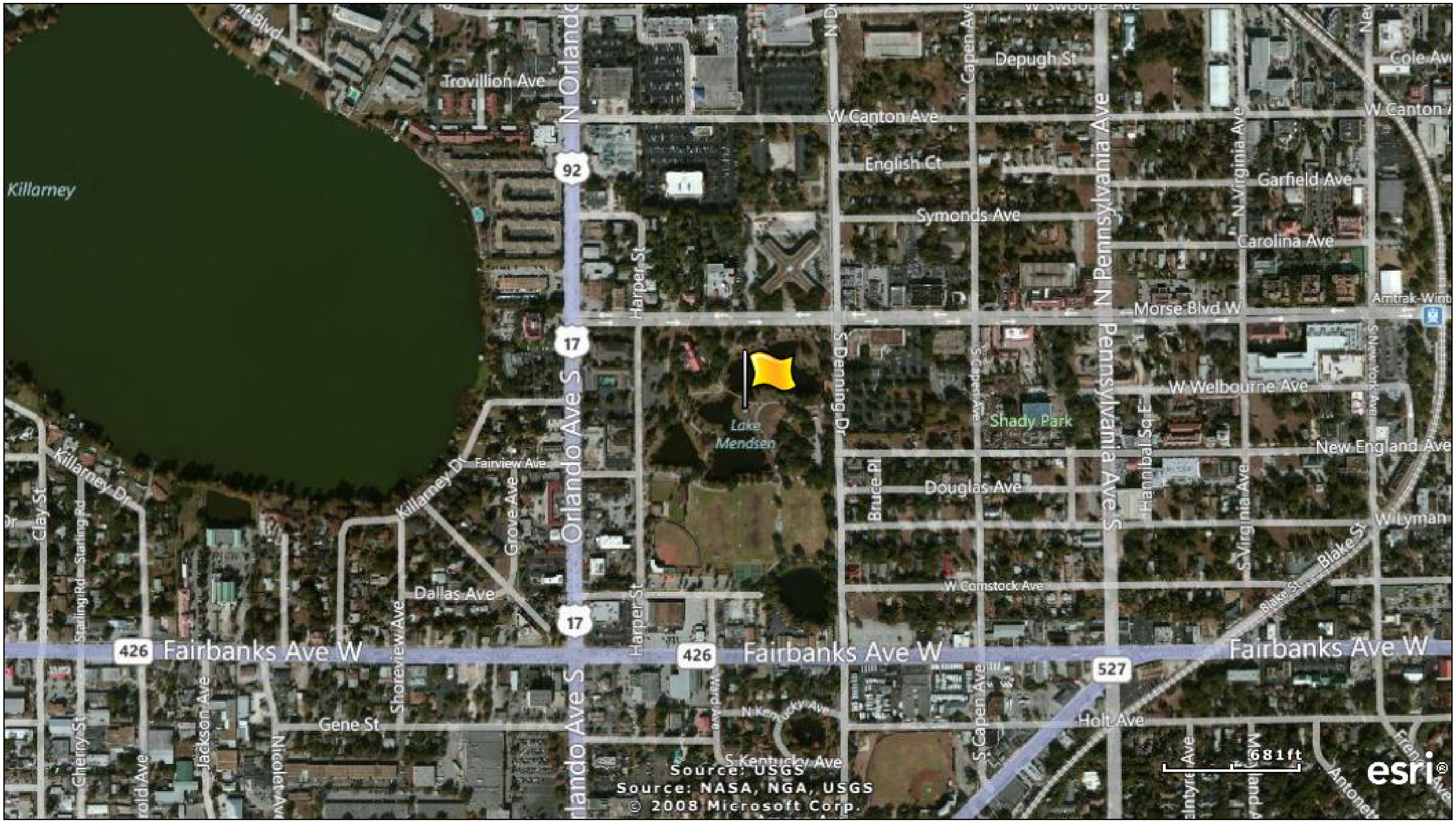


Figure 9-5. Winter Park, Florida (ORFL) Monitoring Site



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

Figure 9-6. Orlando, Florida (PAFL) Monitoring Site

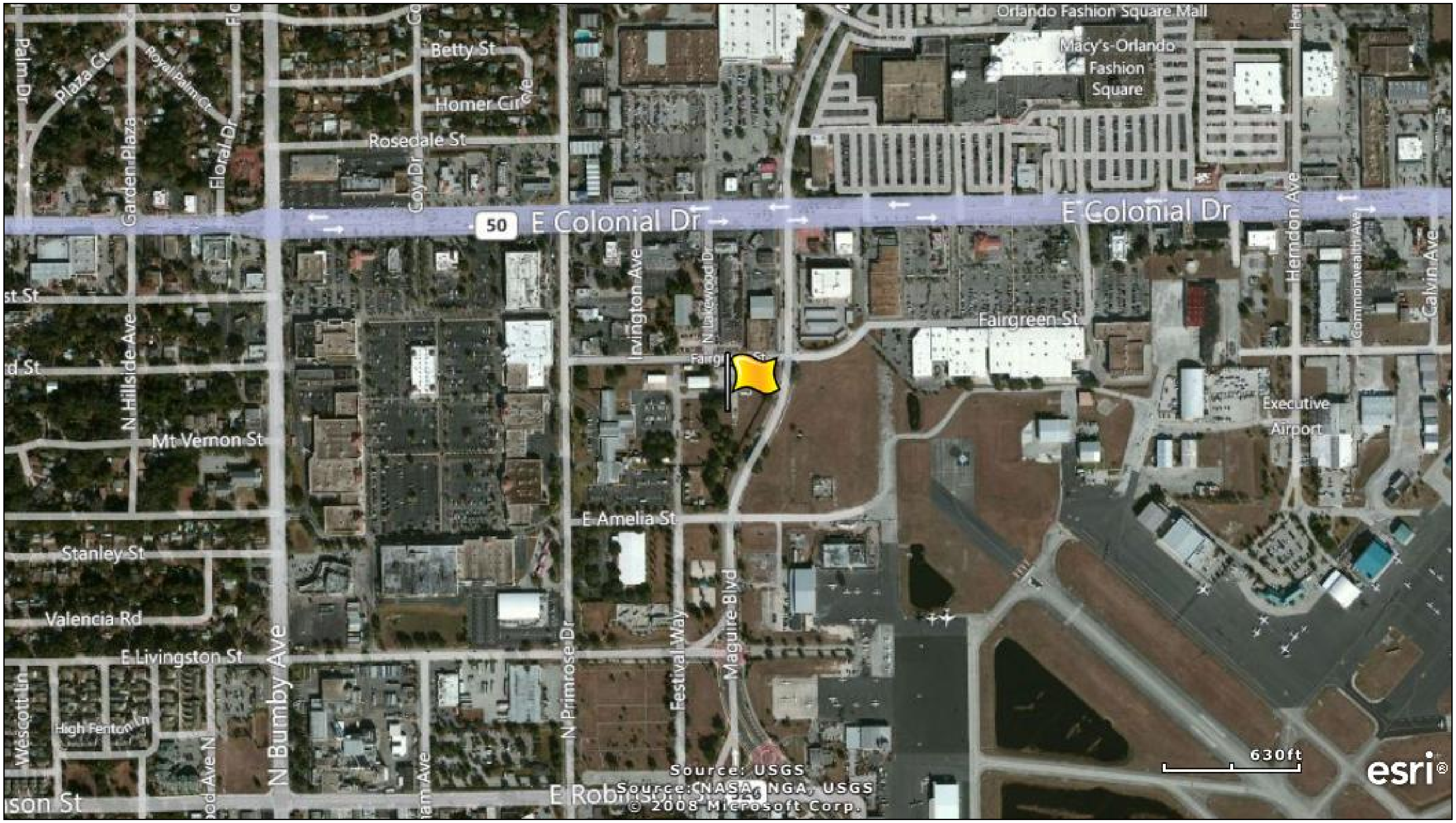
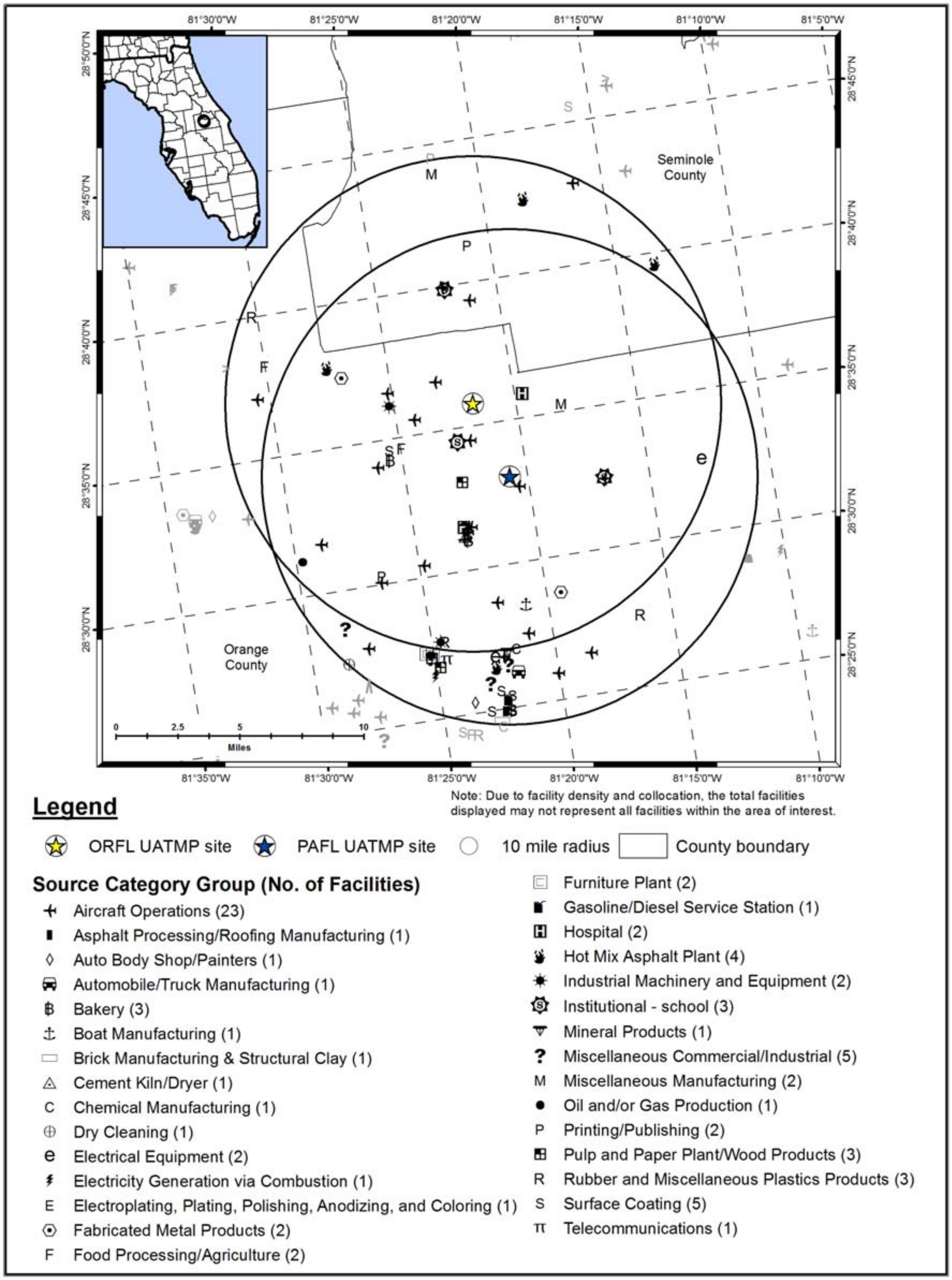


Figure 9-7. NEI Point Sources Located Within 10 Miles of ORFL and PAFL



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	27.850041, -82.714590	Residential	Suburban	VOCs, Meteorological parameters, PM_{10} Speciation, Black carbon, $PM_{2.5}$ Speciation, $PM_{2.5}$.
SYFL	12-057-3002	Plant City	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.
ORFL	12-095-2002	Winter Park	Orange	Orlando-Kissimmee, FL	28.596444, -81.362444	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, FL	28.550833, -81.345556	Commercial	Suburban	Meteorological parameters, PM_{10}, $PM_{2.5}$.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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. 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.

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.

SYFL is located in Plant City, 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 in a rural area, although, as Figure 9-3 shows, a residential community and country club lie just to the west of the site. Located to the south of the site 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 9-4 shows the location of the Tampa/St. Petersburg sites in relation to each other. SYFL is located the farthest east and AZFL is the farthest west, although SKFL is located within a few miles of AZFL. A large cluster of point sources is located just north of SKFL. Another cluster of emissions sources is located about halfway between SYFL and the other two sites, although grayed out and not included in the facility counts in Figure 9-4. Aircraft operations, which include airports as well as small runways, heliports, or landing pads; printing and publishing facilities; and fabricated metal product facilities are the source categories with the highest number of emissions sources in the Tampa/St. Petersburg area (based on the areas covered by the 10-mile radii).

ORFL is located in Winter Park, north of Orlando. Figure 9-5 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 northern Orlando, on the northwestern edge of the Orlando Executive Airport property, as shown in Figure 9-6. 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 9-6). 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 9-7 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 aircraft operations source category has the highest 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 county-level population and vehicle registration information. Table 9-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 9-2 also contains traffic volume information for each site. Finally, 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]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
AZFL	917,398	877,075	0.96	580,599	555,080	40,500	21,395,381
SKFL				705,597	674,583	47,000	
SYFL	1,267,775	1,135,945	0.90	321,686	288,235	10,600	34,351,899
ORFL	1,169,107	1,056,627	0.90	1,003,806	907,230	32,500	33,325,315
PAFL				880,133	795,455	46,000	

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)

[2] County-level vehicle registration reflects 2011 data from the Florida Department of Highway Safety & Motor Vehicles (FL DHSMV, 2011)

[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)

[4] AADT reflects 2011 data from the Florida DOT (FL DOT, 2011a)

[5] County-level VMT reflects 2011 data for all public roads from the Florida DOT (FL DOT, 2011b)

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 over 1 million people. Broward County ranks just less than Orange County compared to other counties with NMP sites covered in this report.

- Of the five Florida monitoring sites, ORFL has the highest population within 10 miles of all the Florida sites. ORFL's 10-mile population ranks 12th highest among NMP sites. Note the difference between SYFL's 10-mile and county-level populations. This is an example of a site located within a populous county that is not near the population center.

- The vehicle registration counts for two of the three Florida counties are over 1 million, with Hillsborough County having the most and Pinellas County having the least. The 10-mile ownership estimates are more variable, with SYFL having the least number of vehicles and ORFL having the most.

- The vehicle-per-person ratios range from 0.90 (both Orange and Hillsborough Counties) to 0.96 (Pinellas County).

- The traffic volume near SYFL is the lowest among the Florida sites and highest near SKFL. Traffic volumes near most of the Florida monitoring sites are in the middle of the range compared to other NMP sites, with traffic near SYFL being in the bottom third compared to other NMP sites. The following list provides the roadways or intersections from which the traffic data were obtained: AZFL - 66th Street North, north of 9th Street; ORFL - Orlando Avenue, north of Morse Boulevard; PAFL - East Colonial Drive, between Primrose Road and Bumby Avenue; SKFL - Park Boulevard, east of 66th Street North; and SYFL - Martin Luther King Jr. Boulevard (574), east of McIntosh Road.

- VMT is highest for Hillsborough County and lowest for Pinellas County (among the Florida sites). 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. Precipitation tends to be concentrated during the summer, as afternoon thunderstorms occur frequently. 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 (Bair, 1992 and FCC, 2013).

9.2.2 Meteorological Conditions in 2011

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year. 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 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.

Table 9-3. Average Meteorological Conditions near the Florida Monitoring Sites

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)
St. Petersburg, Florida - AZFL									
St. Petersburg/ Whitted Airport 92806 (27.77, -82.63)	6.77 miles 94° (E)	Sample Day	79.6 ± 2.1	73.6 ± 2.3	65.1 ± 2.6	68.3 ± 2.3	76.1 ± 2.5	1016.7 ± 1.0	7.6 ± 0.8
		2011	80.4 ± 0.9	74.2 ± 0.9	65.4 ± 1.0	68.7 ± 0.9	75.4 ± 1.0	1016.5 ± 0.4	7.3 ± 0.3
Pinellas Park, Florida - SKFL									
St Petersburg-Clearwater Intl. Airport 12873 (27.91, -82.69)	4.46 miles 12° (NNE)	Sample Day	80.8 ± 2.2	72.9 ± 2.3	63.0 ± 2.6	66.8 ± 2.2	72.8 ± 2.2	1017.0 ± 1.0	6.6 ± 0.6
		2011	81.6 ± 0.9	73.4 ± 0.9	63.3 ± 1.0	67.1 ± 0.9	72.4 ± 0.9	1017.0 ± 0.4	6.5 ± 0.2
Plant City, Florida - SYFL									
Plant City Municipal Airport 92824 (28.00, -82.16)	4.56 miles 50° (NE)	Sample Day	83.2 ± 2.5	73.0 ± 2.5	62.9 ± 2.8	66.8 ± 2.4	73.9 ± 2.4	NA	4.4 ± 0.4
		2011	84.7 ± 0.9	73.9 ± 0.9	63.5 ± 1.0	67.4 ± 0.9	73.5 ± 1.0	NA	4.2 ± 0.2
Winter Park, Florida - ORFL									
Orlando Executive Airport 12841 (28.55, -81.33)	3.95 miles 145° (SE)	Sample Day	82.2 ± 2.4	72.9 ± 2.3	62.4 ± 2.5	66.4 ± 2.2	72.1 ± 2.2	1017.1 ± 1.1	6.1 ± 0.6
		2011	82.8 ± 0.9	73.0 ± 0.9	62.1 ± 1.0	66.3 ± 0.9	71.3 ± 1.0	1017.4 ± 0.4	5.8 ± 0.2

[1] Sample day averages are highlighted 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 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)
Orlando, Florida - PAFL									
Orlando Executive Airport 12841 (28.55, -81.33)	0.84 miles 111° (ESE)	Sample Day	81.1 ± 3.7	71.9 ± 3.6	61.2 ± 3.9	65.4 ± 3.5	71.4 ± 3.1	1017.9 ± 1.5	5.8 ± 0.9
		2011	82.8 ± 0.9	73.0 ± 0.9	62.1 ± 1.0	66.3 ± 0.9	71.3 ± 1.0	1017.4 ± 0.4	5.8 ± 0.2

[1] Sample day averages are highlighted 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 the entire year for 2011. 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 2011 at the Florida monitoring sites were representative of average weather conditions experienced throughout the entire year. The largest difference is shown for PAFL and the temperature parameters. Sampling at PAFL took place on a 1-in-12 day schedule, yielding roughly half the sample days as the other Florida monitoring sites. This may result in more variability in the sample day averages. Temperatures on sample days at SYFL also appear slightly cooler than those for the entire year. SYFL did not deviate from the 1-in-6 day sample schedule until then end of the year, where make-up samples were collected at SYFL in December, which may explain the differences shown in Table 9-3.

9.2.3 Back Trajectory Analysis

Figure 9-8 is the composite back trajectory map for days on which samples were collected at the AZFL monitoring site in 2011. Included in Figure 9-8 are four back trajectories per sample day. Figure 9-9 is the corresponding cluster analysis. Similarly, Figures 9-10 through 9-17 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 9-8 through 9-17 represents 100 miles.

Figure 9-8. 2011 Composite Back Trajectory Map for AZFL

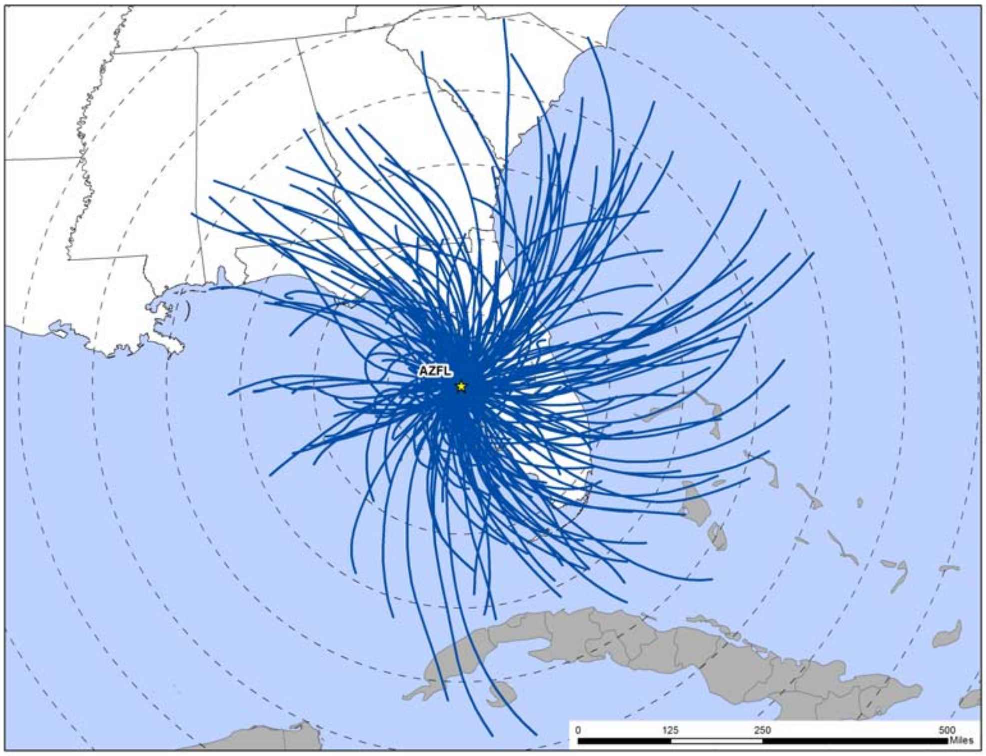


Figure 9-9. Back Trajectory Cluster Map for AZFL

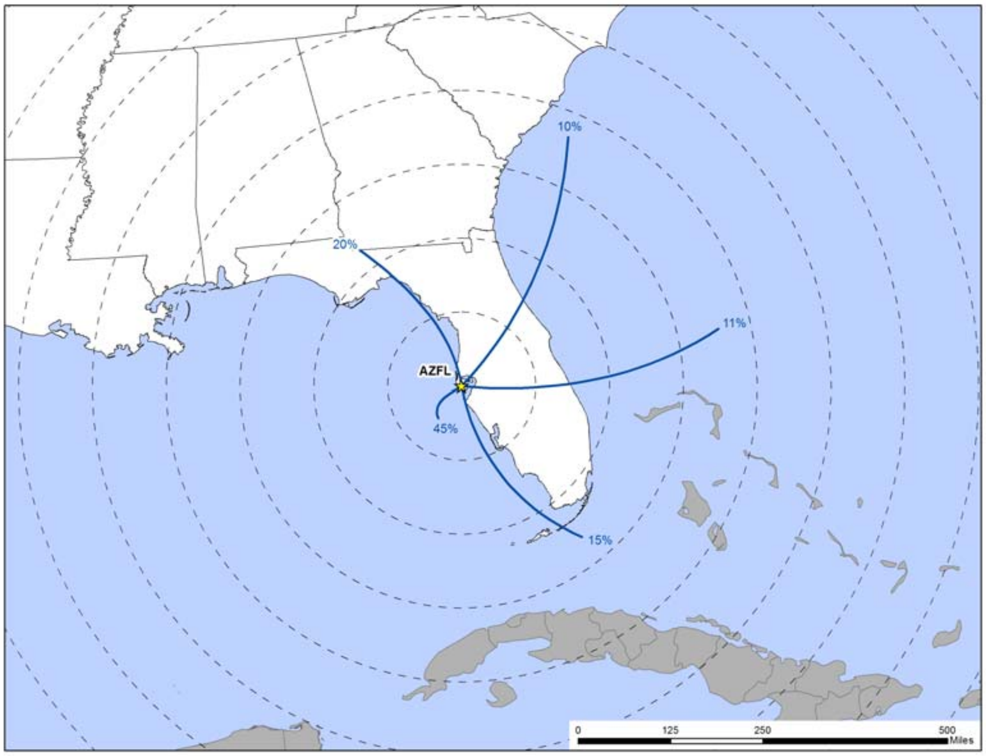


Figure 9-10. 2011 Composite Back Trajectory Map for SKFL

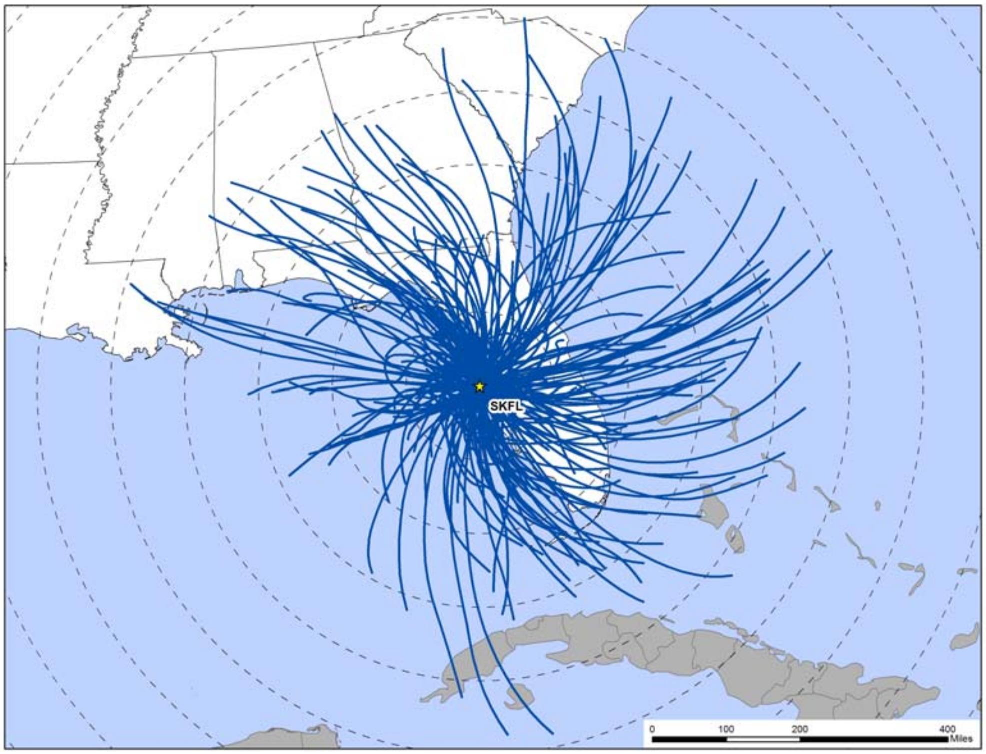


Figure 9-11. Back Trajectory Cluster Map for SKFL

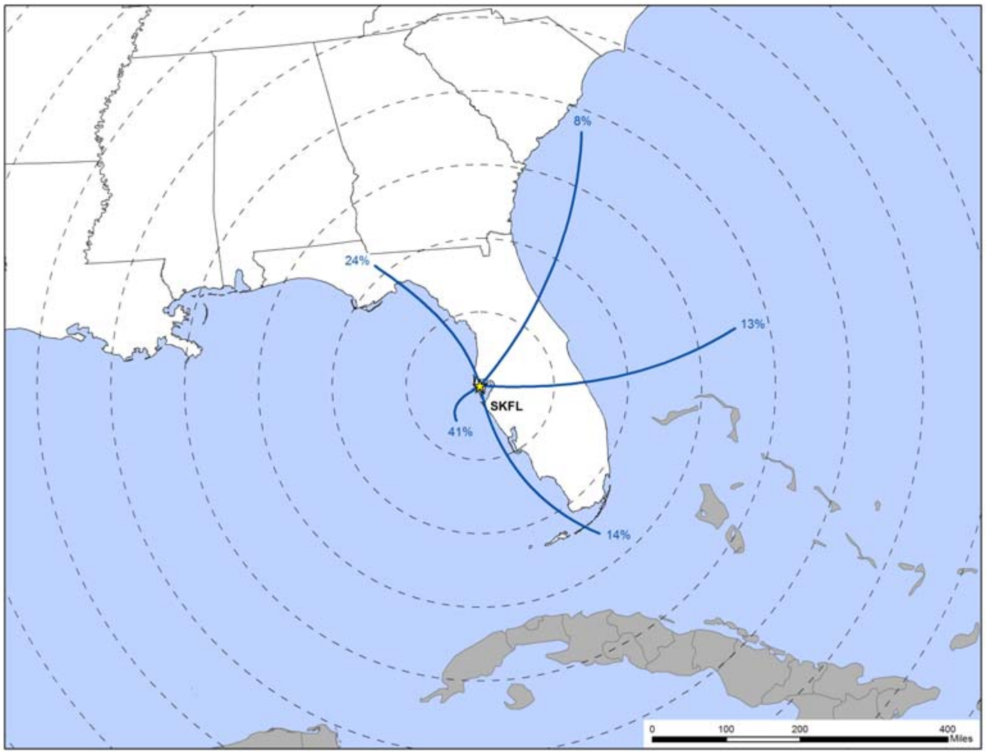


Figure 9-12. 2011 Composite Back Trajectory Map for SYFL

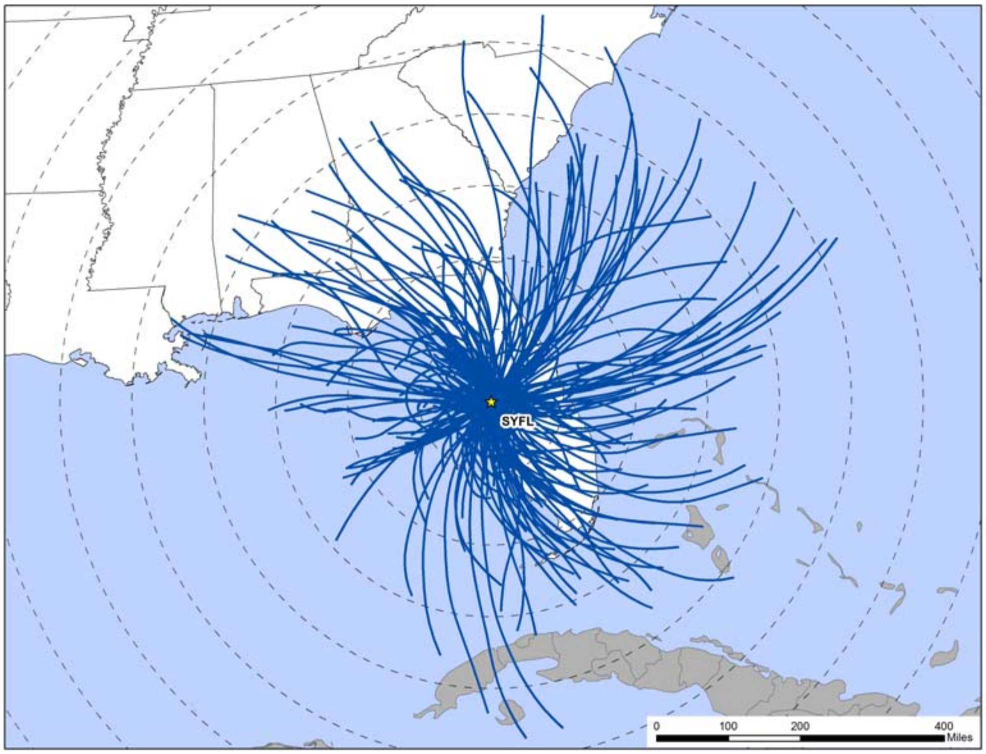


Figure 9-13. Back Trajectory Cluster Map for SYFL

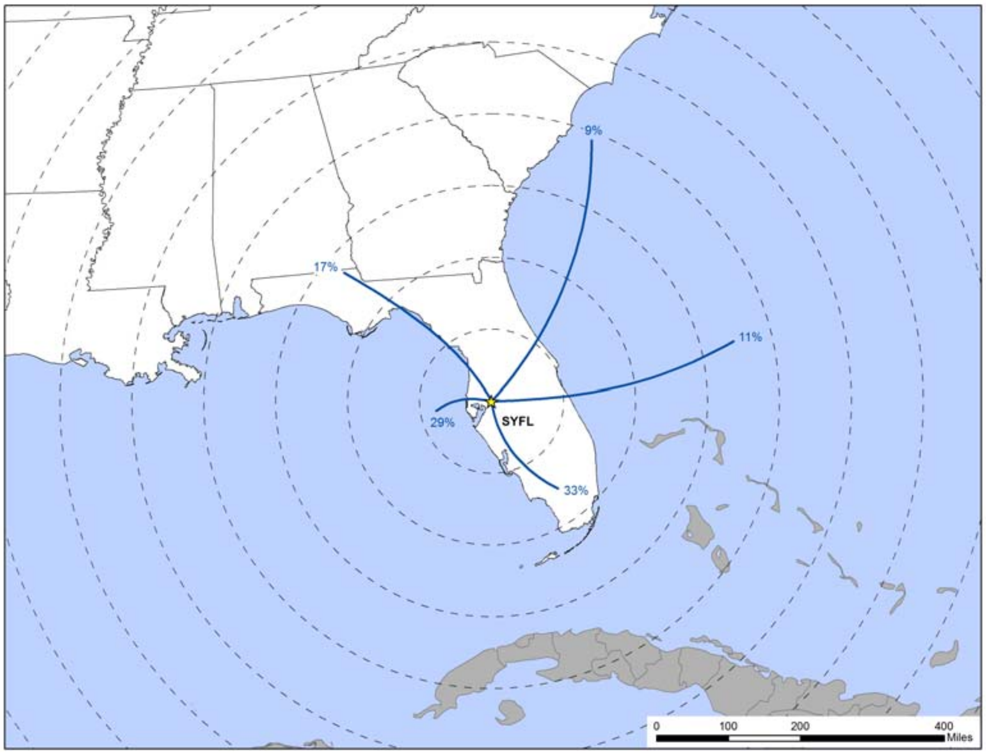


Figure 9-14. 2011 Composite Back Trajectory Map for ORFL

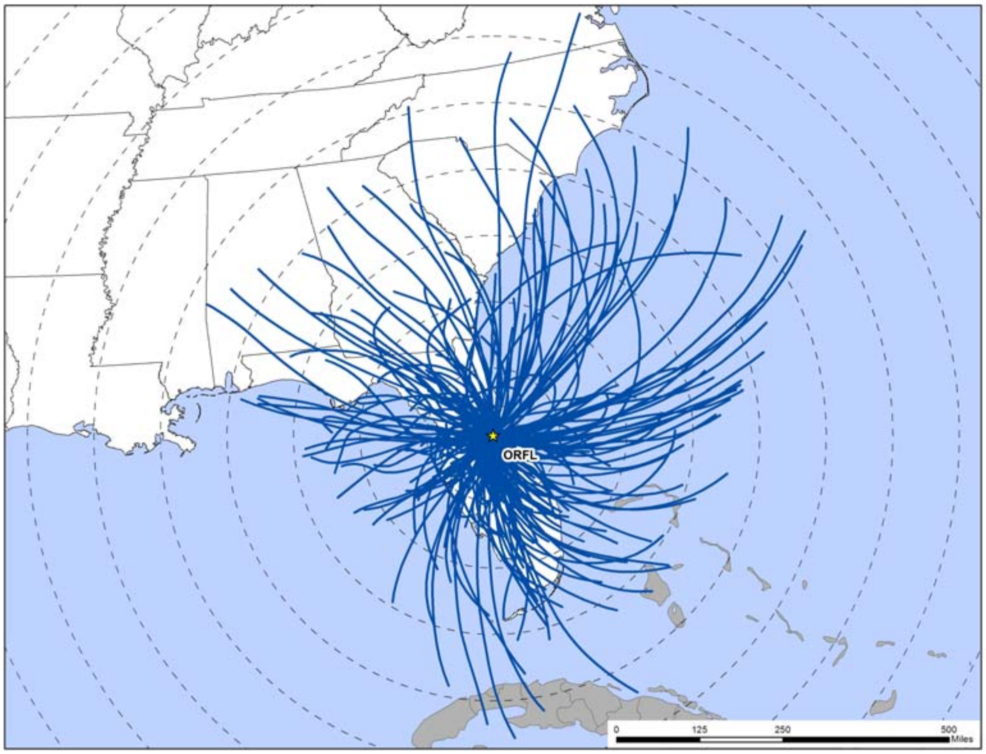


Figure 9-15. Back Trajectory Cluster Map for ORFL

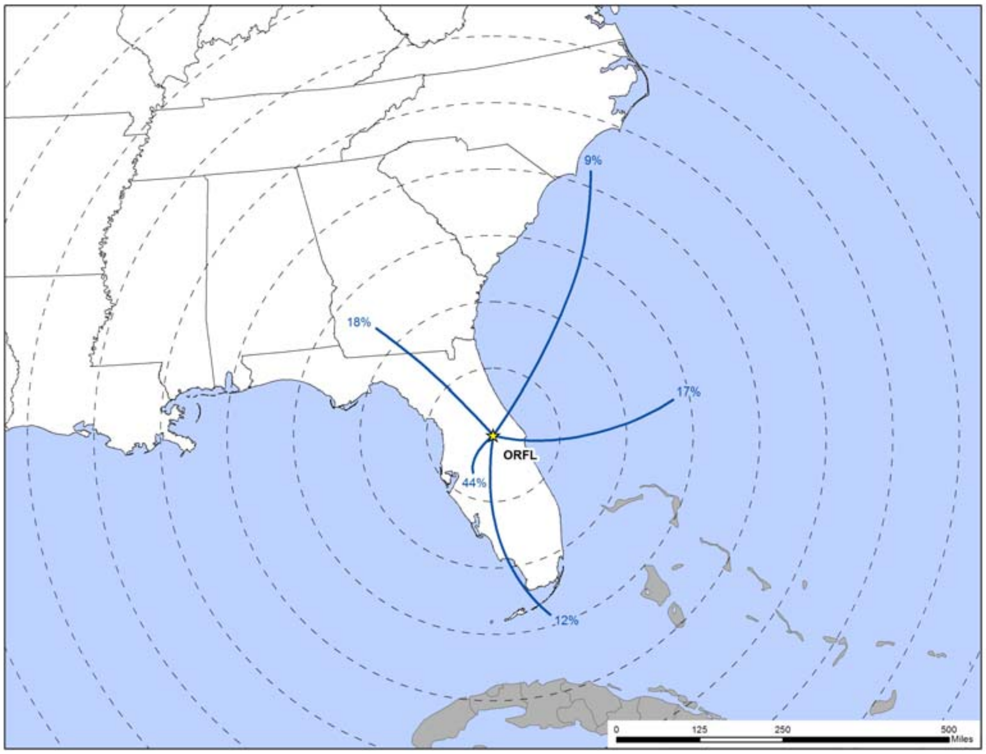


Figure 9-16. 2011 Composite Back Trajectory Map for PAFL

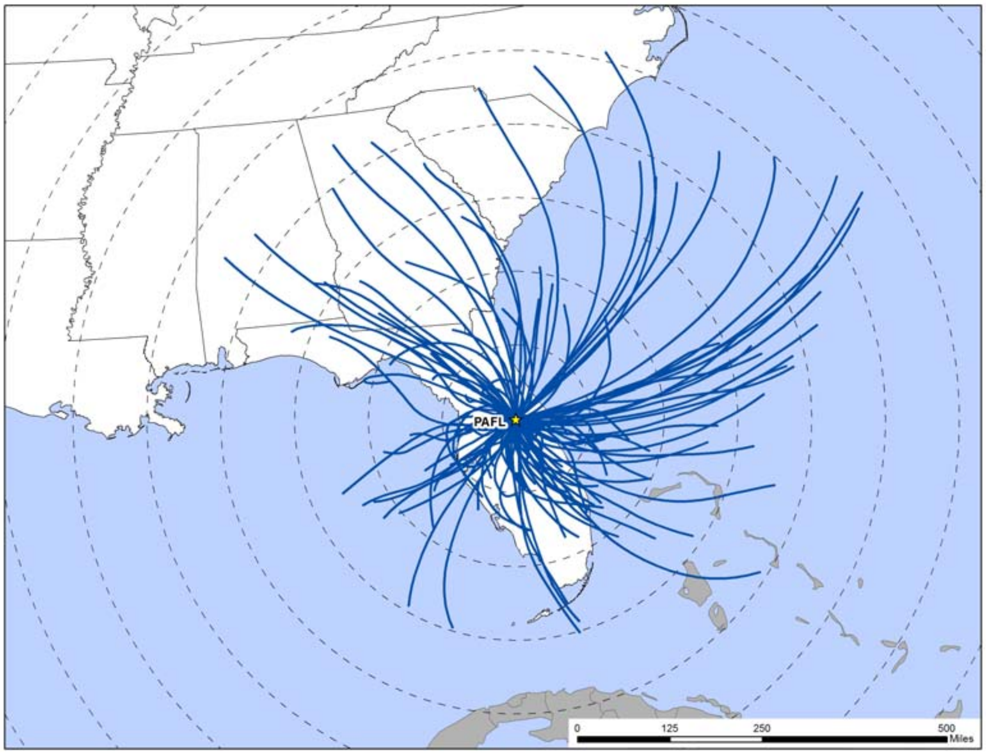
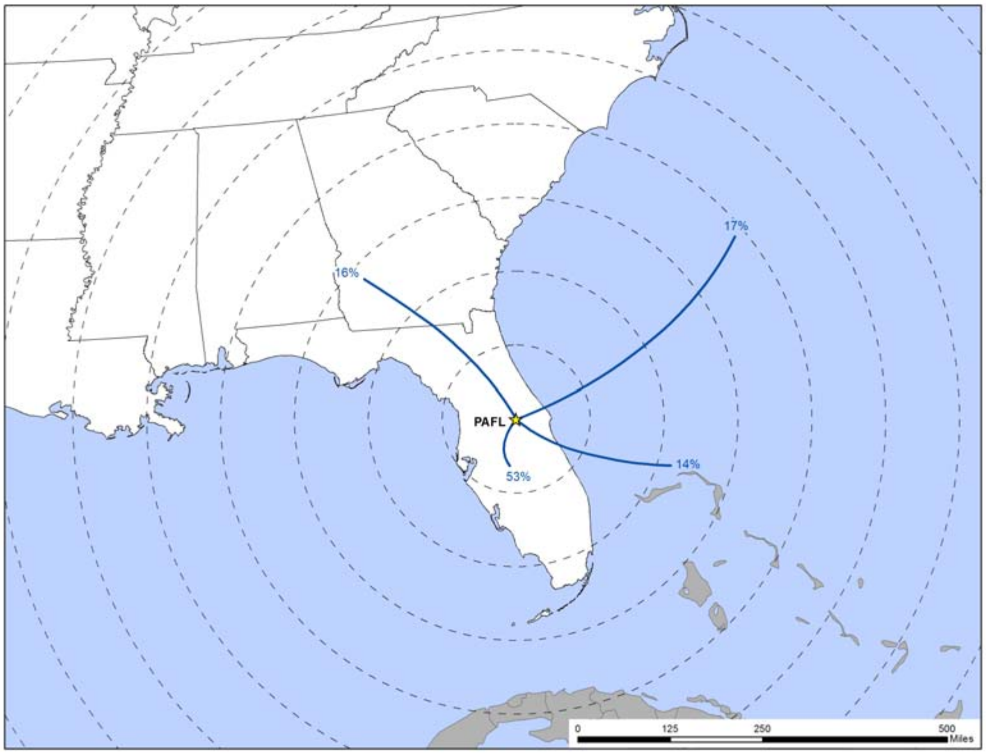


Figure 9-17. Back Trajectory Cluster Map for PAFL



Observations from Figures 9-8 through 9-13 for the Tampa/St. Petersburg sites include the following:

- The composite back trajectory maps for the Tampa/St. Petersburg sites are generally 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 monitoring sites, with the average trajectory length ranging from 215 miles for AZFL to 222 miles for SYFL. For AZFL and SKFL, the farthest away a back trajectory originated was just greater than 500 miles away, originating eastward over the Atlantic Ocean. For SYFL, the longest back trajectory originated over central North Carolina, nearly 550 miles away. However, most trajectories (roughly 88 percent for each site) originated within 400 miles of the Tampa/St. Petersburg monitoring sites.

- The cluster maps for AZFL, SKFL, and SYFL are similar to each other in geographical breakup, although the percentages differ somewhat. The cluster maps for all three sites show that the approximately one-third or more of the back trajectories are represented by the short cluster originating just west of the Tampa/St. Petersburg area and over the Gulf of Mexico. This cluster includes back trajectories of varying lengths originating to the west of the sites over the Gulf of Mexico as well as shorter trajectories originating from a variety of directions around the sites.

- The cluster maps group the remaining back trajectories into four directions: northwestward over the Florida Panhandle, northeastward off the Southeast Coast, eastward over the Atlantic Ocean, and southward over south Florida and the Straights of Florida.

Observations from Figures 9-14 through 9-17 for ORFL and PAFL include the following:

- The composite back trajectory map for PAFL has fewer trajectories compared to the 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 24-hour air shed domains were similar in size compared to the Tampa/St. Petersburg monitoring sites. The longest trajectory originated northeastward over the Atlantic Ocean for PAFL, or 560 miles away, with a few additional back trajectories originating from a similar location. The longest back trajectory for ORFL originated in southeast Virginia, nearly 650 miles away. PAFL does not have a similar back trajectory because this site did not sample on this date.

- Nearly 90 percent of back trajectories originated with 400 miles of ORFL and PAFL.

- The cluster map for ORFL is similar to the cluster maps for the Tampa/St. Petersburg sites in trajectory distribution. Nearly half of all back trajectories are represented by the short cluster originating to the southwest of the site (44 percent). This cluster includes back trajectories originating from a variety of directions, although primarily from the western quadrants, and less than 200 miles away. The cluster map groups the remaining back trajectories into four directions: those originating northwestward over the Florida Panhandle, Georgia, and Alabama; those originating northeastward off the Southeast Coast; those originating eastward over the Atlantic Ocean and northern Bahamas; and those originating southward over south Florida and the surrounding waters.

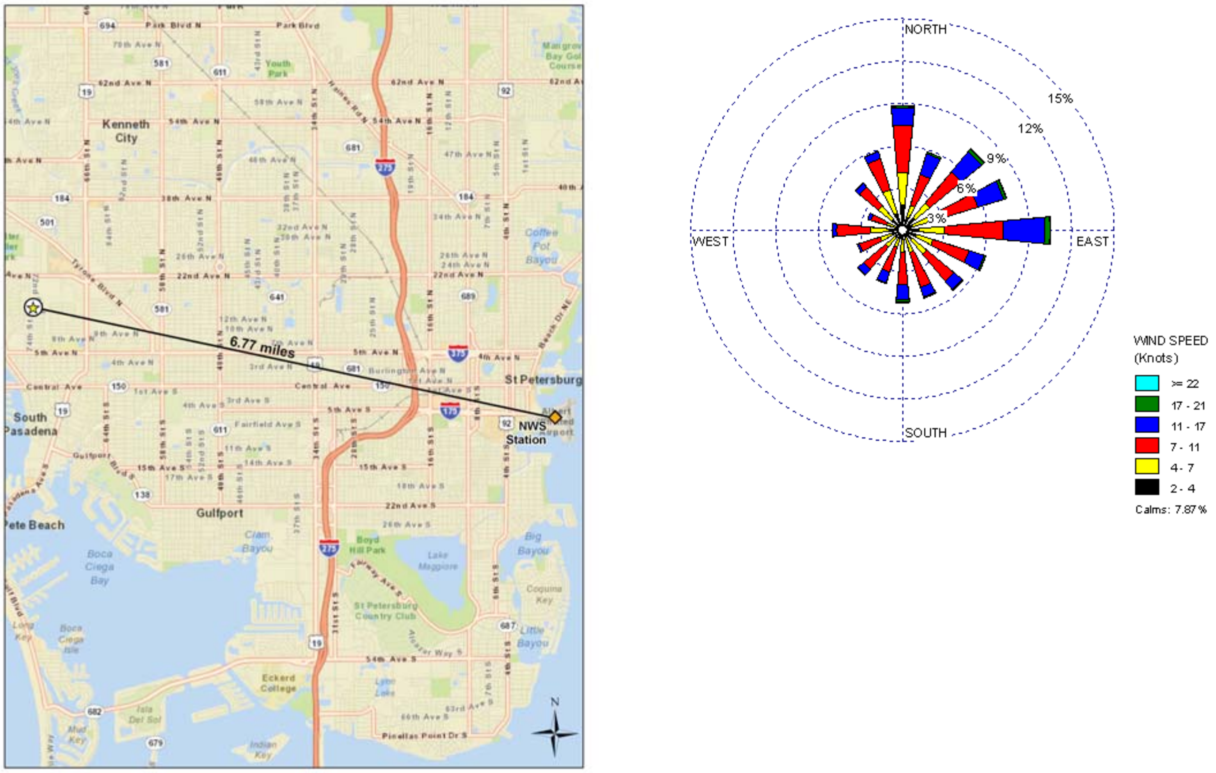
- The cluster map for PAFL has a short cluster (53 percent) similar to the one for ORFL, but this cluster also includes those back trajectories originating from south Florida (while the cluster map for ORFL separates them into a separate cluster).
- The cluster map for PAFL groups the remaining back trajectories as follows: northwestward over the Florida Panhandle, Georgia, and Alabama; northeastward off the Southeast Coast, and east-southeastward over the Atlantic Ocean.

9.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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.

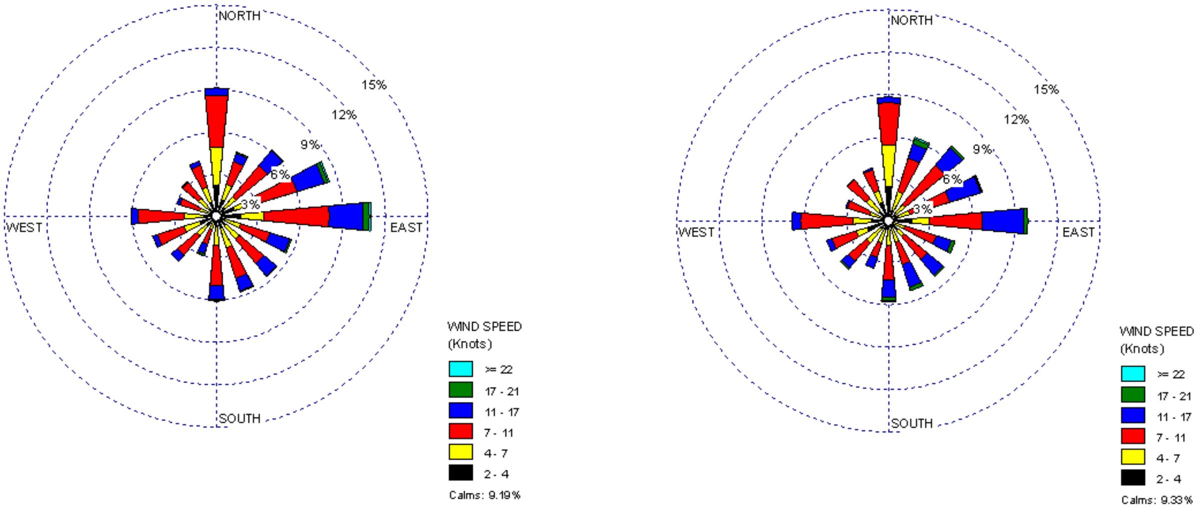
Figure 9-18 presents a map showing the distance between the NWS station and AZFL, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 9-18 also presents three different wind roses for the AZFL monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 9-19 through 9-22 present the three wind roses and distance maps for SKFL, SYFL, ORFL, and PAFL, respectively.

Figure 9-18. Wind Roses for the St. Petersburg/Whitted Airport Weather Station near AZFL



Distance between AZFL and NWS Station

2001-2010 Historical Wind Rose

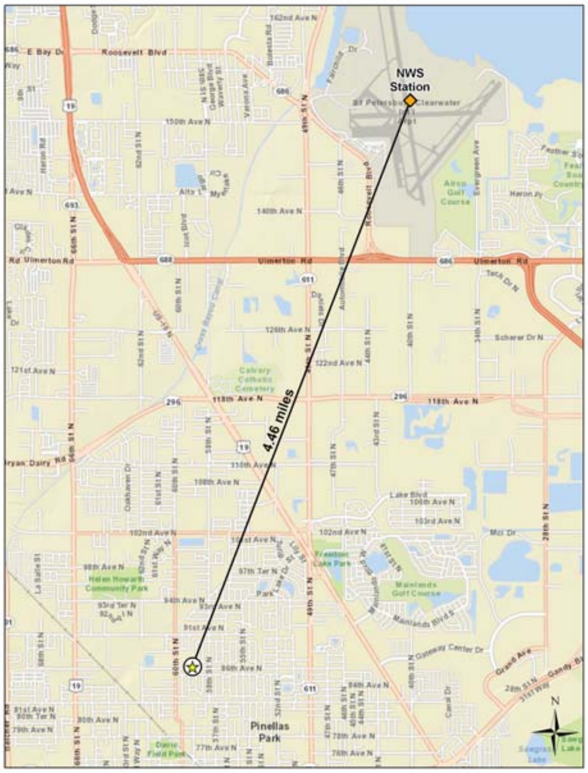


2011 Wind Rose

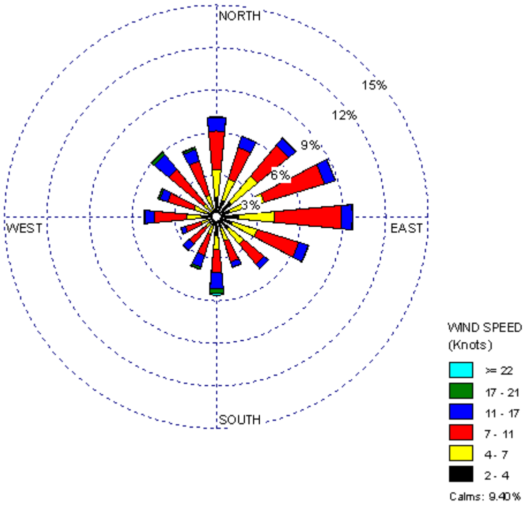
Sample Day Wind Rose

Figure 9-19. Wind Roses for the St. Petersburg/Clearwater International Airport Weather Station near SKFL

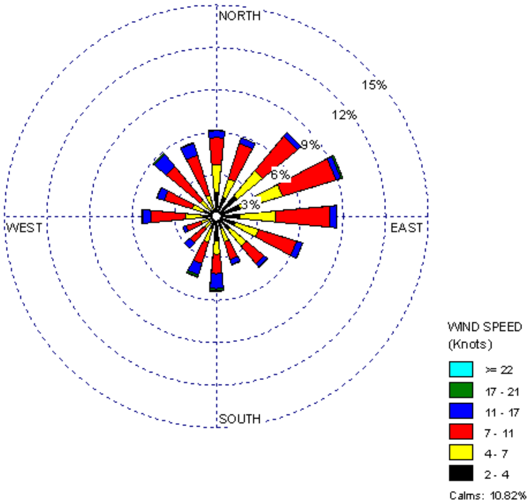
Distance between SKFL and NWS Station



2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

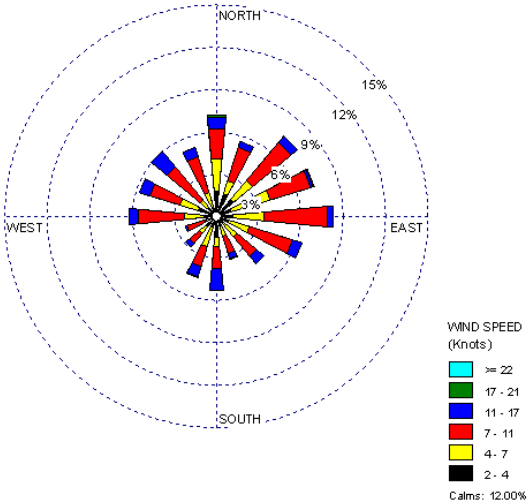
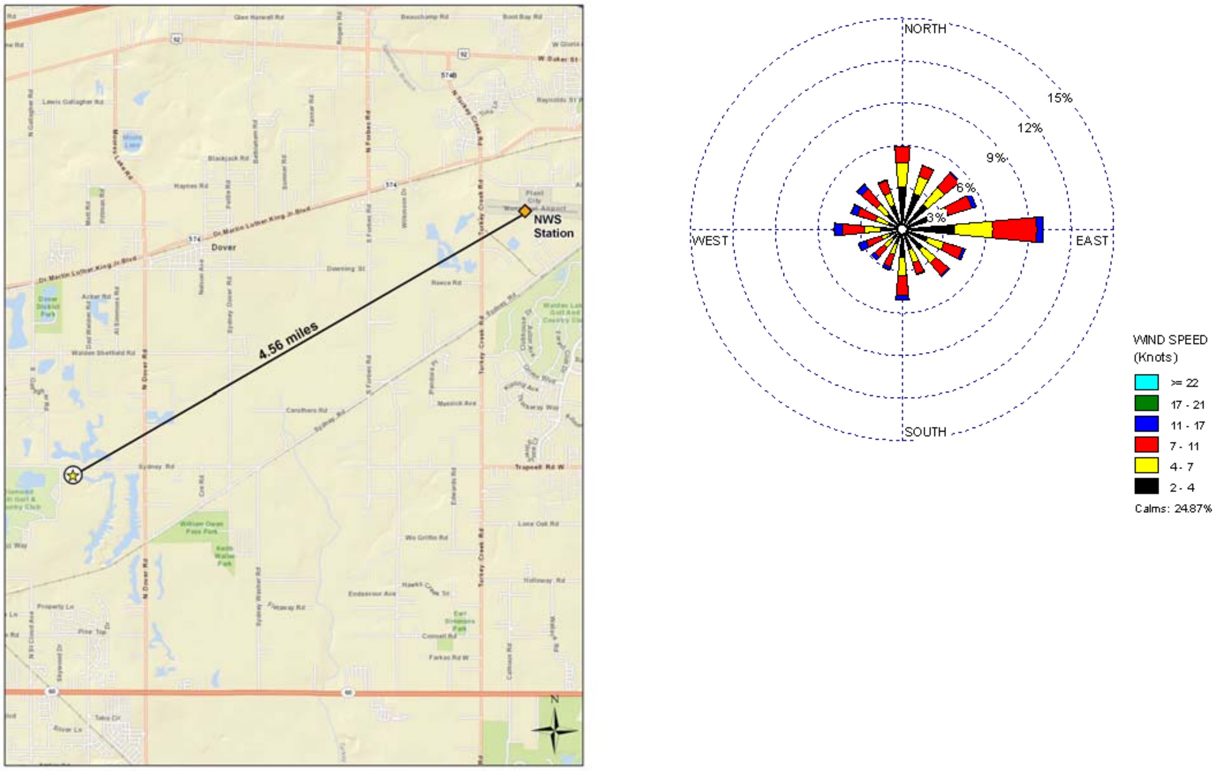


Figure 9-20. Wind Roses for the Plant City Municipal Airport Weather Station near SYFL



Distance between SYFL and NWS Station

2008-2010 Historical Wind Rose

2011 Wind Rose

Sample Day Wind Rose

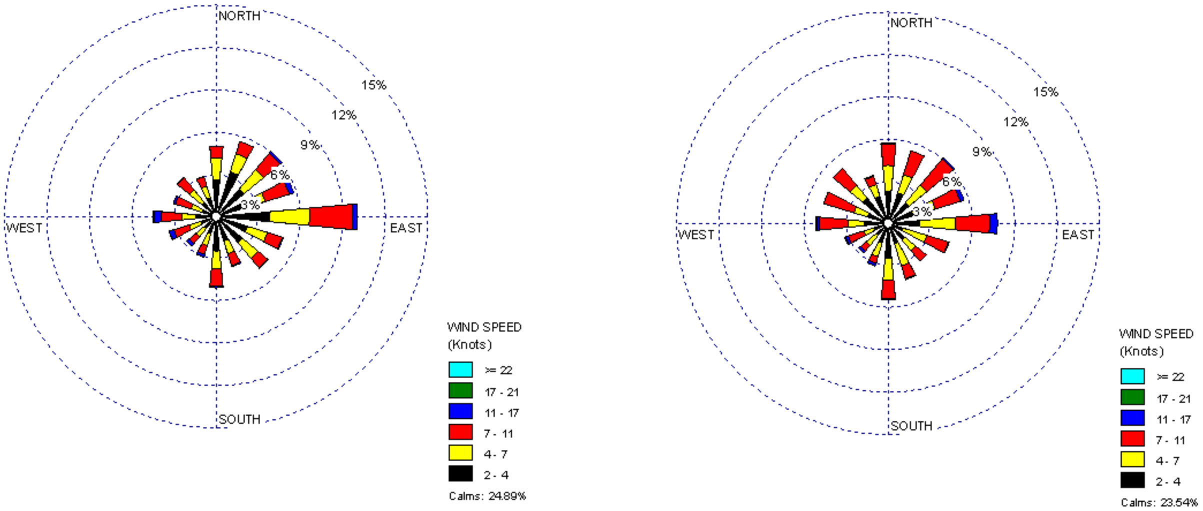
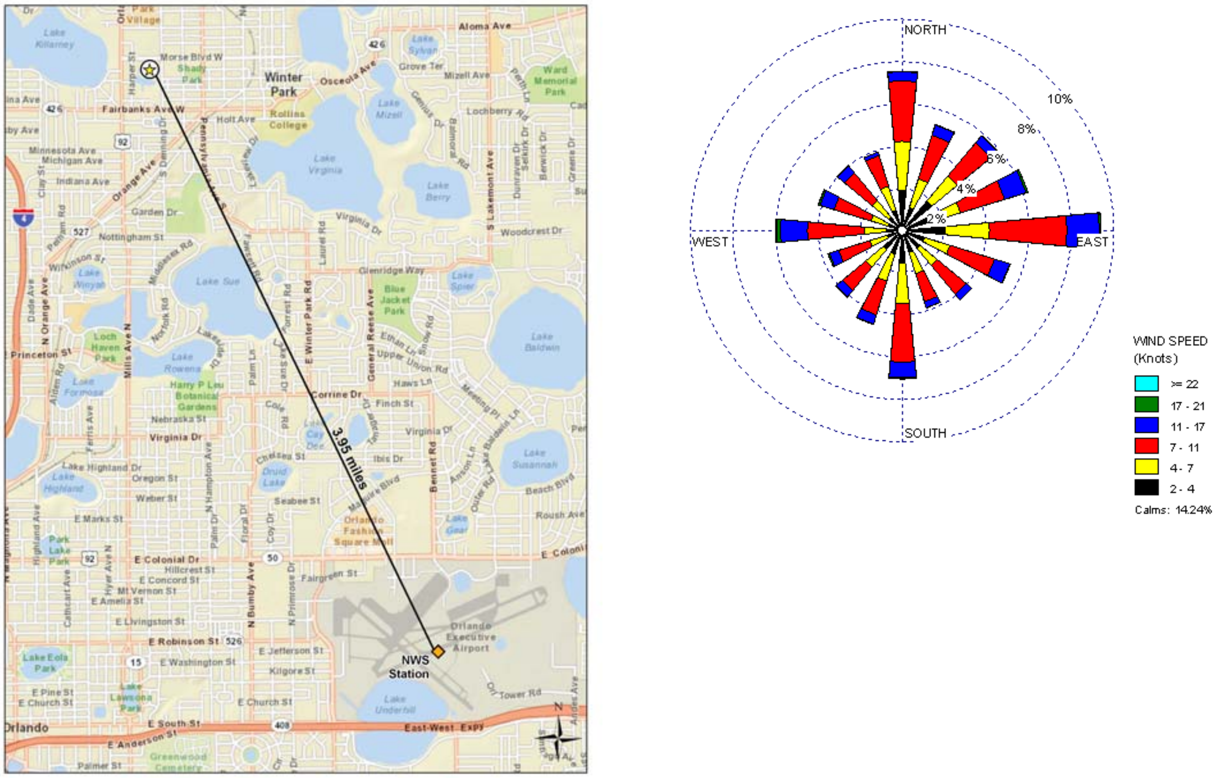
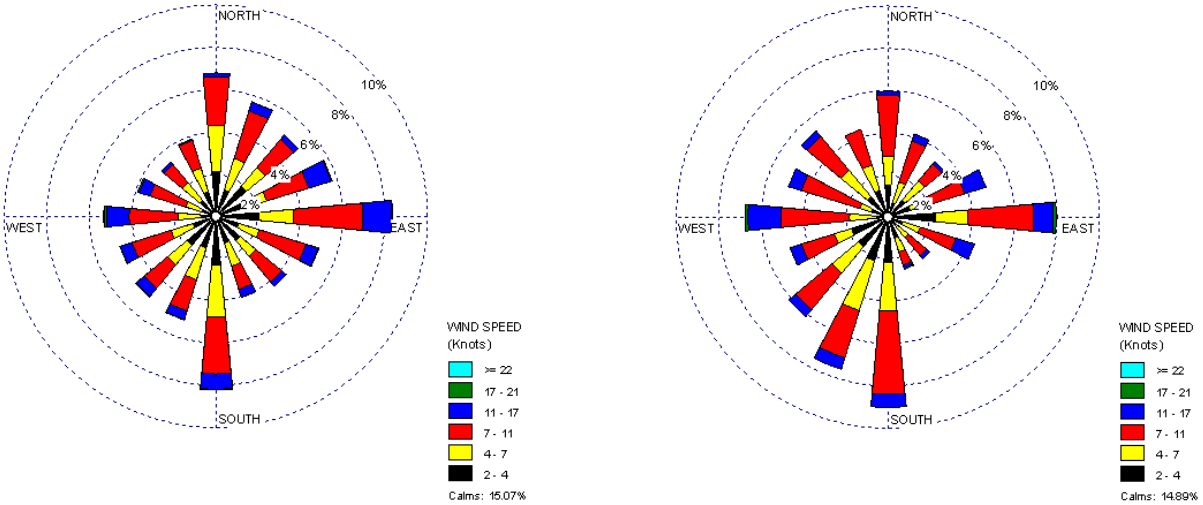


Figure 9-21. Wind Roses for the Orlando Executive Airport Weather Station near ORFL



Distance between ORFL and NWS Station

2001-2010 Historical Wind Rose



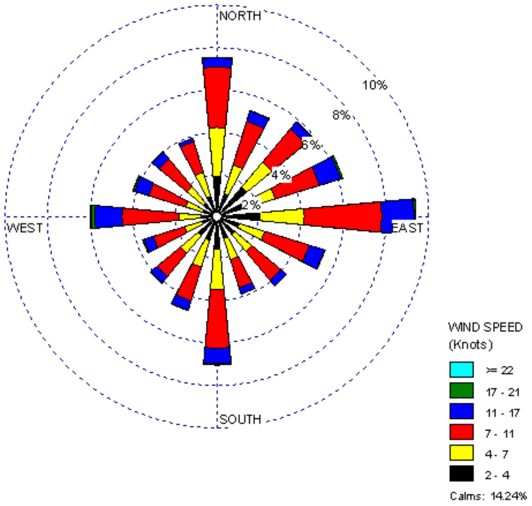
2011 Wind Rose

Sample Day Wind Rose

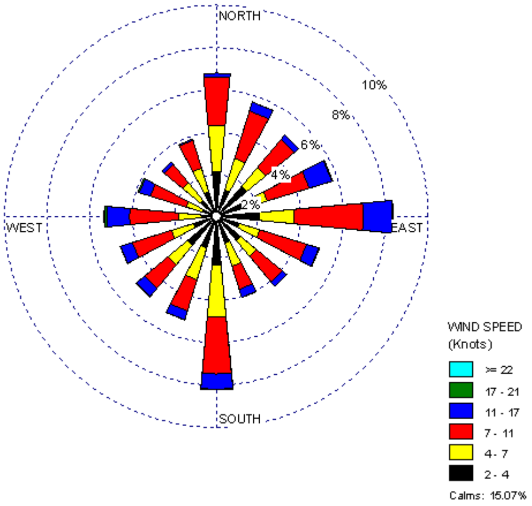
Figure 9-22. Wind Roses for the Orlando Executive Airport Weather Station near PAFL

Distance between PAFL and NWS Station

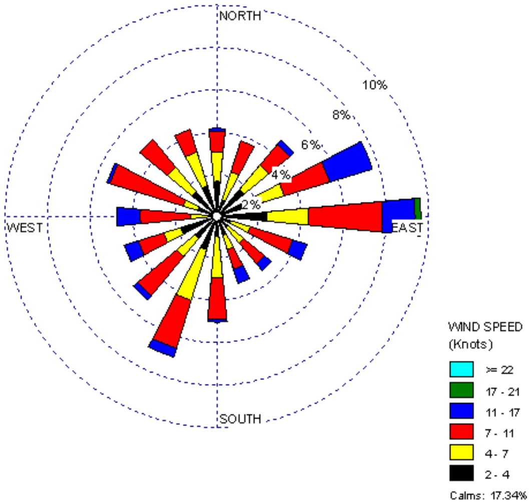
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



Observations from Figure 9-18 for AZFL include the following:

- The NWS weather station at St. Petersburg/Whitted Airport is located approximately 6.8 miles east of AZFL. Between them is most of the city of St. Petersburg. Note that the Whitted Airport is 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 calm winds (≤ 2 knots) accounted for less than 10 percent of the hourly wind measurements. Winds from the north, northeasterly quadrant, and east were the most commonly observed wind directions near AZFL while winds from the western quadrants were observed less frequently.

- The full-year wind rose shows that while winds from all directions were observed near AZFL, winds from the north and east were the predominant wind directions, similar to the historical wind rose.

- The sample day wind patterns favor the full-year wind patterns, indicating that conditions on sample days were representative of wind conditions experienced in 2011.

- Both the full-year and sample day wind roses resemble the historical wind rose, indicating that conditions on sample days and over the entire year were similar to wind conditions experienced historically.

Observations from Figure 9-19 for SKFL include the following:

- The NWS weather station at St. Petersburg/Clearwater Airport is located just less than 4.5 miles north-northeast of SKFL. Note that 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 2011 and sample day wind roses resemble the historical wind rose, indicating that conditions on sample days and over the entire year were similar to wind conditions experienced historically.

Observations from Figure 9-20 for SYFL include the following:

- The NWS 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 sites. This station did not begin operating until 2006 and data availability is lacking until mid-2007; thus, the historical wind rose includes data from the first full-year of data (2008) through 2010.

- The historical wind rose shows that calm winds (≤ 2 knots) account for approximately 25 percent of the hourly wind measurements between 2008 and 2010. Winds from the eastern quadrants were observed more often than the western quadrants, although winds from all directions were observed near SYFL.

- 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 9-21 and 9-22 for ORFL and PAFL include the following:

- The closest NWS 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 2011 sample day wind rose for ORFL exhibits the same prominence of easterly, northerly, and southerly winds, but winds from the southwest quadrant (and northwest quadrant to some extent) account for a higher percentage of wind observations than they do for the historical and full-year wind roses.

- The 2011 sample day wind rose for PAFL shares the easterly prominence with the 2011 wind rose, but that is where the similarities in wind direction end. Winds from the south and north account for fewer observations and winds from the east-northeast account for more. Further, winds from the western quadrants account for more observations than those from the eastern quadrants (with the exception of winds from the east-northeast and east). 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

Site-specific "pollutants of interest" were determined for the Florida monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 9-4 presents the results of the preliminary risk-based screening process for each Florida monitoring site. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. AZFL and ORFL sampled for carbonyl compounds only. SKFL and SYFL sampled hexavalent chromium and PAHs in addition to carbonyl compounds. PAFL sampled only PM_{10} metals.

Table 9-4. Risk-Based Screening Results for the Florida Monitoring Sites

Pollutant	**Screening Value ($\mu g/m^3$)**	**# of Failed Screens**	**# of Measured Detections**	**% of Screens Failed**	**% of Total Failures**	**Cumulative % Contribution**
St. Petersburg, Florida - AZFL						
Formaldehyde	0.077	62	62	100.00	50.41	50.41
Acetaldehyde	0.45	61	62	98.39	49.59	100.00
Total		123	124	99.19		
Pinellas Park, Florida - SKFL						
Acetaldehyde	0.45	61	61	100.00	34.66	34.66
Formaldehyde	0.077	61	61	100.00	34.66	69.32
Naphthalene	0.029	52	61	85.25	29.55	98.86
Hexavalent Chromium	0.000083	1	55	1.82	0.57	99.43
Propionaldehyde	0.8	1	61	1.64	0.57	100.00
Total		176	299	58.86		

Table 9-4. Risk-Based Screening Results for the Florida Monitoring Sites (Continued)

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Plant City, Florida - SYFL						
Formaldehyde	0.077	60	60	100.00	38.46	38.46
Acetaldehyde	0.45	57	60	95.00	36.54	75.00
Naphthalene	0.029	37	60	61.67	23.72	98.72
Acenaphthene	0.011	2	60	3.33	1.28	100.00
Total		156	240	65.00		
Winter Park, Florida - ORFL						
Acetaldehyde	0.45	60	60	100.00	50.00	50.00
Formaldehyde	0.077	60	60	100.00	50.00	100.00
Total		120	120	100.00		
Orlando, Florida - PAFL						
Arsenic (PM_{10})	0.00023	28	31	90.32	100.00	100.00
Total		28	31	90.32		

Observations from Table 9-4 include the following:

- Acetaldehyde and formaldehyde were the only two pollutants to fail screens for AZFL and ORFL. Although these two pollutants contributed equally to the total number of failed screens for ORFL, there was one more failed screen for formaldehyde than acetaldehyde for AZFL. These two sites sampled only carbonyl compounds; among the carbonyl compounds, only acetaldehyde, formaldehyde, and propionaldehyde have risk screening values. Propionaldehyde did not fail any screens for these two sites.

- Five pollutants, of which four are NATTS MQO Core Analytes, failed screens for SKFL. Acetaldehyde, formaldehyde, and naphthalene were identified as pollutants of interest via the risk-based screening process. Hexavalent chromium was added to SKFL's pollutants of interest because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of SKFL's failed screens. Benzo(a)pyrene was also added as a pollutant of interest for SKFL, even though it did not fail any screens, because it is a NATTS MQO Core Analyte. Benzo(a)pyrene is not shown in Table 9-4 but is shown in subsequent tables in the sections that follow.

- Four pollutants, of which three are NATTS MQO Core Analytes, failed screens for SYFL. Acetaldehyde, formaldehyde, and naphthalene were identified as pollutants of interest via the risk-based screening process. Benzo(a)pyrene and hexavalent chromium were added to SYFL's pollutants of interest because they are NATTS MQO Core Analytes, even though their concentrations did not fail any screens. These pollutants are not shown in Table 9-4 but are shown in subsequent tables in the sections that follow.

- Formaldehyde failed 100 percent of screens for all four sites sampling carbonyl compounds.

- Arsenic was the only speciated metal to fail screens for PAFL. Ninety percent of the measurements of arsenic failed screens. Five additional pollutants were added to PAFL's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens (beryllium, cadmium, lead, manganese, and nickel). These pollutants are not shown in Table 9-4 but are shown in subsequent tables in the sections that follow.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Florida monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for the Florida monitoring sites are provided in Appendices L, M, N, and O.

9.4.1 2011 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 of 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, metals, 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 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	62/62	2.98 ± 0.59	2.46 ± 0.67	2.25 ± 0.49	1.07 ± 0.16	2.13 ± 0.30
Formaldehyde	62/62	1.69 ± 0.28	1.86 ± 0.30	1.81 ± 0.33	2.03 ± 0.20	1.86 ± 0.13
Pinellas Park, Florida - SKFL						
Acetaldehyde	61/61	3.15 ± 1.02	1.76 ± 0.24	1.58 ± 0.28	1.33 ± 0.19	1.95 ± 0.31
Formaldehyde	61/61	1.16 ± 0.31	2.72 ± 0.36	2.60 ± 0.31	2.13 ± 0.26	2.16 ± 0.21
Benzo(a)pyrene[a]	55/61	0.05 ± 0.02	0.03 ± 0.01	0.04 ± 0.01	0.07 ± 0.05	0.05 ± 0.01
Hexavalent Chromium[a]	55/62	0.02 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.01 ± 0.01	0.02 ± <0.01
Naphthalene[a]	61/61	83.83 ± 35.05	79.78 ± 25.27	99.97 ± 31.68	66.37 ± 24.19	82.22 ± 14.07
Plant City, Florida - SYFL						
Acetaldehyde	60/60	1.04 ± 0.18	1.34 ± 0.40	1.00 ± 0.25	0.75 ± 0.09	1.03 ± 0.13
Formaldehyde	60/60	1.62 ± 0.27	3.36 ± 0.97	2.75 ± 0.65	1.49 ± 0.20	2.30 ± 0.34
Benzo(a)pyrene[a]	25/60	0.02 ± 0.01	0.02 ± 0.02	0.01 ± 0.01	0.05 ± 0.03	0.02 ± 0.01
Hexavalent Chromium[a]	42/59	0.01 ± <0.01	0.02 ± 0.01	0.02 ± 0.01	0.01 ± <0.01	0.01 ± <0.01
Naphthalene[a]	60/60	47.12 ± 15.91	46.58 ± 16.20	36.77 ± 9.75	38.20 ± 13.96	42.00 ± 6.68
Winter Park, Florida - ORFL						
Acetaldehyde	60/60	1.82 ± 0.37	2.08 ± 0.24	1.81 ± 0.28	1.67 ± 0.26	1.85 ± 0.14
Formaldehyde	60/60	1.42 ± 0.28	2.12 ± 0.30	2.48 ± 0.36	1.49 ± 0.25	1.89 ± 0.18

[a] Average concentrations provided below the blue line for this site and/or pollutant are presented in ng/m^3 for ease of viewing.

Table 9-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Florida 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)
Orlando, Florida - PAFL[a]						
Arsenic (PM$_{10}$)[a]	31/31	0.63 ± 0.31	0.31 ± 0.07	0.79 ± 0.36	0.70 ± 0.47	0.62 ± 0.17
Beryllium (PM$_{10}$)[a]	31/31	0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Cadmium (PM$_{10}$)[a]	31/31	0.07 ± 0.02	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.03	0.06 ± 0.01
Lead (PM$_{10}$)[a]	31/31	2.25 ± 1.04	2.07 ± 0.86	1.86 ± 0.74	2.35 ± 1.40	2.13 ± 0.47
Manganese (PM$_{10}$)[a]	31/31	1.83 ± 0.47	2.39 ± 0.82	2.74 ± 0.78	1.96 ± 0.81	2.23 ± 0.35
Nickel (PM$_{10}$)[a]	31/31	0.63 ± 0.15	0.98 ± 0.32	0.77 ± 0.10	0.53 ± 0.07	0.72 ± 0.10

[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:

- SYFL's annual average concentration of formaldehyde (2.30 ± 0.34 µg/m^3) is the highest annual average concentration among the Florida sites. The annual average concentration of formaldehyde is higher than the annual average acetaldehyde concentration for both SKFL and SYFL; the annual average of acetaldehyde is higher than formaldehyde for AZFL; and the annual averages for the two carbonyl compounds were similar to each for ORFL.

- The annual average concentrations of formaldehyde range from 1.89 ± 0.18 µg/m^3 (ORFL) to 2.30 ± 0.34 µg/m^3 (SYFL). The annual average concentrations of acetaldehyde range from 1.03 ± 0.13 µg/m^3 (SYFL) to 2.13 ± 0.30 µg/m^3 (AZFL).

- The first quarter acetaldehyde average for SKFL is greater than the other quarterly average concentrations and has a relatively large confidence interval associated with it. A review of the data shows that the maximum concentration of acetaldehyde measured at SKFL was measured on February 14, 2011 (8.94 µg/m^3) and is more than twice the next highest concentration measured at SKFL (4.33 µg/m^3 measured on January 3, 2011). The nine highest concentrations of acetaldehyde were measured at SKFL during the first quarter of 2011.

- Concentrations of formaldehyde appear to be higher during the warmer months of the year, as the second and third quarter formaldehyde averages for SYFL and ORFL are greater than the other quarterly average concentrations. This trend appears to continue at SKFL but the confidence intervals calculated for these averages indicate that the difference among the quarterly averages is not statistically significant. This trend is not shown for AZFL.

- As previously discussed, SKFL and SYFL both sampled hexavalent chromium and PAHs in addition to carbonyl compounds. Hexavalent chromium, naphthalene, and benzo(a)pyrene are all pollutants of interest for these two sites. The annual average concentrations of these three pollutants are higher for SKFL than SYFL, particularly for naphthalene.

- For PAFL, manganese and lead have the highest annual average concentrations among the PM_{10} metals. These are the only two metals with annual average concentrations greater than 1 ng/m^3.

- For PAFL, the first and fourth quarter lead averages have relatively large confidence intervals associated with them. A review of the data shows that two highest concentrations of lead were measured on December 29, 2011 (6.53 ng/m^3) and March 16, 2011 (5.16 ng/m^3). All other measurements of lead are less than 4 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 or Table 4-11 for PAHs.

- SKFL has the eighth highest annual average concentration of hexavalent chromium among NMP sites sampling this pollutant, as shown in Table 4-12.

- Because only nine NMP sites sampled PM_{10} metals, all nine sites appear in Table 4-12. The annual average concentrations of the PM_{10} metals for PAFL ranked eighth or ninth with the exception of arsenic, which ranked fifth.

9.4.2 Concentration Comparison

In order to better illustrate how a site's annual concentration averages compare to the program-level averages, a site-specific box plot was created for the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde and formaldehyde were created for AZFL, SKFL, SYFL, and ORFL. Box plots were also created for benzo(a)pyrene, hexavalent chromium, and naphthalene for SKFL and SYFL and for arsenic, lead, and manganese for PAFL. Figures 9-23 through 9-30 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.

Figure 9-23. Program vs. Site-Specific Average Acetaldehyde Concentrations

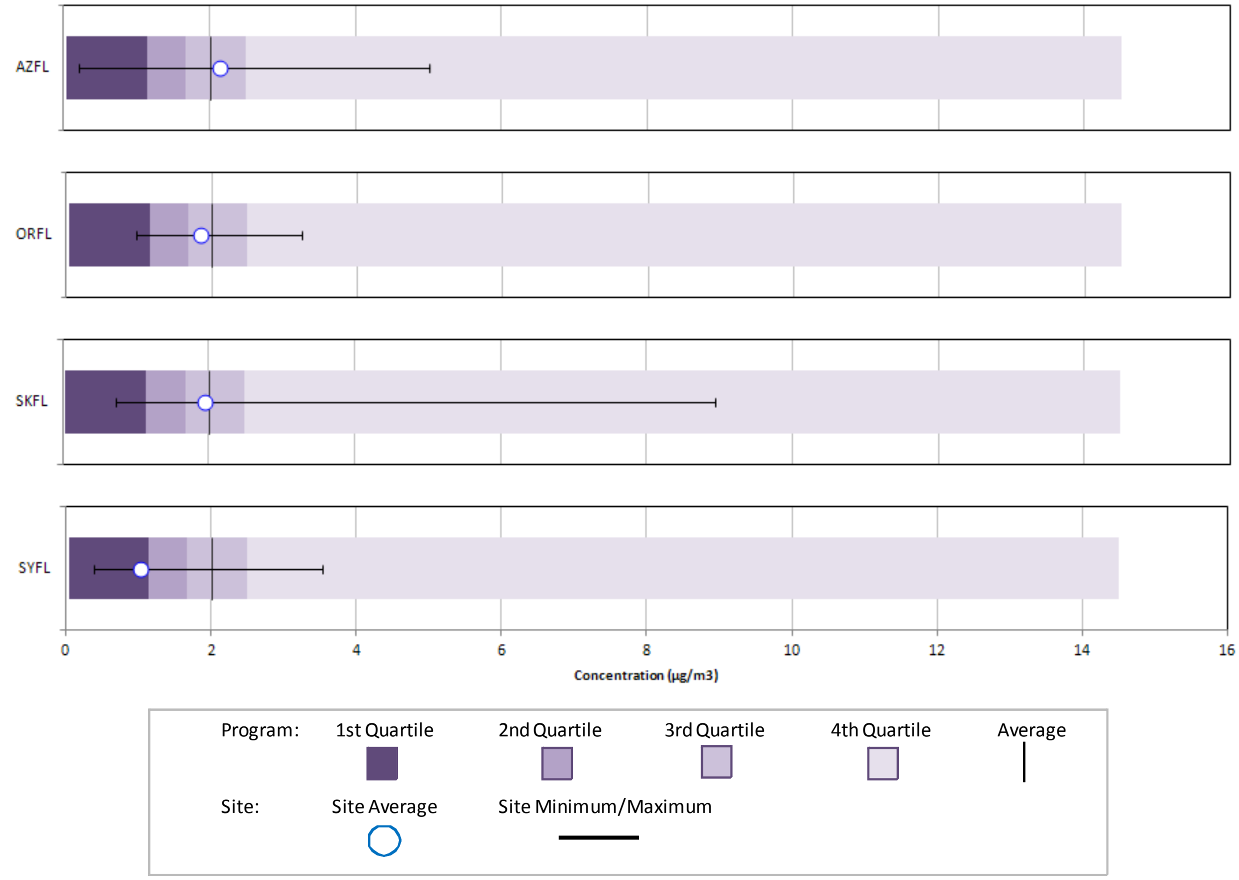


Figure 9-24. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

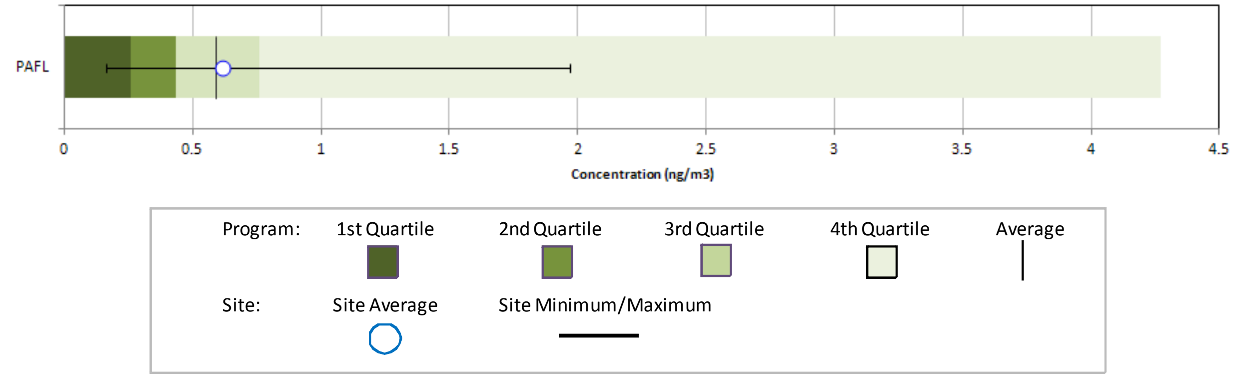


Figure 9-25. Program vs. Site-Specific Average Benzo(a)pyrene Concentrations

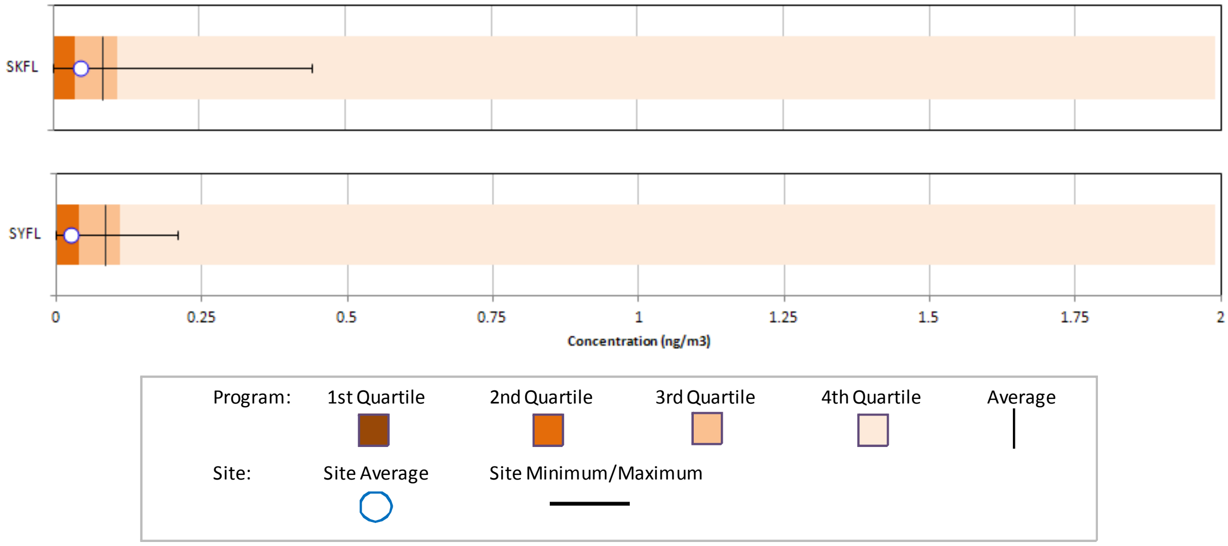


Figure 9-26. Program vs. Site-Specific Average Formaldehyde Concentrations

Figure 9-27. Program vs. Site-Specific Average Hexavalent Chromium Concentrations

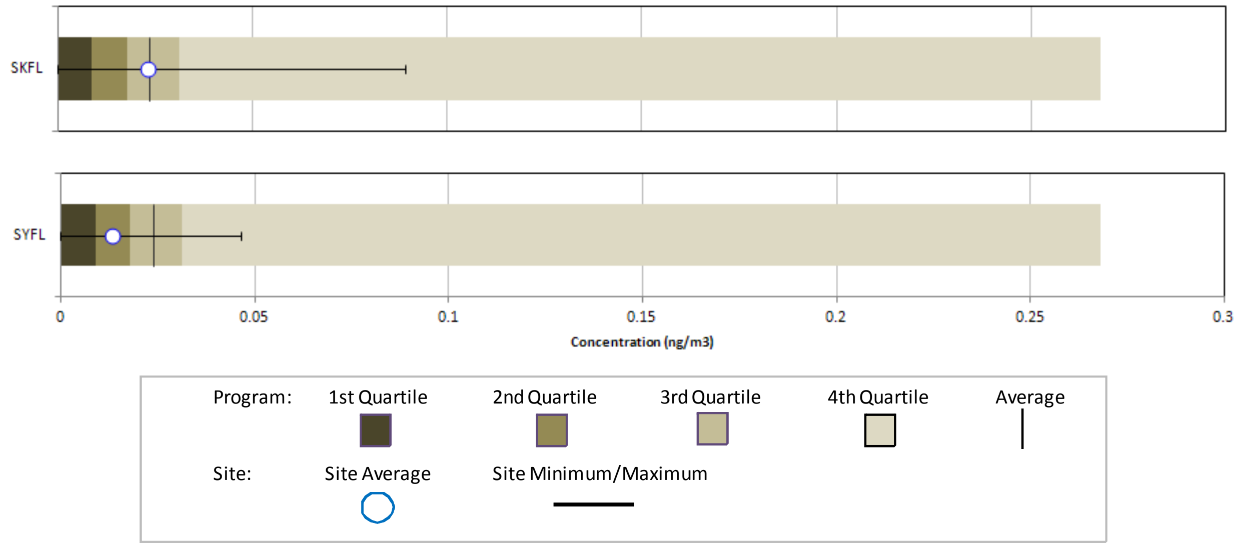


Figure 9-28. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

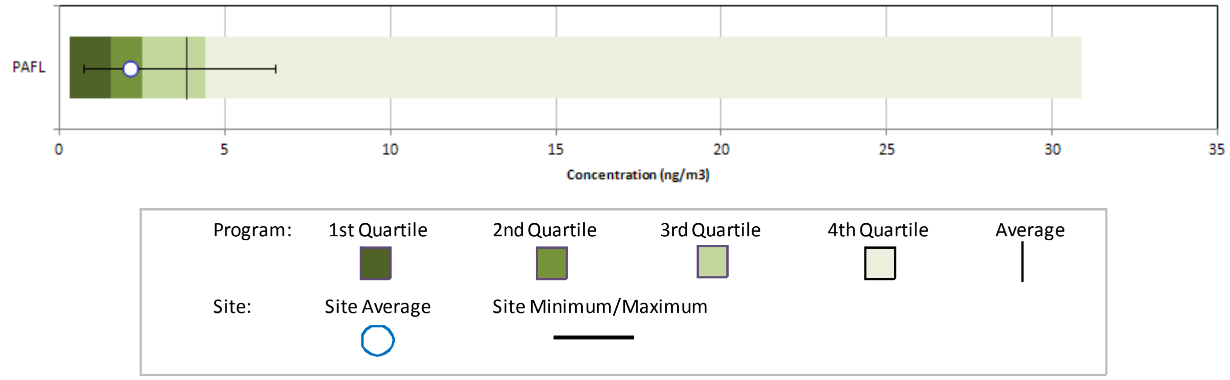


Figure 9-29. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

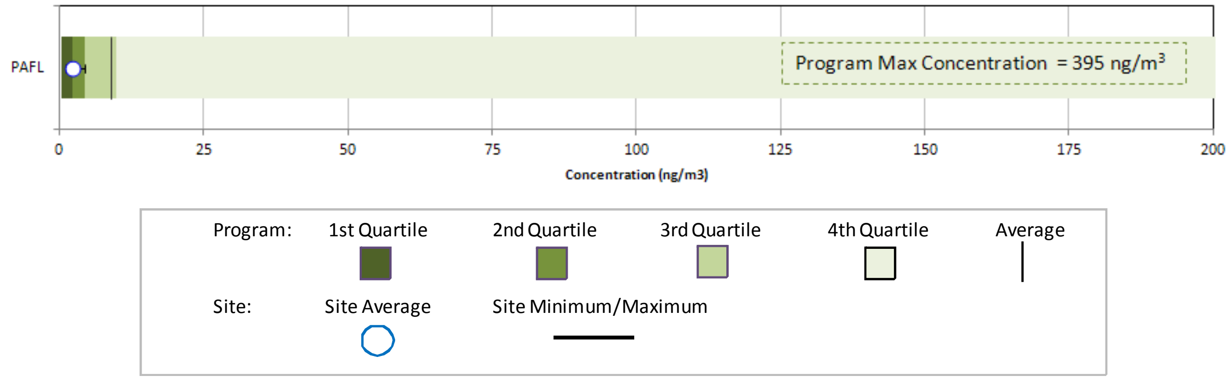
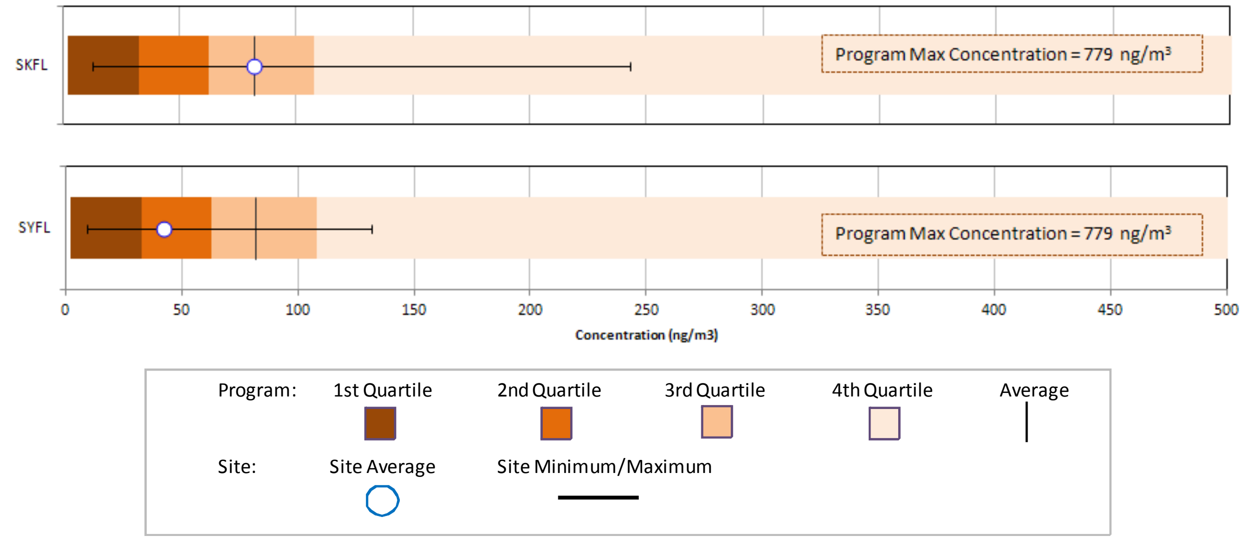


Figure 9-30. Program vs. Site-Specific Average Naphthalene Concentrations



Observations from Figures 9-23 through 9-30 include the following:

- Figure 9-23 for acetaldehyde shows that the annual average concentration for AZFL is the only one that is greater than the program-level average concentration among the Florida sites, although the annual average for SKFL (1.95 µg/m^3) is just less than the program-level average (2.00 µg/m^3). SKFL's maximum concentration is the fourth highest acetaldehyde concentration measured among NMP sites sampling this pollutant. There were no non-detects of acetaldehyde measured at the Florida sites or across the program.

- Figure 9-24 for arsenic shows that PAFL's annual average concentration is just greater than the program-level average concentration. The maximum arsenic concentration measured at PAFL is less than 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 9-25 presents the box plots for benzo(a)pyrene. Note that the program-level first quartile for this pollutant is zero and is not visible on the box plots. The box plots show that the annual average concentration for SKFL is slightly higher than the annual average concentration for SYFL and that both annual average concentrations are less than the program-level average concentration. The annual average for SYFL is also less than the program-level median concentration. Figure 9-25 also shows that the maximum concentrations measured at these sites are considerably less than the maximum concentration measured across the program.

- Figure 9-26 for formaldehyde shows that the annual average concentrations of formaldehyde for AZFL, SKFL, SYFL, and ORFL are all less than the program-level average concentration. There is little difference among the site-specific annual averages of formaldehyde across the Florida sites (less than 0.45 µg/m^3 separates them). Note that the range of formaldehyde concentrations measured at SYFL is roughly twice the range measured at AZFL, SKFL, and ORFL.

- Figure 9-27 presents the box plots for hexavalent chromium, which was measured at SKFL and SYFL. The annual average concentration for SKFL is similar to the program-level average while the annual average for SYFL is less than the program-level average. SYFL's annual average concentration is also less than the program-level median concentration. The maximum concentrations measured at SKFL and SYFL are both less than the maximum concentration measured among NMP sites sampling this pollutant.

- Figure 9-28 for lead shows that PAFL's annual average concentration is less than both the program-level average and median concentrations. The maximum lead concentration measured at PAFL is considerably less than the maximum concentration measured among NMP sites sampling PM_{10} metals.

- Figure 9-29 presents the box plot for manganese. Note that the program-level maximum concentration (395 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 200 $\mu g/m^3$. Figure 9-29 shows that PAFL's annual average concentration is less than the program-level average, median, and first quartile concentrations. The maximum manganese concentration measured at PAFL is roughly equivalent to the program-level median concentration. This site has the smallest range of manganese measurements among NMP sites sampling PM_{10} metals.

- Figure 9-30 presents the box plots for naphthalene. Note that the program-level maximum concentration (779 ng/m^3) is not shown directly on the box plots as the scale has been reduced to 500 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. The box plots show that the annual average concentration for SKFL is nearly twice the annual average concentration for SYFL. SKFL's annual naphthalene concentration is just greater than the program-level average concentration, although difficult to discern in Figure 9-30. The maximum concentration measured at SKFL is more than 100 ng/m^3 greater than the maximum concentration measured at SYFL.

9.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. AZFL, ORFL, SKFL, and SYFL have sampled carbonyl compounds as part of the NMP for at least 5 consecutive years. Thus, Figures 9-31 through 9-38 present the annual statistical metrics for acetaldehyde and formaldehyde for each of these sites. In addition, SYFL has sampled hexavalent chromium since 2005; thus, Figure 9-39 presents the annual statistical metrics for hexavalent chromium for SYFL. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. Sampling for PAHs at SKFL and SYFL, hexavalent chromium at SKFL, and PM_{10} metals at PAFL began in 2008, which is less than the 5 consecutive year criteria; thus, the trends analysis was not conducted for the pollutants for these methods.

Figure 9-31. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at AZFL

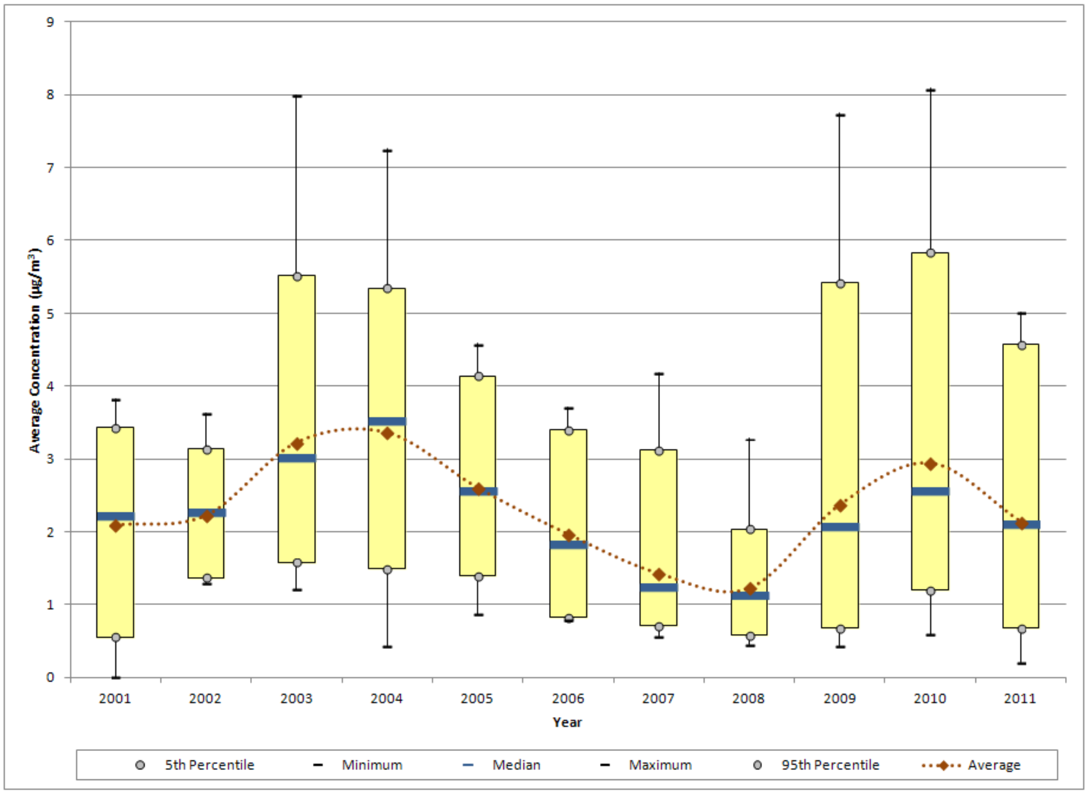


Figure 9-32. Annual Statistical Metrics for Formaldehyde Concentrations Measured at AZFL

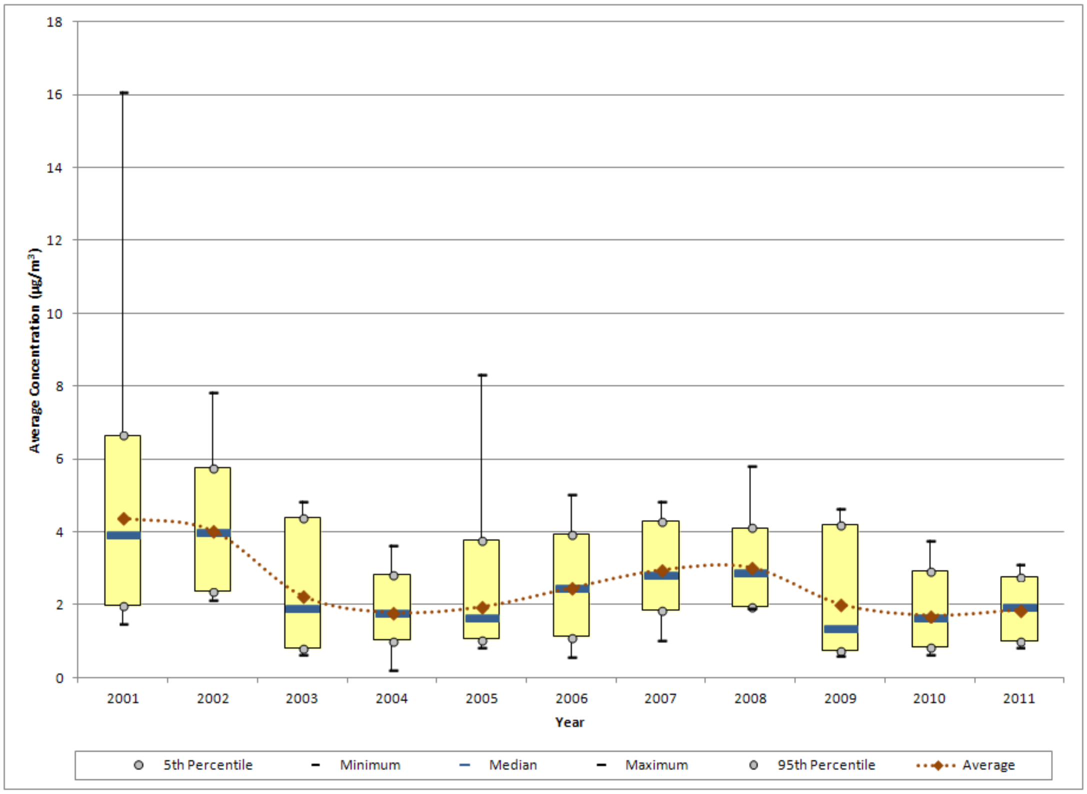


Figure 9-33. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at ORFL

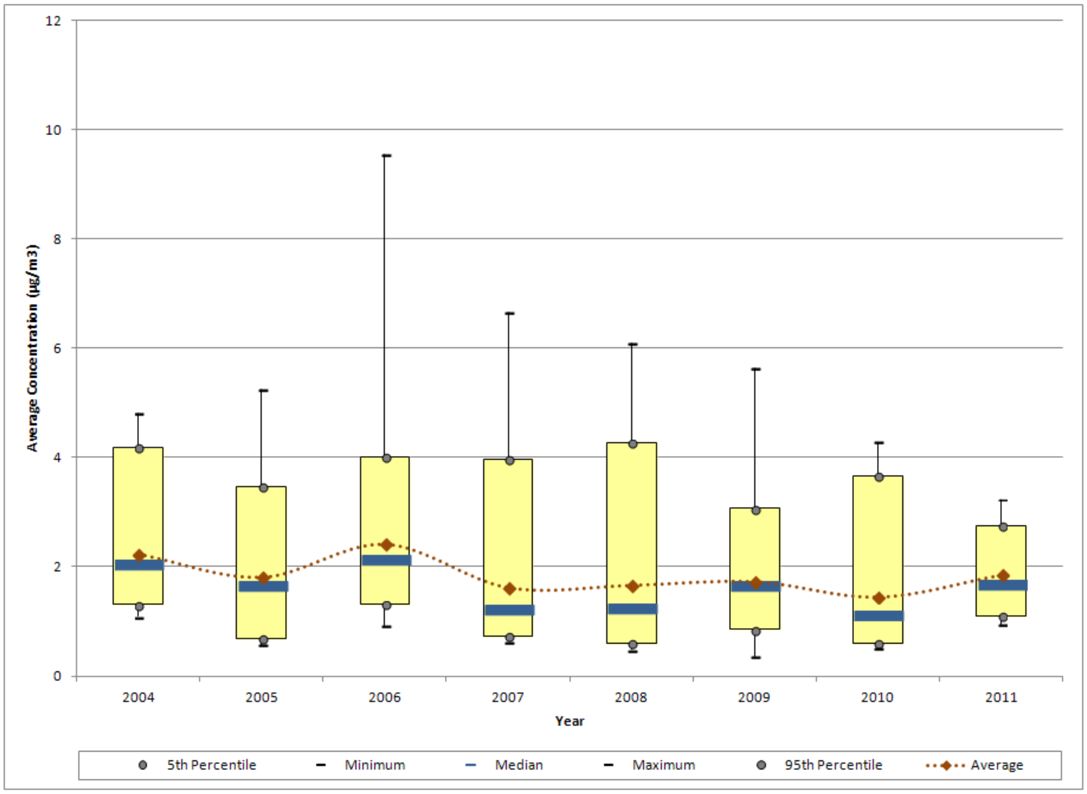


Figure 9-34. Annual Statistical Metrics for Formaldehyde Concentrations Measured at ORFL

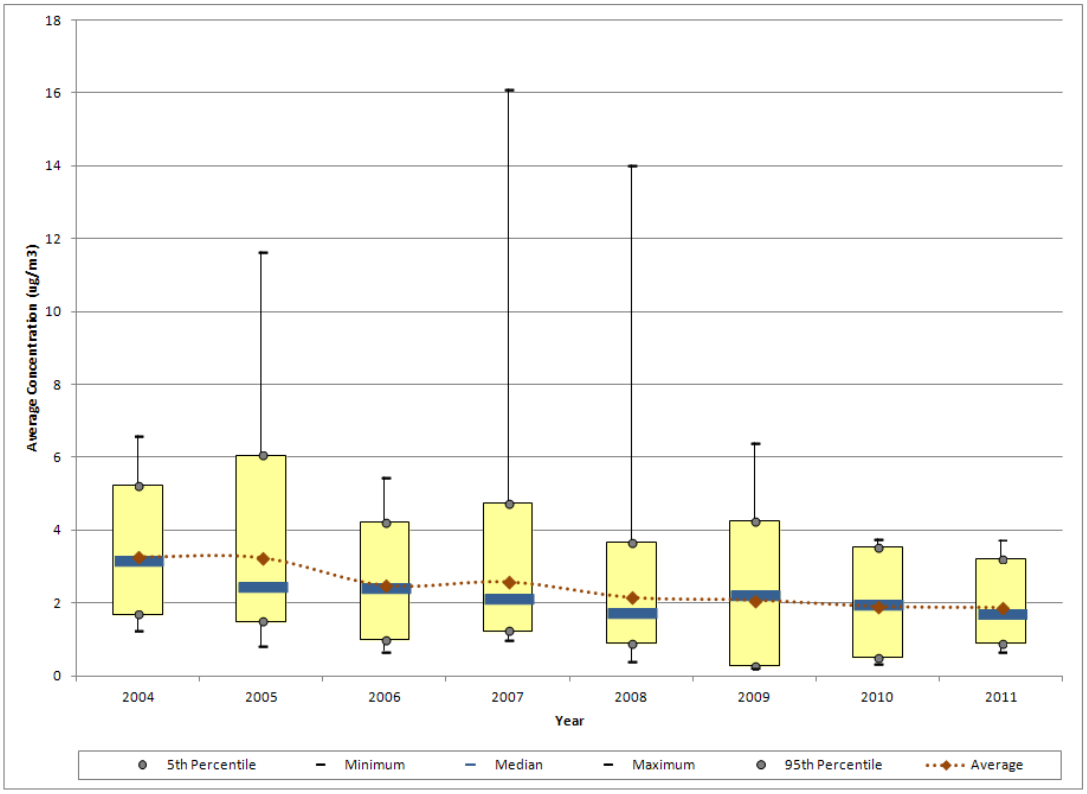


Figure 9-35. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at SKFL

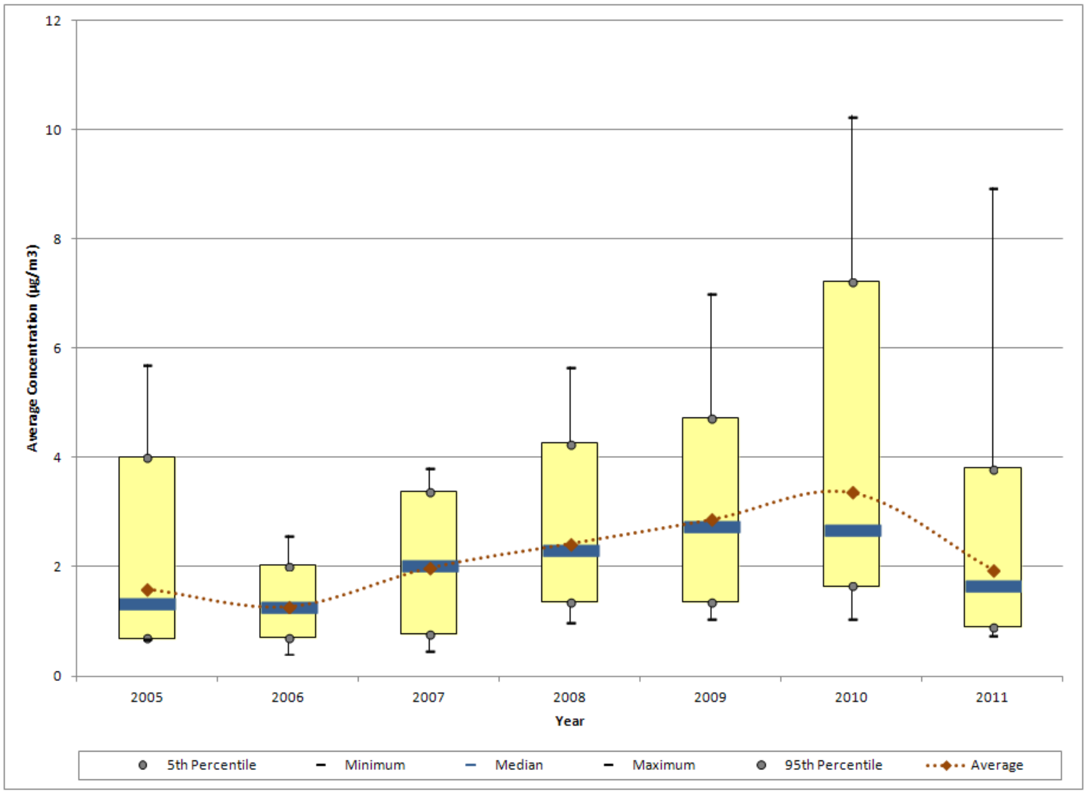


Figure 9-36. Annual Statistical Metrics for Formaldehyde Concentrations Measured at SKFL

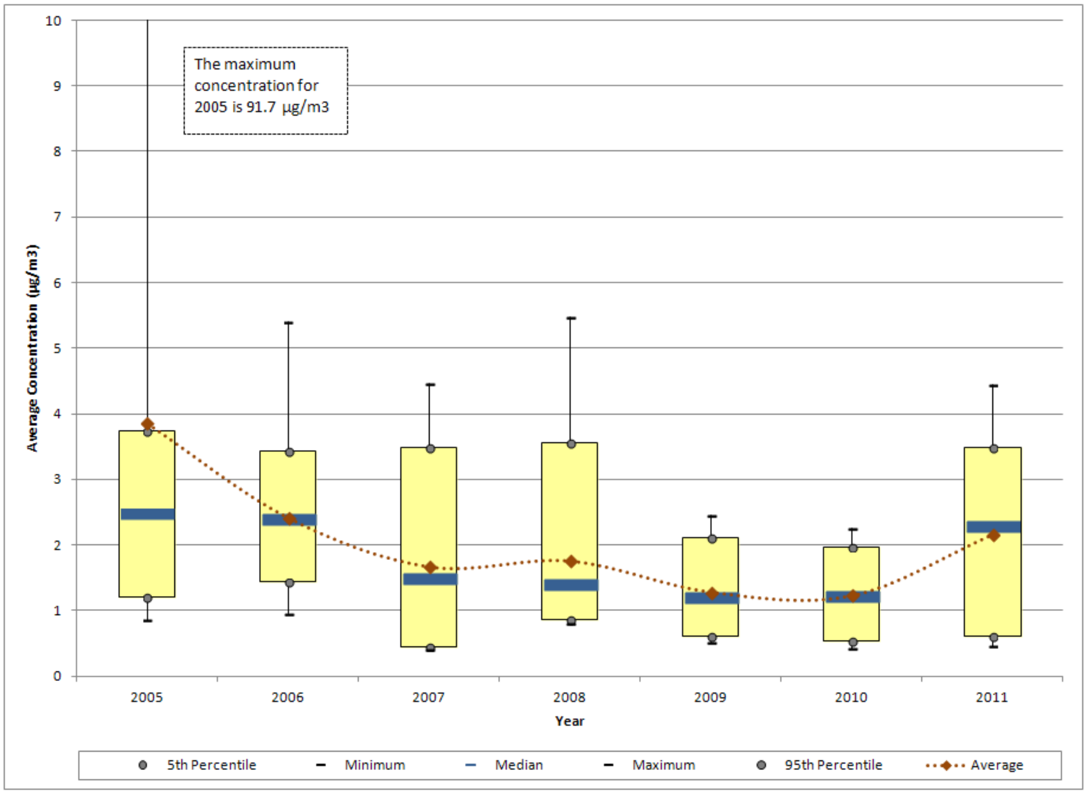


Figure 9-37. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at SYFL

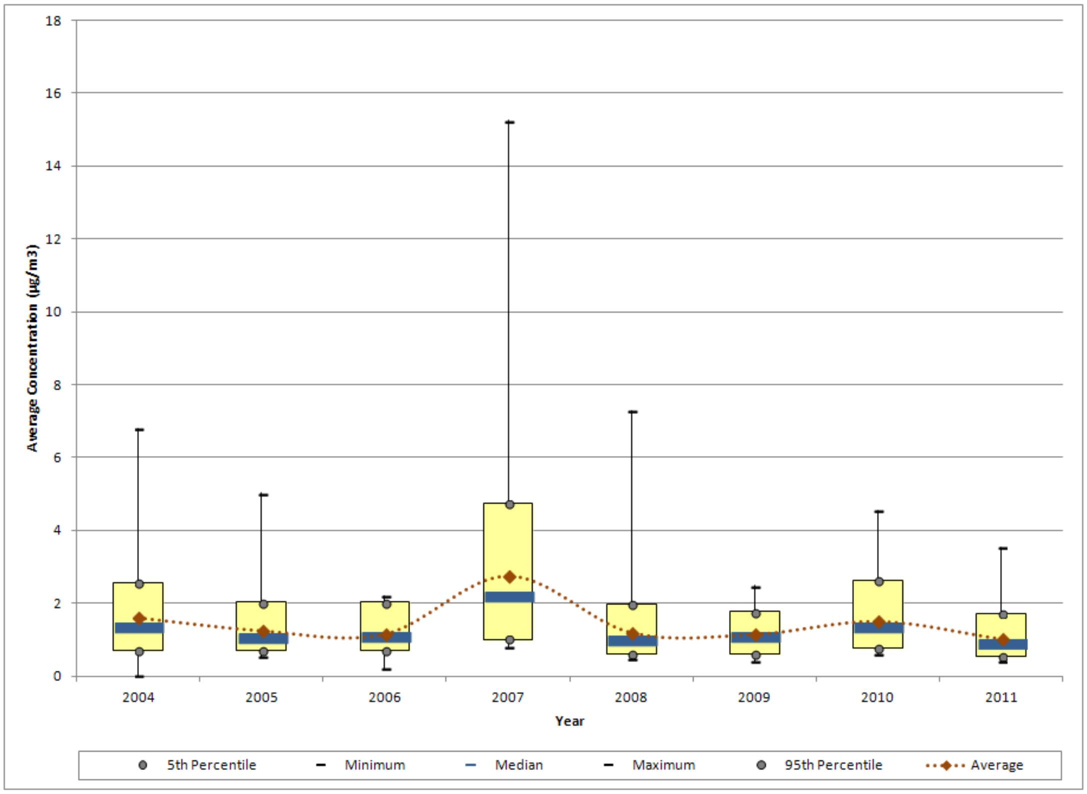


Figure 9-38. Annual Statistical Metrics for Formaldehyde Concentrations Measured at SYFL

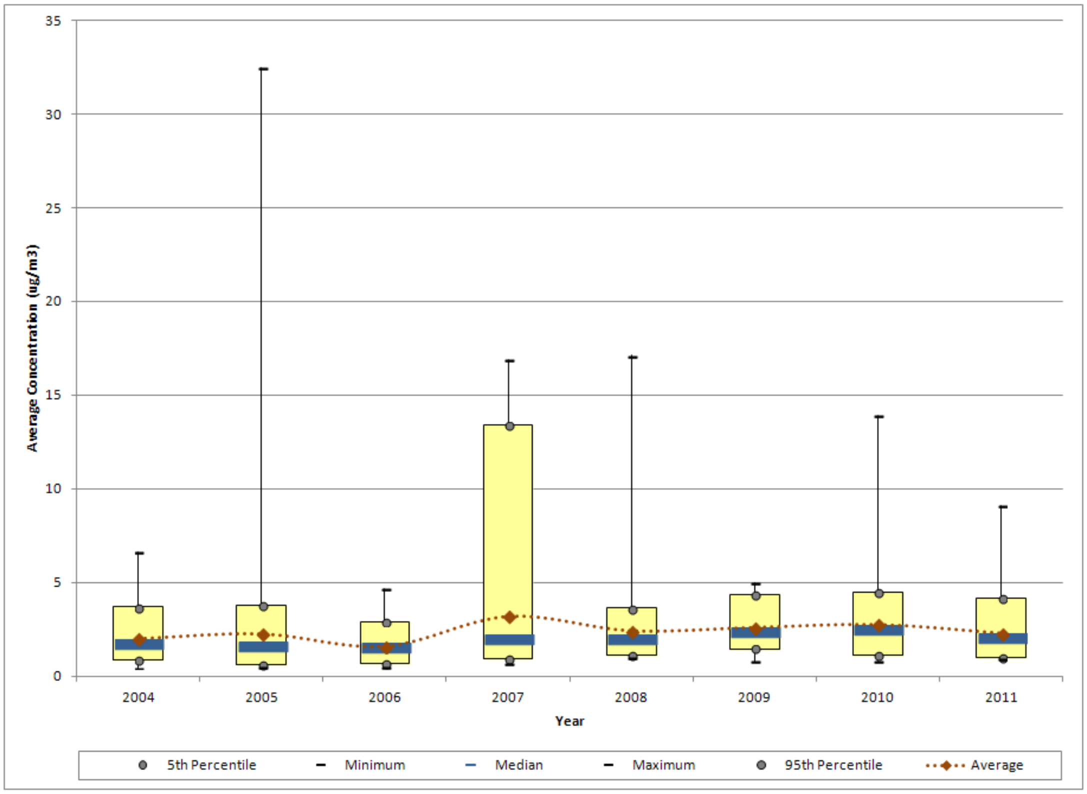
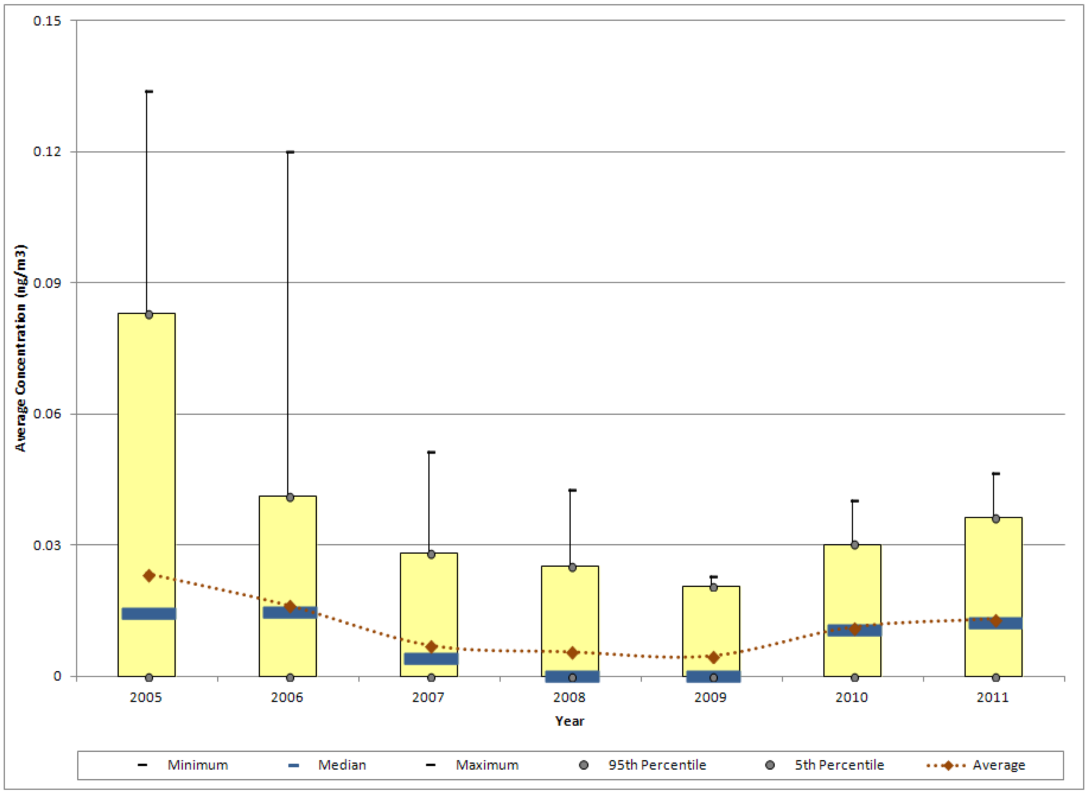


Figure 9-39. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at SYFL



Observations from Figure 9-31 for acetaldehyde measurements at AZFL include the following:

- Carbonyl compounds have been measured at AZFL since 2001, making this site one of the longest running UATMP 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 average and median acetaldehyde concentrations increased through 2004 then began to decrease significantly. The average 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 average concentration. Although a decrease is shown for 2011, additional years of sampling are required to determine if this decrease will continue.

- With the exception of 2001, the minimum concentration for each year is greater than zero. Only two non-detects of acetaldehyde have been reported since the onset of carbonyl compound sampling (both in 2001).

Observations from Figure 9-32 for formaldehyde measurements 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 average formaldehyde concentration 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 for 2009.

- The trends shown for formaldehyde in Figure 9-32 are almost the opposite of the trends shown for acetaldehyde in Figure 9-30.

- The range of formaldehyde concentrations measured at AZFL is at a minimum for 2011.

- The minimum concentration for each period is greater than zero. No non-detects of formaldehyde have been reported since the onset of carbonyl compound sampling in 2001.

Observations from Figure 9-33 for acetaldehyde measurements at ORFL include the following:

- Sampling for carbonyl compounds began at ORFL in April 2003. Because fewer than 85 percent of possible samples were collected in 2003, Figure 9-33 excludes data from 2003.
- The maximum acetaldehyde concentration was measured in 2006 (9.55 µg/m^3).
- The average concentration was at a maximum in 2006. After 2006, the average concentrations have varied from 1.45 µg/m^3 in 2010 to 1.85 µg/m^3 in 2011.
- Even though the range of acetaldehyde concentrations measured at ORFL is at a minimum for 2011, the average concentration is at a maximum for the period from 2007 to 2011 (as is the median concentration).
- The minimum concentration for each period is greater than zero, indicating that no non-detects of acetaldehyde have been reported for this pollutant.

Observations from Figure 9-34 for formaldehyde measurements 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 average concentrations exhibit a steady decreasing trend. 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 2011, similar to acetaldehyde.
- The minimum concentration for each year is greater than zero, indicating that no non-detects of formaldehyde have been reported for this pollutant.

Observations from Figure 9-35 for acetaldehyde measurements at SKFL include the following:

- Sampling for carbonyl compounds began at SKFL in July 2004. Because fewer than 85 percent of possible samples were collected in 2004, Figure 9-35 excludes data from 2004.
- The maximum acetaldehyde concentration shown was measured in 2010 (10.3 µg/m^3). The four highest concentrations of acetaldehyde were all measured in 2010 and 2011.

- The average acetaldehyde concentration increased steadily between 2007 and 2010, after which a significant decrease is shown for 2011. Additional sampling is needed to see if this decrease continues.

- The range of concentrations measured, as indicated by the minimum and maximum concentrations as well as the 5th and 95th percentiles, increased from 2007 through 2010. Although the second highest concentration was measured at SKFL in 2011, the 95th percentile is significantly lower for 2011.

- The minimum concentration for each year is greater than zero, indicating that no non-detects of acetaldehyde have been reported for this pollutant.

Observations from Figure 9-36 for formaldehyde measurements at SKFL include the following:

- The maximum formaldehyde concentration was measured at SKFL on July 9, 2005 (91.7 µg/m^3). Note that for 2005, the average concentration is greater than the 95th percentile, reflecting the effects that an outlier can have on statistical measurements. All other concentrations measured at this site were less than 6 µg/m^3 for the years shown.

- The average and median concentrations exhibit a steady decreasing trend over the years shown, with the exception of 2011.

- The range of concentrations measured, as indicated by the minimum and maximum concentrations as well as the 5th and 95th percentiles, decreased significantly for 2009 and 2010, then increased for 2011. Note that the median is greater than the average concentration for 2011, which is unusual. This means that there is more variability in the concentrations measured in 2011 than in 2010. For instance, the median concentration for 2011 is greater than the maximum concentration measured for 2010, which means that 50 percent of the concentrations measured in 2011 are greater than the maximum concentration measured in 2010.

- The minimum concentration for each period is greater than zero, indicating that no non-detects of formaldehyde have been reported for this pollutant.

Observations from Figure 9-37 for acetaldehyde measurements at SYFL include the following:

- Carbonyl compounds have been measured at SYFL 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).

- With the exception of 2007, the average concentrations have fluctuated between 1.03 µg/m^3 (2011) and 1.60 µg/m^3 (2004).

- All of the statistical parameters increased for 2007. Aside from the two measurements of acetaldehyde discussed above, 2007 had the greatest number of acetaldehyde concentrations greater than 3 µg/m^3 (16), while every other year of sampling had three or less. Thus, it is not just the outliers driving this average concentration.

- Only one non-detect of acetaldehyde has been reported since the onset of carbonyl compound sampling at SYFL.

Observations from Figure 9-38 for formaldehyde measurements at SYFL include the following:

- The maximum formaldehyde concentration measured at SYFL was measured in 2005 (32.5 µg/m^3) and was nearly twice the next highest concentration measured in 2008 (17.1 µg/m^3), although several measurements similar in magnitude to this one were also measured in 2007. In all, eight formaldehyde concentrations greater than 10 µg/m^3 have been measured at SYFL.

- The average formaldehyde concentration has fluctuated over the years, ranging from 1.58 µg/m^3 in 2006 to 3.19 µg/m^3 in 2007.

- Similar to acetaldehyde, all of the statistical parameters exhibit an increase for 2007, even though the maximum concentrations were not measured during this year. The difference between the 5th and 95th percentiles for 2007 compared to the difference for the remaining years show that the measurements were higher in 2007. The number of formaldehyde concentrations greater than 5 µg/m^3 is highest for 2007 (seven), while every other year of sampling had two or less.

- The minimum concentration for each year is greater than zero. No non-detects of formaldehyde have been reported since the onset of carbonyl compound sampling in 2004.

Observations from Figure 9-39 for hexavalent chromium measurements at SYFL include the following:

- Hexavalent chromium sampling at SYFL began in January 2005.

- The maximum hexavalent chromium concentration measured at SYFL (0.134 ng/m^3) was measured on July 3, 2005 and is similar in magnitude to the next highest concentrations, measured on July 4, 2006 (0.120 ng/m^3) and March 17, 2005 (0.119 ng/m^3). These are the only three measurements greater than 0.1 ng/m^3.

- The average hexavalent chromium concentration has decreased significantly over the years since the onset of sampling, reaching a minimum in 2009. This is the year with the smallest range of concentrations measured. With the exception of the minimum and fifth percentiles, all statistical parameters increased in 2010 and again in 2011.

- For 2008 and 2009, the median concentration decreased to zero, indicating that at least 50 percent of the measurements were non-detects. The percentage of non-detects increased from 28 percent in 2006 to a maximum of 70 percent in 2009. The number of non-detects decreased in 2010 (41 percent) and again in 2011 (17 percent). The changes in the statistical parameters are at least partially attributable to the number of non-detects (and thus, zeros) factored into the calculations.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 Hazard Approximation (HQ)
St. Petersburg, Florida - AZFL						
Acetaldehyde	0.0000022	0.009	62/62	2.13 ± 0.3	4.70	0.24
Formaldehyde	0.000013	0.0098	62/62	1.86 ± 0.13	24.15	0.19
Pinellas Park, Florida - SKFL						
Acetaldehyde	0.0000022	0.009	61/61	1.95 ± 0.31	4.29	0.22
Benzo(a)pyrene [a]	0.00176	--	55/61	<0.01 ± <0.01	0.08	--
Formaldehyde	0.000013	0.0098	61/61	2.16 ± 0.21	28.09	0.22
Hexavalent Chromium[a]	0.012	0.0001	55/62	<0.01 ± <0.01	0.28	<0.01
Naphthalene [a]	0.000034	0.003	61/61	0.08 ± 0.01	2.80	0.03
Plant City, Florida - SYFL						
Acetaldehyde	0.0000022	0.009	60/60	1.03 ± 0.13	2.26	0.11
Benzo(a)pyrene [a]	0.00176	--	25/60	<0.01 ± <0.01	0.04	--
Formaldehyde	0.000013	0.0098	60/60	2.30 ± 0.34	29.84	0.23
Hexavalent Chromium[a]	0.012	0.0001	42/59	0.01 ± <0.01	0.16	<0.01
Naphthalene [a]	0.000034	0.003	60/60	0.04 ± 0.01	1.43	0.01
Winter Park, Florida - ORFL						
Acetaldehyde	0.0000022	0.009	60/60	1.85 ± 0.14	4.06	0.21
Formaldehyde	0.000013	0.0098	60/60	1.89 ± 0.18	24.60	0.19

-- = 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.

Table 9-6. Risk Approximations for the Florida 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 Hazard Approximation (HQ)
Orlando, Florida - PAFL						
Arsenic (PM_{10})[a]	0.0043	0.000015	31/31	<0.01 ± <0.01	2.66	0.04
Beryllium (PM_{10})[a]	0.0024	0.00002	31/31	<0.01 ± <0.01	0.01	<0.01
Cadmium (PM_{10})[a]	0.0018	0.00001	31/31	<0.01 ± <0.01	0.10	0.01
Lead (PM_{10})[a]	--	0.00015	31/31	<0.01 ± <0.01	--	0.01
Manganese (PM_{10})[a]	--	0.00005	31/31	<0.01 ± <0.01	--	0.04
Nickel (PM_{10})[a]	0.00048	0.00009	31/31	<0.01 ± <0.01	0.35	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 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 24.15 in-a-million (AZFL) to 29.84 in-a-million (SYFL).
- The cancer risk approximations for acetaldehyde are an order of magnitude less than the cancer risk approximations for formaldehyde, ranging from 2.26 in-a-million (SYFL) to 4.70 in-a-million (AZFL).
- For the two sites sampling PAHs and hexavalent chromium in addition to carbonyl compounds, naphthalene has the third highest cancer risk approximations for each site, behind formaldehyde and acetaldehyde. Cancer risk approximations for hexavalent chromium and benzo(a)pyrene are less than 1.0 in-a-million for both sites.
- For PAFL, arsenic has the highest cancer risk approximation (2.66 in-a-million). The cancer risk approximations are less than 1.0 in-a-million for the remaining metals, where a cancer URE is available.
- 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.

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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 9-6. Table 9-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 9-6.

The pollutants listed in Tables 9-7 and 9-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, 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 9.3, AZFL and ORFL sampled for carbonyl compounds only; SKFL and SYFL sampled hexavalent chromium and PAHs in addition to carbonyl compounds; and PAFL sampled only PM_{10} metals. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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	430.92	Benzene	3.36E-03	Formaldehyde	24.15
Ethylbenzene	261.69	Formaldehyde	2.78E-03	Acetaldehyde	4.70
Formaldehyde	214.09	1,3-Butadiene	1.79E-03		
Acetaldehyde	118.05	Nickel, PM	1.35E-03		
1,3-Butadiene	59.55	Hexavalent Chromium, PM	9.45E-04		
Naphthalene	26.34	Naphthalene	8.96E-04		
Dichloromethane	10.63	Ethylbenzene	6.54E-04		
POM, Group 2b	3.58	Arsenic, PM	4.13E-04		
Nickel, PM	2.82	POM, Group 2b	3.15E-04		
Tetrachloroethylene	0.84	Acetaldehyde	2.60E-04		
Pinellas Park, Florida (Pinellas County) - SKFL					
Benzene	430.92	Benzene	3.36E-03	Formaldehyde	28.09
Ethylbenzene	261.69	Formaldehyde	2.78E-03	Acetaldehyde	4.29
Formaldehyde	214.09	1,3-Butadiene	1.79E-03	Naphthalene	2.80
Acetaldehyde	118.05	Nickel, PM	1.35E-03	Hexavalent Chromium	0.28
1,3-Butadiene	59.55	Hexavalent Chromium, PM	9.45E-04	Benzo(a)pyrene	0.08
Naphthalene	26.34	Naphthalene	8.96E-04		
Dichloromethane	10.63	Ethylbenzene	6.54E-04		
POM, Group 2b	3.58	Arsenic, PM	4.13E-04		
Nickel, PM	2.82	POM, Group 2b	3.15E-04		
Tetrachloroethylene	0.84	Acetaldehyde	2.60E-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)**
Plant City, Florida (Hillsborough County) - SYFL					
Benzene	545.24	Formaldehyde	4.33E-03	Formaldehyde	29.84
Ethylbenzene	339.12	Benzene	4.25E-03	Acetaldehyde	2.26
Formaldehyde	333.41	1,3-Butadiene	2.31E-03	Naphthalene	1.43
Acetaldehyde	174.74	Hexavalent Chromium, PM	1.44E-03	Hexavalent Chromium	0.16
1,3-Butadiene	77.10	Nickel, PM	1.38E-03	Benzo(a)pyrene	0.04
Naphthalene	37.70	Naphthalene	1.28E-03		
Dichloromethane	11.51	Arsenic, PM	1.01E-03		
Methyl *tert* butyl ether	8.62	Ethylbenzene	8.48E-04		
POM, Group 2b	5.02	POM, Group 2b	4.42E-04		
Nickel, PM	2.88	Acetaldehyde	3.84E-04		
Winter Park, Florida (Orange County) - ORFL					
Benzene	581.25	Formaldehyde	4.56E-03	Formaldehyde	24.60
Formaldehyde	350.51	Benzene	4.53E-03	Acetaldehyde	4.06
Ethylbenzene	334.02	1,3-Butadiene	2.42E-03		
Acetaldehyde	169.72	Naphthalene	1.18E-03		
1,3-Butadiene	80.64	Ethylbenzene	8.35E-04		
Naphthalene	34.81	Hexavalent Chromium, PM	6.86E-04		
Dichloromethane	10.25	POM, Group 2b	5.43E-04		
POM, Group 2b	6.17	Acetaldehyde	3.73E-04		
Tetrachloroethylene	2.34	POM, Group 3	3.57E-04		
Propylene oxide	1.17	Arsenic, PM	2.84E-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	581.25	Formaldehyde	4.56E-03	Arsenic	2.66
Formaldehyde	350.51	Benzene	4.53E-03	Nickel	0.35
Ethylbenzene	334.02	1,3-Butadiene	2.42E-03	Cadmium	0.10
Acetaldehyde	169.72	Naphthalene	1.18E-03	Beryllium	0.01
1,3-Butadiene	80.64	Ethylbenzene	8.35E-04		
Naphthalene	34.81	Hexavalent Chromium, PM	6.86E-04		
Dichloromethane	10.25	POM, Group 2b	5.43E-04		
POM, Group 2b	6.17	Acetaldehyde	3.73E-04		
Tetrachloroethylene	2.34	POM, Group 3	3.57E-04		
Propylene oxide	1.17	Arsenic, PM	2.84E-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	1,374.54	Acrolein	625,802.58	Acetaldehyde	0.24
Xylenes	1,035.91	Nickel, PM	31,311.86	Formaldehyde	0.19
Methanol	540.89	1,3-Butadiene	29,777.05		
Benzene	430.92	Formaldehyde	21,845.80		
Hexane	353.10	Benzene	14,364.15		
Ethylbenzene	261.69	Acetaldehyde	13,116.58		
Formaldehyde	214.09	Xylenes	10,359.11		
Acetaldehyde	118.05	Manganese, PM	10,118.05		
Styrene	113.79	Naphthalene	8,780.20		
Ethylene glycol	73.16	Lead, PM	6,986.71		
Pinellas Park, Florida (Pinellas County) - SKFL					
Toluene	1,374.54	Acrolein	625,802.58	Formaldehyde	0.22
Xylenes	1,035.91	Nickel, PM	31,311.86	Acetaldehyde	0.22
Methanol	540.89	1,3-Butadiene	29,777.05	Naphthalene	0.03
Benzene	430.92	Formaldehyde	21,845.80	Hexavalent Chromium	<0.01
Hexane	353.10	Benzene	14,364.15		
Ethylbenzene	261.69	Acetaldehyde	13,116.58		
Formaldehyde	214.09	Xylenes	10,359.11		
Acetaldehyde	118.05	Manganese, PM	10,118.05		
Styrene	113.79	Naphthalene	8,780.20		
Ethylene glycol	73.16	Lead, PM	6,986.71		

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)**
Plant City, Florida (Hillsborough County) - SYFL					
Toluene	1,643.63	Acrolein	851,462.75	Formaldehyde	0.23
Xylenes	1,310.35	Cyanide Compounds, gas	535,232.13	Acetaldehyde	0.11
Methanol	688.28	1,3-Butadiene	38,551.07	Naphthalene	0.01
Benzene	545.24	Formaldehyde	34,021.47	Hexavalent Chromium	<0.01
Hexane	438.64	Nickel, PM	31,976.42		
Cyanide Compounds, gas	428.19	Manganese, PM	23,688.87		
Hydrochloric acid	350.01	Acetaldehyde	19,415.44		
Ethylbenzene	339.12	Benzene	18,174.77		
Formaldehyde	333.41	Hydrochloric acid	17,500.47		
Acetaldehyde	174.74	Arsenic, PM	15,600.20		
Winter Park, Florida (Orange County) - ORFL					
Toluene	1,693.63	Acrolein	870,786.72	Acetaldehyde	0.21
Xylenes	1,316.88	1,3-Butadiene	40,319.80	Formaldehyde	0.19
Methanol	629.52	Formaldehyde	35,765.86		
Benzene	581.25	Benzene	19,374.99		
Hexane	434.13	Acetaldehyde	18,857.75		
Formaldehyde	350.51	Xylenes	13,168.77		
Ethylbenzene	334.02	Cyanide Compounds, gas	12,178.13		
Acetaldehyde	169.72	Naphthalene	11,604.18		
Styrene	164.64	Arsenic, PM	4,404.23		
Ethylene glycol	81.80	Lead, PM	3,678.02		

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	1,693.63	Acrolein	870,786.72	Manganese	0.04
Xylenes	1,316.88	1,3-Butadiene	40,319.80	Arsenic	0.04
Methanol	629.52	Formaldehyde	35,765.86	Lead	0.01
Benzene	581.25	Benzene	19,374.99	Nickel	0.01
Hexane	434.13	Acetaldehyde	18,857.75	Cadmium	0.01
Formaldehyde	350.51	Xylenes	13,168.77	Beryllium	<0.01
Ethylbenzene	334.02	Cyanide Compounds, gas	12,178.13		
Acetaldehyde	169.72	Naphthalene	11,604.18		
Styrene	164.64	Arsenic, PM	4,404.23		
Ethylene glycol	81.80	Lead, PM	3,678.02		

Observations from Table 9-7 include the following:

- Benzene, formaldehyde, and ethylbenzene 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 all three counties, although the order varies.

- Seven of the highest emitted pollutants in Hillsborough and Orange Counties also have the highest toxicity-weighted emissions. Eight of the highest emitted pollutants in Pinellas 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.

- PAFL sampled only PM_{10} metals; arsenic has the highest cancer risk approximation for this site. Arsenic ranks 10th among the toxicity-weighted emissions for Orange County, but is not among the highest emitted pollutants, indicating the relative toxicity of a low quantity of emissions.

- Hexavalent chromium, which was sampled for at SKFL and SYFL, ranks between fourth and sixth among each county's toxicity-weighted emissions but is not among the highest emitted for any of the Florida counties.

- POM, Group 2b is one of the highest emitted "pollutants" in all three counties and appears among the pollutants with the highest toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at SKFL and SYFL including acenaphthene, benzo(e)pyrene, and fluorene. None of these pollutants failed screens for SKFL or SYFL.

Observations from Table 9-8 include the following:

- Toluene, xylenes, and methanol 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.

- Four of the highest emitted pollutants in Pinellas and Orange Counties also have the highest toxicity-weighted emissions. Five of the highest emitted pollutants in Hillsborough County also have the highest toxicity-weighted emissions.

- Formaldehyde and acetaldehyde, which have the highest noncancer hazard approximations for the sites sampling carbonyl compounds, 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 in any of the three counties. For PAFL, arsenic and lead are among the pollutants with the highest toxicity-weighted emissions. None of the metals sampled at PAFL are among the highest emitted pollutants in Orange County.

9.6 Summary of the 2011 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. Five pollutants (three carbonyls, naphthalene, and hexavalent chromium) failed screens for SKFL. Four pollutants (two carbonyls and two PAHs) failed screens for SYFL. Arsenic was the only PM_{10} metal to fail screens for PAFL.*

- ❖ *Acetaldehyde had the highest annual average concentration for AZFL, formaldehyde had the highest annual average concentration for SKFL and SYFL, and the annual averages of these two pollutants were roughly the same for ORFL. Manganese and lead had the highest annual average concentration of the metals sampled at PAFL.*

- ❖ *Formaldehyde concentrations were higher during the warmer months of the year at SYFL and ORFL.*

- ❖ *Concentrations of formaldehyde have a decreasing trend at ORFL since the onset of sampling. In recent years, concentrations of hexavalent chromium have been increasing at SYFL. Concentrations of acetaldehyde decreased significantly between 2010 and 2011 at AZFL and SKFL. Conversely, formaldehyde concentrations at SKFL have increased between 2010 and 2011.*

10.0 Site in Georgia

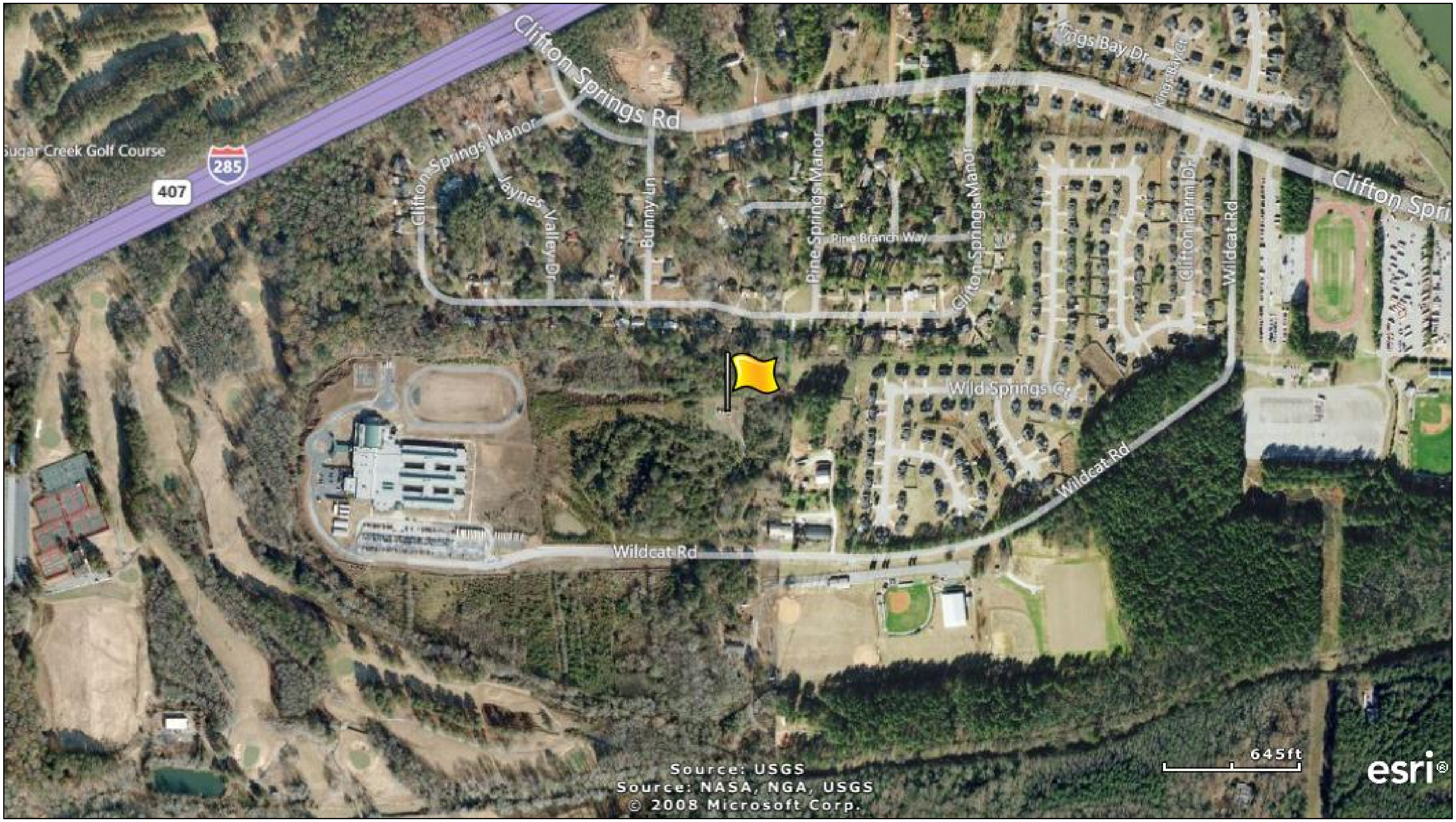
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Georgia, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data 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 in its urban location. Figure 10-2 identifies nearby point source emissions locations by source category, as reported in the 2008 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

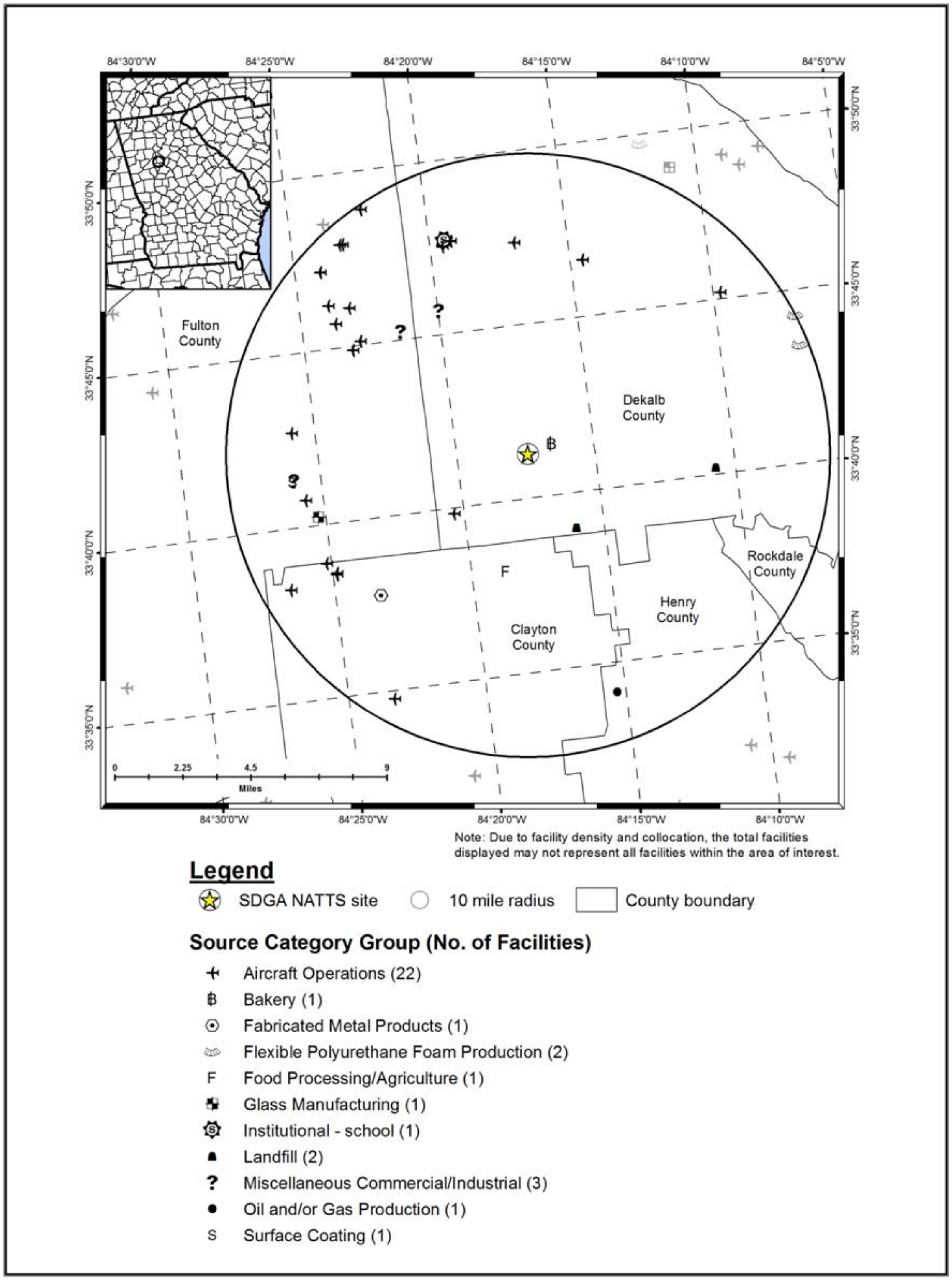


Table 10-1. Geographical Information for the Georgia Monitoring Site

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-Marietta, GA	33.688007, -84.290325	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.

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2012c); 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. 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 bakery) is located in close proximity to SDGA. Additional sources are located primarily on the west side of the 10-mile radius. The aircraft operations source category (which includes airports as well as small runways, heliports, or landing pads) 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 county-level population and vehicle registration information. Table 10-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within DeKalb County. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 10-2 also contains traffic volume information for SDGA. Finally, 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]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
SDGA	699,893	472,535	0.68	730,133	492,952	140,820	20,187,000

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Georgia Department of Revenue (GA DOR, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data from the Georgia DOT (GA DOT, 2011a)
[5] County-level VMT reflects 2011 data for all public roads from the Georgia DOT (GA DOT, 2011b)
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 same is also true for its 10-mile population and estimated vehicle ownership.
- The vehicle-per-person ratio is among the lower ratios compared to other NMP sites.
- The traffic volume experienced near SDGA ranks eighth highest compared to other NMP monitoring sites. The traffic estimate provided is for I-285, north of Clifton Spring Road.
- The daily VMT for DeKalb County is in the middle of the range among 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, although autumn is the driest season (Bair, 1992 and GSCO, 1998).

10.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2011 (NCDC, 2011). 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 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 for 2011. 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 appear slightly cooler and drier than weather conditions throughout the year. This is likely a result of a number of make-up samples collected at SDGA in the month of December.

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 in 2011. 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.

Table 10-3. Average Meteorological Conditions near the Georgia Monitoring Site

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)
Decatur, Georgia - SDGA									
W.B. Hartsfield/Atlanta Intl. Airport 13874 (33.64, -84.43)	8.18 miles 239° (WSW)	Sample Day	71.3 ± 4.0	61.7 ± 3.8	47.2 ± 3.9	54.0 ± 3.4	62.4 ± 2.9	1017.5 ± 1.3	7.4 ± 0.7
		2011	73.6 ± 1.6	63.9 ± 1.6	49.5 ± 1.5	55.9 ± 1.4	62.9 ± 1.3	1017.2 ± 0.6	7.0 ± 0.3

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

Figure 10-3. 2011 Composite Back Trajectory Map for SDGA

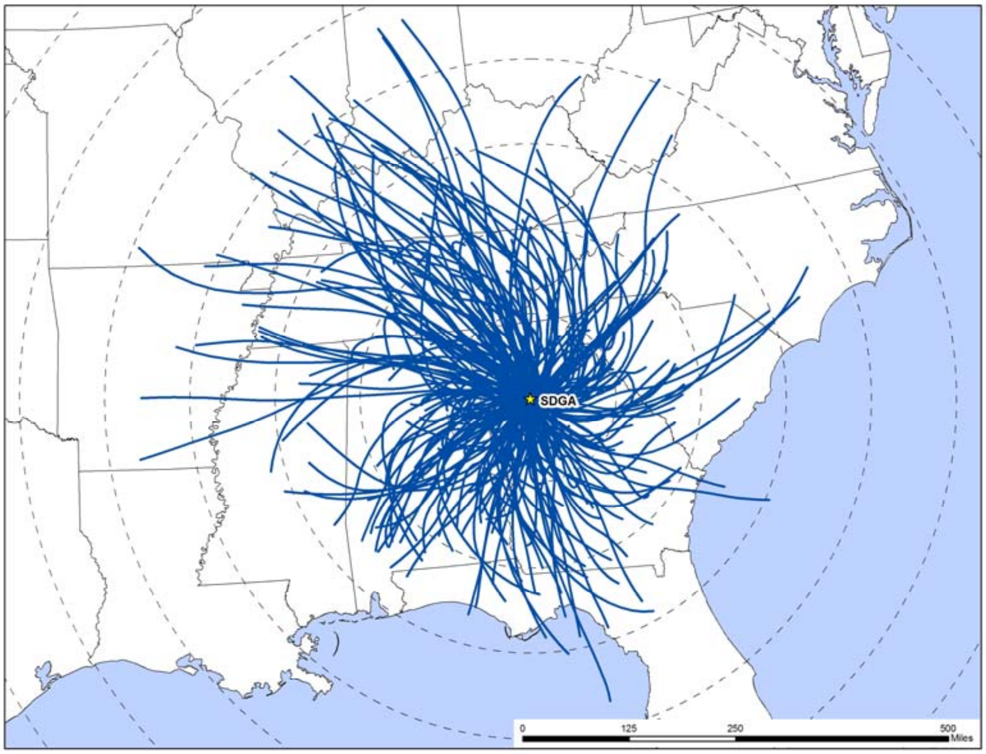
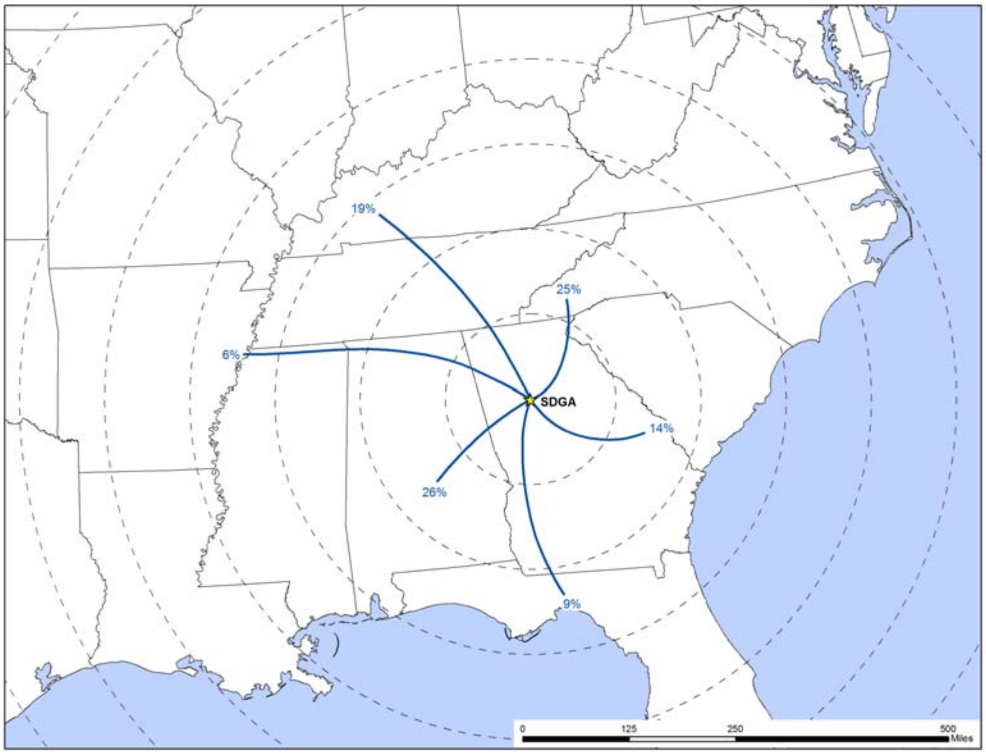


Figure 10-4. Back Trajectory Cluster Map for SDGA



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.

- 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 trajectory originated was central Missouri, or nearly 500 miles away, the average back trajectory length is 200 miles. Eighty-four percent of back trajectories originated within 300 miles of the site. The longest trajectories tended to originate from the northwest and west, over Indiana, Illinois, Missouri, and Arkansas.

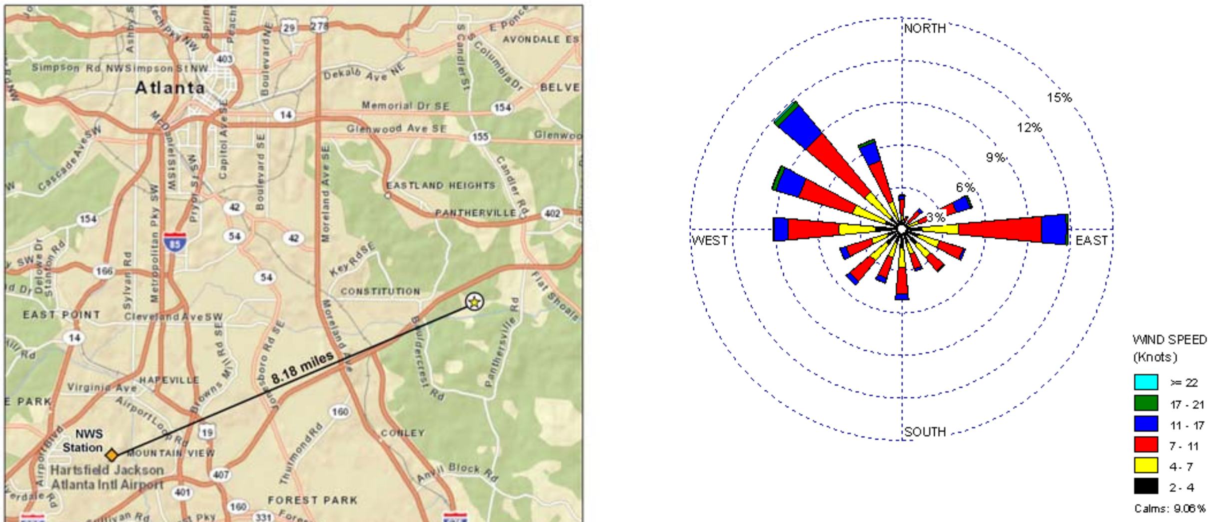
- The cluster analysis confirms that the longest trajectories originated from the northwest and west while the shortest trajectories originated from the north, east, and southwest. Over one-quarter of the back trajectories originated from the southwest over Alabama and tended to be less than 200 miles in length. Another 25 percent of trajectories originated from the north over Tennessee and North Carolina. Nearly 20 percent of back trajectories originated from the northwest over Kentucky, Illinois, and Indiana. Fourteen percent originated to the east, nine percent originated to the south over the Florida Panhandle, and six percent originated westward over Arkansas.

10.2.4 Wind Rose Comparison

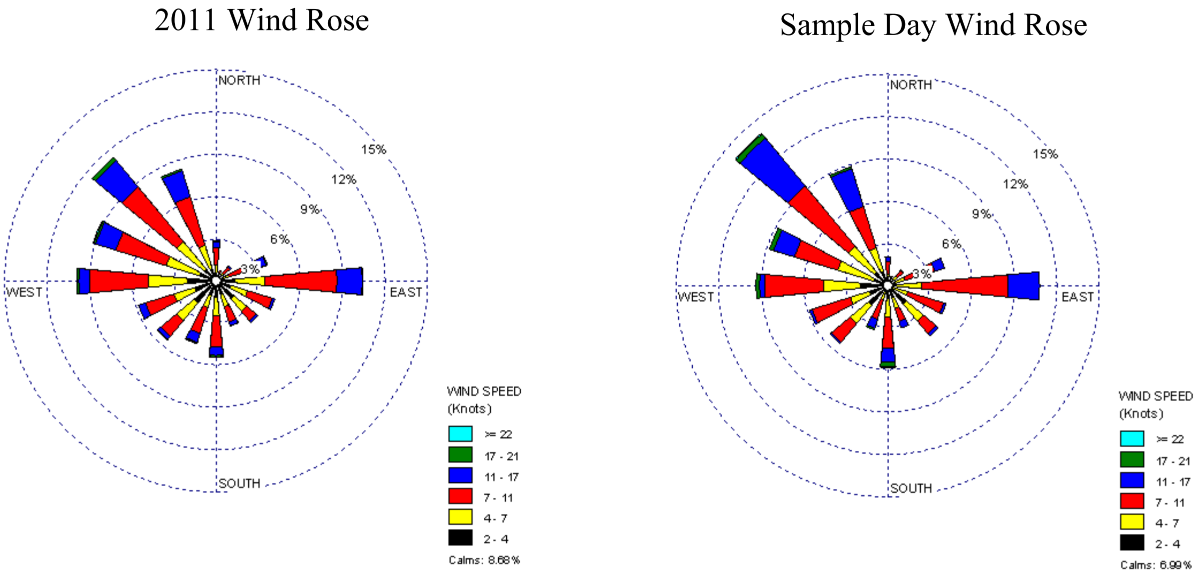
Hourly surface wind data from the NWS weather station at Hartsfield International Airport near SDGA were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a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

Figure 10-5 presents a map showing the distance between the NWS 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 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 10-5. Wind Roses for the Hartsfield International Airport Weather Station near SDGA


Distance between SDGA and NWS Station

2001-2010 Historical Wind Rose


2011 Wind Rose

Sample Day Wind Rose

Observations from Figure 10-5 for SDGA include the following:

- The NWS weather station at Hartsfield International Airport is the closest weather station to SDGA. The weather station is located approximately 8.2 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 both the full-year and sample day wind roses are similar to those of the historical wind rose, although northwesterly winds account for a greater percentage of wind observations on the sample day wind rose.

10.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for SDGA in order to allow 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." 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 10-4 presents the results of the preliminary risk-based screening process for SDGA. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for the monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. SDGA sampled for PAHs and hexavalent chromium.

Table 10-4. Risk-Based Screening Results for the Georgia Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Decatur, Georgia - SDGA						
Naphthalene	0.029	54	61	88.52	96.43	96.43
Acenaphthene	0.011	1	61	1.64	1.79	98.21
Fluorene	0.011	1	61	1.64	1.79	100.00
Total		56	183	30.60		

Observations from Table 10-4 for SDGA include the following:

- Naphthalene, acenaphthene, and fluorene failed screens. Naphthalene failed the majority of the screens (roughly 96 percent), accounting for 54 of the 56 total failed screens; the other two pollutants failed only one screen each.

- Naphthalene was the only pollutant initially identified as a pollutant of interest based on the risk-based screening process. Benzo(a)pyrene and hexavalent chromium were added as pollutants of interest for SDGA because they are NATTS MQO Core Analytes, even though they did not fail any screens. These pollutants are not shown in Table 10-4 but are shown in subsequent tables in the sections that follow.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for SDGA, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for SDGA are provided in Appendices M and O.

10.4.1 2011 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 of 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	27/61	0.09 ± 0.05	<0.01 ± 0.01	0.02 ± 0.02	0.08 ± 0.06	0.05 ± 0.02
Hexavalent Chromium	47/61	0.02 ± 0.01	0.02 ± <0.01	0.01 ± 0.01	0.01 ± <0.01	0.01 ± <0.01
Naphthalene	61/61	86.71 ± 31.86	104.86 ± 36.88	92.53 ± 35.91	82.09 ± 27.64	90.82 ± 15.61

Observations for SDGA from Table 10-5 include the following:

- The annual average concentration of naphthalene is significantly higher than the annual average concentrations of benzo(a)pyrene and hexavalent chromium. Concentrations of naphthalene measured at SDGA range from 10.3 ng/m^3 to 294 ng/m^3. SDGA's annual average concentration of naphthalene ranks tenth highest among NMP sites sampling this pollutant (as shown in Table 4-11).

- The first and fourth quarter averages of benzo(a)pyrene are greater than the other quarterly averages and have relatively large confidence intervals associated with them. This pollutant was detected in less than half of the PAH samples collected (27 out of 61). All but one of the 10 highest concentrations of this pollutant (those greater than 0.01 ng/m^3) were measured in the first and fourth quarters of 2011. Conversely, this pollutant was detected only once during the second quarter and four times during the third quarter.

- Hexavalent chromium concentrations span an order of magnitude, ranging from 0.0049 ng/m^3 to 0.0382 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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzo(a)pyrene, hexavalent chromium, and naphthalene were created for SDGA. Figures 10-6 through 10-8 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 10-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

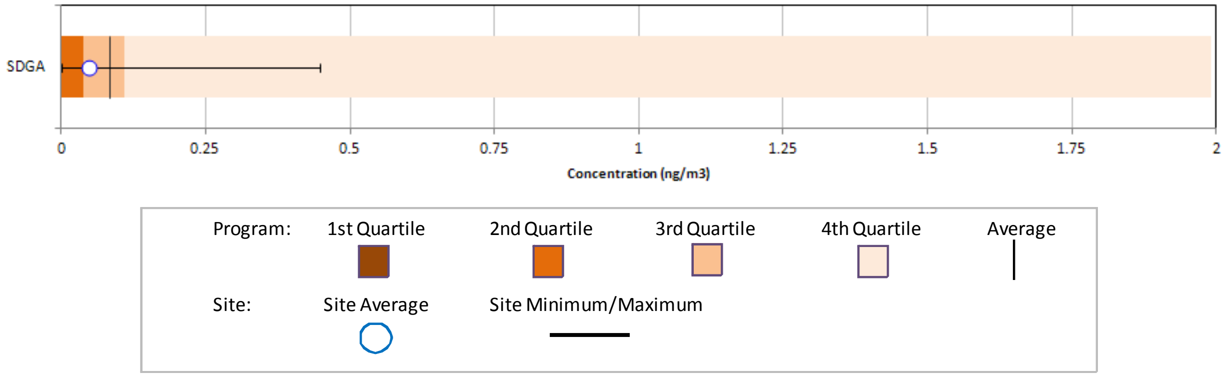


Figure 10-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

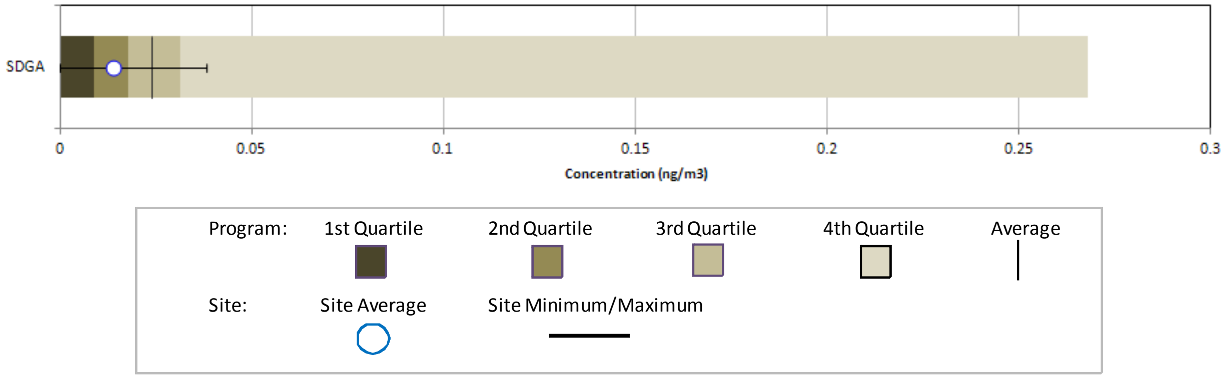
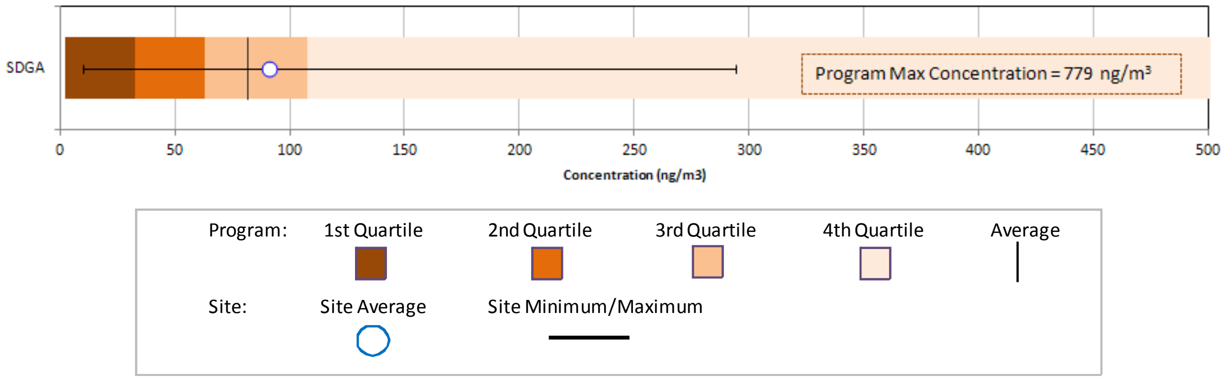


Figure 10-8. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 10-6 through 10-8 include the following:

- Figure 10-6 is the box plot for benzo(a)pyrene. Note that the first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average concentration for SDGA is less than the program-level average concentration but greater than the program-level median. Figure 10-6 also shows that the maximum concentration measured at SDGA is less than the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at SDGA.

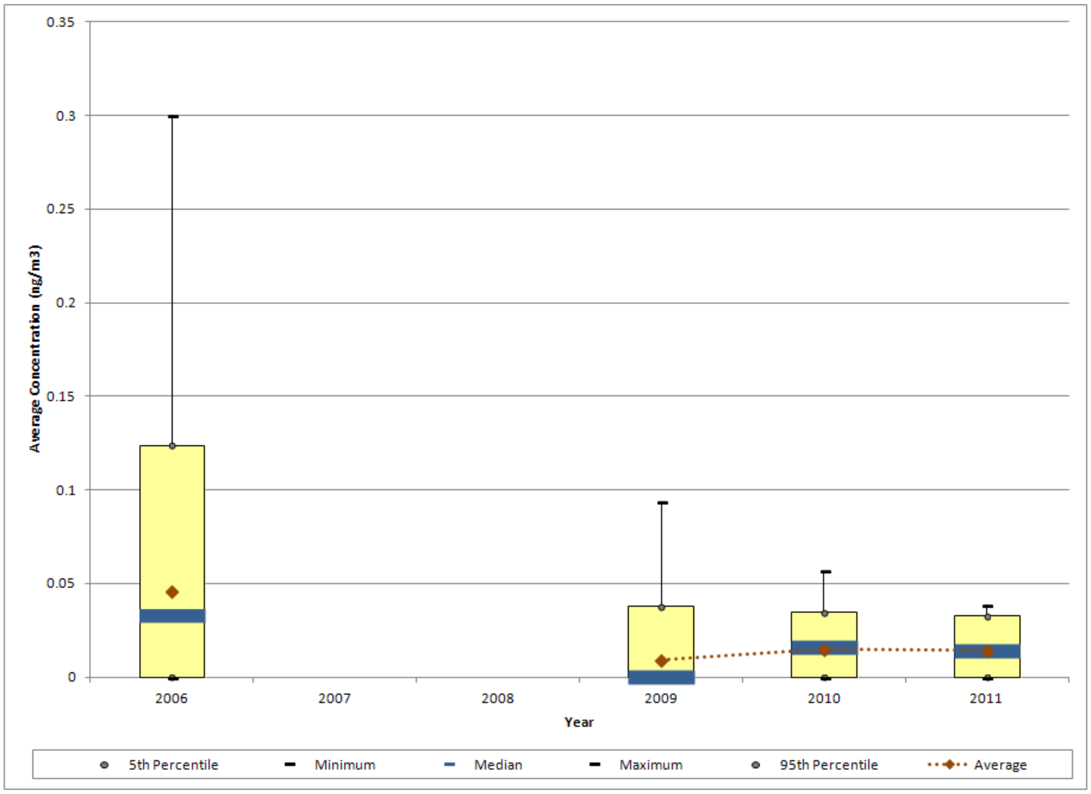
- Figure 10-7 is the box plot for hexavalent chromium. Figure 10-7 shows that the annual average concentration of hexavalent chromium for SDGA is less than the program-level average concentration. SDGA's annual average concentration is also less than the program-level median concentration. The maximum concentration measured at SDGA is significantly less than the program-level maximum concentration, but greater than the program-level third quartile concentration. Several non-detects of hexavalent chromium were measured at SDGA.

- Figure 10-8 is the box plot for naphthalene. Note that the program-level maximum concentration (779 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 500 ng/m^3. Figure 10-8 shows that the annual average concentration of naphthalene for SDGA is greater than the program-level average concentration. The maximum naphthalene concentration measured at SDGA is less than the program-level maximum concentration. There were no non-detects of naphthalene measured at SDGA or across the program.

10.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. SDGA has sampled hexavalent chromium under the NMP since 2005. Thus, Figure 10-9 presents the annual statistical metrics for hexavalent chromium for SDGA. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. SDGA began sampling PAHs in 2007, but did not begin until April, which does not allow for the completeness criteria specified in Section 3.5.4 to be met; thus, the trends analysis was not conducted for the pollutants for these methods.

Figure 10-9. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at SDGA



Observations from Figure 10-9 include the following:

- Although hexavalent chromium sampling began in 2005 at SDGA, sampling did not begin until late February, which does not yield enough samples for the statistical metrics to be calculated for 2005, based on the criteria specified in Section 3.5.4. Thus, Figure 10-9 begins with 2006.

- Due to sampler issues, sampling for hexavalent chromium was discontinued from September 2007 through May 2008; therefore, no statistical metrics are presented for 2007 or 2008.

- The maximum concentration measured for each year shown has decreased by an order of magnitude (0.300 ng/m^3 in 2006 to 0.0382 ng/m^3 in 2011). Yet, the difference between the 5th and 95th percentiles exhibits little change over the last three years of sampling, indicating that the majority of the measurements fall within roughly the same range, at least since 2009.

- The difference between the median and average concentration for each year has decreased, indicating decreasing variability within the measurements. For 2011, the difference between these two statistical parameters is 0.00011 ng/m^3.

- The minimum, 5th percentile, and median concentrations for 2009 are all 0, indicating that at least 50 percent of the measurements are non-detects; as a result, zeros were substituted for more than half of the samples (for statistical purposes). The number of non-detects began to decrease after 2009, down to 19 percent for 2010 and 14 percent for 2011.

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 3.5.5 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 Gerogia 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 to 14 days); intermediate (exposures of 15 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 2011.

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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 Hazard Approximation (HQ)
Decatur, Georgia - SDGA						
Benzo(a)pyrene	0.00176	--	27/61	0.05 ± 0.02	0.09	--
Hexavalent Chromium	0.012	0.0001	47/61	0.01 ± <0.01	0.17	<0.01
Naphthalene	0.000034	0.003	61/61	90.82 ± 15.61	3.09	0.03

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

Observations for SDGA from Table 10-6 include the following:

- Naphthalene was the only pollutant of interest for which the cancer risk approximation was greater than 1.0 in-a-million (3.09 in-a-million).
- Noncancer hazard approximations for naphthalene and hexavalent chromium were less than 1.0, indicating that no adverse health effects are expected from these individual pollutants. Benzo(a)pyrene does not have a noncancer RfC.

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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 10-6. Table 10-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from the annual averages provided in Table 10-6.

The pollutants listed in Tables 10-7 and 10-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, 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 10.3, SDGA sampled for PAHs and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

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					
Benzene	378.41	Benzene	2.95E-03	Naphthalene	3.09
Ethylbenzene	213.44	Formaldehyde	2.49E-03	Hexavalent Chromium	0.17
Formaldehyde	191.48	1,3-Butadiene	1.39E-03	Benzo(a)pyrene	0.09
Acetaldehyde	102.73	Naphthalene	8.19E-04		
1,3-Butadiene	46.29	Ethylbenzene	5.34E-04		
Naphthalene	24.10	Hexavalent Chromium, PM	3.82E-04		
Dichloromethane	6.82	POM, Group 2b	3.07E-04		
POM, Group 2b	3.49	Acetaldehyde	2.26E-04		
POM, Group 1a	0.49	Arsenic, PM	1.31E-04		
Methyl *tert* butyl ether	0.29	POM, Group 5a	1.01E-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					
Toluene	1,018.74	Acrolein	576,341.15	Naphthalene	0.03
Xylenes	794.36	1,3-Butadiene	23,142.89	Hexavalent Chromium	<0.01
Methanol	430.90	Formaldehyde	19,539.04		
Benzene	378.41	Benzene	12,613.63		
Hexane	223.04	Acetaldehyde	11,414.67		
Ethylbenzene	213.44	Naphthalene	8,033.73		
Formaldehyde	191.48	Xylenes	7,943.60		
Acetaldehyde	102.73	Lead, PM	4,023.67		
Ethylene glycol	56.41	2,4-Toluene diisocyanate	2,140.67		
1,3-Butadiene	46.29	Arsenic, PM	2,029.50		

Observations from Table 10-7 include the following:

- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in DeKalb County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are benzene, formaldehyde, and 1,3-butadiene.
- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for DeKalb County.
- Naphthalene, which has the highest cancer risk approximation for SDGA, has the fourth highest toxicity-weighted emissions and sixth highest emissions for DeKalb County.
- Hexavalent chromium ranks sixth highest for toxicity-weighted emissions, but is not among the highest emitted pollutants in DeKalb County.
- POM, Group 2b is the eighth 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 acenaphthene and fluorene each failed a single screen, neither pollutant was identified as a pollutant of interest for SDGA.
- Benzo(a)pyrene is part of POM, Group 5a. POM, Group 5a ranks tenth for toxicity-based emissions, but is not among the highest emitted pollutants in DeKalb County.

Observations from Table 10-8 include the following:

- Toluene, xylenes, and methanol are the highest emitted pollutants with noncancer RfCs in DeKalb County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, 1,3-butadiene, and formaldehyde.
- 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 sixth. Hexavalent chromium does not appear on either emissions-based list.

10.6 Summary of the 2011 Monitoring Data for SDGA

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

- *Naphthalene, acenaphthene, and fluorene failed screens for SDGA, although naphthalene accounted for the majority of failed screens.*

- *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for SDGA.*

- *Benzo(a)pyrene concentrations were highest during the colder months of the year.*

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.

Both Illinois sites are located in northwestern suburbs of Greater Chicago, with NBIL located in Northbrook and SPIL located in Schiller Park. Figures 11-1 and 11-2 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban locations. Figure 11-3 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. 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. Table 11-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 11-1. Northbrook, Illinois (NBIL) Monitoring Site

Source: USGS
Source: NASA, NGA, USGS
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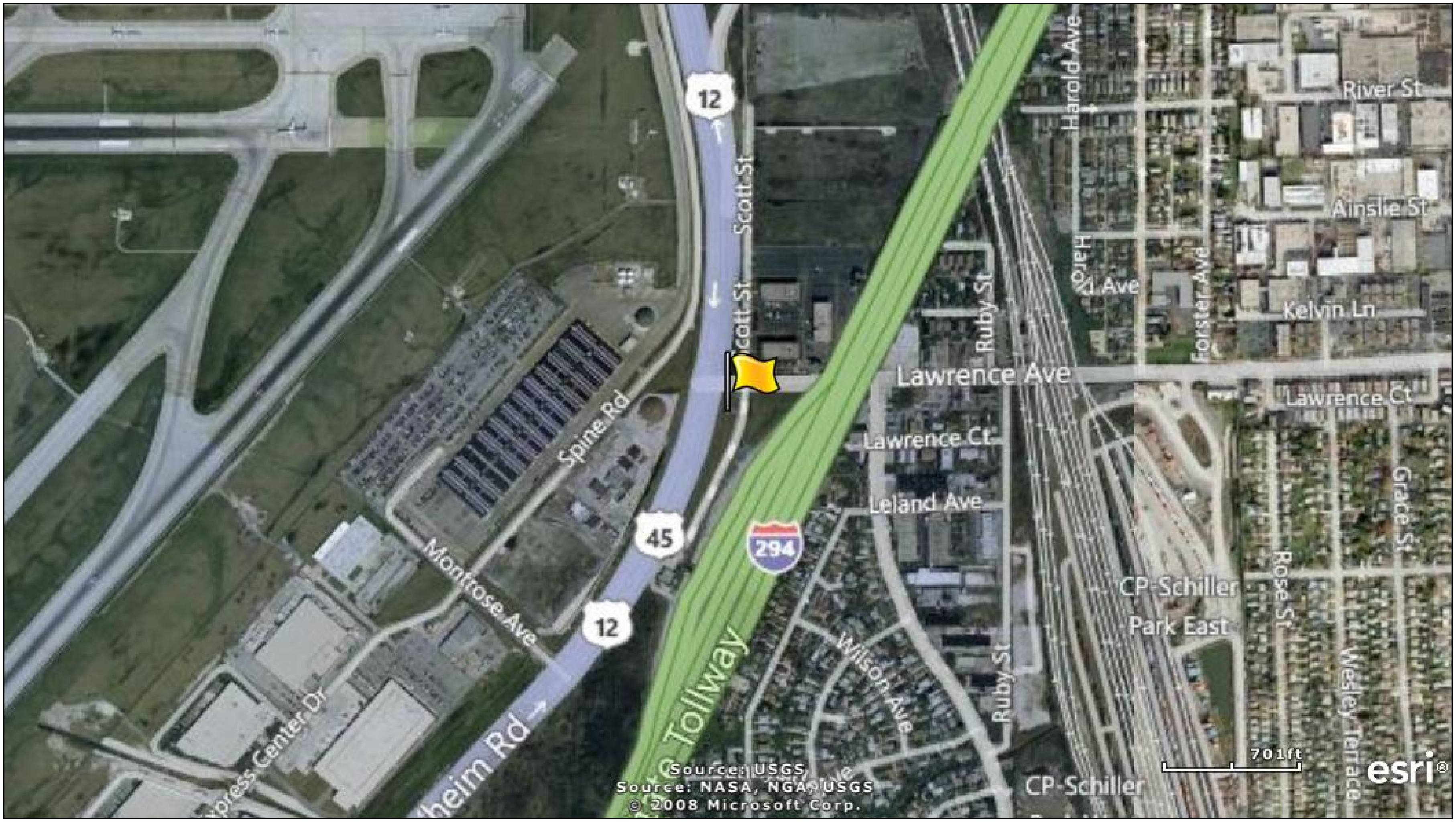
Figure 11-2. Schiller Park, Illinois (SPIL) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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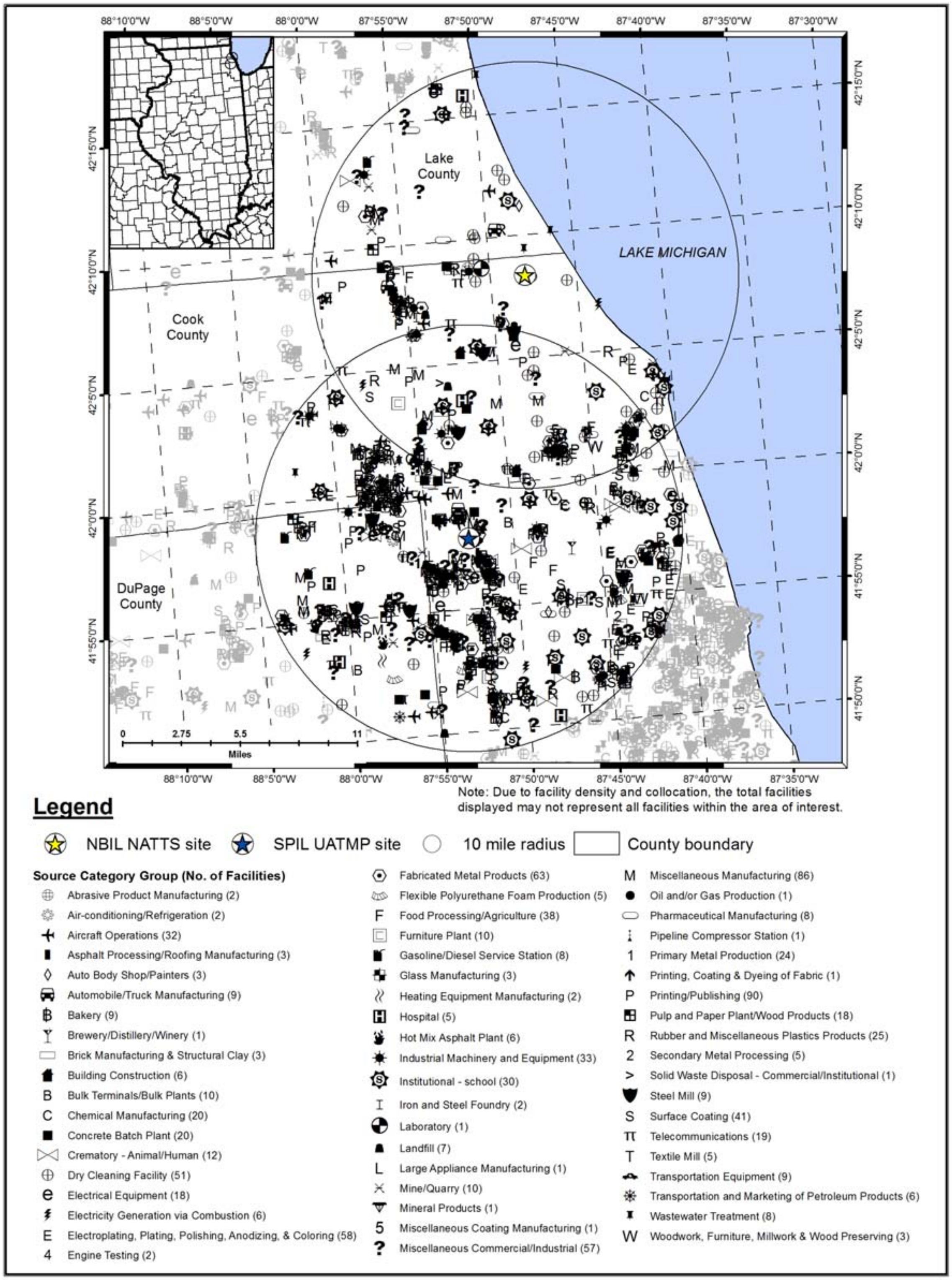
Figure 11-3. NEI Point Sources Located Within 10 Miles of NBIL and SPIL



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

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-Joliet-Naperville, IL-IN-WI MSA (Chicago Div)	42.139996, -87.799227	Residential	Suburban	TSP, TSP Metals, CO, Hg, SO_2, NO, NO_2, NO_x, NH_3, PAMS, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, $PM_{2.5}$ Speciation.
SPIL	17-031-3103	Schiller Park	Cook County	Chicago-Joliet-Naperville, IL-IN-WI MSA (Chicago Div)	41.965193, -87.876265	Mobile	Suburban	TSP, TSP Metals, CO, NO, NO_2, NO_x, Meteorological parameters, $PM_{2.5}$.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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 the Illinois monitoring sites are printing and publishing; fabricated metal products; electroplating, plating, polishing, anodizing, and coloring; and dry cleaning. 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, the closest point source to SPIL is involved in electroplating, plating, polishing, anodizing, and coloring.

Table 11-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Illinois monitoring sites. Table 11-2 includes county-level population and vehicle registration information. Table 11-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 11-2 also contains traffic volume information for each site. Finally, Table 11-2 presents the county-level daily VMT for Cook 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]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
NBIL	5,217,080	2,072,399	0.40	890,037	353,553	34,600	86,863,779
SPIL				2,028,028	805,601	190,000	

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the IL Secretary of State (IL SOS, 2011)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2010 data for SPIL and 2011 data for NBIL from the Illinois DOT (IL DOT, 2010 and 2011a)
[5] County-level VMT reflects 2011 data from the Illinois DOT (IL DOT, 2011b)
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.

- The vehicle-per-person ratio for these sites is the third lowest compared to other NMP sites.

- The 10-mile radius population and estimated vehicle ownership are much higher near SPIL than NBIL.

- SPIL experiences a higher annual average daily traffic volume than NBIL. SPIL's traffic volume is the fourth highest among all NMP sites, behind ELNJ, CELA, and SEWA, while the traffic volume for NBIL is in the middle of the range among NMP sites. Traffic data for SPIL is provided for I-294 at Lawrence Avenue; traffic data for NBIL is for Dundee Road near the railroad crossing.

- The Cook County daily VMT ranks third among counties with NMP sites, behind only Los Angeles County, CA and Maricopa County, AZ (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 summertime, afternoon lake breezes can cool the city when winds from the south and southwest push temperatures upward. In the winter, 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” (Bair, 1992).

11.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). The two closest weather stations are located at Palwaukee Municipal Airport (near NBIL) and O’Hare International Airport (near SPIL), WBAN 04838 and 94846, respectively. Additional information about the Palwaukee and O’Hare 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 the entire year for 2011. Also included in Table 11-3 is the 95 percent confidence interval for each parameter. As shown in Table 11-3, temperatures on sample days appear cooler than temperatures over the course of the year at both sites. For NBIL, the difference may be attributable to make-up samples. More make-up samples were collected during the first and fourth (and colder) quarters of the year compared to those collected during the second and third (and warmer) quarters of the year. Only two make-up samples were collected at SPIL, both during December.

Table 11-3. Average Meteorological Conditions near the Illinois Monitoring Sites

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)
Northbrook, Illinois - NBIL									
Palwaukee Municipal Airport 04838 (42.12, -87.91)	5.27 miles 250° (WSW)	Sample Day	57.0 ± 5.0	49.4 ± 4.6	38.7 ± 4.4	44.3 ± 4.1	68.8 ± 2.4	1016.8 ± 1.5	6.5 ± 0.7
		2011	58.7 ± 2.1	51.0 ± 2.0	40.5 ± 1.9	45.9 ± 1.8	69.4 ± 1.1	1015.9 ± 0.7	6.5 ± 0.3
Schiller Park, Illinois - SPIL									
O'Hare International Airport 94846 (41.99, -87.91)	2.32 miles 303° (WNW)	Sample Day	57.3 ± 5.4	49.6 ± 5.0	39.3 ± 4.5	44.5 ± 4.4	70.0 ± 2.7	1016.0 ± 1.6	8.2 ± 0.9
		2011	58.5 ± 2.2	50.9 ± 2.0	40.7 ± 1.9	45.8 ± 1.8	70.4 ± 1.2	1015.4 ± 0.7	8.2 ± 0.3

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

11.2.3 Back Trajectory Analysis

Figure 11-4 is the composite back trajectory map for days on which samples were collected at the NBIL monitoring site in 2011. Included in Figure 11-4 are four back trajectories per sample day. Figure 11-5 is the corresponding cluster analysis. Similarly, Figure 11-6 is the composite back trajectory map for days on which samples were collected at SPIL and Figure 11-7 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 11-4 through 11-7 represents 100 miles.

Figure 11-4. 2011 Composite Back Trajectory Map for NBIL

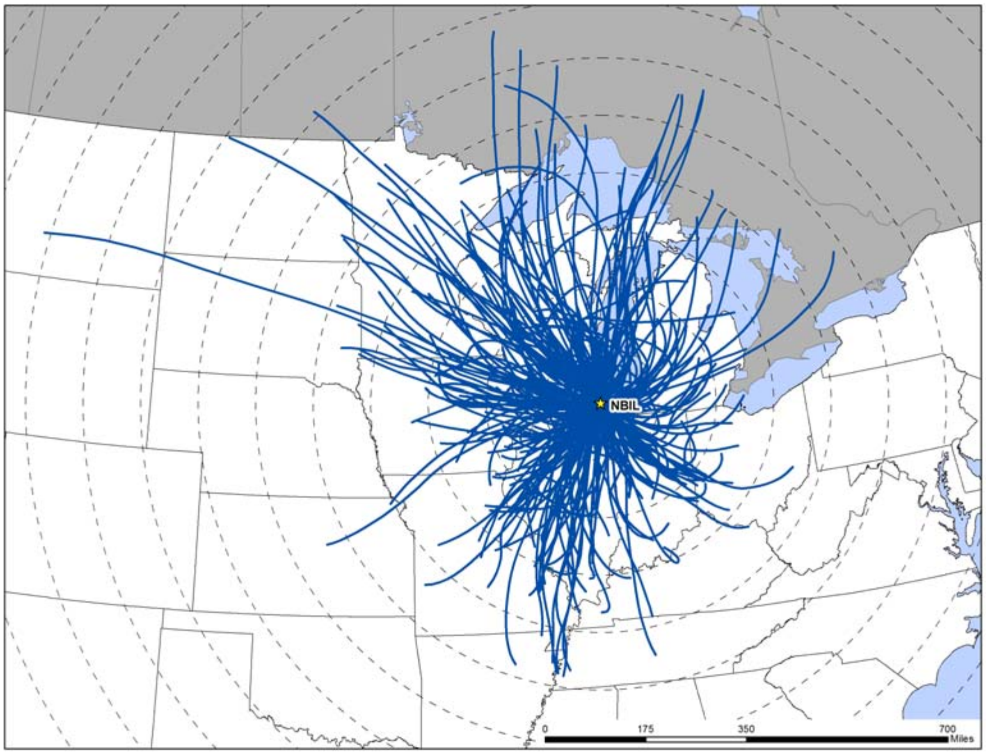


Figure 11-5. Back Trajectory Cluster Map for NBIL

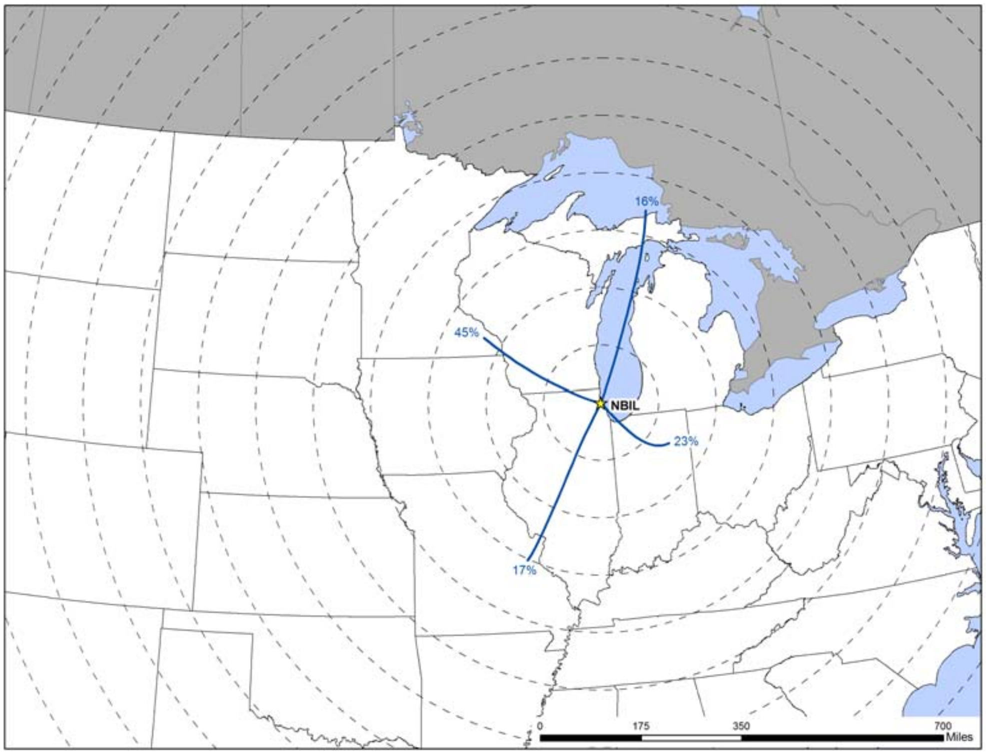


Figure 11-6. 2011 Composite Back Trajectory Map for SPIL

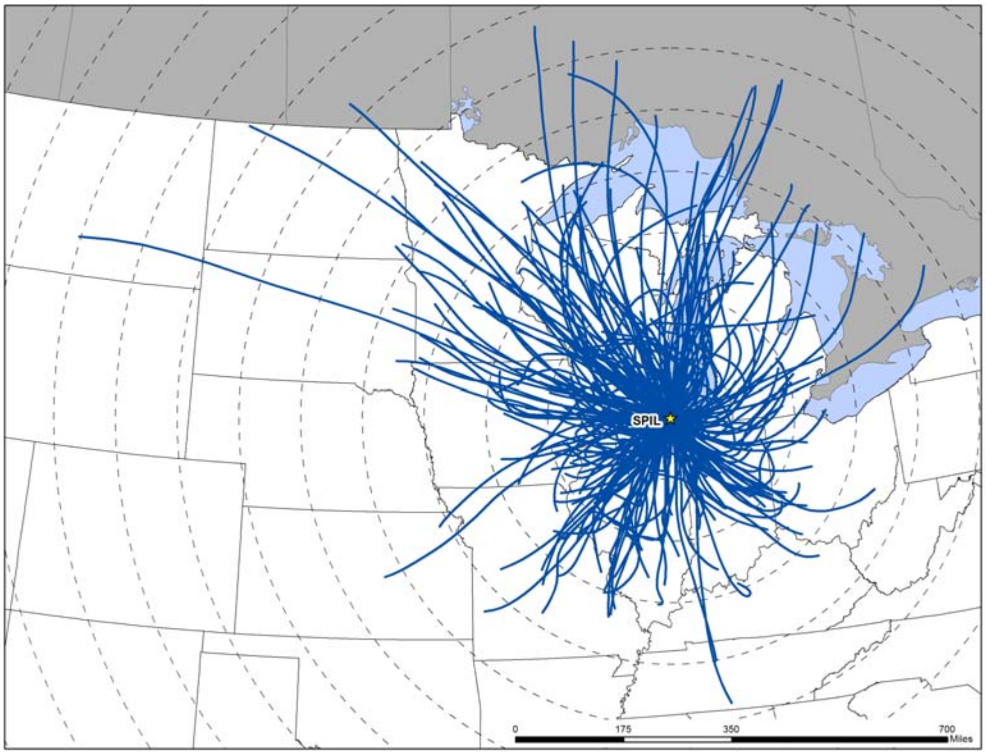
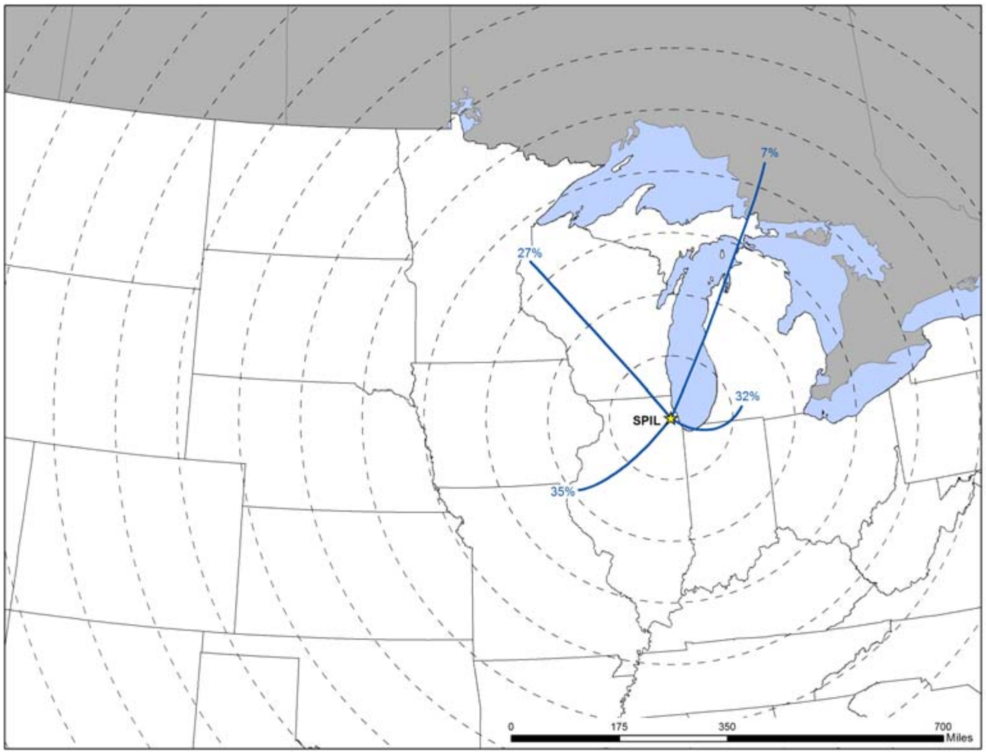


Figure 11-7. Back Trajectory Cluster Map for SPIL



Observations from Figures 11-4 through 11-7 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 trajectory origin appears to be from the 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 trajectory for each site was greater than 1,000 miles in length and originated over Montana. These two trajectories are the longest back trajectories computed among NMP sites. However, the average back trajectory length for these sites is approximately 270 miles and greater than 80 percent of back trajectories originated within 400 miles of the sites.

- The cluster map for NBIL is similar to the cluster map for SPIL in geographical distribution of the clusters but the percentage of trajectories representing each cluster varies. Sixty-two percent of back trajectories originated from a direction with a westerly component for each site. The trajectories originating over Iowa (or due west) were grouped with trajectories originating from the northwest for NBIL and with trajectories originating from the southwest for SPIL.

- Thirty-nine percent of back trajectories originated from a direction with an easterly component for each site. For NBIL, all back trajectories originating from the north and northeast are grouped together, regardless of the length of trajectory, and are represented by the cluster trajectory over Lake Superior (16 percent). Back trajectories originating from the east, southeast, and south were grouped together, as represented by the short cluster originating over Indiana (23 percent). For SPIL, the model grouped short trajectories with an easterly component together under the short cluster trajectory originating from the east (32 percent), while grouping only the longer trajectories from the north and northeast together under the longer cluster trajectory originating to the northeast (7 percent).

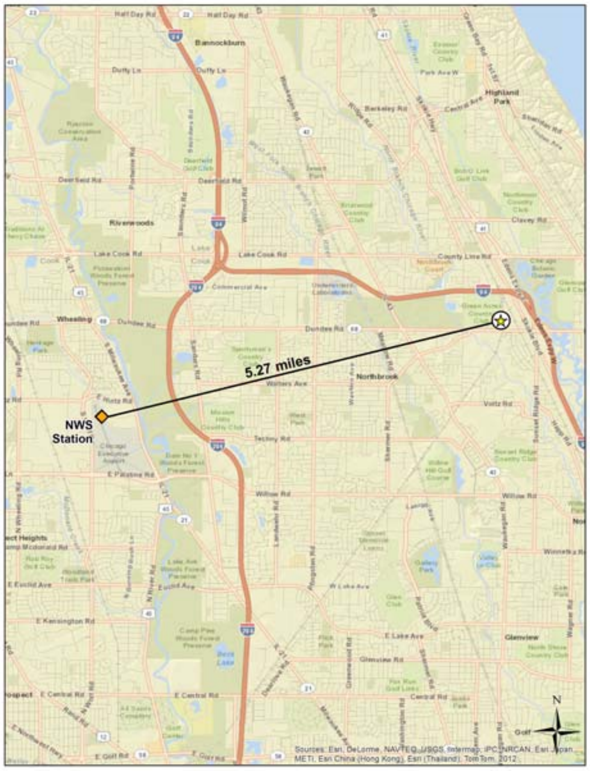
11.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS weather stations at Palwaukee Municipal Airport (for NBIL) and O'Hare International Airport (for SPIL) 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 11-8 presents a map showing the distance between the NWS station and NBIL, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 11-8 also presents three different wind roses for the NBIL monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 11-9 presents the distance map and three wind roses for SPIL.

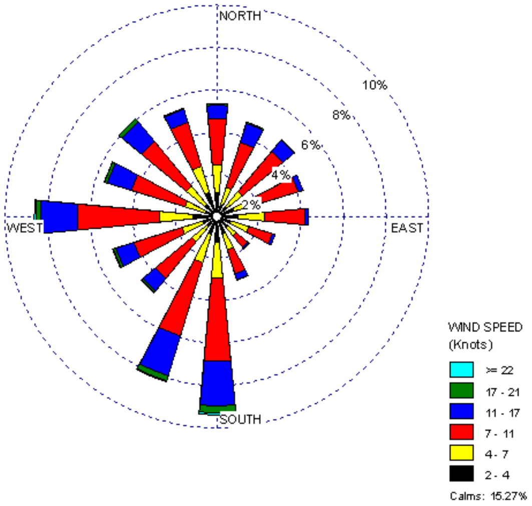
Figure 11-8. Wind Roses for the Palwaukee Municipal Airport Weather Station near NBIL

Distance between NBIL and NWS Station

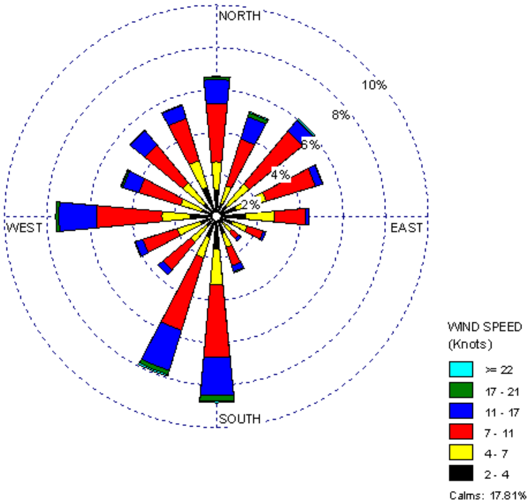


Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2012

2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

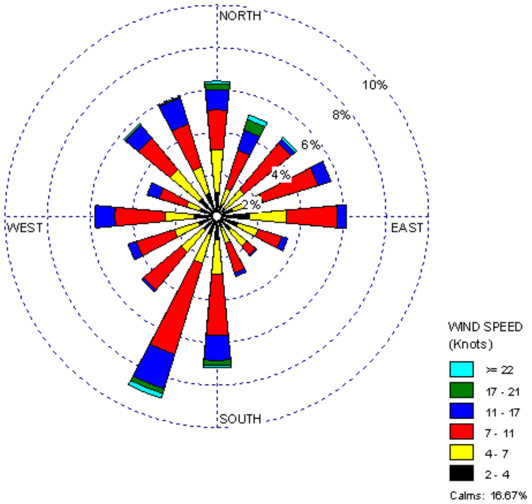
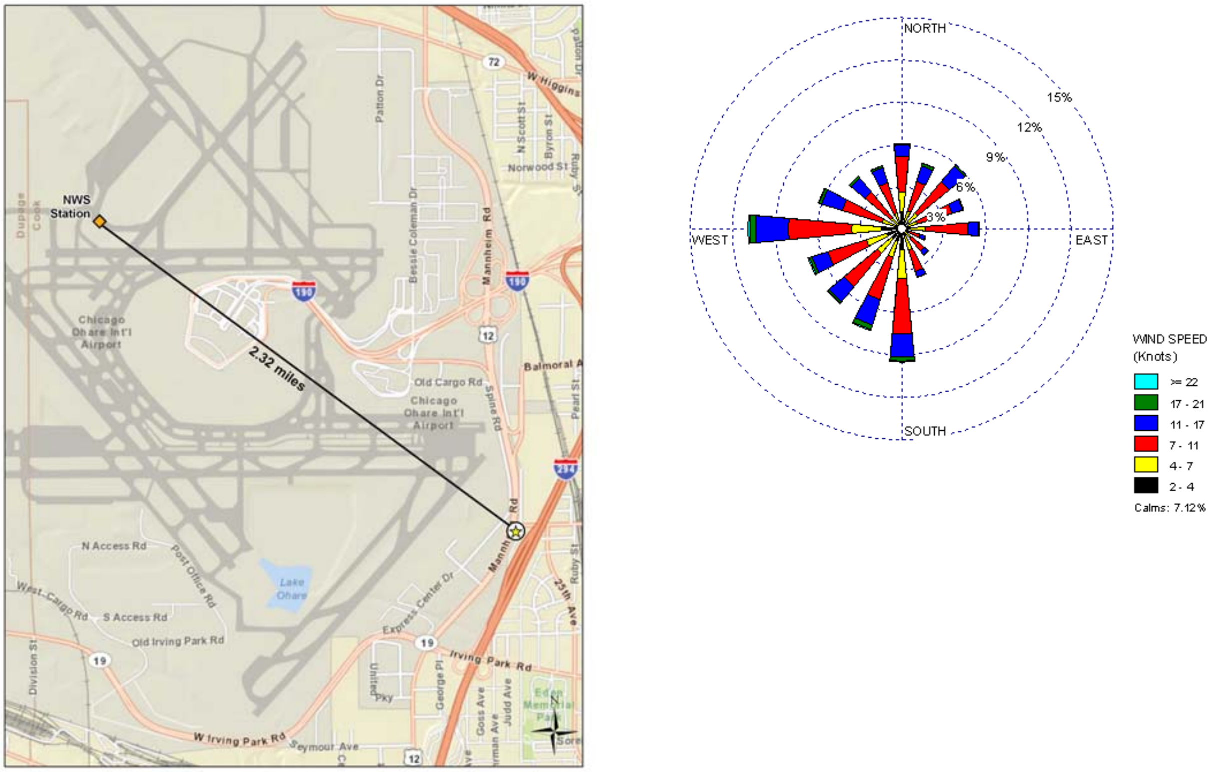
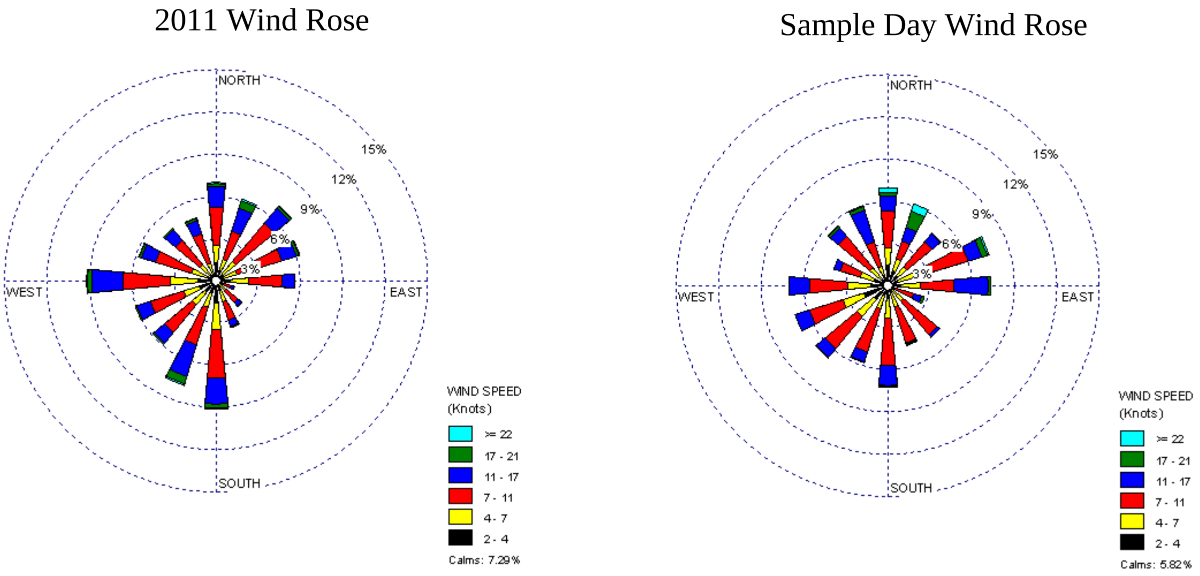


Figure 11-9. Wind Roses for the O'Hare International Airport Weather Station near SPIL



Distance between SPIL and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

Observations from Figure 11-8 for NBIL include the following:

- The Palwaukee Municipal Airport weather station is located approximately 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 15 percent of the hourly measurements.
- The 2011 wind rose exhibits similar patterns in wind directions as the historical wind rose, indicating that wind conditions in 2011 were similar to what is experienced historically.
- The sample day wind patterns generally resemble the full-year wind patterns, although there were fewer westerly wind observations.

Observations from Figure 11-9 for SPIL include the following:

- The O'Hare International Airport weather station is located 2.3 miles west-northwest of SPIL. The bulk 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 (greater than 40 percent). Winds from these directions also tended to be the strongest. Winds from the southeast quadrant were observed the least. Calm winds (≤ 2 knots) were observed for less than 10 percent of the hourly measurements.
- The 2011 wind rose exhibits similar patterns in wind directions as the historical wind rose, although fewer wind observations from the southwest to west appear to be reflected in wind observations from the northeast quadrant.
- The sample day wind patterns exhibit a more even distribution of wind observations, with most directions accounting for five to seven percent of the wind observations (with the exception of east-southeast and west-northwest).

11.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Illinois monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 11-4 presents the results of the preliminary risk-based screening process. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. NBIL sampled for VOCs, carbonyl compounds, SNMOCs, metals (PM$_{10}$), PAHs, and hexavalent chromium, and is one of only two NMP sites sampling for all six pollutant groups. SPIL 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	62	62	100.00	11.15	11.15
Acetaldehyde	0.45	60	62	96.77	10.79	21.94
Benzene	0.13	55	55	100.00	9.89	31.83
Carbon Tetrachloride	0.17	55	55	100.00	9.89	41.73
Naphthalene	0.029	53	61	86.89	9.53	51.26
Arsenic (PM$_{10}$)	0.00023	46	53	86.79	8.27	59.53
1,3-Butadiene	0.03	37	41	90.24	6.65	66.19
Acrylonitrile	0.015	35	35	100.00	6.29	72.48
Manganese (PM$_{10}$)	0.005	31	53	58.49	5.58	78.06
Fluorene	0.011	21	61	34.43	3.78	81.83
Acenaphthene	0.011	20	61	32.79	3.60	85.43
1,2-Dichloroethane	0.038	18	18	100.00	3.24	88.67
Fluoranthene	0.011	15	61	24.59	2.70	91.37
Chloroform	9.8	13	55	23.64	2.34	93.71
Ethylbenzene	0.4	9	55	16.36	1.62	95.32
Dichloromethane	7.7	6	55	10.91	1.08	96.40
p-Dichlorobenzene	0.091	4	18	22.22	0.72	97.12
Hexachloro-1,3-butadiene	0.045	4	4	100.00	0.72	97.84
Nickel (PM$_{10}$)	0.0021	4	53	7.55	0.72	98.56
Benzo(a)pyrene	0.00057	2	59	3.39	0.36	98.92
Lead (PM$_{10}$)	0.015	2	53	3.77	0.36	99.28
Trichloroethylene	0.2	2	24	8.33	0.36	99.64

Table 11-4. Risk-Based Screening Results for the Illinois Monitoring Sites (Continued)

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.18	99.82
Xylenes	10	1	55	1.82	0.18	100.00
Total		556	1110	50.09		
Schiller Park, Illinois - SPIL						
Acetaldehyde	0.45	62	62	100.00	15.31	15.31
Formaldehyde	0.077	62	62	100.00	15.31	30.62
Benzene	0.13	56	56	100.00	13.83	44.44
Carbon Tetrachloride	0.17	56	56	100.00	13.83	58.27
1,3-Butadiene	0.03	55	55	100.00	13.58	71.85
Acrylonitrile	0.015	47	47	100.00	11.60	83.46
Trichloroethylene	0.2	21	42	50.00	5.19	88.64
p-Dichlorobenzene	0.091	15	33	45.45	3.70	92.35
1,2-Dichloroethane	0.038	15	15	100.00	3.70	96.05
Ethylbenzene	0.4	7	55	12.73	1.73	97.78
Hexachloro-1,3-butadiene	0.045	3	3	100.00	0.74	98.52
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.49	99.01
Carbon Disulfide	70	1	56	1.79	0.25	99.26
Chloromethylbenzene	0.02	1	1	100.00	0.25	99.51
1,2-Dibromoethane	0.0017	1	1	100.00	0.25	99.75
Propionaldehyde	0.8	1	62	1.61	0.25	100.00
Total		405	608	66.61		

Observations from Table 11-4 include the following:

- Twenty-four pollutants, including 13 NATTS MQO Core Analytes, failed screens for NBIL. Approximately 50 percent of the measured detections of these pollutants failed screens.

- Based on the risk-based screening process, 15 pollutants, of which nine are NATTS MQO Core Analytes, were identified as pollutants of interest for NBIL. Four additional NATTS MQO Core Analytes (trichloroethylene, nickel, lead, and benzo(a)pyrene) were added to the pollutants of interest for NBIL, even though they did not contribute to 95 percent of the failed screens for NBIL. Five additional pollutants were added to the pollutants of interest for NBIL because they are NATTS MQO Core Analytes, even though they did not fail any screens (beryllium, cadmium, hexavalent chromium, tetrachloroethylene, and vinyl chloride). These five pollutants are not shown in Table 11-4 but are shown in subsequent tables in the sections that follow.

- Benzene, carbon tetrachloride, and formaldehyde were detected in every VOC or carbonyl compound sample collected at NBIL and failed 100 percent of screens. Additional pollutants also failed 100 percent of screens, but the detection rate was lower (such as acrylonitrile and 1,2-dichloroethane).

- Sixteen pollutants, including six NATTS MQO Core Analytes, failed screens for SPIL.

- Based on the risk-based screening process, nine pollutants, of which six are NATTS MQO Core Analytes, were identified as pollutants of interest for SPIL. Three additional NATTS MQO Core Analytes were added to the pollutants of interest for SPIL, even though they did not fail any screens (chloroform, tetrachloroethylene, and vinyl chloride). These pollutants are not shown in Table 11-4 but are shown in subsequent tables in the sections that follow.

- Acetaldehyde, benzene, carbon tetrachloride, and formaldehyde were detected in every VOC and carbonyl compound sample collected at SPIL and failed 100 percent of their screens. Other pollutants also failed 100 percent of screens, but the detection rate was lower.

- 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.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Illinois monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for NBIL and SPIL are provided in Appendices J through O.

11.4.1 2011 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 of 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, metals, and hexavalent chromium 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	62/62	1.00 ± 0.25	1.08 ± 0.32	1.60 ± 0.35	1.87 ± 0.52	1.41 ± 0.20
Acrylonitrile	35/55	0.14 ± 0.05	0.21 ± 0.04	NA	0.01 ± 0.03	0.13 ± 0.03
Benzene	55/55	0.99 ± 0.56	0.55 ± 0.10	NA	0.69 ± 0.16	0.71 ± 0.16
1,3-Butadiene	41/55	0.29 ± 0.39	0.03 ± 0.02	NA	0.08 ± 0.04	0.12 ± 0.10
Carbon Tetrachloride	55/55	0.56 ± 0.05	0.64 ± 0.06	NA	0.69 ± 0.06	0.64 ± 0.03
Chloroform	55/55	2.51 ± 1.17	12.41 ± 4.97	NA	3.79 ± 4.46	6.06 ± 2.17
1,2-Dichloroethane	18/55	0.01 ± 0.02	0.01 ± 0.02	NA	0.07 ± 0.02	0.03 ± 0.01
Ethylbenzene	55/55	0.20 ± 0.09	0.45 ± 0.41	NA	0.26 ± 0.08	0.32 ± 0.12
Formaldehyde	62/62	2.49 ± 1.82	2.04 ± 0.95	3.18 ± 0.84	2.39 ± 1.10	2.53 ± 0.57
Tetrachloroethylene	53/55	0.31 ± 0.31	0.57 ± 0.28	NA	0.18 ± 0.06	0.35 ± 0.13
Trichloroethylene	24/55	0.04 ± 0.03	0.04 ± 0.04	NA	0.04 ± 0.03	0.04 ± 0.02
Vinyl Chloride	8/55	<0.01 ± <0.01	<0.01 ± <0.01	NA	<0.01 ± 0.01	<0.01 ± <0.01
Acenaphthene [a]	61/61	2.63 ± 0.76	10.73 ± 5.57	29.14 ± 9.26	7.79 ± 7.07	13.14 ± 4.14
Arsenic (PM$_{10}$) [a]	53/53	NA	0.68 ± 0.29	0.80 ± 0.29	0.89 ± 0.36	0.73 ± 0.15

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)
Benzo(a)pyrene [a]	59/61	0.21 ± 0.10	0.14 ± 0.05	0.08 ± 0.02	0.16 ± 0.07	0.15 ± 0.03
Beryllium (PM$_{10}$) [a]	51/53	NA	0.01 ± <0.01	<0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01
Cadmium (PM$_{10}$) [a]	53/53	NA	0.13 ± 0.06	0.12 ± 0.05	0.19 ± 0.07	0.14 ± 0.03
Fluoranthene [a]	61/61	2.02 ± 0.56	6.94 ± 3.46	17.28 ± 5.24	2.78 ± 1.74	7.59 ± 2.29
Fluorene [a]	61/61	2.94 ± 0.64	10.94 ± 5.95	30.24 ± 9.82	7.33 ± 6.21	13.46 ± 4.25
Hexavalent Chromium [a]	50/61	0.02 ± 0.01	0.02 ± 0.01	0.01 ± <0.01	0.02 ± 0.01	0.02 ± <0.01
Lead (PM$_{10}$) [a]	53/53	NA	2.95 ± 1.31	3.44 ± 1.34	6.46 ± 3.34	4.16 ± 1.07
Manganese (PM$_{10}$) [a]	53/53	NA	8.73 ± 5.52	7.66 ± 2.70	11.45 ± 6.47	8.30 ± 2.29
Naphthalene [a]	61/61	48.33 ± 13.63	54.35 ± 19.54	157.13 ± 45.66	127.06 ± 103.17	99.39 ± 29.75
Nickel (PM$_{10}$)[a]	53/53	NA	1.20 ± 0.19	1.35 ± 0.47	1.46 ± 0.59	1.27 ± 0.21
Schiller Park, Illinois - SPIL						
Acetaldehyde	62/62	5.29 ± 2.04	2.26 ± 0.51	2.38 ± 0.40	1.95 ± 0.66	2.94 ± 0.61
Acrylonitrile	47/56	0.95 ± 0.19	0.83 ± 0.14	0.85 ± 0.11	0.46 ± 0.29	0.77 ± 0.11
Benzene	56/56	0.77 ± 0.11	0.82 ± 0.25	0.78 ± 0.18	1.02 ± 0.35	0.85 ± 0.12
1,3-Butadiene	55/56	0.13 ± 0.04	0.15 ± 0.07	0.15 ± 0.06	0.20 ± 0.09	0.16 ± 0.03
Carbon Tetrachloride	56/56	0.50 ± 0.04	0.60 ± 0.05	0.60 ± 0.02	0.64 ± 0.05	0.58 ± 0.02
Chloroform	38/56	0.05 ± 0.02	0.11 ± 0.04	0.10 ± 0.05	0.10 ± 0.07	0.09 ± 0.02
p-Dichlorobenzene	33/56	0.04 ± 0.04	0.08 ± 0.06	0.07 ± 0.04	0.10 ± 0.08	0.07 ± 0.03
1,2-Dichloroethane	15/56	0.01 ± 0.01	0.04 ± 0.03	0.01 ± 0.02	0.03 ± 0.02	0.02 ± 0.01
Formaldehyde	62/62	3.89 ± 1.13	3.16 ± 0.97	3.80 ± 0.80	2.35 ± 0.74	3.29 ± 0.46
Tetrachloroethylene	53/56	0.29 ± 0.22	0.32 ± 0.21	0.25 ± 0.07	0.36 ± 0.12	0.31 ± 0.08
Trichloroethylene	42/56	0.15 ± 0.15	0.67 ± 0.52	0.39 ± 0.31	1.28 ± 1.44	0.64 ± 0.41
Vinyl Chloride	6/56	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	0.01 ± 0.01	<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 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 by mass are chloroform (6.06 ± 2.17 μg/m^3), formaldehyde (2.53 ± 0.57 μg/m^3), and acetaldehyde (1.41 ± 0.20 μg/m^3). The annual average concentrations for the remaining pollutants of interest were less than 1.00 μg/m^3.

- Third quarter average concentrations could not be calculated for the VOCs because fewer than 75 percent of samples were valid during this quarter. For this same reason, first quarter average concentrations could not be calculated for the PM_{10} metals.

- The annual average concentration of chloroform for NBIL is unusually high compared to other sites sampling this pollutant. The second quarter average is considerably higher than the other available quarterly average concentrations and the confidence interval associated with the fourth quarter average concentration is greater than the quarterly average itself. These indicate that the measurements of chloroform are highly variable and that outliers are likely present. Chloroform concentrations range from 0.308 to 32.9 μg/m^3, with a median concentration of 2.05 μg/m^3. The maximum concentration of chloroform was measured at NBIL on December 2, 2011 (32.9 μg/m^3), although a similar concentration was also measured June 26, 2011 (32.8 μg/m^3). These are the highest concentrations of chloroform measured across the program and of the 12 concentrations greater than 10 μg/m^3 measured across the program, 11 were measured at NBIL. Of the 63 measurements of chloroform greater than 1 μg/m^3, 44 were measured at NBIL (with 16 measured at DEMI, one at PXSS, and two at S4MO). These findings are consistent with findings discussed in previous NMP reports.

- The first quarter average concentrations for both benzene and 1,3-butadiene are the highest of the quarterly averages and have relatively large confidence intervals compared to the other quarterly averages, particularly 1,3-butadiene. A review of the data shows that the two highest concentrations of benzene and 1,3-butadiene were measured on the first two sample dates in January. The maximum concentration of benzene was measured on January 9, 2011 (4.51 μg/m^3) and the second highest concentration was measured on January 3, 2011 (2.15 μg/m^3). The maximum concentration of 1,3-butadiene was measured on January 9, 2011 (2.68 μg/m^3) and the second highest concentration was measured on January 3, 2011 (1.21 μg/m^3). NBIL's maximum 1,3-butadiene concentrations rank second and fourth among NMP sites sampling this pollutant and are the only two 1,3-butadiene concentrations measured at NBIL greater than 1 μg/m^3. For benzene, these two concentrations are the only concentrations measured at NBIL greater than 2 μg/m^3 (and only four benzene concentrations measured at NBIL are greater than 1 μg/m^3).

- The second quarter average concentration of ethylbenzene is roughly twice as high as the other quarterly averages, where they could be calculated, and has a relatively large confidence interval associated with it. The maximum ethylbenzene concentration was measured on June 8, 2011 (3.20 μg/m^3) and is more than twice the next highest concentration (1.18 μg/m^3, measured on August 25, 2011). All other measurements of this pollutant are less than 1 μg/m^3. The third highest concentration of ethylbenzene was measured on January 9, 2011, the same day the highest concentrations of benzene and 1,3-butadiene were measured.

- The first quarter average concentration of tetrachloroethylene is equivalent to its confidence interval, indicating that outliers may be affecting this quarterly average. The confidence interval for the second quarter average is also relatively large compared to the average itself. A review of the data shows that concentrations of tetrachloroethylene range from 0.068 $\mu g/m^3$ to 2.42 $\mu g/m^3$, with a median concentration of 0.177 $\mu g/m^3$. The maximum concentration was measured on March 16, 2011 (2.42 $\mu g/m^3$), although a similar concentration was also measured on May 21, 2011 (2.18 $\mu g/m^3$). These two tetrachloroethylene measurements rank second and third highest among all NMP sites sampling VOCs.

- The third quarter average concentrations of acenaphthene, fluoranthene, and fluorene were significantly higher than the other quarterly averages. The maximum concentration of each of these pollutants was measured on July 5, 2011. The highest concentrations of these pollutants were measured in June, July, August, and October.

- The third and fourth quarter average concentrations of naphthalene were more than twice the first and second quarterly averages. The highest concentrations of naphthalene were measured in July, August, and October. The maximum naphthalene concentration (799 ng/m^3) was measured at NBIL on October 6, 2011, with the second highest concentration (322 ng/m^3) measured on the following sample day (October 12, 2011). The concentration measured on October 6, 2011 is the maximum naphthalene concentration measured across all NMP sites sampling PAHs.

- Among the PM_{10} metals, manganese has the highest annual average concentration (8.30 ± 2.29 ng/m^3). The quarterly average concentrations for most of the PM_{10} metals are highest for the fourth quarter, although the difference is not statistically significant among the quarters for most of them. This is most notable for lead and manganese. A review of the highest concentrations for each of the metals reveals that some of the highest concentrations of the metals were measured in the sample collected October 6, 2011.

Observations for SPIL from Table 11-5 include the following:

- The pollutants with the highest annual average concentrations by mass are formaldehyde (3.29 ± 0.46 $\mu g/m^3$) and acetaldehyde (2.94 ± 0.61 $\mu g/m^3$). These are the only pollutants with annual average concentrations greater than 1 $\mu g/m^3$.

- Concentrations of most of the pollutants of interest for SPIL did not vary significantly across calendar quarters. However, a few quarterly averages do stand out, as described below.

- The first quarter average concentration of acetaldehyde is twice as high as the other quarterly averages and has a relatively large confidence interval associated with it. A review of the data shows that seven of the eight highest concentrations of acetaldehyde (those greater than 5 $\mu g/m^3$) were measured during the first quarter of 2011, and ranged from 5.74 $\mu g/m^3$ (measured on January 21, 2011) to 14.5 $\mu g/m^3$

(measured on January 9, 2011). The two highest concentrations of acetaldehyde measured among NMP sites sampling carbonyl compounds were measured at SPIL (14.5 µg/m^3 and 11.2 µg/m^3).

- The fourth quarter average concentration of trichloroethylene is higher than the other quarters and all four quarterly averages of this pollutant have relatively large confidence intervals associated with them. This indicates that the concentrations of trichloroethylene are highly variable. A review of the data shows that the highest trichloroethylene concentration was measured on October 12, 2011 (8.40 µg/m^3) and is the highest trichloroethylene concentration measured among NMP sites sampling VOCs. Of the 11 concentrations of trichloroethylene greater than 1 µg/m^3 across the program, nine of these were measured at SPIL. The two highest concentrations measured at SPIL (8.40 µg/m^3 and 7.22 µg/m^3) were both measured in October, leading to the relatively high fourth quarter average concentration. Trichloroethylene concentrations ranged from 0.0377 µg/m^3 to 8.40 µg/m^3, with a median concentration of 0.145 µg/m^3 and 14 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 NBIL and SPIL from those tables include the following:

- NBIL and SPIL appear in Tables 4-9 through 4-12 a total of 27 times.

- As shown in Table 4-9, NBIL’s annual average concentration of chloroform is the highest annual average among all NMP sites sampling this pollutant. Further, the annual average concentration of chloroform for NBIL is nearly eight times higher than the next highest annual average (calculated for DEMI). This finding is similar to the findings in the 2010 NMP report, although the difference is significantly higher for 2011. NBIL also has the highest annual average concentration of vinyl chloride, even though it was only detected eight times.

- SPIL has the highest annual average concentration of trichloroethylene, which is seven times greater than the next highest annual average concentration of this pollutant (calculated for ELNJ). This is also similar to the 2010 NMP report. SPIL also has the highest annual average concentration of acrylonitrile.

- SPIL has the second highest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds, as shown in Table 4-10, behind only ELNJ.

- NBIL has the highest annual average concentration of fluorene and second highest annual average concentration of acenaphthene among NMP sites sampling PAHs, as shown in Table 4-11. Even though the maximum naphthalene concentration across the program was measured at NBIL, the annual average concentration of naphthalene for NBIL ranks sixth.

- As shown in Table 4-12, the annual average concentrations for NBIL were among the top five for all of the program-level PM_{10} metal pollutants of interest. However, it is important to note that only nine sites sampled PM_{10} metals and have enough data for annual averages to be calculated.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde were created for both NBIL and SPIL. Box plots were also created for arsenic, benzo(a)pyrene, hexavalent chromium, lead, manganese, and naphthalene for NBIL. Figures 11-10 through 11-19 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.

Figure 11-10. Program vs. Site-Specific Average Acetaldehyde Concentrations

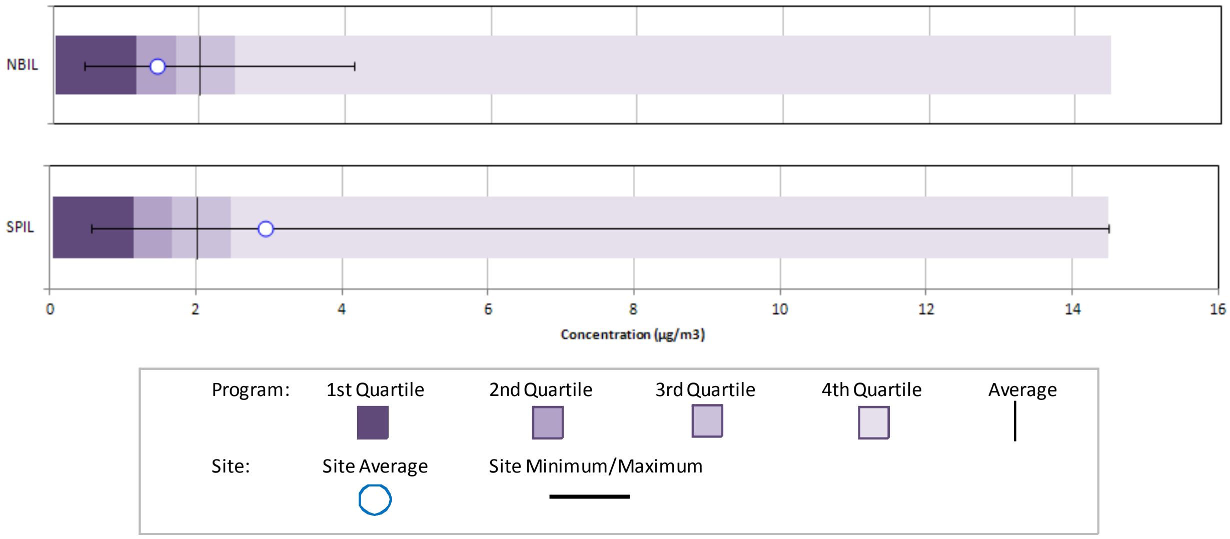


Figure 11-11. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

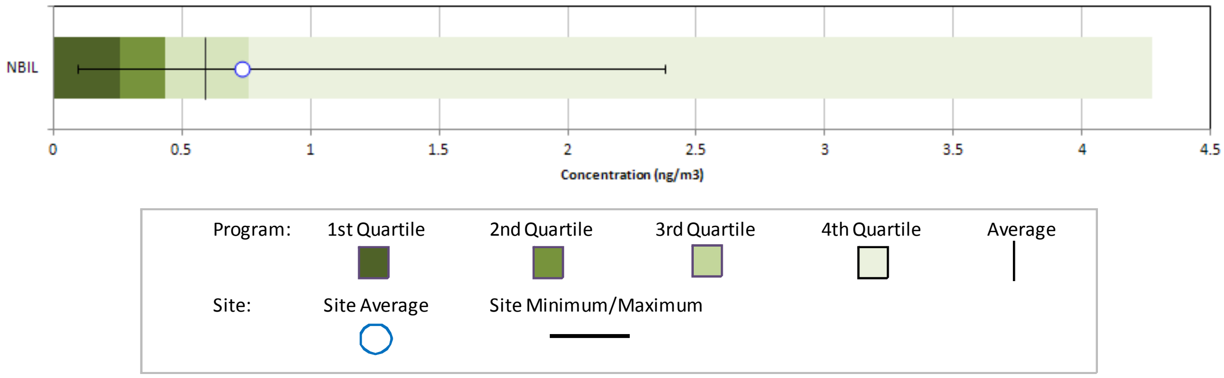


Figure 11-12. Program vs. Site-Specific Average Benzene Concentrations

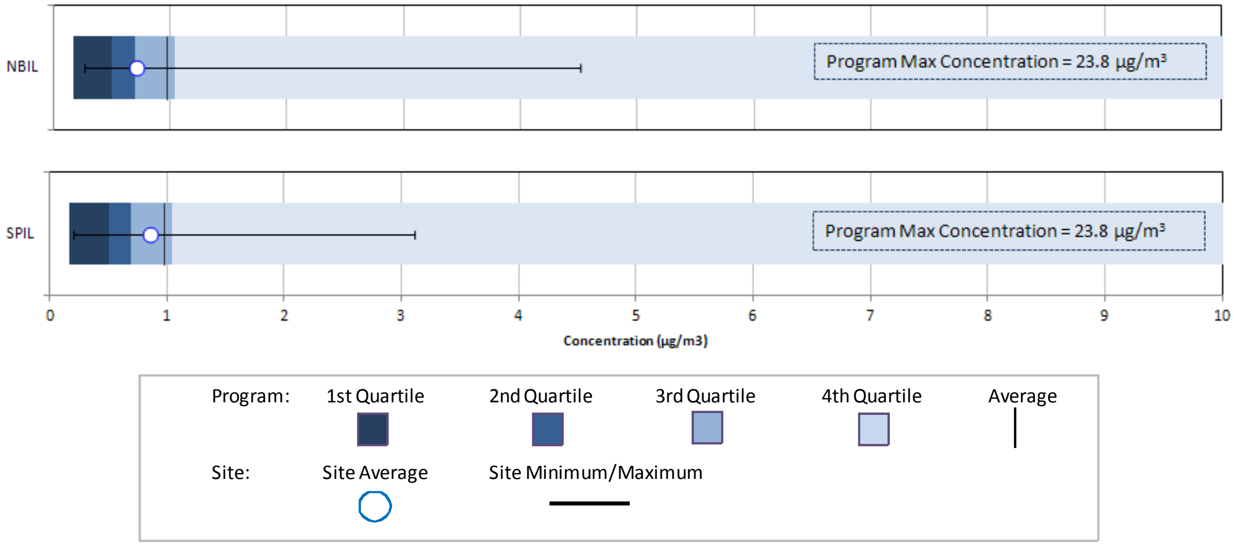


Figure 11-13. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

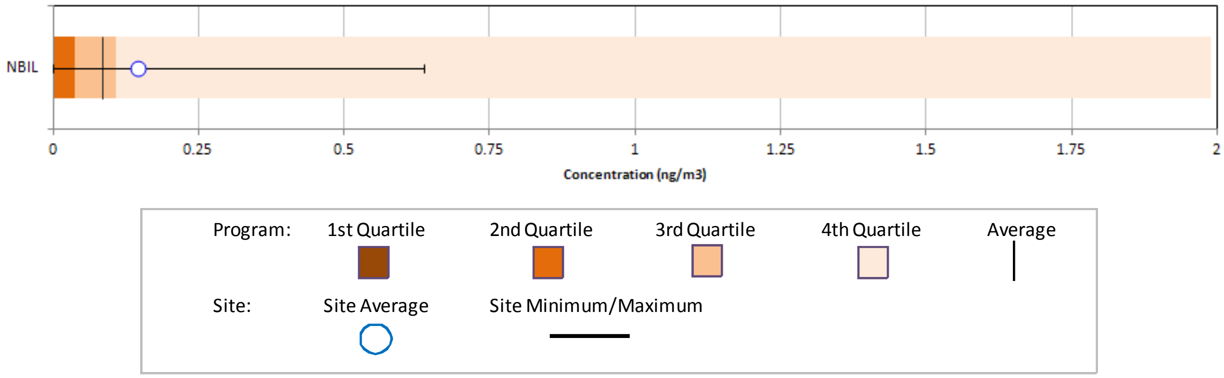


Figure 11-14. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

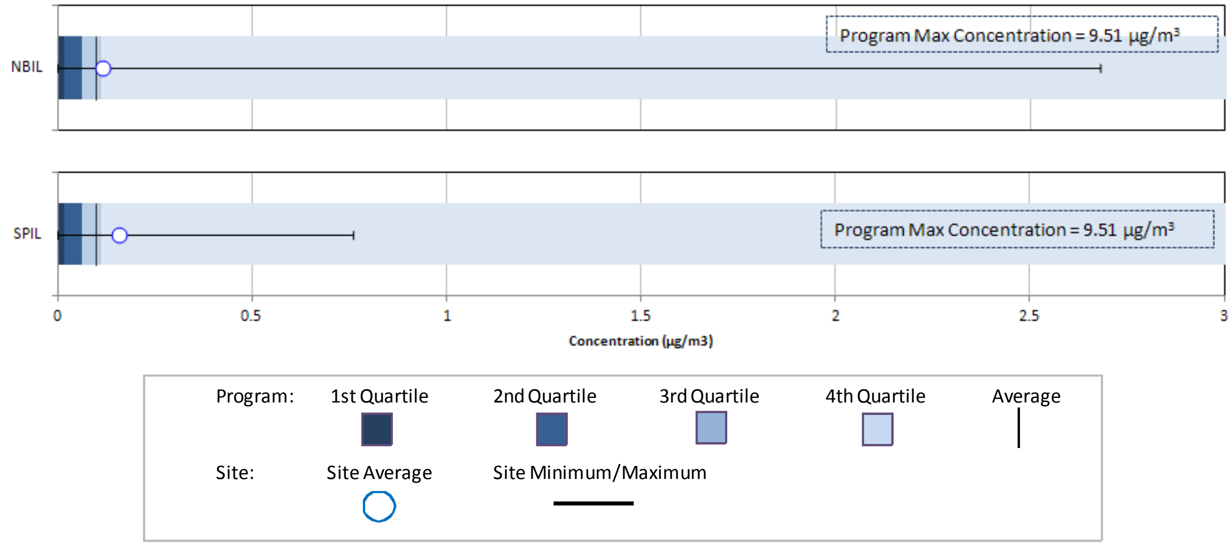


Figure 11-15. Program vs. Site-Specific Average Formaldehyde Concentrations

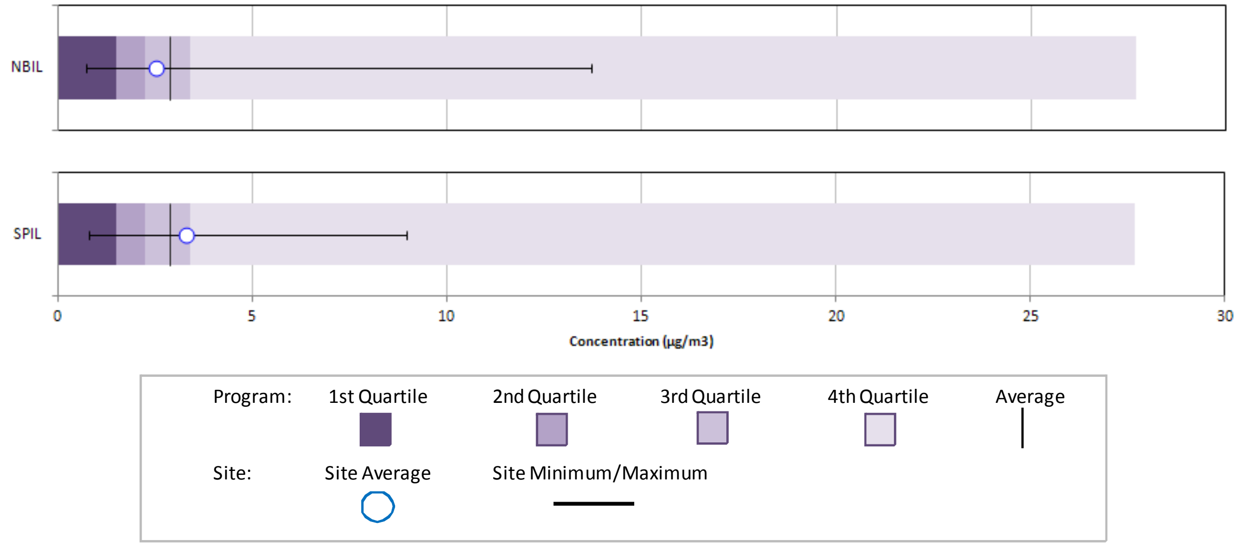


Figure 11-16. Program vs. Site-Specific Average Hexavalent Chromium Concentration

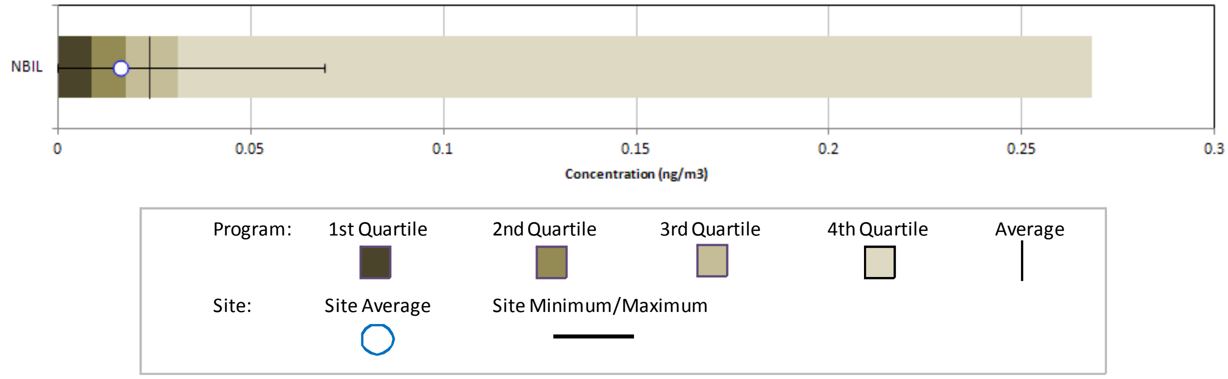


Figure 11-17. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

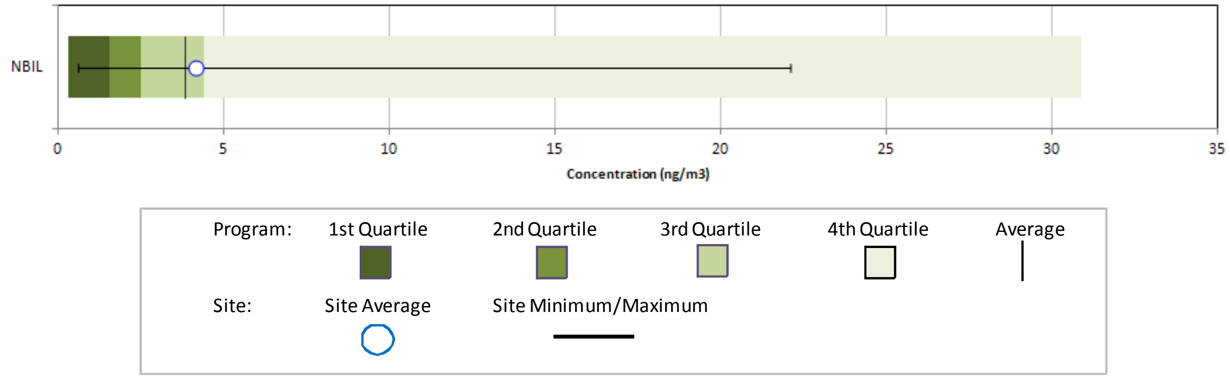


Figure 11-18. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

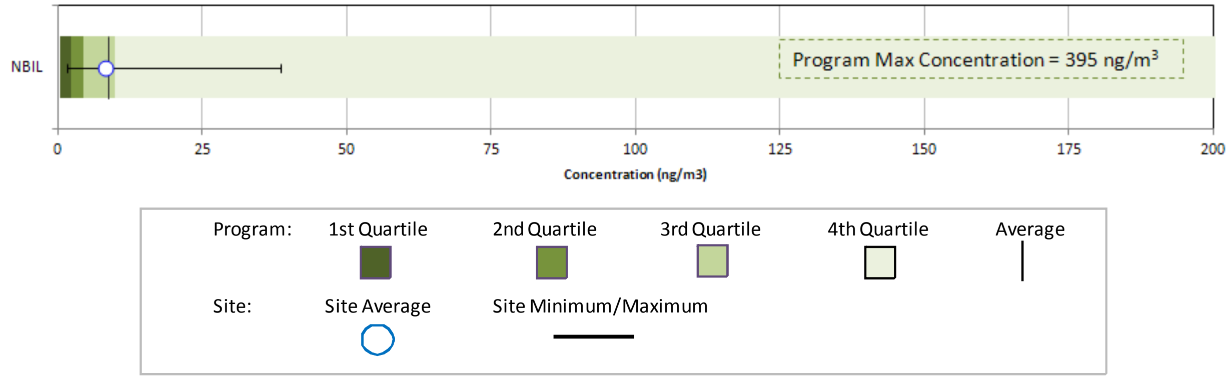
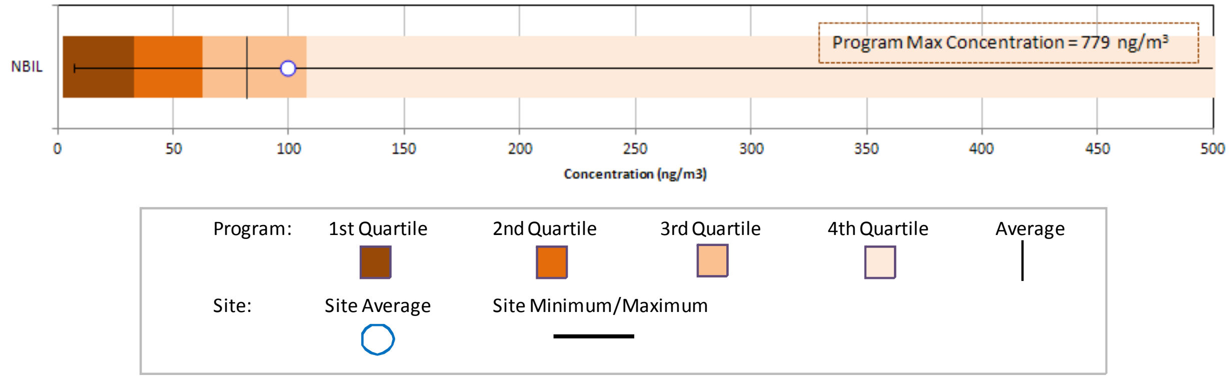


Figure 11-19. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 11-10 through 11-19 include the following:

- Figure 11-10 shows that the annual average acetaldehyde concentration for SPIL is twice the annual average acetaldehyde concentration for NBIL. NBIL's annual average is less than both the program-level average and median concentrations while the annual average for SPIL is greater than the program-level average and third quartile. As discussed in the previous section, the two maximum acetaldehyde concentrations measured among NMP sites sampling this pollutant were measured at SPIL. There were no non-detects of acetaldehyde measured at either site or across the program.

- Figure 11-11 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 greater than the program-level average concentration but just less than the program-level third quartile. The maximum concentration measured at NBIL is 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 11-12 shows the box plots for benzene. Note that the program-level maximum concentration (23.8 $\mu g/m^3$) 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 has been reduced to 10 $\mu g/m^3$. Figure 11-12 shows that while SPIL's annual average benzene concentration is greater than NBIL's annual average benzene concentration, the range of measurements is larger for NBIL than SPIL. However, both annual averages are less than the program-level average concentration. There were no non-detects of benzene measured at either site or across the program.

- Figure 11-13 is the box plot for benzo(a)pyrene. Note that the program-level first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average benzo(a)pyrene concentration for NBIL is greater than the program-level average concentration and third quartile. Figure 11-13 also shows that the maximum concentration measured at NBIL is less than the maximum concentration measured across the program. Two non-detects of benzo(a)pyrene were measured at NBIL.

- Similar to the benzene graph, the program-level maximum 1,3-butadiene concentration (9.51 $\mu g/m^3$) is not shown directly on the box plots as the scale has been reduced to 3 $\mu g/m^3$ in Figure 11-14 to allow for the observation of data points at the lower end of the concentration range. Figure 11-14 shows that both sites' annual average 1,3-butadiene concentrations are greater than the program-level average and, although difficult to discern in Figure 11-14, the program-level third quartile. As discussed in the previous section, the maximum 1,3-butadiene concentration for NBIL is the second highest among NMP sites sampling this pollutant. A single non-detect of 1,3-butadiene was measured at SPIL while 14 non-detects were measured at NBIL.

- Figure 11-15 presents the box plots for formaldehyde. The box plots show that NBIL's annual average formaldehyde concentration is less than the program-level average while SPIL's annual average formaldehyde concentration is greater than the program-level average concentration. Figure 11-15 also shows that the range of concentrations measured is larger for NBIL than SPIL. There were no non-detects of formaldehyde measured at either site or across the program.

- Figure 11-16 shows that the annual average concentration of hexavalent chromium for NBIL is less than the program-level average and median concentrations. The maximum concentration measured at NBIL is less than the program-level maximum concentration. There were several non-detects of hexavalent chromium measured at NBIL and across the program.

- Figure 11-17 is the box plot for lead, which was measured at NBIL only. The box plot shows that the annual average concentration of lead for NBIL is greater than the program-level average but less than the program-level third quartile. While the maximum lead concentration measured at NBIL is less than the maximum concentration measured across the program, it was the sixth highest measurement of lead among NMP sites sampling PM_{10} metals. There were no non-detects of lead measured at NBIL or across the program.

- Figure 11-18 is the box plot for manganese (PM_{10}). Note that the program-level maximum concentration (395 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 200 ng/m^3 to allow for the observation of data points at the lower end of the concentration range. The box plot shows that the annual average concentration for NBIL is just less than the program-level average concentration. The maximum concentration measured at NBIL is considerably less than the maximum measured across the program. Although difficult to discern in Figure 11-18, there were no non-detects of manganese measured at NBIL or across the program.

- Figure 11-19 is the box plot for naphthalene. The program-level maximum concentration (779 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 ng/m^3 in order to allow for the observations of data points at the lower end of the concentration range. Figure 11-19 shows that the maximum concentration of naphthalene measured at NBIL is off the scale of the box plot; this measurement is the maximum naphthalene concentration measured among all NMP sites sampling this pollutant. The annual average concentration for NBIL is greater than the program-level average concentration but less than the program-level third quartile. There were no non-detects of naphthalene measured at NBIL or across the program.

11.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. NBIL and SPIL have sampled VOCs under the NMP since 2003. Both sites have also sampled carbonyl compounds since 2005. Additionally, NBIL has sampled PM_{10} metals and hexavalent chromium since 2005. Figures 11-20 through 11-27 present the annual statistical metrics for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, lead, and manganese for NBIL, respectively. Figures 11-28 through 11-31 present the annual statistical metrics for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde for SPIL, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. NBIL began sampling PAHs under the NMP in 2008, which is less than 5 consecutive years; therefore, the trends analysis was not conducted for the PAHs.

Figure 11-20. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at NBIL

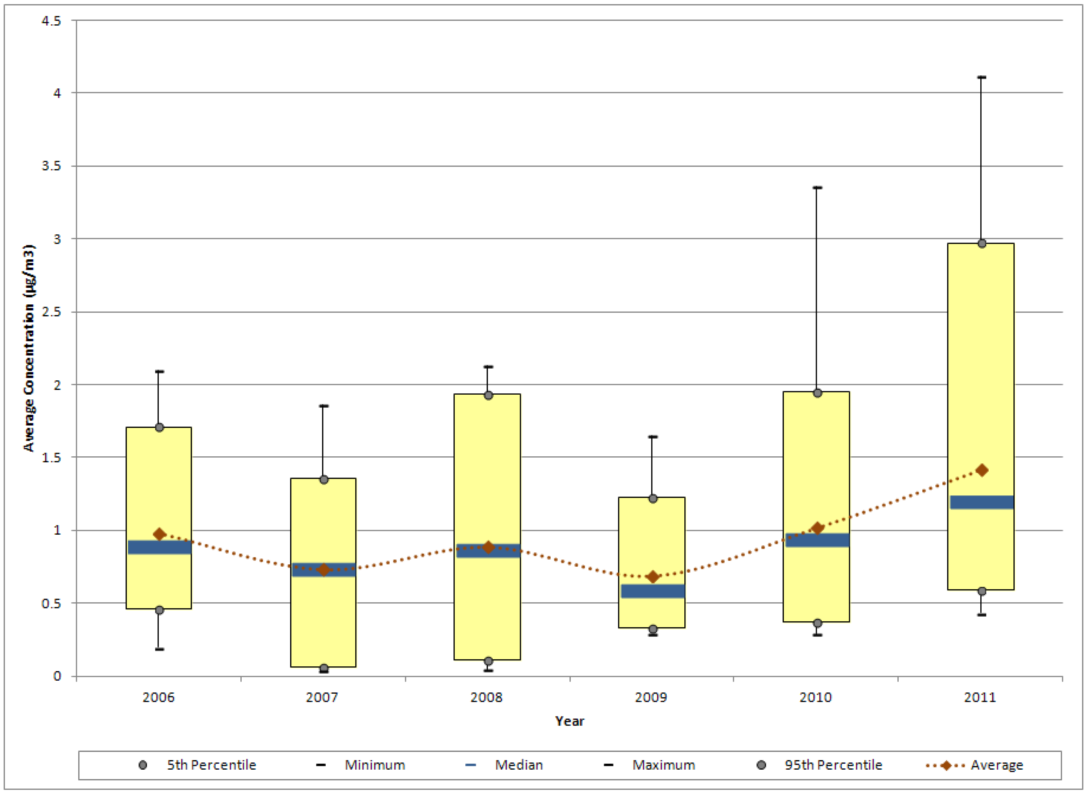


Figure 11-21. Annual Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at NBIL

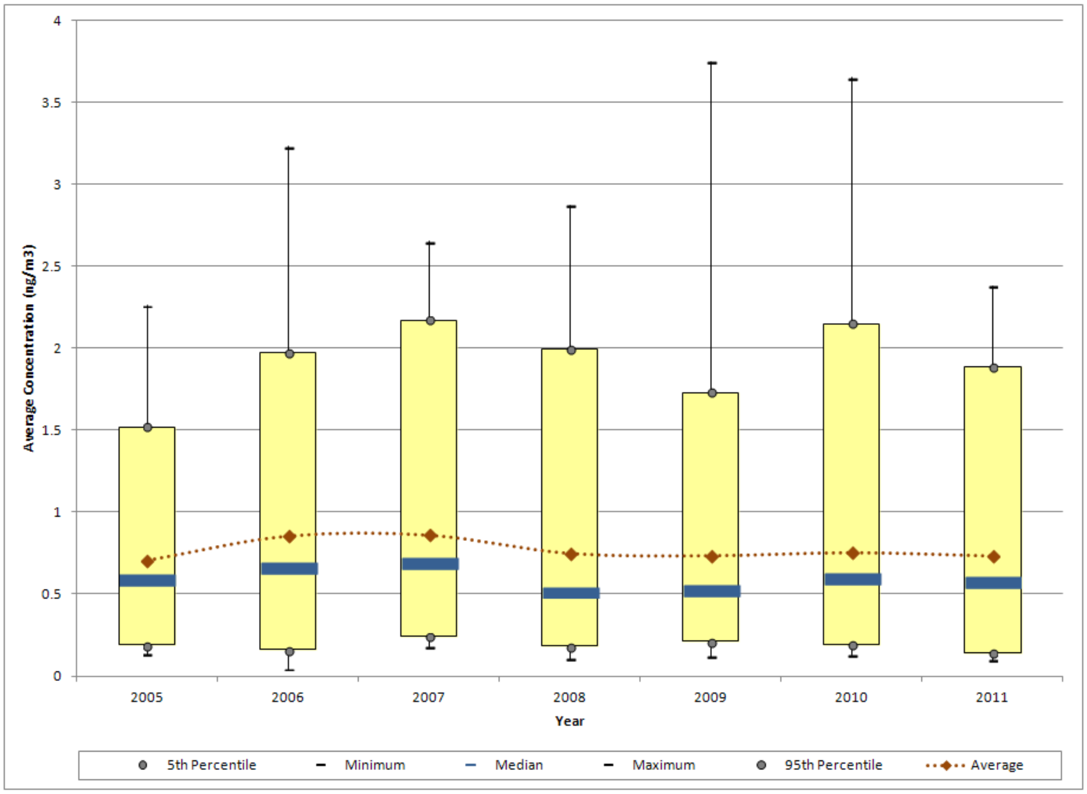


Figure 11-22. Annual Statistical Metrics for Benzene Concentrations Measured at NBIL

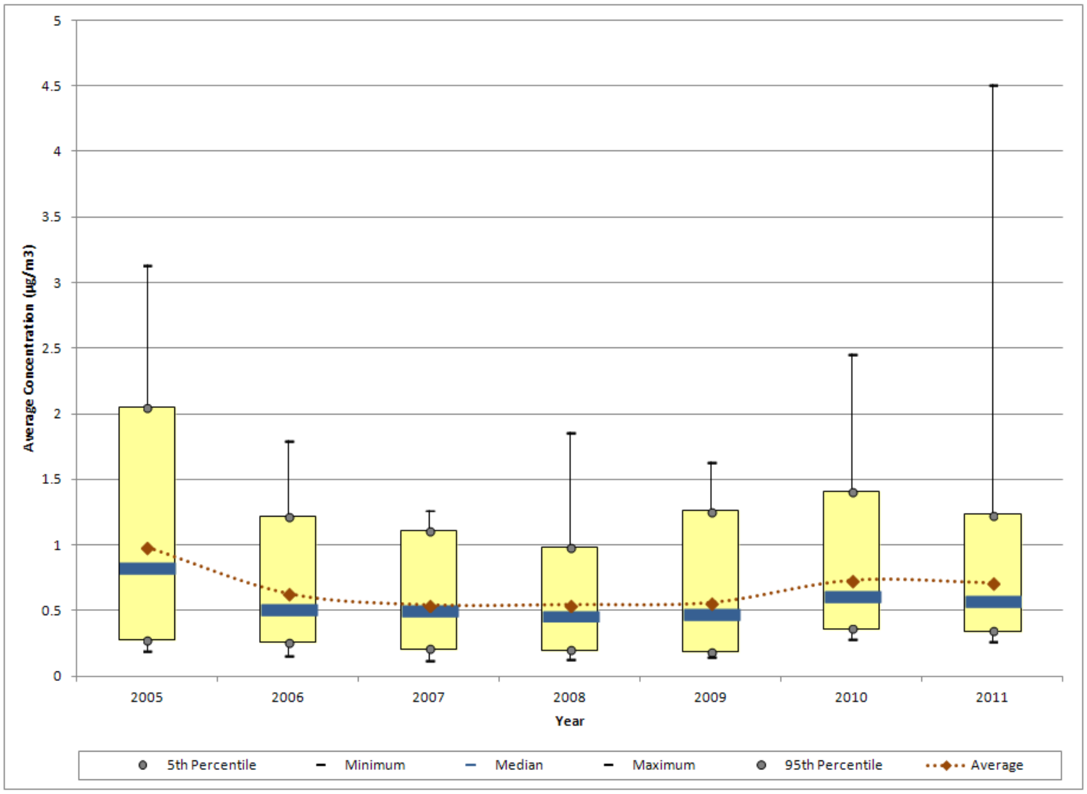


Figure 11-23. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at NBIL

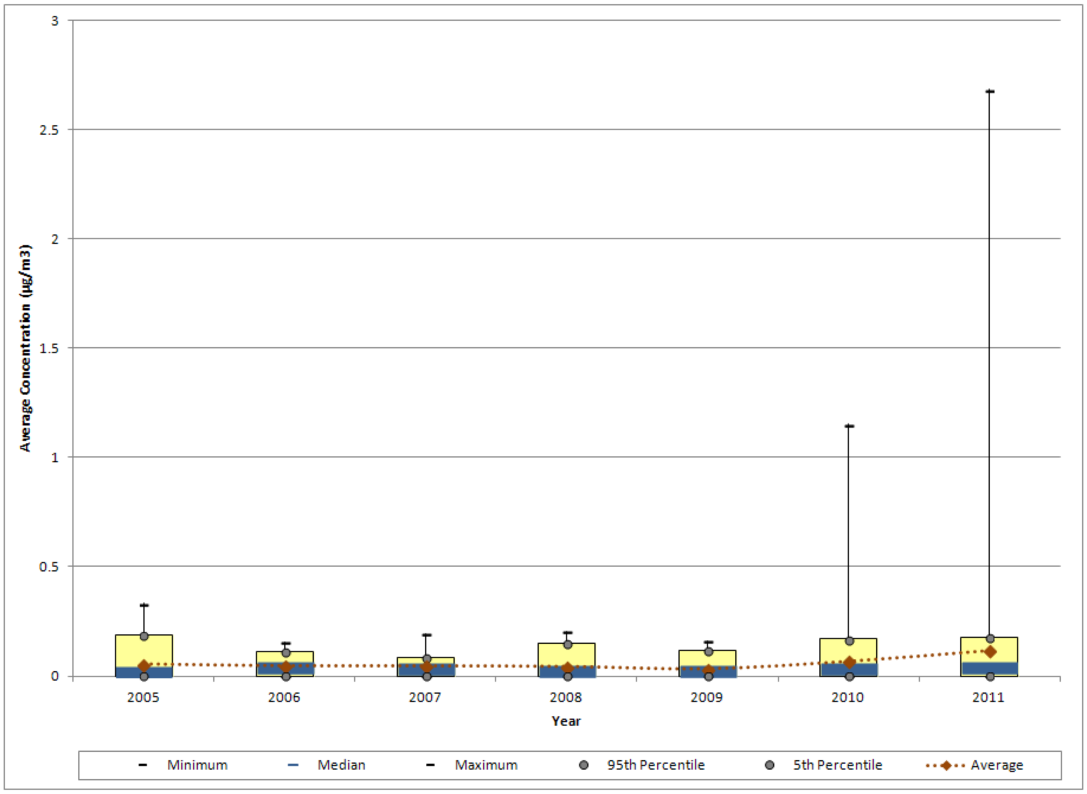
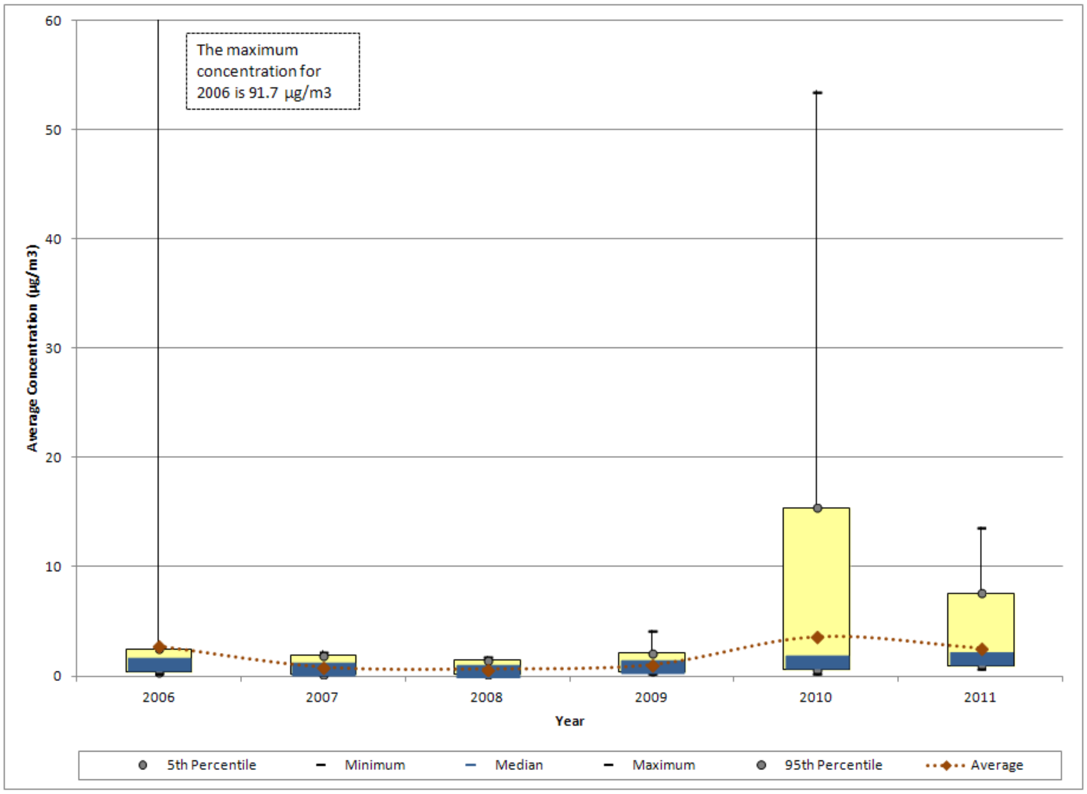


Figure 11-24. Annual Statistical Metrics for Formaldehyde Concentrations Measured at NBIL



.Figure 11-25. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at NBIL

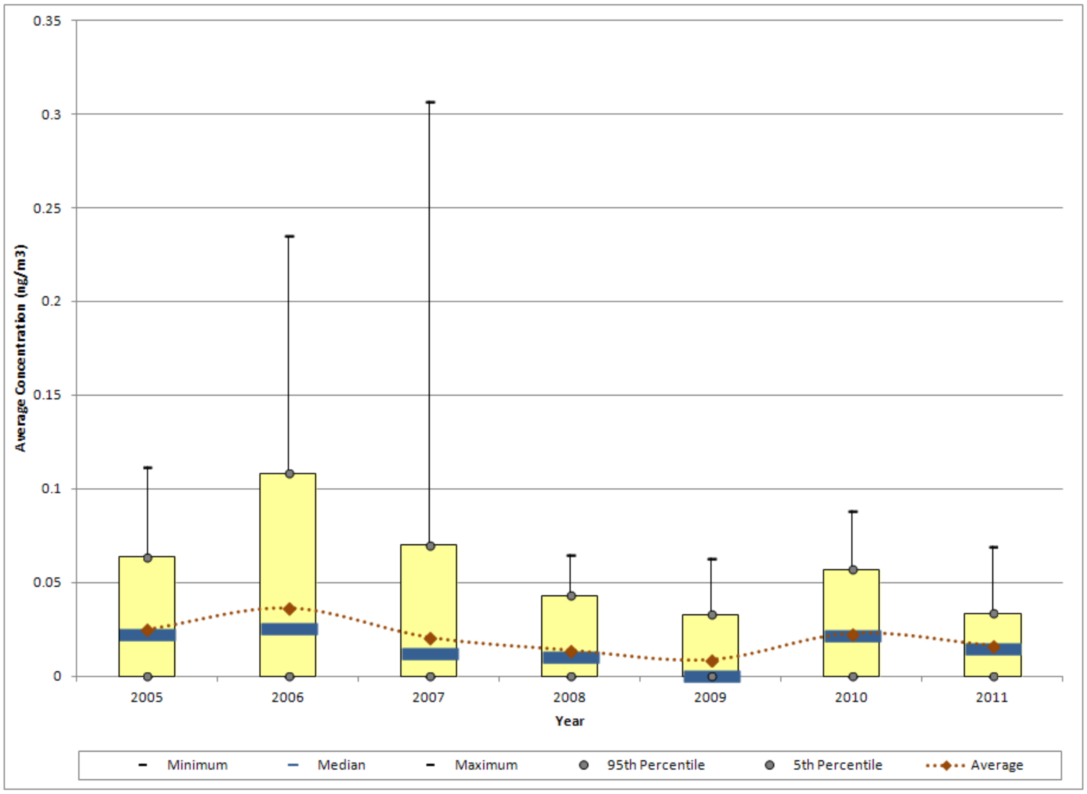


Figure 11-26. Annual Statistical Metrics for Lead (PM_{10}) Concentrations Measured at NBIL

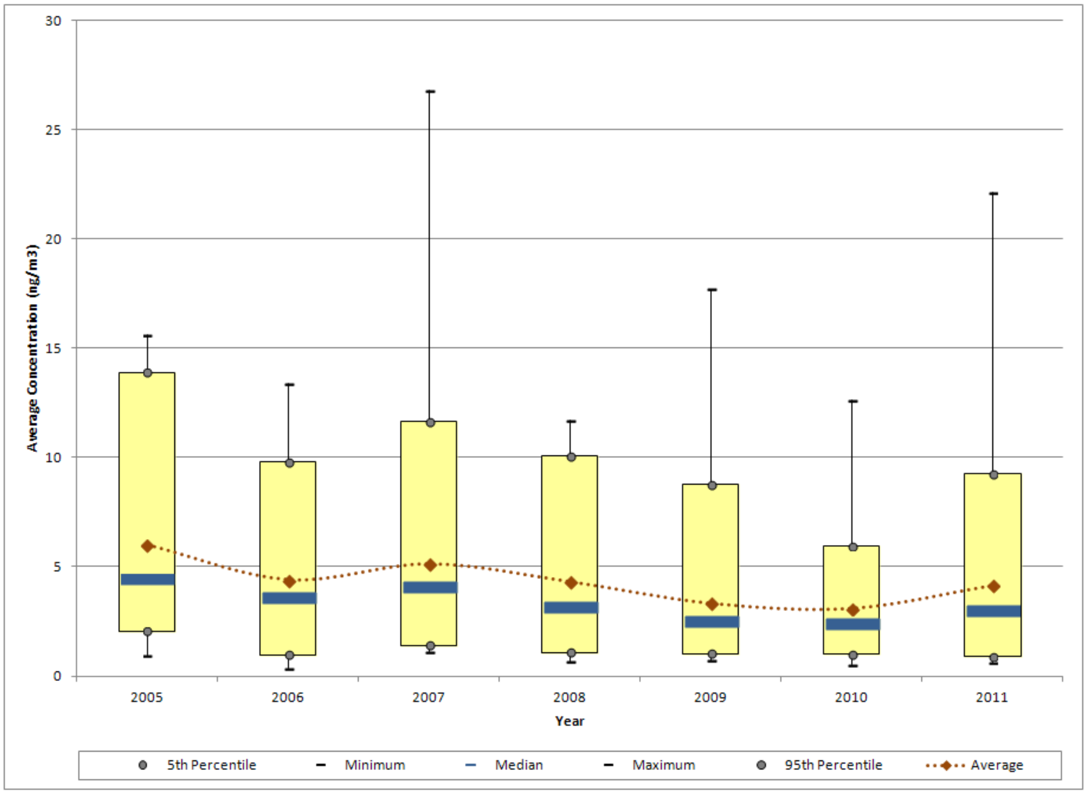


Figure 11-27. Annual Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at NBIL

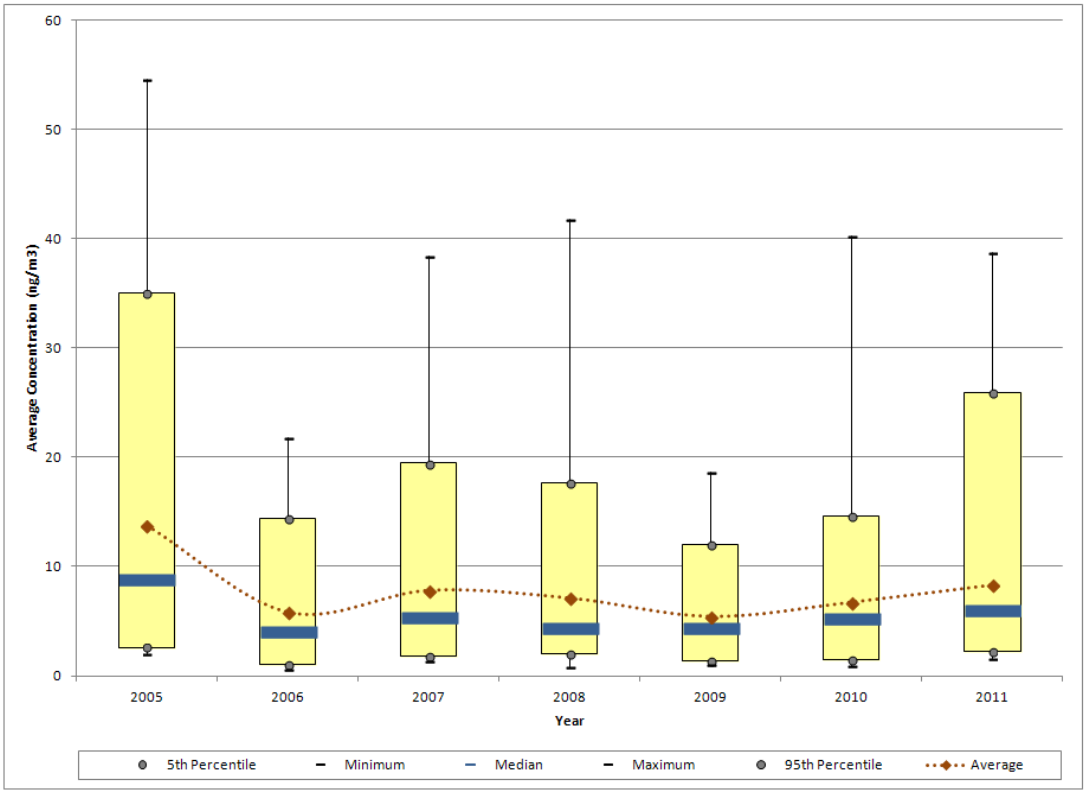


Figure 11-28. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at SPIL

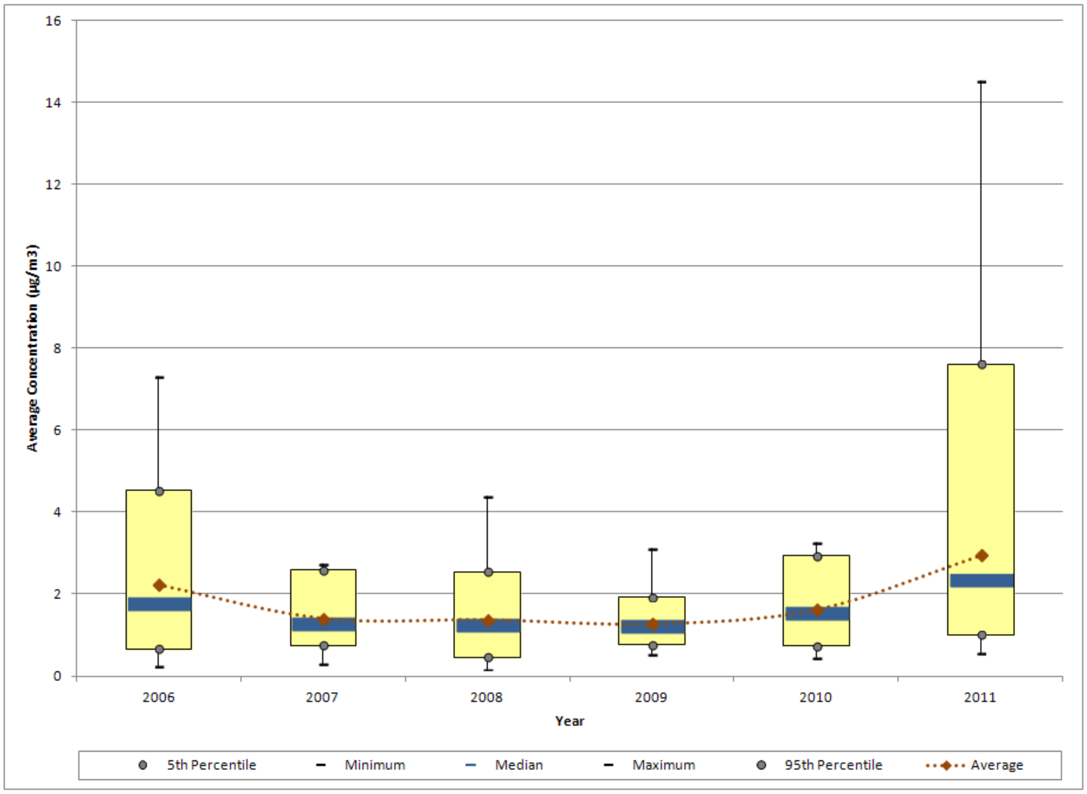


Figure 11-29. Annual Statistical Metrics for Benzene Concentrations Measured at SPIL

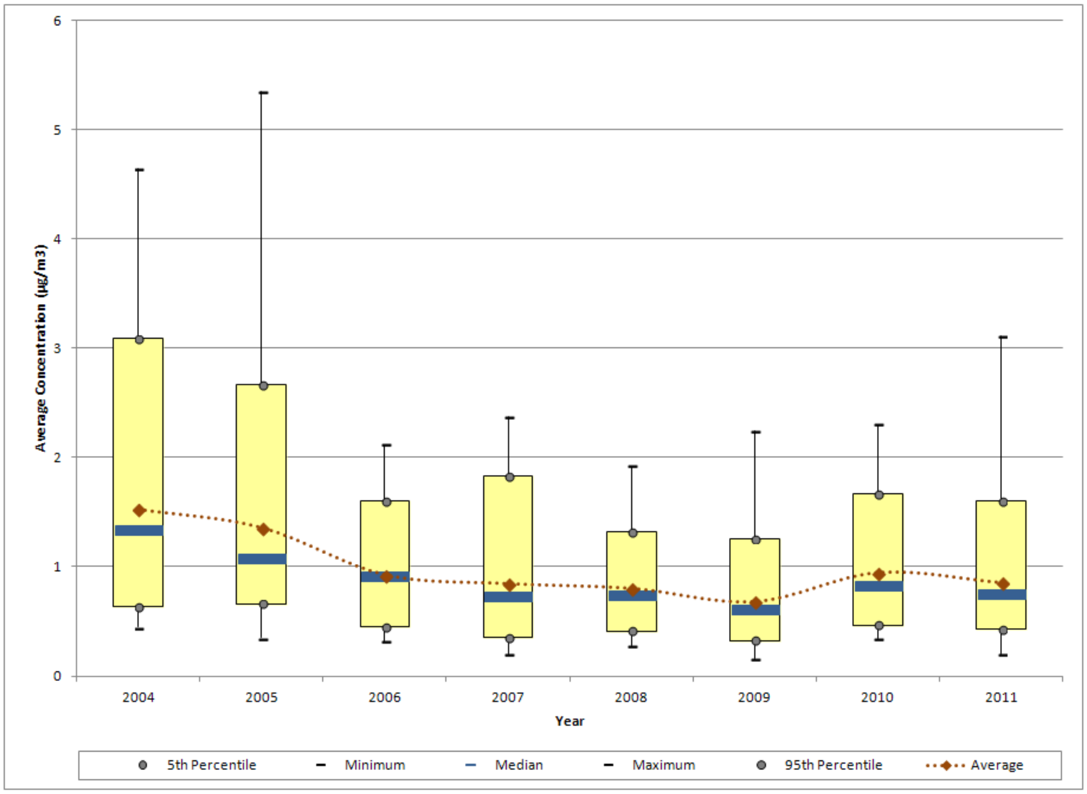


Figure 11-30. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at SPIL

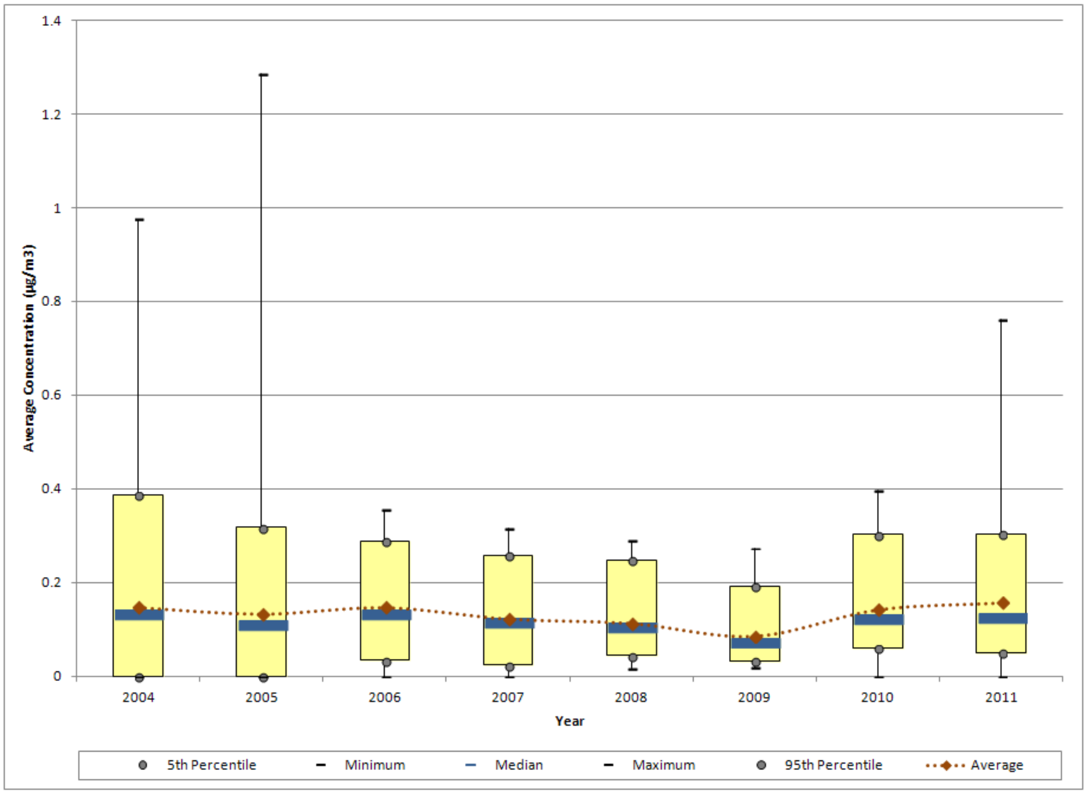
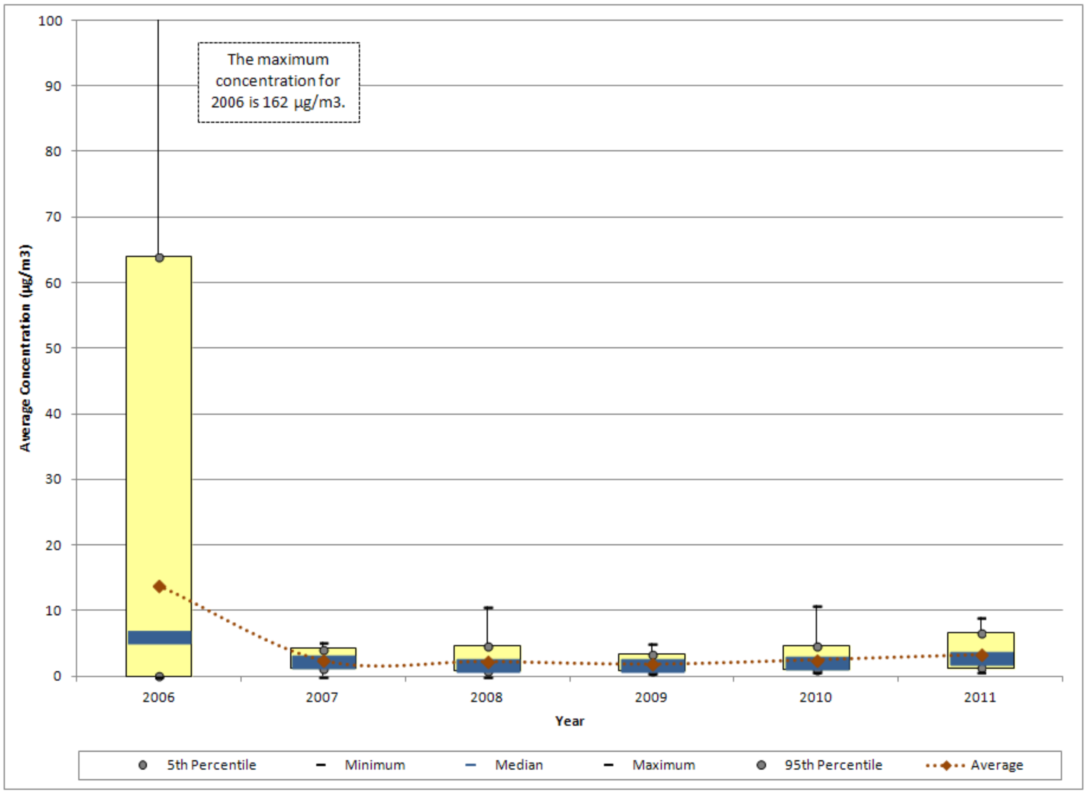


Figure 11-31. Annual Statistical Metrics for Formaldehyde Concentrations Measured at SPIL



Observations from Figure 11-20 for acetaldehyde measurements at NBIL include the following:

- Although carbonyl compound sampling at NBIL began in 2005, sampling did not begin until March, which does not yield enough samples for the statistical metrics to be calculated for 2005, based on the criteria specified in Section 3.5.4. Thus, Figure 11-20 begins with 2006.

- The maximum acetaldehyde concentration (4.12 µg/m^3) was measured in 2011, as was the second highest concentration (3.47 µg/m^3). In fact, of the 19 acetaldehyde concentrations greater than 2 µg/m^3 measured at NBIL, 11 were measured in 2011.

- All of the statistical metrics exhibit an increase from 2009 to 2010 and again for 2011. The 95th percentile for 2011 is greater than the maximum concentration measured for most years of sampling.

- The difference between the average and median concentrations is at a maximum for 2011, reflecting greater variability in the acetaldehyde measurements.

- The minimum concentration for each year is greater than zero, indicating that there were no non-detects of acetaldehyde reported for the years shown.

Observations from Figure 11-21 for arsenic (PM_{10}) measurements 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.
- The average concentrations exhibit little significant change over the course of sampling. The average concentrations increased from 2005 to 2006, reached a maximum for 2007 (0.86 ng/m^3), and then returned to previous levels in 2008, after which the average concentration has remained steady. Since 2008, the average concentrations have ranged from 0.73 ng/m^3 (2011) to 0.75 ng/m^3 (2010).
- Note that 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.

Observations from Figure 11-22 for benzene measurements at NBIL include the following:

- Although sampling for VOCs at NBIL began in 2003, sampling did not begin until April, which does not yield enough samples for the statistical metrics to be calculated for 2003, based on the criteria specified in Section 3.5.4. In addition, sampling for VOCs was discontinued in October 2004 through the end of the year. Thus, Figure 11-22 begins with 2005.
- The maximum benzene concentration was measured on January 9, 2011 and is the only measurement greater than 4 µg/m^3 measured at NBIL.
- The average (and median) concentration decreased significantly from 2005 to 2006, and continued to decreased through 2007, then remained at the same level for 2008 and 2009. The average benzene concentration increased from 2009 to 2010. Even with the maximum concentration measured in 2011, the average concentration remained fairly static (and the 95th percentile actually decreased).
- The minimum concentration for each year is greater than zero, indicating that there were no non-detects of benzene reported for the years shown.

Observations from Figure 11-23 for 1,3-butadiene measurements 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.

- The average concentration changed little through 2009, after which an increase is shown.

- 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 still within the same range. For example, for 2011, only three measurements were greater than the 95th percentile; this is also true for 2010.

- For each year shown, the minimum and 5th percentile are zero, indicating the presence of non-detects (at least 5 percent of the measurements). The number of non-detects reported has fluctuated over the years of sampling, from as high as 43 percent (2005) to as low as seven percent (2007).

Observations from Figure 11-24 for formaldehyde measurements 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 measurement 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 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 in general, as indicated by seven-fold increase in the 95th percentile. Although difficult to discern in Figure 11-24, the average concentration 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 difficult to discern in Figure 11-24, the minimum concentration for each year is greater than zero, indicating that there were no non-detects of formaldehyde reported for the years shown.

Observations from Figure 11-25 for hexavalent chromium measurements at NBIL include the following:

- Hexavalent chromium sampling at NBIL began in January 2005.

- The maximum hexavalent chromium concentration was measured on July 5, 2007 (0.307 ng/m^3). Only five additional measurements from NBIL are greater than 0.1 ng/m^3, and range from 0.108 ng/m^3 to 0.235 ng/m^3. Four of the top six concentrations were measured in 2006, with the fifth measured in 2005.

- Both the minimum concentration and 5th percentile for all years are zero, indicating the presence of non-detects. For 2009, the median concentration is also zero, indicating that at least 50 percent of the measurements are non-detects.

- The average (and median) concentration of hexavalent chromium decreased significantly between 2006 and 2009. The maximum, 95th percentile, median, and average concentrations all exhibit an increase for 2010. For 2011, the range of concentrations (based on the minimum and maximum concentrations as well as the 5th and 95th percentiles) is more similar to the statistical metrics for 2009, although both the average and median concentrations are higher for 2011, most likely because the number of non-detects is significantly lower (from 56 percent non-detects in 2009 down to 18 percent in 2011).

Observations from Figure 11-26 for lead (PM_{10}) measurements at NBIL include the following:

- The maximum lead concentration was measured on July 5, 2007 (26.8 ng/m^3), which is the same day the maximum hexavalent chromium concentration was measured. The only other concentration greater than 20 ng/m^3 was measured in October 2011.

- The average concentrations exhibit a decreasing trend from 2008 through 2010, but increased in 2011 back to 2008 levels.

- The average and median concentrations differ by nearly 1 ng/m^3 for each year.

- The minimum concentration for each year is greater than zero, indicating that there were no non-detects of lead reported since the onset of metals sampling.

Observations from Figure 11-27 for manganese (PM_{10}) measurements at NBIL include the following:

- The maximum manganese concentration was measured on August 26, 2005 (54.6 ng/m^3). Concentrations in the 40-45 ng/m^3 range have been measured in 2005, 2008, and 2010.

- The average concentration decreased significantly from 2005 to 2006. Note that the average concentration for 2005 is greater than or similar to the 95th percentiles for some of the years that follow. After 2005, changes in the averages are statistically insignificant.

- Nearly all of the statistical metrics are at a minimum for 2009.

- The minimum concentration for each year is greater than zero, indicating that there were no non-detects of manganese reported since the onset of metals sampling.

Observations from Figure 11-28 for acetaldehyde measurements at SPIL include the following:

- Although carbonyl compound sampling at SPIL began in 2005, sampling did not begin in earnest until March, which does not yield enough samples for the statistical metrics to be calculated for 2005, based on the criteria specified in Section 3.5.4. Thus, Figure 11-28 begins with 2006.

- The maximum acetaldehyde concentration was measured on January 9, 2011. The four highest concentrations of acetaldehyde were measured in 2011 and of the 10 acetaldehyde concentrations greater than 5.0 μg/m^3 measured at SPIL, eight measured in 2011.

- The average concentration decreased from 2006 to 2007, then held steady through 2009. The average concentration increased slightly in 2010 then increased significantly in 2011. All of the statistical metrics increased for 2011, including the 95th percentile, indicating that the increases shown are not attributable to a handful of outliers.

- Note that the minimum concentration for each year is greater than zero, indicating that there were no non-detects of acetaldehyde reported for SPIL over the period shown.

Observations from Figure 11-29 for benzene measurements at SPIL include the following:

- Although sampling for VOCs at SPIL began in 2003, sampling did not begin in until April 2003, which does not yield enough samples for the statistical metrics to be calculated for 2003, based on the criteria specified in Section 3.5.4. Thus, Figure 11-29 begins with 2004.

- The maximum benzene concentration was measured on October 13, 2005, although a similar concentration was also measured in February 2005.

- The average benzene concentration has decreased over the years, reaching a minimum of 0.68 μg/m^3 for 2009. The average concentration then increased for 2010, with a slight decrease for 2011.

- The minimum concentration for each year is greater than zero, indicating that no non-detects of benzene have been reported for SPIL over the period shown.

Observations from Figure 11-30 for 1,3-butadiene measurements at SPIL include the following:

- The maximum concentration of 1,3-butadiene was measured on February 3, 2005 (1.29 µg/m^3) and is the only measurement greater than 1 µg/m^3. Only five concentrations greater than 0.5 µg/m^3 have been measured at SPIL, one in 2004, two in 2005, and two in 2011.

- The average concentration of 1,3-butadiene began to decrease in 2007 and reached a minimum in 2009 (0.085 µg/m^3). The increase from 2009 to 2010 is significant, with a 40 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, has been decreasing over the years, but increased significantly for 2010, which continued into 2011.

- The detection rate for 1,3-butadiene has increased over time, ranging from approximately 45 percent non-detects in 2004 down to zero in 2008 and 2009 and one non-detect each for 2010 and 2011.

Observations from Figure 11-31 for formaldehyde measurements at SPIL include the following:

- The maximum formaldehyde concentration was measured on May 29, 2006 and is more than 10 times the maximum concentrations for any of the other years shown in Figure 11-31. Of the 26 formaldehyde concentrations greater than 10 µg/m^3, all but two were measured in 2006.

- The average concentration for 2006 is 13.76 µg/m^3. After 2006, the average concentration decreased each year, reaching a minimum of 1.85 µg/m^3 for 2009. Although difficult to discern in Figure 11-31, the average concentration has increased each year since 2009.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 Hazard Approximation (HQ)
Northbrook, Illinois - NBIL						
Acenaphthene [a]	0.000088	--	61/61	0.01 ± <0.01	1.16	--
Acetaldehyde	0.0000022	0.009	62/62	1.41 ± 0.20	3.11	0.16
Acrylonitrile	0.000068	0.002	35/55	0.13 ± 0.03	9.07	0.07
Arsenic (PM_{10})[a]	0.0043	0.000015	53/53	<0.01 ± <0.01	3.15	0.05
Benzene	0.0000078	0.03	55/55	0.71 ± 0.16	5.53	0.02
Benzo(a)pyrene [a]	0.00176	--	59/61	<0.01 ± <0.01	0.26	--
Beryllium (PM_{10}) [a]	0.0024	0.00002	51/53	<0.01 ± <0.01	0.02	<0.01
1,3-Butadiene	0.00003	0.002	41/55	0.12 ± 0.10	3.45	0.06
Cadmium (PM_{10}) [a]	0.0018	0.00001	53/53	<0.01 ± <0.01	0.26	0.01
Carbon Tetrachloride	0.000006	0.1	55/55	0.64 ± 0.03	3.84	0.01
Chloroform	--	0.098	55/55	6.06 ± 2.17	--	0.06
1,2-Dichloroethane	0.000026	2.4	18/55	0.03 ± 0.01	0.67	<0.01
Ethylbenzene	0.0000025	1	55/55	0.32 ± 0.12	0.80	<0.01
Fluoranthene [a]	0.000088	--	61/61	0.01 ± <0.01	0.67	--
Fluorene [a]	0.000088	--	61/61	0.01 ± <0.01	1.18	--
Formaldehyde	0.000013	0.0098	62/62	2.53 ± 0.57	32.89	0.26
Hexavalent Chromium [a]	0.012	0.0001	50/61	<0.01 ± <0.01	0.20	<0.01
Lead (PM_{10}) [a]	--	0.00015	53/53	<0.01 ± <0.01	--	0.03
Manganese (PM_{10}) [a]	--	0.00005	53/53	0.01 ± <0.01	--	0.17
Naphthalene [a]	0.000034	0.003	61/61	0.10 ± 0.03	3.38	0.03
Nickel (PM_{10}) [a]	0.00048	0.00009	53/53	<0.01 ± <0.01	0.61	0.01
Tetrachloroethylene	0.00000026	0.04	53/55	0.35 ± 0.13	0.09	0.01
Trichloroethylene	0.0000048	0.002	24/55	0.04 ± 0.02	0.21	0.02
Vinyl Chloride	0.0000088	0.1	8/55	<0.01 ± <0.01	0.03	<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 11-5.

Table 11-6. Risk Approximations for the Illinois 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 Hazard Approximation (HQ)
Schiller Park, Illinois - SPIL						
Acetaldehyde	0.0000022	0.009	62/62	2.94 ± 0.61	6.48	0.33
Acrylonitrile	0.000068	0.002	47/56	0.77 ± 0.11	52.22	0.38
Benzene	0.0000078	0.03	56/56	0.85 ± 0.12	6.64	0.03
1,3-Butadiene	0.00003	0.002	55/56	0.16 ± 0.03	4.69	0.08
Carbon Tetrachloride	0.000006	0.1	56/56	0.58 ± 0.02	3.50	0.01
Chloroform	--	0.098	38/56	0.09 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	33/56	0.07 ± 0.03	0.80	<0.01
1,2-Dichloroethane	0.000026	2.4	15/56	0.02 ± 0.01	0.59	<0.01
Formaldehyde	0.000013	0.0098	62/62	3.29 ± 0.46	42.81	0.34
Tetrachloroethylene	0.00000026	0.04	53/56	0.31 ± 0.08	0.08	0.01
Trichloroethylene	0.0000048	0.002	42/56	0.64 ± 0.41	3.05	0.32
Vinyl Chloride	0.0000088	0.1	6/56	<0.01 ± <0.01	0.03	<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 11-5.

Observations for NBIL from Table 11-6 include the following:

- Chloroform, formaldehyde, and acetaldehyde are the pollutants with the highest annual average concentrations for NBIL.

- Formaldehyde, acrylonitrile, and benzene have the highest cancer risk approximations.

- None of NBIL's pollutants of interest 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 formaldehyde (0.26).

- Note that chloroform, which has the highest annual average for NBIL, has no cancer URE. The noncancer hazard approximation for this pollutant is low (0.06).

Observations for SPIL from Table 11-6 include the following:

- Formaldehyde, acetaldehyde, and benzene are the pollutants with the highest annual average concentrations for SPIL.
- Acrylonitrile has the highest cancer risk approximation for SPIL (52.22 in-a-million), followed by formaldehyde (42.81 in-a-million). The cancer risk approximation for acrylonitrile is the fifth highest cancer risk approximation among all site-specific pollutants of interest and the only pollutant besides formaldehyde program-wide with a cancer risk approximation greater than 30 in-a-million.
- None of SPIL's pollutants of interest have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants. The pollutants with the highest noncancer hazard approximations are acrylonitrile and formaldehyde (0.38 and 0.34, respectively) although acetaldehyde and trichloroethylene have noncancer hazard approximations of similar magnitudes.
- In most cases, the risk approximations for SPIL are greater than the risk approximations for NBIL. This is most apparent for acrylonitrile, formaldehyde, and trichloroethylene, with chloroform being the exception.

11.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 11-7 and 11-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from annual averages provided in Table 11-6. Table 11-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 11-6.

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	1,445.06	Formaldehyde	1.37E-02	Formaldehyde	32.89
Formaldehyde	1,055.89	Benzene	1.13E-02	Acrylonitrile	9.07
Ethylbenzene	791.28	Hexavalent Chromium, PM	6.92E-03	Benzene	5.53
Acetaldehyde	689.38	1,3-Butadiene	6.28E-03	Carbon Tetrachloride	3.84
1,3-Butadiene	209.30	Naphthalene	4.30E-03	1,3-Butadiene	3.45
Tetrachloroethylene	190.73	Cadmium, PM	2.67E-03	Naphthalene	3.38
Trichloroethylene	134.75	Nickel, PM	2.44E-03	Arsenic	3.15
Naphthalene	126.41	Arsenic, PM	2.17E-03	Acetaldehyde	3.11
Dichloromethane	93.18	Ethylbenzene	1.98E-03	Fluorene	1.18
POM, Group 2b	20.55	POM, Group 2b	1.81E-03	Acenaphthene	1.16
Schiller Park, Illinois (Cook County) - SPIL					
Benzene	1,445.06	Formaldehyde	1.37E-02	Acrylonitrile	52.22
Formaldehyde	1,055.89	Benzene	1.13E-02	Formaldehyde	42.81
Ethylbenzene	791.28	Hexavalent Chromium, PM	6.92E-03	Benzene	6.64
Acetaldehyde	689.38	1,3-Butadiene	6.28E-03	Acetaldehyde	6.48
1,3-Butadiene	209.30	Naphthalene	4.30E-03	1,3-Butadiene	4.69
Tetrachloroethylene	190.73	Cadmium, PM	2.67E-03	Carbon Tetrachloride	3.50
Trichloroethylene	134.75	Nickel, PM	2.44E-03	Trichloroethylene	3.05
Naphthalene	126.41	Arsenic, PM	2.17E-03	*p*-Dichlorobenzene	0.80
Dichloromethane	93.18	Ethylbenzene	1.98E-03	1,2-Dichloroethane	0.59
POM, Group 2b	20.55	POM, Group 2b	1.81E-03	Tetrachloroethylene	0.08

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	5,432.03	Acrolein	3,705,826.42	Formaldehyde	0.26
Xylenes	3,804.27	Manganese, PM	161,905.82	Manganese	0.17
Methanol	3,800.86	Cadmium, PM	148,156.47	Acetaldehyde	0.16
1,1,1-Trichloroethane	3,014.08	Formaldehyde	107,743.48	Acrylonitrile	0.07
Methyl isobutyl ketone	2,290.29	1,3-Butadiene	104,651.38	Chloroform	0.06
Benzene	1,445.06	Acetaldehyde	76,598.28	1,3-Butadiene	0.06
Formaldehyde	1,055.89	Trichloroethylene	67,372.78	Arsenic	0.05
Hexane	1,006.50	Nickel, PM	56,590.58	Naphthalene	0.03
Ethylbenzene	791.28	Benzene	48,168.61	Lead	0.03
Acetaldehyde	689.38	Naphthalene	42,137.52	Benzene	0.02
Schiller Park, Illinois (Cook County) – SPIL					
Toluene	5,432.03	Acrolein	3,705,826.42	Acrylonitrile	0.38
Xylenes	3,804.27	Manganese, PM	161,905.82	Formaldehyde	0.34
Methanol	3,800.86	Cadmium, PM	148,156.47	Acetaldehyde	0.33
1,1,1-Trichloroethane	3,014.08	Formaldehyde	107,743.48	Trichloroethylene	0.32
Methyl isobutyl ketone	2,290.29	1,3-Butadiene	104,651.38	1,3-Butadiene	0.08
Benzene	1,445.06	Acetaldehyde	76,598.28	Benzene	0.03
Formaldehyde	1,055.89	Trichloroethylene	67,372.78	Tetrachloroethylene	0.01
Hexane	1,006.50	Nickel, PM	56,590.58	Carbon Tetrachloride	0.01
Ethylbenzene	791.28	Benzene	48,168.61	Chloroform	<0.01
Acetaldehyde	689.38	Naphthalene	42,137.52	*p*-Dichlorobenzene	<0.01

The pollutants listed in Tables 11-7 and 11-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 11.3, SPIL sampled for VOCs and carbonyl compounds. NBIL sampled for these pollutants as well, but also sampled for SNMOCs, PM_{10} metals, PAHs, and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 11-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Cook County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Cook County are formaldehyde, benzene, and hexavalent chromium.
- Six of the highest emitted pollutants in Cook County also have the highest toxicity-weighted emissions.
- For both monitoring sites, formaldehyde, acrylonitrile, and benzene have the highest cancer risk approximations, although not necessarily in that order. Formaldehyde and benzene are the top two pollutants on both emissions-based lists, while acrylonitrile appears on neither emissions-based list.
- Carbon tetrachloride, which also appears among the pollutants with the highest cancer risk approximations for both sites, does not appear on either emissions-based list.
- Several metals appear among the pollutants with the highest toxicity-weighted emissions, including arsenic, which has the seventh highest cancer risk approximation for NBIL. SPIL did not sample metals. None of these metals appear among the highest emitted pollutants.
- 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.

- POM, Group 2b ranks tenth for both the quantity emitted and the toxicity-weighted emissions in Cook County. POM, Group 2b includes acenaphthene, fluorene, and fluoranthene, all three of which are pollutants of interest for NBIL.

Observations from Table 11-8 include the following:

- Toluene, xylenes, and methanol are the highest emitted pollutants with noncancer RfCs in Cook County.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for Cook County are acrolein, manganese, and cadmium. Although acrolein was sampled for at both NBIL and SPIL, 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 also have the highest toxicity-weighted emissions (benzene, formaldehyde, and acetaldehyde).

- Formaldehyde, manganese, and acetaldehyde have the highest noncancer hazard approximations for NBIL (albeit less than an HQ of 1.0). Formaldehyde and acetaldehyde appear on both emissions-based lists while manganese has the second highest toxicity-weighted emissions, but is not among the highest emitted pollutants in Cook County.

- Acrylonitrile has the highest noncancer hazard approximation for SPIL (albeit less than an HQ of 1.0). This pollutant appears on neither emissions-based list.

11.6 Summary of the 2011 Monitoring Data for NBIL and SPIL

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

- ❖ *Twenty-four pollutants, including 13 NATTS MQO Core Analytes, failed screens for NBIL. Sixteen pollutants, including six NATTS MQO Core Analytes, failed screens for SPIL.*

- ❖ *The pollutant with the highest annual average concentration among the pollutants of interest for NBIL was chloroform. NBIL's annual average concentration of chloroform was the highest annual average among all NMP sites sampling this pollutant.*

- ❖ *The pollutant with the highest annual average concentration among the pollutants of interest for SPIL was formaldehyde.SPIL has the highest annual average concentration of acrylonitrile and trichloroethylene among NMP sites sampling these pollutants.*

- *Concentrations of acetaldehyde and 1,3-butadiene have been increasing in recent years at NBIL and SPIL.*

12.0 Sites in Indiana

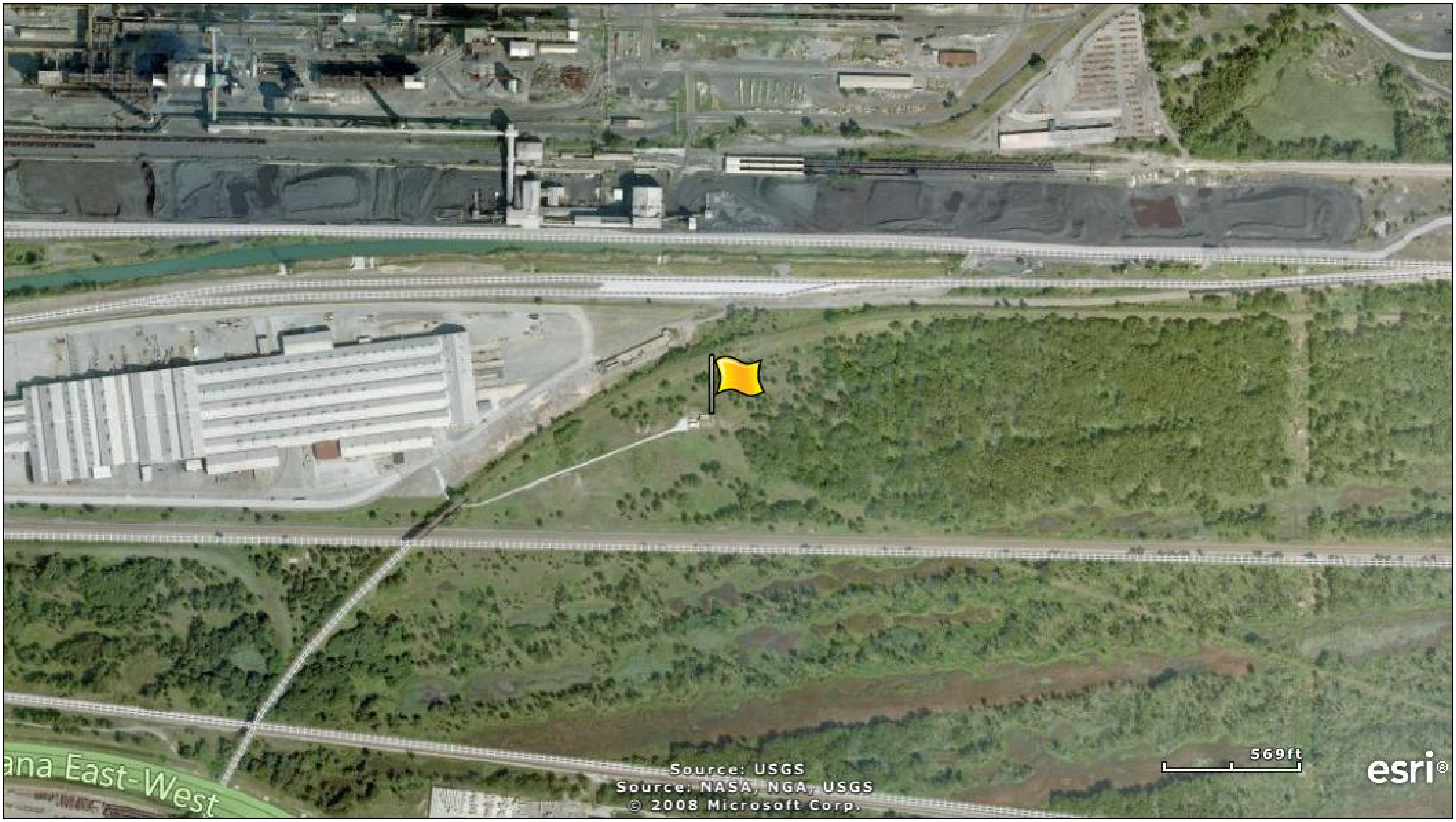
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP sites in Indiana, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data 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 site (INDEM) is located in the Chicago-Naperville-Joliet, IL-IN-WI MSA, while a second site (WPIN) is located in the Indianapolis-Carmel, IN MSA. Figures 12-1 and 12-3 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban locations. Figures 12-2 and 12-4 identify nearby point source emissions locations by source category near INDEM and WPIN, respectively, as reported in the 2008 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
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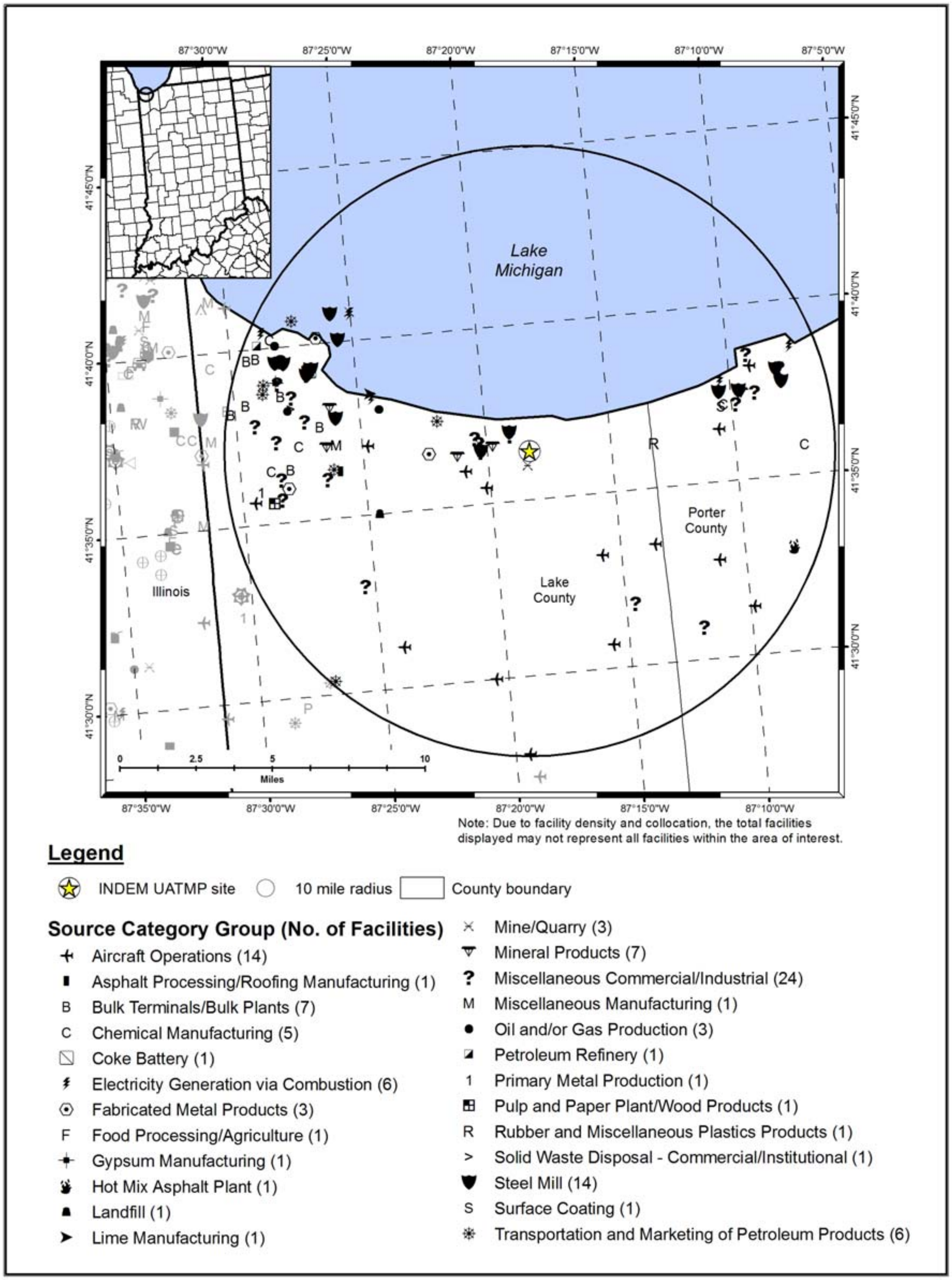
Figure 12-2. NEI Point Sources Located Within 10 Miles of INDEM



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

Figure 12-3. Indianapolis, Indiana (WPIN) Monitoring Site

Source: USGS
Source: NASA, NGA, USGS
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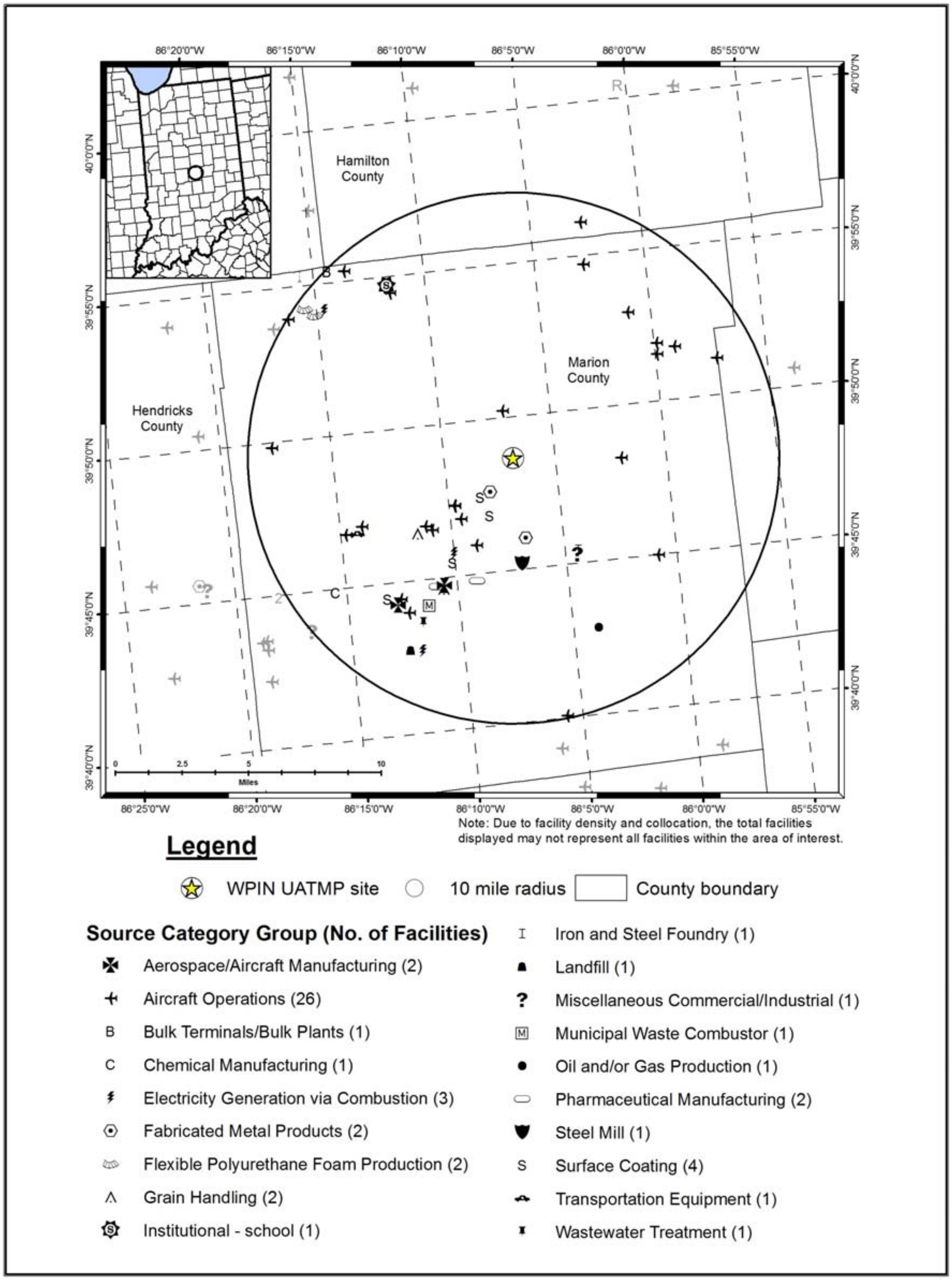
Figure 12-4. NEI Point Sources Located Within 10 Miles of WPIN



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-Joliet-Naperville, IL-IN-WI MSA (Gary Div)	41.606667, -87.304722	Industrial	Urban/City Center	VOCs, SO_2, NO, NO_2, NO_x, PAMS, O_3, Meteorological parameters, PM_{10}, Black carbon, UV Carbon, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Tetrahydrofuran, 1,4-Dioxane.
WPIN	18-097-0078	Indianapolis	Marion	Indianapolis-Carmel, IN MSA	39.811097, -86.114469	Residential	Suburban	TSP Metals, CO, VOCs, SNMOCs, SO_2, NO_y, NO, O_3, Meteorological parameters, PM_{10}, Black carbon, UV Carbon, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Tetrahydrofuran, 1,4-Dioxane, PM Coarse.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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. The sources closest to INDEM are a mine/quarry, a steel mill, and a facility that falls into the miscellaneous commercial/industrial category. The emissions source categories with the highest number of sources within 10 miles of INDEM include steel mills; aircraft operations; mineral products; and bulk terminals and plants.

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 aircraft operations source category, which include airports as well as small runways, heliports, or landing pads. The sources closest to WPIN are an aircraft operations facility and a fabricated metal products facility.

Table 12-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Indiana monitoring sites. Table 12-2 includes county-level population and vehicle registration information. Table 12-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 12-2 also contains traffic volume information for each site. Finally, Table 12-2 presents the county-level daily VMT for Marion and Lake Counties.

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Table 12-2. Population, Motor Vehicle, and Traffic Information for the Indiana Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
INDEM	495,558	419,431	0.85	411,932	348,652	34,240	16,226,000
WPIN	911,296	820,767	0.90	797,291	718,087	143,970	32,005,000

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Indiana Bureau of Motor Vehicles (IN BMV, 2012)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2010 data from the Indiana DOT (IN DOT, 2010)
[5] County-level VMT reflects 2011 data from the Indiana DOT (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 10-mile population and estimated vehicle registration follow a similar pattern as the county-level values.

- The county-level and 10-mile populations are in the middle third of populations among NMP sites as are the county-level and 10-mile vehicle registrations.

- The vehicle-per-person ratios for both Indiana sites are in the middle of the range among the ratios for NMP sites.

- 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 while the traffic volume for INDEM is based on data from I-90 at 12/20. The traffic volume near WPIN is the seventh highest among NMP sites.

- The VMT for Marion County is almost twice the VMT for Lake County. The Marion County VMT ranked tenth 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, and 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 (Bair, 1992; Gary, 2013; and 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. The prevailing wind direction is southwesterly (Bair, 1992 and ISCO, 2002).

12.2.2 Meteorological Conditions in 2011

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). 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 the entire year for 2011. 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 were representative of average weather conditions throughout the year for WPIN. For INDEM, sample days appear slightly cooler and less moist than all days throughout 2011, although the difference is not statistically significant.

Table 12-3. Average Meteorological Conditions near the Indiana Monitoring Sites

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)
Gary, Indiana - INDEM									
Lansing Municipal Airport 04879 (41.54, -87.52)	11.36 miles 241° (WSW)	Sample Day	58.0 ± 5.8	49.6 ± 5.2	40.3 ± 4.8	45.0 ± 4.7	72.9 ± 2.7	NA	7.2 ± 0.9
		2011	59.3 ± 2.2	51.1 ± 2.0	42.2 ± 1.9	46.6 ± 1.8	74.1 ± 1.2	NA	7.0 ± 0.4
Indianapolis, Indiana - WPIN									
Eagle Creek Airpark 53842 (39.83, -86.30)	9.13 miles 270° (W)	Sample Day	61.3 ± 5.2	53.1 ± 5.0	42.9 ± 4.7	47.9 ± 4.5	71.1 ± 3.1	1016.3 ± 1.7	5.6 ± 0.7
		2011	62.3 ± 2.1	54.1 ± 1.9	43.6 ± 1.8	48.7 ± 1.7	70.3 ± 1.2	1015.6 ± 0.7	5.7 ± 0.3

[1] Sample day averages are highlighted to 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 in 2011. 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.
- The 24-hour air shed domain for INDEM was among the larger in size compared to other NMP sites, with an average trajectory length of 263 miles. The farthest away a back trajectory originated was over northwest North Dakota, or nearly 875 miles away. However, most trajectories (approximately 90 percent) originated within 450 miles of INDEM, with the longest trajectories originating from the west, northwest, and north.
- The short cluster trajectory originating over Lake Michigan represents nearly one-third of back trajectories and includes trajectories originating from a direction with a northerly component and within 200 miles of the sites. Twenty-two percent of trajectories originated from the southwest of INDEM over Illinois and Missouri. Another 21 percent of back trajectories originated from the west to northwest to north of the site. Fifteen percent of trajectories originated from the southeast quadrant while 11 percent originated from the northeast quadrant.

Figure 12-5. 2011 Composite Back Trajectory Map for INDEM

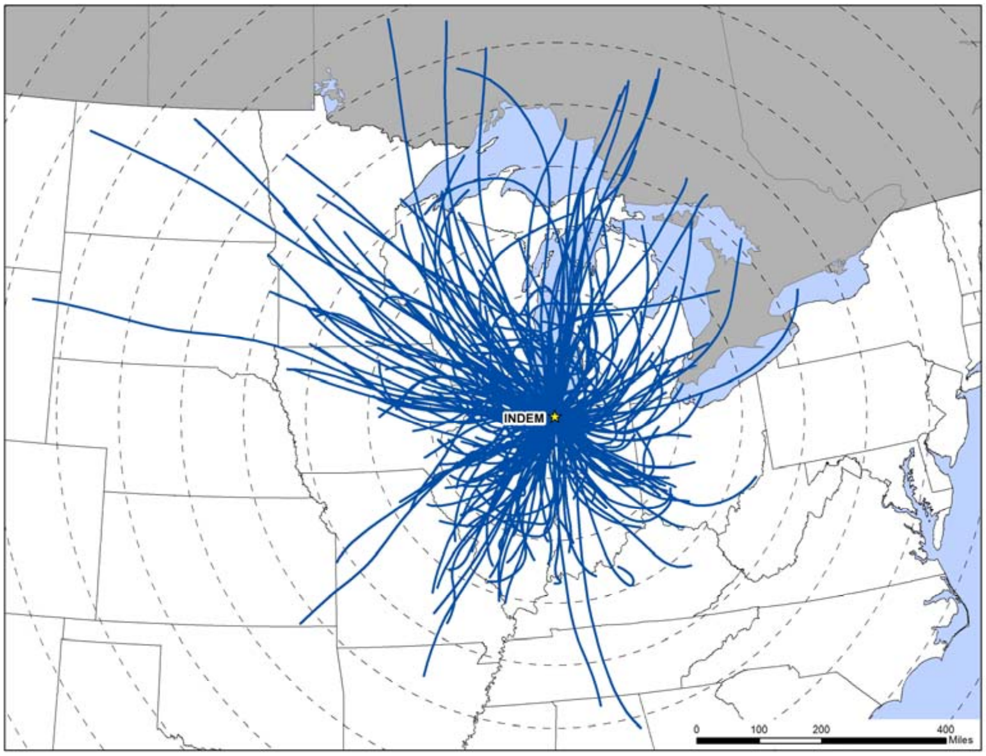


Figure 12-6. Back Trajectory Cluster Map for INDEM

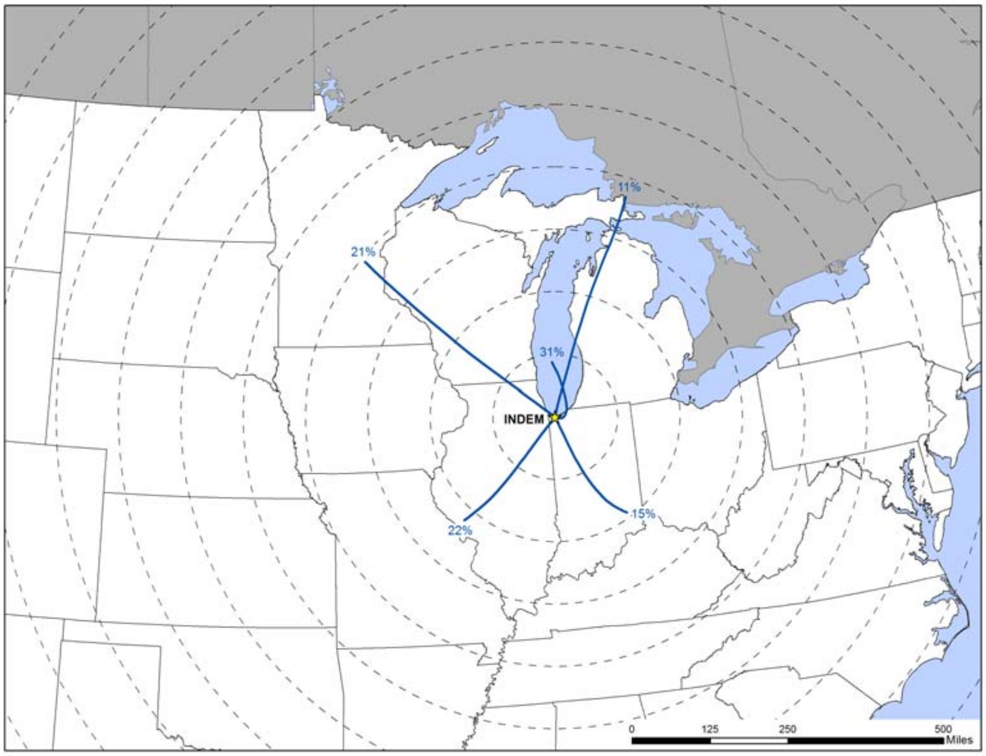


Figure 12-7. 2011 Composite Back Trajectory Map for WPIN

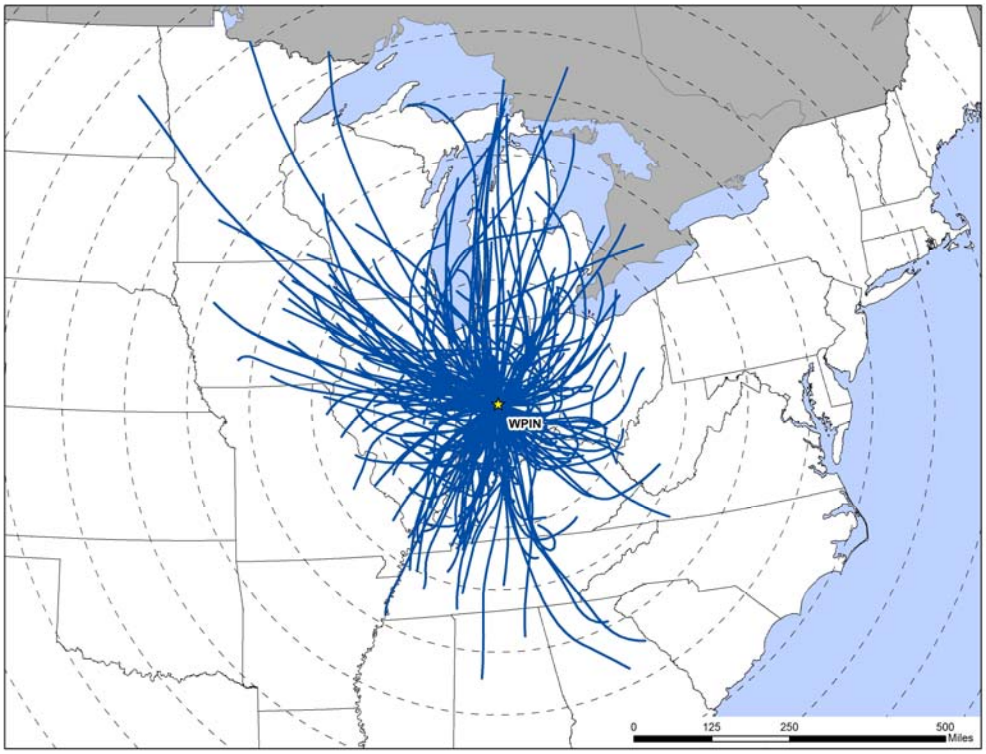
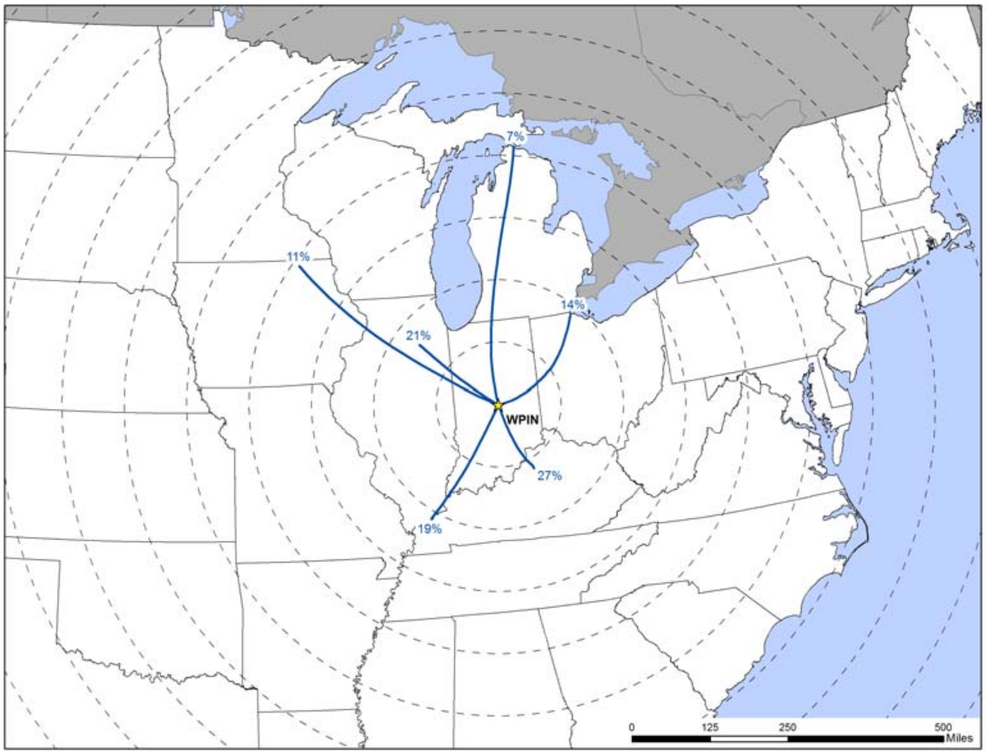


Figure 12-8. Back Trajectory Cluster Map for WPIN



Observations from Figures 12-7 and 12-8 for WPIN include the following:

- The composite back trajectory map for WPIN shows that back trajectories originated from a variety of directions, similar to INDEM.
- The 24-hour air shed domain for WPIN is similar in size to many other NMP monitoring sites, with an average trajectory length of 225 miles. The farthest away a back trajectory originated was over eastern North Dakota, or greater than 750 miles away, although most trajectories (90 percent) originated within 400 miles of WPIN. Back trajectories originating to the northwest and north tended to be the longest.
- The cluster analysis for WPIN shows that back trajectories originating from the northwest account for nearly one-third of back trajectories but are split into two cluster trajectories to account for varying lengths of trajectories. The shorter cluster trajectory originating over Illinois (21 percent) represents back trajectories originating from the west, northwest, and north and generally less than 250 miles in length. The short cluster trajectory originating over northern Kentucky represents back trajectories originating from the east, southeast, and south but of varying distances. Back trajectories also originated southwestward over Illinois and Kentucky; over Ohio, Michigan, and the eastern Great Lakes; and northward over Michigan and Lakes Michigan, Superior, and Huron, and parts of Ontario, Canada.

12.2.4 Wind Rose Comparison

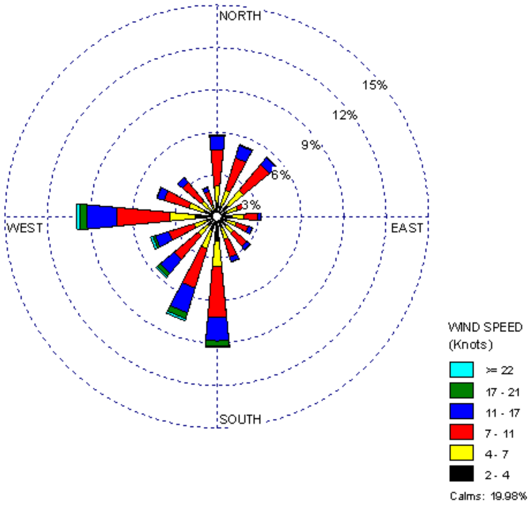
Hourly surface wind data from the NWS weather stations near the Indiana sites, as presented in Section 12.2.2, were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 12-9 presents a map showing the distance between the NWS 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 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and 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.

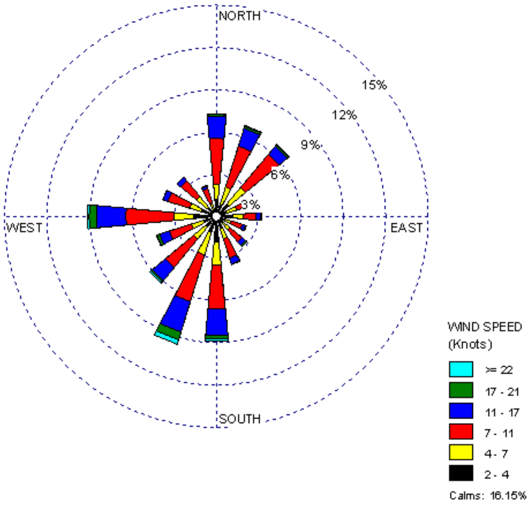
Figure 12-9. Wind Roses for the Lansing Municipal Airport Weather Station near INDEM

Distance between INDEM and NWS Station

2003-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

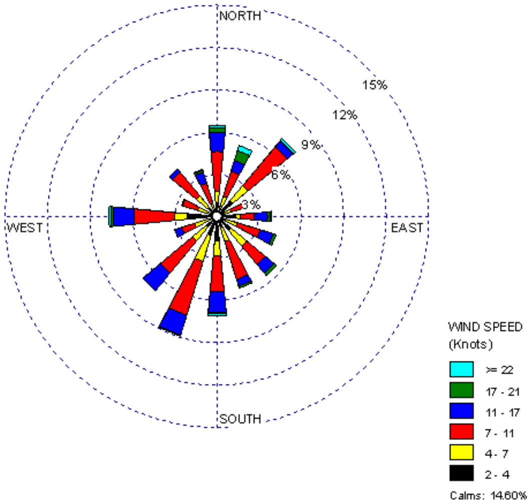
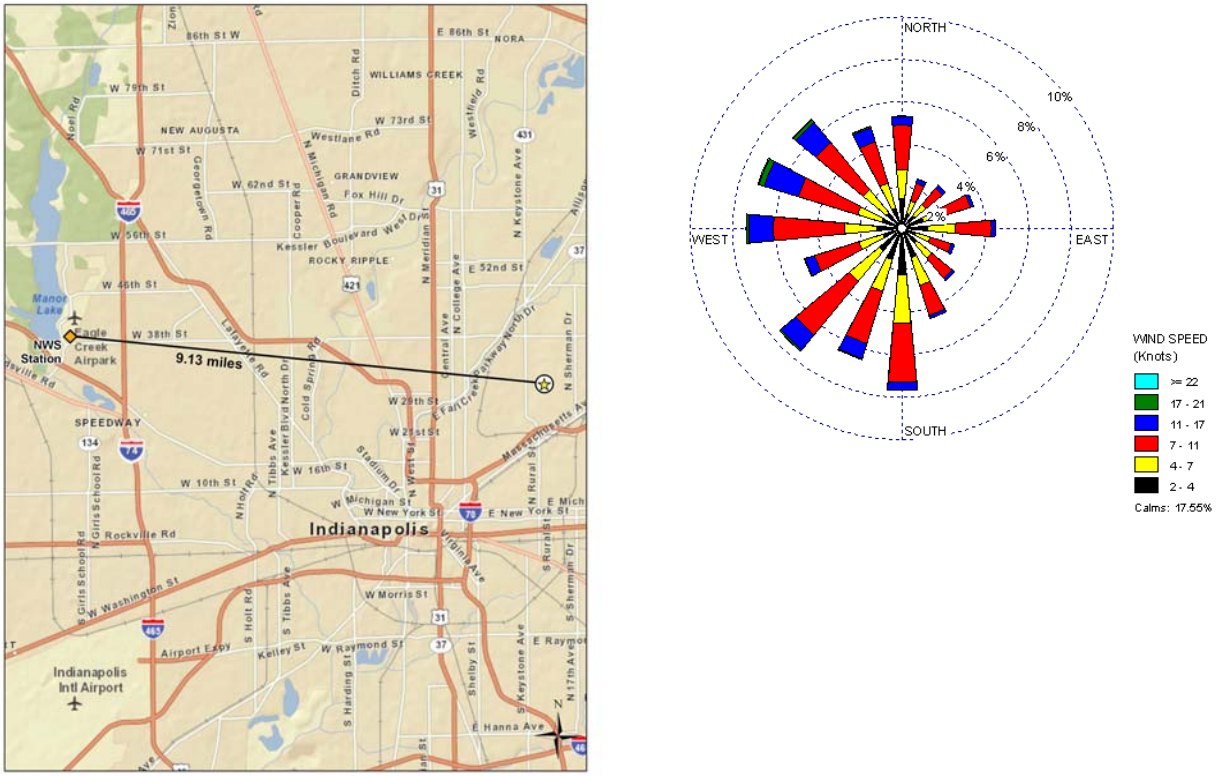
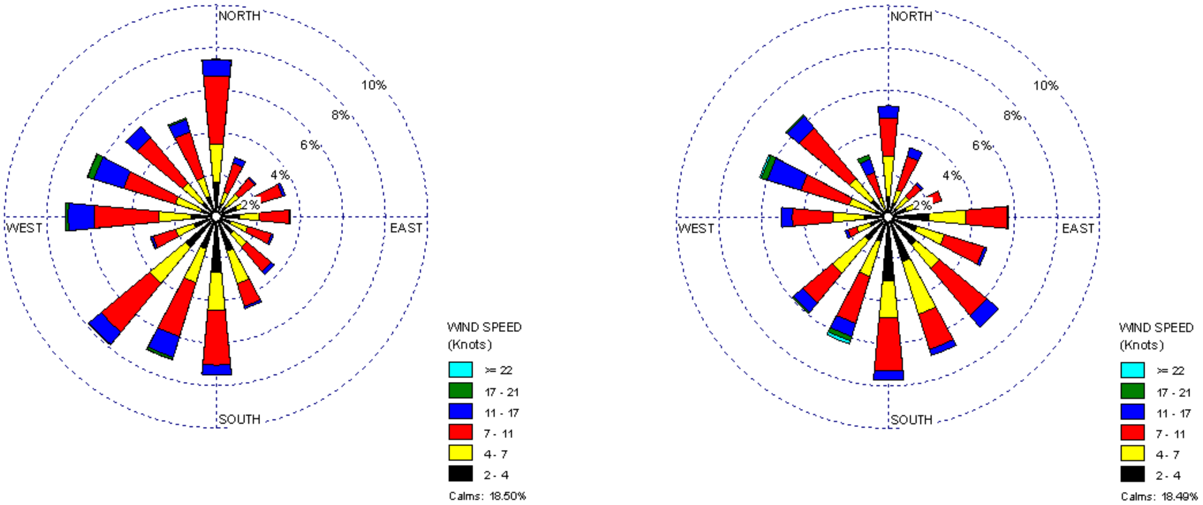


Figure 12-10. Wind Roses for the Indianapolis International Airport Weather Station near WPIN



Distance between WPIN and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

Observations from Figure 12-9 for INDEM include the following:

- The NWS weather station at Lancing Municipal Airport is the closest weather station to INDEM, although it is located approximately 11.4 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 2003-2010 time frame. Northerly to northeasterly winds off Lake Michigan accounted for just less than 20 percent of the wind measurements, as did calm winds. The strongest winds blew from the south to southwest to west of INDEM.

- The wind patterns shown on the 2011 wind rose resemble the wind patterns shown on the historical wind rose, although there are slightly fewer calm winds.

- The sample day wind rose exhibits similarities with the historical and full-year wind roses, but differences are also evident. The calm rate is lower and there is a higher percentage of winds from the southeast quadrant. Winds from the east-southeast to south-southeast account for approximately three times as many wind observations on sample days as they did throughout the year.

Observations from Figure 12-10 for WPIN include the following:

- The NWS weather station at Eagle Creek Airpark is the closest weather station to WPIN and is located approximately 9.1 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 2001-2010, while winds from the eastern quadrants were observed less than one-quarter of the time. Calm winds (≤ 2 knots) were observed for nearly 18 percent of observations. The strongest winds tended to flow from the northwest.

- The wind patterns on the 2011 wind rose resemble the historical wind patterns, although there were fewer northwesterly winds and more northerly winds.

- The sample day wind rose has a significantly higher number of winds from the east to south-southeast than the full-year wind rose. A similar observation is noted for the INDEM sample day wind rose. There were also fewer northerly and westerly wind observations on sample days.

12.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Indiana monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 12-4 presents the results of the preliminary risk-based screening process for the Indiana monitoring sites. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. 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						
Acetaldehyde	0.45	57	57	100.00	49.57	49.57
Formaldehyde	0.077	57	57	100.00	49.57	99.13
Propionaldehyde	0.8	1	57	1.75	0.87	100.00
Total		115	171	67.25		
Indianapolis, Indiana - WPIN						
Acetaldehyde	0.45	51	51	100.00	50.00	50.00
Formaldehyde	0.077	51	51	100.00	50.00	100.00
Total		102	102	100.00		

Observations from Table 12-4 include the following:

- Formaldehyde, acetaldehyde, and propionaldehyde are the only carbonyl compounds with risk screening values.

- All three carbonyl compounds with risk screening values failed screens for INDEM. Acetaldehyde and formaldehyde failed 100 percent of screens while propionaldehyde failed only one screen.

- Acetaldehyde and formaldehyde failed screens for WPIN. They contributed equally to the total number of failed screens. Both pollutants failed 100 percent of total failed screens.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Indiana monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for INDEM and WPIN are provided in Appendix L.

12.4.1 2011 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 of 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	57/57	1.11 ± 0.15	NA	1.43 ± 0.24	1.43 ± 0.35	1.27 ± 0.13
Formaldehyde	57/57	2.02 ± 0.19	NA	3.03 ± 0.69	1.86 ± 0.48	2.30 ± 0.27
Indianapolis, Indiana - WPIN						
Acetaldehyde	51/51	NA	3.11 ± 0.49	2.51 ± 0.46	1.74 ± 0.37	NA
Formaldehyde	51/51	NA	6.24 ± 1.32	4.69 ± 0.86	2.50 ± 0.46	NA

Observations for the Indiana sites from Table 12-5 include the following:

- The annual average concentration of formaldehyde is greater than the annual average concentration of acetaldehyde for INDEM.

- Second quarter average concentrations could not be calculated for INDEM due to too many invalidated samples within that quarter.

- Intermittent sampler issues resulted in a lack of first quarter and annual averages for WPIN. However, Appendix L provides the pollutant-specific average concentrations for all valid samples collected over the entire sample period for each site.

- The second quarter averages of acetaldehyde and formaldehyde are higher than the other quarterly averages for WPIN. The confidence interval for the second quarter formaldehyde average is rather large, indicating the potential influence of outliers. A review of the data shows that the highest formaldehyde concentration for WPIN was measured on June 8, 2011 (11.1 µg/m^3). Four of the six highest concentrations of formaldehyde (those greater than 6 µg/m^3) were measured at WPIN during the second quarter. Concentrations of formaldehyde ranged from 1.41 µg/m^3 to 11.1 µg/m^3 with a median concentration of 4.22 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 Indiana sites from those tables include the following:

- INDEM does not appear in Table 4-10. Its annual average concentration of formaldehyde ranks 17th and its annual average concentration of acetaldehyde ranks 22nd 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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde and formaldehyde were created for INDEM. Annual averages could not be calculated for WPIN, therefore, this site has no figures in this section. Figures 12-11 and 12-12 overlay INDEM'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 12-11. Program vs. Site-Specific Average Acetaldehyde Concentration

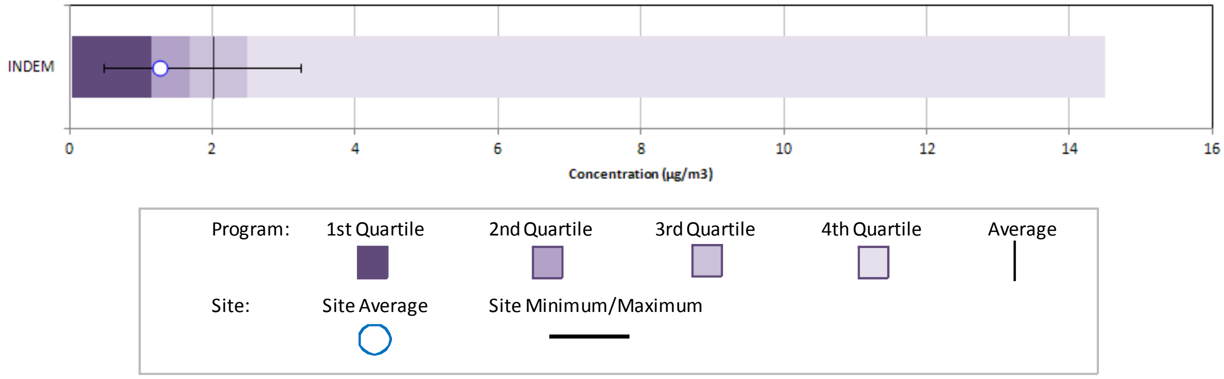
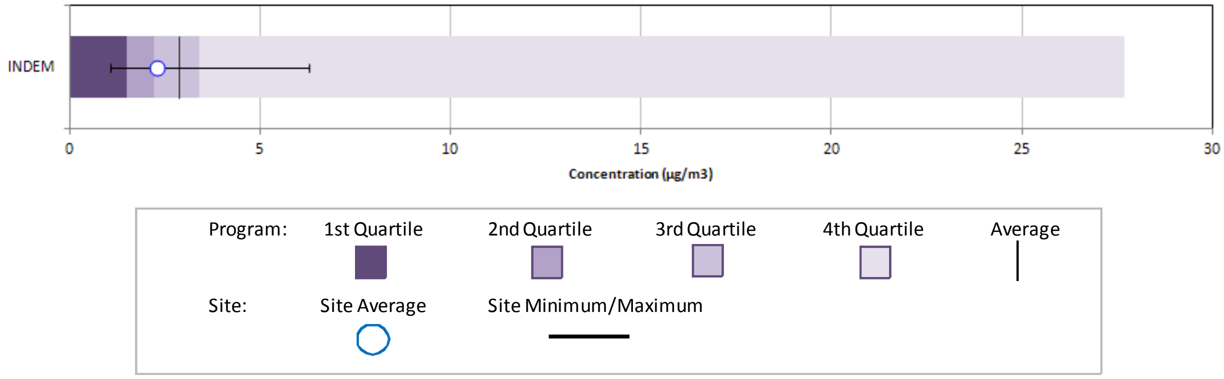


Figure 12-12. Program vs. Site-Specific Average Formaldehyde Concentration



Observations from Figures 12-11 and 12-12 include the following:

- Figure 12-11 shows that the annual average acetaldehyde concentration for INDEM is less than both program-level average concentration and median concentration. In fact, INDEM's annual average is just greater than the program-level first quartile (or 25th percentile). The maximum concentration of acetaldehyde measured at INDEM is considerably less than the maximum concentration measured across the program. There were no non-detects of acetaldehyde measured at INDEM or across the program.

- Figure 12-12 shows that INDEM's annual average formaldehyde concentration is less than the program-level average formaldehyde concentration but greater than the program-level median concentration. The maximum concentration of formaldehyde measured at INDEM is considerably less than the maximum concentration measured across the program. There were no non-detects of formaldehyde measured at INDEM or across the program.

12.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. INDEM has sampled carbonyl compounds since 2004; thus, Figures 12-13 and 12-4 present the annual statistical metrics for acetaldehyde and formaldehyde for INDEM, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. Although WPIN began sampling carbonyl compounds in 2007 and thus, meets the criteria for a trends analysis to be performed, the lack of annual averages for 2011 prevents the analysis from being performed for this site.

Figure 12-13. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at INDEM

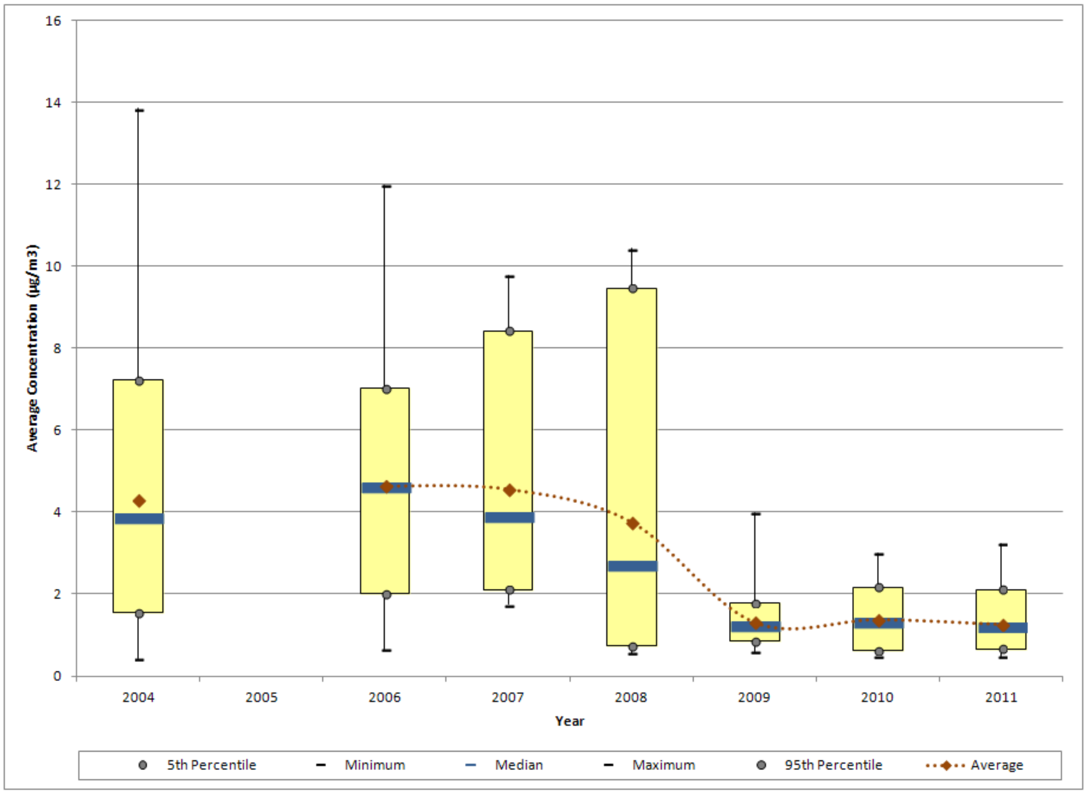
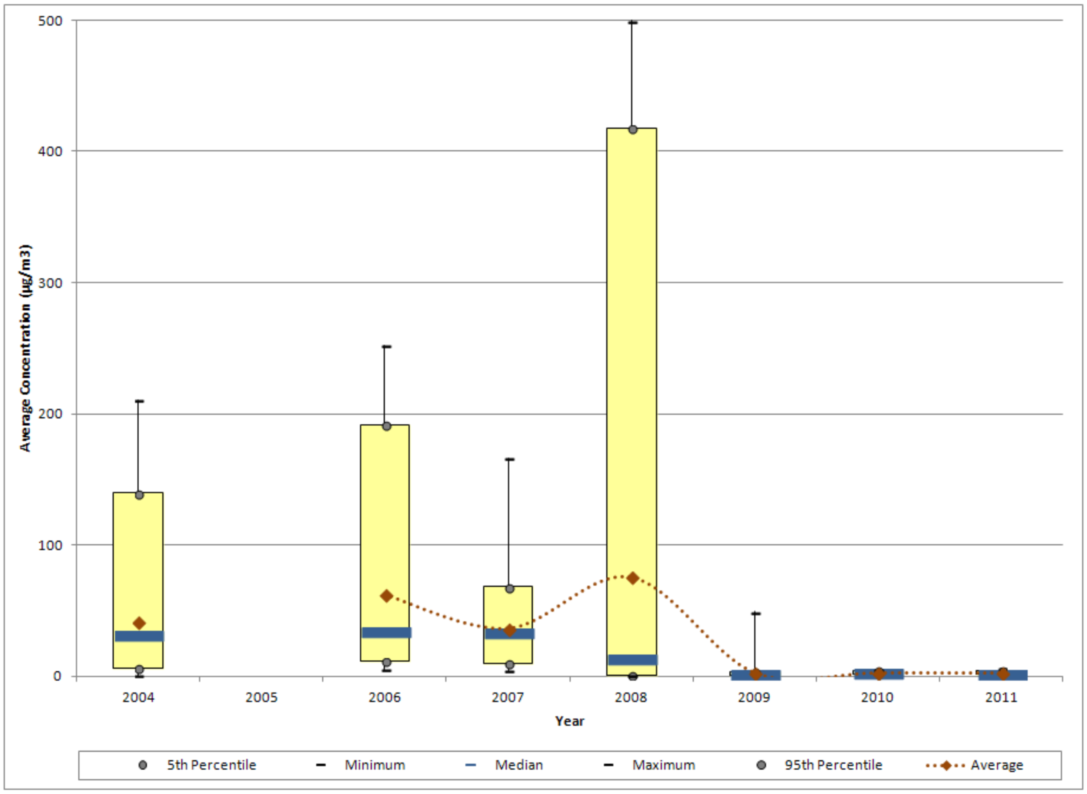


Figure 12-14. Annual Statistical Metrics for Formaldehyde Concentrations Measured at INDEM



Observations from Figure 12-13 for acetaldehyde measurements at INDEM include the following:

- Although carbonyl compound sampling began in 2003 at INDEM, sampling did not begin until June, which does not yield enough samples for the statistical metrics to be calculated for 2003, based on the criteria specified in Section 3.5.4. Thus, Figure 12-13 begins with 2004.
- In addition, there was a 3-month gap in sampling between September and November 2005 at the INDEM site; therefore, no statistical metrics are presented for 2005.
- The maximum acetaldehyde concentration shown (13.8 µg/m^3) was measured at INDEM on June 14, 2004. Four additional concentrations measured at INDEM were greater than 10 µg/m^3 (one in 2006 and three in 2008).
- The average concentration of acetaldehyde decreased significantly from 2007 to 2008, although the maximum and 95th percentile increased for 2008. With the exception of the minimum and 5th percentile, the statistical parameters decreased significantly from 2008 to 2009. The 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 for 2010 are similar in magnitude to the statistical parameters for 2011.
- There have been no non-detects of acetaldehyde measured at INDEM over the years shown.

Observations from Figure 12-14 for formaldehyde measurements 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 499 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 25 measurements of formaldehyde greater than 100 µg/m^3 measured at INDEM, not including the excluded years (2003 and 2005).
- Prior to 2009, the maximum concentration for each year is greater than 100 µg/m^3. Further, the median concentrations for years prior to 2008 are greater than 30 µg/m^3, indicating that at least half of the concentrations were greater than 30 µg/m^3.

- Although the 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 average concentration upward, there were a larger number of concentrations at the lower end of the 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 none (2006) to two (2004).

- All the statistical metrics decreased significantly for 2009 and the years that follow. The average concentration for 2009 is 2.58 µg/m^3 and the average continued to decrease thereafter (although the differences are not statistically significant). In contrast to the previous bullet, the number of measurements greater than 5 µg/m^3 ranged from one to two for each year between 2009 and 2011.

- 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 2009-2011 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.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 Hazard Approximation (HQ)
Gary, Indiana - INDEM						
Acetaldehyde	0.0000022	0.009	57/57	1.27 ± 0.13	2.79	0.14
Formaldehyde	0.000013	0.0098	57/57	2.30 ± 0.27	29.88	0.23
Indianapolis, Indiana - WPIN						
Acetaldehyde	0.0000022	0.009	51/51	NA	NA	NA
Formaldehyde	0.000013	0.0098	51/51	NA	NA	NA

NA = Not available due to the criteria for calculating an annual average.

Observations for the Indiana sites from Table 12-6 include the following:

- The annual average concentration of formaldehyde for INDEM is greater than the annual average concentration of acetaldehyde.
- The cancer risk approximation for formaldehyde is an order of magnitude higher than the cancer risk approximation for acetaldehyde for INDEM.
- None of the pollutants of interest for INDEM have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants.
- Cancer risk and noncancer hazard approximations could not be calculated for the pollutants of interest for WPIN because annual averages are not available.

12.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 12-7 and 12-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 12-6. Table 12-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations, also calculated from annual averages provided in Table 12-6.

The pollutants listed in Tables 12-7 and 12-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, 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 12.3, INDEM and WPIN sampled for carbonyl compounds only. 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, cancer risk and noncancer hazard approximations were not calculated for WPIN. A more in-depth discussion of this analysis is provided in Section 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

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	231.53	Coke Oven Emissions, PM	3.31E-02	Formaldehyde	29.88
Formaldehyde	157.04	Formaldehyde	2.04E-03	Acetaldehyde	2.79
Ethylbenzene	107.50	Hexavalent Chromium, PM	1.81E-03		
Acetaldehyde	100.19	Benzene	1.81E-03		
Coke Oven Emissions, PM	33.43	Naphthalene	1.01E-03		
1,3-Butadiene	29.96	Arsenic, PM	9.93E-04		
Naphthalene	29.83	1,3-Butadiene	8.99E-04		
Dichloromethane	4.72	Nickel, PM	6.66E-04		
POM, Group 2b	2.39	Ethylbenzene	2.69E-04		
Trichloroethylene	2.23	Cadmium, PM	2.63E-04		
Indianapolis, Indiana (Marion County) - WPIN					
Benzene	489.79	Formaldehyde	4.63E-03		
Formaldehyde	356.47	Benzene	3.82E-03		
Ethylbenzene	217.73	1,3-Butadiene	2.02E-03		
Acetaldehyde	205.36	Hexavalent Chromium, PM	1.23E-03		
1,3-Butadiene	67.18	Naphthalene	1.19E-03		
Naphthalene	34.96	Arsenic, PM	1.10E-03		
Tetrachloroethylene	14.44	POM, Group 3	6.97E-04		
Dichloromethane	7.84	POM, Group 2b	5.74E-04		
Trichloroethylene	6.85	Ethylbenzene	5.44E-04		
POM, Group 2b	6.52	Nickel, PM	4.59E-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	676.97	Acrolein	503,495.00	Formaldehyde	0.23
Xylenes	528.24	Manganese, PM	468,665.08	Acetaldehyde	0.14
Methanol	315.13	Lead, PM	109,768.53		
Ethylene glycol	271.89	Cyanide Compounds, gas	36,721.25		
Hexane	231.90	Formaldehyde	16,024.72		
Benzene	231.53	Nickel, PM	15,405.79		
Formaldehyde	157.04	Arsenic, PM	15,399.37		
Hydrochloric acid	153.19	1,3-Butadiene	14,981.21		
Ethylbenzene	107.50	Cadmium, PM	14,626.32		
Acetaldehyde	100.19	Acetaldehyde	11,131.89		
Indianapolis, Indiana (Marion County) - WPIN					
Toluene	1,373.22	Acrolein	1,220,725.02		
Xylenes	935.63	Formaldehyde	36,374.58		
Methanol	684.51	1,3-Butadiene	33,589.47		
Ethylene glycol	504.44	Hydrochloric acid	23,022.60		
Benzene	489.79	Acetaldehyde	22,818.28		
Hydrochloric acid	460.45	Arsenic, PM	17,017.69		
Formaldehyde	356.47	Benzene	16,326.44		
Hexane	269.35	Naphthalene	11,654.54		
Ethylbenzene	217.73	Lead, PM	11,113.23		
Acetaldehyde	205.36	Nickel, PM	10,619.54		

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 hexavalent chromium are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Lake County. Formaldehyde, benzene, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions for Marion County.

- Six of the highest emitted pollutants in both Lake and Marion County also have the highest toxicity-weighted emissions (although the pollutants are not the same between the counties).

- While several metals (arsenic, cadmium, hexavalent chromium, and nickel) 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.

- 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.

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 nearly twice that of Lake County. Xylenes and methanol are the second and third highest emitted pollutants 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 two of the highest emitted pollutants in Lake County also have the highest toxicity-weighted emissions (formaldehyde and acetaldehyde). Several metals (manganese, lead, nickel, arsenic, and cadmium) 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).

12.6 Summary of the 2011 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 WPIN and three failed screens for INDEM.*
- *The annual average concentration of formaldehyde is greater than the annual average concentration of acetaldehyde for INDEM. Annual averages concentrations could not be calculated for WPIN.*
- *Concentrations of formaldehyde and acetaldehyde exhibit a decreasing trend at INDEM.*

13.0 Site in Kentucky

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site 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

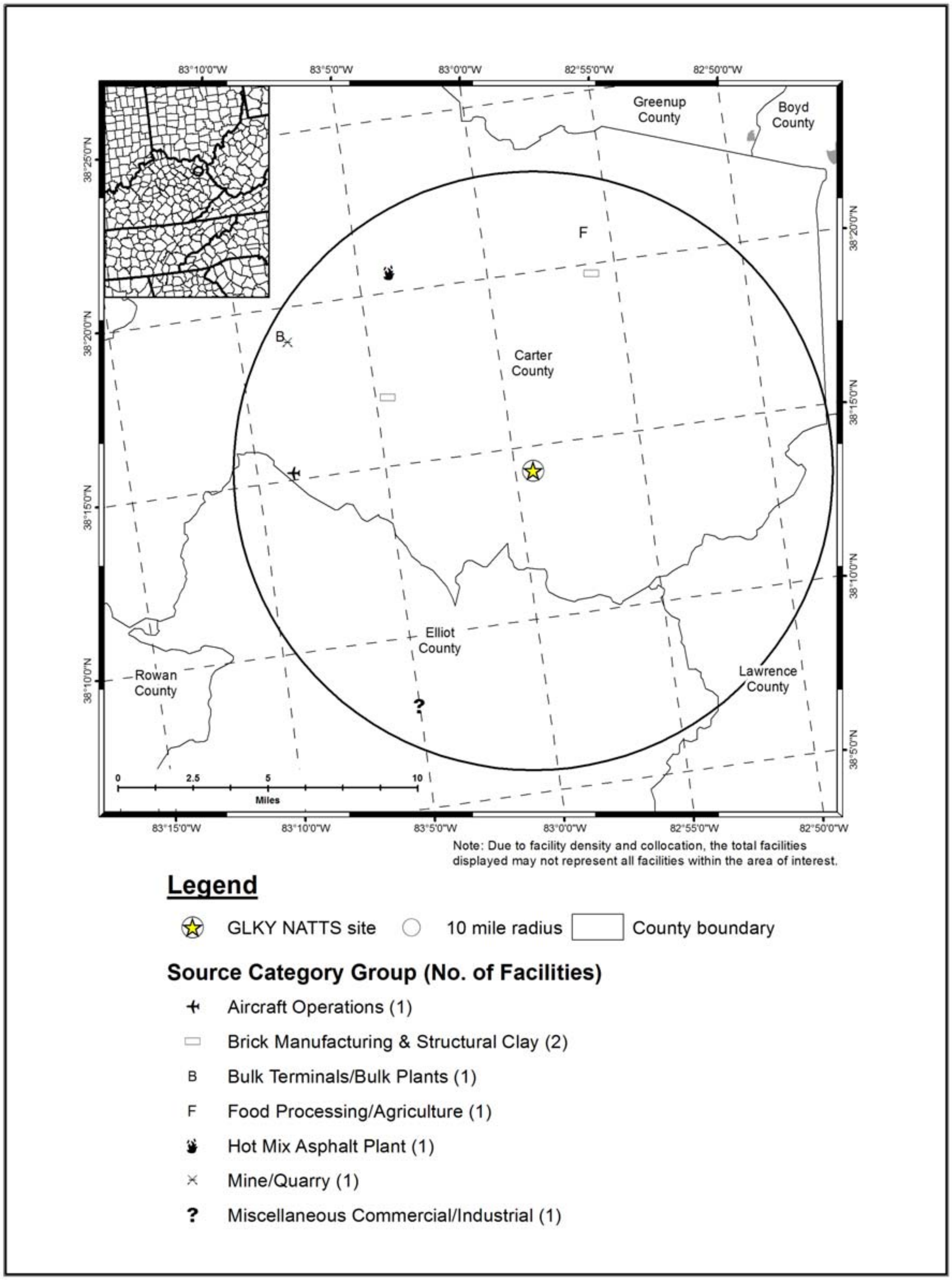
This section characterizes the Kentucky monitoring site by providing geographical and physical information about the location of the site and the surrounding area. This information is provided to give the reader insight regarding factors that may influence the air quality near the site and assist in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

The Kentucky monitoring site is located near Grayson Lake in northeast Kentucky. Figure 13-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its rural location. Figure 13-2 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 13-2. 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 13-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 13-1. Grayson, Kentucky (GLKY) Monitoring Site

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

Figure 13-2. NEI Point Sources Located Within 10 Miles of GLKY



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

Table 13-1. Geographical Information for the Kentucky 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]
GLKY	21-043-005	Grayson	Carter	Not in an MSA	38.238333, -82.988333	Residential	Rural	Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2012c); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

Grayson Lake is located in northeast Kentucky, south of the town of Grayson, and west of the Huntington-Ashland, WV-KY 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, as shown in Figure 13-1, with sandstone cliffs rising to up to 200 feet above the lake surface (KY, 2013 and ACE, 2013). The closest road to the monitoring site is a service road feeding into Camp Grayson. This site serves as the Grayson Lake NATTS site. Figure 13-2 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 13-2, oriented from northeast to southwest. Sources within 10 miles of GLKY are involved in aircraft operations, brick and structural clay manufacturing, food processing, and mining, among others.

Table 13-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Kentucky monitoring site. Table 13-2 includes county-level population and vehicle registration information. Table 13-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 13-2 also contains traffic volume information. Finally, Table 13-2 presents the county-level daily VMT for Carter County.

Table 13-2. Population, Motor Vehicle, and Traffic Information for the Kentucky Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
GLKY	27,586	32,398	1.17	14,610	17,159	428	1,084,000

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Kentucky Transportation Cabinet (KYTC, 2012a)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2009 data from the Kentucky Transportation Cabinet (KYTC, 2009)
[5] County-level VMT reflects 2011 data from the Kentucky Transportation Cabinet (KYTC, 2012b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 13-2 include the following:

- The Carter County population is the second lowest compared to counties with NMP sites (behind only UCSD in Union County, SD). The 10-mile population for GLKY is also on the low side compared to other sites. The corresponding vehicle ownership data mimicked these rankings. The rather low population and vehicle ownership compared to other NMP sites is not surprising given the rural nature of the surrounding area.

- The vehicle-per-person ratio is among the higher ratios compared to other NMP sites.

- The traffic data for GLKY is provided for the intersection of State Road 1496 with Camp Webb Road, one of several secondary roads leading to Grayson Lake. This site has the third lowest traffic volume among NMP sites.

- The daily VMT for Carter County is the second lowest compared to other counties with NMP sites (where VMT data were available), behind only Union County, SD.

13.2 Meteorological Characterization

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

13.2.1 Climate Summary

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, 2013).

13.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2011 (NCDC, 2011). The closest weather station to GLKY is located at Tri-State/M.J. Ferguson Field Airport (WBAN 03860). Additional information about this weather station, such as the distance between the site and the weather station, 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 Site

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)
Grayson, Kentucky - GLKY									
Tri-St/M.J. Ferguson Field Airport 03860 (38.38, -82.56)	24.27 miles 58° (ENE)	Sample Day	65.3 ± 4.4	55.6 ± 4.1	45.7 ± 4.6	50.7 ± 4.0	72.6 ± 3.3	1016.4 ± 1.5	4.2 ± 0.6
		2011	65.7 ± 1.8	56.1 ± 1.7	46.5 ± 1.8	51.2 ± 1.6	73.4 ± 1.3	1016.3 ± 0.7	4.2 ± 0.2

[1] Sample day averages are highlighted 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 the entire year for 2011. Also included in Table 13-3 is the 95 percent confidence interval for each parameter. As shown in Table 13-3, average meteorological conditions on sample days near GLKY were representative of average weather conditions throughout the year.

13.2.3 Back Trajectory Analysis

Figure 13-3 is the composite back trajectory map for days on which samples were collected at the GLKY monitoring site in 2011. Included in Figure 13-3 are four back trajectories per sample day. Figure 13-4 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 13-3 and 13-4 represents 100 miles.

Observations from Figures 13-3 and 13-4 for GLKY include the following:

- Back trajectories originated from a variety of directions at GLKY. An imaginary line drawn north-south through the center of Figure 13-3 would show that a higher number of trajectories originated from a direction with a westerly component than an easterly component.

- The farthest away a back trajectory originated was over southeast Minnesota, or just greater than 600 miles away; however, the average trajectory length was 212 miles and 86 percent of trajectories originated within 350 miles of the monitoring site.

- Back trajectories originating to the west and northwest of GLKY account for nearly 40 percent of back trajectories, but are represented by two clusters in Figure 13-4. One cluster (26 percent) includes back trajectories originating over Ohio and Indiana while the other cluster (13 percent) includes longer back trajectories originating over Illinois or farther to the west or northwest. Another nearly 40 percent of back trajectories originated to the southwest of GLKY. This cluster trajectory includes back trajectories of varying lengths. Fifteen percent of back trajectories originated to the north-northwest to north-northeast of GLKY, as represented by the cluster trajectory originating over Lake Erie. The cluster trajectory originating over Virginia (10 percent) includes shorter trajectories originating to the east over West Virginia and Virginia or longer trajectories originating to the southeast over North Carolina.

Figure 13-3. 2011 Composite Back Trajectory Map for GLKY

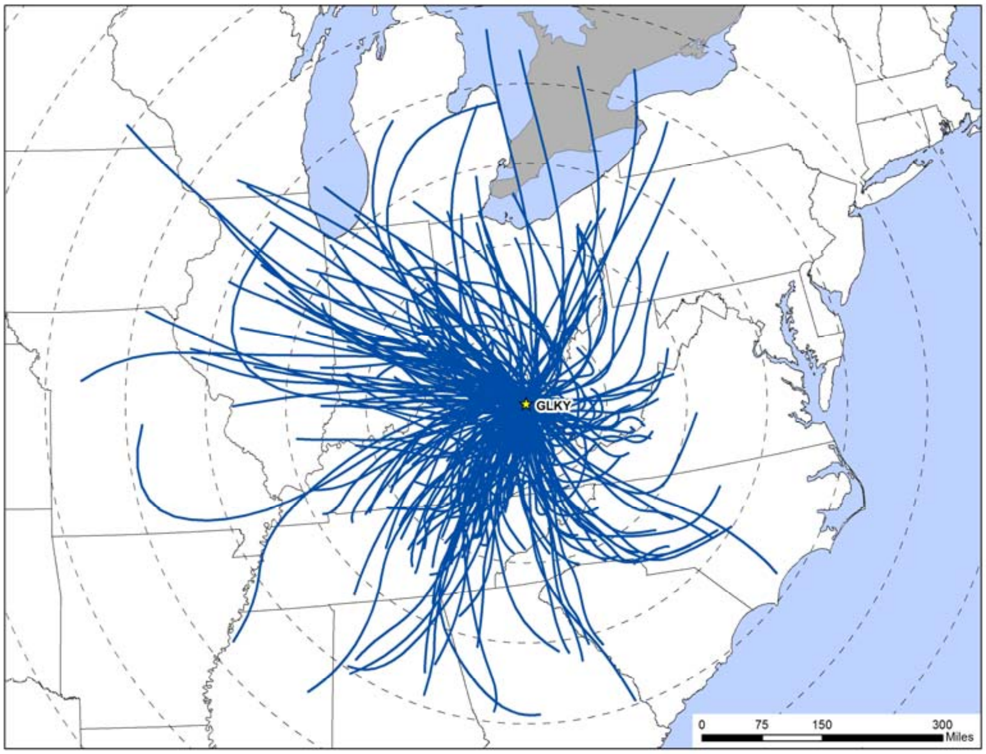
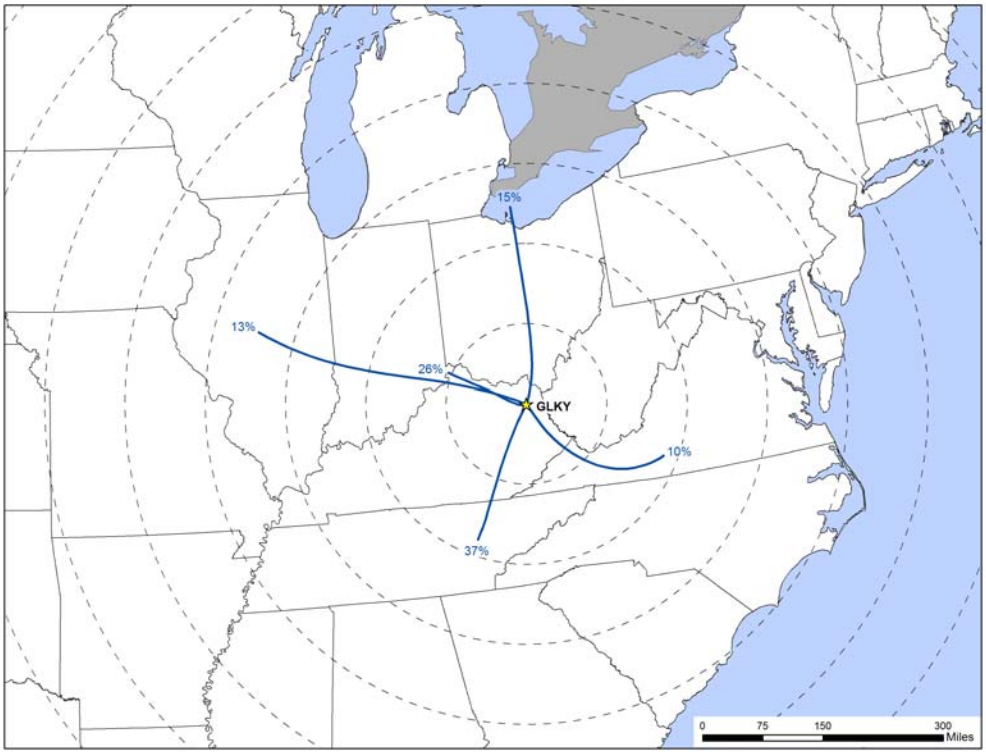


Figure 13-4. Back Trajectory Cluster Map for GLKY



13.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS weather station at the Tri-State/M.J. Ferguson Field Airport near GLKY 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.

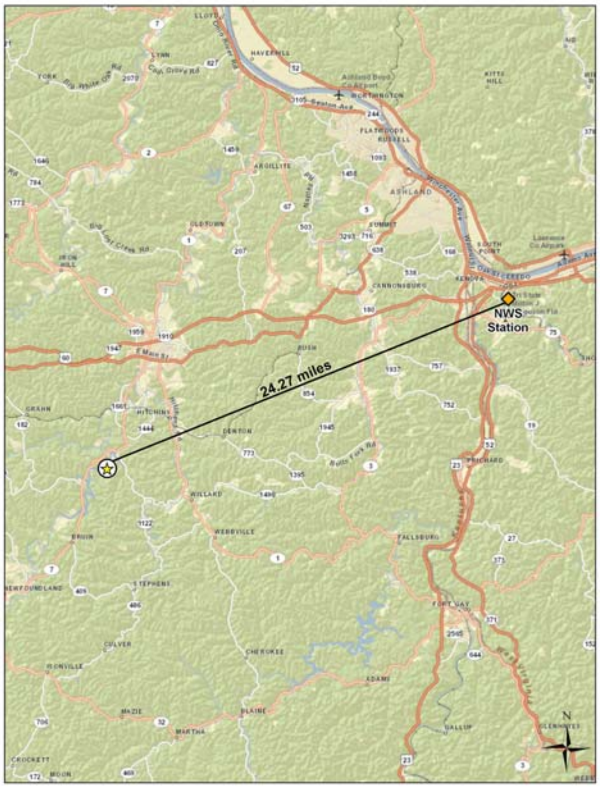
Figure 13-5 presents a map showing the distance between the NWS station and GLKY, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 13-5 also presents three different wind roses for the GLKY monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 13-5 for GLKY include the following:

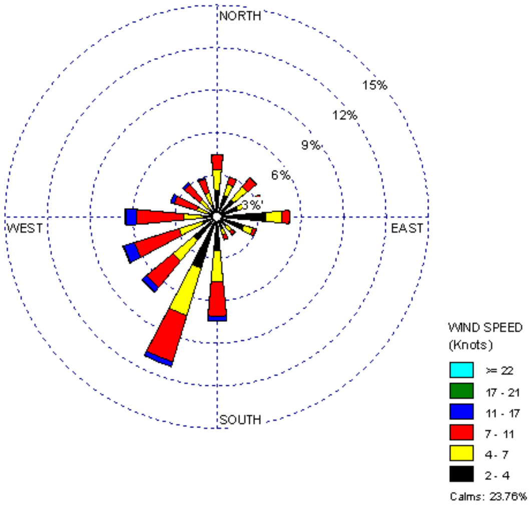
- The Tri-State/M.J. Ferguson Field weather station is located over 24 miles to the east-northeast of GLKY and just across the state border in West Virginia.
- The historical wind rose shows that calm winds were observed for more than 23 percent of the hourly measurements near GLKY. Winds from the south to southwest to west make up the majority of observations near GLKY, particularly those from south-southwest.
- The wind patterns on the 2011 wind rose are similar to those on the historical wind rose, but calm winds accounted for a slightly higher percentage of the wind observations in 2011 (27 percent).
- The sample day wind rose resembles both the historical and full-year wind roses, although with fewer southerly winds and more northeasterly winds. This indicates the wind conditions on sample days were generally representative of those experienced throughout 2011 and historically.

Figure 13-5. Wind Roses for the Tri-State/M.J. Ferguson Field Airport Weather Station near GLKY

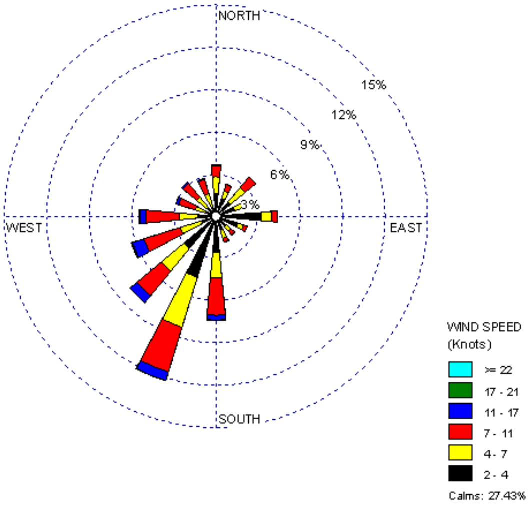
Distance between GLKY and NWS Station



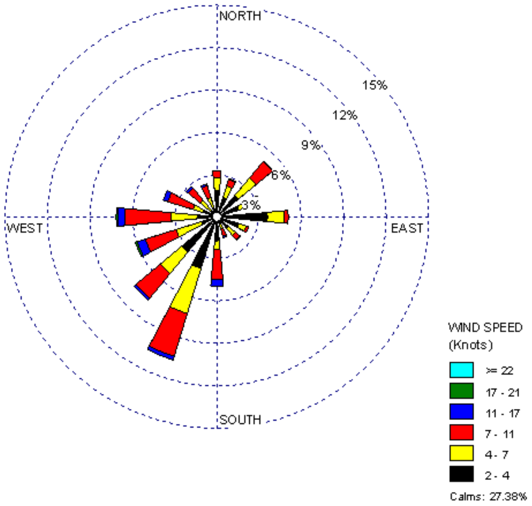
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



13.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for GLKY in order to allow 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.” 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 13-4 presents the results of the preliminary risk-based screening process for GLKY. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for the monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. GLKY sampled for hexavalent chromium, PM_{10} metals, carbonyl compounds, PAHs, and VOCs.

Observations from Table 13-4 include the following:

- GLKY sampled hexavalent chromium, VOCs, and PAHs throughout 2011, but did not begin sampling metals through the NMP until May and carbonyl compounds until August.
- Fifteen pollutants failed screens for GLKY, including nine NATTS MQO Core Analytes.
- Ten pollutants were initially identified as pollutants of interest via the risk-based screening process, of which six are NATTS MQO Core Analytes. Naphthalene and nickel were added as pollutants of interest for GLKY because they are NATTS Core Analytes, even though they did not contribute to 95 percent of the total failed screens. Nine additional pollutants were added to GLKY’s pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens. These nine pollutants are not shown in Table 13-4 but are shown in subsequent tables in the sections that follow.
- Benzene and formaldehyde were detected in each VOC and carbonyl compound sample, respectively, and failed 100 percent of screens. Other pollutants also failed 100 percent of screens but were detected less frequently.

Table 13-4. Risk-Based Screening Results for the Kentucky Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Grayson, Kentucky - GLKY						
Benzene	0.13	61	61	100.00	20.13	20.13
Carbon Tetrachloride	0.17	60	61	98.36	19.80	39.93
1,3-Butadiene	0.03	36	43	83.72	11.88	51.82
Arsenic (PM_{10})	0.00023	31	41	75.61	10.23	62.05
Formaldehyde	0.077	26	26	100.00	8.58	70.63
Acetaldehyde	0.45	22	26	84.62	7.26	77.89
1,2-Dichloroethane	0.038	21	21	100.00	6.93	84.82
Acrylonitrile	0.015	20	20	100.00	6.60	91.42
Hexachloro-1,3-butadiene	0.045	8	10	80.00	2.64	94.06
Manganese (PM_{10})	0.005	6	41	14.63	1.98	96.04
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	1.32	97.36
Naphthalene	0.029	3	61	4.92	0.99	98.35
1,2-Dibromoethane	0.0017	2	2	100.00	0.66	99.01
p-Dichlorobenzene	0.091	2	21	9.52	0.66	99.67
Nickel (PM_{10})	0.0021	1	41	2.44	0.33	100.00
Total		303	479	63.26		

13.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Kentucky monitoring site. Where applicable, the following calculations and data analyses were performed: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for GLKY, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for GLKY are provided in Appendices J, L, M, N, and O.

13.4.1 2011 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Kentucky 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 of 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 site are presented in Table 13-5, where applicable. Note that concentrations of the PAHs, metals, and hexavalent chromium for GLKY 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 13-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky 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)
Grayson, Kentucky - GLKY						
Acetaldehyde	26/26	NA	NA	NA	0.78 ± 0.21	NA
Acrylonitrile	20/61	0	0.01 ± 0.02	0.05 ± 0.07	0.58 ± 0.07	0.16 ± 0.07
Benzene	61/61	0.62 ± 0.06	0.46 ± 0.08	0.58 ± 0.19	0.69 ± 0.30	0.59 ± 0.09
1,3-Butadiene	43/61	0.04 ± 0.01	0.02 ± 0.01	0.03 ± 0.02	0.05 ± 0.01	0.04 ± 0.01
Carbon Tetrachloride	61/61	0.53 ± 0.08	0.59 ± 0.04	0.69 ± 0.04	0.69 ± 0.05	0.63 ± 0.03
Chloroform	15/61	0.02 ± 0.02	0.02 ± 0.02	0.06 ± 0.04	0.01 ± 0.01	0.03 ± 0.01
1,2-Dichloroethane	21/61	0.02 ± 0.02	0.04 ± 0.03	0.01 ± 0.01	0.05 ± 0.02	0.03 ± 0.01
Formaldehyde	26/26	NA	NA	NA	0.77 ± 0.25	NA
Hexachloro-1,3-butadiene	10/61	0.01 ± 0.02	0.02 ± 0.02	0.02 ± 0.02	<0.01 ± 0.01	0.01 ± 0.01
Tetrachloroethylene	30/61	0.06 ± 0.02	0.04 ± 0.02	0.02 ± 0.02	0.03 ± 0.02	0.04 ± 0.01
Trichloroethylene	4/61	0	<0.01 ± 0.01	0.01 ± 0.01	<0.01 ± 0.01	<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 pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Table 13-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Kentucky Monitoring Site (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)
Vinyl Chloride	3/61	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	0	<0.01 ± <0.01
Arsenic (PM$_{10}$)[a]	41/41	NA	NA	0.50 ± 0.15	0.50 ± 0.16	NA
Benzo(a)pyrene [a]	29/61	0.04 ± 0.03	0.01 ± 0.01	0.01 ± 0.01	0.06 ± 0.04	0.03 ± 0.01
Beryllium (PM$_{10}$) [a]	41/41	NA	NA	0.01 ± <0.01	0.01 ± 0.01	NA
Cadmium (PM$_{10}$) [a]	41/41	NA	NA	0.09 ± 0.03	0.10 ± 0.04	NA
Hexavalent Chromium [a]	37/61	0.01 ± <0.01	0.01 ± 0.01	0.01 ± <0.01	0.01 ± 0.01	0.01 ± <0.01
Lead (PM$_{10}$) [a]	41/41	NA	NA	2.01 ± 0.82	2.58 ± 1.07	NA
Manganese (PM$_{10}$) [a]	41/41	NA	NA	2.73 ± 0.84	4.17 ± 2.68	NA
Naphthalene [a]	61/61	20.50 ± 3.12	12.78 ± 3.26	12.89 ± 3.19	20.44 ± 3.68	16.59 ± 1.84
Nickel (PM$_{10}$) [a]	41/41	NA	NA	0.28 ± 0.07	0.55 ± 0.42	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 GLKY from Table 13-5 include the following:

- Annual average concentrations could not be calculated for the PM$_{10}$ metals because sampling did not begin until May 2011. This is also true for the carbonyl compounds because they did not begin sampling until August. However, Appendix L and Appendix N provide the pollutant-specific average concentrations for all valid metals and carbonyl compound samples collected over the entire sample period.

- None of the annual average concentrations for the pollutants of interest for GLKY, where they could be calculated, were greater than 1 µg/m^3. Carbon tetrachloride (0.63 ± 0.03 µg/m^3) and benzene (0.59 ± 0.09 µg/m^3) have the highest annual average concentrations for GLKY.

- The fourth quarter average acrylonitrile concentration is significantly higher than the other quarterly averages. This pollutant was not detected at all in the first quarter of 2011, was detected twice in the second quarter, and three times in the third. Thus, the other 15 measured detections were measured during the fourth quarter. Sorting the measurements in a descending order almost puts the data in order by descending date, with the lowest concentrations measured earlier in the year and the highest concentrations measured late in the year.

- The fourth quarter average concentration of benzene is similar to the other quarterly averages in magnitude, but its confidence interval is much larger. The maximum concentration of benzene was measured at GLKY on November 29, 2011 (2.63 µg/m^3). The next highest concentration measured during the fourth quarter was less than half that concentration (0.906 µg/m^3).

- Concentrations of benzo(a)pyrene were highest during the first and fourth quarters of 2011, as indicated by the quarterly averages. Five concentrations greater than 0.15 ng/m^3 were measured at GLKY, two in January, one in October, and two in December. Of the 29 measured detections of benzo(a)pyrene, eight were measured during the first quarter, four were measured during the second quarter, four were measured during the third quarter, and 13 were measured during the fourth quarter.

- Similar to benzo(a)pyrene, the quarterly averages for naphthalene indicate that concentrations tended to be lower during the warmer months and higher during the colder 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 GLKY from those tables include the following:

- GLKY appears in Table 4-9 for VOCs four times but does not appear in any of the other tables.

- GLKY has the third highest annual average concentration of acrylonitrile among NMP sites sampling VOCs, behind only SPIL and UCSD.

- GLKY ranked seventh for three VOCs: 1,2-dichloroethane, carbon tetrachloride, and hexachloro-1,3-butadiene.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzene, benzo(a)pyrene, 1,3-butadiene, hexavalent chromium, and naphthalene were created for GLKY. Box plots were not created for metals or carbonyl compounds because annual averages could not be calculated for these pollutants. Figures 13-6 through 13-10 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 13-6. Program vs. Site-Specific Average Benzene Concentration

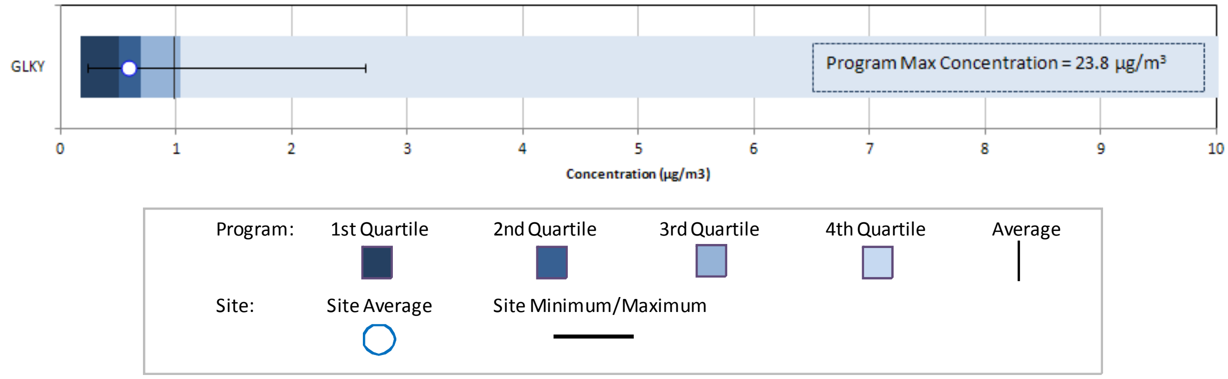


Figure 13-7. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

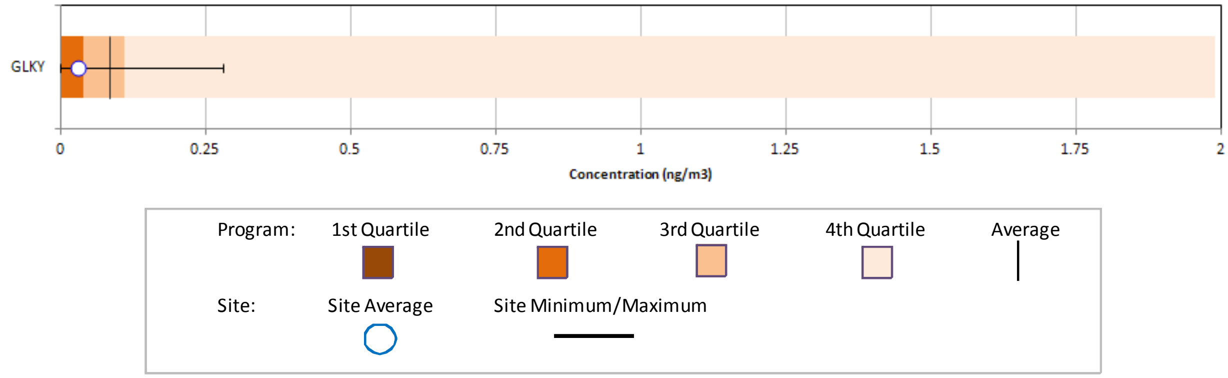


Figure 13-8. Program vs. Site-Specific Average 1,3-Butadiene Concentration

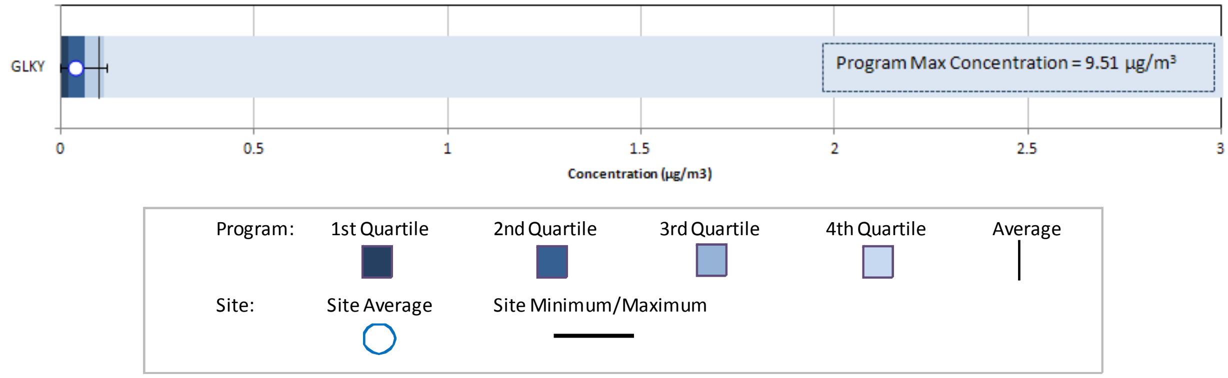


Figure 13-9. Program vs. Site-Specific Average Hexavalent Chromium Concentration

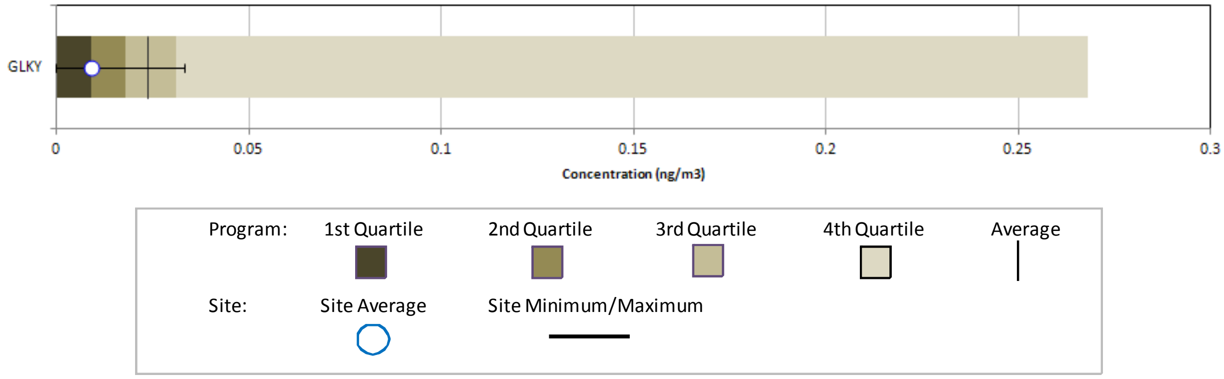
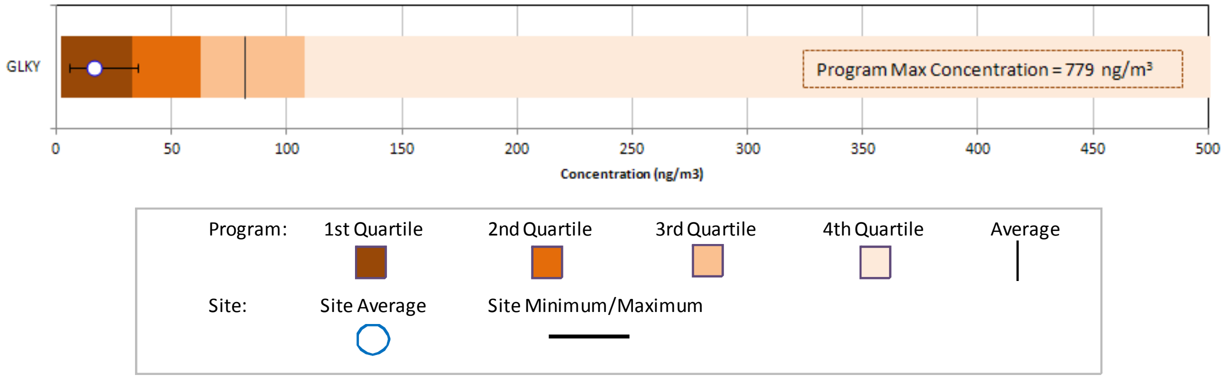


Figure 13-10. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 13-6 through 13-10 include the following:

- Figure 13-6 is the box plot for benzene. Note that the program-level maximum concentration (23.8 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 10 µg/m^3. This box plot shows that the annual average concentration for GLKY is less than the program-level average concentration as well as the program-level median concentration. The annual average benzene concentration for GLKY is among the lowest annual averages for this pollutant. There were no non-detects of benzene measured at this site (or among sites sampling VOCs).

- Figure 13-7 is the box plot for benzo(a)pyrene. Note that the first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average concentration for GLKY is less than the program-level average concentration as well as the program-level median concentration. Several non-detects of benzo(a)pyrene were measured at GLKY.

- Similar to benzene, the scale for 1,3-butadiene has been adjusted in Figure 13-8 as a result of a relatively large maximum concentration. The program-level maximum concentration (9.51 µg/m^3) is not shown directly on the box plot in order to allow for observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 3.00 µg/m^3. Figure 13-8 shows that the annual average concentration of 1,3-butadiene for GLKY is less than both the program-level average and median concentrations. The maximum 1,3-butadiene concentration measured at GLKY is just greater than the program-level third quartile. Several non-detects of 1,3-butadiene were measured at GLKY.

- Figure 13-9 is the box plot for hexavalent chromium. This box plot shows that the annual average hexavalent chromium concentration for GLKY is just greater than the program-level first quartile. The annual average hexavalent chromium concentration for GLKY is among the lowest annual averages among NMP sites sampling this pollutant. The maximum hexavalent chromium concentration measured at GLKY is just greater than the program-level third quartile. Several non-detects of hexavalent chromium were measured at GLKY.

- Figure 13-10 is the box plot for naphthalene. Note that the program-level maximum concentration (779 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 ng/m^3 to allow for observation of data points at the lower end of the concentration range. Figure 13-10 shows that the annual average concentration of naphthalene for GLKY is less than the program-level first quartile. This site has the smallest range of naphthalene concentrations measured among all sites sampling this pollutant. Nearly the entire range of measurements is less than the program-level first quartile (only one measurement is greater than the program-level first quartile). This site has the third-lowest annual average concentration among NMP sites sampling PAHs.

13.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. Sampling at GLKY under the NMP began in 2008; therefore, a trends analysis was not conducted 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 site. Refer to Sections 3.3 and 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

13.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for GLKY 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 or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 13-6, where applicable. Cancer risk approximations are presented as probabilities while the noncancer hazard approximations are ratios and thus, unitless values.

Table 13-6. Risk Approximations for the Kentucky 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 Hazard Approximation (HQ)
Grayson, Kentucky - GLKY						
Acetaldehyde	0.0000022	0.009	26/26	NA	NA	NA
Acrylonitrile	0.000068	0.002	20/61	0.16 ± 0.07	10.93	0.08
Arsenic (PM_{10})[a]	0.0043	0.000015	41/41	NA	NA	NA
Benzene	0.0000078	0.03	61/61	0.59 ± 0.09	4.57	0.02
Benzo(a)pyrene[a]	0.00176	--	29/61	<0.01 ± <0.01	0.05	--
Beryllium (PM_{10})[a]	0.0024	0.00002	41/41	NA	NA	NA
1,3-Butadiene	0.00003	0.002	43/61	0.04 ± 0.01	1.07	0.02
Cadmium (PM_{10})[a]	0.0018	0.00001	41/41	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	61/61	0.63 ± 0.03	3.75	0.01
Chloroform	--	0.098	15/61	0.03 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	21/61	0.03 ± 0.01	0.72	<0.01
Formaldehyde	0.000013	0.0098	26/26	NA	NA	NA
Hexachloro-1,3-butadiene	0.000022	0.09	10/61	0.01 ± 0.01	0.30	<0.01
Hexavalent Chromium[a]	0.012	0.0001	37/61	<0.01 ± <0.01	0.11	<0.01
Lead (PM_{10})[a]	--	0.00015	41/41	NA	NA	NA
Manganese (PM_{10})[a]	--	0.00005	41/41	NA	--	NA
Naphthalene[a]	0.000034	0.003	61/61	0.02 ± <0.01	0.56	0.01
Nickel (PM_{10})[a]	0.00048	0.00009	41/41	NA	NA	NA
Tetrachloroethylene	0.00000026	0.04	30/61	0.04 ± 0.01	0.01	<0.01
Trichloroethylene	0.0000048	0.002	4/61	<0.01 ± <0.01	0.02	<0.01
Vinyl Chloride	0.0000088	0.1	3/61	<0.01 ± <0.01	0.01	<0.01

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 13-5.

Observations for GLKY from Table 13-6 include the following:

- The pollutants of interest with the highest annual average concentrations for GLKY are carbon tetrachloride, benzene, and acrylonitrile.

- The pollutants with the highest cancer risk approximations for GLKY are acrylonitrile, benzene, and carbon tetrachloride. Only one other pollutant of interest for GLKY has a cancer risk approximation greater than 1.0 in-a-million (1,3-butadiene).

- All of the noncancer hazard approximations for the pollutants of interest for GLKY are considerably less than an HQ of 1.0 (0.08 or less), indicating that no adverse health effects are expected from these individual pollutants. The highest noncancer hazard approximation was calculated for acrylonitrile.

- Annual averages, and therefore cancer risk and noncancer hazard approximations, could not be calculated for the metal and carbonyl compound pollutants of interest.

13.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 13-7 and 13-8 present an evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 13-7 presents the 10 pollutants with the highest emissions from the 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 13-6. Table 13-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 13-6.

Table 13-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Kentucky 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)**
Grayson, Kentucky (Carter County) - GLKY					
Benzene	26.56	Benzene	2.07E-04	Acrylonitrile	10.93
Formaldehyde	15.19	Formaldehyde	1.97E-04	Benzene	4.57
Ethylbenzene	11.80	1,3-Butadiene	9.09E-05	Carbon Tetrachloride	3.75
Acetaldehyde	9.53	Naphthalene	7.00E-05	1,3-Butadiene	1.07
1,3-Butadiene	3.03	POM, Group 2b	3.56E-05	1,2-Dichloroethane	0.72
Naphthalene	2.06	Hexavalent Chromium, PM	3.33E-05	Naphthalene	0.56
POM, Group 2b	0.40	Ethylbenzene	2.95E-05	Hexachloro-1,3-butadiene	0.30
Dichloromethane	0.25	POM, Group 3	2.47E-05	Hexavalent Chromium	0.11
POM, Group 6	0.04	Acetaldehyde	2.10E-05	Benzo(a)pyrene	0.05
POM, Group 1a	0.02	POM, Group 5a	1.78E-05	Trichloroethylene	0.02

Table 13-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Kentucky 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)**
Grayson, Kentucky (Carter County) - GLKY					
Toluene	59.99	Acrolein	52,572.66	Acrylonitrile	0.08
Xylenes	44.41	Formaldehyde	1,549.95	Benzene	0.02
Benzene	26.56	1,3-Butadiene	1,514.80	1,3-Butadiene	0.02
Methanol	15.98	Cyanide Compounds, gas	1,335.64	Carbon Tetrachloride	0.01
Hexane	15.43	Acetaldehyde	1,058.92	Naphthalene	0.01
Formaldehyde	15.19	Benzene	885.42	Trichloroethylene	<0.01
Ethylbenzene	11.80	Naphthalene	686.00	Tetrachloroethylene	<0.01
Acetaldehyde	9.53	Xylenes	444.15	Chloroform	<0.01
1,3-Butadiene	3.03	Arsenic, PM	138.10	Hexachloro-1,3-butadiene	<0.01
Styrene	2.50	Propionaldehyde	111.83	Hexavalent Chromium	<0.01

The pollutants listed in Tables 13-7 and 13-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, 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 13.3, GLKY sampled for hexavalent chromium, carbonyl compounds, PM_{10} metals, PAHs, and VOCs. 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. As mentioned in Section 13.5.2, because annual averages could not be calculated for the metals or carbonyl compounds, cancer risk and noncancer hazard approximations were not calculated. A more in-depth discussion of this analysis is provided in Section 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 13-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Carter County. The emissions for this county are low compared to other counties with NMP sites.
- Benzene, formaldehyde, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Carter County.
- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Carter County. Note that benzene and formaldehyde top both lists.
- Acrylonitrile, which has the highest cancer risk approximation among the pollutants of interest for GLKY, appears on neither emissions-based list. This is also true for carbon tetrachloride, which has the highest annual average concentration and the third highest cancer risk approximation for GLKY.
- Benzene, 1,3-butadiene, and naphthalene appear on both emissions-based lists for Carter County and have one of the 10 highest cancer risk approximations for this site.
- Hexavalent chromium, which has the eighth highest cancer risk approximation, ranks sixth for toxicity-weighted emissions but is not one of the highest emitted pollutants in Carter County.
- Three POM Groups appear among the highest emitted pollutants (POM, Groups 1a, 2b, and 6). Three POM Groups also appear among the pollutants with the highest toxicity-weighted emissions (POM, Groups 2b, 3, and 5a). Benzo(a)pyrene, a

pollutant of interest for GLKY, is part of POM Group 5a. Several pollutants, such acenaphthene, benzo(e)pyrene, and fluorene, are measured using Method TO-13 and are part of POM, Group 2b, which appears on both emissions-based lists. Several other pollutants, such benzo(a)anthracene and indeno(1,2,3-cd)pyrene, are also measured using Method TO-13 and are part of POM, Group 6, which is one of the highest emitted "pollutants" in Carter County.

Observations from Table 13-8 include the following:

- Toluene, xylenes, and benzene are the highest emitted pollutants with noncancer RfCs in Carter County.

- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) is acrolein. 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.

- Acrylonitrile, which has the highest noncancer hazard approximation among the pollutants of interest for GLKY, appears on neither emissions-based list. Conversely, benzene and 1,3-butadiene appear on all three lists.

13.6 Summary of the 2011 Monitoring Data for GLKY

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

- ❖ *Fifteen pollutants, including nine NATTS MQO Core Analytes, failed screens for GLKY.*

- ❖ *None of the annual average concentrations of the pollutants of interest for GLKY, where they could be calculated, were greater than 1 µg/m*^{3}.

- ❖ *GLKY had the third highest annual average concentration of acrylonitrile among NMP sites sampling VOCs.*

- ❖ *GLKY had the smallest range of naphthalene concentrations measured among all NMP sites sampling this pollutant.*

- ❖ *Because sampling for* PM_{10} *metals and carbonyl compounds did not begin until May 2011 and August 2011, respectively, annual average concentrations could not be calculated for these pollutants.*

14.0 Site in Massachusetts

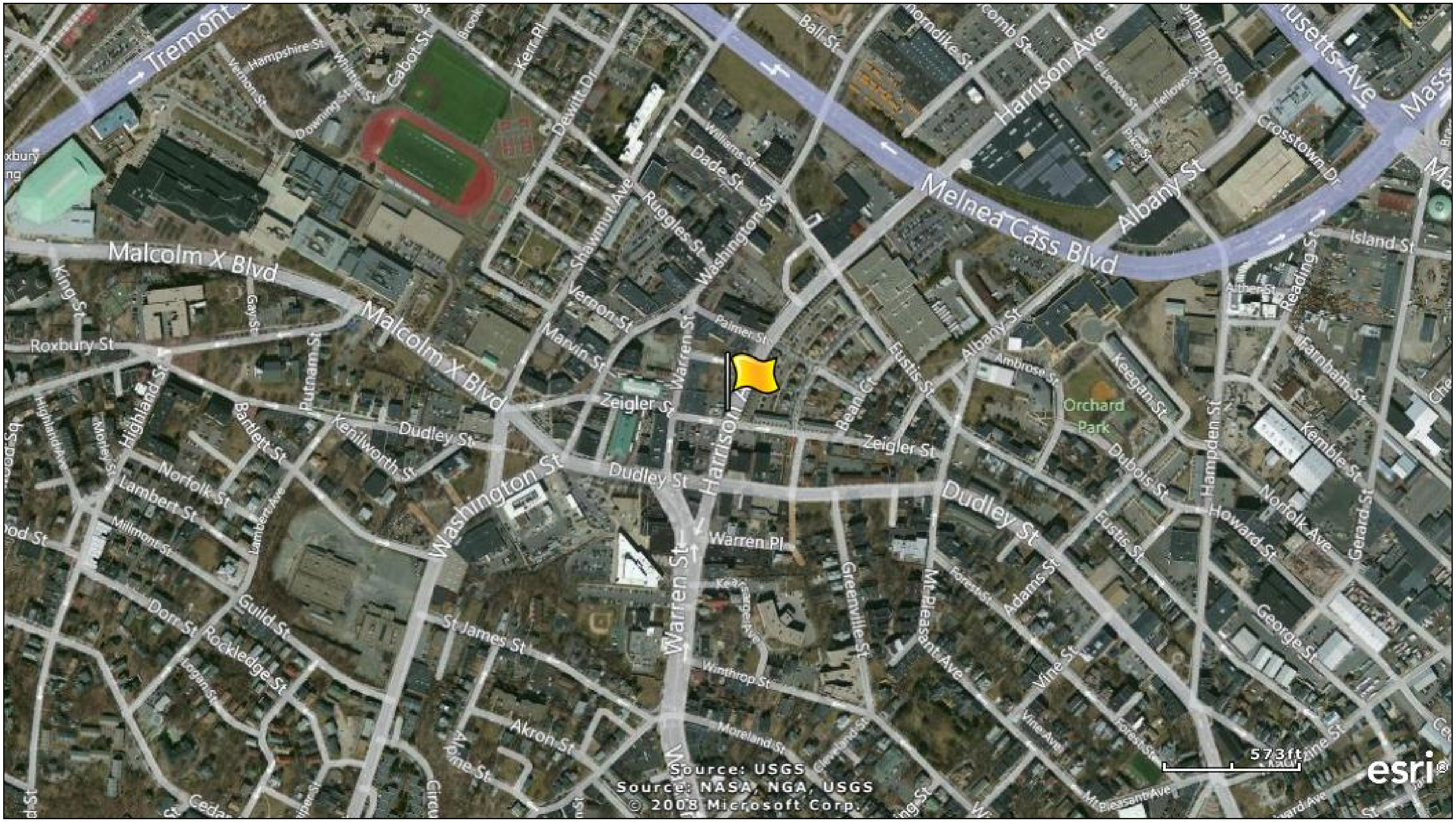
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Massachusetts, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the 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.

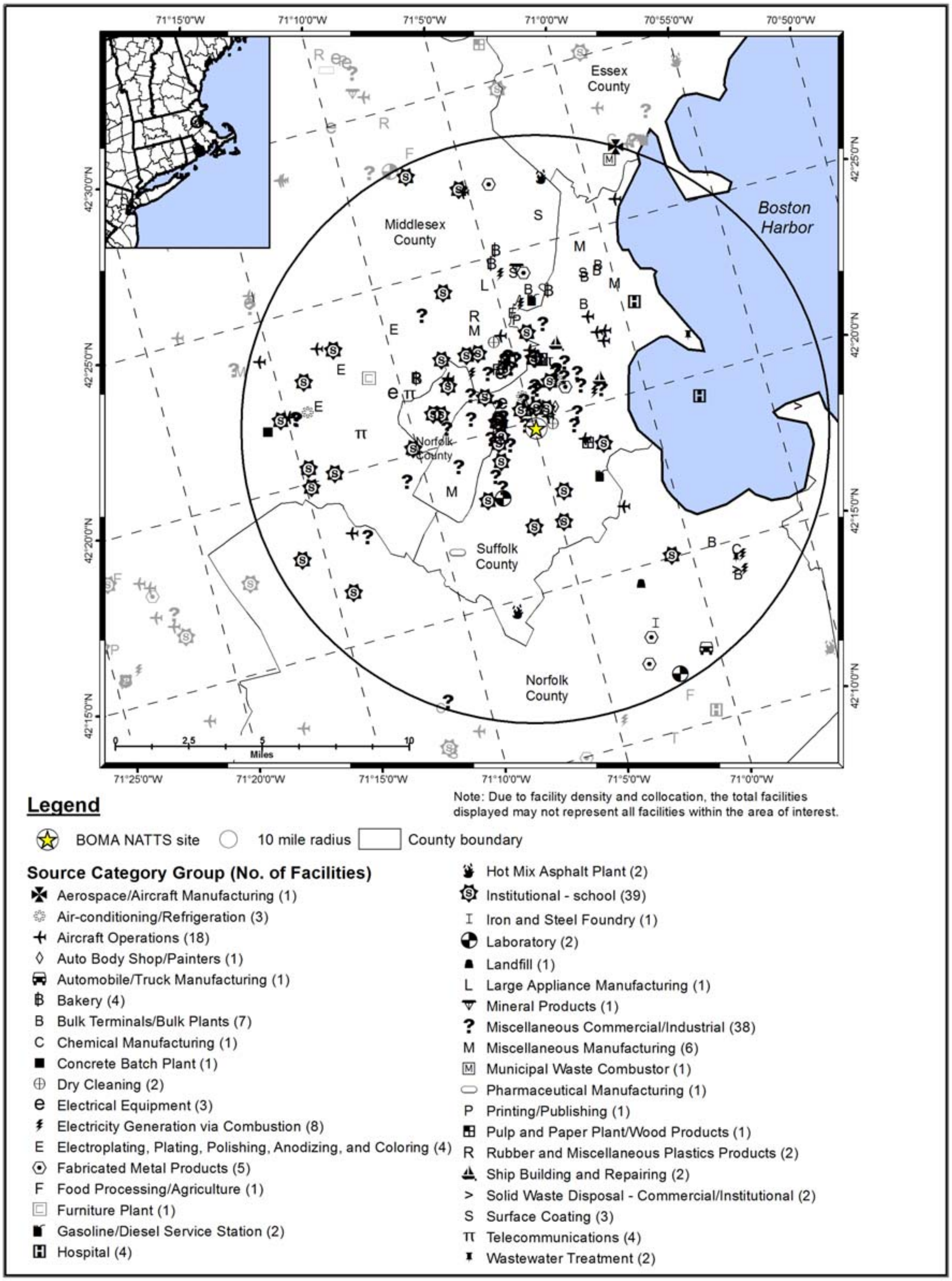
The BOMA monitoring site is located in Boston. Figure 14-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its urban location. Figure 14-2 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. 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
© 2008 Microsoft Corp.

Figure 14-2. NEI Point Sources Located Within 10 Miles of BOMA



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

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-Quincy, MA-NH MSA (Boston Div)	42.32944, -71.0825	Commercial	Urban/City Center	Lead (TSP), CO, VOCs, SO_2, NO, NO_2, NO_x, PAMS/NMOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, Black carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2012c); 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 approximately 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 categories with the highest number of emissions sources surrounding BOMA include institutional facilities (schools); aircraft operations, which includes airports as well as small runways, heliports, or landing pads; and electricity generating units (via combustion).

Table 14-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Massachusetts monitoring site. Table 14-2 includes county-level population and vehicle registration information. Table 14-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 14-2 also contains traffic volume information for BOMA. Finally, 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]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
BOMA	730,932	481,199	0.66	1,671,730	1,100,560	31,400	10,695,874

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Massachusetts Registry of Motor Vehicles (MA RMV, 2012)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2007 data from the Massachusetts DOT (MA DOT, 2007)
[5] County-level VMT reflects 2011 data for from the Massachusetts DOT (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 compared to other counties with NMP sites, while BOMA's 10-mile population is among the higher 10-mile populations (ranking 6th).

- Similar to the populations, the Suffolk County vehicle registration is in the middle of the range compared to other counties with NMP sites, while its 10-mile estimated vehicle ownership is among the higher estimates (ranking 5th).

- The vehicle-per-person ratio is the fourth lowest ratio when compared to other 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 between Washington Street and Harrison Avenue.

- The daily VMT for Suffolk County is in the middle of the range compared to other counties with NMP sites (where VMT data were available).

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 (Bair, 1992 and NOAA, 2013a).

14.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2011 (NCDC, 2011). 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 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 for 2011. Also included in Table 14-3 is the 95 percent confidence interval for each parameter. As shown in Table 14-3, average meteorological conditions on sample days at BOMA were representative of average weather conditions throughout the year.

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 in 2011. 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.

Table 14-3. Average Meteorological Conditions near the Massachusetts Monitoring Site

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)
Boston, Massachusetts - BOMA									
Logan International Airport 14739 (42.36, -71.01)	4.05 miles 42° (NE)	Sample Day	60.5 ± 4.3	53.3 ± 4.1	41.4 ± 4.7	47.9 ± 3.9	67.0 ± 4.0	1014.5 ± 2.0	9.4 ± 0.8
		2011	60.2 ± 1.8	53.2 ± 1.8	41.2 ± 1.9	47.7 ± 1.6	66.4 ± 1.6	1015.0 ± 0.8	9.1 ± 0.3

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

Figure 14-3. 2011 Composite Back Trajectory Map for BOMA

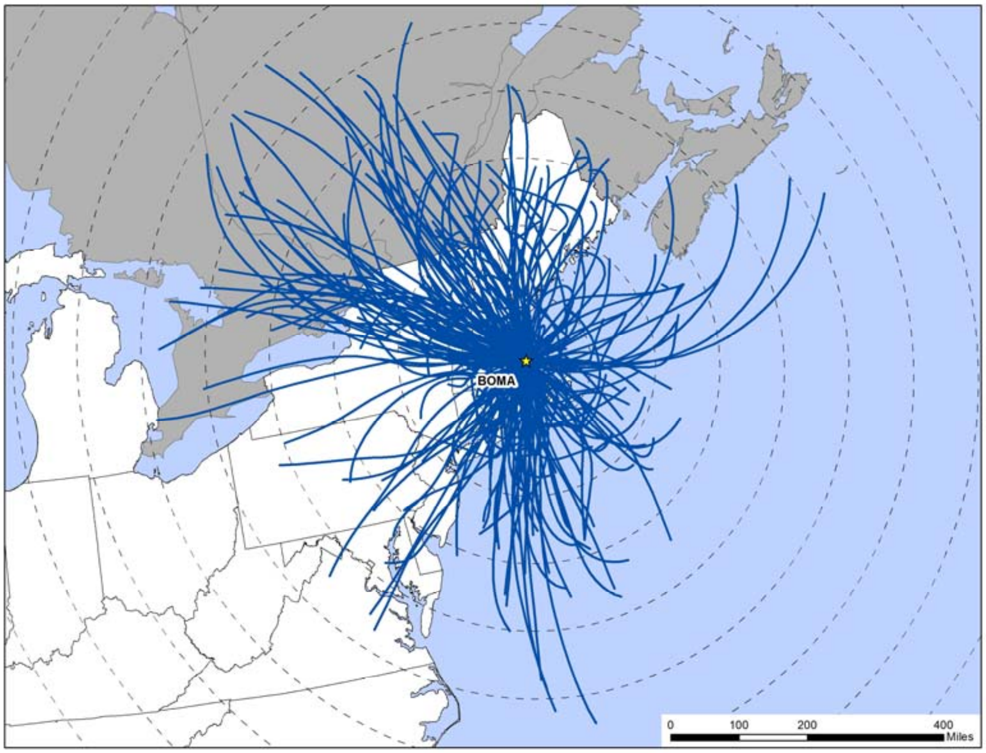
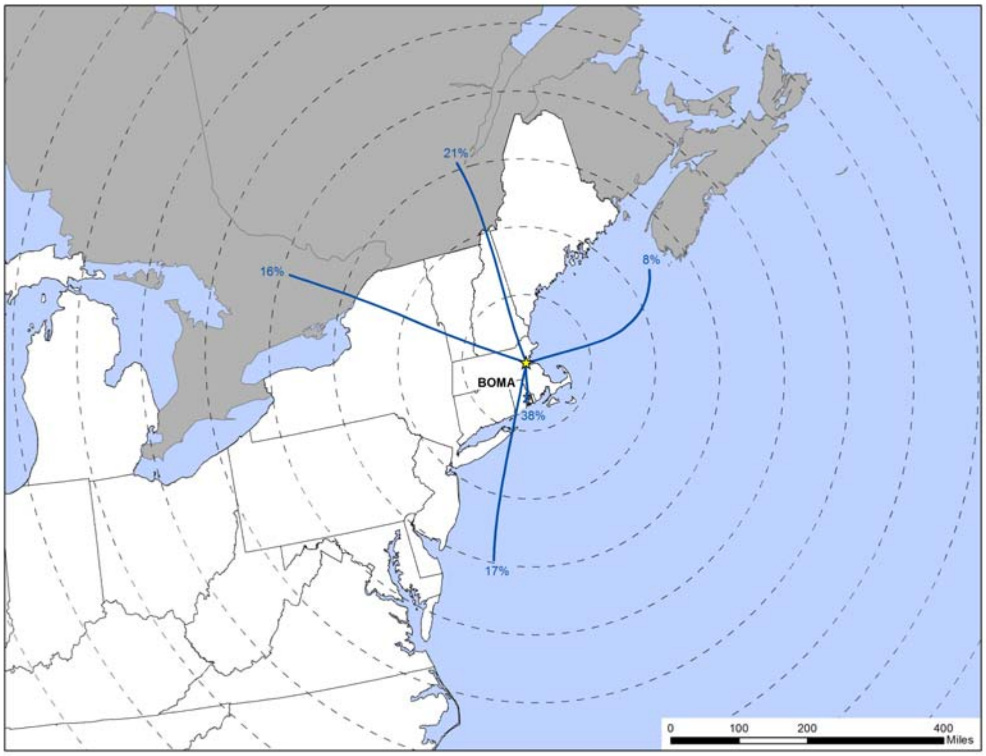


Figure 14-4. Back Trajectory Cluster Map for BOMA



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 to the northwest and south of the site, with the longest trajectories originating to the west and northwest over Canada.
- The 24-hour air shed domain for BOMA is similar in size to other NMP monitoring sites. The farthest away a back trajectory originated was nearly 600 miles, over Quebec, Canada, although back trajectories of similar length also originated over southern Ontario, Canada. The average trajectory length was 251 miles and most back trajectories (84 percent) originated within 400 miles of the monitoring site.
- Nearly 40 percent of back trajectories originated within 200 miles of BOMA, as indicated by the short cluster trajectory originating to the south of the site. This cluster trajectory represents back trajectories originating from all directions of relatively short length. It is important to recall that the HYSPLIT model includes both distance and direction when determining clusters. Another 21 percent of back trajectories originated to the north of BOMA, over the eastern Canadian provinces. Seventeen percent of back trajectories originated to the south of BOMA, although this cluster trajectory also includes back trajectories originating to the southwest over the Mid-Atlantic states and Pennsylvania. The direction from which the least number of back trajectories originated was east, at eight percent.

14.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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 NWS 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 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

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 on 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, farther inland.

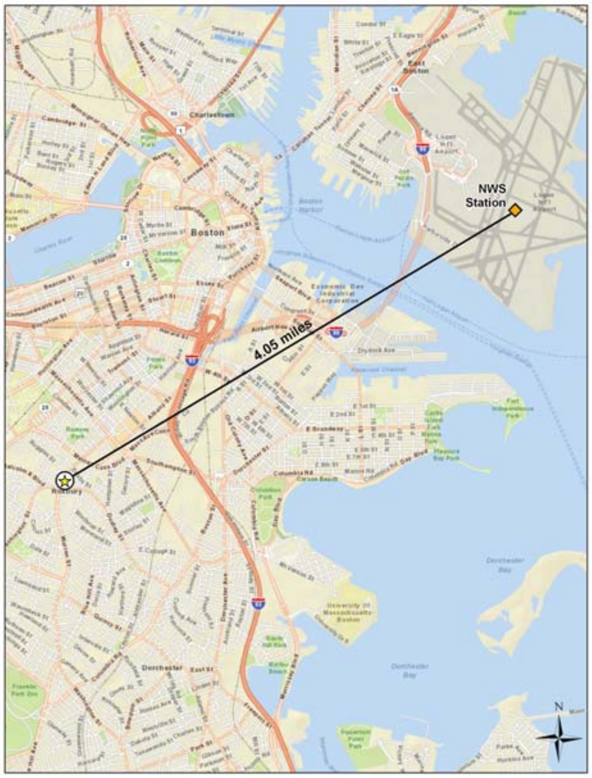
- The historical wind rose shows that calm winds (≤ 2 knots) account for only three percent of wind observations. Winds with a westerly component (south-southwest to north-northwest) make up the bulk (nearly 60 percent) of winds greater than 2 knots.

- The wind patterns shown on the 2011 wind rose resemble the historical wind patterns, indicating that wind conditions during 2011 were typical of conditions experienced historically near BOMA.

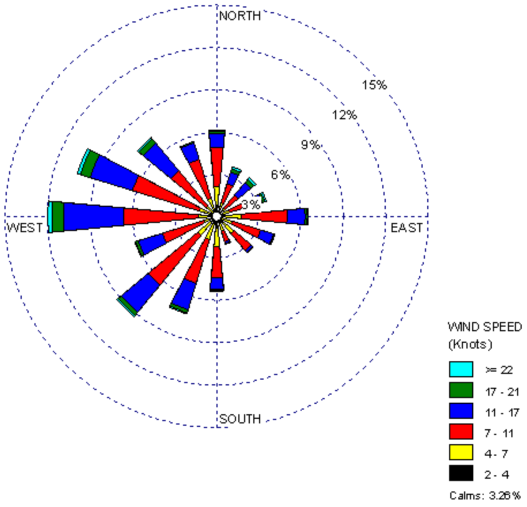
- The sample day wind patterns resemble the full-year and historical wind patterns, indicating that wind conditions on sample days were representative of those experienced over the entire year and historically.

Figure 14-5. Wind Roses for the Logan International Airport Weather Station near BOMA

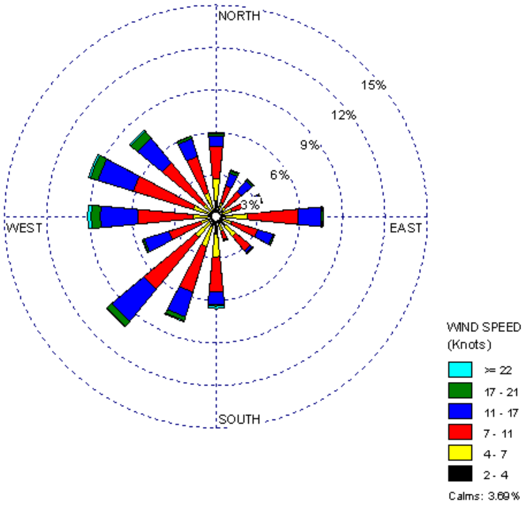
Distance between BOMA and NWS Station



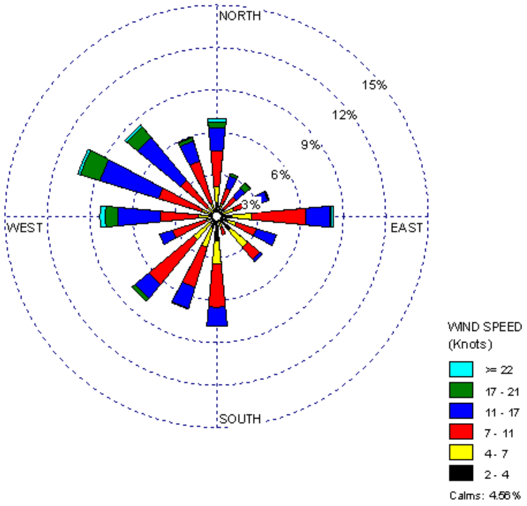
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



14.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Massachusetts monitoring site in order to allow 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." 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 14-4 presents the results of the preliminary risk-based screening process for BOMA. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for the monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. 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 ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Boston, Massachusetts - BOMA						
Naphthalene	0.029	54	61	88.52	44.26	44.26
Arsenic (PM_{10})	0.00023	48	60	80.00	39.34	83.61
Manganese (PM_{10})	0.005	12	60	20.00	9.84	93.44
Nickel (PM_{10})	0.0021	5	60	8.33	4.10	97.54
Acenaphthene	0.011	1	61	1.64	0.82	98.36
Fluorene	0.011	1	61	1.64	0.82	99.18
Hexavalent Chromium	0.000083	1	54	1.85	0.82	100.00
Total		122	417	29.26		

Observations from Table 14-4 include the following:

- Seven pollutants failed at least one screen for BOMA; of these, five are NATTS MQO Core Analytes.

- Naphthalene accounted for nearly half of the total failed screens for BOMA. Naphthalene and arsenic together account for nearly 85 percent of the total failed screens.

- Four pollutants, naphthalene and three PM_{10} metals, were initially identified as pollutants of interest for BOMA. Hexavalent chromium was added to the pollutants of interest for BOMA because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of the failed screens. Benzo(a)pyrene, beryllium, cadmium, and lead were also added to BOMA's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens. These four pollutants are not shown in Table 14-4 but are shown in subsequent tables in the sections that follow.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for BOMA, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for BOMA are provided in Appendices M through O.

14.4.1 2011 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 of 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})	60/60	0.26 ± 0.06	0.45 ± 0.14	0.61 ± 0.16	0.38 ± 0.11	0.43 ± 0.07
Benzo(a)pyrene	61/61	0.15 ± 0.04	0.11 ± 0.03	0.07 ± 0.03	0.12 ± 0.02	0.11 ± 0.02
Beryllium (PM_{10})	60/60	0.03 ± 0.03	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	0.01 ± 0.01
Cadmium (PM_{10})	60/60	0.13 ± 0.02	0.15 ± 0.03	0.14 ± 0.02	0.10 ± 0.02	0.13 ± 0.01
Hexavalent Chromium	54/61	0.02 ± 0.01	0.03 ± 0.01	0.04 ± 0.02	0.02 ± 0.01	0.03 ± 0.01
Lead (PM_{10})	60/60	3.18 ± 1.25	3.50 ± 1.10	2.89 ± 0.54	2.74 ± 0.71	3.07 ± 0.44
Manganese (PM_{10})	60/60	2.77 ± 0.85	4.58 ± 1.15	3.42 ± 0.64	3.11 ± 0.75	3.48 ± 0.44
Naphthalene	61/61	55.51 ± 11.52	55.96 ± 12.84	75.12 ± 16.68	53.83 ± 12.85	60.35 ± 6.84
Nickel (PM_{10})	60/60	1.29 ± 0.21	1.68 ± 0.45	1.39 ± 0.43	1.16 ± 0.20	1.38 ± 0.17

Observations for BOMA from Table 14-5 include the following:

- Naphthalene is the pollutant with the highest annual average concentration by mass (60.35 ± 6.84 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 (3.48 ± 0.44 ng/m^3).

- The first quarter concentration of beryllium (0.03 ± 0.03 ng/m^3) is higher than the other quarterly averages (each of them is less than 0.01 ng/m^3). A review of the data shows that the maximum concentration of beryllium was measured at BOMA on January 21, 2011 (0.202 ng/m^3). This measurement is an order of magnitude higher than the next highest concentration measured at BOMA and the fifth highest beryllium concentration measured across the program. In addition, all seven beryllium concentrations greater than 0.01 ng/m^3 were measured during the first quarter of 2011 (four in January, one in February, and two in March).

- The first and second quarter average lead concentrations are higher than the other quarterly averages and have larger confidence interval associated with them. A review of the data shows that the maximum lead concentration was measured on February 8, 2011 (10.4 ng/m^3) although a similar concentration was also measured on June 8, 2011 (10.3 ng/m^3). These two measurements are twice the next highest concentration (5.61 ng/m^3). The median lead concentration for BOMA is 2.78 ng/m^3.

- The second 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 two maximum manganese concentrations were measured on June 8, 2011 (9.48 ng/m^3) and June 2, 2011 (7.08 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 BOMA from those tables include the following:

- BOMA's annual average concentration of benzo(a)pyrene ranks seventh highest among sites sampling PAHs.

- BOMA's annual average concentration of beryllium ranks third highest among other sites sampling PM_{10} metals. BOMA also ranks fourth for nickel and fifth for cadmium and lead.

- BOMA's annual average concentration of hexavalent chromium ranks seventh highest among sites sampling this pollutant.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for arsenic, benzo(a)pyrene, hexavalent chromium, lead, manganese, and naphthalene were created for BOMA. Figures 14-6 through 14-11 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

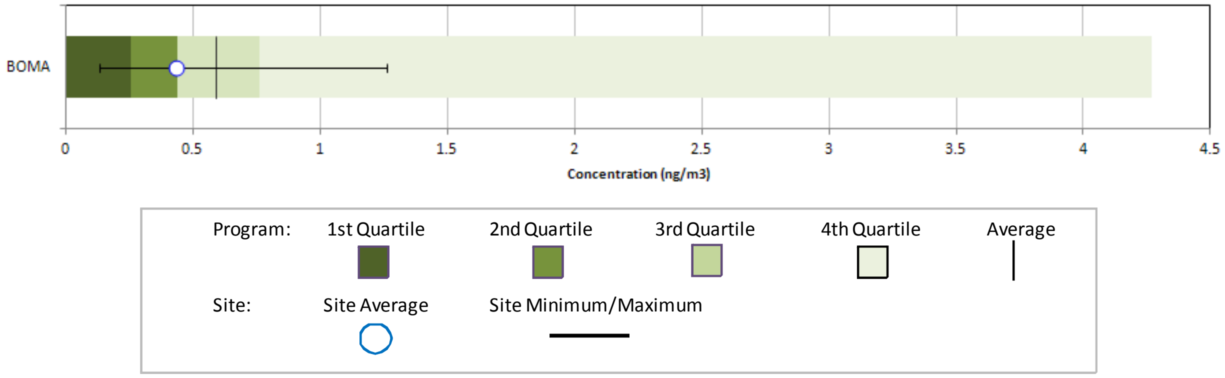


Figure 14-7. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

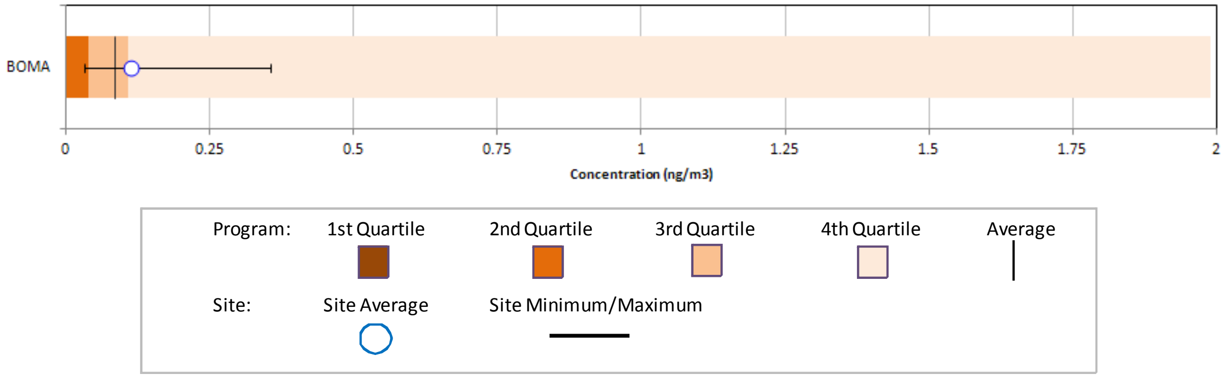


Figure 14-8. Program vs. Site-Specific Average Hexavalent Chromium Concentration

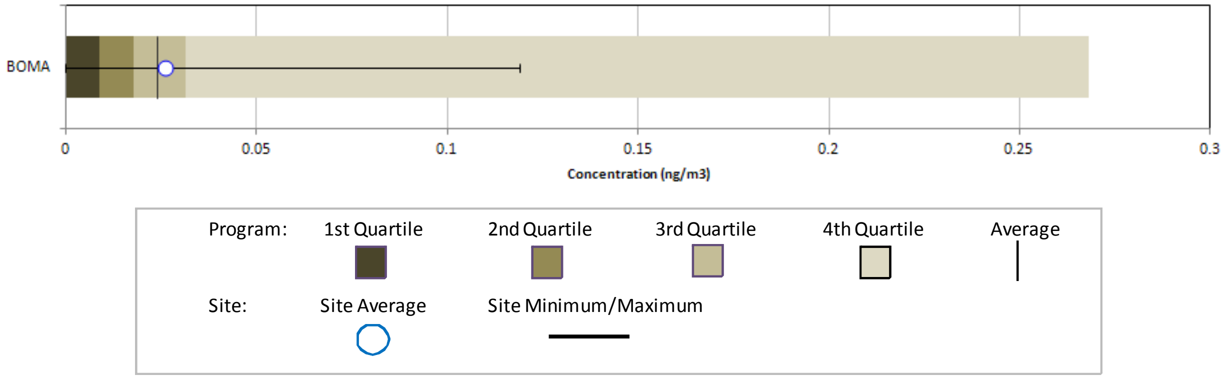


Figure 14-9. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

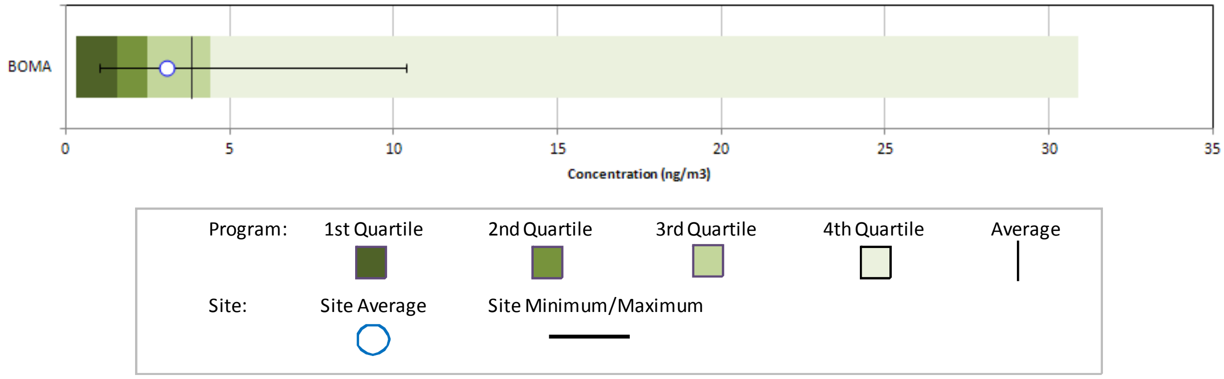


Figure 14-10. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

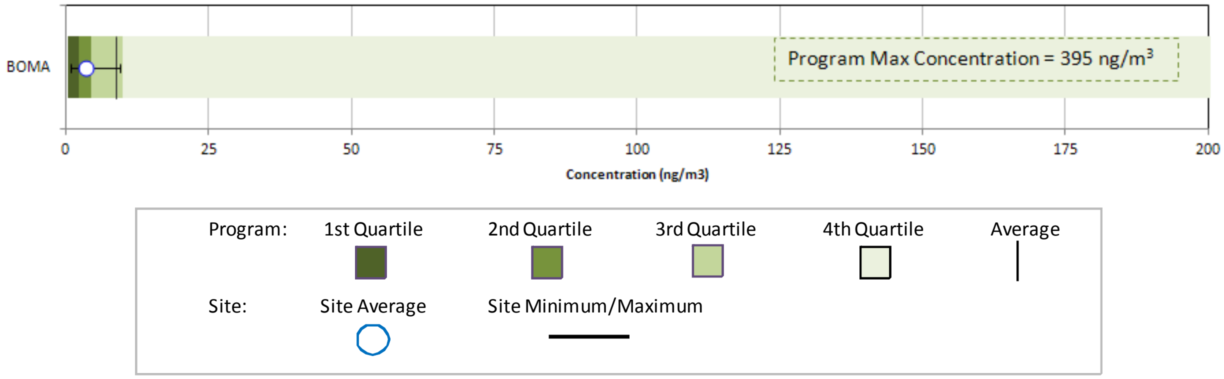
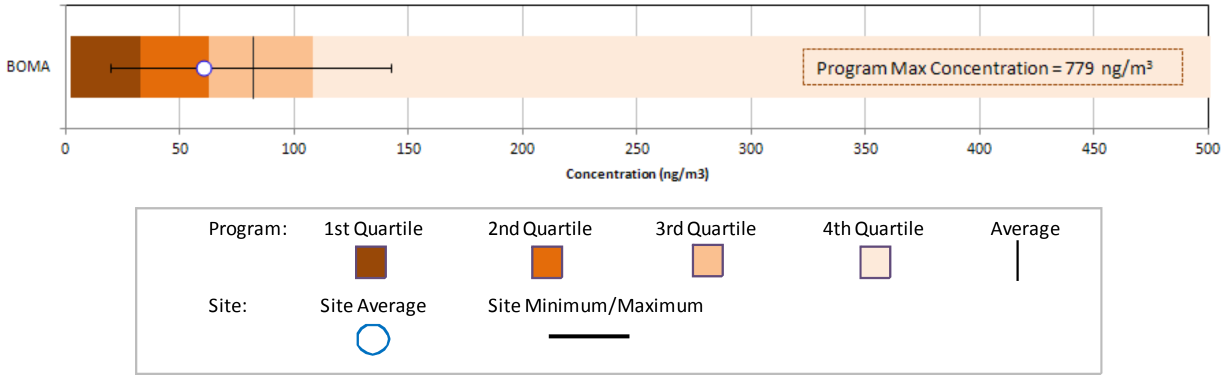


Figure 14-11. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 14-6 through 14-11 include the following:

- Figure 14-6 shows that BOMA's annual average arsenic (PM_{10}) concentration is less than the program-level average concentration for arsenic (PM_{10}) but is 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 benzo(a)pyrene. Note that the first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average concentration for BOMA is greater than the program-level average concentration and roughly equivalent to the program-level third quartile. Figure 14-7 also shows that the maximum concentration measured at BOMA is less than the maximum concentration measured across the program. There were no non-detects of benzo(a)pyrene measured at BOMA.

- Figure 14-8 is the box plot for hexavalent chromium. This figure shows that the annual average concentration of hexavalent chromium for BOMA is just greater than the program-level average concentration. The maximum concentration measured at BOMA is less than the maximum concentration measured at the program level. Several non-detects of hexavalent chromium were measured at BOMA.

- Figure 14-9 shows that the annual average lead (PM_{10}) concentration for BOMA is less than the program-level average concentration but greater than the program-level median concentration. The maximum lead concentration measured at BOMA is less than the maximum concentration measured at the program level. There were no non-detects of lead at BOMA or across the program.

- Figure 14-10 is the box plot for manganese (PM_{10}). Note that the program-level maximum concentration (395 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 200 ng/m^3. Figure 14-10 shows that the range of manganese concentrations measured at BOMA is relatively small compared to the range of manganese concentrations measured across the program. Although difficult to discern in Figure 14-10, the annual average manganese (PM_{10}) concentration for BOMA is less than half the program-level average concentration and is less than the program-level median concentration as well. The maximum manganese concentration measured at BOMA is less than the program-level third quartile and just greater than the program-level average concentration.

- Similar to manganese, the program-level maximum concentration (799 ng/m^3) is not shown directly on the box plot for naphthalene in Figure 14-11 as the scale has been reduced to 500 ng/m^3 to allow for observation of data points at the lower end of the concentration range. Figure 14-11 shows that the annual average naphthalene concentration for BOMA is less than both the program-level average and median concentrations. The maximum concentration measured at BOMA is considerably less than the maximum concentration measured at the program level. There were no non-detects of naphthalene measured at BOMA.

14.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. BOMA has been sampling metals since 2003 and hexavalent chromium since 2005. Thus, Figures 14-12 through 14-15 present the annual statistical metrics for arsenic, hexavalent chromium, lead, and manganese for BOMA, respectively. The statistical metrics presented for calculating trends include the substitution of zeros for non-detects. BOMA began sampling PAHs under the NMP in 2008; thus, the trends analysis was not conducted for the PAHs because the 5 consecutive year criterion is not met.

Figure 14-12. Annual Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at BOMA

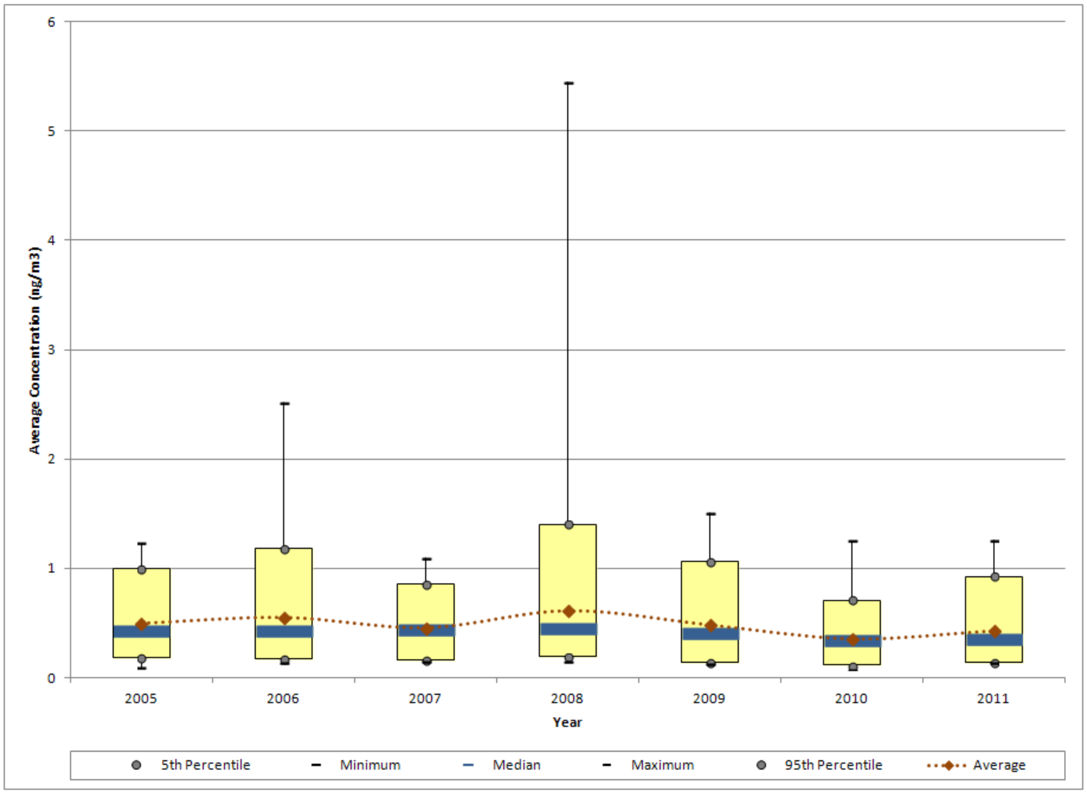


Figure 14-13. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at BOMA

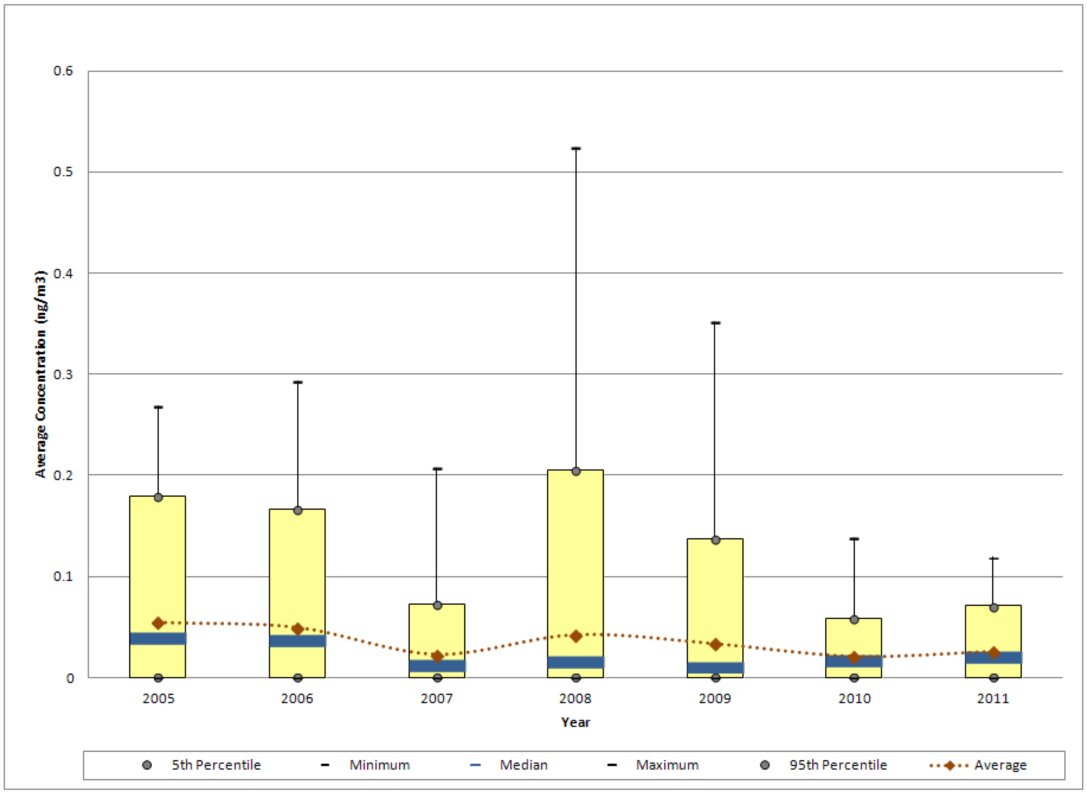


Figure 14-14 Annual Statistical Metrics for Lead (PM_{10}) Concentrations Measured at BOMA

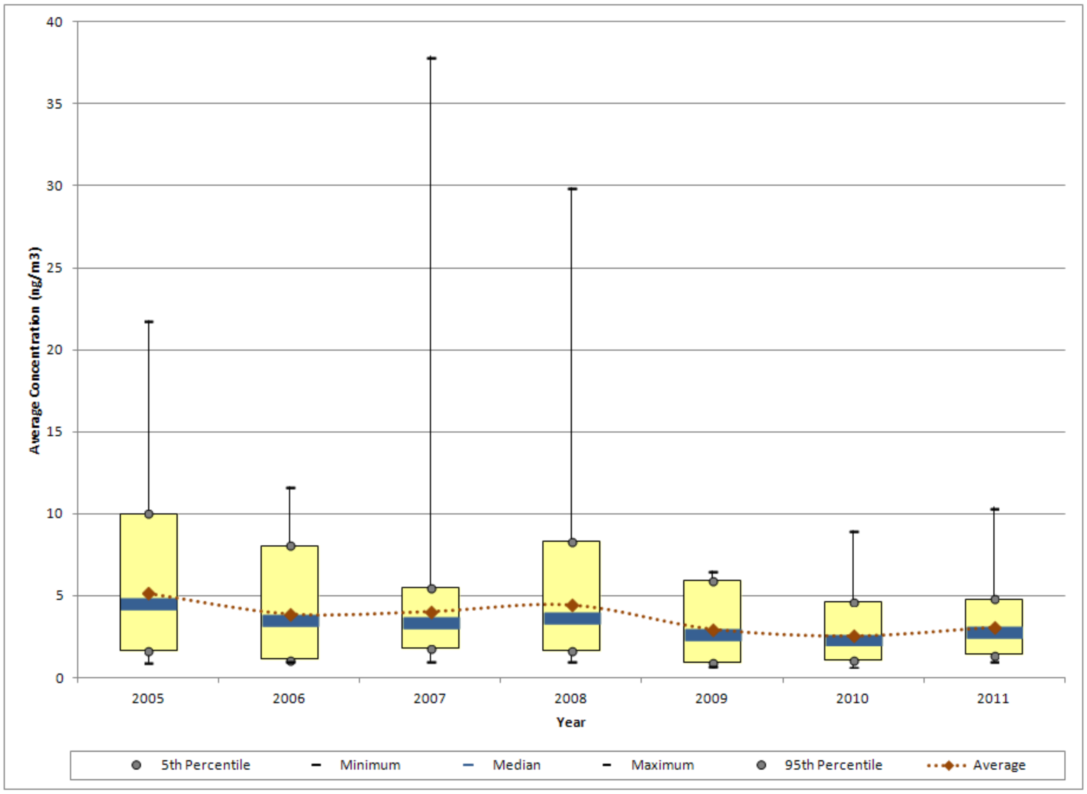
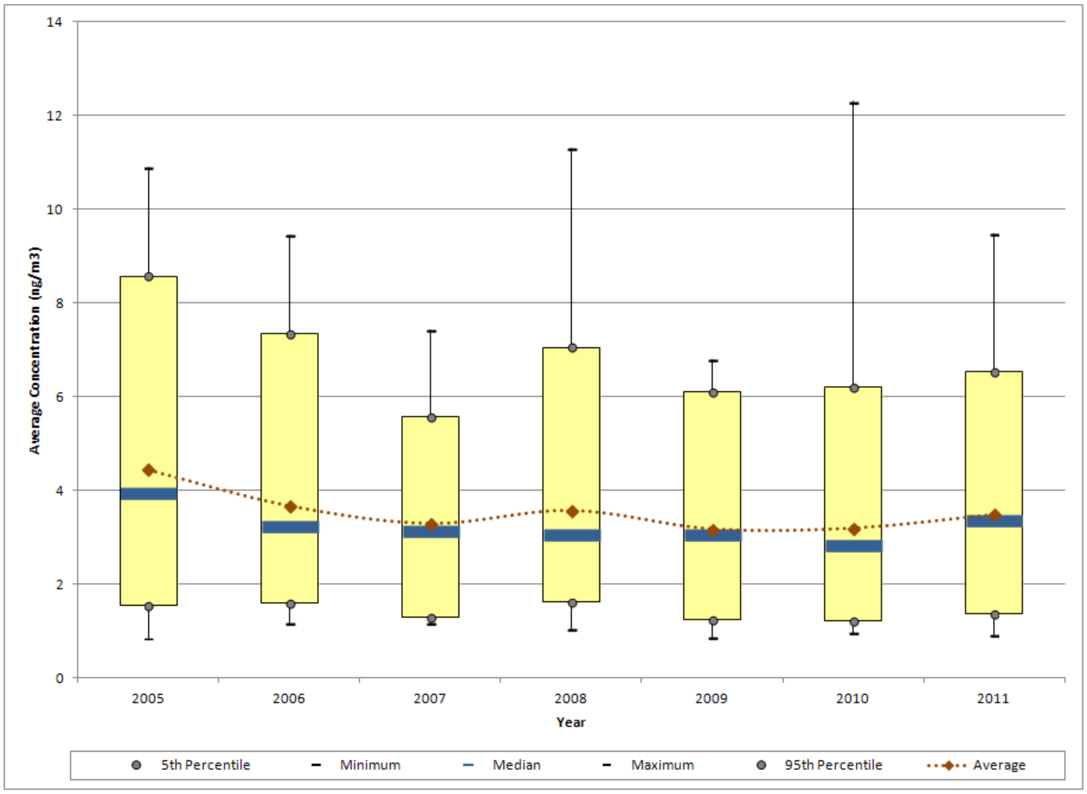


Figure 14-15. Annual Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at BOMA



Observations from Figure 14-12 for arsenic measurements at BOMA include the following:

- While PM_{10} metals sampling 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 in parts of April, May, September, and October 2004, which results in the dataset not meeting the criteria specified in Section 3.5.4; thus, 2004 is also excluded from Figure 14-12.

- 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.

- Figure 14-12 shows that while there have been fluctuations in the average concentration of arsenic at BOMA, the differences are not significant. The average concentrations of arsenic have ranged from 0.36 ng/m^3 (2010) to 0.61 ng/m^3 (2008). The median concentrations follow a similar trend but with less variation, ranging from 0.34 ng/m^3 (2010) to 0.46 ng/m^3 (2008).

- The minimum concentration measured for each year is greater than zero, indicating that there have been no non-detects of arsenic measured at BOMA since 2005.

Observations from Figure 14-13 for hexavalent chromium measurements 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 average concentration decreased significantly from 2006 to 2007, then increased for 2008. A decreasing trend is also shown after 2008, although a slight increase is shown for 2011.

- 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 seven percent (2006) to 26 percent (2009).

Observations from Figure 14-14 for lead measurements at BOMA include the following:

- The maximum lead concentration shown (37.9 ng/m^3) was measured in 2007. Only three concentrations measured at BOMA are greater than 20 ng/m^3 and these were measured in 2005, 2007, and 2008.

- The difference between the 5th and 95th percentiles for 2007 is nearly the same as 2010 and 2011, where the range of measurements is significantly smaller. This indicates that the majority of measurements in 2007 fell within a relatively small range, despite the maximum concentration shown.

- The average concentration of lead exhibits an overall decreasing trend over the years of sampling, reaching a minimum for 2010 and increasing slightly for 2011. However, the variability in the measurements, particularly for 2007 and 2008, make it difficult to draw definitive conclusions about this dataset.

- The minimum concentration measured for each year is greater than zero, indicating that there were no non-detects of lead measured at BOMA since 2005.

Observations from Figure 14-15 for manganese measurements at BOMA include the following:

- The maximum manganese concentration shown was measured on July 7, 2010 (12.3 ng/m^3). Only three manganese concentrations measured at BOMA are greater than 10 ng/m^3, and these were measured in 2005, 2008, and 2010.

- Figure 14-15 shows that the average concentration of manganese decreased from 2005 to 2006. Between 2006 and 2011, the average and median concentrations of manganese have changed relatively little. The average concentration for 2005 is 4.44 ng/m^3, after which it ranges from 3.17 ng/m^3 (2009) to 3.67 ng/m^3 (2006). Similarly, the median concentration for 2005 is 3.96 ng/m^3, after which it ranges from 2.83 ng/m^3 (2010) to 3.37 ng/m^3 (2011).

- The minimum concentration measured for each year is greater than zero, indicating that there were no non-detects of manganese measured at BOMA since 2005.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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.

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 Hazard Approximation (HQ)
Boston, Massachusetts - BOMA						
Arsenic (PM_{10})	0.0043	0.000015	60/60	0.43 ± 0.07	1.85	0.03
Benzo(a)pyrene	0.00176	--	61/61	0.11 ± 0.02	0.20	--
Beryllium (PM_{10})	0.0024	0.00002	60/60	0.01 ± 0.01	0.02	<0.01
Cadmium (PM_{10})	0.0018	0.00001	60/60	0.13 ± 0.01	0.23	0.01
Hexavalent Chromium	0.012	0.0001	54/61	0.03 ± 0.01	0.31	<0.01
Lead (PM_{10})	--	0.00015	60/60	3.07 ± 0.44	--	0.02
Manganese (PM_{10})	--	0.00005	60/60	3.48 ± 0.44	--	0.07
Naphthalene	0.000034	0.003	61/61	60.35 ± 6.84	2.05	0.02
Nickel (PM_{10})	0.00048	0.00009	60/60	1.38 ± 0.17	0.66	0.02

-- = a Cancer URE or Noncancer RfC is not available

Observations for BOMA from Table 14-6 include the following:

- Naphthalene has the highest annual average concentration for BOMA. Manganese, lead, and nickel also have annual average concentrations greater than 1.0 ng/m^3.
- Naphthalene and arsenic are the only pollutants of interest with cancer risk approximations greater than 1.0 in-a-million (2.05 in-a-million and 1.85 in-a-million, respectively).
- None of BOMA's pollutants of interest have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected due to these individual pollutants.

14.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 14-7 and 14-8 present a risk-based 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 14-6. Table 14-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 14-6.

The pollutants listed in Tables 14-7 and 14-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. The cancer risk and noncancer hazard approximations based on the site's annual averages are limited to those pollutants for which the site sampled. As discussed in Section 14.3, BOMA sampled for PAHs, PM_{10} metals, and hexavalent chromium. In addition, the cancer risk and noncancer hazard approximations are limited to those pollutants with enough data to meet the criteria for an annual average to be calculated. A more in-depth discussion of this analysis is provided in Section 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

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					
Benzene	168.18	Formaldehyde	2.13E-03	Naphthalene	2.05
Formaldehyde	164.08	Benzene	1.31E-03	Arsenic	1.85
Ethylbenzene	83.84	Nickel, PM	8.99E-04	Nickel	0.66
Acetaldehyde	79.23	1,3-Butadiene	7.99E-04	Hexavalent Chromium	0.31
1,3-Butadiene	26.64	POM, Group 3	6.36E-04	Cadmium	0.23
Naphthalene	14.54	Naphthalene	4.94E-04	Benzo(a)pyrene	0.20
Dichloromethane	5.42	Hexavalent Chromium, PM	4.31E-04	Beryllium	0.02
POM, Group 2b	3.92	POM, Group 2b	3.45E-04		
Methyl *tert* butyl ether	3.63	Arsenic, PM	2.86E-04		
Nickel, PM	1.87	Ethylbenzene	2.10E-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	456.02	Acrolein	313,612.93	Manganese	0.07
Xylenes	372.68	Nickel, PM	20,816.71	Arsenic	0.03
Benzene	168.18	Formaldehyde	16,743.22	Lead	0.02
Formaldehyde	164.08	1,3-Butadiene	13,322.42	Naphthalene	0.02
Hexane	97.07	Acetaldehyde	8,803.49	Nickel	0.02
Ethylbenzene	83.84	Benzene	5,606.08	Cadmium	0.01
Acetaldehyde	79.23	Naphthalene	4,847.85	Beryllium	<0.01
Ethylene glycol	44.58	Arsenic, PM	4,440.73	Hexavalent Chromium	<0.01
1,3-Butadiene	26.64	Xylenes	3,726.77		
Glycol ethers, gas	18.42	Cadmium, PM	2,204.94		

Observations from Table 14-7 include the following:

- Benzene, formaldehyde, and ethylbenzene 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 nickel.

- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions.

- Naphthalene and arsenic are the pollutants with the highest cancer risk approximations for BOMA. Naphthalene ranks sixth among the highest emitted pollutants and sixth for toxicity-weighted emissions. Arsenic ranks ninth on the list of highest toxicity-weighted emissions but is not among the highest emitted.

- Nickel, which has the third highest cancer risk approximation (albeit low) for BOMA, appears on both emissions-based lists. Hexavalent chromium, which has the fourth highest cancer risk approximation, ranks seventh on the list of highest toxicity-weighted emissions but is not among the highest emitted.

- POM, Group 2b ranks eighth for both quantity of emissions and toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at BOMA including acenaphthene, fluoranthene, fluorene, and perylene. None of the PAHs included in POM, Group 2b were identified as pollutants of interest for BOMA, although both acenaphthene and fluorene failed screens (one each). Benzo(a)pyrene is part of POM, Group 5a, which is not listed on either emissions-based list.

Observations from Table 14-8 include the following:

- Toluene, xylenes, and benzene 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, nickel, and formaldehyde.

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

- While nickel, arsenic, and cadmium are among the pollutants with the highest toxicity-weighted emissions, no metals appear among the highest emitted pollutants. Nickel, which has the second highest toxicity-weighted emissions (of those pollutants with a noncancer RfC), has a negligible noncancer hazard approximation, as do the remaining pollutants of interest for BOMA.

- Manganese, which has the highest noncancer hazard approximation for BOMA (albeit low), appears on neither emissions-based list.

14.6 Summary of the 2011 Monitoring Data for BOMA

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

- *Seven pollutants failed screens for BOMA, of which five are NATTS MQO Core Analytes. Naphthalene and arsenic account for a majority of the failed screens.*

- *Naphthalene had the highest annual average concentration among the pollutants of interest for BOMA.*

- *Concentrations of the metal pollutants of interest have not changed significantly over recent years.*

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-Livonia, MI MSA. Figures 15-1 through 15-3 are the composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban locations. Figure 15-4 identifies nearby point source emissions locations by source category, as reported in the 2008 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

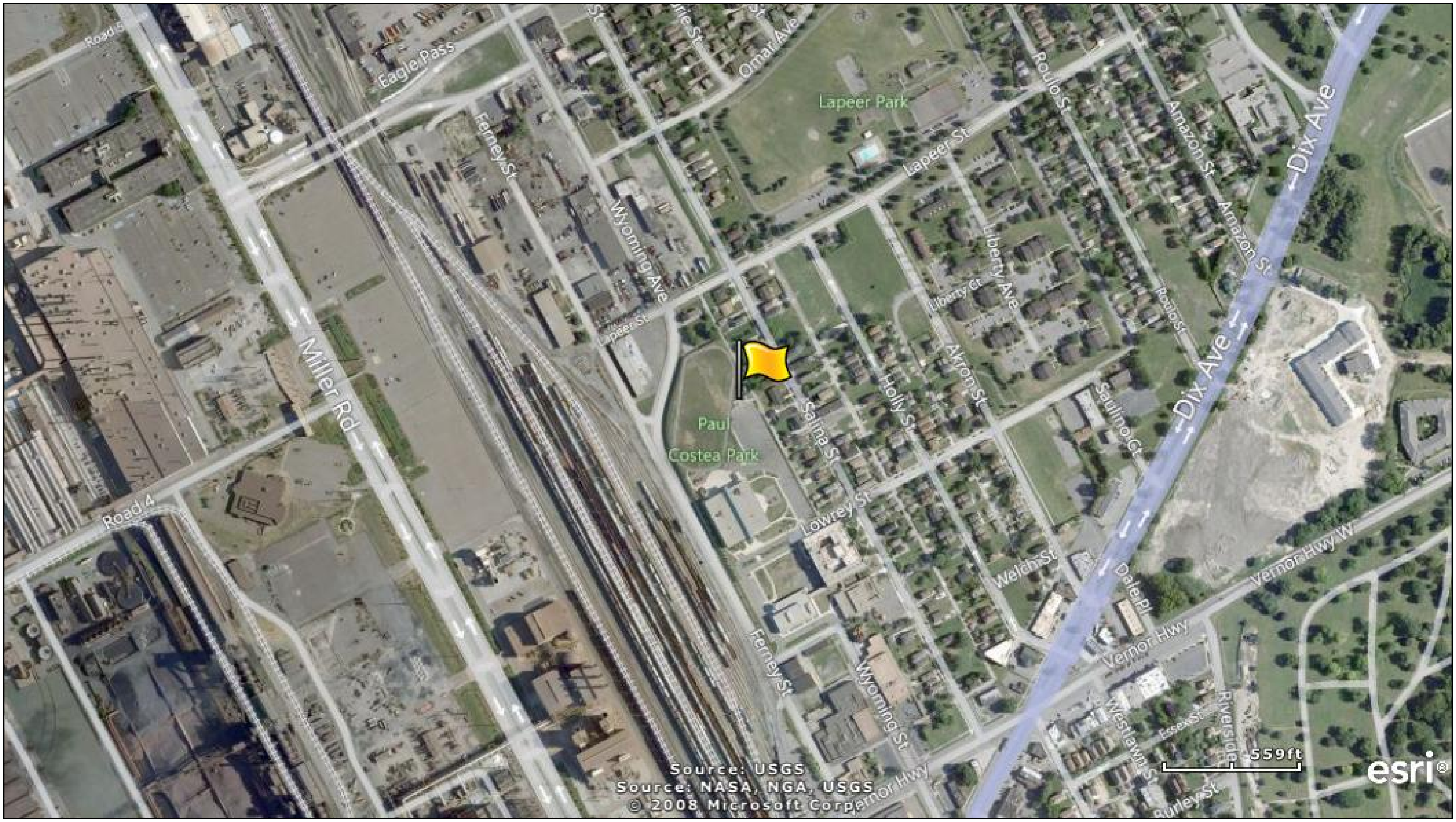
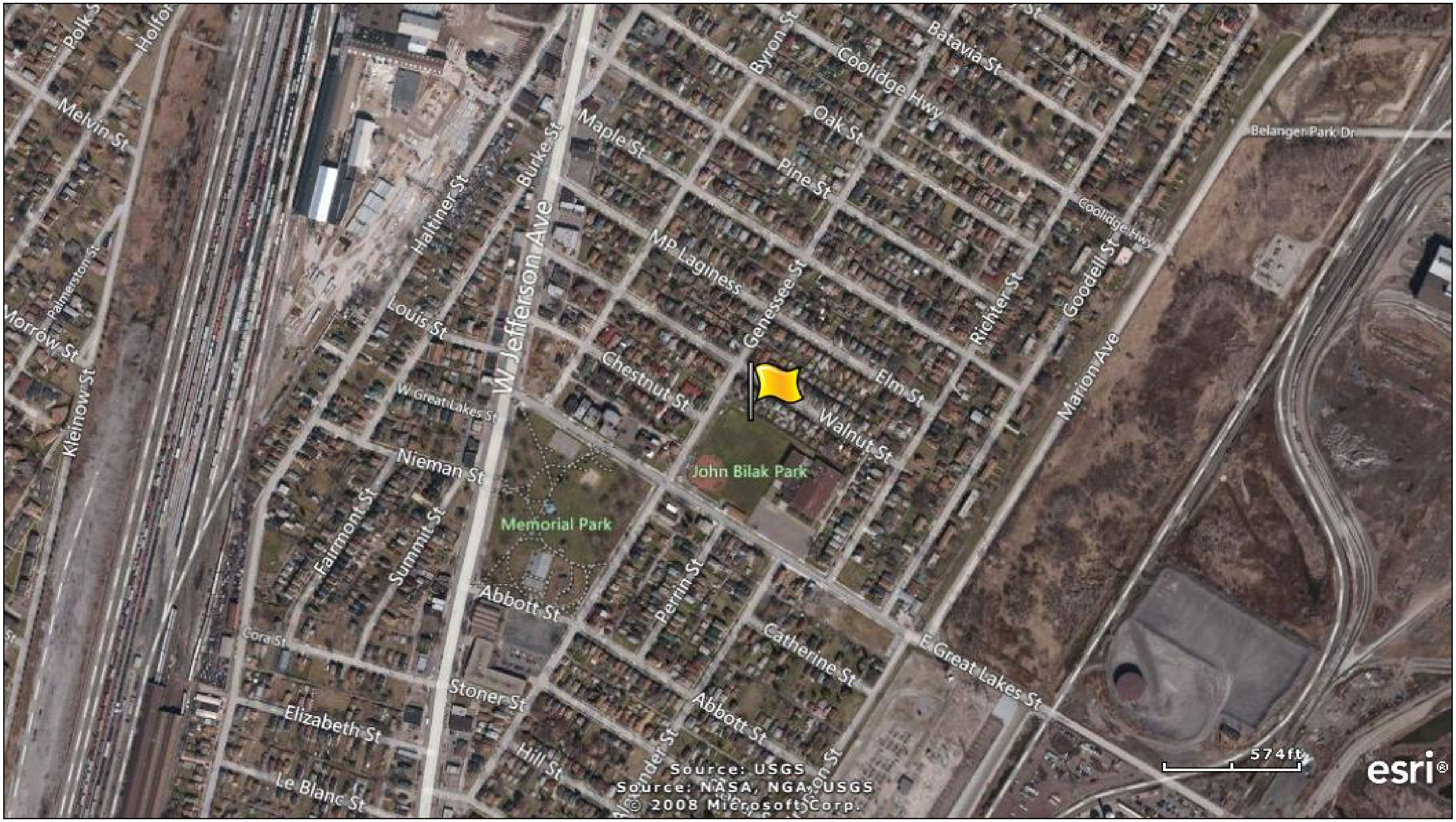


Figure 15-2. River Rouge, Michigan (RRMI) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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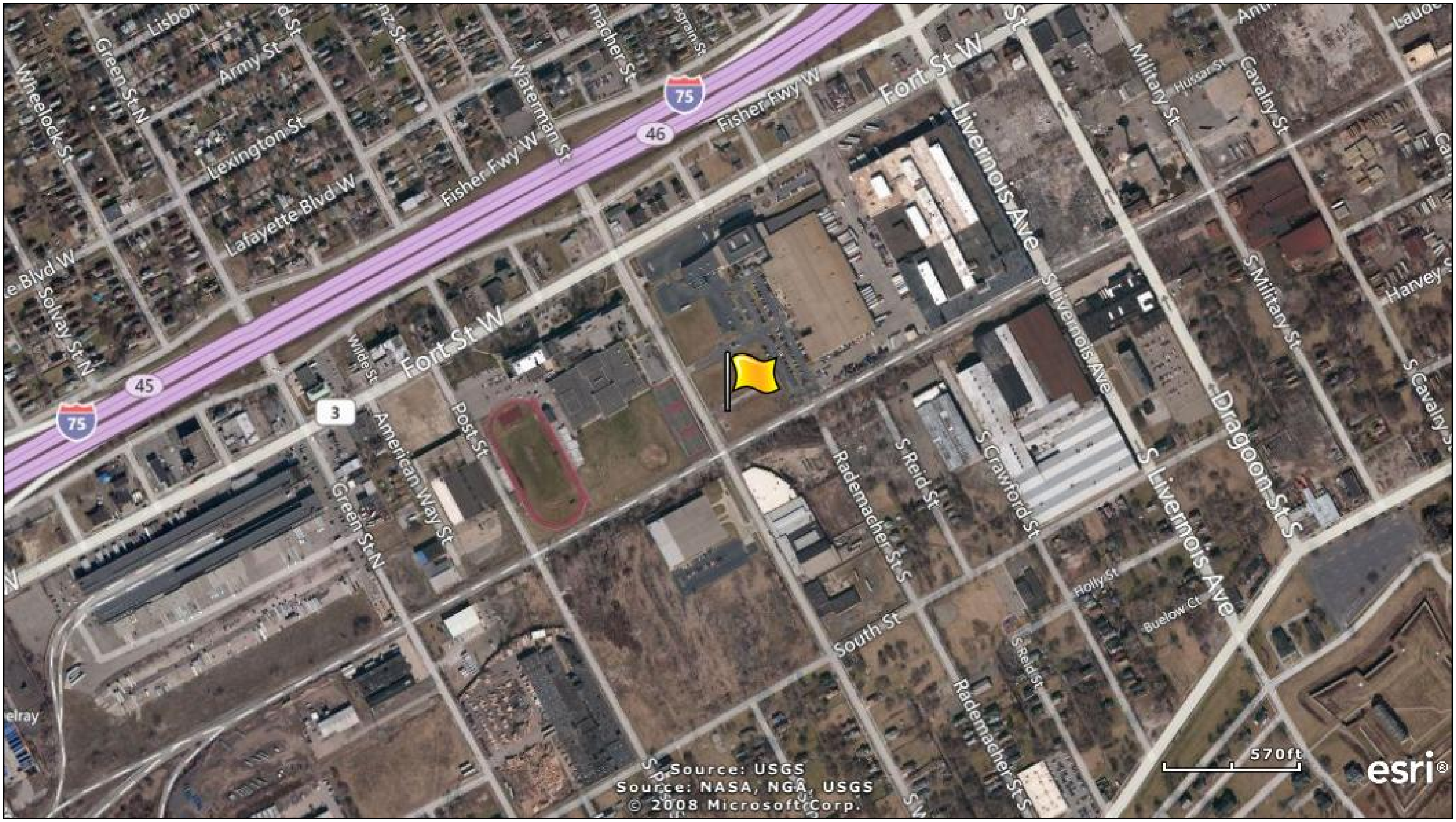
Figure 15-3. Detroit, Michigan (SWMI) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 15-4. NEI Point Sources Located Within 10 Miles of DEMI, RRMI, and SWMI

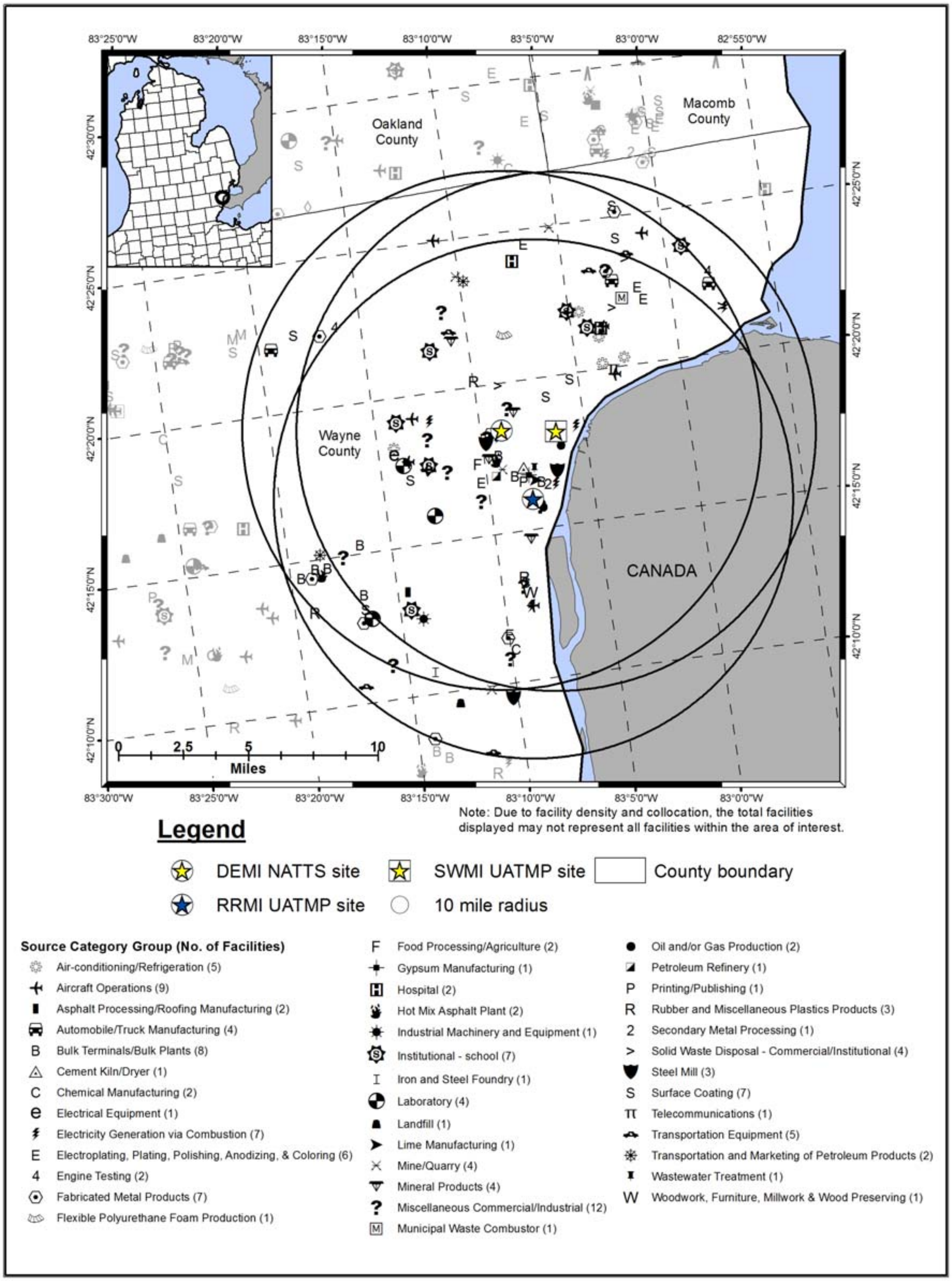


Table 15-1. Geographical Information for the Michigan Monitoring Sites

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-Livonia, MI MSA (Detroit Div)	42.30754, -83.14961	Industrial	Suburban	TSP Metals, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation.
RRMI	26-163-0005	River Rouge	Wayne	Detroit-Warren-Livonia, MI MSA (Detroit Div)	42.267222, -83.132222	Industrial	Suburban	TSP Metals, Meteorological parameters, PM_{10}, PM_{10} Manganese.
SWMI	26-163-0015	Detroit	Wayne	Detroit-Warren-Livonia, MI MSA (Detroit Div)	42.302778, -83.106667	Commercial	Urban/City Center	SO_2, TSP Metals, Soil Index, VOCs, Meteorological parameters, PM_{10}, PM_{10} Manganese, $PM_{2.5}$, and $PM_{2.5}$ Speciation

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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 at Paul Costea Park 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 and I-94.

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 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 and 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 northwest 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 southwest of DEMI. Another cluster of sources is located just north of RRMI. The source categories with the most point sources within 10 miles of the sites include the aircraft operations source category, which includes airports as well as small runways, heliports, or landing pads; bulk terminals and bulk plants; electricity generation via combustion; fabricated metals facilities; institutional facilities (schools); and surface coating facilities. Although difficult to discern in Figure 15-4, the closest source to DEMI is involved in food processing; the closest source to SWMI is involved in electricity generation via combustion; and the closest source to RRMI is involved in asphalt processing/roofing manufacturing.

Table 15-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Michigan monitoring sites. Table 15-2 includes county-level population and vehicle registration information. Table 15-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 15-2 also contains traffic volume information for each site. Finally, 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]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
DEMI	1,802,096	1,334,752	0.74	1,046,574	775,162	92,800	42,804,737
RRMI				773,610	572,987	98,500	
SWMI				974,585	721,842	93,000	

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Michigan Department of State (MDS, 2011)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data from the Michigan DOT (MI DOT, 2011)
[5] County-level VMT reflects 2011 data for all public roads from the Michigan DOT (MI DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 15-2 include the following:

- Wayne County's population and vehicle registration both rank eighth among counties with NMP sites.
- The vehicle-per-person ratio for these sites is the same and is in the bottom third among NMP sites.
- Among the Michigan monitoring sites, the 10-mile population is highest near DEMI and lowest near RRMI. The 10-mile populations rank between 10th for DEMI and 21st for RRMI among NMP sites. The 10-mile estimated vehicle ownership rankings are similar to the 10-mile population rankings.

- The traffic volumes near the Michigan sites are similar to each other and rank 14th, 15th, and 16th among NMP sites. Traffic for DEMI is provided for I-94, between Ford Plant 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 Springwell Street and Livernois Avenue.

- The Wayne County daily VMT is the fifth 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, while summers are generally mild, although temperatures exceeding 90°F are not uncommon. Two major influences on the city's weather include the urbanization of the area and Lake St. Clair to the east. 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 keeps the city warmer than outlying areas. Winds are often breezy and flow from the southwest on average. Precipitation is fairly well distributed throughout the year, with summer precipitation coming primarily in the form of showers and thunderstorms. Approximately 30 inches of snow falls on average during winter (Bair, 1992 and MSU, 2013).

15.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest these sites were retrieved for 2011 (NCDC, 2011). The closest weather station to all three Detroit 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 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)
Dearborn, Michigan - DEMI									
Detroit City Airport 14822 (42.41, -83.01)	9.70 miles 54° (NE)	Sample Day	56.8 ± 5.2	49.7 ± 4.9	40.2 ± 4.4	45.0 ± 4.3	72.6 ± 3.1	1016.0 ± 1.6	6.7 ± 0.7
		2011	58.0 ± 2.2	50.8 ± 2.0	40.9 ± 1.9	45.9 ± 1.8	71.6 ± 1.2	1015.6 ± 0.7	6.7 ± 0.3
River Rouge, Michigan - RRMI									
Detroit City Airport 14822 (42.41, -83.01)	15.73 miles 32° (NNE)	Sample Day	57.6 ± 5.4	50.4 ± 5.1	40.8 ± 4.5	45.6 ± 4.4	72.4 ± 3.3	1016.1 ± 1.7	6.6 ± 0.7
		2011	58.0 ± 2.2	50.8 ± 2.0	40.9 ± 1.9	45.9 ± 1.8	71.6 ± 1.2	1015.6 ± 0.7	6.7 ± 0.3
Detroit, Michigan - SWMI									
Detroit City Airport 14822 (42.41, -83.01)	11.98 miles 34° (NE)	Sample Day	58.3 ± 7.9	50.7 ± 7.4	41.6 ± 6.5	46.0 ± 6.4	73.7 ± 4.6	1016.4 ± 2.4	5.9 ± 0.9
		2011	58.0 ± 2.2	50.8 ± 2.0	40.9 ± 1.9	45.9 ± 1.8	71.6 ± 1.2	1015.6 ± 0.7	6.7 ± 0.3

[1] Sample day averages are highlighted 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 the entire year for 2011. Also included in Table 15-3 is the 95 percent confidence interval for each parameter. Average meteorological conditions on sample days near the Detroit sites were generally representative of average weather conditions experienced throughout the year, although Table 15-3 shows that the sample day temperature averages for SWMI were most like the full-year averages while sample day temperature averages for DEMI were the least like the full-year averages. This is interesting because SWMI sampled on a 1-in-12 day schedule and is the reason the sample day confidence intervals are larger than the sample day confidence intervals for DEMI and RRMI, which sampled on a 1-in-6 day schedule. The bulk of the samples days for RRMI and DEMI are the same, although sampling at RRMI did not begin until late January 2011.

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 in 2011. 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 and 15-8 are the composite back trajectory map and corresponding cluster analysis for RRMI. Figure 15-9 is the composite back trajectory map for SWMI but the cluster analysis was not performed for this site because there were fewer than 30 sample days.

Figure 15-5. 2011 Composite Back Trajectory Map for DEMI

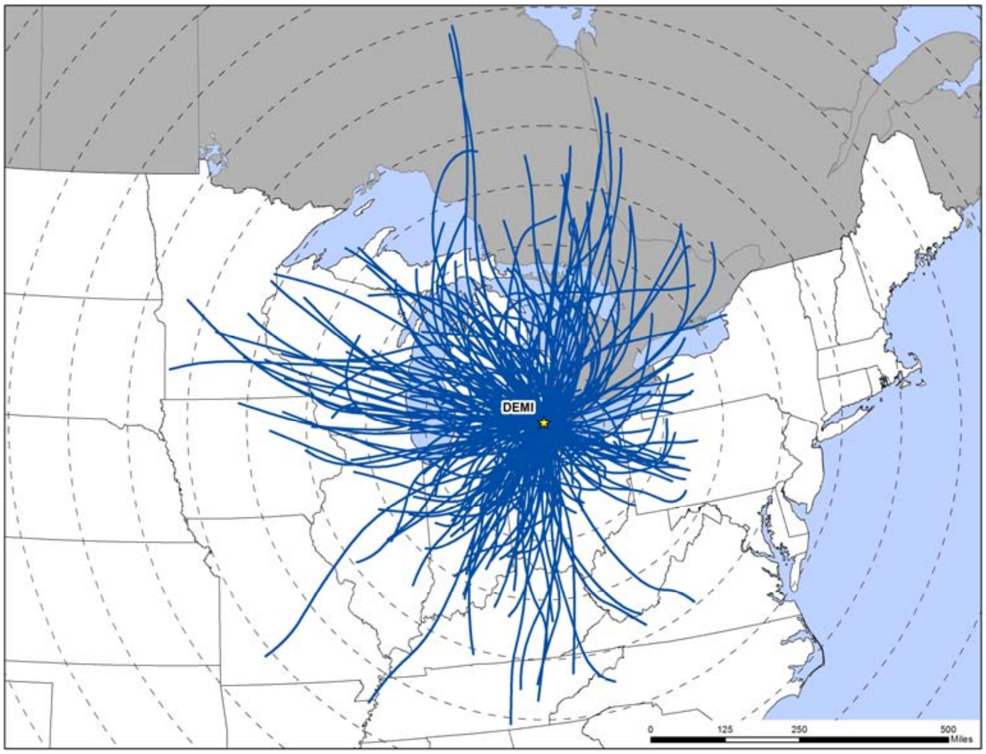


Figure 15-6. Back Trajectory Cluster Map for DEMI

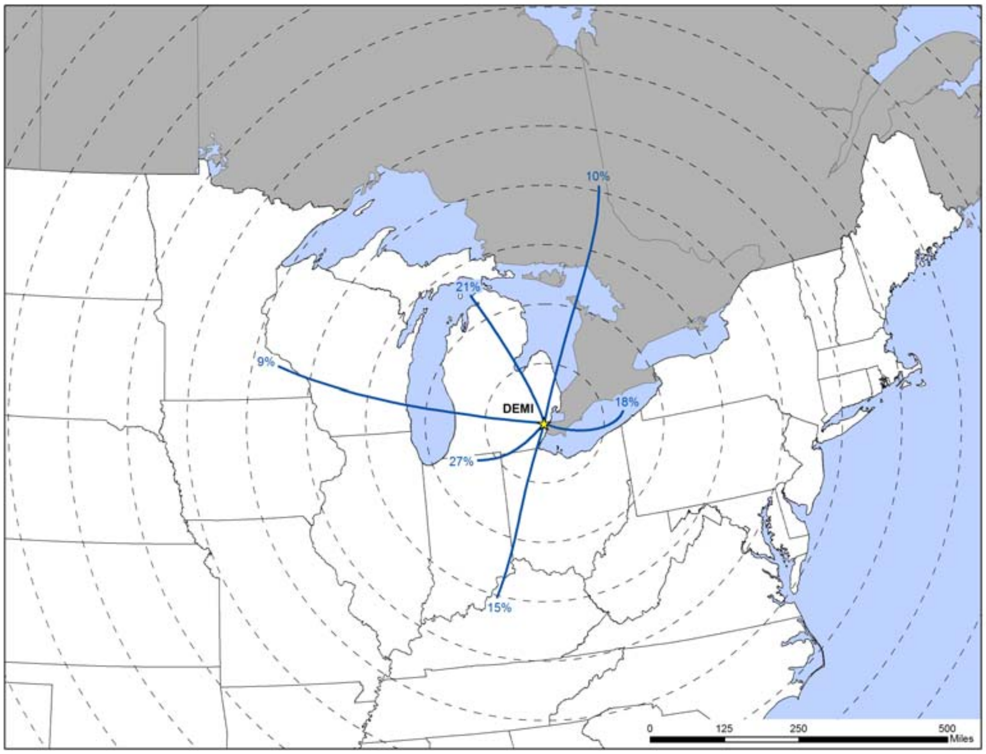


Figure 15-7. 2011 Composite Back Trajectory Map for RRMI

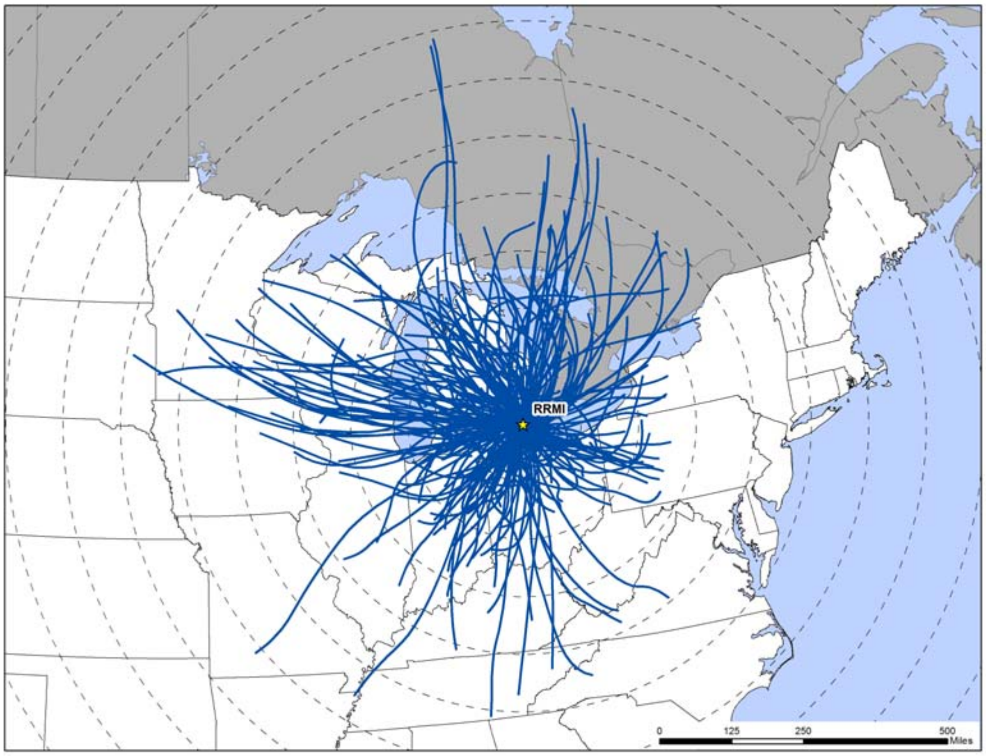


Figure 15-8. Back Trajectory Cluster Map for RRMI

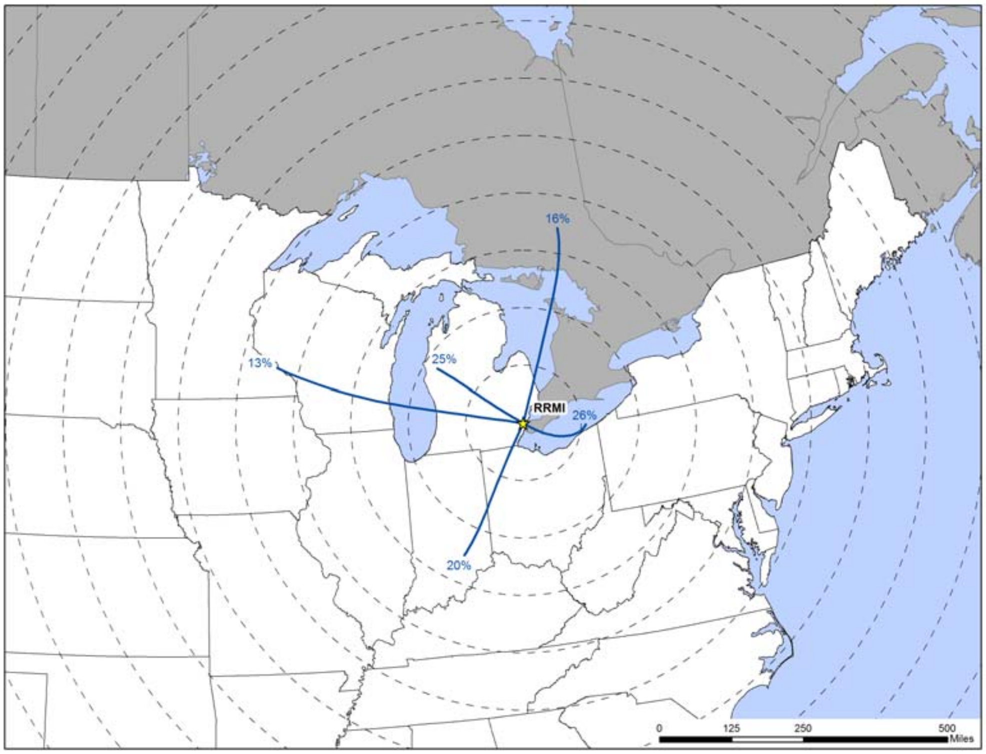
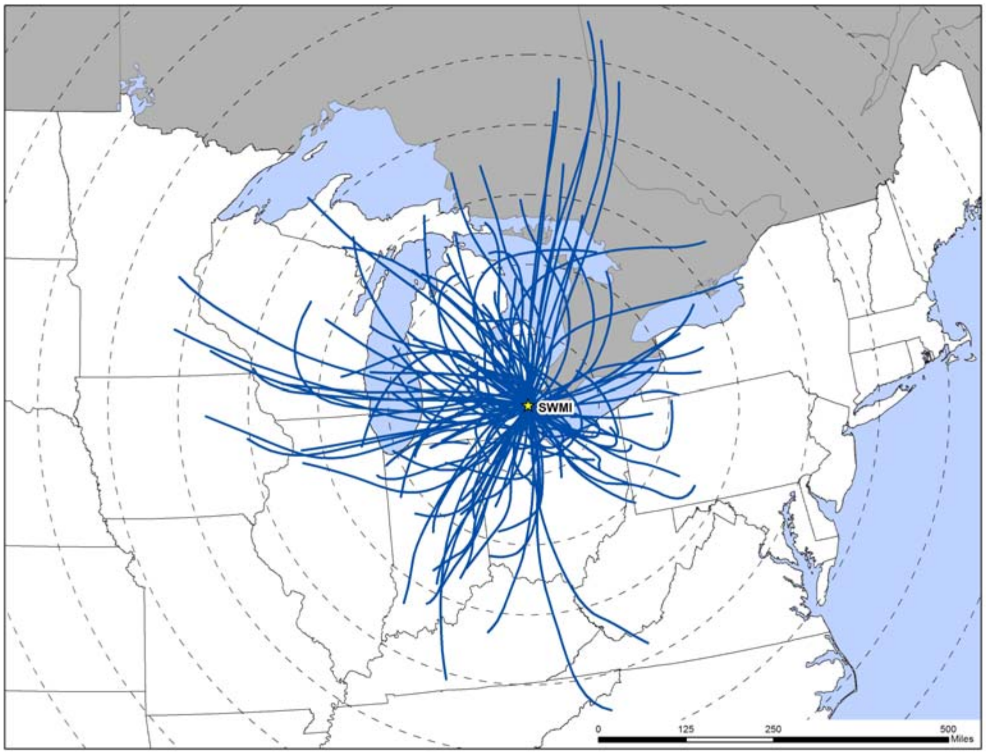


Figure 15-9. 2011 Composite Back Trajectory Map for SWMI



Observations from Figures 15-5 through 15-9 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 resembles the maps for the other two sites but 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.

- Back trajectories originated from a variety of directions at the Detroit monitoring sites. Back trajectories originating to the east of the sites tended to be shorter in length than 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 DEMI was over central Ontario, Canada, or greater than 675 miles away. While the farthest away a back trajectory originated from RRMI was over South Dakota, or nearly 690 miles away, back trajectories of similar length also originated over Ontario. The average 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 trajectory length of 243 miles with greater than 90 percent of back trajectories originating within 450 miles of the site. The farthest away a back trajectory originated was 553 miles over western Quebec, Canada.

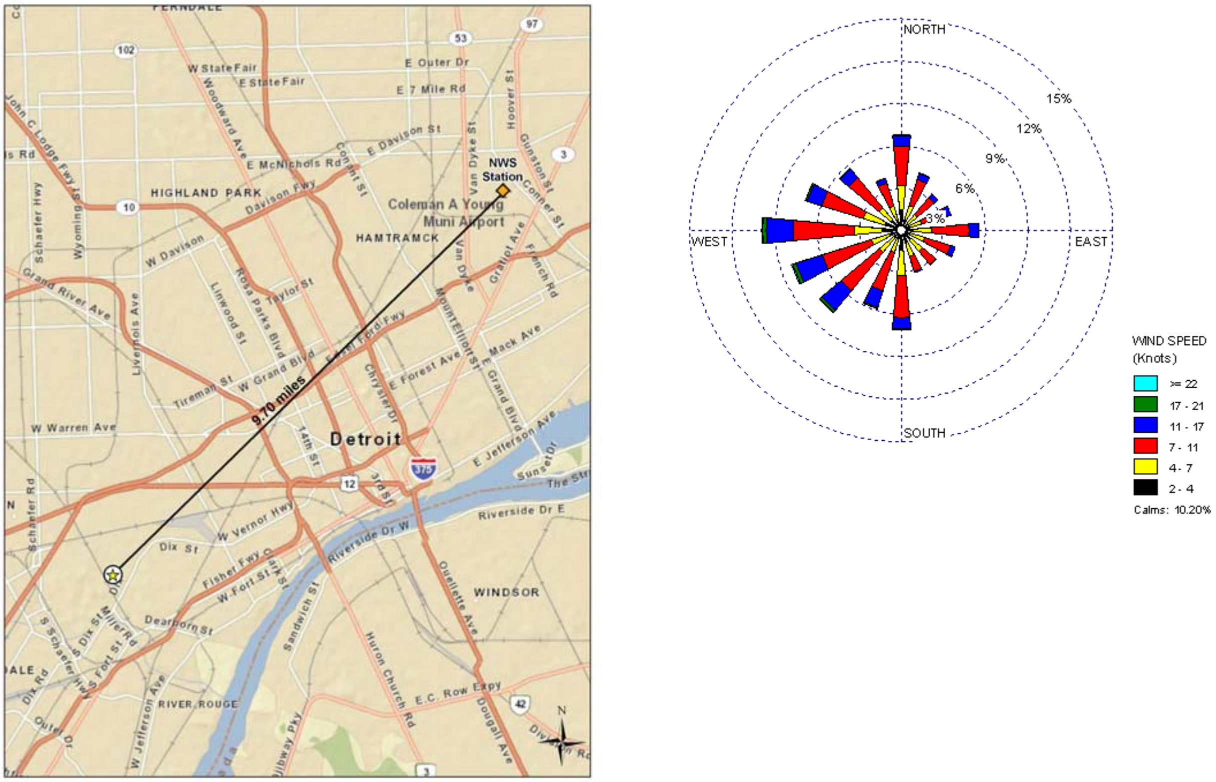
- The cluster analyses for DEMI and RRMI are similar to each other. The main difference is how the HYSPLIT model grouped some of the shorter back trajectories with a westerly component. Both cluster maps show that the bulk of the back trajectories originated from a direction with a westerly component and that they varied in length and therefore geographical origin. The cluster trajectories originating over western Wisconsin, southern Indiana, Lake Erie, and Quebec, Canada are similar in direction and origin for both sites although the percentages vary.

15.2.4 Wind Rose Comparison

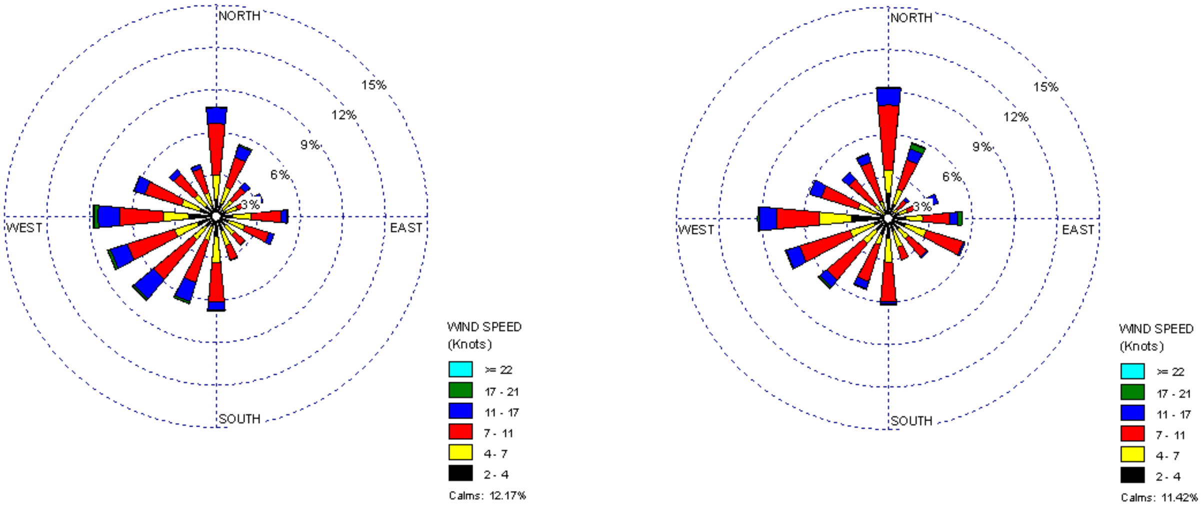
Hourly surface wind data from the NWS weather station at the Detroit City Airport were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass,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

Figure 15-10 presents a map showing the distance between the NWS station and DEMI, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 15-10 also presents three different wind roses for the DEMI monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 15-11 and 15-12 present the distance maps and wind roses for RRMI and SWMI.

Figure 15-10. Wind Roses for the Detroit City Airport Weather Station near DEMI

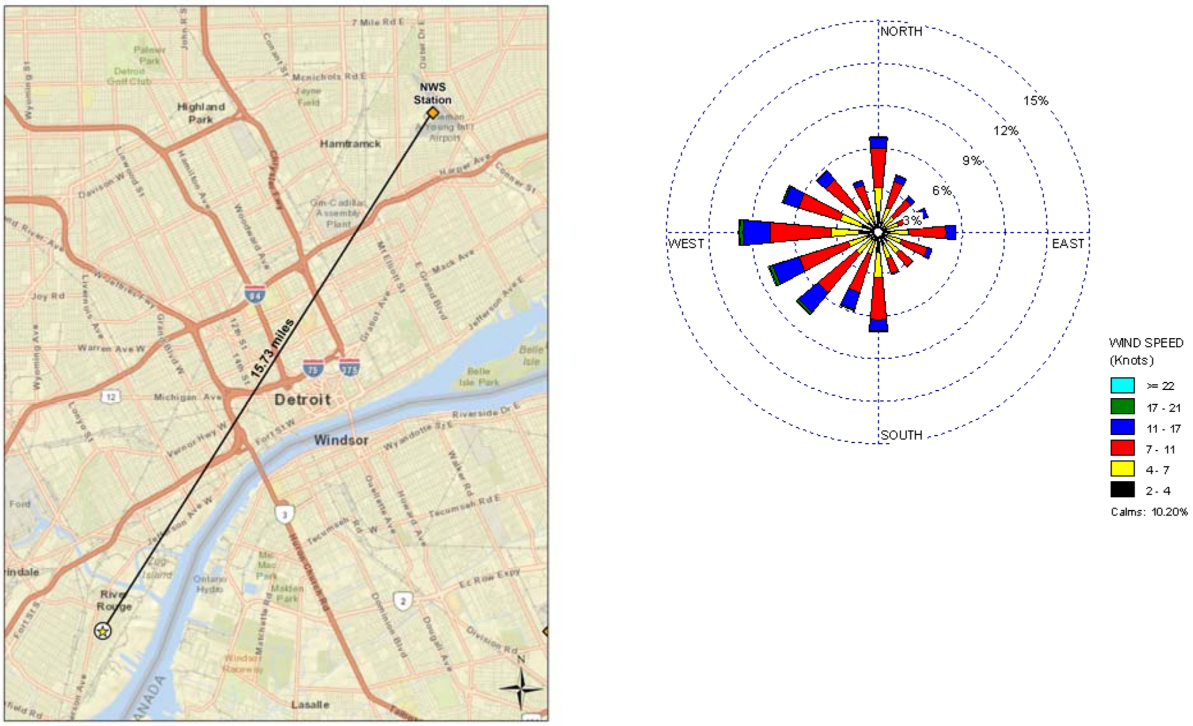

Distance between DEMI and NWS Station

2001-2010 Historical Wind Rose


2011 Wind Rose

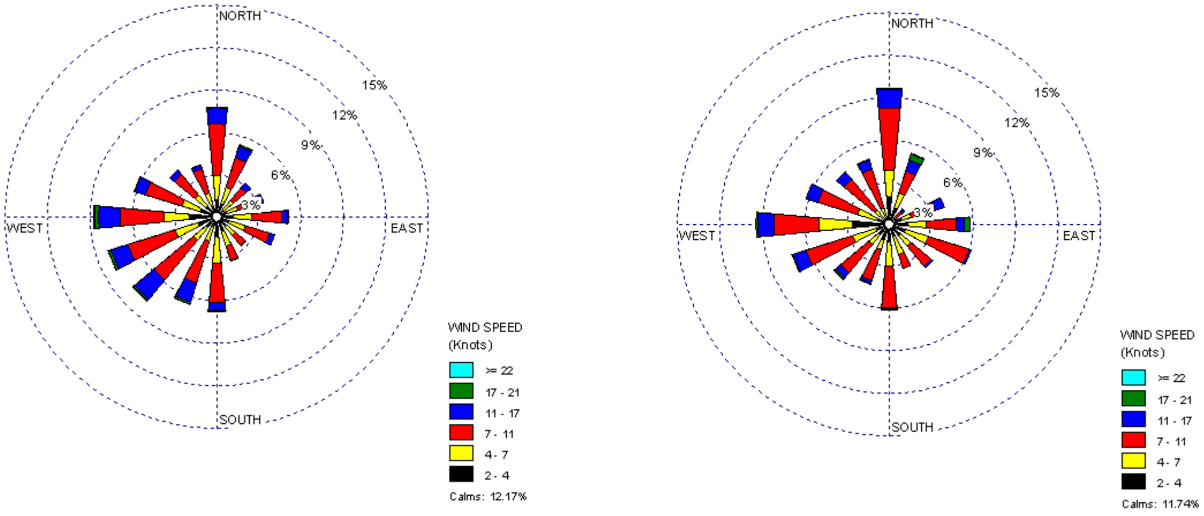
Sample Day Wind Rose

Figure 15-11. Wind Roses for the Detroit City Airport Weather Station near RRMI



Distance between RRMI and NWS Station

2001-2010 Historical Wind Rose

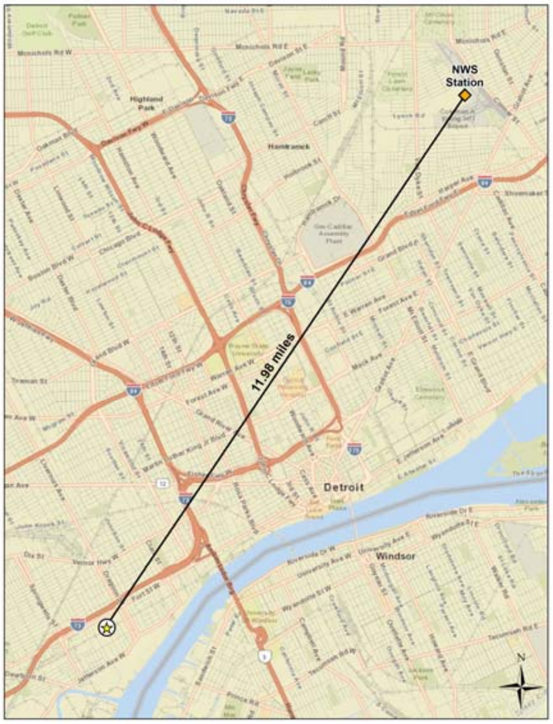


2011 Wind Rose

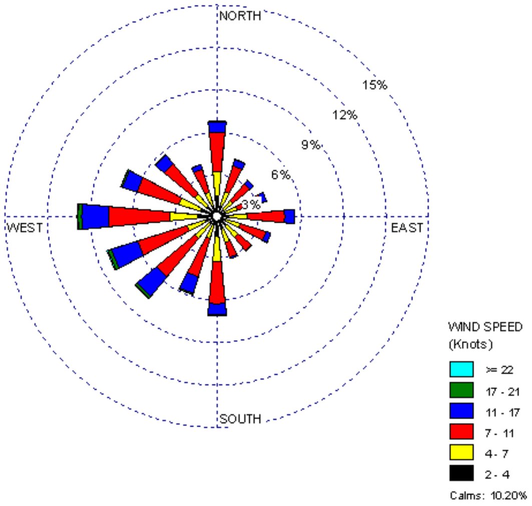
Sample Day Wind Rose

Figure 15-12. Wind Roses for the Detroit City Airport Weather Station near SWMI

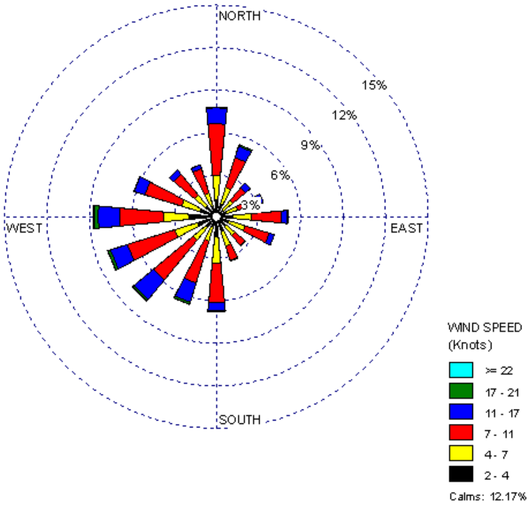
Distance between SWMI and NWS Station



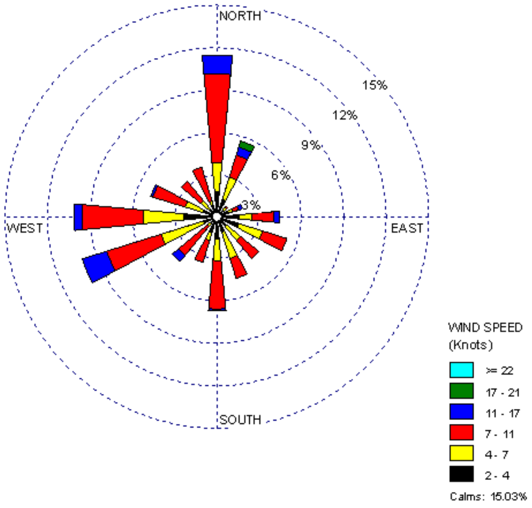
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



Observations from Figures 15-10 through 15-12 include the following:

- The NWS 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 the sites and ranges from 9.70 miles (DEMI) to 15.7 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 2011 wind roses for DEMI are the same as those for RRMI and SWMI.

- The historical wind roses for the Detroit sites show that winds from a variety of directions were observed, although winds from the northeast and southeast quadrants were observed less frequently than winds from other directions. Calm winds (≤ 2 knots) were observed for approximately 10 percent of the hourly measurements.

- The wind patterns on the 2011 wind roses resemble the historical wind patterns, although there were slightly fewer westerly to northwesterly winds and more northerly and north-northeasterly winds. This resemblance indicates that conditions during 2011 were consistent with those experienced historically.

- The sample day wind roses for DEMI and RRMI generally resemble the full-year wind rose, although there were fewer winds from the southwest quadrant and more northerly to north-northeasterly winds on sample days.

- 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 is higher for SWMI and winds from the north, west-southwest, and west account for nearly one-third of the wind observations by themselves. Recall that the sample day wind rose for SWMI has half the wind observations than the sample day wind roses for DEMI and RRMI due to the sampling frequency.

15.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Michigan monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 15-4 presents the results of the preliminary risk-based screening process for the Michigan monitoring sites. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. All three Detroit 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 (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Dearborn, Michigan - DEMI						
Acetaldehyde	0.45	62	62	100.00	13.25	13.25
Formaldehyde	0.077	62	62	100.00	13.25	26.50
Benzene	0.13	61	61	100.00	13.03	39.53
Carbon Tetrachloride	0.17	61	61	100.00	13.03	52.56
Naphthalene	0.029	60	60	100.00	12.82	65.38
1,3-Butadiene	0.03	57	57	100.00	12.18	77.56
Ethylbenzene	0.4	36	61	59.02	7.69	85.26
Acenaphthene	0.011	17	60	28.33	3.63	88.89
Fluorene	0.011	16	60	26.67	3.42	92.31
1,2-Dichloroethane	0.038	11	11	100.00	2.35	94.66
Fluoranthene	0.011	7	60	11.67	1.50	96.15
Hexavalent Chromium	0.000083	6	60	10.00	1.28	97.44
Dichloromethane	7.7	3	61	4.92	0.64	98.08
Benzo(a)pyrene	0.00057	2	58	3.45	0.43	98.50
p-Dichlorobenzene	0.091	2	16	12.50	0.43	98.93
Hexachloro-1,3-butadiene	0.045	2	2	100.00	0.43	99.36
Acrylonitrile	0.015	1	1	100.00	0.21	99.57
Chloroprene	0.0021	1	1	100.00	0.21	99.79
Xylenes	10	1	61	1.64	0.21	100.00
Total		468	875	53.49		
River Rouge, Michigan - RRMI						
Acetaldehyde	0.45	55	57	96.49	50.00	50.00
Formaldehyde	0.077	55	57	96.49	50.00	100.00
Total		110	114	96.49		
Detroit, Michigan - SWMI						
Acetaldehyde	0.45	28	28	100.00	49.12	49.12
Formaldehyde	0.077	28	28	100.00	49.12	98.25
Propionaldehyde	0.8	1	28	3.57	1.75	100.00
Total		57	84	67.86		

Observations from Table 15-4 for DEMI include the following:

- Nineteen pollutants, of which eight are NATTS MQO Core Analytes, failed at least one screen for DEMI.
- Eleven pollutants contributed to 95 percent of the total failed screens for DEMI; of these, six are NATTS MQO Core Analytes. Hexavalent chromium and benzo(a)pyrene were added to the pollutants of interest for DEMI because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of the total failed screens. Four additional pollutants (chloroform, tetrachloroethylene, trichloroethylene, and vinyl chloride) were also added to the list, even though they did not fail any screens, because they too are NATTS MQO Core Analytes. These four pollutants are not shown in Table 15-4 but are shown in subsequent tables in the sections that follow.
- Of the pollutants failing screens, approximately 53 percent of the measured detections failed screens. Ten pollutants failed 100 percent of their screens, although their detection rates varied.
- The six pollutants failing the most screens contributed to over 75 percent of the total failed screens, are all NATTS MQO Core Analytes, and failed 100 percent of their screens.

Observations from Table 15-4 for RRMI and SWMI include the following:

- Acetaldehyde and formaldehyde failed screens for RRMI. These pollutants contributed equally to the total failed screens.
- Acetaldehyde and formaldehyde failed the majority of screens for SWMI, each contributing to 49 percent of the total failed screens. Propionaldehyde failed a single screen for SWMI. These three pollutants are the only carbonyl compounds with risk screening values.

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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Michigan monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for DEMI, RRMI, and SWMI are provided in Appendices J, L, M, and O.

15.4.1 2011 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 of 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	62/62	1.67 ± 0.16	1.80 ± 0.29	1.77 ± 0.30	1.63 ± 0.37	1.72 ± 0.14
Benzene	61/61	0.84 ± 0.10	0.88 ± 0.26	0.90 ± 0.18	0.84 ± 0.17	0.86 ± 0.09
1,3-Butadiene	57/61	0.10 ± 0.01	0.08 ± 0.03	0.09 ± 0.03	0.10 ± 0.03	0.09 ± 0.01
Carbon Tetrachloride	61/61	0.59 ± 0.05	0.63 ± 0.05	0.70 ± 0.04	0.69 ± 0.04	0.65 ± 0.02
Chloroform	61/61	0.52 ± 0.10	1.58 ± 0.24	0.68 ± 0.19	0.52 ± 0.16	0.82 ± 0.14
1,2-Dichloroethane	11/61	0	0.03 ± 0.03	0	0.03 ± 0.02	0.01 ± 0.01
Ethylbenzene	61/61	0.42 ± 0.13	0.45 ± 0.13	0.91 ± 0.40	0.64 ± 0.24	0.61 ± 0.13
Formaldehyde	62/62	2.01 ± 0.23	2.04 ± 0.76	4.14 ± 0.90	2.17 ± 0.49	2.60 ± 0.39

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

Table 15-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Michigan 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)
Tetrachloroethylene	56/61	0.18 ± 0.05	0.15 ± 0.06	0.20 ± 0.06	0.18 ± 0.06	0.18 ± 0.03
Trichloroethylene	5/61	0.01 ± 0.01	0	0.02 ± 0.02	0	0.01 ± 0.01
Vinyl Chloride	8/61	<0.01 ± <0.01	0	0.01 ± <0.01	<0.01 ± 0.01	<0.01 ± <0.01
Acenaphthene[a]	60/60	3.67 ± 1.69	15.04 ± 11.35	27.99 ± 14.22	5.49 ± 2.48	13.42 ± 5.17
Benzo(a)pyrene[a]	58/60	0.15 ± 0.07	0.26 ± 0.26	0.13 ± 0.06	0.21 ± 0.15	0.19 ± 0.07
Fluoranthene[a]	60/60	2.05 ± 0.50	6.52 ± 5.02	10.26 ± 3.87	2.44 ± 0.99	5.45 ± 1.78
Fluorene[a]	60/60	3.66 ± 0.91	12.46 ± 9.32	22.15 ± 9.80	5.36 ± 2.17	11.19 ± 3.84
Hexavalent Chromium[a]	60/61	0.04 ± 0.02	0.05 ± 0.02	0.05 ± 0.02	0.05 ± 0.01	0.05 ± 0.01
Naphthalene[a]	60/60	98.14 ± 13.86	136.83 ± 43.19	217.74 ± 59.44	113.75 ± 32.02	143.35 ± 23.07
River Rouge, Michigan - RRMI						
Acetaldehyde	57/57	1.52 ± 0.45	1.87 ± 0.32	1.87 ± 0.29	1.43 ± 0.30	1.68 ± 0.17
Formaldehyde	57/57	1.90 ± 0.60	3.09 ± 1.04	4.86 ± 0.88	2.79 ± 0.50	3.23 ± 0.47
Detroit, Michigan - SWMI						
Acetaldehyde	28/28	1.32 ± 0.23	1.43 ± 0.60	2.61 ± 1.55	1.56 ± 0.42	1.74 ± 0.43
Formaldehyde	28/28	2.50 ± 0.31	2.93 ± 2.05	4.11 ± 1.11	2.11 ± 0.43	2.90 ± 0.60

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

Observations for DEMI from Table 15-5 include the following:

- The pollutants with the highest annual average concentrations by mass are formaldehyde and acetaldehyde; all other annual average concentrations are less than 1.0 µg/m^3.

- The third quarter average concentration of formaldehyde is twice the other quarterly averages. A review of the data shows that the maximum concentration of formaldehyde was measured on July 20, 2011 (6.99 µg/m^3) although similar concentrations were also measured in June and August. Of the nine concentrations greater than 4 µg/m^3, eight were measured during the third quarter of 2011.

- The second quarter average concentration of chloroform is three times higher than the other quarterly averages. A review of the data shows that the maximum concentration of chloroform was measured on June 20, 2011 (2.25 μg/m^3) although similar concentrations were also measured in May and June. Of the 16 chloroform concentrations greater than 1 μg/m^3, 13 were measured during the second quarter of 2011.

- The third quarter average concentration of ethylbenzene is higher than the other quarter averages and has a relatively high confidence interval associated with it. A review of the data shows that the highest concentration of this pollutant was measured on August 7, 2011 (3.34 μg/m^3) and is nearly twice the next highest concentration (1.91 μg/m^3 measured on August 13, 2011). This concentration is also the sixth highest ethylbenzene concentration measured among NMP sites sampling this pollutant. Of the nine ethylbenzene concentrations greater than 1 μg/m^3 measured at DEMI, more than half were measured during the third quarter of 2011.

- Similar observations for chloroform and ethylbenzene were made in the 2010 NMP report.

- The second and third quarter averages of acenaphthene, fluoranthene, and fluorene are significantly higher than the other quarterly averages and have relatively high confidence intervals associated with them. The highest concentrations of these pollutants were all measured on the same days, June 8, 2011 and July 2, 2011. The highest concentrations of these compounds were measured in June, July, and August, generally on the same days, although the order varied.

- A similar trend is shown for naphthalene. The maximum concentration of naphthalene was also measured on July 2, 2011. This was the fourth highest concentration of naphthalene measured across the program. Of the 12 highest concentrations of naphthalene measured at DEMI (those greater than 200 ng/m^3), nine were measured during the third quarter of 2011 (plus two in June and one in October).

- The second quarter average concentration of benzo(a)pyrene is the same as its associated confidence interval, an indicator of considerable variability in the concentrations measured. The maximum benzo(a)pyrene concentration (1.99 ng/m^3) was measured on May 3, 2011 and is also the maximum concentration measured among NMP sites sampling PAHs. The next highest concentration measured during the second quarter of 2011 at DEMI was considerably less (0.236 ng/m^3) and the median concentration for the second quarter is 0.149 ng/m^3. The fourth quarter average concentration and its associated confidence interval also reflect a relatively high level of variability in the measurements. The only other measurement greater than 1 ng/m^3 at DEMI was measured on October 6, 2011. The next highest concentration measured during the fourth quarter was 0.269 ng/m^3 and the median concentration for the fourth quarter is 0.142 ng/m^3.

Observations for RRMI and SWMI from Table 15-5 include the following:

- The annual average concentration of acetaldehyde for RRMI is similar to the annual average concentration for SWMI. Both are similar to the annual average acetaldehyde concentration for DEMI. The annual formaldehyde averages for the sites vary a little more.

- The third quarter average concentration of acetaldehyde for SWMI is greater than the other quarterly averages and has a relatively large confidence interval associated with it. A review of the data shows that the maximum concentration (6.70 $\mu g/m^3$) was measured on August 7, 2011 and is more than twice the next highest concentration (2.85 $\mu g/m^3$, measured on August 19, 2011).

- The second and third quarter average concentrations of formaldehyde for RRMI and SWMI are higher than the other quarterly averages for 2011 and have relatively large confidence intervals associated with them. The maximum formaldehyde concentration was measured at RRMI on July 20, 2011 (8.25 $\mu g/m^3$), which is the same day the maximum concentration of formaldehyde was measured at DEMI. Because SWMI sampled on a 1-in-12 day sampling schedule, no sample was collected at this site on July 20, 2011. However, the maximum formaldehyde concentration for SWMI (8.36 $\mu g/m^3$) was measured on the same day that the second highest concentration was measured at RRMI, June 8, 2011. The highest concentrations of formaldehyde at both sites were measured between June 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 the Michigan sites from those tables include the following:

- DEMI appears in Tables 4-9 through 4-12 a total of 10 times.

- DEMI has the second highest annual average concentration of chloroform, behind only NBIL, as shown in Table 4-9. However, the difference between the annual chloroform average for DEMI and NBIL is significant.

- The annual average concentration of acenaphthene for DEMI is the highest among NMP sites sampling PAHs. DEMI's annual average concentrations of fluorene and naphthalene each rank second and the annual average concentration of benzo(a)pyrene ranks third among sites sampling PAHs.

- The annual average concentration of hexavalent chromium for DEMI ranks fourth highest among sites sampling this pollutant.

- The rankings for DEMI are similar to those for the 2010 NMP report.

- None of the Michigan sites appear among the sites with the highest annual average concentrations of acetaldehyde. RRMI ranks tenth for its annual average concentration of formaldehyde.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde and formaldehyde were created for all three Michigan sites. In addition, box plots for benzene, benzo(a)pyrene, 1,3-butadiene, hexavalent chromium, and naphthalene were created for DEMI. Figures 15-13 through 15-19 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.

Figure 15-13. Program vs. Site-Specific Average Acetaldehyde Concentrations

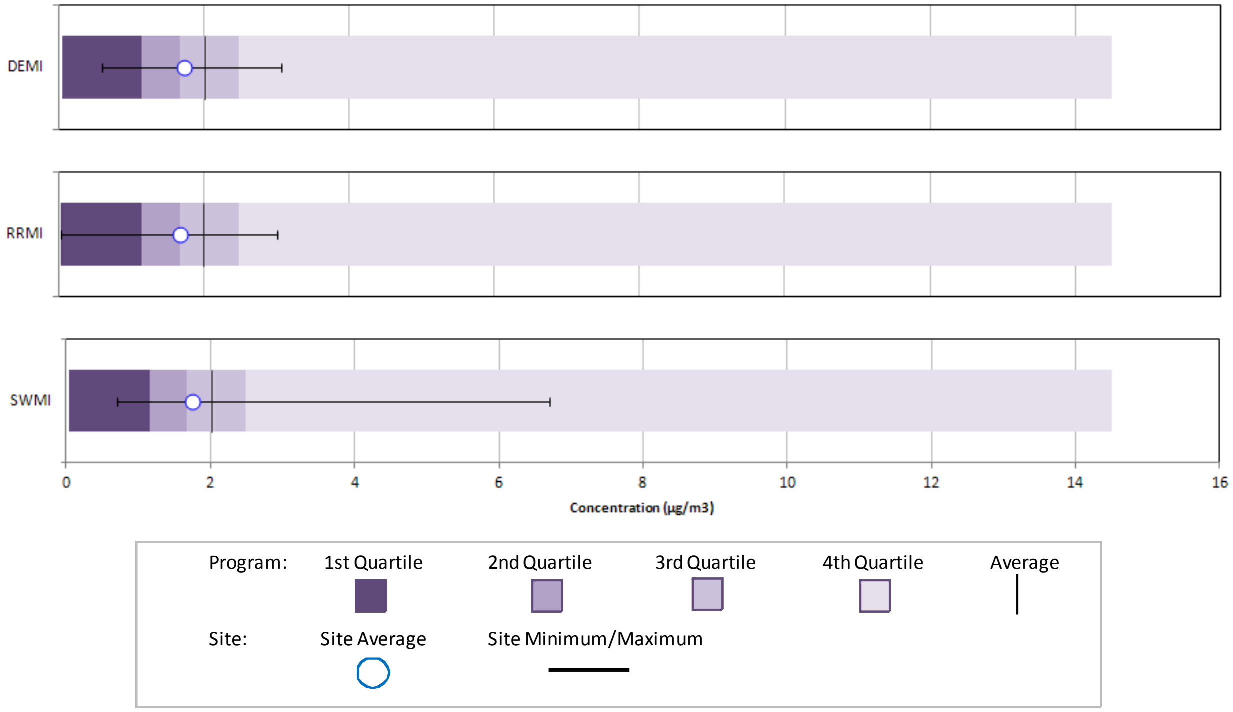


Figure 15-14. Program vs. Site-Specific Average Benzene Concentration

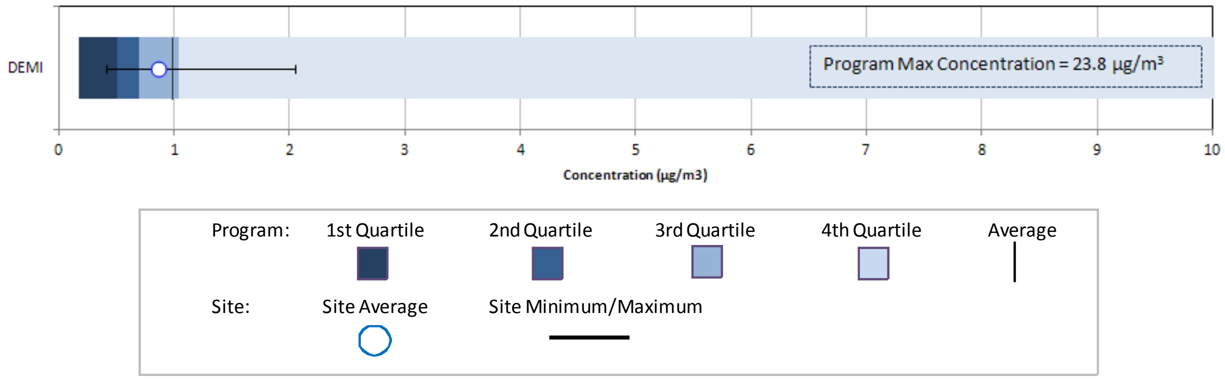


Figure 15-15. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

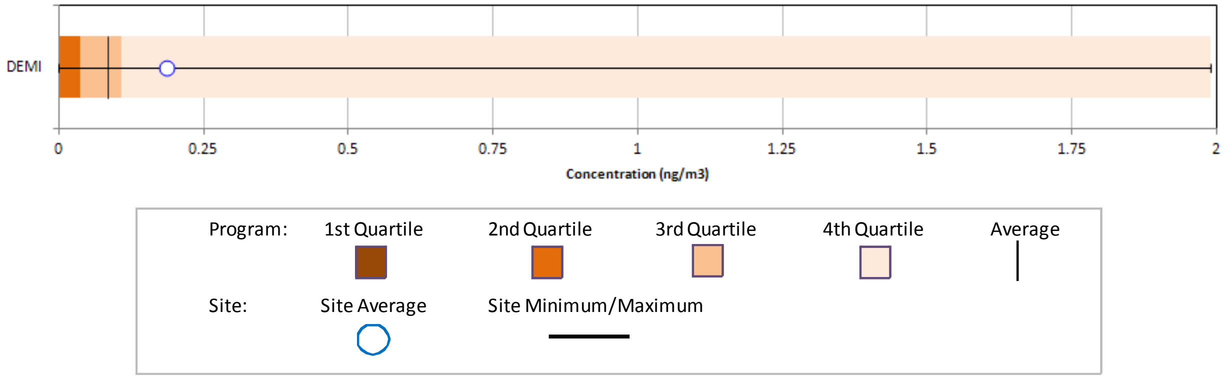


Figure 15-16. Program vs. Site-Specific Average 1,3-Butadiene Concentration

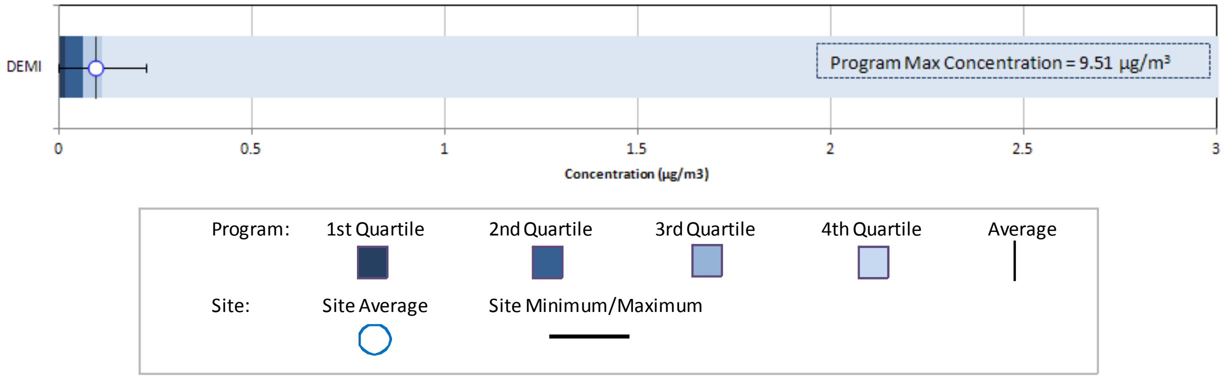


Figure 15-17. Program vs. Site-Specific Average Formaldehyde Concentrations

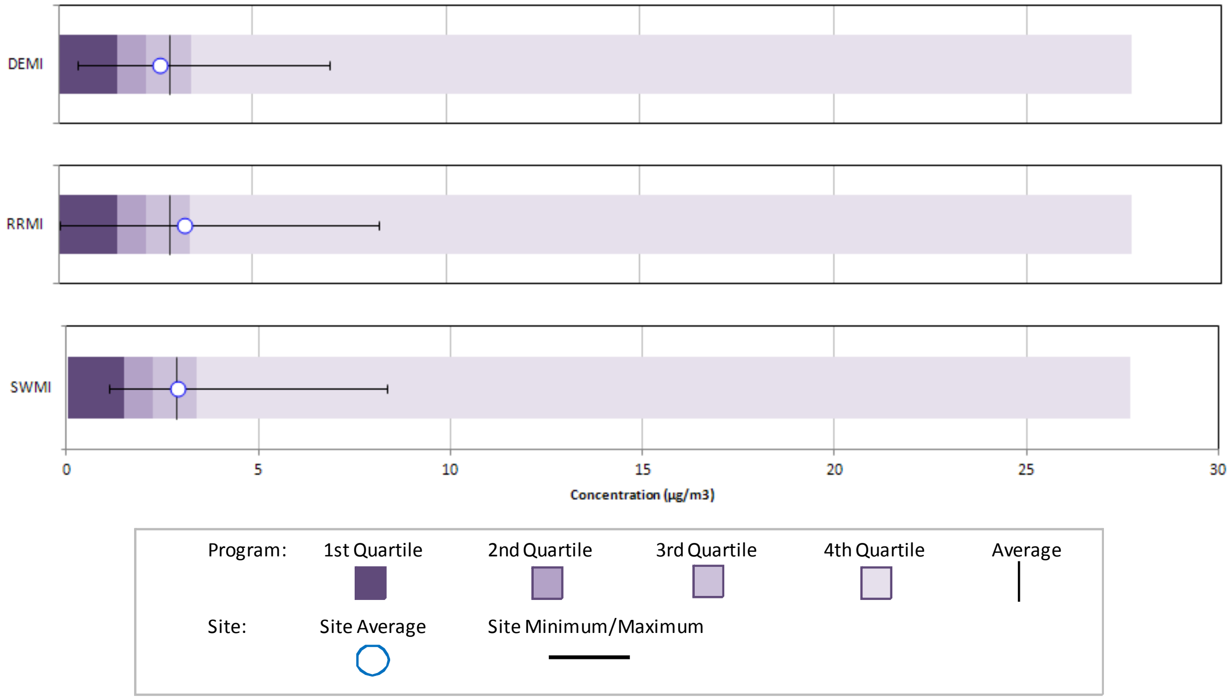


Figure 15-18. Program vs. Site-Specific Average Hexavalent Chromium Concentration

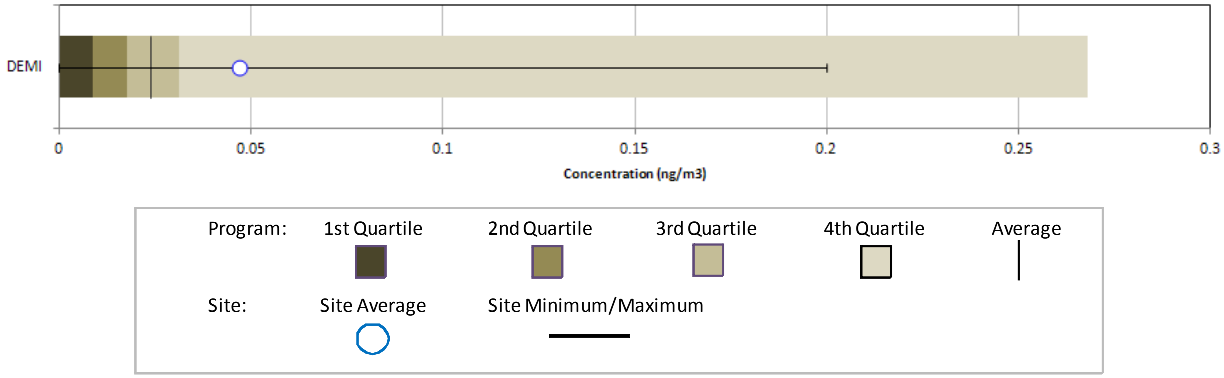
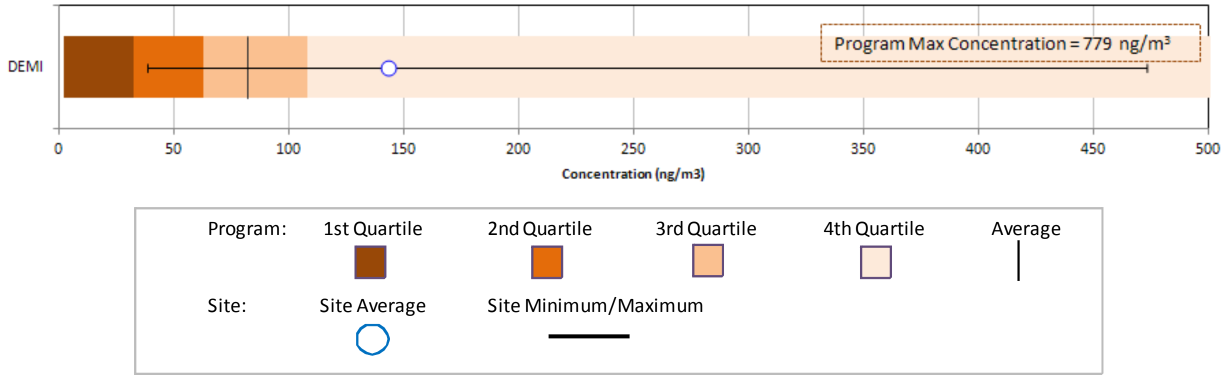


Figure 15-19. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 15-13 through 15-19 include the following:

- Figure 15-13 includes the box plots for acetaldehyde for all three sites. The box plots show that not only are all three sites' annual averages less than the program-level average concentration of acetaldehyde, they are all relatively similar to each other (less than 0.1 µg/m^3 separates them). However, the range of concentrations measured at SWMI is twice as wide as the range measured at DEMI and RRMI. Although no non-detects of acetaldehyde were measured at the Michigan sites or across the program, the two minimum concentrations of acetaldehyde were measured at RRMI.

- Figure 15-14 is the box plot for benzene. Note that the program-level maximum concentration (23.8 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 10 µg/m^3. Figure 15-14 shows that DEMI's annual average benzene concentration is just less than the program-level average concentration. The maximum concentration of benzene measured at DEMI is considerably less than the maximum concentration measured at the program level. There were no non-detects of benzene measured at DEMI or across the program.

- Figure 15-15 is the box plot for benzo(a)pyrene for DEMI. Note that the program-level first quartile for this pollutant is zero and is not visible on this box plot. The box plot shows that the maximum concentration of benzo(a)pyrene was measured at DEMI. The annual average concentration for DEMI is greater than both the program-level average and third quartile. Recall that the annual average benzo(a)pyrene concentration for DEMI is the third highest annual average concentration of this pollutant among sites sampling PAHs. Two non-detects of benzo(a)pyrene were measured at DEMI.

- Figure 15-16 is the box plot for 1,3-butadiene. Similar to the benzene box plot, the program-level maximum concentration (9.51 µg/m^3) is not shown directly on the box plot as the scale has been reduced to 3 µg/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 15-16 shows that the annual average concentration for DEMI is 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. Four non-detects of 1,3-butadiene were measured at DEMI.

- Figure 15-17 includes the box plots for formaldehyde for all three sites. The box plots show that the annual averages for these three sites vary by less than 0.70 µg/m^3. The annual average for DEMI is just less than the program-level average, the annual average for SWMI is similar to the program-level average, and the annual average for RRMI is just greater than the program-level average. All three annual averages are between the program-level median and third quartile (or between 50th and 75th percentile).The range of concentrations measured is similar for RRMI and SWMI and slightly smaller for DEMI. The maximum concentration measured at each site is less than the maximum concentration measured at the program level. Although no non-detects of formaldehyde were measured at the Michigan sites or across the program, the two minimum concentrations of formaldehyde were measured at RRMI.

- Figure 15-18 is the box plot for hexavalent chromium. The box plot shows that annual average concentration for DEMI is nearly twice the program-level average concentration. The maximum concentration measured at DEMI is not the maximum concentration measured across the program, but it was the second highest. There was a single non-detect of this pollutant measured at DEMI.

- Figure 15-19 is the box plot for naphthalene. Similar to the benzene and 1,3-butadiene box plots, the program-level maximum concentration (779 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 ng/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 15-19 shows that the annual average concentration of naphthalene for DEMI is nearly twice the program-level average concentration. Recall from the previous section that DEMI's annual average concentration is the second highest annual average among NMP sites sampling this pollutant. The maximum naphthalene concentration measured at DEMI is less than the maximum concentration measured across program, although it was the fourth highest naphthalene concentration measured across the program. The minimum naphthalene concentration measured at DEMI is greater than the program-level first quartile (25th percentile).

15.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. DEMI has sampled VOCs and carbonyl compounds under the NMP since 2003 and hexavalent chromium since 2005. Thus, Figures 15-20 through 15-24 present the annual statistical metrics for acetaldehyde, benzene, 1,3-butadiene, formaldehyde, and hexavalent chromium for DEMI. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Sampling for PAHs at DEMI did not begin until 2008, therefore a trends analysis was not conducted for the pollutants for these methods. 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 15-20. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at DEMI

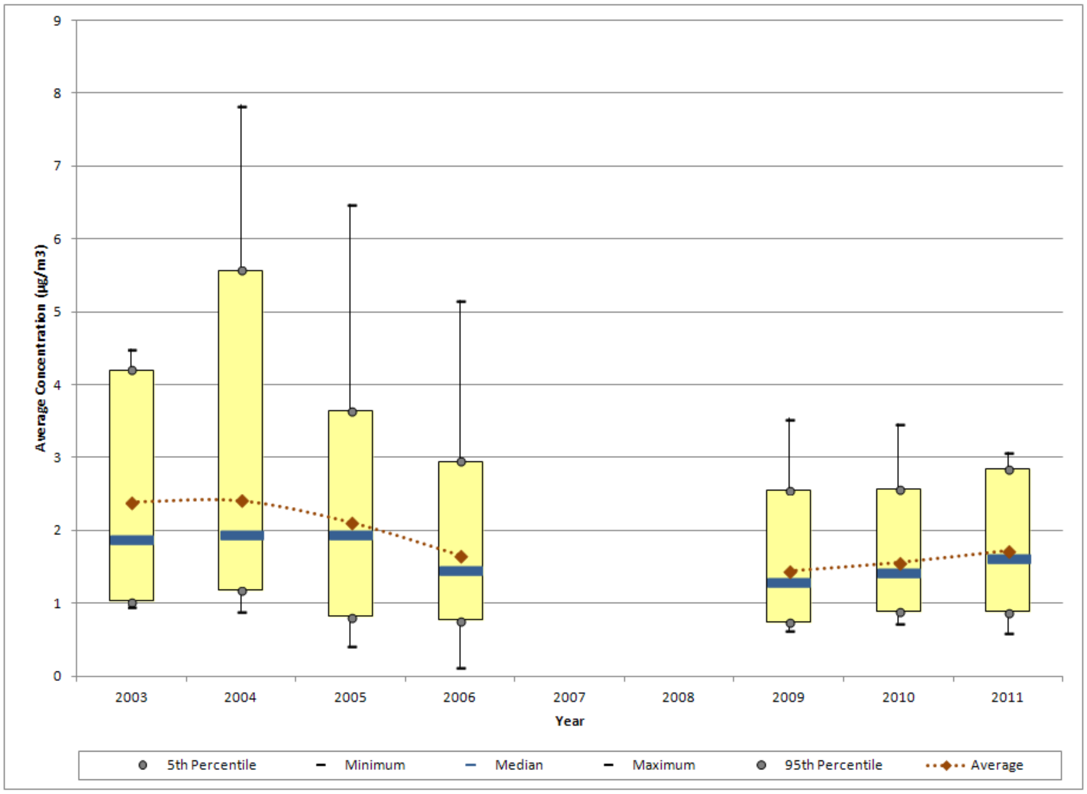


Figure 15-21. Annual Statistical Metrics for Benzene Concentrations Measured at DEMI

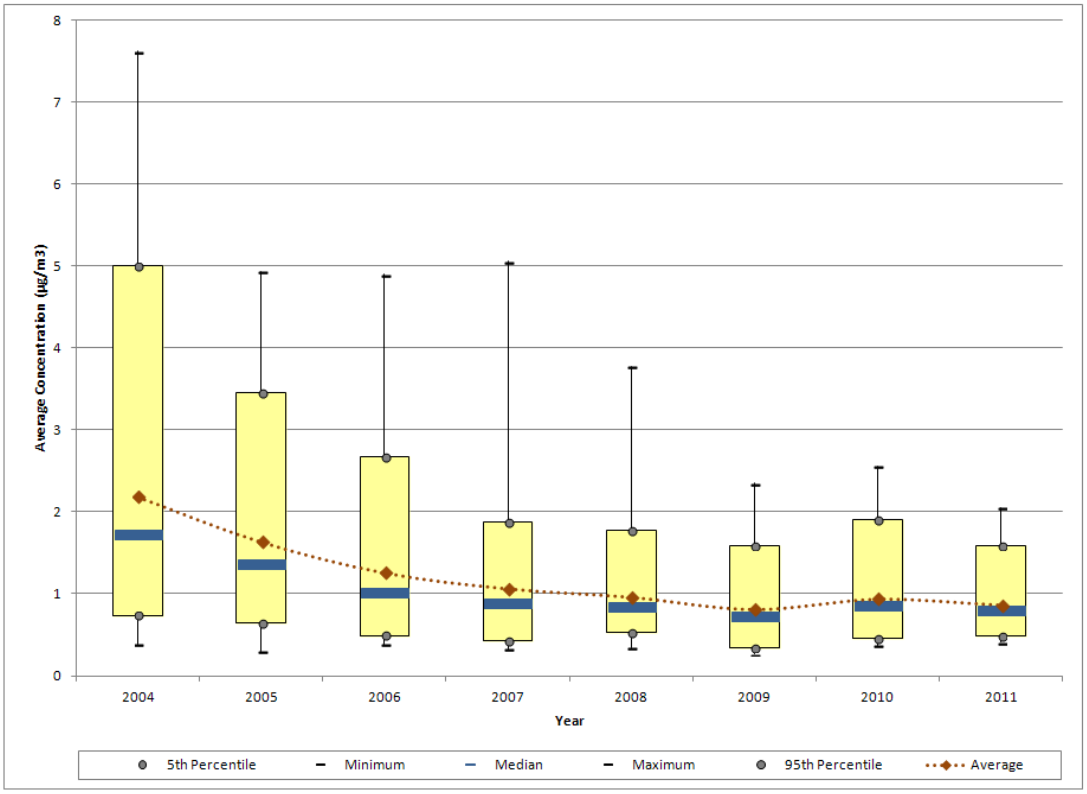


Figure 15-22. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at DEMI

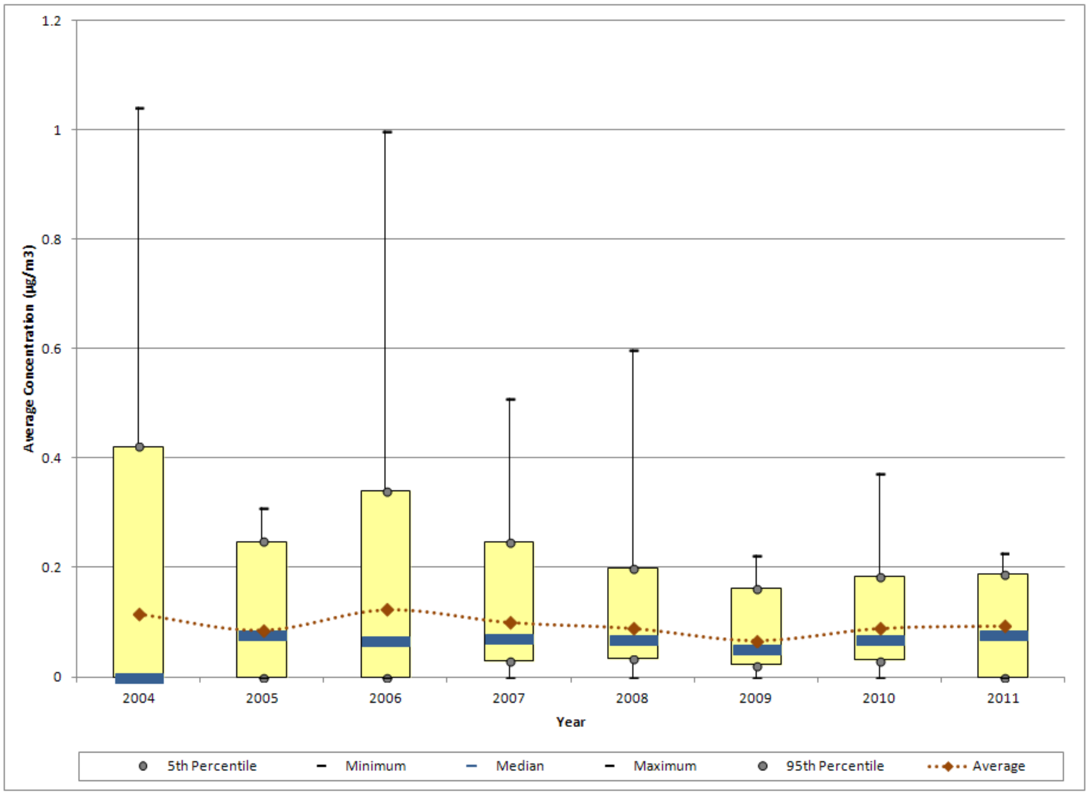


Figure 15-23. Annual Statistical Metrics for Formaldehyde Concentrations Measured at DEMI

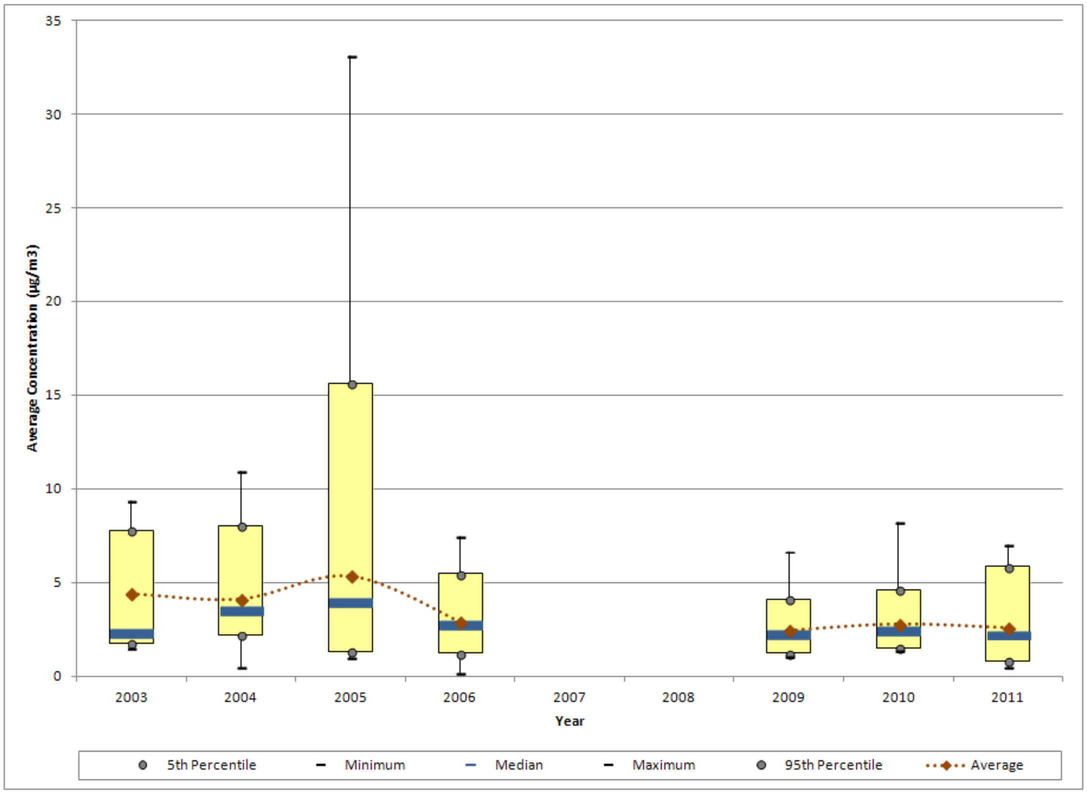
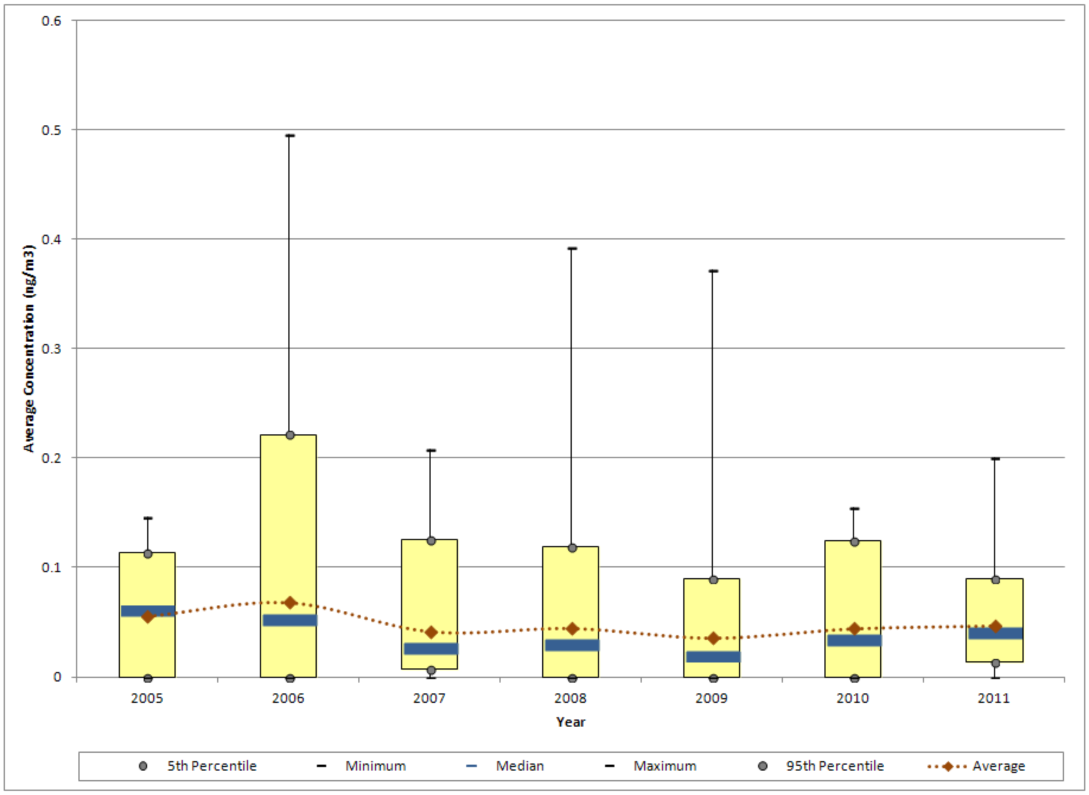


Figure 15-24. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at DEMI



Observations from Figure 15-20 for acetaldehyde measurements at DEMI include the following:

- Carbonyl compounds have been sampled continuously at DEMI under the NMP since 2003. The site began sampling on a 1-in-12 day schedule in 2003 then changed 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 and less than 85 percent in 2008, no statistical metrics are presented for 2007 or 2008.

- The maximum acetaldehyde concentration shown 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 average concentration exhibits a decreasing trend after 2004 and an increasing trend after 2009.

- Even with the maximum concentration at a minimum for 2011, the median, average, and 95th percentile all exhibit slight increases from 2010 levels.

- There have been no non-detects of acetaldehyde measured at DEMI.

Observations from Figure 15-21 for benzene measurements 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 a low completeness; as a result, no statistical metrics are presented for 2003 and Figure 15-21 begins with 2004.

- 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 one other concentration greater than 5 μg/m^3 has been measured at DEMI and was measured in 2007.

- Both the median and average concentrations exhibit a steady decreasing trend over the period shown, reaching a minimum in 2009. Although a slight increase is shown for 2010 followed by a slight decrease in 2011, the changes in the later years are not statistically significant.

- The difference between the median and average concentrations has also decreased, indicating less variability in the measurements. For the last three years of sampling, less than 0.1 μg/m^3 separates these two statistical parameters.

- The minimum concentration is greater than zero for all years shown, indicating that this pollutant has been detected in every VOC sample collected at DEMI.

Observations from Figure 15-22 for 1,3-butadiene measurements at DEMI include the following:

- Recall that even though VOC sampling at DEMI began in 2003, Figure 15-22 begins with data from 2004 due to low completeness in 2003.

- The maximum 1,3-butadiene concentration was measured on October 18, 2004. This is the only 1,3-butadiene measurement greater than 1 μg/m^3, 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 50 percent of the measurements were non-detects. Yet at the same time, 2004 also has the two highest concentrations measured at the site and the maximum 95th percentile. This indicates there is a high level of variability in the measurements. Although there were fewer non-detects in 2006, as indicated by the increase in the median concentration, this year also reflects a high level of variability compared to other years.

- After 2006, the average 1,3-butadiene concentration decreased, reaching a minimum in 2009. Nearly all of the statistical parameters are at a minimum for 2009.

- The number of non-detects measured for 1,3-butadiene decreased significantly after the first few years of sampling. The number of non-detects decreased from 29 in 2004, to 19 in 2005, to five in 2006. Only one to two non-detects were measured in the following years until 2011, when four non-detects were measured.

Observations from Figure 15-23 for formaldehyde measurements 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 and thus, no statistical metrics are presented for 2007 or 2008.

- 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 range 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 average concentration shown between 2005 and 2006 is significant (from 5.35 μg/m^3 to 2.92 μg/m^3). The average concentration for the years following did not vary significantly from the average concentration for 2006.

- Even though the difference between the 5th and 95th percentiles (the range into which the majority of the measurements fall) increased from 2010 to 2011, slight decreases are shown for the median and average concentrations.

- There have been no non-detects of formaldehyde measured at DEMI.

Observations from Figure 15-24 for hexavalent chromium measurements at DEMI include the following:

- 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). A similar concentration was also measured on January 1, 2009 (0.372 ng/m^3).

- Although a decrease in the 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. However, the average concentration changed little after 2006, ranging from 0.036 ng/m^3 in 2009 to 0.047 ng/m^3 in 2011.

- The minimum concentrations and 5th percentiles for several years are zero, indicating the presence of non-detects.

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 3.5.5 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 to 14 days); intermediate (exposures of 15 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 2011.

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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 (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 Hazard Approximation (HQ)
Dearborn, Michigan - DEMI						
Acenaphthene[a]	0.000088	--	60/60	0.01 ± 0.01	1.18	--
Acetaldehyde	0.0000022	0.009	62/62	1.72 ± 0.14	3.78	0.19
Benzene	0.0000078	0.03	61/61	0.86 ± 0.09	6.73	0.03
Benzo(a)pyrene[a]	0.00176	--	58/60	<0.01 ± <0.01	0.33	--
1,3-Butadiene	0.00003	0.002	57/61	0.09 ± 0.01	2.79	0.05
Carbon Tetrachloride	0.000006	0.1	61/61	0.65 ± 0.02	3.92	0.01
Chloroform	--	0.098	61/61	0.82 ± 0.14	--	0.01
1,2-Dichloroethane	0.000026	2.4	11/61	0.01 ± 0.01	0.39	<0.01
Ethylbenzene	0.0000025	1	61/61	0.61 ± 0.13	1.52	<0.01
Fluoranthene[a]	0.000088	--	60/60	0.01 ± <0.01	0.48	--
Fluorene[a]	0.000088	--	60/60	0.01 ± <0.01	0.98	--
Formaldehyde	0.000013	0.0098	62/62	2.60 ± 0.39	33.85	0.27
Hexavalent Chromium[a]	0.012	0.0001	60/61	<0.01 ± <0.01	0.56	<0.01
Naphthalene[a]	0.000034	0.003	60/60	0.14 ± 0.02	4.87	0.05
Tetrachloroethylene	0.00000026	0.04	56/61	0.18 ± 0.03	0.05	<0.01
Trichloroethylene	0.0000048	0.002	5/61	0.01 ± 0.01	0.03	<0.01
Vinyl Chloride	0.0000088	0.1	8/61	<0.01 ± <0.01	0.02	<0.01
River Rouge, Michigan - RRMI						
Acetaldehyde	0.0000022	0.009	57/57	1.68 ± 0.17	3.69	0.19
Formaldehyde	0.000013	0.0098	57/57	3.23 ± 0.47	41.97	0.33
Detroit, Michigan - SWMI						
Acetaldehyde	0.0000022	0.009	28/28	1.74 ± 0.43	3.82	0.19
Formaldehyde	0.000013	0.0098	28/28	2.90 ± 0.60	37.70	0.30

-- = 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 each of the Michigan monitoring sites. This pollutant also has the highest cancer risk approximation for each site, ranging from 33.85 in-a-million for DEMI to 41.97 in-a-million for RRMI.

- The range of cancer risk approximations for acetaldehyde was even tighter, ranging from 3.69 in-a-million for RRMI to 3.82 in-a-million for SWMI.

- Aside from formaldehyde, the pollutants with the highest cancer risk approximations for DEMI were benzene, naphthalene, and carbon tetrachloride.

- None of the pollutants of interest for the Michigan monitoring sites 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 each site is formaldehyde.

15.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 15-7 and 15-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 15-6. Table 15-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 15-6.

The pollutants listed in Table 15-7 and 15-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, 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 15.3, all three Michigan sites sampled carbonyl compounds; DEMI also sampled for VOCs, PAHs, and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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	1,134.11	Coke Oven Emissions, PM	3.54E-02	Formaldehyde	33.85
Formaldehyde	612.43	Benzene	8.85E-03	Benzene	6.73
Ethylbenzene	500.03	Formaldehyde	7.96E-03	Naphthalene	4.87
Acetaldehyde	334.62	POM, Group 5a	7.57E-03	Carbon Tetrachloride	3.92
1,3-Butadiene	134.38	Hexavalent Chromium, PM	6.69E-03	Acetaldehyde	3.78
Naphthalene	74.43	1,3-Butadiene	4.03E-03	1,3-Butadiene	2.79
Dichloromethane	52.69	Arsenic, PM	3.81E-03	Ethylbenzene	1.52
Tetrachloroethylene	47.69	Naphthalene	2.53E-03	Acenaphthene	1.18
Coke Oven Emissions, PM	35.72	Nickel, PM	1.42E-03	Fluorene	0.98
Trichloroethylene	13.67	Ethylbenzene	1.25E-03	Hexavalent Chromium	0.56
River Rouge, Michigan (Wayne County) - RRMI					
Benzene	1,134.11	Coke Oven Emissions, PM	3.54E-02	Formaldehyde	41.97
Formaldehyde	612.43	Benzene	8.85E-03	Acetaldehyde	3.69
Ethylbenzene	500.03	Formaldehyde	7.96E-03		
Acetaldehyde	334.62	POM, Group 5a	7.57E-03		
1,3-Butadiene	134.38	Hexavalent Chromium, PM	6.69E-03		
Naphthalene	74.43	1,3-Butadiene	4.03E-03		
Dichloromethane	52.69	Arsenic, PM	3.81E-03		
Tetrachloroethylene	47.69	Naphthalene	2.53E-03		
Coke Oven Emissions, PM	35.72	Nickel, PM	1.42E-03		
Trichloroethylene	13.67	Ethylbenzene	1.25E-03		

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	1,134.11	Coke Oven Emissions, PM	3.54E-02	Formaldehyde	37.70
Formaldehyde	612.43	Benzene	8.85E-03	Acetaldehyde	3.82
Ethylbenzene	500.03	Formaldehyde	7.96E-03		
Acetaldehyde	334.62	POM, Group 5a	7.57E-03		
1,3-Butadiene	134.38	Hexavalent Chromium, PM	6.69E-03		
Naphthalene	74.43	1,3-Butadiene	4.03E-03		
Dichloromethane	52.69	Arsenic, PM	3.81E-03		
Tetrachloroethylene	47.69	Naphthalene	2.53E-03		
Coke Oven Emissions, PM	35.72	Nickel, PM	1.42E-03		
Trichloroethylene	13.67	Ethylbenzene	1.25E-03		

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					
Hydrochloric acid	3,765.69	Acrolein	1,866,893.10	Formaldehyde	0.27
Toluene	2,480.93	Hydrochloric acid	188,284.52	Acetaldehyde	0.19
Xylenes	1,912.74	Manganese, PM	98,186.30	Naphthalene	0.05
Methanol	1,227.86	1,3-Butadiene	67,191.86	1,3-Butadiene	0.05
Benzene	1,134.11	Cyanide Compounds, gas	64,535.63	Benzene	0.03
Formaldehyde	612.43	Formaldehyde	62,493.26	Chloroform	0.01
Hexane	551.94	Arsenic, PM	58,998.69	Carbon Tetrachloride	0.01
Ethylbenzene	500.03	Benzene	37,803.81	Tetrachloroethylene	<0.01
Acetaldehyde	334.62	Acetaldehyde	37,180.09	Trichloroethylene	<0.01
Methyl isobutyl ketone	277.33	Nickel, PM	32,767.48	Ethylbenzene	<0.01
River Rouge, Michigan (Wayne County) - RRMI					
Hydrochloric acid	3,765.69	Acrolein	1,866,893.10	Formaldehyde	0.33
Toluene	2,480.93	Hydrochloric acid	188,284.52	Acetaldehyde	0.19
Xylenes	1,912.74	Manganese, PM	98,186.30		
Methanol	1,227.86	1,3-Butadiene	67,191.86		
Benzene	1,134.11	Cyanide Compounds, gas	64,535.63		
Formaldehyde	612.43	Formaldehyde	62,493.26		
Hexane	551.94	Arsenic, PM	58,998.69		
Ethylbenzene	500.03	Benzene	37,803.81		
Acetaldehyde	334.62	Acetaldehyde	37,180.09		
Methyl isobutyl ketone	277.33	Nickel, PM	32,767.48		

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					
Hydrochloric acid	3,765.69	Acrolein	1,866,893.10	Formaldehyde	0.30
Toluene	2,480.93	Hydrochloric acid	188,284.52	Acetaldehyde	0.19
Xylenes	1,912.74	Manganese, PM	98,186.30		
Methanol	1,227.86	1,3-Butadiene	67,191.86		
Benzene	1,134.11	Cyanide Compounds, gas	64,535.63		
Formaldehyde	612.43	Formaldehyde	62,493.26		
Hexane	551.94	Arsenic, PM	58,998.69		
Ethylbenzene	500.03	Benzene	37,803.81		
Acetaldehyde	334.62	Acetaldehyde	37,180.09		
Methyl isobutyl ketone	277.33	Nickel, PM	32,767.48		

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, benzene, and formaldehyde.

- Six of the highest emitted pollutants in Wayne County also have the highest toxicity-weighted emissions.

- Formaldehyde has the highest cancer risk approximations for all three Michigan sites. This pollutant appears on both emissions-based lists. Acetaldehyde, the other pollutant of interest in common for all three Michigan sites, 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. Carbon tetrachloride does not appear on either emissions-based list.

- POM, Group 5a ranks fourth for toxicity-weighted emissions in Wayne County. POM, Group 5a includes benzo(a)pyrene, which has one of the lowest cancer risk approximations of the pollutants of interest for DEMI.

Observations from Table 15-8 include the following:

- Hydrochloric acid, toluene, and xylenes are the highest emitted pollutants with noncancer RfCs in Wayne County. Wayne County has the highest hydrochloric acid emissions of any county with an NMP site (by an order of magnitude).

- 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.

- The pollutant with the highest noncancer hazard approximation for all three Michigan sites is formaldehyde, although none of the pollutants of interest have associated noncancer hazard approximations greater than 1.0. Formaldehyde emissions rank sixth for Wayne County and sixth for toxicity-weighted emissions.

- Acetaldehyde is the other pollutant these sites have in common; this pollutant also appears on both emissions-based lists. Acetaldehyde ranks ninth for both quantity emitted and toxicity-weighted emissions.

- Benzene is the only other pollutant that appears on all three lists for DEMI.

15.6 Summary of the 2011 Monitoring Data for DEMI, RRMI, and SWMI

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

- ❖ *Nineteen pollutants, of which eight are NATTS MQO Core Analytes, failed screens for DEMI. Acetaldehyde and formaldehyde both failed screens for RRMI and SWMI and propionaldehyde also failed a single screen for SWMI.*

- ❖ *Of the site-specific pollutants of interest, formaldehyde had the highest annual average concentration for all three sites.*

- ❖ *DEMI has the second highest annual average concentration of chloroform among NMP sites sampling VOCs. DEMI also has the highest annual average concentration of acenaphthene and the second the highest annual average concentrations of fluorene and naphthalene among NMP sites sampling PAHs.*

- ❖ *Concentrations of benzene have been steadily decreasing at DEMI since sampling began at this site.*

16.0 Site in Missouri

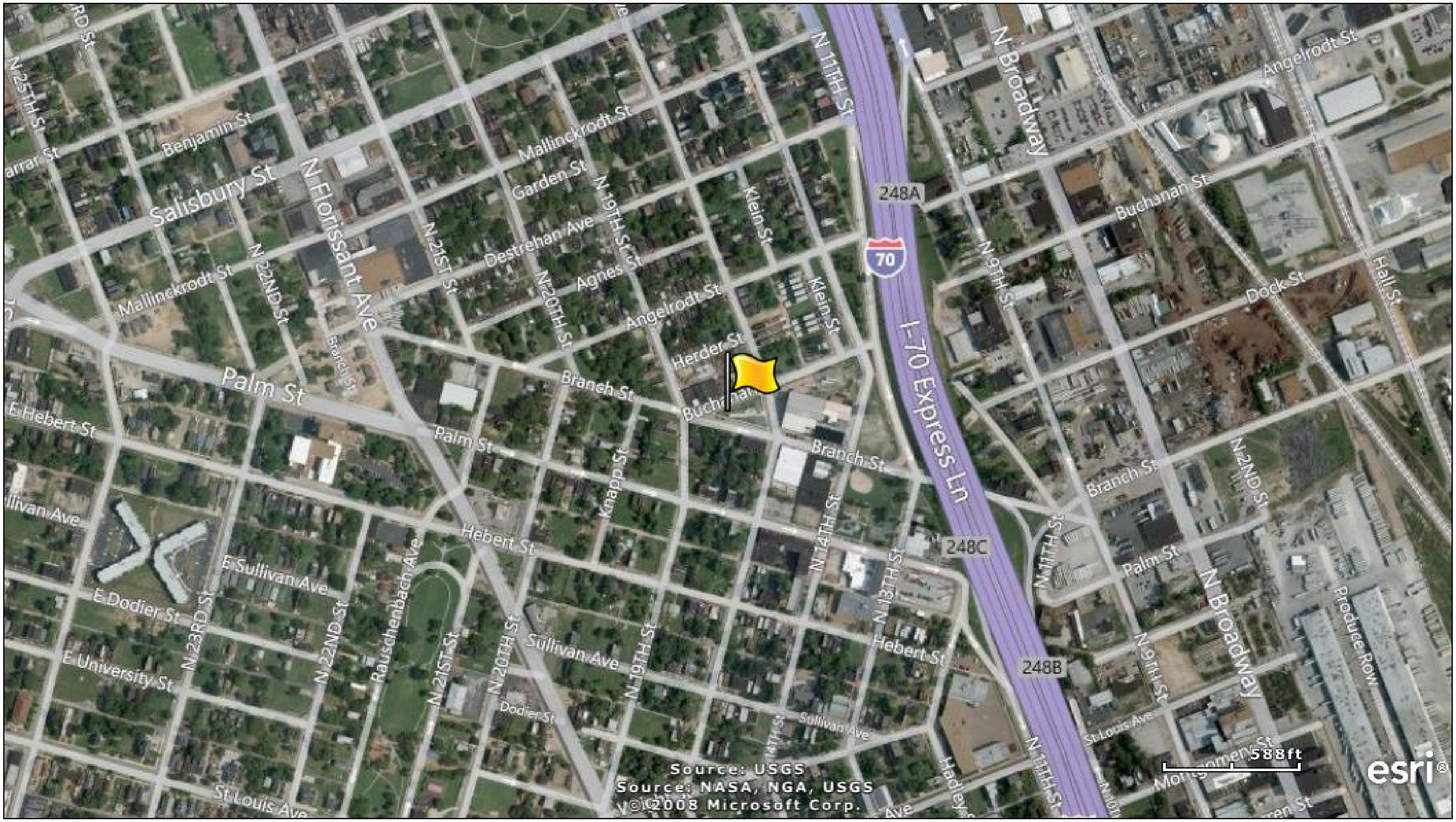
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Missouri, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data 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.

16.1 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.

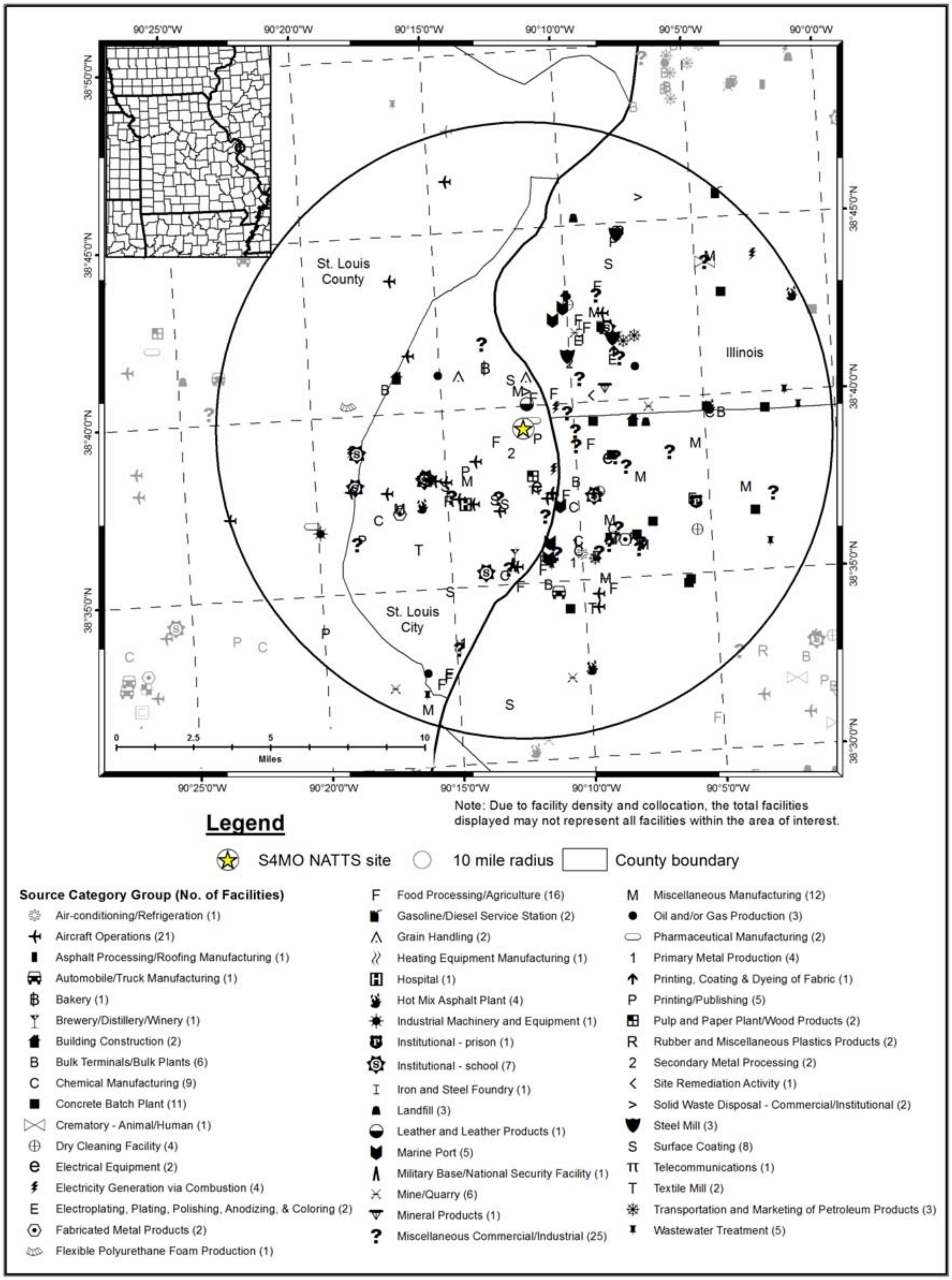
The S4MO monitoring site is located in the St. Louis, MO-IL MSA. Figure 16-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its urban location. Figure 16-2 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI 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. Louis, Missouri (S4MO) Monitoring Site



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

Figure 16-2. 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 16-1. 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	38.656436, -90.198661	Residential	Urban/City Center	CO, O_3, Meteorological parameters, PM_{10}, Black carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation, SO_2, NO_y, NO.

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2012c); 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 16-1 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 16-2 shows that a large number of point sources are located within 10 miles of S4MO. The source categories with the greatest number of point sources surrounding S4MO include aircraft operations, which include airports as well as small runways, heliports, or landing pads; food processing facilities; and concrete batch plants. In the immediate vicinity of S4MO are a pharmaceutical manufacturing facility and a printing and publishing facility.

Table 16-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Missouri monitoring site. Table 16-2 includes county-level population and vehicle registration information. Table 16-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 16-2 also contains traffic volume information for S4MO. Finally, Table 16-2 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 16-2 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 16-2. Population, Motor Vehicle, and Traffic Information for the Missouri Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
S4MO	1,316,761	1,114,812	0.85	796,065	673,974	79,558	23,333,850

[1] County-level population estimate reflects county and city 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] Vehicle registration reflects county and city 2011 data from the Missouri Dept of Revenue (MO DOR, 2012)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data from the Missouri DOT (MO DOT, 2011)
[5] VMT reflects county and city 2011 data for all public roads from the Missouri DOT (MO DOT, 2013)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 16-2 include the following:

- S4MO's county-level population and vehicle registration rank 10th compared to other counties with NMP sites. The 10-mile population and vehicle ownership estimates for S4MO are in the middle third compared to other sites.
- The vehicle-per-person ratio is also in the middle of the range compared to other NMP sites.
- The traffic volume experienced near S4MO ranks 19th among other NMP sites. The traffic estimate provided is for I-70 near Exit 249.
- The St. Louis City and County daily VMT ranks 12th among 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 Missouri on sample days, as well as over the course of the year.

16.2.1 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, somewhat wetter summers; and significant seasonal variability. Warm, moist air flowing northward from the Gulf of Mexico alternating with cold, dry air marching southward from Canada and the northern U.S. result in weather patterns that do not persist for very long. The City of St. Louis experiences the urban heat island effect, retaining more heat within the city than outlying areas (Bair, 1992 and MCC, 2013).

16.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2011 (NCDC, 2011). The closest weather station 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 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 Missouri Monitoring Site

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)
St. Louis, Missouri - S4MO									
St. Louis Downtown Airport 03960 (38.57, -90.16)	6.27 miles 156° (SSE)	Sample Day	64.8 ± 5.3	55.6 ± 4.9	44.7 ± 4.7	50.0 ± 4.4	69.7 ± 3.0	1016.4 ± 1.8	6.3 ± 0.7
		2011	66.5 ± 2.1	56.7 ± 1.9	46.0 ± 1.8	51.1 ± 1.7	70.5 ± 1.2	1015.9 ± 0.7	5.8 ± 0.3

[1] Sample day averages are highlighted 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 the entire year for 2011. Also included in Table 16-3 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 throughout 2011, temperatures do appear slightly cooler on sample days, as shown in Table 16-3. This is likely the result of five additional days in December 2011 when make-up samples were collected.

16.2.3 Back Trajectory Analysis

Figure 16-3 is the composite back trajectory map for days on which samples were collected at the S4MO monitoring site in 2011. 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. 2011 Composite Back Trajectory Map for S4MO

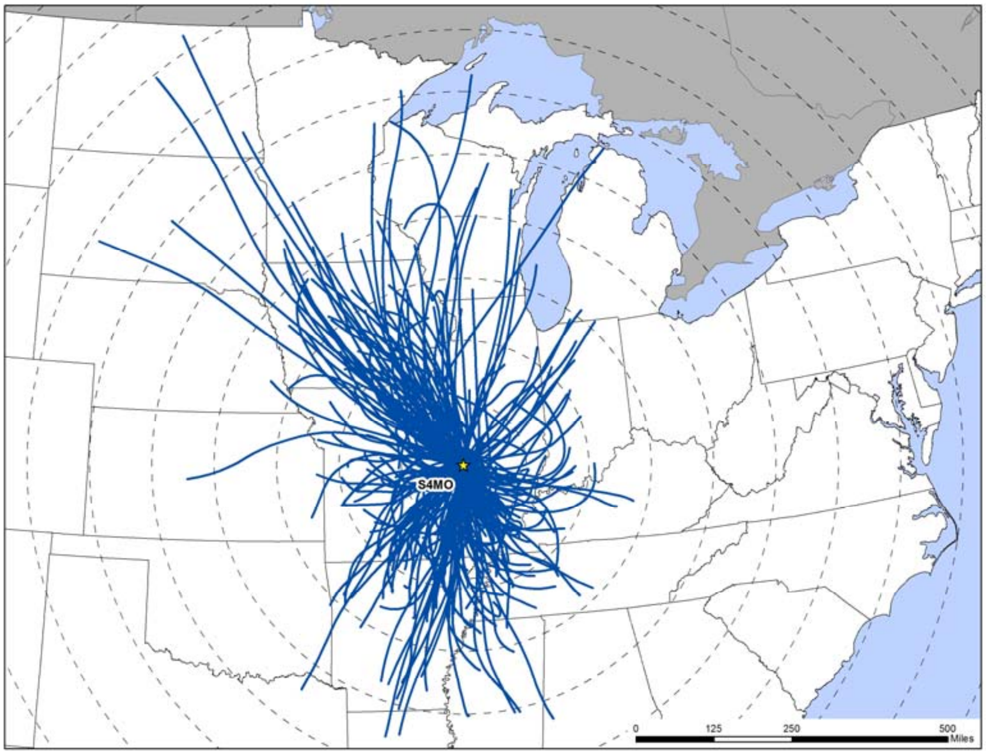
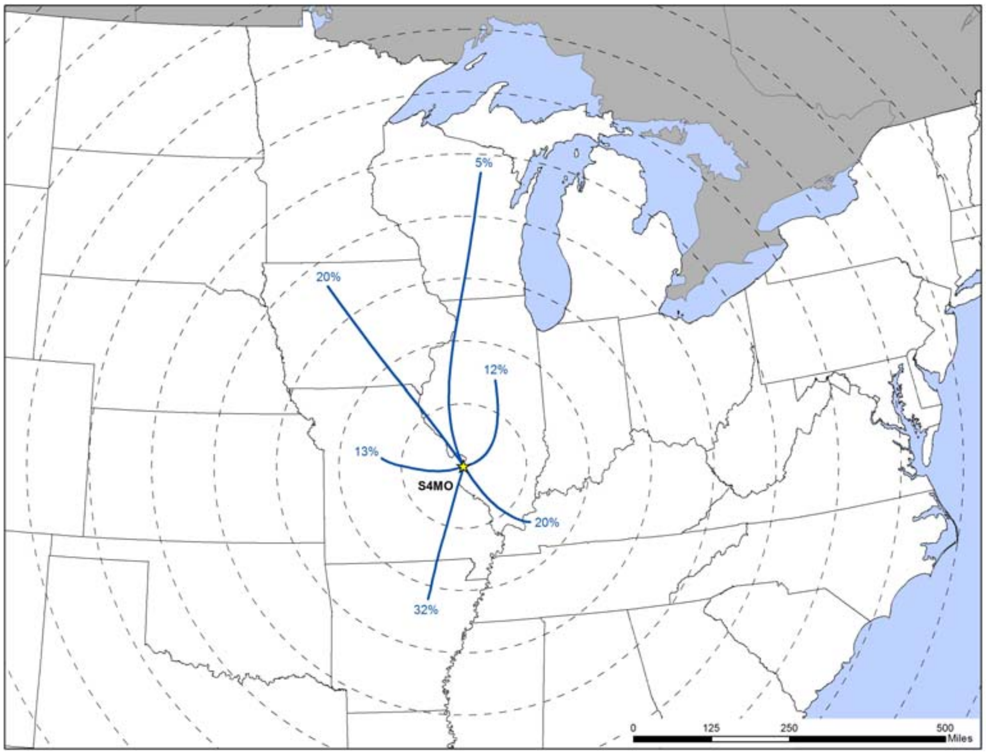


Figure 16-4. Back Trajectory Cluster Map for S4MO



Observations from Figures 16-3 and 16-4 for S4MO include the following:

- Back trajectories originated from a variety of directions at S4MO, although back trajectories from the northwest and south-southeast to south-southwest were most common.

- The 24-hour air shed domain for S4MO is similar in size to other NMP sites. The farthest away a back trajectory originated was greater than 800 miles, over northern North Dakota. However, the average trajectory length was 239 miles and most back trajectories (87 percent) originated within 400 miles of the monitoring site.

- The cluster analysis shows that many (32 percent) back trajectories originated to the south to southwest of S4MO, although of varying lengths. Another 20 percent of back trajectories originated to the southeast to south of S4MO. Thus, greater than 50 percent of back trajectories originated from a direction with a southerly component.

- The longest back trajectories originated to the northwest and north of the site. Twenty percent of back trajectories originated to the northwest of S4MO. Another five percent originated to the north over Wisconsin and the Great Lakes.

- Back trajectories originating from the east or the west tended to be shorter in length. The cluster trajectory originating to the west of S4MO (13 percent) represents back trajectories originating over the state of Missouri. The cluster trajectory originating to the northeast of S4MO (12 percent) represents back trajectories that originate over the states of Illinois and Indiana.

16.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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 16-5 presents a map showing the distance between the NWS station and S4MO, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 16-5 also presents three different wind roses for the S4MO monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 16-5 for S4MO include the following:

- The St. Louis Downtown Airport weather station is located approximately 6.3 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 bulk of the remaining wind observations. The strongest winds were from the west to northwest.

- The wind patterns shown on the 2011 wind rose generally resemble those shown on the historical wind rose, although there were fewer southeasterly winds and more southerly winds.

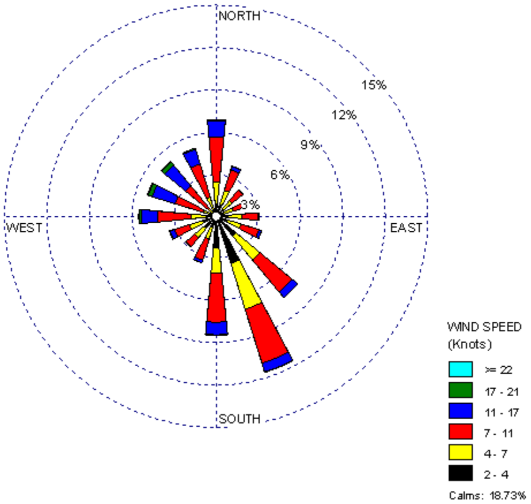
- The sample day wind patterns also resemble the historical and full-year wind patterns, although there was a higher percentage of south-southeasterly winds and slightly fewer calm winds.

- The similarities in the wind patterns between the wind roses indicate that wind conditions on sample days were similar to wind conditions experienced throughout 2011 and historically.

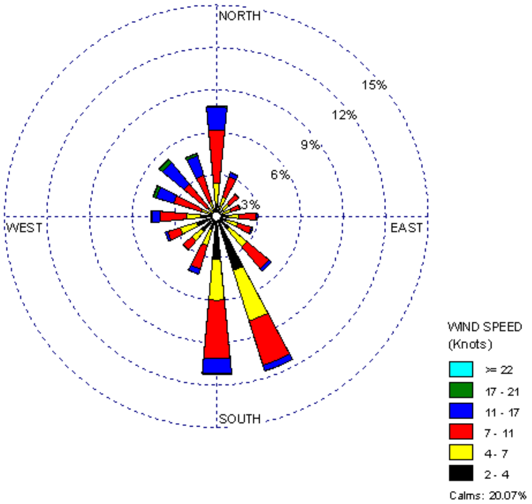
Figure 16-5. Wind Roses for the St. Louis Downtown Airport Weather Station near S4MO

Distance between S4MO and NWS Station

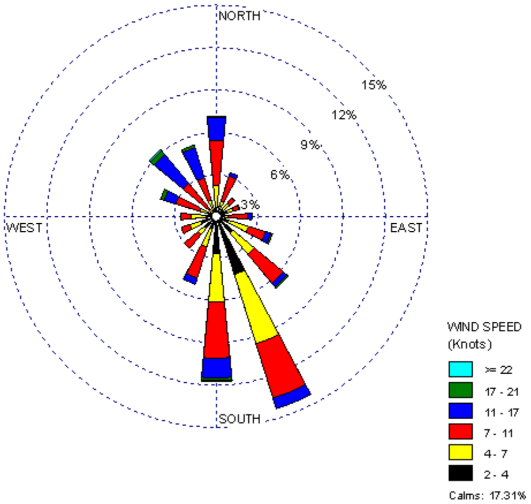
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



16.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for S4MO in order to allow 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." 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 16-4 presents the results of the preliminary risk-based screening process for S4MO. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for the monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. S4MO sampled for VOCs, PAHs, carbonyl compounds, metals (PM_{10}), and hexavalent chromium.

Observations from Table 16-4 include the following:

- Twenty-five pollutants, of which 13 are NATTS MQO Core Analytes, failed at least one screen for S4MO. S4MO failed the greatest number of screens among all NMP sites.

- Formaldehyde, acetaldehyde, and benzene were detected in every carbonyl compound or VOC sample collected and failed 100 percent of screens for S4MO. Other pollutants also failed 100 percent of screens but were detected less frequently: 1,3-butadiene, 1,2-dichloroethane, hexachloro-1,3-butadiene, 1,2-dibromoethane, 1,1,2,2-tetrachloroethane, and chloromethylbenzene. With the exception of 1,3-butadiene, these pollutants were detected in only a few samples.

- Sixteen pollutants were identified as pollutants of interest for S4MO based on the risk-based screening process; of these, 10 are NATTS MQO Core Analytes. Three additional pollutants (nickel, hexavalent chromium, and chloroform) were added to S4MO's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of S4MO's failed screens. Five more pollutants (beryllium, benzo(a)pyrene, tetrachloroethylene, trichloroethylene, and vinyl chloride) were also added to S4MO's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens. These five pollutants are not shown in Table 16-4 but are shown in subsequent tables in the sections that follow.

Table 16-4. Risk-Based Screening Results for the Missouri Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
St. Louis, Missouri - S4MO						
Acetaldehyde	0.45	59	59	100.00	9.80	9.80
Formaldehyde	0.077	59	59	100.00	9.80	19.60
Naphthalene	0.029	59	61	96.72	9.80	29.40
Arsenic (PM$_{10}$)	0.00023	57	59	96.61	9.47	38.87
Benzene	0.13	57	57	100.00	9.47	48.34
Carbon Tetrachloride	0.17	56	57	98.25	9.30	57.64
1,3-Butadiene	0.03	52	52	100.00	8.64	66.28
Manganese (PM$_{10}$)	0.005	44	59	74.58	7.31	73.59
p-Dichlorobenzene	0.091	29	47	61.70	4.82	78.41
Cadmium (PM$_{10}$)	0.00056	20	59	33.90	3.32	81.73
1,2-Dichloroethane	0.038	18	18	100.00	2.99	84.72
Ethylbenzene	0.4	15	57	26.32	2.49	87.21
Acenaphthene	0.011	12	61	19.67	1.99	89.20
Fluorene	0.011	12	61	19.67	1.99	91.20
Lead (PM$_{10}$)	0.015	12	59	20.34	1.99	93.19
Hexachloro-1,3-butadiene	0.045	11	11	100.00	1.83	95.02
1,2-Dibromoethane	0.0017	7	7	100.00	1.16	96.18
Nickel (PM$_{10}$)	0.0021	6	59	10.17	1.00	97.18
1,1,2,2-Tetrachloroethane	0.017	6	6	100.00	1.00	98.17
Propionaldehyde	0.8	4	59	6.78	0.66	98.84
Chloromethylbenzene	0.02	2	2	100.00	0.33	99.17
Hexavalent Chromium	0.000083	2	60	3.33	0.33	99.50
Carbon Disulfide	70	1	57	1.75	0.17	99.67
Chloroform	9.8	1	44	2.27	0.17	99.83
1,1,2-Trichloroethane	0.0625	1	2	50.00	0.17	100.00
Total		602	1,132	53.18		

16.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for S4MO, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for S4MO are provided in Appendices J, L, M, N, and O.

16.4.1 2011 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 of 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 16-5, where applicable. Note that concentrations of the PAHs, metals, 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 16-5. 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	59/59	2.47 ± 0.42	3.14 ± 0.80	3.97 ± 1.03	1.31 ± 0.25	2.75 ± 0.43
Benzene	57/57	0.89 ± 0.14	0.69 ± 0.07	0.76 ± 0.09	0.86 ± 0.15	0.80 ± 0.06
1,3-Butadiene	52/57	0.10 ± 0.03	0.06 ± 0.02	0.07 ± 0.02	0.11 ± 0.03	0.08 ± 0.01
Carbon Tetrachloride	57/57	0.51 ± 0.06	0.60 ± 0.04	0.71 ± 0.06	0.63 ± 0.10	0.61 ± 0.04
Chloroform	44/57	0.12 ± 0.06	0.19 ± 0.15	1.00 ± 1.67	0.09 ± 0.04	0.35 ± 0.40

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 16-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Missouri Monitoring Site (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 ($\mu g/m^3$)
p-Dichlorobenzene	47/57	0.21 ± 0.21	0.12 ± 0.09	0.39 ± 0.41	0.14 ± 0.09	0.21 ± 0.11
1,2-Dichloroethane	18/57	0.02 ± 0.02	0.05 ± 0.03	0.01 ± 0.02	0.04 ± 0.03	0.03 ± 0.01
Ethylbenzene	57/57	0.41 ± 0.10	0.27 ± 0.04	0.37 ± 0.05	0.46 ± 0.09	0.38 ± 0.04
Formaldehyde	59/59	5.30 ± 2.97	4.57 ± 1.56	5.43 ± 1.65	1.76 ± 0.36	4.25 ± 0.92
Hexachloro-1,3-butadiene	11/57	0.04 ± 0.04	0.01 ± 0.02	0.01 ± 0.02	0.03 ± 0.04	0.02 ± 0.01
Tetrachloroethylene	55/57	0.19 ± 0.07	0.16 ± 0.03	0.15 ± 0.04	0.20 ± 0.14	0.18 ± 0.04
Trichloroethylene	25/57	0.04 ± 0.02	0.02 ± 0.02	0.04 ± 0.03	0.04 ± 0.02	0.03 ± 0.01
Vinyl Chloride	8/57	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± 0.01	<0.01 ± <0.01	<0.01 ± <0.01
Acenaphthene[a]	61/61	1.69 ± 0.61	5.87 ± 2.40	10.71 ± 3.79	3.66 ± 2.05	5.41 ± 1.45
Arsenic (PM_{10})[a]	59/59	0.78 ± 0.28	0.81 ± 0.18	0.90 ± 0.21	1.00 ± 0.45	0.87 ± 0.14
Benzo(a)pyrene[a]	59/61	0.16 ± 0.05	0.10 ± 0.05	0.07 ± 0.02	0.18 ± 0.07	0.13 ± 0.03
Beryllium (PM_{10})[a]	59/59	0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01	0.01 ± 0.01	0.01 ± <0.01
Cadmium (PM_{10})[a]	59/59	0.60 ± 0.32	0.63 ± 0.19	0.51 ± 0.23	0.49 ± 0.24	0.56 ± 0.12
Fluorene[a]	61/61	2.54 ± 0.64	6.66 ± 2.58	11.28 ± 3.78	4.18 ± 1.57	6.08 ± 1.40
Hexavalent Chromium[a]	60/61	0.03 ± 0.02	0.04 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.03 ± 0.01
Lead (PM_{10})[a]	59/59	9.53 ± 3.57	10.81 ± 3.27	10.55 ± 3.63	10.67 ± 4.07	10.42 ± 1.72
Manganese (PM_{10})[a]	59/59	7.27 ± 2.07	41.50 ± 52.71	12.67 ± 4.57	11.13 ± 4.63	18.42 ± 13.18
Naphthalene[a]	61/61	74.38 ± 27.68	61.09 ± 16.32	106.70 ± 25.01	88.28 ± 21.76	83.82 ± 11.75
Nickel (PM_{10})[a]	59/59	1.00 ± 0.19	1.53 ± 0.46	1.20 ± 0.79	1.05 ± 0.45	1.20 ± 0.26

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 S4MO from Table 16-5 include the following:

- The pollutants with the highest annual average concentrations by mass are formaldehyde (4.25 ± 0.92 $\mu g/m^3$) and acetaldehyde (2.75 ± 0.43 $\mu g/m^3$). These are the only pollutants of interest with annual averages greater than 1 $\mu g/m^3$.

- The first, second, and third quarter average formaldehyde concentrations are significantly higher than the fourth quarter average and their confidence intervals reflect a relatively high-level of variability in the measurements. Concentrations of formaldehyde ranged from 0.714 µg/m^3 to 17.8 µg/m^3. The two highest concentrations were measured on back-to-back sample days in February. Four concentrations greater than 10 µg/m^3 were measured at S4MO and at least one was measured in each quarter except the fourth quarter. Conversely, the six lowest measurements of formaldehyde were all measured during the fourth quarter of 2011.

- The confidence interval for chloroform is greater than the annual average concentration it is associated with, indicating that there are likely outliers affecting this average. A review of the quarterly averages shows that any outliers were likely measured during the third quarter of 2011. The maximum chloroform concentration was measured at S4MO on July 8, 2011 (11.5 µg/m^3). The next highest concentration measured at S4MO is an order of magnitude less (1.17 µg/m^3). S4MO is the only site besides NBIL with a chloroform concentration greater than 10 µg/m^3.

- The confidence intervals associated with the first and third quarter averages of *p*-dichlorobenzene are greater than or equal to the averages themselves, indicating the likely influence of outliers. A review of the data shows that the maximum *p*-dichlorobenzene concentrations were measured in September (2.83 µg/m^3) and January (1.50 µg/m^3). These are the two highest *p*-dichlorobenzene concentrations measured across all NMP sites sampling VOCs and represent two of the four concentrations of *p*-dichlorobenzene greater than 1 µg/m^3 measured across the program. For perspective, the median *p*-dichlorobenzene concentration for S4MO is 0.096 µg/m^3.

- The quarterly averages of several of the VOCs (benzene, 1,3-butadiene, ethylbenzene, and tetrachloroethylene) appear to be higher during the colder months of the year. However, the confidence intervals indicate that the differences between the quarterly averages are not statistically significant.

- The metals sampler was changed in July 2011, and Teflon® filters were used to collect metals samples rather than quartz filters. It does not appear that the instrumentation and filter changes resulted in a significant difference in the quarterly averages of the metals.

- Manganese has the highest annual average concentration among the PM_{10} metals measured at S4MO. The confidence interval associated with this annual average indicates a high level of variability within the measurements. The second quarter average is more than three times higher than the next highest quarterly average concentration. Further, the confidence interval for the second quarter average is greater than the average concentration itself. A review of the data shows that the maximum concentration of manganese was measured on June 2, 2011 (395 ng/m^3) and is the maximum manganese concentration measured among all NMP sites sampling metals. This measurement is three times greater than the next highest concentration of manganese measured across the program (130 ng/m^3, measured at PXSS) and six times greater than the next highest concentration of manganese measured at S4MO (65.3 ng/m^3). For perspective, the median manganese concentration for S4MO is 10.0 ng/m^3.

- Naphthalene has the highest annual average concentration among the PAHs measured at S4MO. The confidence intervals calculated for the naphthalene averages indicate that there is a high level of variability in the measurements. Concentrations of naphthalene measured at S4MO range from 18.0 ng/m^3 to 238 ng/m^3 with a median concentration of 72.2 ng/m^3.

- Concentrations of acenaphthene and fluorene appear to be highest during the warmer months of the year, particularly the third quarter of 2011. 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, 2011 (31.8 ng/m^3 and 31.4 ng/m^3, respectively). The July 2nd concentrations are almost twice the next highest concentrations measured at S4MO, which were measured on the same date in June. 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. Of the concentrations less than 2 ng/m^3, the measurements were evenly split between the first and fourth quarters.

- 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 2011.

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 21 times, the most of any NMP site.

- S4MO is listed among the sites with the highest annual average concentrations of all VOCs except benzene and 1,3-butadiene. S4MO has the highest annual average concentration of hexachloro-1,3-butadiene and the second highest annual average concentrations of 1,2-dichloroethane and *p*-dichlorobenzene. This site also has the fourth highest annual average concentration of chloroform.

- S4MO has the second highest annual average concentration of formaldehyde and the third highest annual average concentration of acetaldehyde.

- S4MO's annual average concentration of benzo(a)pyrene ranks sixth highest among NMP sites sampling PAHs. This site's annual average acenaphthene and fluorene concentrations each rank seventh among NMP sites sampling PAHs.

- S4MO has the highest annual average concentrations of arsenic, cadmium, and lead among NMP sites sampling PM_{10} metals (and those sampling TSP metals). This site's annual average concentration of manganese ranked second among NMP sites sampling PM_{10} metals.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde, arsenic, benzene, benzo(a)pyrene, 1,3-butadiene, formaldehyde, hexavalent chromium, lead, manganese, and naphthalene were created for S4MO. Figures 16-6 through 16-15 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 16-6. Program vs. Site-Specific Average Acetaldehyde Concentration

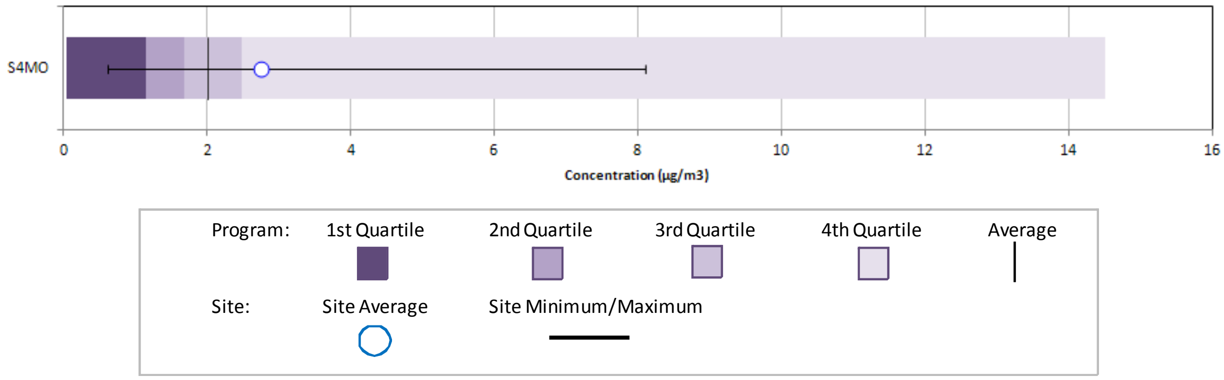


Figure 16-7. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

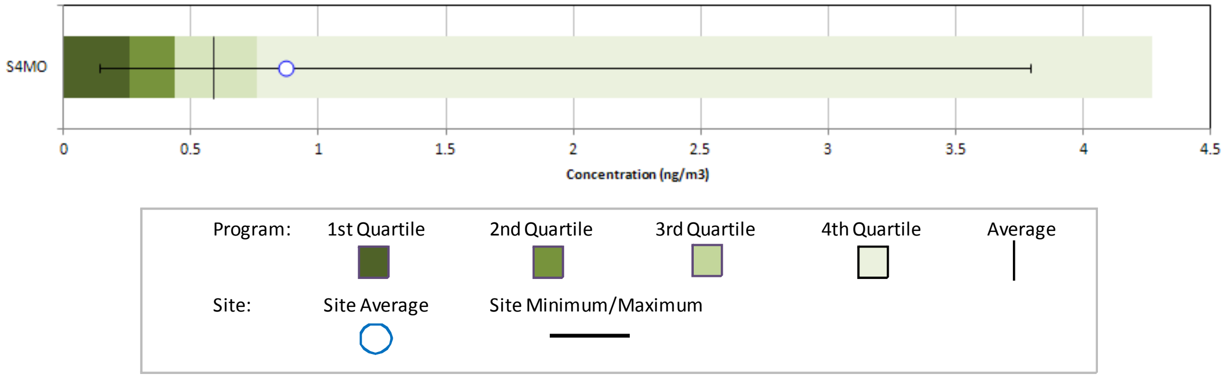


Figure 16-8. Program vs. Site-Specific Average Benzene Concentration

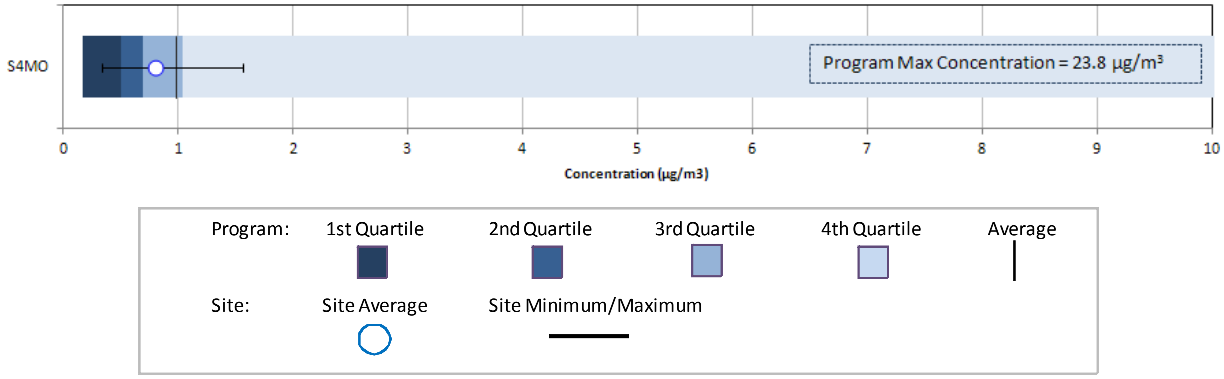


Figure 16-9. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

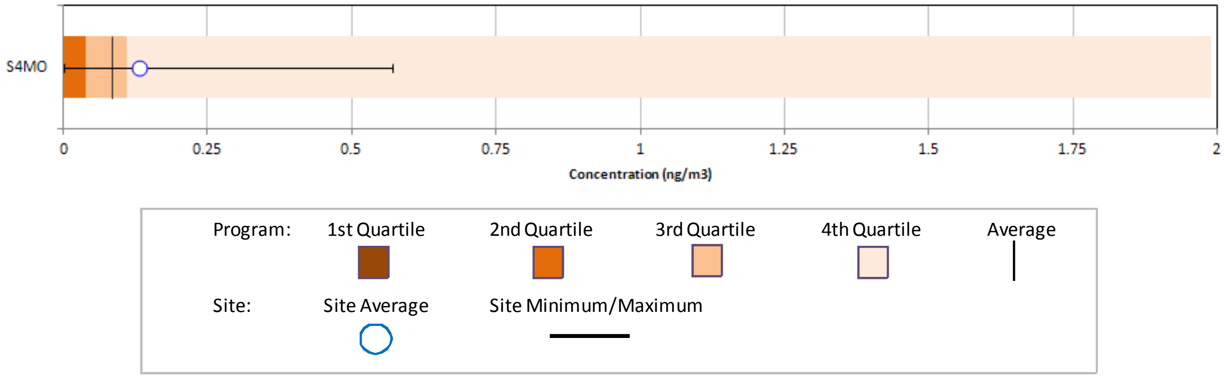


Figure 16-10. Program vs. Site-Specific Average 1,3-Butadiene Concentration

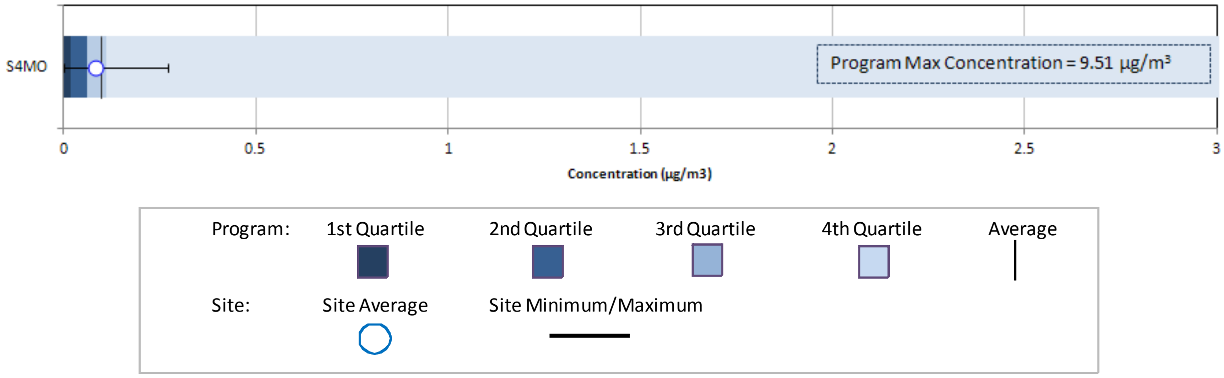


Figure 16-11. Program vs. Site-Specific Average Formaldehyde Concentration

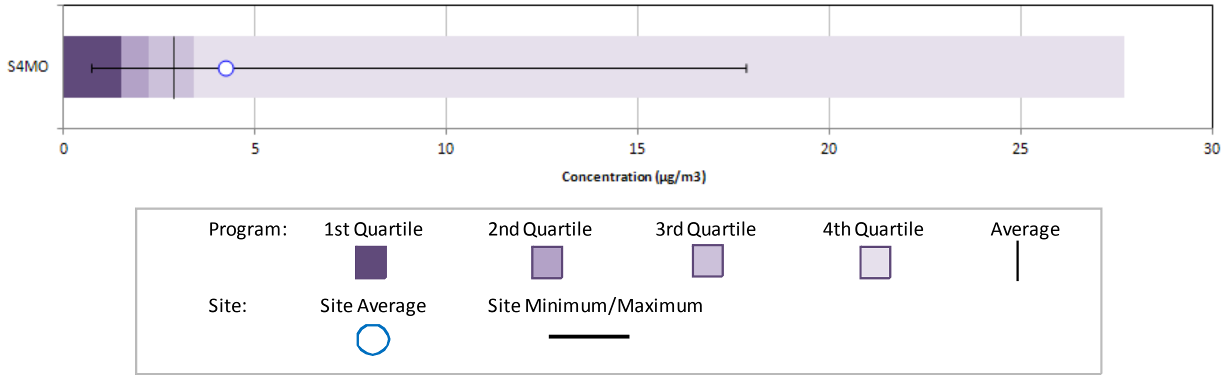


Figure 16-12. Program vs. Site-Specific Average Hexavalent Chromium Concentration

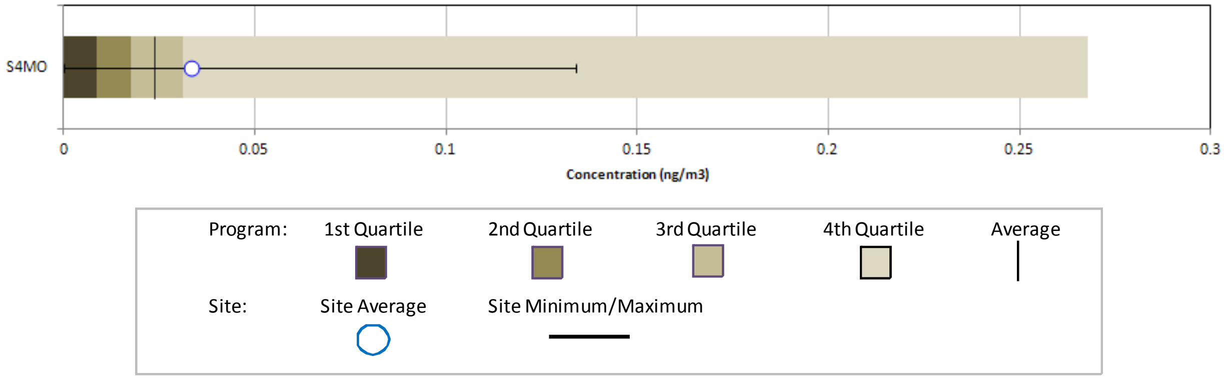


Figure 16-13. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

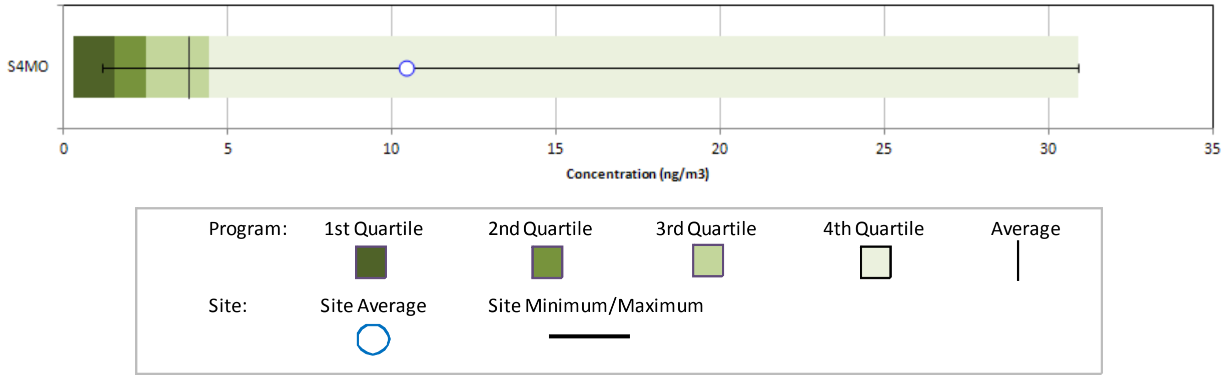


Figure 16-14. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

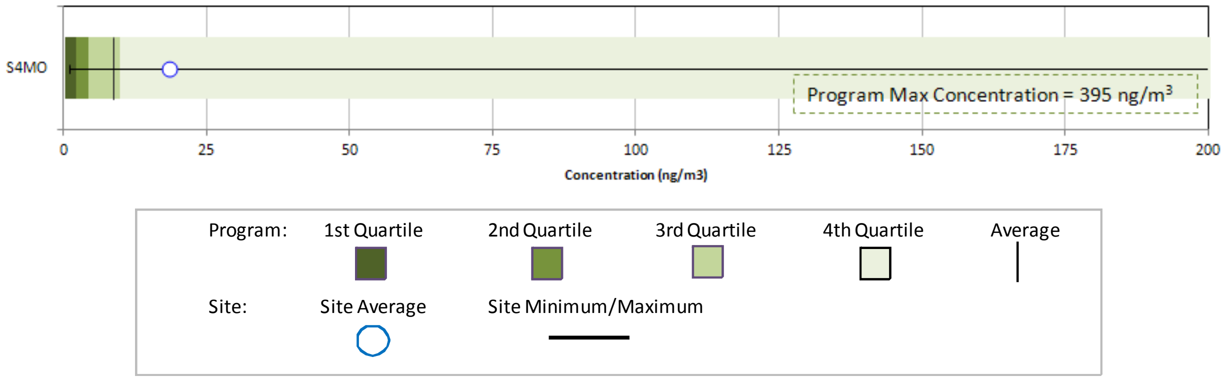
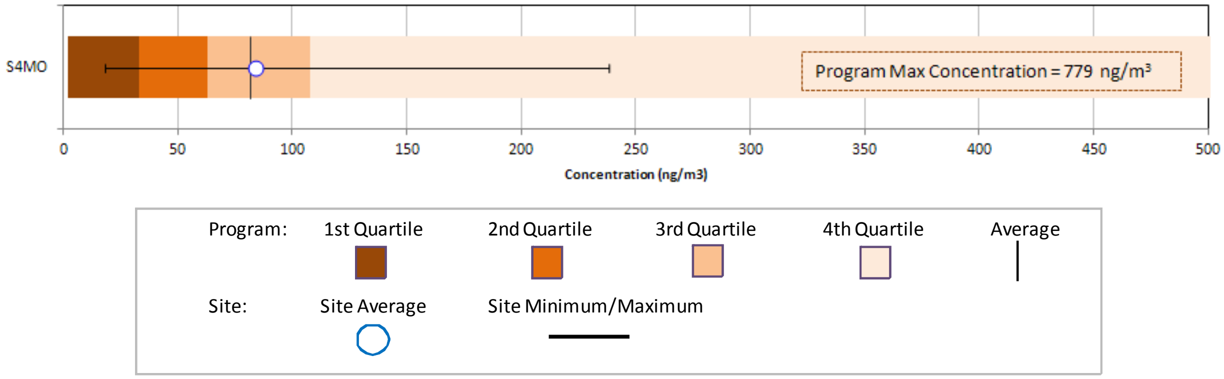


Figure 16-15. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 16-6 through 16-15 include the following:

- Figure 16-6 shows that S4MO's annual average acetaldehyde concentration is greater than the program-level average and third quartile. Although the maximum concentration measured at S4MO is not the maximum concentration measured across the program, it is the fifth highest acetaldehyde concentration measured among NMP sites sampling this pollutant. There were no non-detects of acetaldehyde measured at S4MO or across the program.

- Figure 16-7 shows that 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 highest annual average arsenic concentration among NMP sites sampling metals. The maximum concentration measured at S4MO is the second highest concentration measured across the program. There were no non-detects of arsenic measured at S4MO.

- Figure 16-8 is the box plot for benzene. Note that the program-level maximum concentration (23.8 $\mu g/m^3$) 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 has been reduced to 10 $\mu g/m^3$. Figure 16-8 for benzene shows that the annual average benzene concentration for S4MO is less than the program-level average concentration but greater than the program-level median concentration. The maximum benzene concentration measured at S4MO is considerably less than the maximum concentration measured at the program level. There were no non-detects of benzene measured at S4MO or across the program.

- Figure 16-9 is the box plot for benzo(a)pyrene. Note that the first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average concentration for S4MO is greater than the program-level average and third quartile. Recall from the previous section that the annual average concentration for S4MO ranked third among sites sampling benzo(a)pyrene. Figure 16-9 also shows that the maximum concentration measured at S4MO is less than the maximum concentration measured across the program. Two non-detects of benzo(a)pyrene were measured at S4MO.

- Similar to the benzene graph, the program-level maximum 1,3-butadiene concentration (9.51 $\mu g/m^3$) is not shown directly on the box plot as the scale has been reduced to 3 $\mu g/m^3$ to allow for the observation of data points at the lower end of the concentration range. Figure 16-10 for 1,3-butadiene shows that the annual average concentration for S4MO is less than the program-level average concentration but greater than the program-level median concentration. The maximum concentration measured at S4MO is considerably less than the maximum concentration measured across the program. There were a few non-detects of 1,3-butadiene measured at S4MO.

- Figure 16-11 for formaldehyde shows that the annual average concentration for S4MO is greater than the program-level average concentration as well as 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. There were no non-detects of formaldehyde measured at S4MO or across the program.

- Figure 16-12 shows that the annual average concentration of hexavalent chromium for S4MO is greater than both the program-level average concentration and program-level third quartile. The maximum concentration measured at S4MO is less than the program-level maximum concentration. A single non-detect of hexavalent chromium was measured at S4MO.

- Figure 16-13 shows that S4MO's annual average lead (PM_{10}) concentration is more than double the program-level average concentration. Recall from the previous section that this site has the highest annual average lead concentration among sites sampling metals. In addition, the maximum lead concentration measured at S4MO is the maximum concentration measured across the program. There were no non-detects of lead measured at S4MO or across the program.

- Figure 16-14 is the box plot for manganese (PM_{10}). Note that the program-level maximum concentration (395 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 200 ng/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 16-14 shows that S4MO's annual average manganese (PM_{10}) concentration is greater than both the program-level average concentration and third quartile. Recall from the previous section that this site has the second highest annual average manganese concentration among sites sampling PM_{10} metals. The maximum concentration of manganese measured at S4MO is the maximum concentration measured across the program. There were no non-detects of manganese measured at S4MO or across the program.

- Figure 16-15 is the box plot for naphthalene. Note that the program-level maximum concentration (779 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 ng/m^3 to allow for the observation of data points at the lower end of the concentration range. Figure 16-15 shows that the annual average naphthalene concentration for S4MO is just greater than the program-level average concentration. The maximum naphthalene concentration measured at S4MO is less than the program-level maximum concentration. There were no non-detects of naphthalene measured at S4MO or across the program.

16.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. S4MO has sampled VOCs and carbonyl compounds under the NMP since 2002, PM_{10} metals since 2003, and hexavalent chromium since 2005. Thus, Figures 16-16 through 16-23 present the annual statistical metrics for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, lead, and manganese (respectively) for S4MO. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. S4MO began sampling PAHs under the NMP in 2008; therefore, the trends analysis was not conducted for the PAHs.

Figure 16-16. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at S4MO

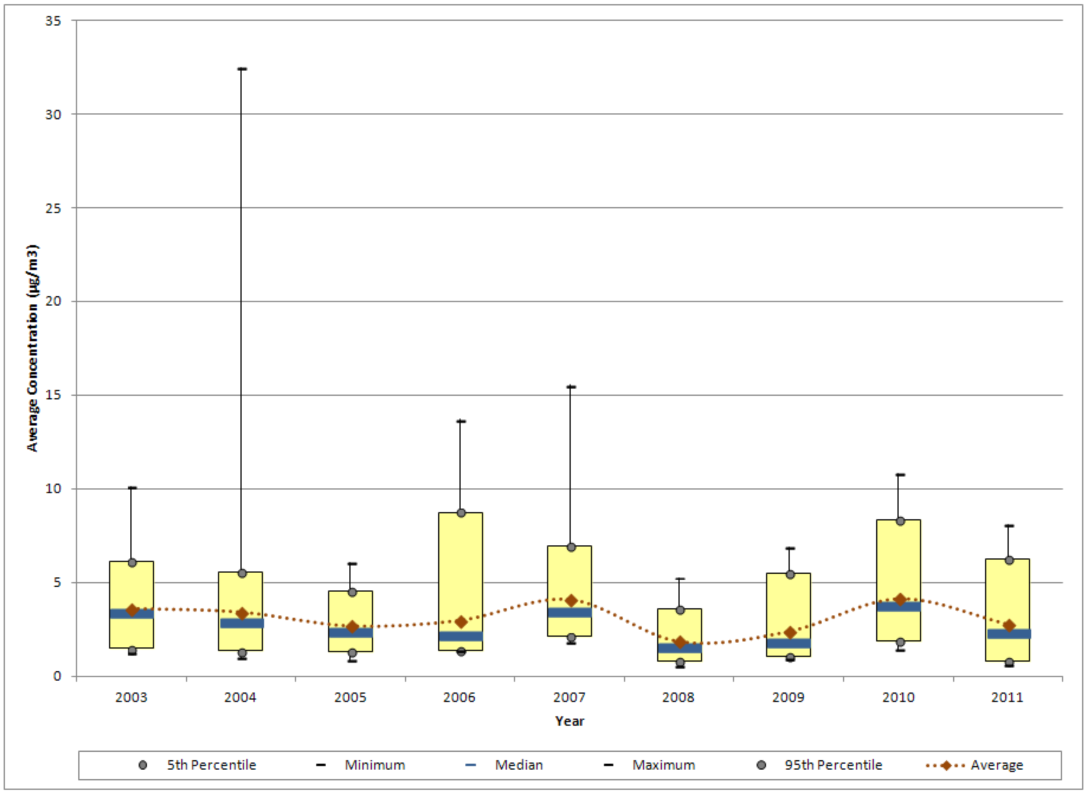


Figure 16-17. Annual Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at S4MO

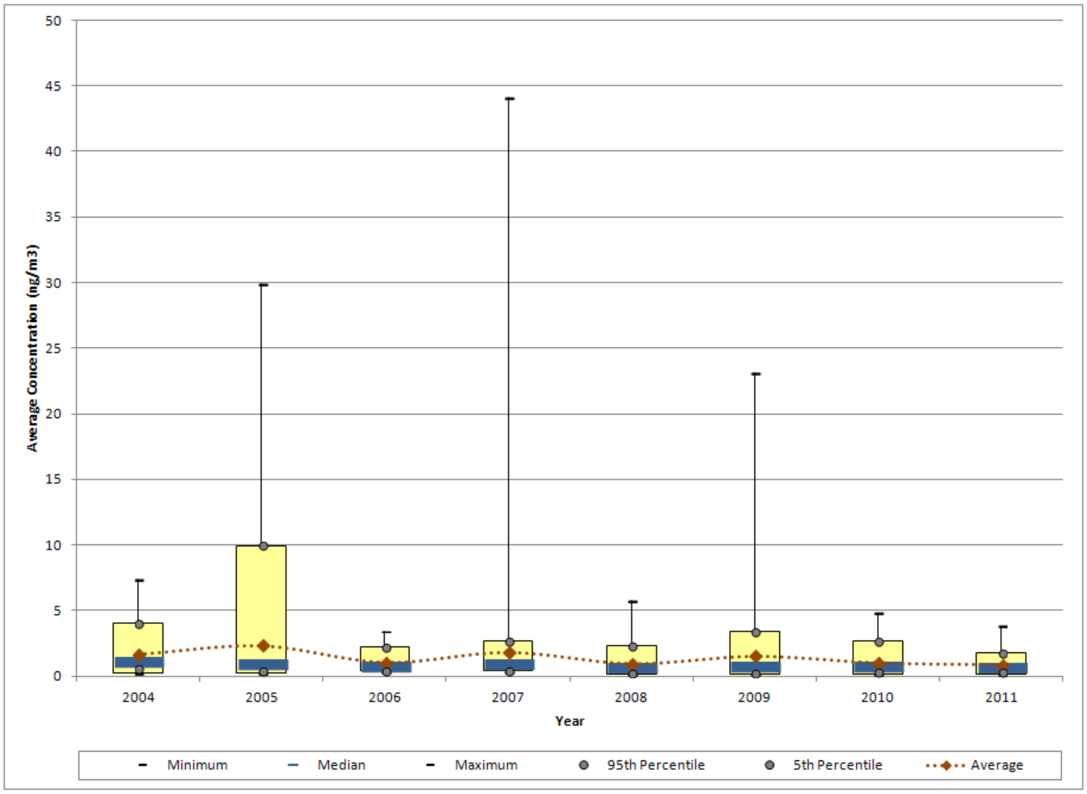


Figure 16-18. Annual Statistical Metrics for Benzene Concentrations Measured at S4MO

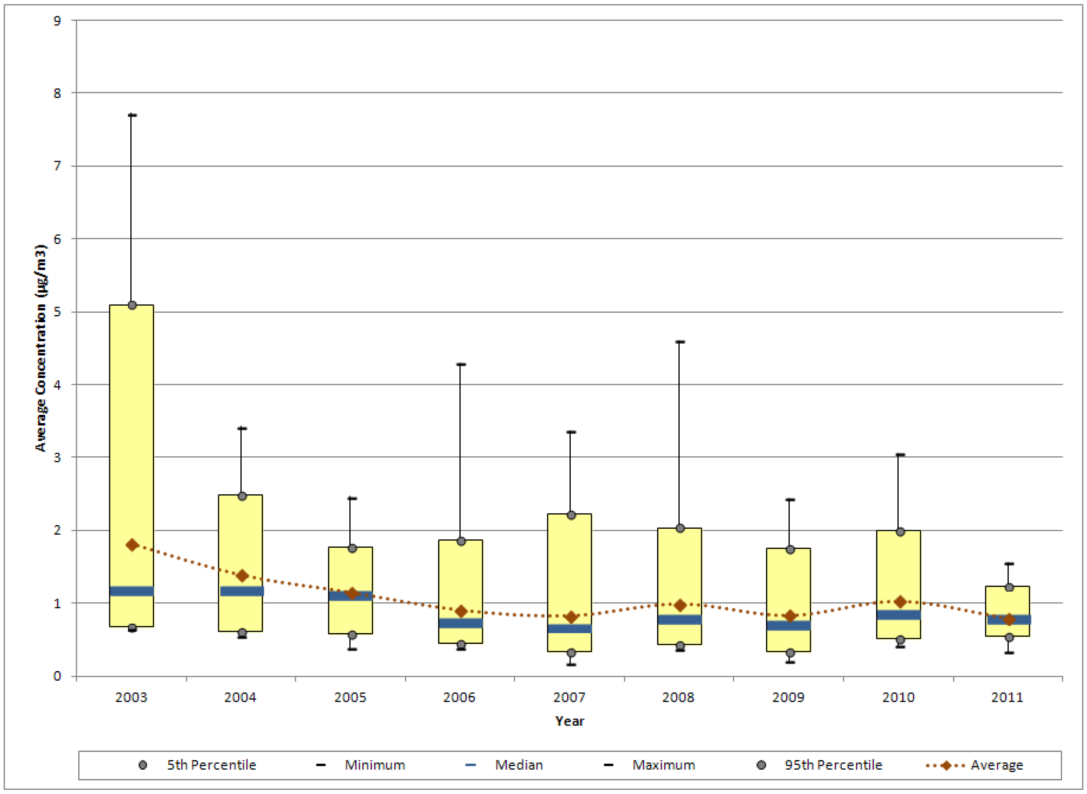


Figure 16-19. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at S4MO

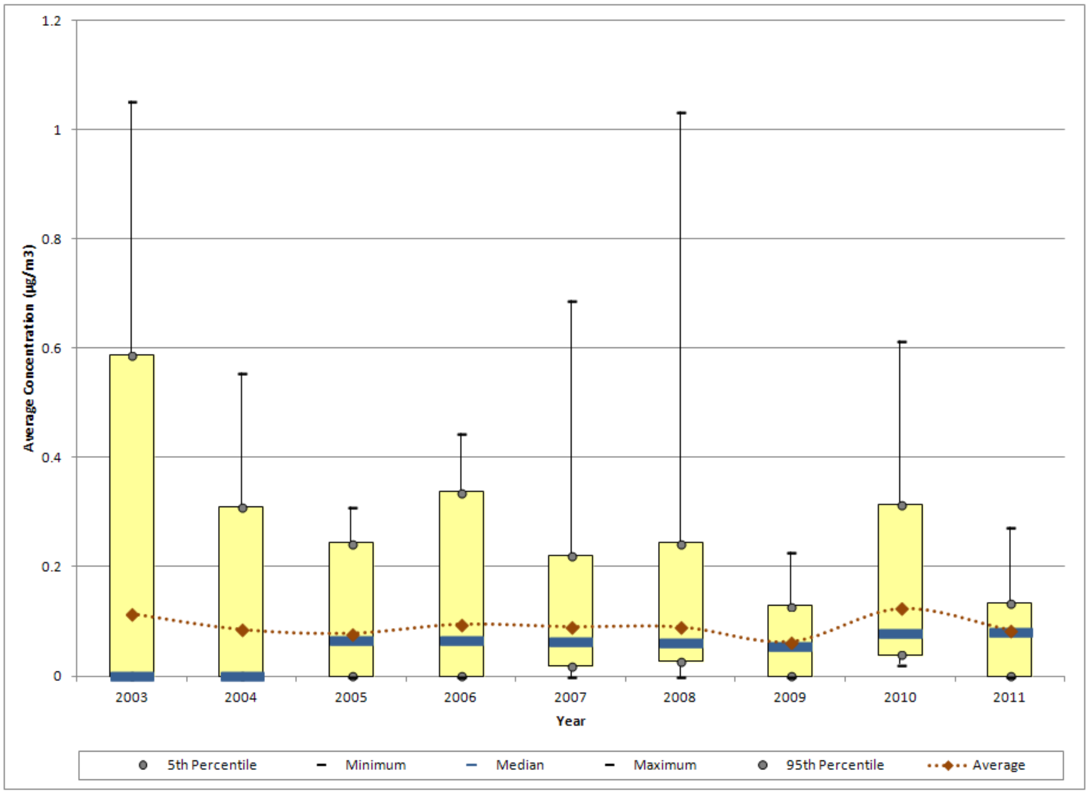


Figure 16-20. Annual Statistical Metrics for Formaldehyde Concentrations Measured at S4MO

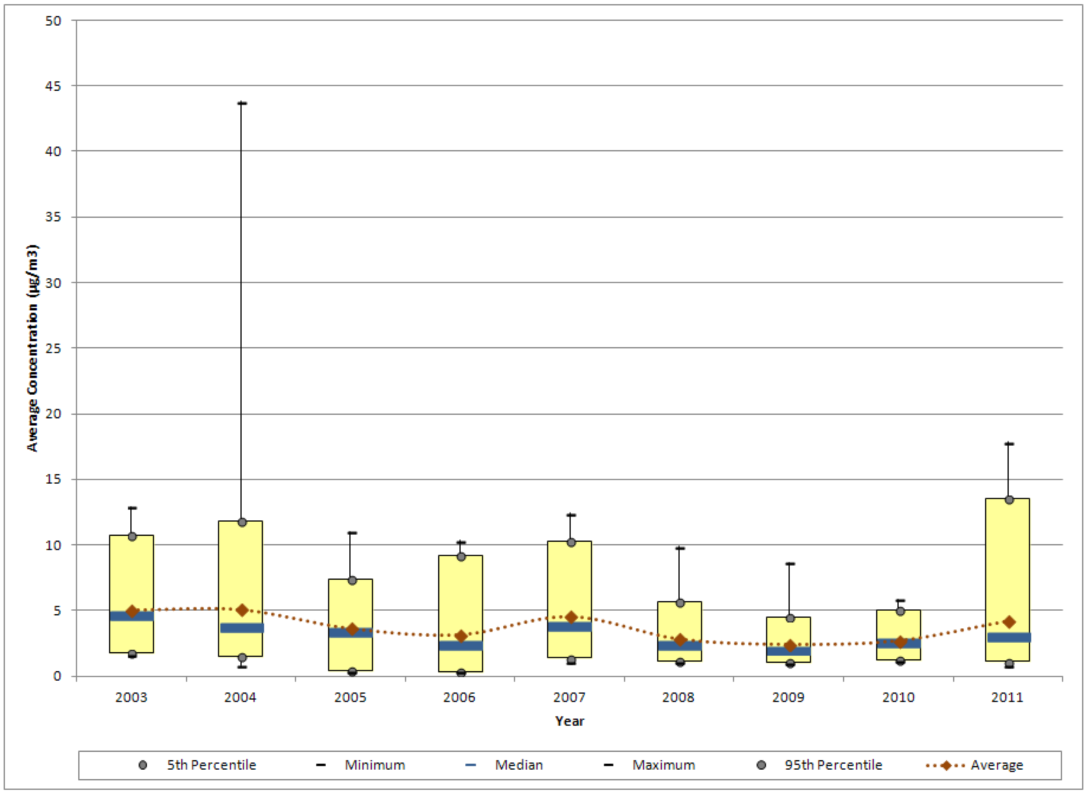


Figure 16-21. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at S4MO

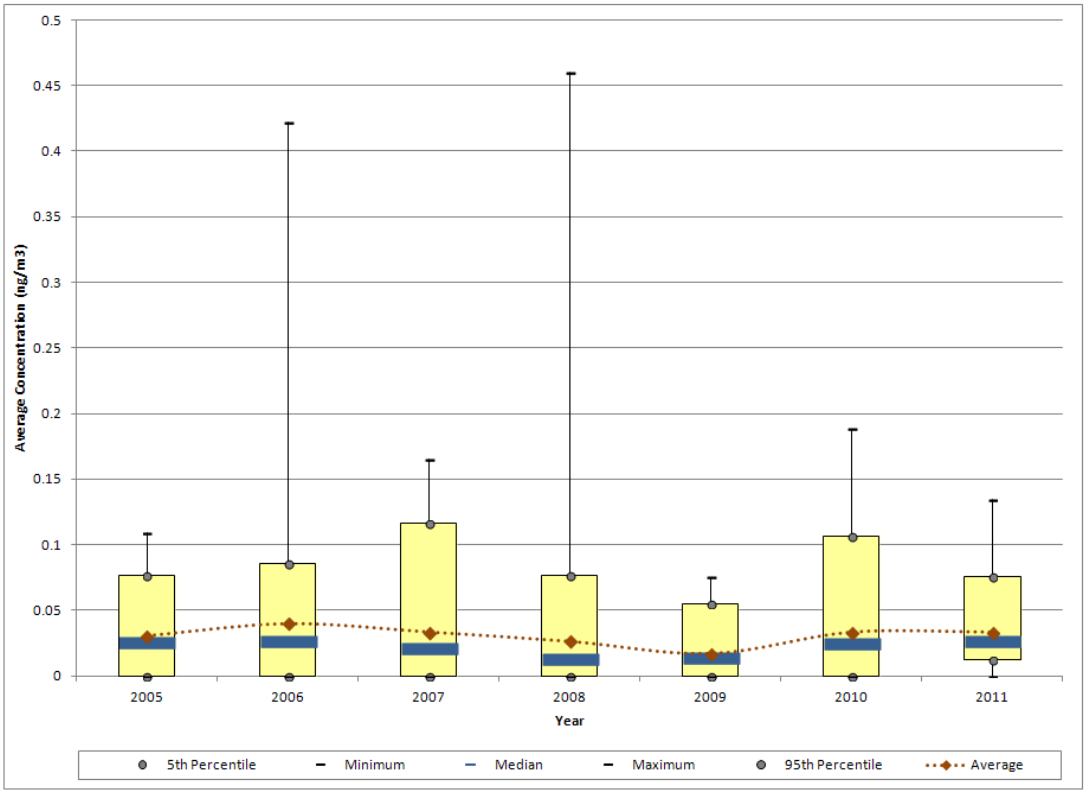


Figure 16-22 Annual Statistical Metrics for Lead (PM_{10}) Concentrations Measured at S4MO

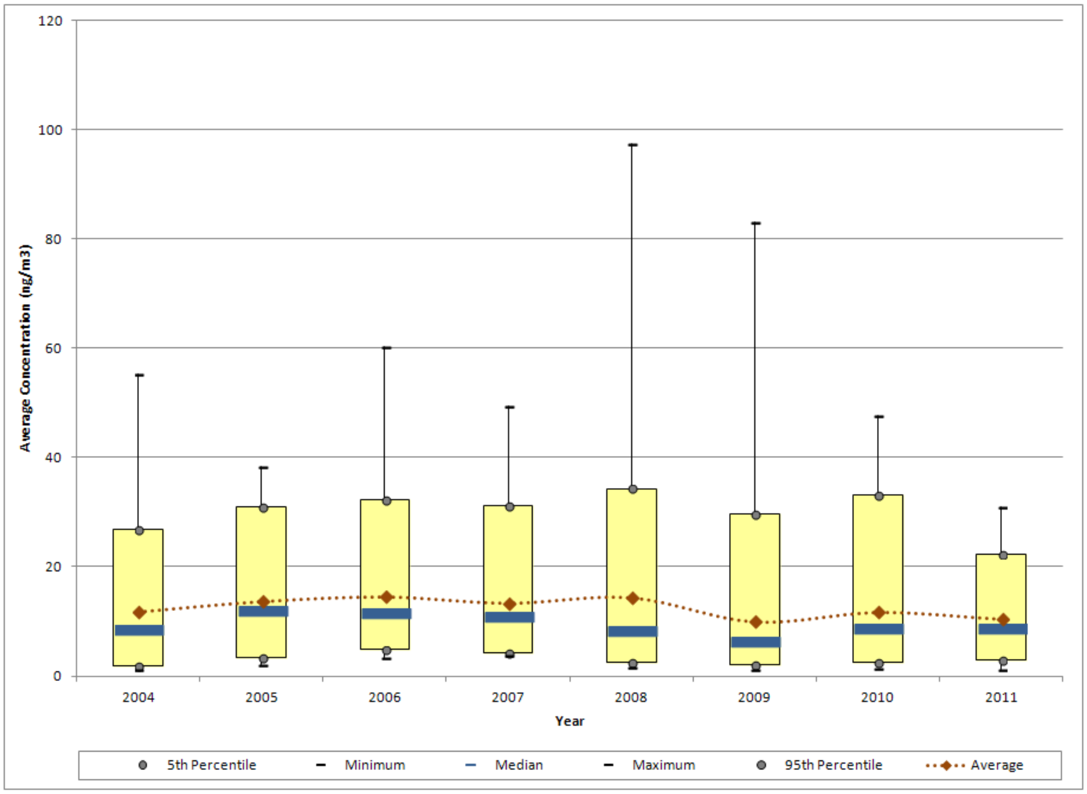
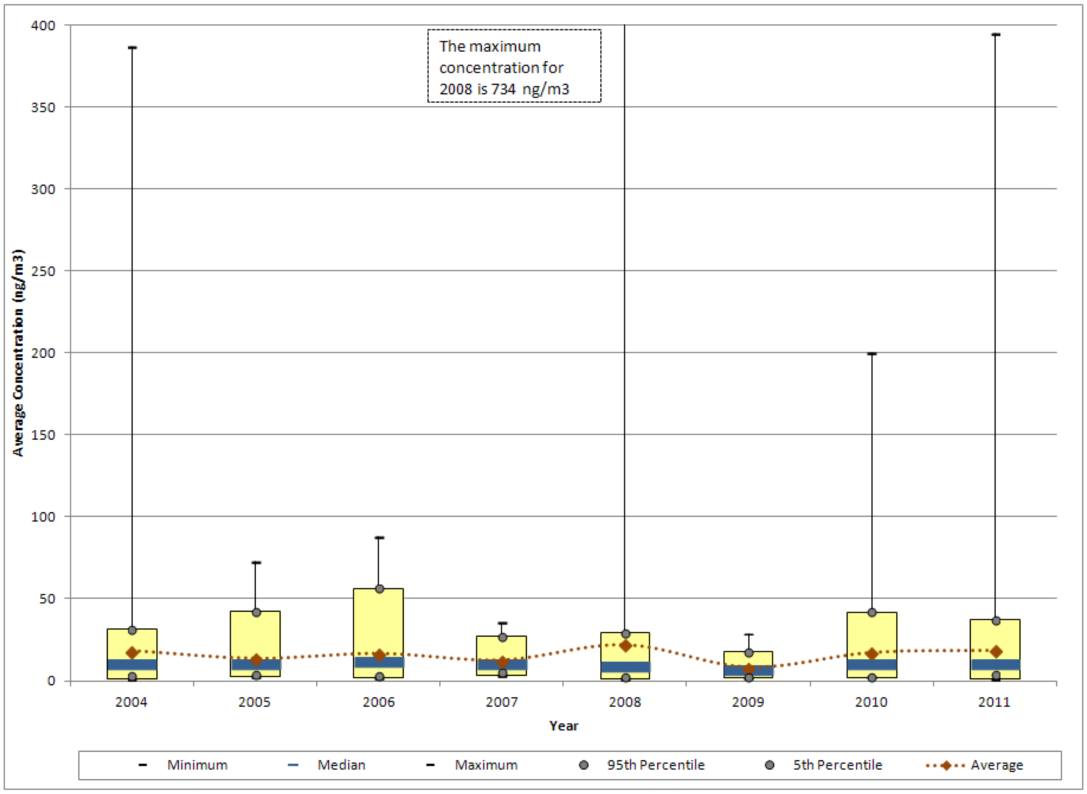


Figure 16-23. Annual Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at S4MO



Observations from Figure 16-16 for acetaldehyde include the following:

- Because carbonyl compound sampling did not begin until December 2002, 2002 data were excluded from this analysis.

- The maximum acetaldehyde concentration was measured in 2004 and is more than twice the next highest concentration (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 (32.5 $\mu g/m^3$) is nearly six times higher than the next highest concentration (5.72 $\mu g/m^3$) measured in 2004 and the median concentration for that year is 2.91 $\mu g/m^3$.

- The average concentrations have an undulating pattern in Figure 16-16 and have fluctuated between 1.83 $\mu g/m^3$ (2008) and 4.10 $\mu g/m^3$ (2010).

- Even though the maximum, 95th percentile, and average concentrations increased from 2005 to 2006, the median concentration actually decreased. Although there were four concentrations greater than 6 $\mu g/m^3$ measured in 2006, the number of concentrations less than 3 $\mu g/m^3$ increased from 36 in 2005 to 47 in 2006.

- After a significant decrease from 2007 to 2008, the average acetaldehyde concentration began increasing. The average concentration for 2010 is the maximum average concentration shown across the years of sampling. A significant decrease is shown from 2010 to 2011.

- The minimum concentration measured is greater than zero for all years shown, indicating that there were no non-detects reported for acetaldehyde.

Observations from Figure 16-17 for arsenic include the following:

- S4MO began sampling metals in July 2003. Because fewer than 85 percent of possible samples were collected in 2003, Figure 16-17 excludes data from 2003.

- The maximum arsenic concentration was measured on December 26, 2007. Only five concentrations greater than 10 ng/m^3 have been measured at S4MO since 2004.

- There is a slight downward trend in the average concentration of arsenic at S4MO, but the magnitude of the outliers measured in 2005, 2007, and 2009 makes this difficult to see. In addition, confidence intervals calculated for the average concentrations are relatively large as a result of the highest concentrations and indicate that these changes are not statistically significant.

- Many of the statistical parameters are at a minimum for 2011.

- Although difficult to discern in Figure 16-17, the minimum concentration measured is greater than zero for all years shown, indicating that there were no non-detects reported for arsenic.

Observations from Figure 16-18 for benzene measurements include the following:

- Because VOC sampling did not begin 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 average concentrations exhibit an overall decreasing trend through 2007, representing a greater than 1 µg/m^3 decrease, although the most significant changes occurred in the early years of sampling. The average concentration has varied between 0.80 µg/m^3 (2011) and 1.03 µg/m^3 (2010) since 2007.

- 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.

- The minimum concentration measured is greater than zero for each year, indicating that there were no non-detects reported for benzene since 2003.

Observations from Figure 16-19 for 1,3-butadiene 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.

- Between 2004 and 2008, the average concentration changed very little, ranging from 0.079 µg/m^3 (2005) to 0.095 µg/m^3 (2006). Greater fluctuations are shown in the years that follow.

Observations from Figure 16-20 for formaldehyde 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). Overall, 21 measurements of formaldehyde greater than 10 µg/m^3 have been measured at S4MO.

- The average concentration has fluctuated over the years of sampling, ranging between 2.46 µg/m^3 (2009) and 5.10 µg/m^3 (2004).

- The average formaldehyde concentration increased significantly from 2010 to 2011. There were 11 concentrations of formaldehyde in 2011 that were greater than the maximum concentration for 2010.

- The minimum concentration measured for each year is greater than zero, indicating that there were no non-detects of formaldehyde reported over the years shown.

Observations from Figure 16-21 for hexavalent chromium include the following:

- The maximum hexavalent chromium concentration was measured on July 5, 2008 (0.460 ng/m^3), although a similar concentration was also measured on July 4, 2006 (0.422 ng/m^3). The third highest hexavalent chromium concentration was measured on July 4, 2010 (0.188 ng/m^3), but is significantly less than the maximum concentrations measured in 2006 and 2008. While only 15 concentrations greater than 0.1 ng/m^3 have been measured at S4MO since the onset of sampling, at least one has been measured each year, with the exception of 2009.

- After an initial increase from 2005 to 2006, the average and median concentrations exhibit a decreasing trend, with nearly all of the statistical parameters reaching a minimum in 2009. The average concentration increased from 2009 to 2010 and held steady for 2011.

- With the exception of 2011, both the minimum concentration and 5th percentile for each year are zero, indicating the presence of non-detects (at least 5 percent). The percentage of non-detects has ranged from less than 2 percent (2011) to 43 percent (2009).

Observations from Figure 16-22 for lead include the following:

- The maximum lead concentration was measured at S4MO in 2008 and was nearly 100 ng/m^3. The second highest concentration was also measured in 2008 (84.8 ng/m^3) although a similar concentration was also measured in 2009.

- Concentrations of lead measured at S4MO exhibit a relatively high level of variability, as illustrated by the minimum and maximum concentrations. The difference between these two statistical metrics has ranged from 30 ng/m^3 (2011) to 96 ng/m^3 (2008).

- The average concentration of lead at S4MO has fluctuated over the years and exhibits no real trend. The averages have ranged from 9.95 ng/m^3 (2009) to 14.5 ng/m^3 (2006). The confidence intervals calculated for these averages are relatively large and therefore support the previous bullet. This site has had the highest annual average concentration of lead for the last several years compared to other NMP sites sampling PM_{10} metals under the NMP.

- The minimum concentration measured for each year is greater than zero, indicating that there were no non-detects of lead reported for the years shown.

Observations from Figure 16-23 for manganese 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).
- Four manganese concentrations greater than 100 ng/m^3 have been measured at S4MO since 2004, each in a different year. For each of these years, the second highest concentration of manganese was an order of magnitude lower. For example, for 2011, the two maximum concentrations are 395 ng/m^3 and 65.3 ng/m^3.
- The average concentration of manganese has ranged from 12.5 ng/m^3 (2007) to 21.9 ng/m^3 (2008). The median concentration, which is influenced less by outliers, has varied less, ranging from 6.82 ng/m^3 (2009) to 11.6 ng/m^3 (2006). The median concentration actually has a decreasing trend from 2006 to 2009, despite the outlier measured in 2008.
- The minimum concentration measured for each year is greater than zero, indicating that there were no non-detects of manganese reported for the years shown.

16.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

16.5.2 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
St. Louis, Missouri - S4MO						
Acenaphthene[a]	0.000088	--	61/61	0.01 ± <0.01	0.48	--
Acetaldehyde	0.0000022	0.009	59/59	2.75 ± 0.43	6.05	0.31
Arsenic (PM_{10})[a]	0.0043	0.000015	59/59	<0.01 ± <0.01	3.76	0.06
Benzene	0.0000078	0.03	57/57	0.80 ± 0.06	6.23	0.03
Benzo(a)pyrene[a]	0.00176	--	59/61	<0.01 ± <0.01	0.23	--
Beryllium (PM_{10})[a]	0.0024	0.00002	59/59	<0.01 ± <0.01	0.02	<0.01
1,3-Butadiene	0.00003	0.002	52/57	0.08 ± 0.01	2.54	0.04
Cadmium (PM_{10})[a]	0.0018	0.00001	59/59	<0.01 ± <0.01	1.00	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 16-5.

Table 16-6. Risk Approximations for the Missouri Monitoring Site (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 Hazard Approximation (HQ)
Carbon Tetrachloride	0.000006	0.1	57/57	0.61 ± 0.04	3.68	0.01
Chloroform	--	0.098	44/57	0.35 ± 0.40	--	<0.01
p-Dichlorobenzene	0.000011	0.8	47/57	0.21 ± 0.11	2.35	<0.01
1,2-Dichloroethane	0.000026	2.4	18/57	0.03 ± 0.01	0.84	<0.01
Ethylbenzene	0.0000025	1	57/57	0.38 ± 0.04	0.94	<0.01
Fluorene[a]	0.000088	--	61/61	0.01 ± <0.01	0.53	--
Formaldehyde	0.000013	0.0098	59/59	4.25 ± 0.92	55.21	0.43
Hexachloro-1,3-butadiene	0.000022	0.09	11/57	0.02 ± 0.01	0.50	<0.01
Hexavalent Chromium[a]	0.012	0.0001	60/61	<0.01 ± <0.01	0.40	<0.01
Lead (PM_{10})[a]	--	0.00015	59/59	0.01 ± <0.01	--	0.07
Manganese (PM_{10})[a]	--	0.00005	59/59	0.02 ± 0.01	--	0.37
Naphthalene[a]	0.000034	0.003	61/61	0.08 ± 0.01	2.85	0.03
Nickel (PM_{10})[a]	0.00048	0.00009	59/59	<0.01 ± <0.01	0.58	0.01
Tetrachloroethylene	0.00000026	0.04	55/57	0.18 ± 0.04	0.05	<0.01
Trichloroethylene	0.0000048	0.002	25/57	0.03 ± 0.01	0.17	0.02
Vinyl Chloride	0.0000088	0.1	8/57	<0.01 ± <0.01	0.03	<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 16-5.

Observations for S4MO from Table 16-6 include the following:

- The pollutants with the highest annual average concentrations for S4MO are formaldehyde, acetaldehyde, and benzene.

- Formaldehyde, benzene, and acetaldehyde have the highest cancer risk approximations for S4MO. The cancer risk approximation for formaldehyde (55.21 in-a-million) is nearly nine times higher than the cancer risk approximations for benzene and acetaldehyde, which were both approximately 6 in-a-million. S4MO's cancer risk approximation for formaldehyde is the second highest cancer risk approximation calculated among the site-specific pollutants of interest across the program.

- Naphthalene has the highest cancer risk approximation among the PAHs (2.58 in-a-million) and arsenic has the highest cancer risk approximation among the metals (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 formaldehyde (0.43), which is the fourth highest noncancer hazard approximation calculated for a site-specific pollutant interest among NMP sites.

16.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 16-7 and 16-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 16-6. Table 16-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations, also calculated from annual averages provided in Table 16-6.

The pollutants listed in Tables 16-7 and 16-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. The cancer risk and noncancer hazard approximations based on the site's annual averages are limited to those pollutants for which each respective site sampled. As discussed in Section 16.3, S4MO sampled for VOCs, PAHs, carbonyl compounds, metals (PM_{10}), and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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 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					
Benzene	148.92	Hexavalent Chromium, PM	2.11E-03	Formaldehyde	55.21
Formaldehyde	118.03	Formaldehyde	1.53E-03	Benzene	6.23
Ethylbenzene	78.65	Arsenic, PM	1.49E-03	Acetaldehyde	6.05
Acetaldehyde	74.93	Benzene	1.16E-03	Arsenic	3.76
1,3-Butadiene	20.98	1,3-Butadiene	6.29E-04	Carbon Tetrachloride	3.68
Trichloroethylene	15.79	Naphthalene	4.47E-04	Naphthalene	2.85
Naphthalene	13.16	Nickel, PM	3.92E-04	1,3-Butadiene	2.54
Dichloromethane	7.23	POM, Group 3	3.24E-04	*p*-Dichlorobenzene	2.35
POM, Group 2b	2.53	POM, Group 2b	2.22E-04	Cadmium	1.00
Methyl *tert* butyl ether	0.86	Ethylbenzene	1.97E-04	Ethylbenzene	0.94

Table 16-8. 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	522.43	Acrolein	316,721.93	Formaldehyde	0.43
Xylenes	358.32	Manganese, PM	34,593.25	Manganese	0.37
Methanol	289.83	Arsenic, PM	23,029.98	Acetaldehyde	0.31
Benzene	148.92	Formaldehyde	12,043.75	Lead	0.07
Formaldehyde	118.03	1,3-Butadiene	10,489.20	Arsenic	0.06
Hexane	116.82	Chlorine	9,452.80	Cadmium	0.06
Hydrochloric acid	109.87	Nickel, PM	9,073.56	1,3-Butadiene	0.04
Ethylbenzene	78.65	Acetaldehyde	8,325.31	Naphthalene	0.03
Acetaldehyde	74.93	Trichloroethylene	7,895.27	Benzene	0.03
Methyl isobutyl ketone	73.11	Lead, PM	6,587.56	Trichloroethylene	0.02

Observations from Table 16-7 include the following:

- Benzene, formaldehyde, and ethylbenzene 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 hexavalent chromium, formaldehyde, and arsenic.

- Six of the highest emitted pollutants also have the highest toxicity-weighted emissions.

- Five of the pollutants with the highest cancer risk approximations for S4MO also appear on both emissions-based lists (formaldehyde, benzene, 1,3-butadiene, ethylbenzene, and naphthalene). Other pollutants with the highest cancer risk approximations for S4MO appear on one emissions-based list but not the other. While arsenic is not one of the highest emitted pollutants, it ranks third for its toxicity-weighted emissions. While acetaldehyde does not appear on the list of highest toxicity-weighted emissions, it is the fourth highest emitted pollutant in the city of St. Louis.

- POM, Group 2b is the ninth highest emitted "pollutant" in St. Louis and ranks ninth 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 16-8 include the following:

- Toluene, xylenes, and methanol 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, manganese, and arsenic. 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.

- Only two of the highest emitted pollutants in the city of St. Louis also have the highest toxicity-weighted emissions (formaldehyde and acetaldehyde).

- Formaldehyde and acetaldehyde are the pollutants with the highest and third highest noncancer hazard approximations for S4MO, respectively, and are the only two pollutants of interest to appear on both emissions-based lists. Manganese, the pollutant with the second highest noncancer hazard approximation, is the pollutant with the second highest toxicity-weighted emissions but is not one of the highest emitted.

16.6 Summary of the 2011 Monitoring Data for S4MO

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

- *Twenty-five pollutants, of which 13 are NATTS MQO Core Analytes, failed screens for S4MO.*

- *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 had the highest annual average concentrations of hexachloro-1,3-butadiene, arsenic, cadmium, and lead among all NMP sites sampling these pollutants. S4MO had the second highest annual average concentrations of 1,2-dichloroethane, p-dichlorobenzene, formaldehyde, and manganese among all NMP sites sampling these pollutants.*

- *The trends analysis shows that concentrations of benzene have been decreasing at S4MO, particularly the earlier years of sampling.*

17.0 Sites in New Jersey

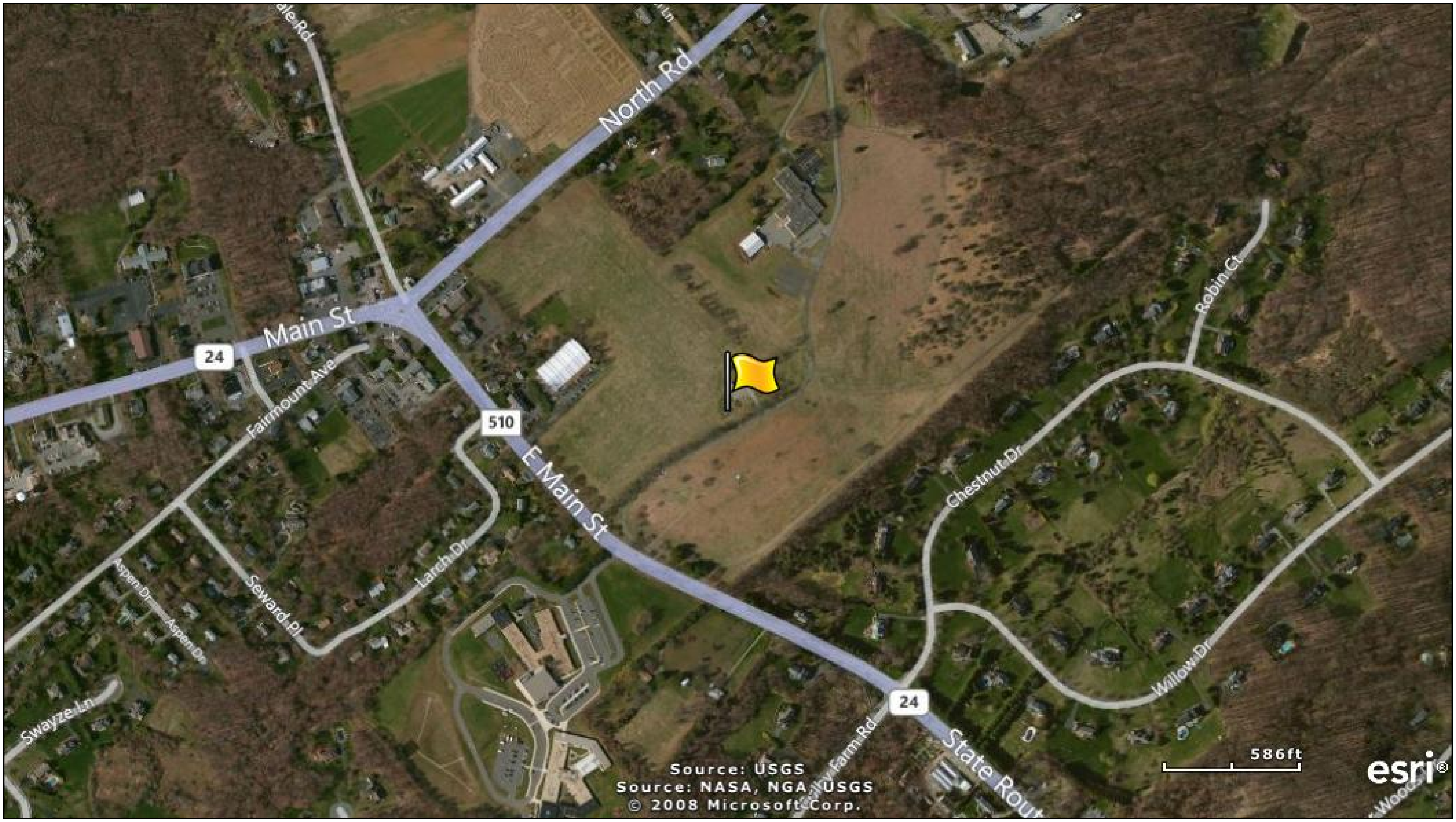
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at UATMP and CSATAM sites in New Jersey, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included 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.

17.1 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-Northern New Jersey-Long Island, NY-NJ-PA MSA, although within different divisions. Figure 17-1 is a composite satellite image retrieved from ArcGIS Explorer showing the CHNJ monitoring site in its urban location. Figure 17-2 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Figures 17-3 through 17-7 are the composite satellite maps and emissions source maps for the remaining New Jersey monitoring sites. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figures 17-2, 17-5, and 17-7. 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 maps, 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. Chester, New Jersey (CHNJ) Monitoring Site



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

Figure 17-2. NEI Point Sources Located Within 10 Miles of CHNJ

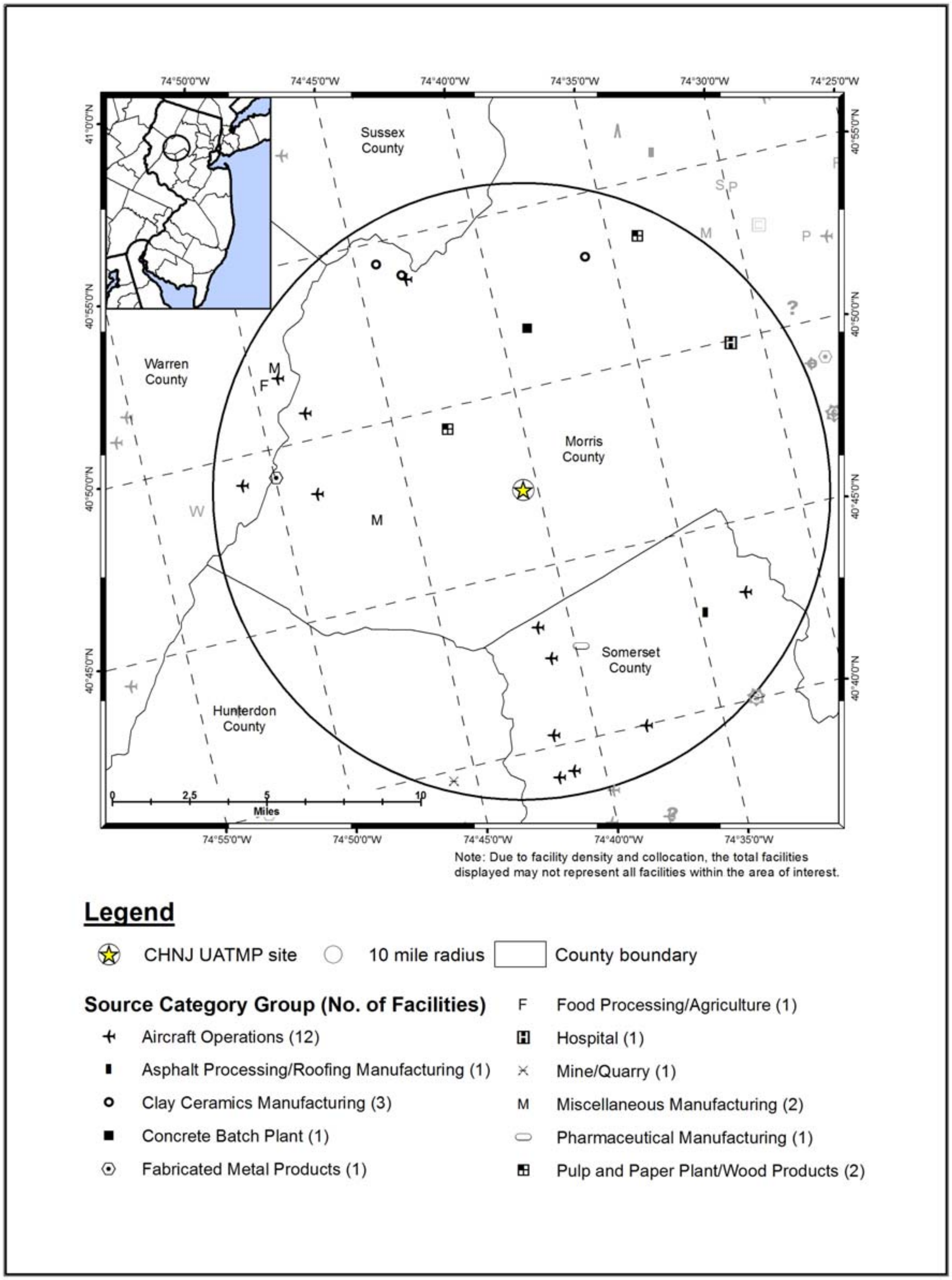
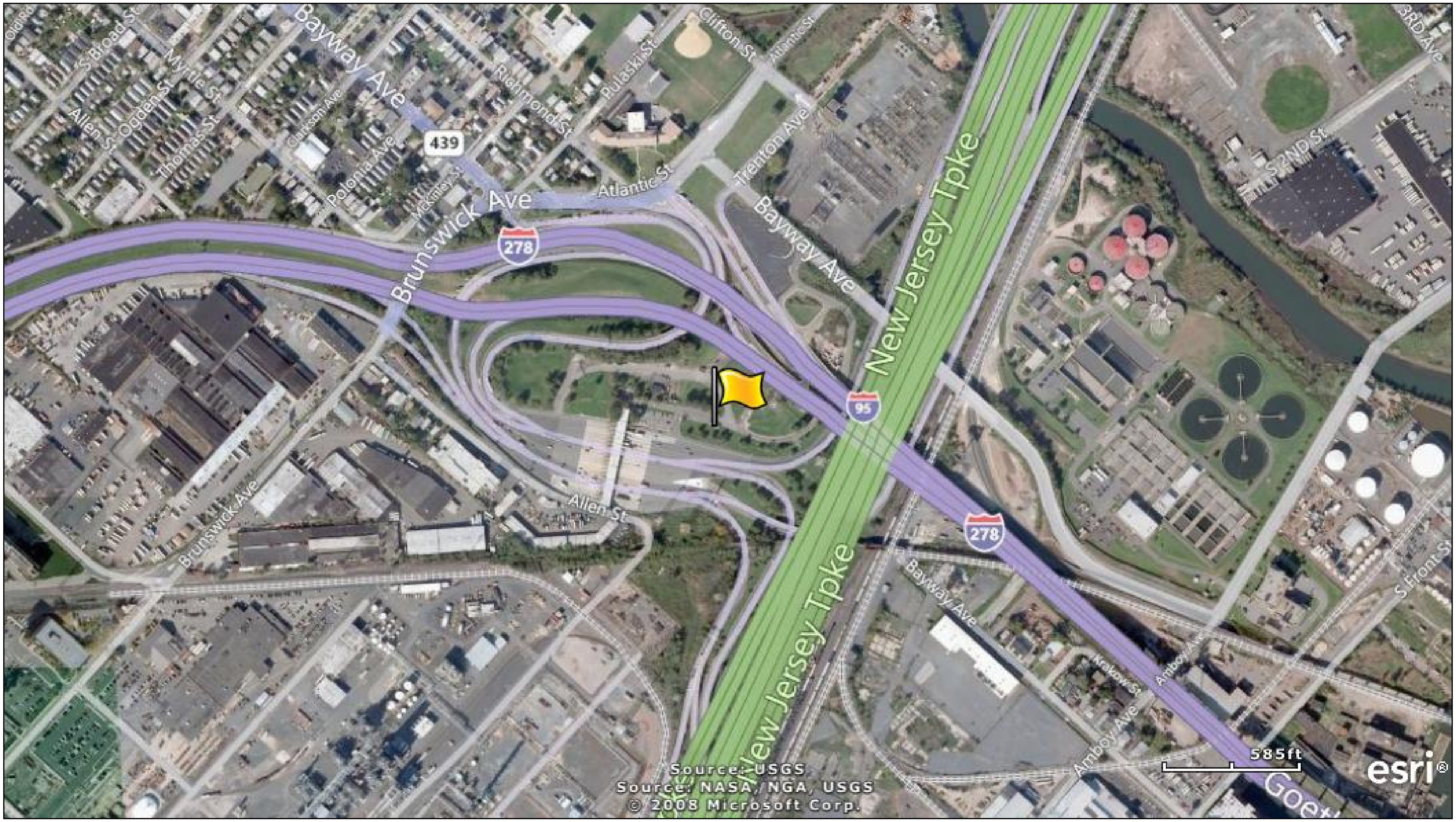


Figure 17-3. Elizabeth, New Jersey (ELNJ) Monitoring Site



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

Figure 17-4. New Brunswick, New Jersey (NBNJ) Monitoring Site

Source: USGS
Source: NASA, NGA, USGS
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Figure 17-5. NEI Point Sources Located Within 10 Miles of ELNJ and NBNJ

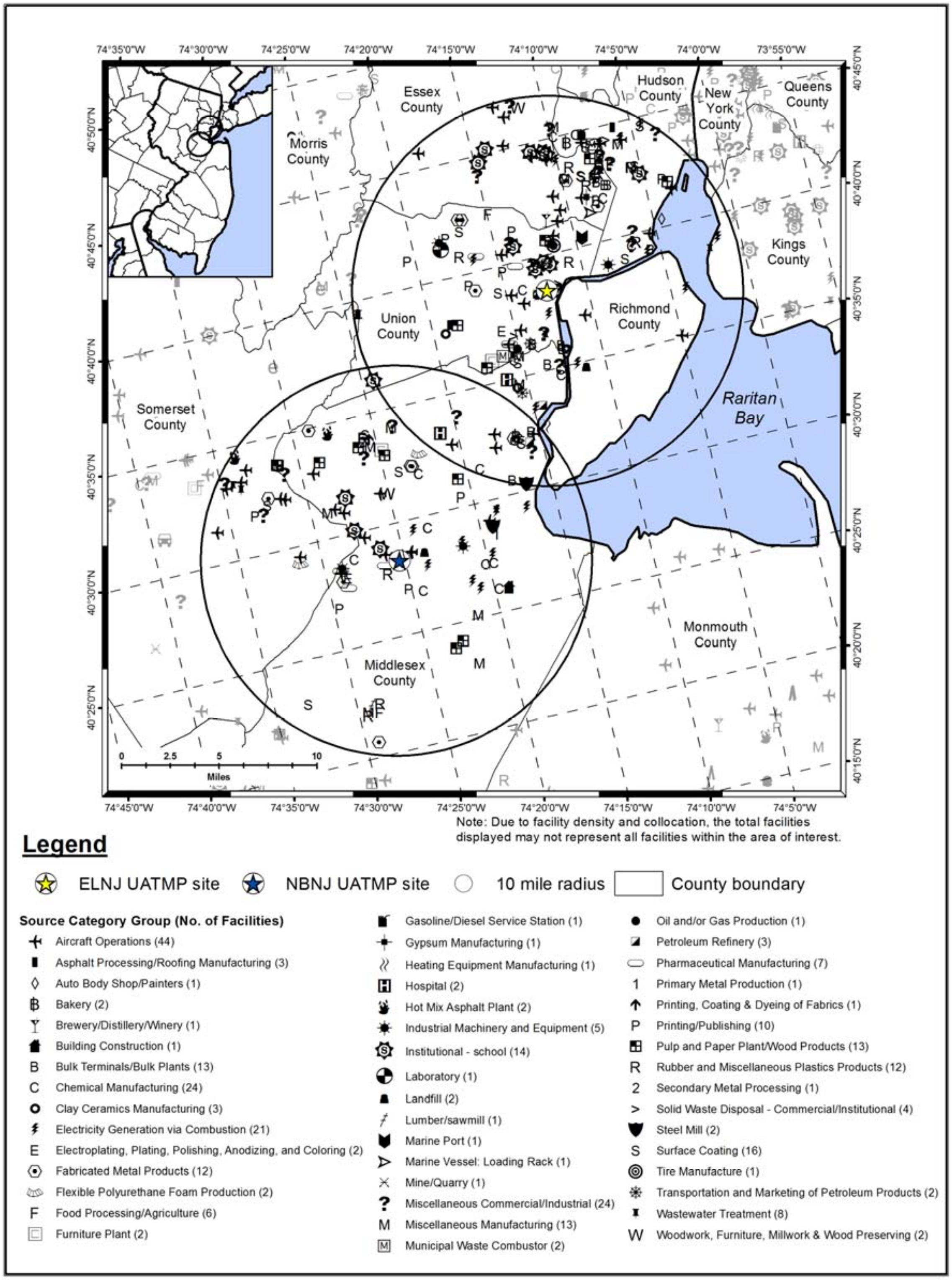


Figure 17-6. Paterson, New Jersey (PANJ) Monitoring Site

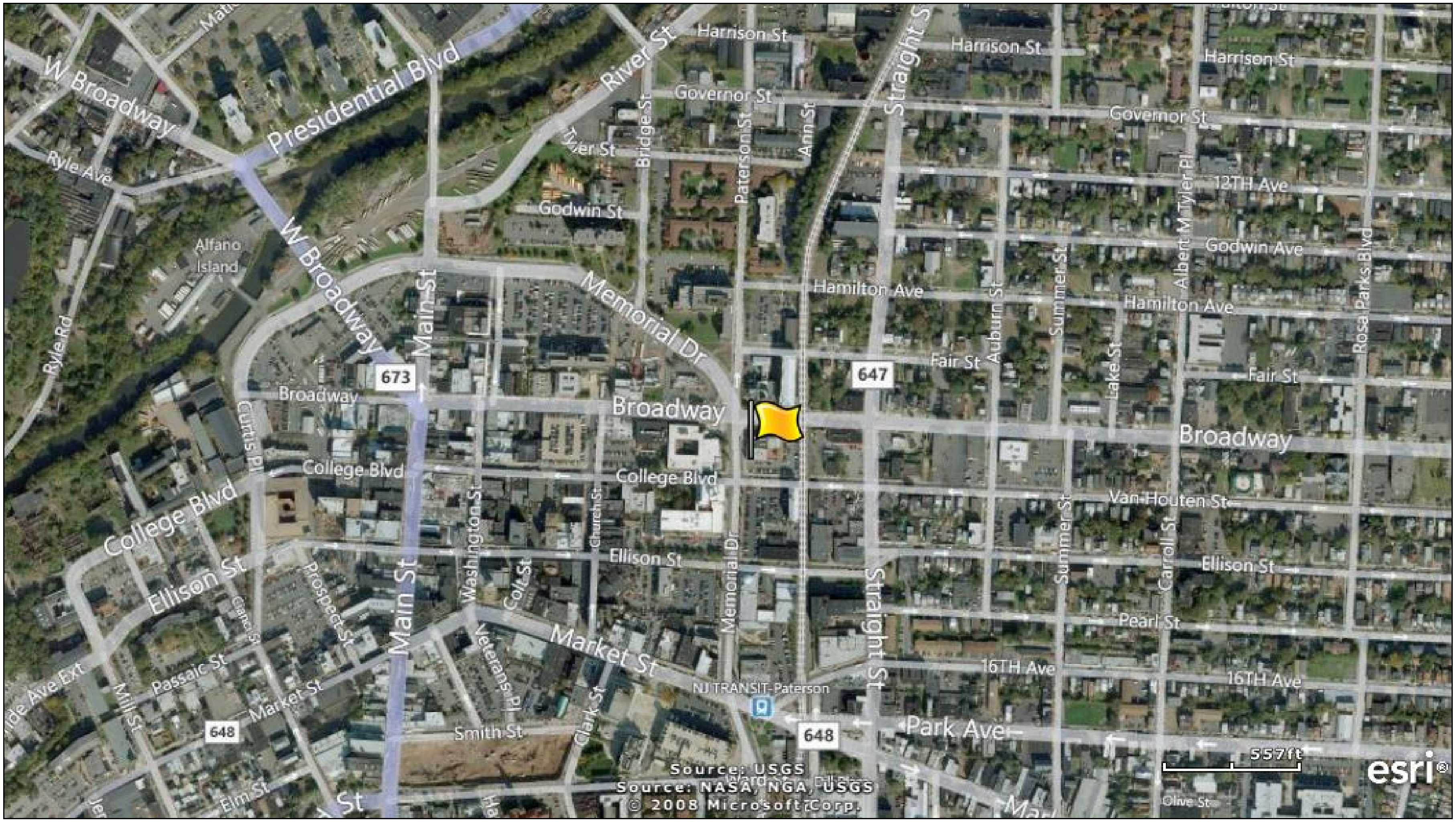
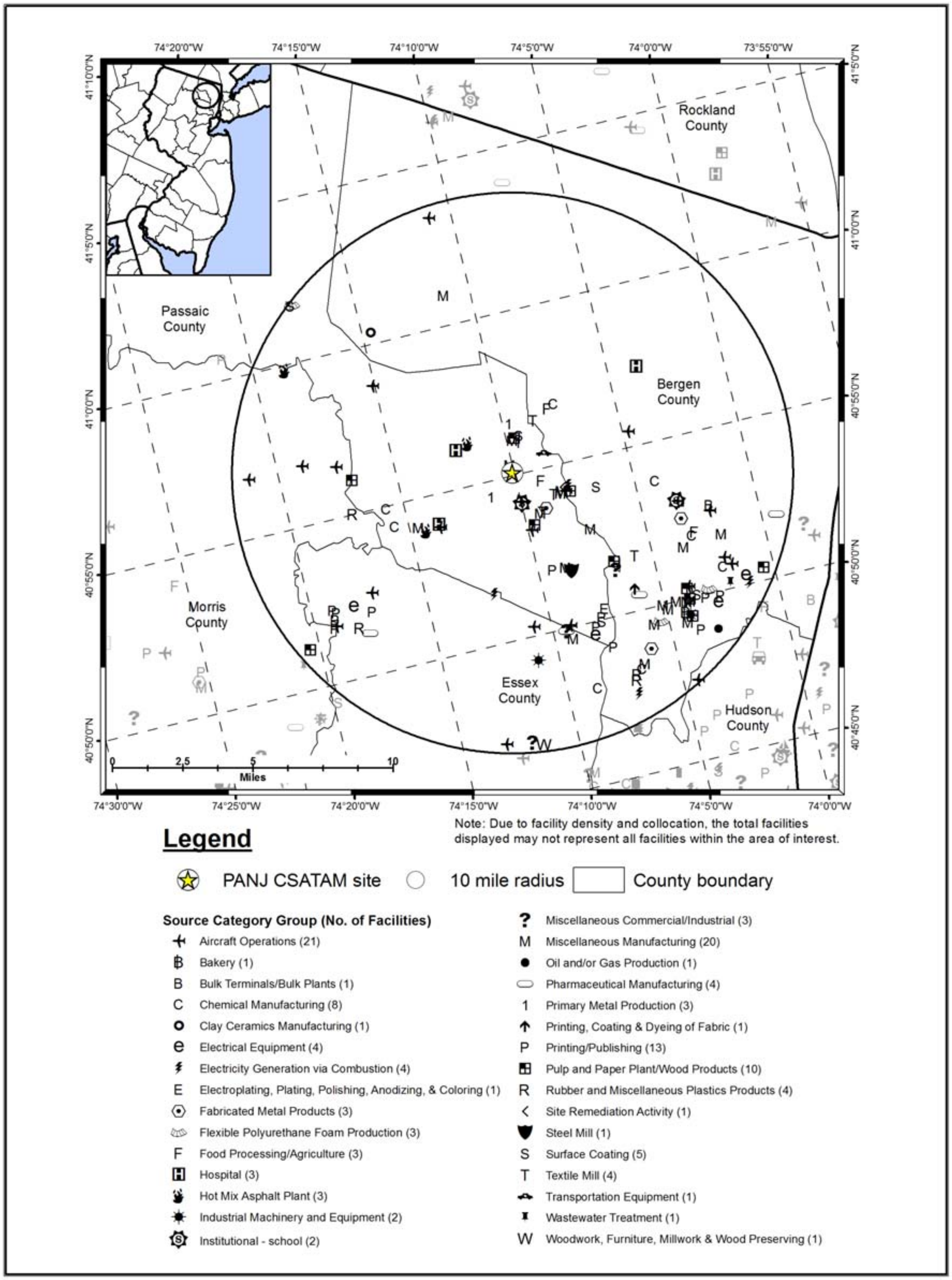


Figure 17-7. NEI Point Sources Located Within 10 Miles of PANJ



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 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-Northern New Jersey-Long Island, NY-NJ-PA MSA (Newark Div)	40.78763, -74.6763	Agricultural	Rural	SO_2, NO, NO_2, O_3, Meteorological parameters, $PM_{2.5}$, $PM_{2.5}$ Speciation
ELNJ	34-039-0004	Elizabeth	Union	New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (Newark Div)	40.64144, -74.20836	Industrial	Suburban	CO, SO_2, NO_2, NO_x, Meteorological parameters, $PM_{2.5}$, $PM_{2.5}$ Speciation
NBNJ	34-023-0006	New Brunswick	Middlesex	New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (Edison Div)	40.472786, -74.42251	Agricultural	Rural	Meteorological parameters, $PM_{2.5}$, $PM_{2.5}$ Speciation
PANJ	34-031-0005	Paterson	Passaic	New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (New York Div)	40.918381, -74.168092	Commercial	Urban/City Center	Meteorological Parameters, $PM_{2.5}$

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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 17-1 shows that CHNJ is located in an open area near Building 1 on the property of Bell Labs, which is owned by Alcatel-Lucent. 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 17-2 shows that few sources are close to CHNJ and that the source category with the greatest number of emissions sources surrounding CHNJ is the aircraft operations category, which includes airports as well as small runways, heliports, or landing pads. The source closest to CHNJ is in the pulp and paper/wood products source category.

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 17-3 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 New Brunswick, less than 20 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 17-4. 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 17-4.

Figure 17-5 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 bulk 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 aircraft operations, chemical manufacturing, electricity generation via combustion, and surface coating. The emissions sources in closest proximity to the ELNJ monitoring site are in the miscellaneous manufacturing, wastewater treatment, chemical manufacturing, electricity generation via combustion, and petroleum refining categories. The emissions sources in closest proximity to the NBNJ monitoring site are involved in aircraft operations and pharmaceutical manufacturing.

PANJ is located in northern New Jersey, in the town of Paterson, north of Newark and between Clifton and Hackensack. The monitoring site is located at the local health department with residential areas to the east and commercial areas to the west, as shown in Figure 17-6. The Passaic River runs northeast-southwest just north of PANJ and is shown in the upper left corner of Figure 17-6. Interstate-80 runs east-west less than 1 mile south of PANJ. Figure 17-7 shows that the majority of point sources within 10 miles of PANJ are located to the southeast of the site. Many of the point sources near PANJ are involved in aircraft operations, printing and publishing, or pulp and paper products, although the source closest to PANJ falls in the miscellaneous industries category.

Table 17-2 presents additional site-characterizing information, including indicators of mobile source activity, for the New Jersey monitoring sites. Table 17-2 includes a county-level population for each site. County-level vehicle registration data for Union, Morris, Passaic, 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, was allocated to the county level using the county-level proportion of the state population from the U.S. Census Bureau. Table 17-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 17-2 also contains traffic volume information for each site. Finally, Table 17-2 presents the county-level daily VMT for Middlesex, Morris, Passaic, and Union Counties.

Table 17-2. Population, Motor Vehicle, and Traffic Information for the New Jersey Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
CHNJ	494,976	389,359	0.79	237,740	187,012	12,917	14,256,044
ELNJ	539,494	424,894	0.79	2,189,758	1,724,607	250,000	12,485,902
NBNJ	814,217	640,893	0.79	810,434	637,915	114,322	20,415,685
PANJ	502,007	396,602	0.79	1,356,675	1,071,818	22,272	8,178,167

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)

[2] County-level vehicle registration reflects ratios based on 2010 state-level vehicle registration data from the FHWA and the 2010 county-level proportion of the state population data (FHWA, 2011 and Census Bureau, 2011)

[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)

[4] AADT for ELNJ reflects 2006 data from NJ Department of Treasury and 2010 data from the New Jersey DOT for the other sites (Steer, 2008 and NJ DOT, 2010a)

[5] County-level VMT reflects 2010 data from the New Jersey DOT (NJ DOT, 2010b)

Observations from Table 17-2 include the following:

- Middlesex County, where NBNJ is located, has the highest county-level population of the New Jersey sites while Morris County, where CHNJ is located, has the least. ELNJ has the highest 10-mile population among the four New Jersey sites while CHNJ has the least. The 10-mile populations for both ELNJ and PANJ are greater than 1 million people.

- Compared to NMP monitoring sites in other locations, the county-level populations are in the middle of the range. However, ELNJ has one of the highest 10-mile populations, ranking third among NMP sites. The 10-mile populations for the other New Jersey sites range from eight highest (PANJ) to 36th highest (CHNJ).

- The estimated county-level vehicle registration is highest for NBNJ while the vehicle ownerships across the remaining New Jersey sites are fairly similar to each other. The county-level registration estimates for all the sites are in the middle of the range compared to other NMP sites. ELNJ and PANJ have the highest 10-mile vehicle ownership estimates compared to the other New Jersey sites and rank second and sixth compared to other NMP sites.

- ELNJ and NBNJ experience a significantly higher average traffic volume than CHNJ and PANJ. Traffic data for ELNJ are provided for I-95, between Exit 13 and 13A; this is the highest traffic volume among all NMP sites. Traffic data for CHNJ are provided for Main Street (County Road 513) near Highway 206 in downtown Chester; traffic data for NBNJ are provided for US-1 near State Road 617 (Ryders Lane); and traffic data for PANJ are provided for Memorial Drive between Ellison Street and College Boulevard.

- Among the New Jersey counties with monitoring sites, VMT for Middlesex County is highest while VMT for Passaic County is the lowest. However, county-level 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).

17.2 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.

17.2.1 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 temperature. 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. 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 (Bair, 1992 and Rutgers, 2013).

17.2.2 Meteorological Conditions in 2011

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). The three closest weather stations are located at Somerville-Somerset Airport (near CHNJ and NBNJ), Newark International Airport (near ELNJ), and Essex County Airport (near PANJ), WBAN 54785, 14734, and 54743, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, 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 New Jersey Monitoring Sites

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)
Chester, New Jersey - CHNJ									
Somerville, New Jersey/Somerset Airport 54785 (40.62, -74.67)	11.30 miles 165° (SSE)	Sample Day	63.3 ± 4.6	53.2 ± 4.3	42.2 ± 4.7	48.0 ± 4.1	69.8 ± 3.5	1015.8 ± 1.8	3.4 ± 0.6
		2011	63.8 ± 1.9	53.3 ± 1.8	43.0 ± 2.0	48.4 ± 1.7	71.7 ± 1.3	1015.4 ± 0.8	2.9 ± 0.2
Elizabeth, New Jersey - ELNJ									
Newark International Airport 14734 (40.68, -74.17)	3.45 miles 20° (NNE)	Sample Day	64.3 ± 4.6	56.6 ± 4.3	41.9 ± 4.7	49.6 ± 3.9	61.0 ± 3.8	1015.8 ± 1.9	8.0 ± 0.9
		2011	65.2 ± 1.9	57.4 ± 1.8	42.9 ± 1.9	50.3 ± 1.6	61.6 ± 1.5	1015.6 ± 0.8	7.6 ± 0.3
New Brunswick, New Jersey - NBNJ									
Somerville, New Jersey/Somerset Airport 54785 (40.62, -74.67)	16.06 miles 297° (WNW)	Sample Day	63.0 ± 4.3	53.1 ± 4.1	42.4 ± 4.5	48.1 ± 3.9	70.7 ± 3.4	1015.6 ± 1.8	3.4 ± 0.6
		2011	63.8 ± 1.9	53.3 ± 1.8	43.0 ± 2.0	48.4 ± 1.7	71.7 ± 1.3	1015.4 ± 0.8	2.9 ± 0.2
Paterson, New Jersey - PANJ									
Essex County Airport 54743 (40.88, -74.28)	6.39 miles 229° (SW)	Sample Day	48.1 ± 8.2	39.8 ± 7.8	26.3 ± 8.2	34.7 ± 7.2	61.7 ± 8.2	1017.5 ± 5.7	5.1 ± 1.3
		2011	62.9 ± 1.9	53.9 ± 1.8	42.8 ± 2.0	48.6 ± 1.7	69.5 ± 1.5	1016.3 ± 0.8	3.5 ± 0.2

[1] Sample day averages are highlighted 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 the entire year for 2011. Also included in Table 17-3 is the 95 percent confidence interval for each parameter. As shown in Table 17-3, average meteorological conditions on sample days were representative of average weather conditions throughout the year for CHNJ, ELNJ, and NBNJ. It appears that sample days at PANJ were cooler, drier, and windier than for the entire year as a whole. However, a 1-year monitoring effort at PANJ was completed in May 2011, thereby missing the warmer months of the year.

17.2.3 Back Trajectory Analysis

Figure 17-8 is the composite back trajectory map for days on which samples were collected at the CHNJ monitoring site in 2011. Included in Figure 17-8 are four back trajectories per sample day. Figure 17-9 is the corresponding cluster analysis. Similarly, Figures 17-10 through 17-13 are the composite back trajectory maps and corresponding cluster analyses for ELNJ and NBNJ. Figure 17-14 is the composite back trajectory map for PANJ but a cluster analysis was not performed for this site because there were fewer than 30 sample days. 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 17-8 through 17-14 represents 100 miles.

Figure 17-8. 2011 Composite Back Trajectory Map for CHNJ

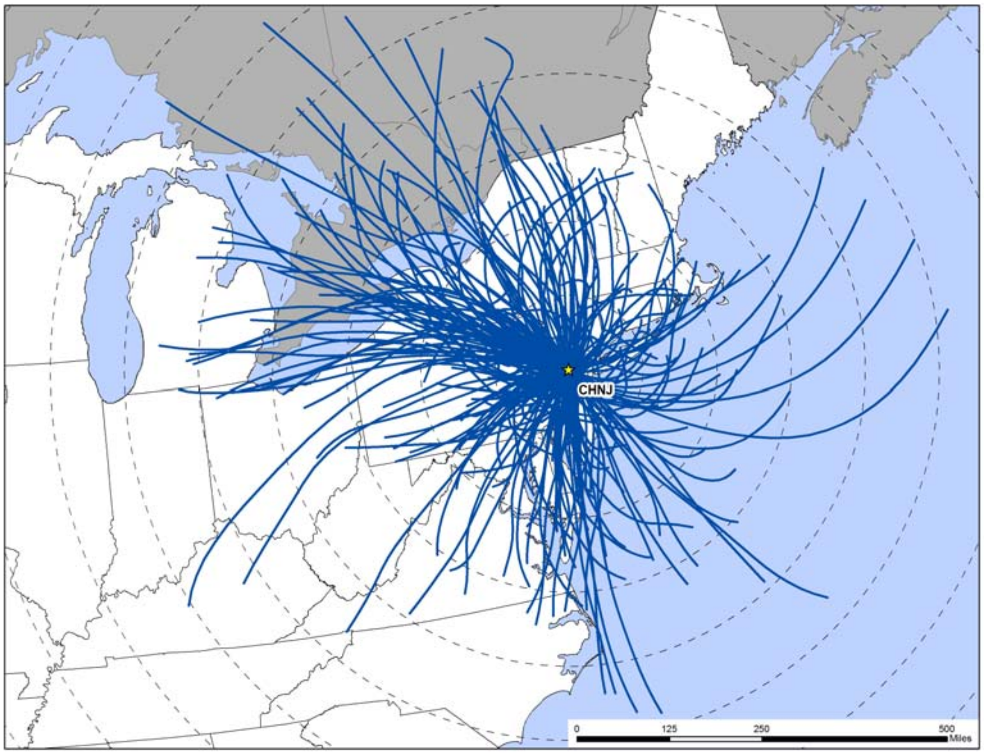


Figure 17-9. Back Trajectory Cluster Map for CHNJ

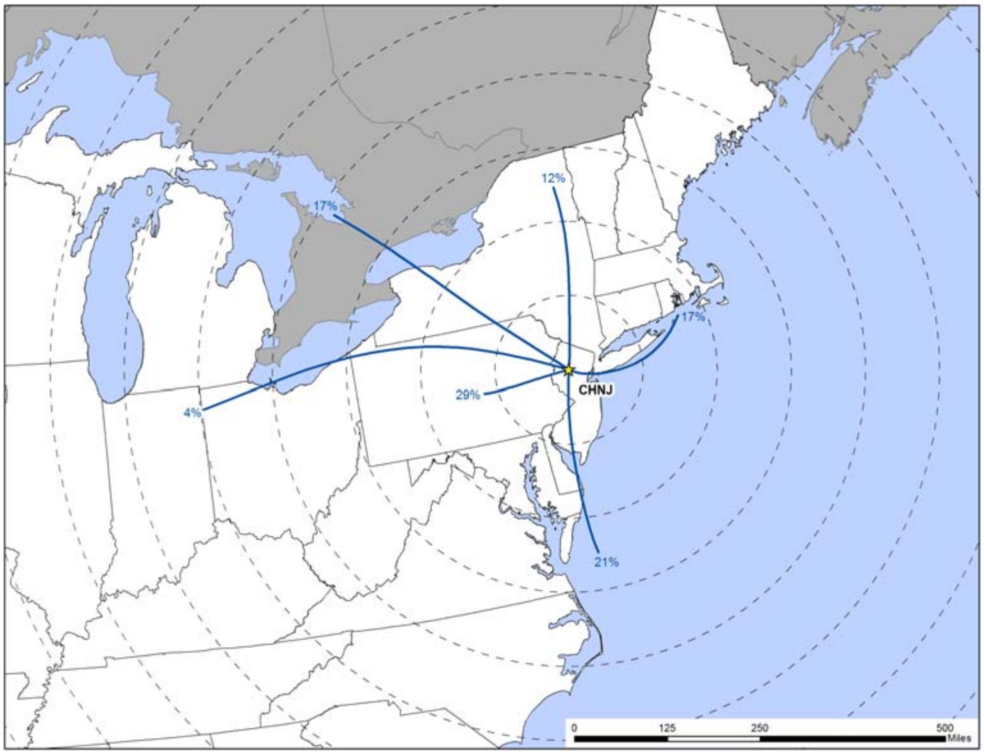


Figure 17-10. 2011 Composite Back Trajectory Map for ELNJ

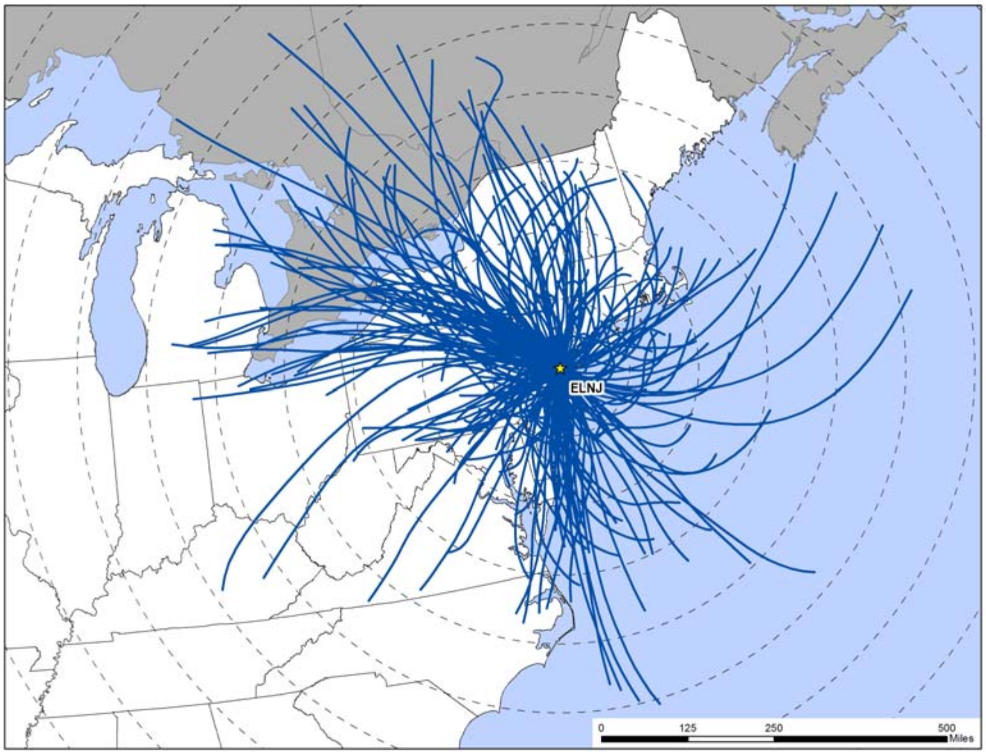


Figure 17-11. Back Trajectory Cluster Map for ELNJ

Figure 17-12. 2011 Composite Back Trajectory Map for NBNJ

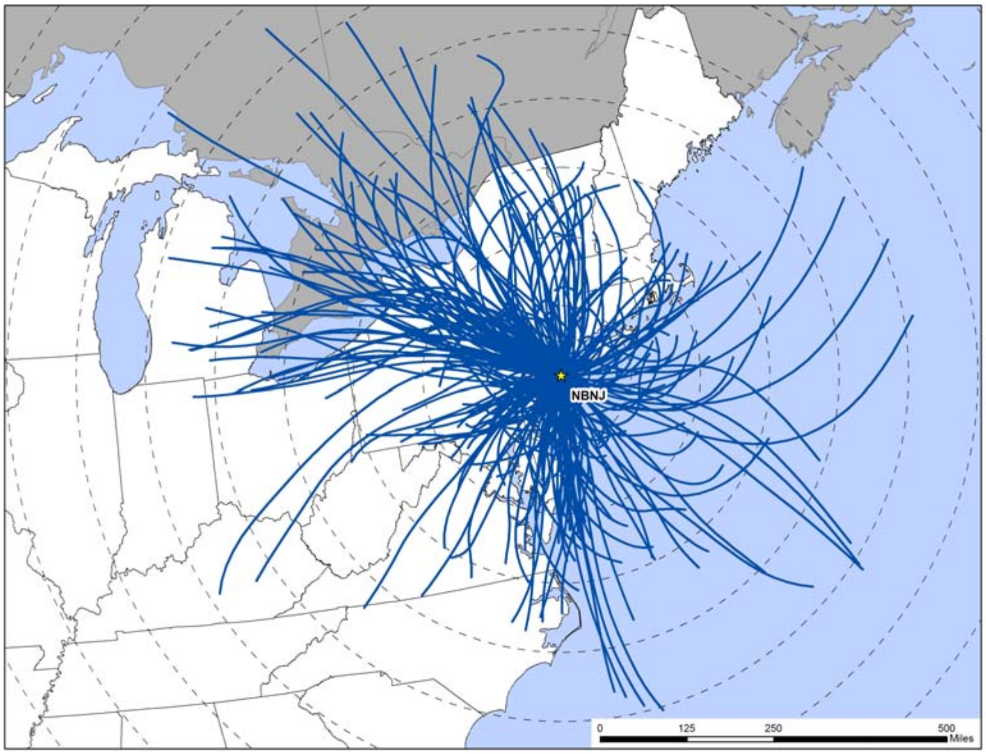
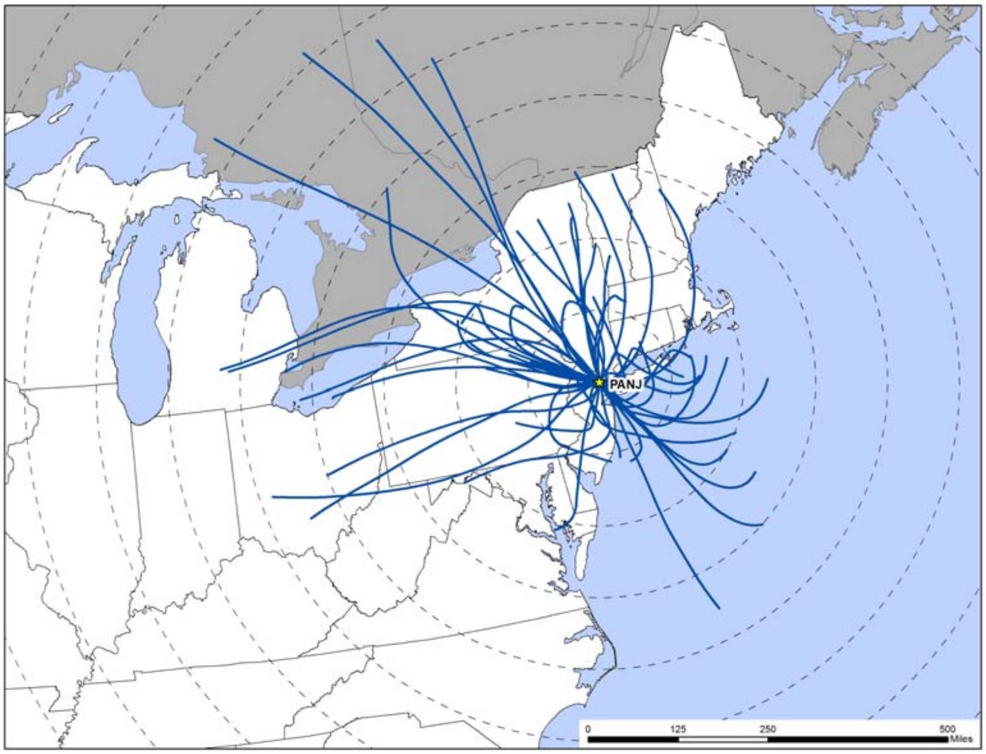


Figure 17-13. Back Trajectory Cluster Map for NBNJ

Figure 17-14. 2011 Composite Back Trajectory Map for PANJ



Observations from Figures 17-8 through 17-14 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 back trajectory map for PANJ includes one-third of the back trajectories compared to the other sites as PANJ stopped sampling in May 2011 and sampled on a 1-in-12 day sachedule.

- Back trajectories originated from a variety of directions at the sites. In general, the longest back trajectories originated from 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 600 miles in length originated near Lake Superior and Ontario, Canada. The average trajectory length for these sites ranged from 251 miles (CHNJ) to 259 miles (NBNJ).

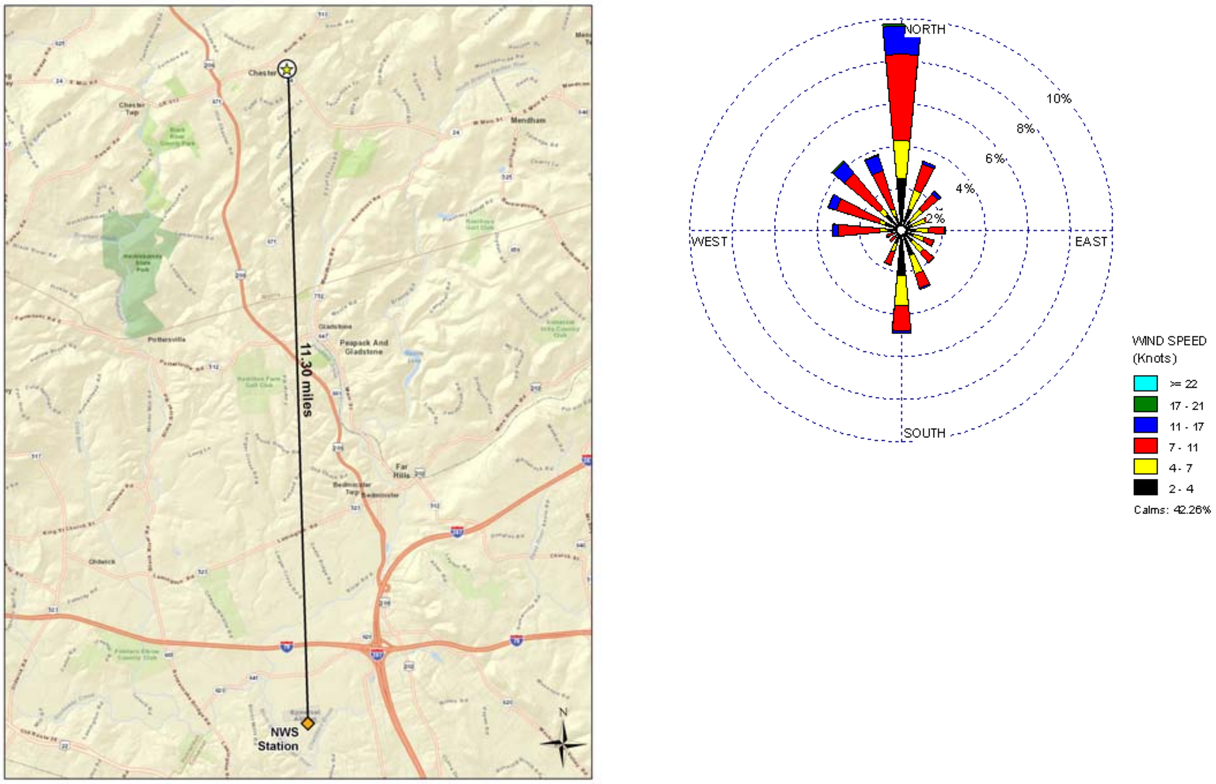
- The cluster trajectories for the New Jersey sites are similar to each other in geographical distribution, although the percentages vary. Each of the cluster maps has a relatively short cluster originating to the west of the sites over central Pennsylvania, representing approximately 30 percent of back trajectories. This cluster trajectory represents relatively short back trajectories (<250 miles) originating from a direction with a westerly component. Another roughly 20 percent of back trajectories originated from the west and northwest of the site but of longer length. For CHNJ and ELNJ, these are split into two clusters, one from the west and one from the northwest. Roughly 20 percent of back trajectories originated to the south, 20 percent to the east, and 10 percent to the north.

17.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS weather stations nearest the New Jersey sites, as presented in Section 17.2.2, 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.

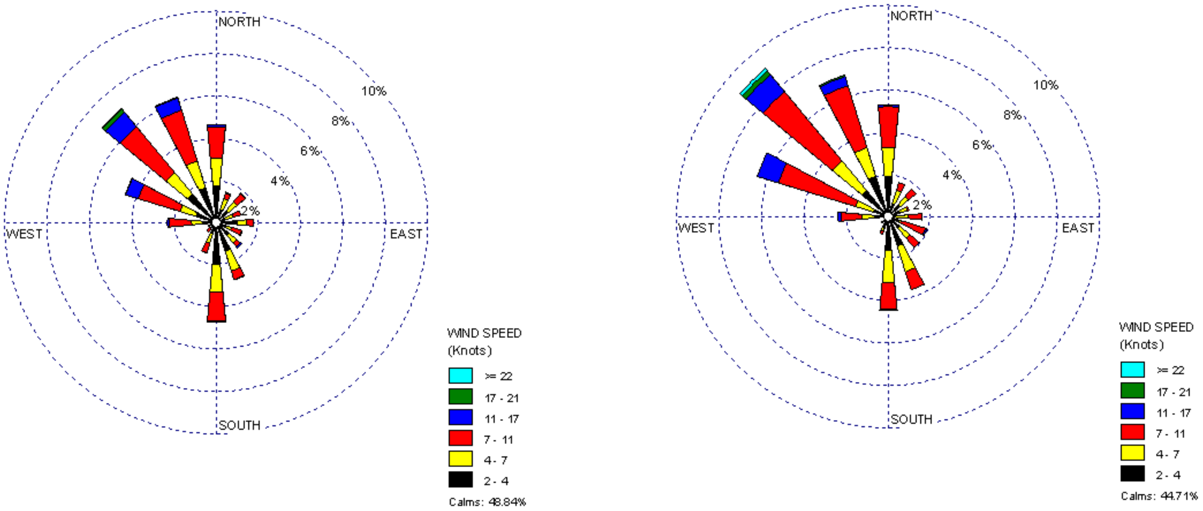
Figure 17-15 presents a map showing the distance between the NWS station and CHNJ, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 17-15 also presents three different wind roses for the CHNJ monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 17-16 through 17-18 present the distance maps and wind roses for ELNJ, NBNJ, and PANJ, respectively.

Figure 17-15. Wind Roses for the Summerville-Somerset Airport Weather Station near CHNJ



Distance between CHNJ and NWS Station

2001-2010 Historical Wind Rose

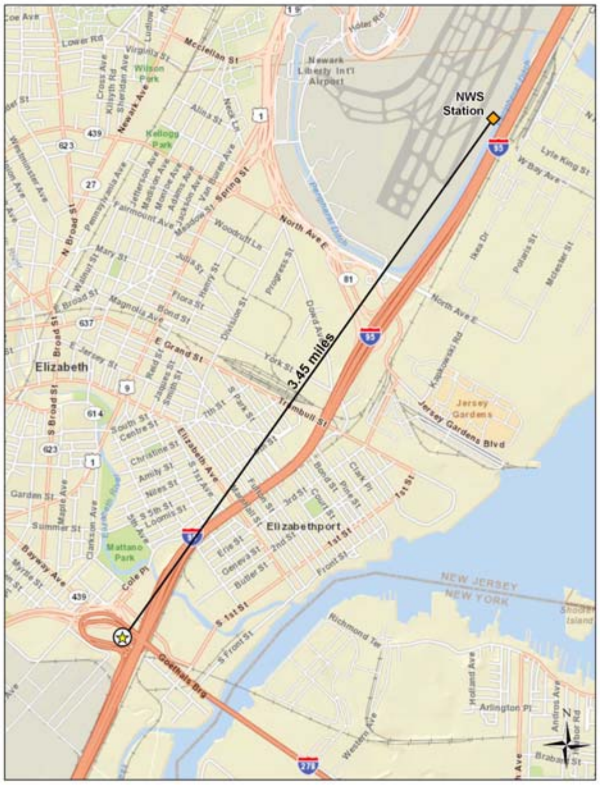


2011 Wind Rose

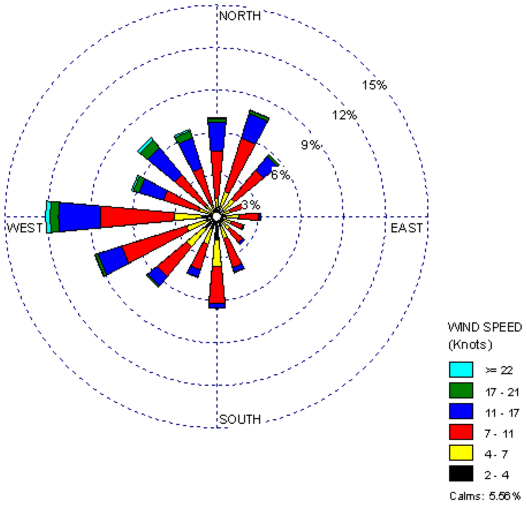
Sample Day Wind Rose

Figure 17-16. Wind Roses for the Newark International Airport Weather Station near ELNJ

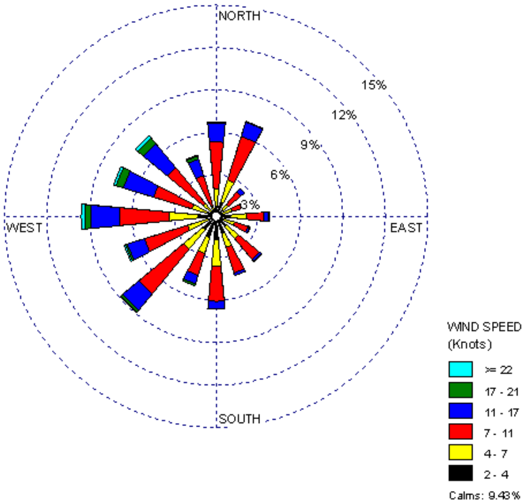
Distance between ELNJ and NWS Station



2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

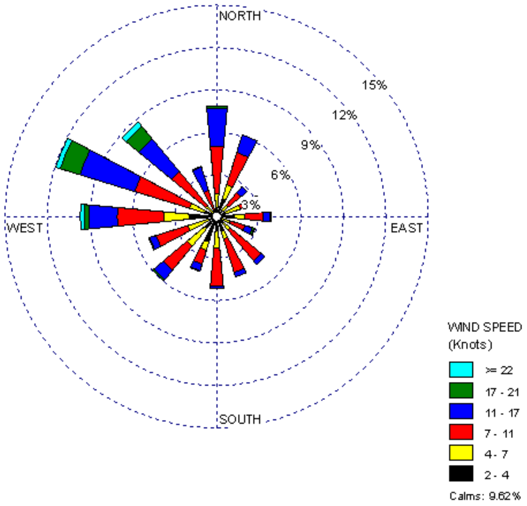
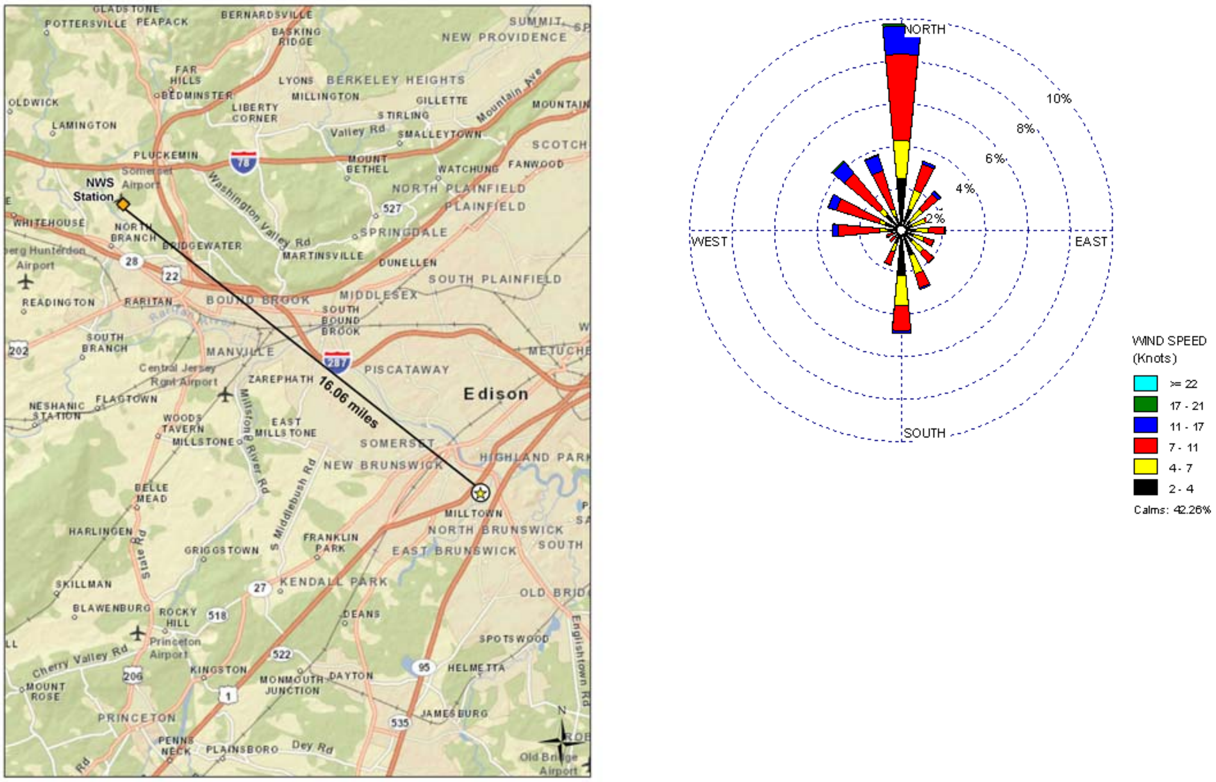


Figure 17-17. Wind Roses for the Summerville-Somerset Airport Weather Station near NBNJ

Distance between NBNJ and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

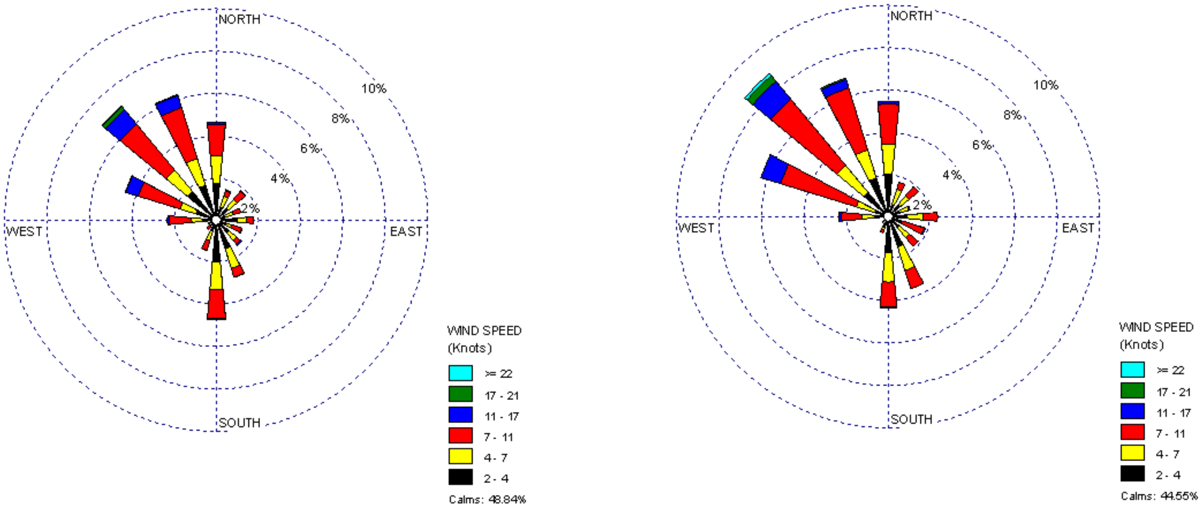
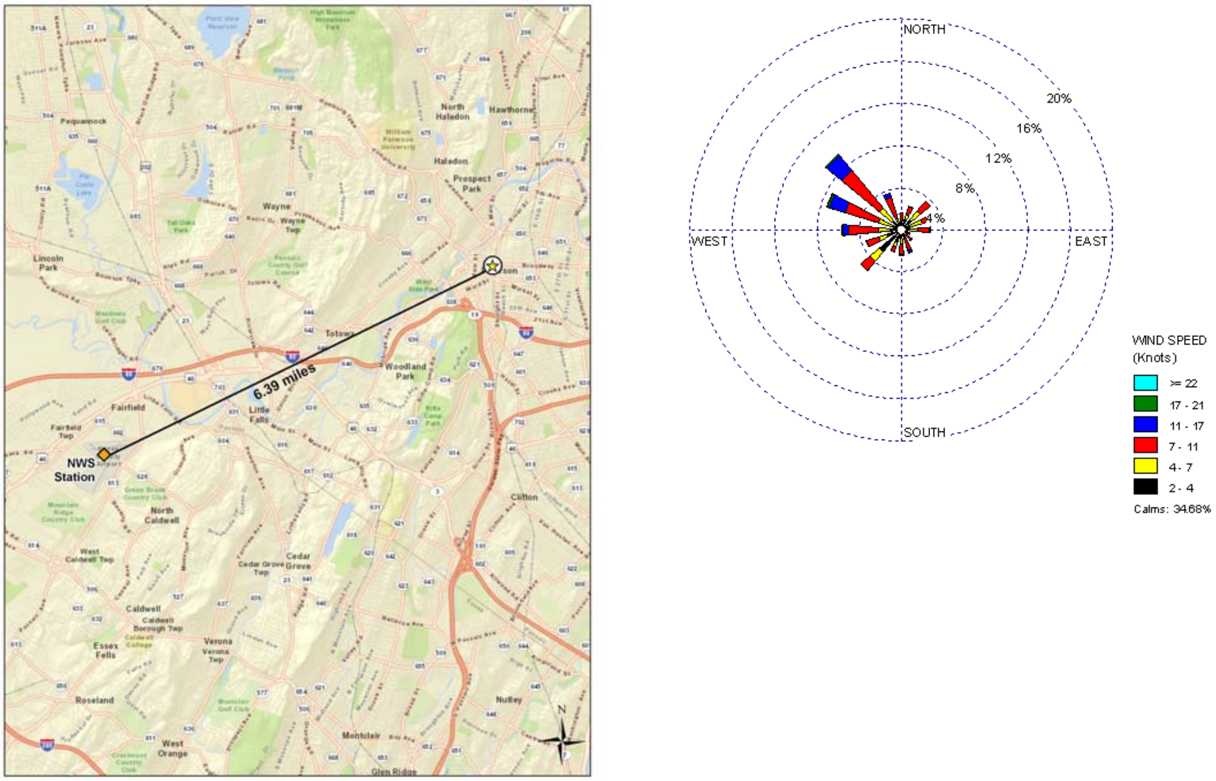
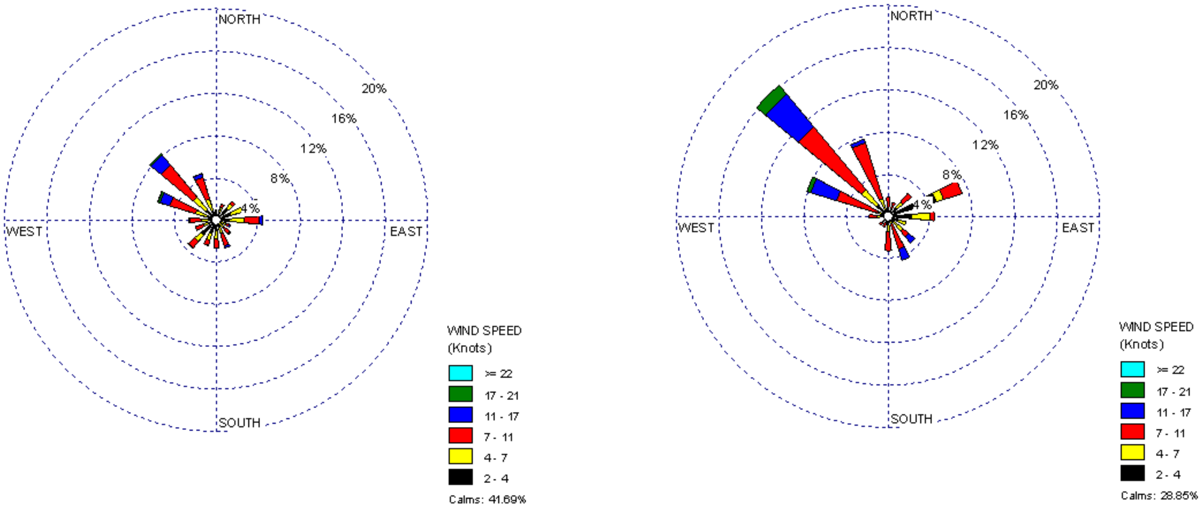


Figure 17-18. Wind Roses for the Essex County Airport Weather Station near PANJ



Distance between PANJ and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

Observations from Figures 17-15 and 17-17 for CHNJ and NBNJ include the following:

- The NWS weather station at Somerville/Somerset Airport is the closest weather station to both CHNJ and NBNJ. The Somerville/Somerset Airport weather station is located approximately 11.3 miles south-southeast of CHNJ and 16.1 miles west-northwest of NBNJ.

- The wind data for the historical and full-year wind roses for CHNJ and NBNJ are identical because they are from the same weather station.

- The historical wind roses for these sites show that calm winds accounted for greater than 40 percent of observations. For wind speeds greater than 2 knots, northerly winds were observed most frequently, accounting for nearly 10 percent of the observations, while winds from the southwest quadrant were rarely observed.

- Calm winds account nearly 50 percent of the wind observations throughout 2011. Winds from the northwest quadrant, including northerly winds, account for another one-quarter of wind observations throughout 2011.

- Wind patterns on sample day wind roses resemble the full-year wind patterns, with even more wind observations from the northwest quadrant. The similarities in the wind patterns indicate that conditions on sample days were similar to conditions experienced near these sites over the course of 2011.

- While the 2011 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 winds from the northwest quadrant. A similar observation was made for 2009 in the 2008-2009 NMP report and in the 2010 NMP report.

Observations from Figure 17-16 for ELNJ include the following:

- The Newark International Airport weather station is located approximately 3.5 miles north-northeast of ELNJ.

- The historical wind rose shows that winds from a variety of directions were observed near ELNJ, although easterly winds and winds from the southeast quadrant were observed infrequently. Calm winds were observed for less than six percent of observations. The strongest winds were associated with westerly and northwesterly winds.

- The wind patterns shown on the 2011 wind rose are similar to the historical wind patterns, although there are some differences. For instance, the calm rate for 2011 is higher than the historical calm rate. Westerly and west-southwesterly winds were slightly less prominent in 2011 compared to historical observations.

- The sample day wind rose has a similar calm rate as the 2011 full-year wind rose, but there are a number of differences as well. Winds from the southwest quadrant were observed less while winds from the west-northwest and northwest were observed more frequently on sample days.

Observations from Figure 17-18 for PANJ include the following:

- The Essex County Airport weather station is located approximately 6.4 miles southwest of PANJ.

- The historical wind rose shows that calm winds account for approximately one-third of the wind observations near PANJ. Winds from the western quadrants account for the majority of winds greater than 2 knots, particularly winds from the west-northwest and northwest. The strongest winds were associated with westerly to northwesterly winds.

- The 2011 wind rose shows that calm winds accounted for greater than 40 percent of wind observations in 2011 and that west-northwesterly to north-northwesterly winds account for the majority of wind observations greater than 2 knots. This represents a northward shift in the predominant wind direction compared to the historical wind rose.

- The sample day wind rose for PANJ exhibits several differences from the historical and full-year wind roses. The sample day wind rose has a lower percentage of calm winds. The percentage of northwesterly wind observations is double that shown in the full-year wind rose. There is also a higher percentage of winds from the east-northeast and fewer from the southwest quadrant. This wind rose likely reflects a seasonal pattern as it only includes sample days through May 2011 to correspond with the sample period.

17.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the New Jersey monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 17-4 presents the results of the preliminary risk-based screening process for the New Jersey sites. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. All three UATMP sites sampled for VOCs and carbonyl compounds while PANJ sampled for VOCs only.

Table 17-4. 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	61	61	100.00	17.68	17.68
Benzene	0.13	61	61	100.00	17.68	35.36
Carbon Tetrachloride	0.17	61	61	100.00	17.68	53.04
Formaldehyde	0.077	61	61	100.00	17.68	70.72
Acrylonitrile	0.015	35	35	100.00	10.14	80.87
1,3-Butadiene	0.03	24	31	77.42	6.96	87.83
1,2-Dichloroethane	0.038	19	19	100.00	5.51	93.33
Hexachloro-1,3-butadiene	0.045	6	6	100.00	1.74	95.07
p-Dichlorobenzene	0.091	5	25	20.00	1.45	96.52
1,1,2,2-Tetrachloroethane	0.017	5	5	100.00	1.45	97.97
Chloromethylbenzene	0.02	1	1	100.00	0.29	98.26
1,2-Dibromoethane	0.0017	1	1	100.00	0.29	98.55
Dichloromethane	7.7	1	61	1.64	0.29	98.84
Ethylbenzene	0.4	1	61	1.64	0.29	99.13
1,1,2-Trichloroethane	0.0625	1	1	100.00	0.29	99.42
Trichloroethylene	0.2	1	5	20.00	0.29	99.71
Xylenes	10	1	61	1.64	0.29	100.00
Total		345	556	62.05		
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	0.45	61	61	100.00	15.02	15.02
Benzene	0.13	61	61	100.00	15.02	30.05
Formaldehyde	0.077	61	61	100.00	15.02	45.07
Carbon Tetrachloride	0.17	60	61	98.36	14.78	59.85
1,3-Butadiene	0.03	59	59	100.00	14.53	74.38
Ethylbenzene	0.4	29	61	47.54	7.14	81.53
p-Dichlorobenzene	0.091	27	49	55.10	6.65	88.18
1,2-Dichloroethane	0.038	16	16	100.00	3.94	92.12
Acrylonitrile	0.015	11	11	100.00	2.71	94.83
Propionaldehyde	0.8	9	61	14.75	2.22	97.04
Hexachloro-1,3-butadiene	0.045	4	6	66.67	0.99	98.03
1,2-Dibromoethane	0.0017	3	3	100.00	0.74	98.77
Trichloroethylene	0.2	2	24	8.33	0.49	99.26

Table 17-4. Risk-Based Screening Results for the New Jersey Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Dichloromethane	7.7	1	61	1.64	0.25	99.51
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.25	99.75
Xylenes	10	1	61	1.64	0.25	100.00
Total		406	657	61.80		
New Brunswick, New Jersey - NBNJ						
Acetaldehyde	0.45	62	62	100.00	17.03	17.03
Formaldehyde	0.077	62	62	100.00	17.03	34.07
Benzene	0.13	58	58	100.00	15.93	50.00
Carbon Tetrachloride	0.17	57	58	98.28	15.66	65.66
1,3-Butadiene	0.03	39	42	92.86	10.71	76.37
Acrylonitrile	0.015	25	25	100.00	6.87	83.24
1,2-Dichloroethane	0.038	19	19	100.00	5.22	88.46
p-Dichlorobenzene	0.091	15	39	38.46	4.12	92.58
Hexachloro-1,3-butadiene	0.045	8	9	88.89	2.20	94.78
Ethylbenzene	0.4	7	58	12.07	1.92	96.70
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	1.10	97.80
1,2-Dibromoethane	0.0017	2	2	100.00	0.55	98.35
Bromomethane	0.5	1	37	2.70	0.27	98.63
Chloromethylbenzene	0.02	1	1	100.00	0.27	98.90
Dichloromethane	7.7	1	58	1.72	0.27	99.18
Propionaldehyde	0.8	1	62	1.61	0.27	99.45
1,1,2-Trichloroethane	0.0625	1	1	100.00	0.27	99.73
Xylenes	10	1	58	1.72	0.27	100.00
Total		364	655	55.57		
Paterson, New Jersey - PANJ						
Benzene	0.13	12	12	100.00	19.05	19.05
1,3-Butadiene	0.03	12	12	100.00	19.05	38.10
Carbon Tetrachloride	0.17	10	12	83.33	15.87	53.97
p-Dichlorobenzene	0.091	10	12	83.33	15.87	69.84
Ethylbenzene	0.4	9	12	75.00	14.29	84.13
1,2-Dibromoethane	0.0017	3	3	100.00	4.76	88.89
Acrylonitrile	0.015	2	2	100.00	3.17	92.06
1,2-Dichloroethane	0.038	2	2	100.00	3.17	95.24
Hexachloro-1,3-butadiene	0.045	2	2	100.00	3.17	98.41
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	1.59	100.00
Total		63	70	90.00		

Observations from Table 17-4 include the following:

- Seventeen pollutants failed at least one screen for CHNJ (including six NATTS MQO Core Analytes); 16 failed screens for ELNJ (including six NATTS MQO Core Analytes); 18 failed screens for NBNJ (including five NATTS MQO Core Analytes); and 10 failed screens for PANJ (including three NATTS MQO Core Analytes).

- The risk-based screening process identified eight pollutants of interest for CHNJ (of which five are NATTS MQO Core Analytes). Trichloroethylene was added as a pollutant of interest because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of failed screens. Chloroform, tetrachloroethylene, and vinyl chloride were added as pollutants of interest because they are also NATTS MQO Core Analytes, even though they did not fail any screens. These three pollutants are not shown in Table 17-4 but are shown in subsequent tables in the sections that follow.

- The risk-based screening process identified 10 pollutants of interest for ELNJ (of which five are NATTS MQO Core Analytes). Trichloroethylene was added as a pollutant of interest because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of failed screens. Chloroform, tetrachloroethylene, and vinyl chloride were also added because they are NATTS MQO Core Analytes, even though they did not fail any screens. These three pollutants are not shown in Table 17-4 but are shown in subsequent tables in the sections that follow.

- The risk-based screening process identified 10 pollutants of interest for NBNJ (of which five are NATTS MQO Core Analytes). Chloroform, tetrachloroethylene, trichloroethylene, and vinyl chloride were added as pollutants of interest because they are also NATTS MQO Core Analytes, even though they did not fail any screens. These four pollutants are not shown in Table 17-4 but are shown in subsequent tables in the sections that follow.

- The risk-based screening process identified nine pollutants of interest for PANJ (of which three are NATTS MQO Core Analytes). Chloroform, tetrachloroethylene, trichloroethylene, and vinyl chloride were added as pollutants of interest because they are also NATTS MQO Core Analytes, even though they did not fail any screens. These four pollutants are not shown in Table 17-4 but are shown in subsequent tables in the sections that follow.

- For CHNJ, many of the pollutants failed a single screen. This may indicate that the concentrations on a single day may be the cause. A review of the data shows that many of these failed screens were for the same sample day. The concentrations of dichloromethane, ethylbenzene, trichloroethylene, and xylenes all failed the screen for July 8, 2011. 1,2-Dibromoethane and 1,1,2-trichloroethane failed screen a single for May 27, 2011.

- The concentrations of dichloromethane, trichloroethylene, and xylenes all failed the screen for July 8, 2011 for ELNJ, which is the same date as several of the pollutants of interest for CHNJ. 1,2-Dibromoethane also failed the screen for May 27, 2011 for ELNJ.

- While there are no similarities in failed screens for NBNJ with CHNJ or ELNJ, there are some common sample days among the pollutants failing relatively few screens. Chloromethylbenzene, 1,2-dibromoethane, and 1,1,2-trichloroethane each failed the screen for November 2, 2011, as did 1,1,2,2-tetrachloroethane. Dichloromethane and xylenes each failed the screen for April 9, 2011.

- Many of the pollutants listed for PANJ failed screens on February 20, 2011; May 9, 2011; and May 15, 2011.

17.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the New Jersey monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for the New Jersey sites are provided in Appendices J and L.

17.4.1 2011 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 of 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 17-5, 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 17-5. 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 (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)
Chester, New Jersey - CHNJ						
Acetaldehyde	61/61	1.15 ± 0.21	1.82 ± 0.49	1.72 ± 0.43	1.76 ± 0.41	1.61 ± 0.20
Acrylonitrile	35/61	0.08 ± 0.03	0.12 ± 0.05	0.19 ± 0.17	0.03 ± 0.03	0.10 ± 0.05
Benzene	61/61	0.60 ± 0.08	0.44 ± 0.09	0.50 ± 0.22	0.57 ± 0.09	0.53 ± 0.07
1,3-Butadiene	31/61	0.02 ± 0.01	0.01 ± 0.01	0.03 ± 0.03	0.04 ± 0.01	0.02 ± 0.01
Carbon Tetrachloride	61/61	0.55 ± 0.04	0.62 ± 0.07	0.68 ± 0.08	0.65 ± 0.07	0.62 ± 0.03
Chloroform	50/61	0.08 ± 0.01	0.11 ± 0.03	0.13 ± 0.11	0.10 ± 0.02	0.10 ± 0.03
1,2-Dichloroethane	19/61	0.01 ± 0.01	0.03 ± 0.03	0.05 ± 0.07	0.05 ± 0.02	0.03 ± 0.02
Formaldehyde	61/61	0.75 ± 0.14	2.87 ± 1.48	4.16 ± 1.73	1.66 ± 0.21	2.37 ± 0.63
Hexachloro-1,3-butadiene	6/61	0.02 ± 0.02	0.02 ± 0.03	0.01 ± 0.01	0	0.01 ± 0.01
Tetrachloroethylene	40/61	0.08 ± 0.01	0.10 ± 0.06	0.12 ± 0.13	0.07 ± 0.03	0.09 ± 0.04
Trichloroethylene	5/61	0	0.01 ± 0.01	0.17 ± 0.34	<0.01 ± 0.01	0.05 ± 0.09
Vinyl Chloride	5/61	0	<0.01 ± <0.01	<0.01 ± 0.01	<0.01 ± <0.01	<0.01 ± <0.01
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	61/61	2.15 ± 0.40	3.44 ± 0.85	4.11 ± 0.78	3.28 ± 0.85	3.24 ± 0.39
Acrylonitrile	11/61	0.01 ± 0.02	0.10 ± 0.06	0	0.04 ± 0.08	0.04 ± 0.03
Benzene	61/61	0.92 ± 0.14	0.91 ± 0.20	1.18 ± 0.41	1.09 ± 0.28	1.03 ± 0.13
1,3-Butadiene	59/61	0.11 ± 0.03	0.12 ± 0.03	0.14 ± 0.03	0.17 ± 0.04	0.14 ± 0.02
Carbon Tetrachloride	61/61	0.50 ± 0.04	0.62 ± 0.06	0.67 ± 0.04	0.66 ± 0.10	0.61 ± 0.04
Chloroform	48/61	0.08 ± 0.02	0.18 ± 0.06	0.18 ± 0.09	0.12 ± 0.04	0.14 ± 0.03
p-Dichlorobenzene	49/61	0.06 ± 0.02	0.15 ± 0.08	0.11 ± 0.05	0.08 ± 0.03	0.10 ± 0.02
1,2-Dichloroethane	16/61	0.01 ± 0.02	0.03 ± 0.03	0.03 ± 0.04	0.04 ± 0.03	0.03 ± 0.01
Ethylbenzene	61/61	0.30 ± 0.06	0.46 ± 0.13	0.82 ± 0.62	0.45 ± 0.12	0.51 ± 0.16
Formaldehyde	61/61	2.06 ± 0.46	3.63 ± 1.06	4.70 ± 0.91	3.41 ± 0.62	3.45 ± 0.44

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

Table 17-5. 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 (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)
Propionaldehyde	61/61	0.28 ± 0.06	0.51 ± 0.14	0.67 ± 0.13	0.37 ± 0.09	0.45 ± 0.06
Tetrachloroethylene	56/61	0.14 ± 0.04	0.25 ± 0.09	0.24 ± 0.16	0.18 ± 0.05	0.20 ± 0.05
Trichloroethylene	24/61	0.03 ± 0.02	0.05 ± 0.04	0.27 ± 0.39	0.03 ± 0.02	0.09 ± 0.09
Vinyl Chloride	4/61	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
New Brunswick, New Jersey - NBNJ						
Acetaldehyde	62/62	2.38 ± 0.55	2.90 ± 0.70	2.74 ± 0.43	1.92 ± 0.34	2.49 ± 0.27
Acrylonitrile	25/58	0.08 ± 0.04	0.14 ± 0.06	0.17 ± 0.21	0.02 ± 0.03	0.09 ± 0.05
Benzene	58/58	0.84 ± 0.23	0.65 ± 0.27	0.51 ± 0.08	0.76 ± 0.17	0.70 ± 0.10
1,3-Butadiene	42/58	0.05 ± 0.03	0.03 ± 0.03	0.04 ± 0.02	0.08 ± 0.02	0.06 ± 0.01
Carbon Tetrachloride	58/58	0.45 ± 0.07	0.56 ± 0.09	0.69 ± 0.05	0.63 ± 0.08	0.59 ± 0.04
Chloroform	48/58	0.07 ± 0.03	0.17 ± 0.05	0.16 ± 0.06	0.11 ± 0.03	0.13 ± 0.02
p-Dichlorobenzene	39/58	0.04 ± 0.03	0.10 ± 0.06	0.07 ± 0.03	0.05 ± 0.02	0.06 ± 0.02
1,2-Dichloroethane	19/58	<0.01 ± 0.01	0.03 ± 0.04	<0.01 ± 0.01	0.06 ± 0.02	0.03 ± 0.01
Ethylbenzene	58/58	0.24 ± 0.04	1.22 ± 1.95	0.39 ± 0.14	0.28 ± 0.06	0.49 ± 0.39
Formaldehyde	62/62	1.41 ± 0.31	2.70 ± 2.05	4.94 ± 4.02	1.98 ± 1.29	2.71 ± 1.10
Hexachloro-1,3-butadiene	9/58	0.03 ± 0.03	0.02 ± 0.03	0.01 ± 0.01	0.01 ± 0.02	0.02 ± 0.01
Tetrachloroethylene	50/58	0.10 ± 0.03	0.16 ± 0.08	0.11 ± 0.04	0.13 ± 0.04	0.13 ± 0.02
Trichloroethylene	15/58	0.02 ± 0.02	0.03 ± 0.04	0.02 ± 0.03	0.02 ± 0.02	0.02 ± 0.01
Vinyl Chloride	7/58	0.01 ± 0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± 0.01	<0.01 ± <0.01
Paterson, New Jersey - PANJ						
Acrylonitrile	2/12	0	NA	NA	NA	NA
Benzene	12/12	1.20 ± 0.15	NA	NA	NA	NA
1,3-Butadiene	12/12	0.19 ± 0.02	NA	NA	NA	NA
Carbon Tetrachloride	12/12	0.42 ± 0.17	NA	NA	NA	NA

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

Table 17-5. 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 ($\mu g/m^3$)
Chloroform	5/12	0.05 ± 0.05	NA	NA	NA	NA
1,2-Dibromoethane	3/12	0.01 ± 0.03	NA	NA	NA	NA
p-Dichlorobenzene	12/12	0.13 ± 0.03	NA	NA	NA	NA
1,2-Dichloroethane	2/12	0	NA	NA	NA	NA
Ethylbenzene	12/12	0.42 ± 0.08	NA	NA	NA	NA
Hexachloro-1,3-butadiene	2/12	0.02 ± 0.04	NA	NA	NA	NA
Tetrachloroethylene	12/12	0.19 ± 0.06	NA	NA	NA	NA
Trichloroethylene	7/12	0.05 ± 0.03	NA	NA	NA	NA
Vinyl Chloride	3/12	<0.01 ± 0.01	NA	NA	NA	NA

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

Observations for CHNJ from Table 17-5 include the following:

- The pollutants of interest with the highest annual average concentrations by mass are formaldehyde, acetaldehyde, and carbon tetrachloride. Only the two carbonyl compounds have annual average concentrations greater than 1 $\mu g/m^3$.

- Concentrations of formaldehyde appear to be higher during the warmer months, based on the quarterly averages. The second and third quarter averages are higher than the other quarterly averages and have significantly large confidence intervals. A review of the data shows that the maximum formaldehyde concentration was measured on July 26, 2011 (15.45 $\mu g/m^3$). The 18 highest formaldehyde concentrations (those greater than 2.25 $\mu g/m^3$) were all measured between May and September. Conversely, of the 19 concentrations less than 1 $\mu g/m^3$, 17 were measured in the first quarter, one was measured in the second quarter, and one was measured in the fourth quarter.

- Concentrations of acrylonitrile appear highest during the third quarter of 2011, but the confidence interval for this average is nearly as high as the average itself. A review of the data shows that the maximum acrylonitrile concentration was measured on August 19, 2011 (1.37 $\mu g/m^3$) and is an order of magnitude higher than the next highest concentration (0.294 $\mu g/m^3$, measured on August 1, 2011). The three highest measurements of acrylonitrile were all measured in August.

- Several of the VOCs have third quarter average concentrations that are greater than the other quarterly average concentrations and/or have relatively large confidence intervals. For many of these, the maximum concentration was measured on July 8, 2011. And for most of these, the difference between the July 8, 2011 measurement and the next highest concentration is significant. For example, the benzene concentration on July 8, 2011 (2.07 µg/m^3) is twice the next highest concentration (1.01 µg/m^3, measured on December 5, 2011). As a second example, the tetrachloroethylene concentration measured on July 8, 2011 (1.09 µg/m^3) is nearly four times higher than the next highest concentration (0.299 µg/m^3, measured on May 3, 2011). This trend can also be seen in the data for 1,3-butadiene, chloroform, 1,2-dichloroethane, and trichloroethylene. This date was also discussed in Section 17.3.

Observations for ELNJ from Table 17-5 include the following:

- The pollutants of interest with the highest annual average concentrations by mass are formaldehyde, acetaldehyde, and benzene. These are the only pollutants with annual average concentrations greater than 1 µg/m^3.

- The concentrations of many of the pollutants of interest for ELNJ appear to be higher during the warmer months of the year, as illustrated by the quarterly average concentrations, particularly the carbonyl compounds. However, most of the differences are not statistically significant.

- Acrylonitrile was detected in only 11 samples collected at ELNJ and spanned an order of magnitude (0.0969 µg/m^3 to 0.605 µg/m^3). There were two measured detections during the first quarter, eight in the second quarter, none in the third quarter, and one in the fourth quarter, which happened to be the maximum concentration measured at ELNJ. Thus, the fourth quarter average was determined from one single measurement and 15 non-detects.

- The third quarter average ethylbenzene concentration is twice the other quarterly averages and has a relatively large confidence interval. A review of the data shows that the maximum concentration of ethylbenzene was measured on July 8, 2011 (5.00 µg/m^3) and is more than five times the next highest concentration (0.979 µg/m^3). Several of the VOCs were highest on July 8, 2011, including chloroform, 1,2-dichloroethane, tetrachloroethylene, and trichloroethylene.

Observations for NBNJ from Table 17-5 include the following:

- The pollutants of interest with the highest annual average concentrations by mass are formaldehyde, acetaldehyde, and benzene. Acetaldehyde and formaldehyde are the only pollutants with annual average concentrations greater than 1 µg/m^3.

- The second, third, and fourth quarter average concentrations of formaldehyde have relatively large confidence intervals associated with them relative to the averages themselves. Concentrations of formaldehyde measured at NBNJ range from 0.81 µg/m^3 to 27.7 µg/m^3. The maximum concentration of formaldehyde was measured at NBNJ on September 6, 2011 and is the maximum concentration measured across the program. Three additional formaldehyde concentrations greater than 10 µg/m^3 were measured at NBNJ, one each in the second, third, and fourth quarters of 2011.

- The confidence interval associated with third quarter average concentration of acrylonitrile is larger than the average itself, indicating that the concentration average is likely influenced by outliers. The maximum concentration of acrylonitrile is 1.34 µg/m^3 and was measured on September 24, 2011. This concentration is more than four times the next highest concentration measured at NBNJ (0.307 µg/m^3 measured on October 6, 2011). This pollutant was detected in less than half of the VOC samples collected and concentrations of acrylonitrile range from 0.083 µg/m^3 to 1.34 µg/m^3.

- The second quarter ethylbenzene concentration is more than three times the other quarterly averages and its confidence interval is greater than the average itself. A review of the data shows that the maximum concentration of ethylbenzene was measured at NBNJ on April 9, 2011 (11.5 µg/m^3). This measurement is more than 10 times the next highest concentration measured at NBNJ (1.07 µg/m^3) and is the highest concentration measured across the program. Several of the VOCs were highest on April 9, 2011, including 1,2-dichloroethane, *p*-dichlorobenzene, tetrachloroethylene, and trichloroethylene.

Observations for PANJ from Table 17-5 include the following:

- VOC sampling at PANJ ended in the middle of May 2011. Thus, only first quarter average concentrations could be calculated (second quarter concentrations were not calculated because there were not enough samples collected to meet the completeness criteria). However, Appendix J provides the pollutant-specific average concentration for all valid samples collected at PANJ over the entire sample period.

- Benzene is the pollutant with the highest first quarter average concentration for PANJ and is the only pollutant for which a first quarter average is greater than 1 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 New Jersey sites from those tables include the following:

- The New Jersey sites appear in Table 4-9 for VOCs a total of 23 times (CHNJ - 7; ELNJ - 8; and NBNJ - 8). At least one New Jersey site appears among the rankings for each of the program-level pollutants of interest and all three New Jersey sites appear for acrylonitrile, chloroform, 1,2-dichloroethane, and trichloroethylene.

- CHNJ has the highest annual average concentration of 1,2-dichloroethane among NMP sites sampling VOCs. The highest ranking for ELNJ is second for trichloroethylene; the highest ranking for NBNJ is second for vinyl chloride.

- The New Jersey sites appear in Table 4-10 for carbonyl compounds a total of three times. ELNJ and NBNJ have the highest and fifth highest annual average concentrations of acetaldehyde, respectively, while ELNJ has the eighth highest annual average concentration of formaldehyde.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde were created for CHNJ, ELNJ, and NBNJ. Box plots were not created for PANJ because annual averages could not be calculated for this site. Figures 17-19 through 17-22 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.

Figure 17-19. Program vs. Site-Specific Average Acetaldehyde Concentrations

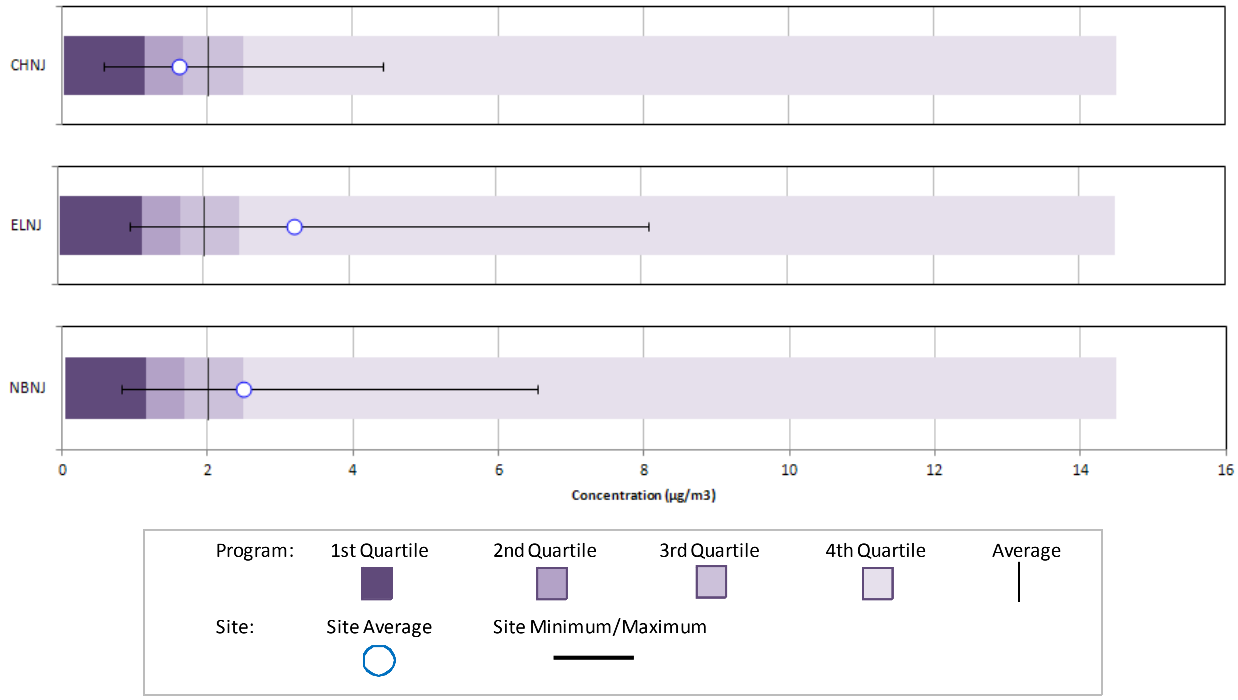


Figure 17-20. Program vs. Site-Specific Average Benzene Concentrations

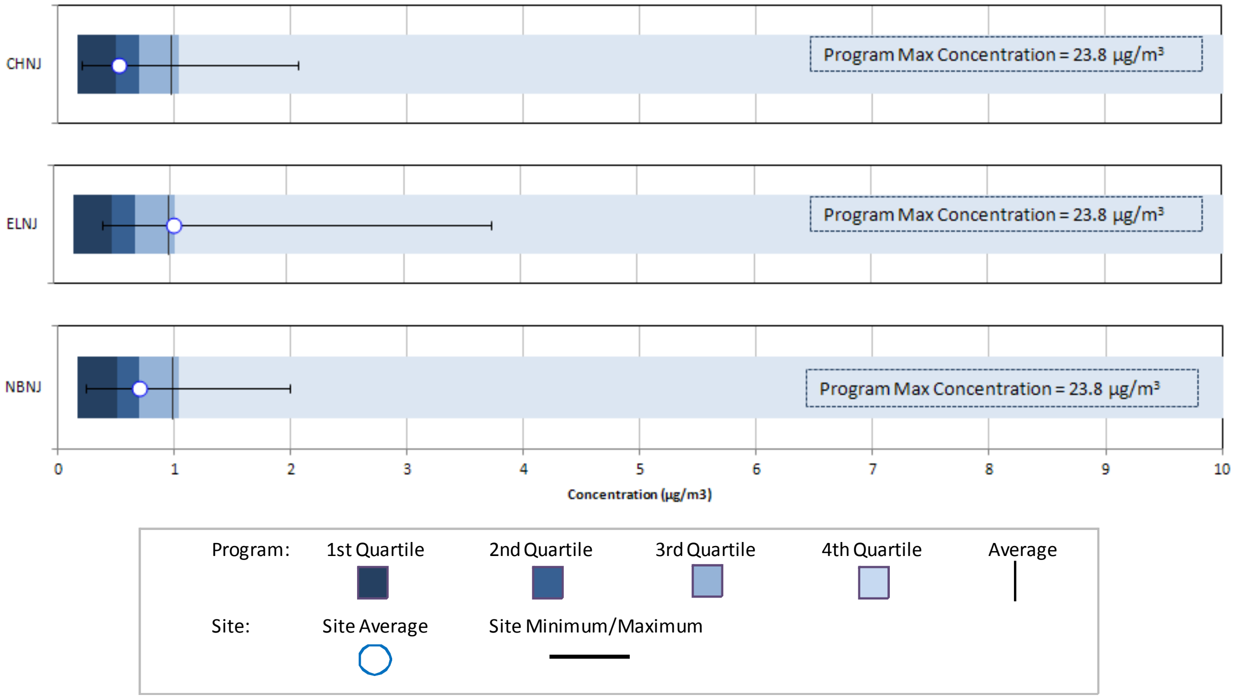


Figure 17-21. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

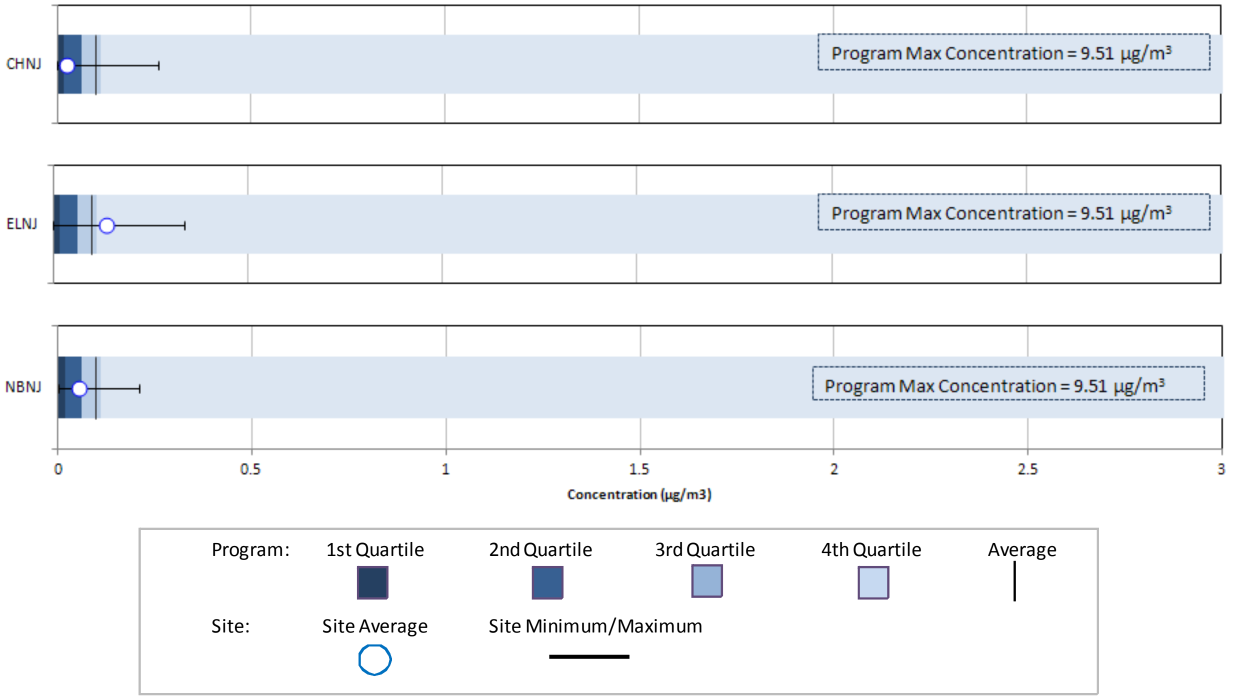
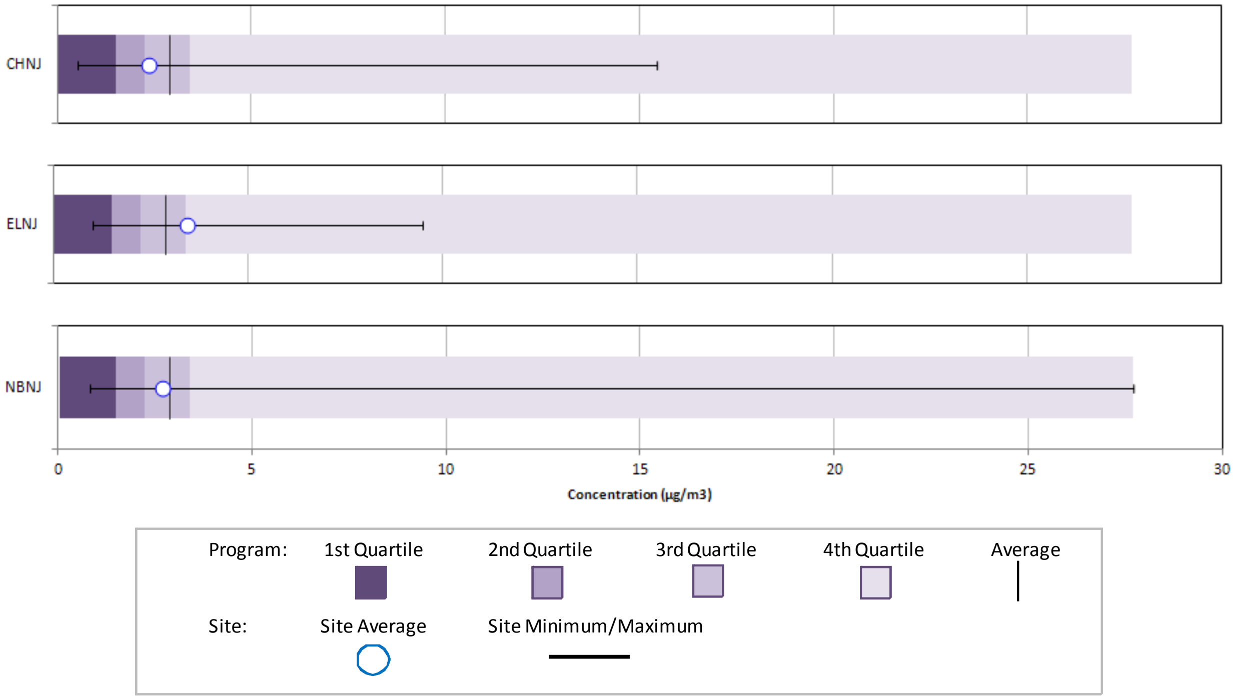


Figure 17-22. Program vs. Site-Specific Average Formaldehyde Concentrations



Observations from Figures 17-19 through 17-22 include the following:

- Figure 17-19 shows that while CHNJ's annual average acetaldehyde concentration is less than the program-level average concentration, the annual averages for ELNJ and NBNJ are greater than the program-level average concentration. In addition, the annual average for NBNJ is equivalent to the program-level third quartile while the annual average for ELNJ is greater than the program-level third quartile. The range of acetaldehyde measurements is greatest for ELNJ and least for CHNJ. There were no non-detects of acetaldehyde measured at the New Jersey sites or across the program.

- Figure 17-20 presents the box plots for benzene. Note that the program-level maximum concentration (23.8 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 has been reduced to 10 µg/m^3. This figure shows that the annual average benzene concentration for CHNJ is just greater than the program-level first quartile. This site has one of the lowest annual average benzene concentrations among sites sampling benzene. NBNJ's annual average benzene concentration is less the program-level average but equivalent to the program-level median concentration. The annual average concentration for ELNJ is just greater than the program-level average concentration. The range of concentrations measured for ELNJ is roughly twice the range measured at CHNJ and NBNJ. There were no non-detects of benzene measured at the New Jersey sites or across the program.

- Figure 17-21 presents the box plots for 1,3-butadiene. Similar to the benzene box plots, the program-level maximum concentration (9.51 µg/m^3) is not shown directly on the box plots as the scale has been reduced to 3 µg/m^3 to allow for the observation of data points at the lower end of the concentration range. The statistical metrics shown for each site follow a similar trend as the metrics on the benzene box plots. 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 median concentration. ELNJ's annual average concentration is greater than the program-level third quartile. The range of measurements was smallest for NBNJ and greatest for ELNJ. Non-detects were measured at all three sites, but the number of non-detects varied significantly. Approximately half of the 1,3-butadiene measurements at CHNJ were non-detects, approximately one-quarter of the measurements at NBNJ were non-detects, and two non-detects were measured at ELNJ.

- Figure 17-22 for formaldehyde shows that while the annual average concentrations of formaldehyde for CHNJ and NBNJ are less than the program-level average, the annual average for ELNJ is greater than the program-level average concentration. Even though the range of measurements for ELNJ is the smallest among the New Jersey sites, ELNJ has the highest annual average concentration of formaldehyde among the three sites. Although the maximum formaldehyde concentration measured across the program was measured at NBNJ, this site's annual average ranked 13th among NMP sites sampling carbonyl compounds. By comparison, ELNJ ranked 8th and CHNJ 16th. There were no non-detects of formaldehyde measured at the New Jersey sites or across the program.

17.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. 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 17-23 through 17-34 present the annual statistical metrics for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde for CHNJ, ELNJ, and NBNJ, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. Because sampling at PANJ is being conducted for a one-year period ending in May 2011, a trends analysis could not be performed.

Figure 17-23. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at CHNJ

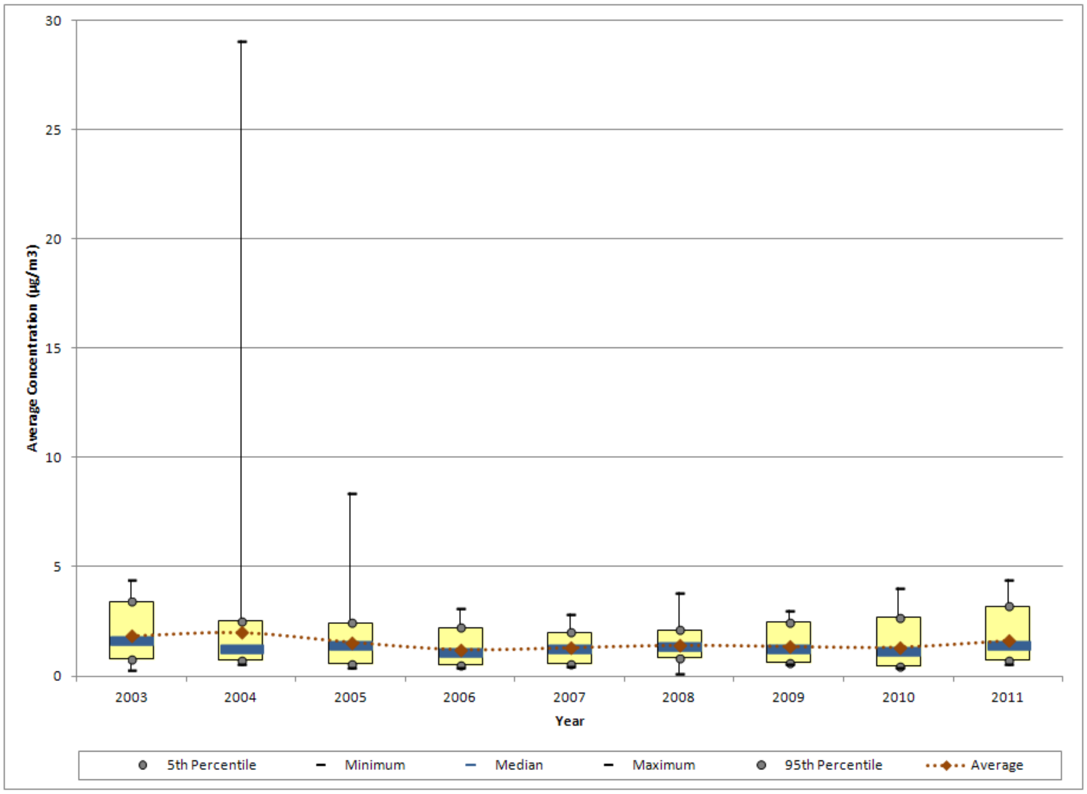


Figure 17-24. Annual Statistical Metrics for Benzene Concentrations Measured at CHNJ

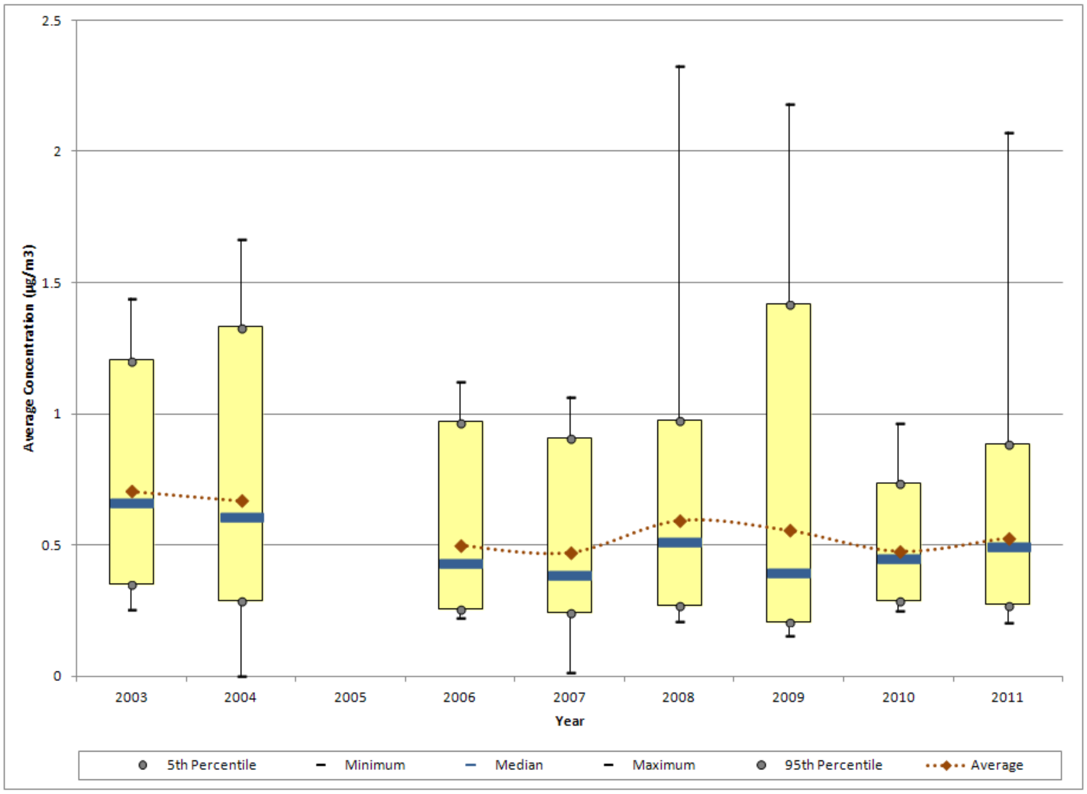


Figure 17-25. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at CHNJ

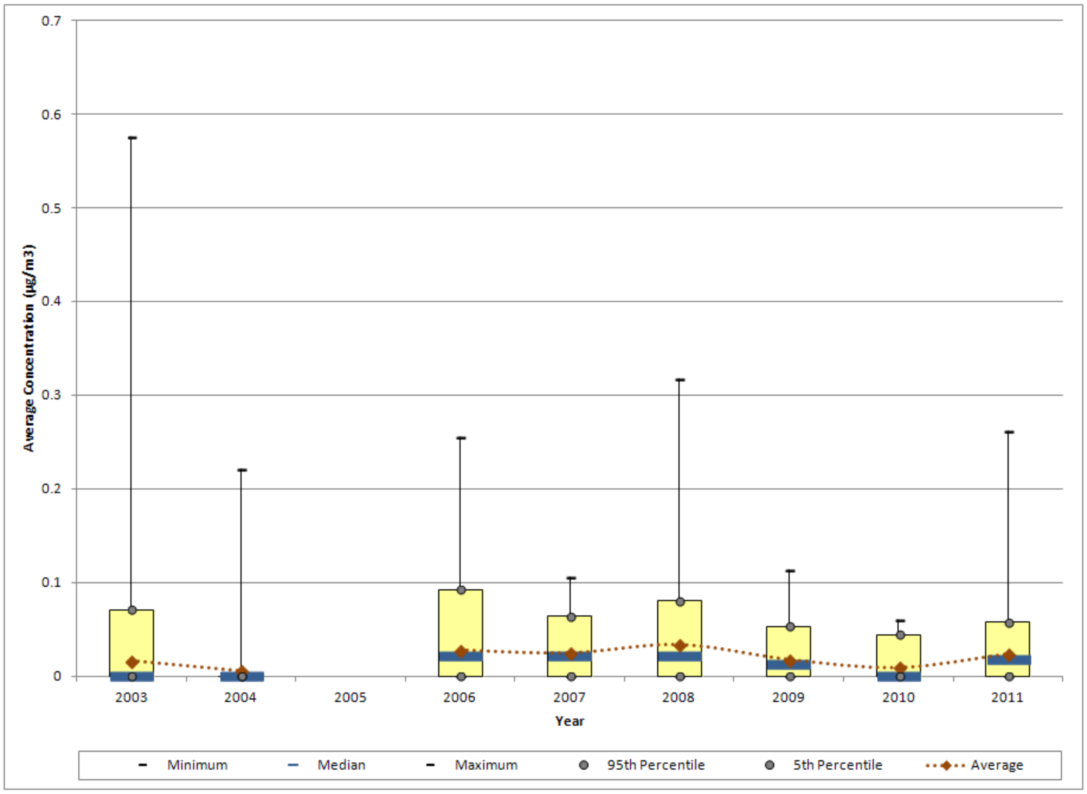


Figure 17-26. Annual Statistical Metrics for Formaldehyde Concentrations Measured at CHNJ

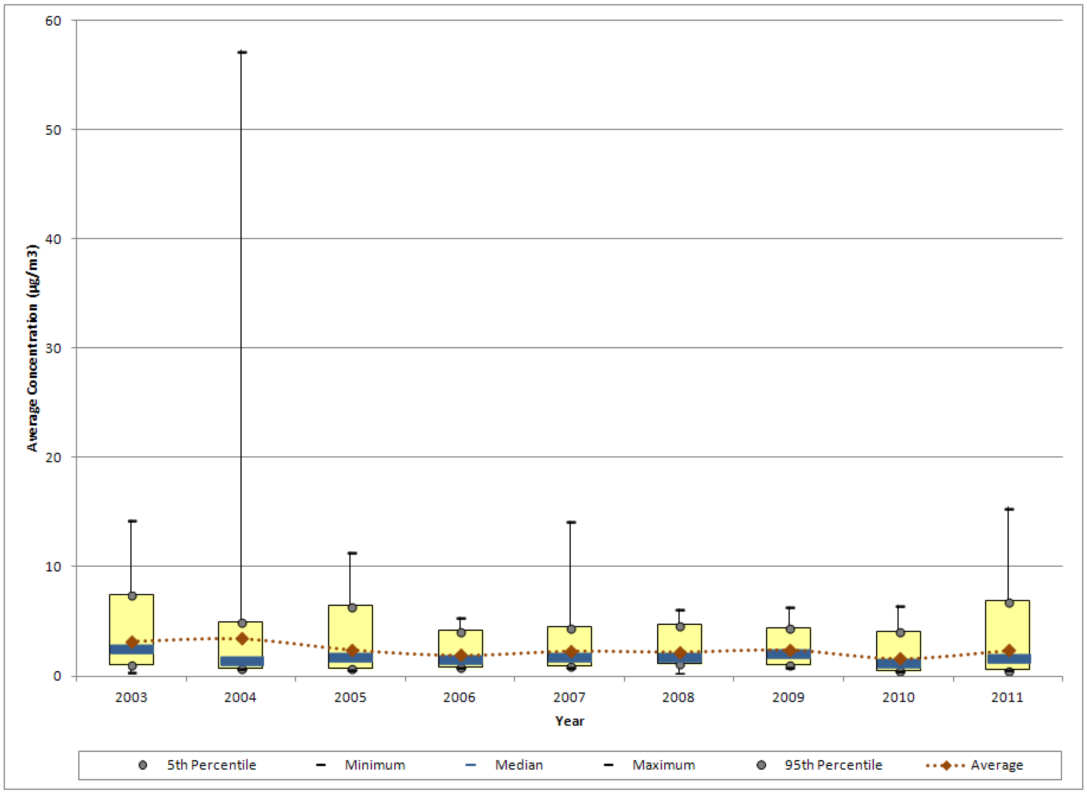


Figure 17-27. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at ELNJ

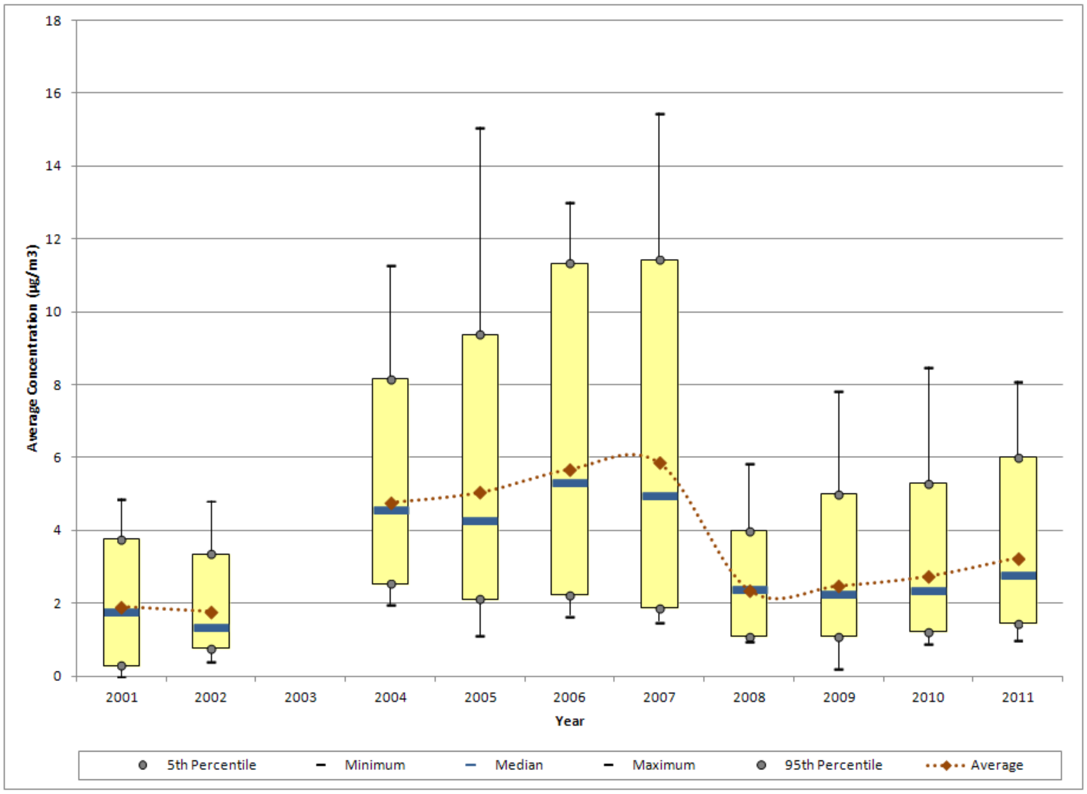
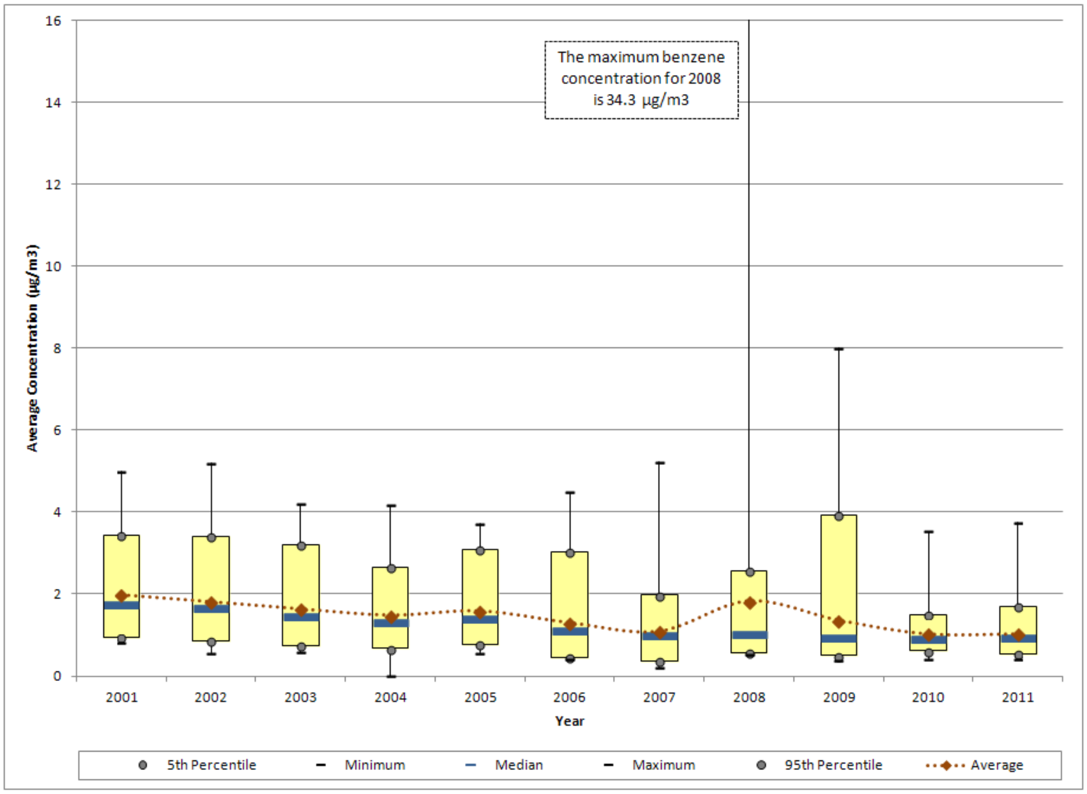


Figure 17-28. Annual Statistical Metrics for Benzene Concentrations Measured at ELNJ



The maximum benzene concentration for 2008 is 34.3 µg/m3

Figure 17-29. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at ELNJ

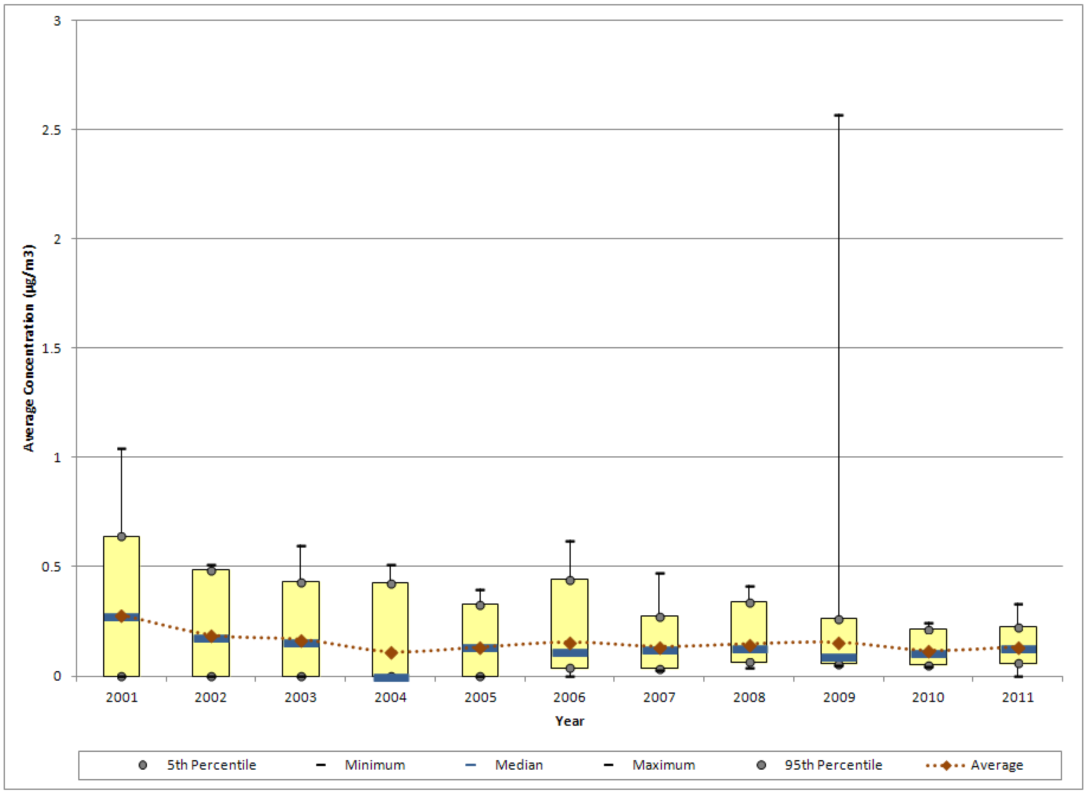


Figure 17-30. Annual Statistical Metrics for Formaldehyde Concentrations Measured at ELNJ

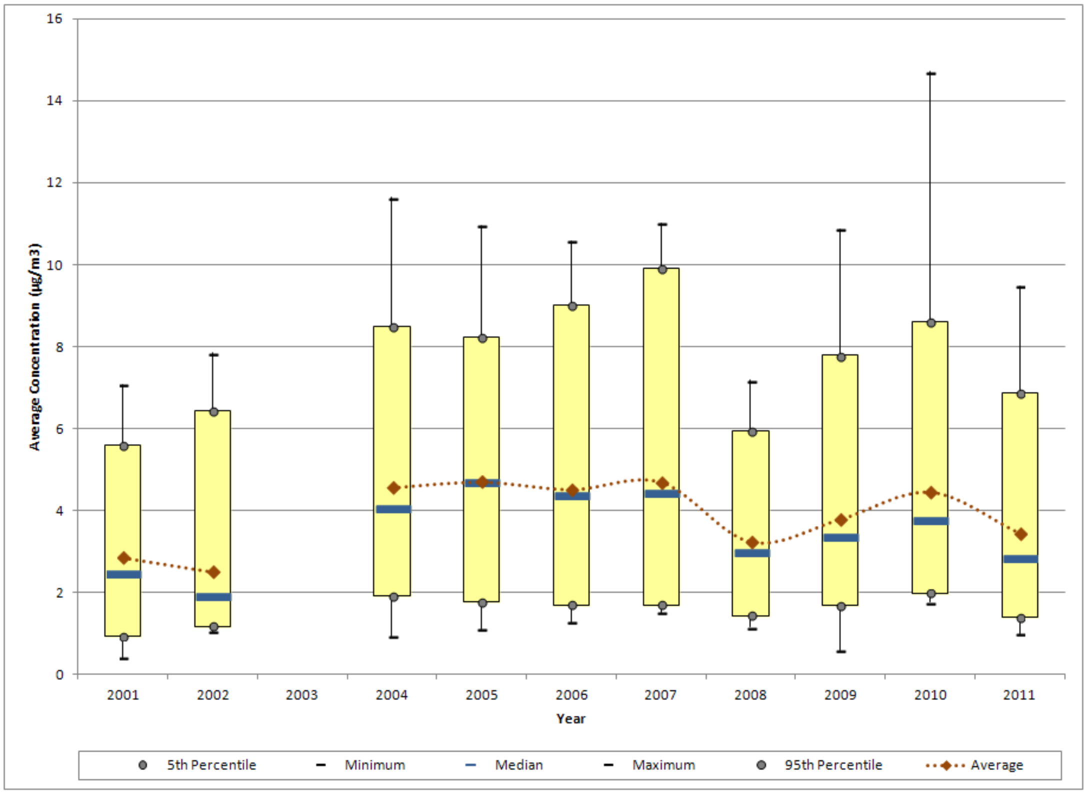


Figure 17-31. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at NBNJ

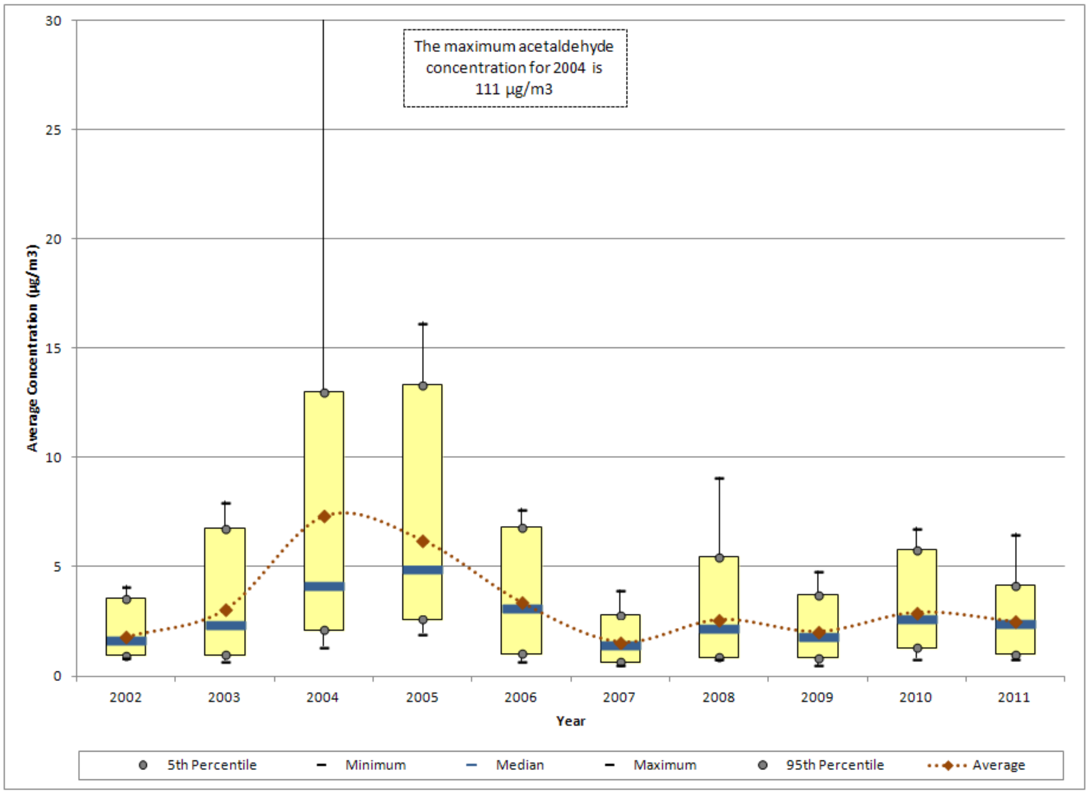


Figure 17-32. Annual Statistical Metrics for Benzene Concentrations Measured at NBNJ

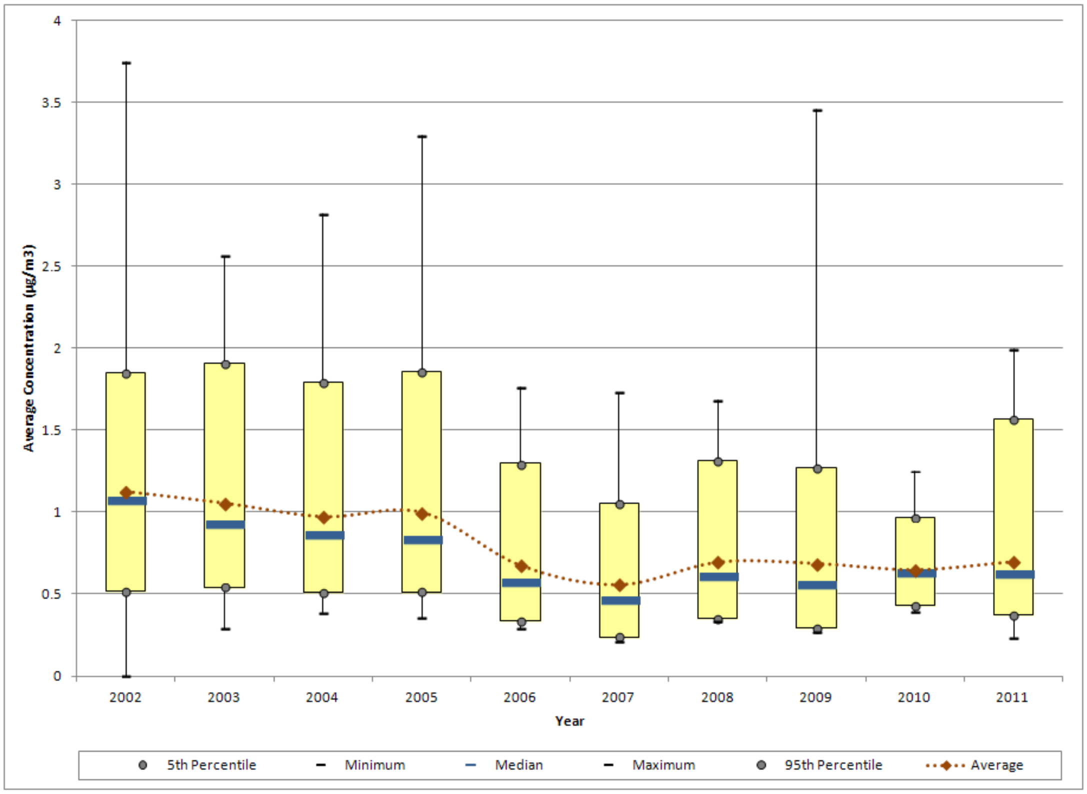


Figure 17-33. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at NBNJ

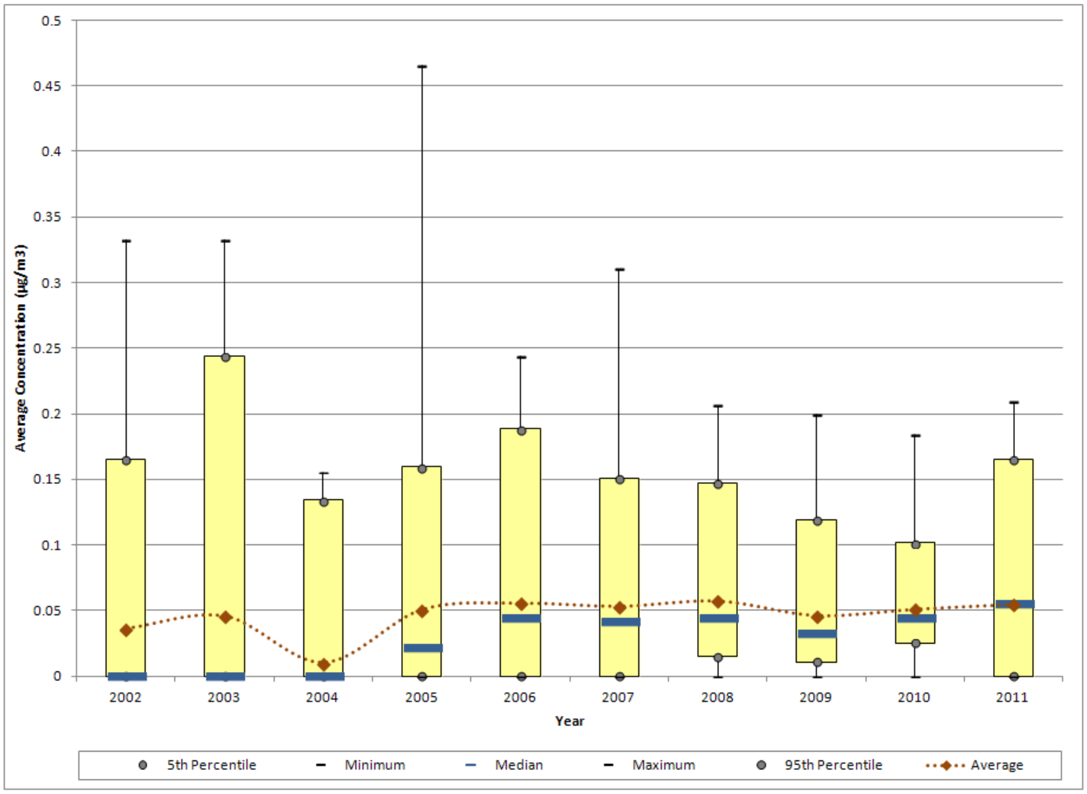
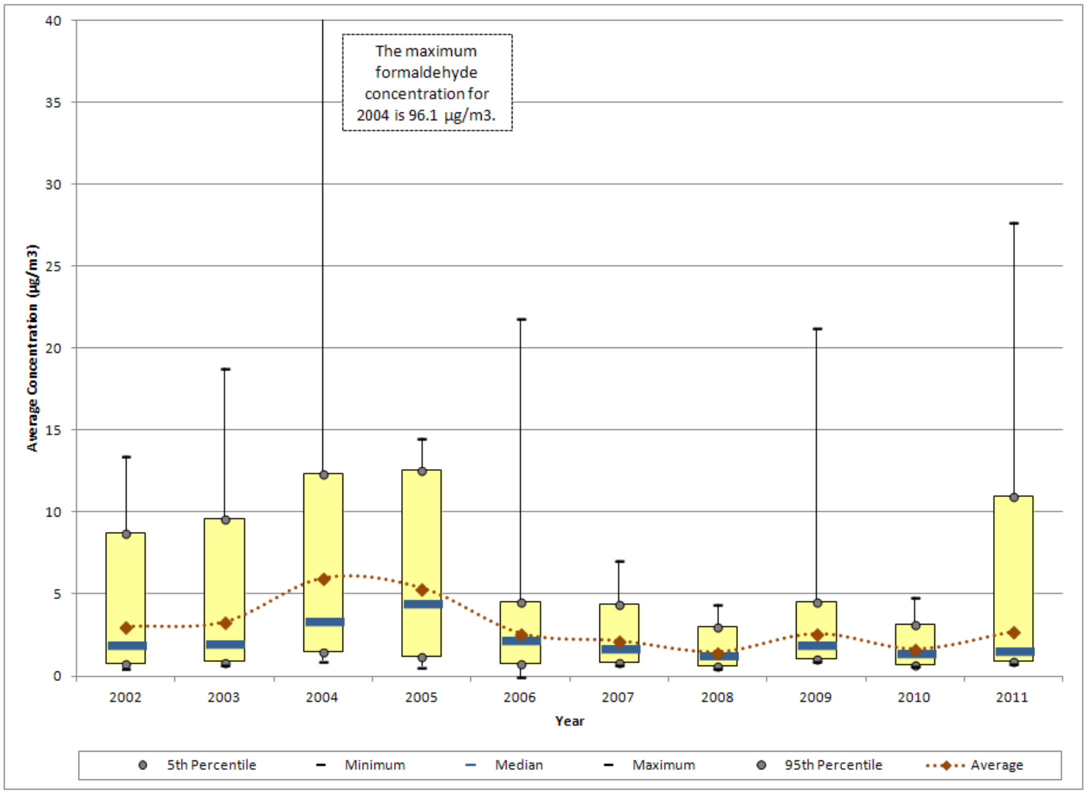


Figure 17-34. Annual Statistical Metrics for Formaldehyde Concentrations Measured at NBNJ


The maximum formaldehyde concentration for 2004 is 96.1 µg/m3.

Observations from Figure 17-23 for acetaldehyde measurements at CHNJ include the following:

- Although carbonyl compound sampling at CHNJ began in 2001, sampling did not begin until May, which does not yield enough samples for the statistical metrics to be calculated for 2001, based on the criteria specified in Section 3.5.4. In addition, data from 2002 are not provided due to a completeness less than 85 percent in 2002. Thus, Figure 17-23 begins with 2003.

- The maximum acetaldehyde concentration was measured in 2004. The second and third highest concentrations were measured in 2004 and 2005; excluding these three concentrations, all other acetaldehyde concentrations measured at CHNJ were less than 5 µg/m^3.

- Although difficult to discern in Figure 17-23, a decreasing trend in the average and median acetaldehyde concentrations is shown though 2006, after which the median and average concentrations leveled out until 2011, when an increase is noted. However, the high concentrations measured in 2004 and 2005 result in confidence intervals that are relatively large and indicate that these changes are not statistically significant.

- All the statistical metrics calculated exhibit an increase from 2010 to 2011.

- There have been no non-detects of acetaldehyde measured at CHNJ over the period shown.

Observations from Figure 17-24 for benzene measurements at CHNJ include the following:

- Similar to carbonyl compounds, VOC sampling at CHNJ began in 2001. However, sampling did not begin until May, which does not yield enough samples for the statistical metrics to be calculated for 2001, based on the criteria specified in Section 3.5.4. In addition, data from 2002 and 2005 are not provided due to a completeness less than 85 percent for those years.

- Only six benzene concentrations greater than 2 µg/m^3 have been measured at CHNJ during the years shown. Two were measured in 2008, three in 2009, and one in 2011.

- The average and median concentrations exhibit a decreasing trend through 2007, although no data is shown for 2005. Even though an increase in the average concentration is shown from 2007 to 2008, confidence intervals calculated indicate that the changes are not statistically significant. Since 2006, the average concentration has ranged from 0.47 µg/m^3 (2007) to 0.59 µg/m^3 (2008).

Observations from Figure 17-25 for 1,3-butadiene measurements at CHNJ include the following:

- The maximum 1,3-butadiene concentration shown was measured in 2003 and is nearly twice the next highest concentration, which was measured in 2008. The third highest concentration was measured in 2011. Only five concentrations measured at CHNJ are greater than 0.2 µg/m^3.

- For 2003 and 2004, the minimum, first quarter, and median concentrations are all zero. This is because 88 percent of the measurements were non-detects for 2003 and 96 percent were non-detects for 2004. The percentage of non-detects decreased to less than 40 percent for 2006; this decrease continued, reaching a minimum in 2008, after which an increasing number of non-detects was reported. For 2010, the median was again zero, indicating that at least 50 percent of the measurements were non-detects.

- The average and median concentrations have a decreasing trend from 2008 through 2010. All of the statistical metrics exhibit an increase for 2011.

Observations from Figure 17-26 for formaldehyde measurements at CHNJ include the following:

- The statistical metrics presented for formaldehyde mimic those for acetaldehyde in Figure 17-23 in regards to trending.

- The maximum formaldehyde concentration was measured in 2004. This concentration of formaldehyde is nearly four times the maximum concentrations shown for other periods excluding 2004. The second highest concentration was also measured in 2004, but was nearly half the magnitude. These two maximum concentrations were measured on the same days as the maximum acetaldehyde concentrations. The third highest concentration of formaldehyde was measured in 2011, although similar concentrations were also measured in 2003 and 2007.

- Although difficult to discern in Figure 17-26, a decreasing trend in the average and median formaldehyde concentrations is shown though 2006, after which the median and average concentrations leveled out until 2010, when the average concentration reached a minimum. The average concentration then increased for 2011. However, the high concentrations measured in 2004 result in confidence intervals that are relatively large, making the identification of trends difficult.

- 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.

- There have been no non-detects of formaldehyde measured at CHNJ over the period shown.

Observations from Figure 17-27 for acetaldehyde measurements at ELNJ include the following:

- ELNJ is the longest running UATMP site. Carbonyl compound sampling at ELNJ began in January 2000. However, sporadic sampling at the beginning of 2000 combined with a 1-in-12 day sampling schedule led to a completeness less than 85 percent. Thus, Figure 17-27 begins with 2001. Completeness was also low in 2003 due to a 1-month period when samples were not collected in January 2003; thus, no 2003 data are presented in Figure 17-27.

- The maximum acetaldehyde concentration shown 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 average concentration of acetaldehyde has a steadily increasing trend through 2007, after which a significant decrease is exhibited. Although an increasing trend is also shown between 2008 and 2011, these averages are roughly half the magnitude of those shown before 2008.

- There have been no non-detects of acetaldehyde measured at ELNJ over the period shown.

Observations from Figure 17-28 for benzene measurements at ELNJ include the following:

- VOC sampling at ELNJ began in January 2000. However, sporadic sampling at the beginning of 2000 combined with a 1-in-12 day sampling schedule led to a completeness less than 85 percent. Thus, Figure 17-28 also begins with 2001.

- 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. Only five benzene concentrations greater than 5 µg/m^3 have been measured at ELNJ.

- A decreasing trend in the average and median concentrations is shown through 2007. With the exception of the median concentration, all of the statistical parameters exhibit an increase for 2008. If the maximum concentration for 2008 was removed from the data set, the average concentration would exhibit a negligible increase for 2008. Thus, it is this single concentration that is driving the average concentration. The median concentration is influenced less by outliers, as this statistical parameter represents the midpoint, or 50th percentile, of a data set. That the median did not change between 2007 and 2008 is further proof that this single outlier is driving the average concentration upward.

- Even though some of the highest concentrations were measured in 2009, as indicated by the maximum and 95th percentile, the average concentration decreased from 2008 to 2009, likely a result of the sheer magnitude of the outlier affecting the 2008 calculations.

- Figure 17-28 shows that benzene concentrations for 2010 and 2011 returned to levels similar to 2007.

Observations from Figure 17-29 for 1,3-butadiene measurements 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 two concentrations are the only concentrations of 1,3-butadiene measured at ELNJ greater than 1 µg/m^3.

- Figure 17-29 shows a decreasing trend in the average concentration through 2004, then a leveling off of average concentrations that continues through the 2011. Even with the higher concentration measured in 2009, the average concentration for 2009 is similar to the average concentration for 2008. Between 2004 and 2011, the average concentration has ranged from 0.11 µg/m^3 (2004) to 0.16 µg/m^3 (2009).

- Even with the maximum concentration measured in 2009, the difference between the 5th and 95th percentiles has been decreasing since the onset of sampling, reaching a minimum in 2011. This indicates an overall decrease in the majority of concentrations measured at ELNJ.

Observations from Figure 17-30 for formaldehyde measurements at ELNJ include the following:

- The maximum formaldehyde concentration shown was measured in 2010, as was the second highest concentration. A total of 11 concentrations greater than 10 µg/m^3 have been measured at ELNJ.

- Figure 17-30 shows that there was an increase in formaldehyde concentrations from 2002 to 2004, although there is no data shown for 2003. Between 2004 and 2007, there was relatively little change in the average formaldehyde concentration. Similar to acetaldehyde, the average concentration of formaldehyde decreased significantly between 2007 and 2008, after which an increasing trend is shown. While the trends graph for acetaldehyde shows a continued increase for 2011, the average formaldehyde concentration decreased for 2011.

Observations from Figure 17-31 for acetaldehyde measurements at NBNJ include the following:

- Although carbonyl compound sampling at NBNJ began in 2001, sampling did not begin until May, which does not yield enough samples for the statistical metrics to be calculated for 2001, based on the criteria specified in Section 3.5.4. Thus, Figure 17-31 begins with 2002.

- 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 in 2004 or 2005 (and the other was measured in 2008). This, along with the outlier concentration measured in 2004, explains the significant increase in the statistical metrics from 2003 to 2004. Even without an outlier for 2005, most of the statistical metrics for 2005 exhibit slight increases from 2004 levels. The average, however, does not. If the outlier was removed from the data set for 2004, the average concentration for 2004 would be slightly less than the average concentration for 2005.

- The average concentration decreases significantly from 2005 to 2006 and reaches a minimum for 2007, as do all of the other statistical parameters. After 2007, the average concentration fluctuates between 2 µg/m^3 and 3 µg/m^3.

- There have been no non-detects of acetaldehyde measured at NBNJ.

Observations from Figure 17-32 for benzene measurements at NBNJ include the following:

- VOC sampling at NBNJ also began in May 2001. Because seven months of sampling does not yield enough samples for the statistical metrics to be calculated for 2001, based on the criteria specified in Section 3.5.4, Figure 17-32 also begins with 2002.

- The maximum benzene concentration was measured in 2002, but similar concentrations were also measured in 2005 and 2009. These are the only three concentrations of benzene greater than 3 µg/m^3 measured at NBNJ.

- Although a slight decreasing trend is shown between 2002 and 2004, a significant decrease is shown between 2005 and 2007, where several of the statistical parameters reached a minimum. The average concentration increased slightly for 2008, after which little change is observed. The average concentration ranges from 0.65 µg/m^3 (2010) to 0.70 µg/m^3 (2011) between 2008 and 2011.

Observations from Figure 17-33 for 1,3-butadiene measurements at NBNJ include the following:

- The maximum 1,3-butadiene concentration was measured in 2005 and is the only measurement greater than 0.35 µg/m^3 measured at NBNJ.

- The minimum, 5th percentile, and median concentrations are all zero for 2002 through 2004. This indicates that at least 50 percent of the measurements were non-detects for these years. The number of non-detects began to decrease in 2005 (47 percent) and reached a minimum in 2008 (2 percent). The number of non-detects increased to 29 percent for 2011. The increase in non-detects for 2011 is evident, at least in part, from the decrease in the 5th percentile shown from 2010 to 2011.

- The average concentration of 1,3-butadiene at NBNJ 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 greater than 90 percent from 2003 to 2004. Thus, many zeros were substituted into this average. Conversely, the increase in the average concentration shown from 2004 to 2005 results from a combination of fewer non-detects and a larger range of measurements. The average concentration of 1,3-butadiene after 2004 exhibits little change and ranges from 0.046 µg/m^3 (2009) to 0.057 µg/m^3 (2008).

Observations from Figure 17-34 for formaldehyde measurements at NBNJ include the following:

- The maximum formaldehyde concentration (96.1 µg/m^3) was measured 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 in 2004, 2006, 2009, and 2011.

- Similar to acetaldehyde, several of the statistical metrics exhibit increases from 2003 to 2004. Also similar to acetaldehyde, while the average concentration decreased from 2004 to 2005, many of the other statistical metrics did not, indicating that concentrations on a whole were higher in 2005 and not just influenced by outlier(s).

- After 2005, concentrations of formaldehyde decreased steadily, reaching a minimum in 2008. This year also had the smallest range of formaldehyde measurements. After 2008, the average concentration fluctuated. Although the average concentration for 2011 is not statistically different than the average concentrations for the last few years of sampling, the 95th percentile for 2011 increased significantly, doubling or tripling compared to previous years. This indicates that more of the measurements are falling into a higher range than in previous years.

17.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

17.5.2 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
Chester, New Jersey - CHNJ						
Acetaldehyde	0.0000022	0.009	61/61	1.61 ± 0.20	3.55	0.18
Acrylonitrile	0.000068	0.002	35/61	0.10 ± 0.05	7.13	0.05
Benzene	0.0000078	0.03	61/61	0.53 ± 0.07	4.12	0.02
1,3-Butadiene	0.00003	0.002	31/61	0.02 ± 0.01	0.71	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.62 ± 0.03	3.74	0.01
Chloroform	--	0.098	50/61	0.10 ± 0.03	--	<0.01
1,2-Dichloroethane	0.000026	2.4	19/61	0.03 ± 0.02	0.88	<0.01
Formaldehyde	0.000013	0.0098	61/61	2.37 ± 0.63	30.80	0.24
Hexachloro-1,3-butadiene	0.000022	0.09	6/61	0.01 ± 0.01	0.24	<0.01
Tetrachloroethylene	0.00000026	0.04	40/61	0.09 ± 0.04	0.02	<0.01
Trichloroethylene	0.0000048	0.002	5/61	0.05 ± 0.09	0.23	0.02
Vinyl Chloride	0.0000088	0.1	5/61	<0.01 ± <0.01	0.02	<0.01
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	0.0000022	0.009	61/61	3.24 ± 0.39	7.14	0.36
Acrylonitrile	0.000068	0.002	11/61	0.04 ± 0.03	2.50	0.02
Benzene	0.0000078	0.03	61/61	1.03 ± 0.13	8.00	0.03
1,3-Butadiene	0.00003	0.002	59/61	0.14 ± 0.02	4.05	0.07
Carbon Tetrachloride	0.000006	0.1	61/61	0.61 ± 0.04	3.68	0.01
Chloroform	--	0.098	48/61	0.14 ± 0.03	--	<0.01
p-Dichlorobenzene	0.000011	0.8	49/61	0.10 ± 0.02	1.10	<0.01
1,2-Dichloroethane	0.000026	2.4	16/61	0.03 ± 0.01	0.73	<0.01
Ethylbenzene	0.0000025	1	61/61	0.51 ± 0.16	1.27	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.45 ± 0.44	44.84	0.35

NA = Not available due to the criteria for calculating an annual average
-- = a Cancer URE or Noncancer RfC is not available

Table 17-6. Risk Approximations for the New Jersey 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 Hazard Approximation (HQ)
Propionaldehyde	--	0.008	61/61	0.45 ± 0.06	--	0.06
Tetrachloroethylene	0.00000026	0.04	56/61	0.20 ± 0.05	0.05	0.01
Trichloroethylene	0.0000048	0.002	24/61	0.09 ± 0.09	0.45	0.05
Vinyl Chloride	0.0000088	0.1	4/61	<0.01 ± <0.01	0.01	<0.01
New Brunswick, New Jersey - NBNJ						
Acetaldehyde	0.0000022	0.009	62/62	2.49 ± 0.27	5.47	0.28
Acrylonitrile	0.000068	0.002	25/58	0.09 ± 0.05	6.20	0.05
Benzene	0.0000078	0.03	58/58	0.70 ± 0.10	5.45	0.02
1,3-Butadiene	0.00003	0.002	42/58	0.06 ± 0.01	1.66	0.03
Carbon Tetrachloride	0.000006	0.1	58/58	0.59 ± 0.04	3.52	0.01
Chloroform	--	0.098	48/58	0.13 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	39/58	0.06 ± 0.02	0.68	<0.01
1,2-Dichloroethane	0.000026	2.4	19/58	0.03 ± 0.01	0.79	<0.01
Ethylbenzene	0.0000025	1	58/58	0.49 ± 0.39	1.23	<0.01
Formaldehyde	0.000013	0.0098	62/62	2.71 ± 1.10	35.23	0.28
Hexachloro-1,3-butadiene	0.000022	0.09	9/58	0.02 ± 0.01	0.33	<0.01
Tetrachloroethylene	0.00000026	0.04	50/58	0.13 ± 0.02	0.03	<0.01
Trichloroethylene	0.0000048	0.002	15/58	0.02 ± 0.01	0.11	0.01
Vinyl Chloride	0.0000088	0.1	7/58	<0.01 ± <0.01	0.03	<0.01
Paterson, New Jersey - PANJ						
Acrylonitrile	0.000068	0.002	2/12	NA	NA	NA
Benzene	0.0000078	0.03	12/12	NA	NA	NA
1,3-Butadiene	0.00003	0.002	12/12	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	12/12	NA	NA	NA

NA = Not available due to the criteria for calculating an annual average
-- = a Cancer URE or Noncancer RfC is not available

Table 17-6. 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 Hazard Approximation (HQ)
Chloroform	--	0.098	5/12	NA	NA	NA
1,2-Dibromoethane	0.0006	0.009	3/12	NA	NA	NA
p-Dichlorobenzene	0.000011	0.8	12/12	NA	NA	NA
1,2-Dichloroethane	0.000026	2.4	2/12	NA	NA	NA
Ethylbenzene	0.0000025	1	12/12	NA	NA	NA
Hexachloro-1,3-butadiene	0.000022	0.09	2/12	NA	NA	NA
Tetrachloroethylene	0.00000026	0.04	12/12	NA	NA	NA
Trichloroethylene	0.0000048	0.002	7/12	NA	NA	NA
Vinyl Chloride	0.0000088	0.1	3/12	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 from Table 17-6 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, followed by acrylonitrile and benzene. 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.

- 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. 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.

- 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 acrylonitrile and acetaldehyde (with benzene nearly equivalent to acetaldehyde). 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.

- Because annual averages could not be calculated for PANJ, cancer risk and noncancer hazard approximations could not be calculated either.

17.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 17-7 and 17-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 17-6. Table 17-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations, also calculated from annual averages provided in Table 17-6.

The pollutants listed in Tables 17-7 and 17-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 17.3, CHNJ, ELNJ, and NBNJ sampled for VOCs and carbonyl compounds. 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. The completeness criteria were not met by PANJ because of the short sampling duration; as a result, annual averages, and thus cancer risk and noncancer hazard approximations, were not calculated for this site. A more in-depth discussion of this analysis is provided in Section 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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 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					
Benzene	207.44	Benzene	1.62E-03	Formaldehyde	30.80
Ethylbenzene	118.39	Formaldehyde	1.45E-03	Acrylonitrile	7.13
Formaldehyde	111.67	1,3-Butadiene	9.72E-04	Benzene	4.12
Acetaldehyde	75.87	Naphthalene	4.41E-04	Carbon Tetrachloride	3.74
1,3-Butadiene	32.41	Hexavalent Chromium, PM	3.11E-04	Acetaldehyde	3.55
Naphthalene	12.97	Ethylbenzene	2.96E-04	1,2-Dichloroethane	0.88
Dichloromethane	9.08	POM, Group 2b	1.74E-04	1,3-Butadiene	0.71
POM, Group 2b	1.98	Acetaldehyde	1.67E-04	Hexachloro-1,3-butadiene	0.24
POM, Group 1a	0.32	Arsenic, PM	1.31E-04	Trichloroethylene	0.23
POM, Group 6	0.16	POM, Group 3	1.24E-04	Tetrachloroethylene	0.02
Elizabeth, New Jersey (Union County) - ELNJ					
Benzene	160.93	Formaldehyde	1.45E-03	Formaldehyde	44.84
Formaldehyde	111.28	Benzene	1.26E-03	Benzene	8.00
Ethylbenzene	89.90	1,3-Butadiene	7.04E-04	Acetaldehyde	7.14
Acetaldehyde	67.31	Nickel, PM	6.52E-04	1,3-Butadiene	4.05
Dichloromethane	41.31	Hexavalent Chromium, PM	6.03E-04	Carbon Tetrachloride	3.68
1,3-Butadiene	23.48	Naphthalene	3.88E-04	Acrylonitrile	2.50
Naphthalene	11.41	Arsenic, PM	2.37E-04	Ethylbenzene	1.27
POM, Group 2b	1.57	Ethylbenzene	2.25E-04	*p*-Dichlorobenzene	1.10
Nickel, PM	1.36	Acetaldehyde	1.48E-04	1,2-Dichloroethane	0.73
Propylene oxide	0.70	POM, Group 2b	1.38E-04	Trichloroethylene	0.45

Table 17-7. 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)**
New Brunswick, New Jersey (Middlesex County) - NBNJ					
Benzene	263.33	Formaldehyde	2.28E-03	Formaldehyde	35.23
Formaldehyde	175.06	Benzene	2.05E-03	Acrylonitrile	6.20
Ethylbenzene	146.78	1,3-Butadiene	1.20E-03	Acetaldehyde	5.47
Acetaldehyde	107.72	Naphthalene	7.01E-04	Benzene	5.45
1,3-Butadiene	40.00	Hexavalent Chromium, PM	4.61E-04	Carbon Tetrachloride	3.52
Naphthalene	20.62	Ethylbenzene	3.67E-04	1,3-Butadiene	1.66
Dichloromethane	7.26	Nickel, PM	2.67E-04	Ethylbenzene	1.23
POM, Group 2b	2.82	POM, Group 2b	2.48E-04	1,2-Dichloroethane	0.79
Ethylene oxide	1.05	Acetaldehyde	2.37E-04	*p*-Dichlorobenzene	0.68
Tetrachloroethylene	0.96	Arsenic, PM	1.84E-04	Hexachloro-1,3-butadiene	0.33
Paterson, New Jersey (Passaic County) - PANJ					
Benzene	115.84	Benzene	9.04E-04		
Ethylbenzene	63.19	Formaldehyde	8.08E-04		
Formaldehyde	62.14	1,3-Butadiene	5.25E-04		
Acetaldehyde	41.52	Naphthalene	2.47E-04		
1,3-Butadiene	17.51	Hexavalent Chromium, PM	1.63E-04		
Naphthalene	7.26	Ethylbenzene	1.58E-04		
Dichloromethane	3.63	POM, Group 2b	9.60E-05		
POM, Group 2b	1.09	Acetaldehyde	9.14E-05		
POM, Group 1a	0.32	POM, Group 3	8.90E-05		
POM, Group 6	0.09	Arsenic, PM	7.09E-05		

Table 17-8. 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	624.27	Acrolein	302,596.87	Formaldehyde	0.24
Xylenes	493.82	1,3-Butadiene	16,206.30	Acetaldehyde	0.18
Benzene	207.44	Formaldehyde	11,395.19	Acrylonitrile	0.05
Hexane	131.84	Acetaldehyde	8,429.94	Trichloroethylene	0.02
Ethylbenzene	118.39	Benzene	6,914.65	Benzene	0.02
Formaldehyde	111.67	Xylenes	4,938.24	1,3-Butadiene	0.01
Acetaldehyde	75.87	Lead, PM	4,349.55	Carbon Tetrachloride	0.01
1,3-Butadiene	32.41	Naphthalene	4,323.69	Tetrachloroethylene	<0.01
Ethylene glycol	29.66	Arsenic, PM	2,026.03	Chloroform	<0.01
Naphthalene	12.97	Propionaldehyde	1,006.84	Hexachloro-1,3-butadiene	<0.01
Elizabeth, New Jersey (Union County) - ELNJ					
Toluene	471.64	Acrolein	267,278.15	Acetaldehyde	0.36
Xylenes	352.06	Nickel, PM	15,081.94	Formaldehyde	0.35
Benzene	160.93	1,3-Butadiene	11,739.58	1,3-Butadiene	0.07
Formaldehyde	111.28	Formaldehyde	11,354.92	Propionaldehyde	0.06
Hexane	109.81	Acetaldehyde	7,478.86	Trichloroethylene	0.05
Ethylbenzene	89.90	Benzene	5,364.23	Benzene	0.03
Acetaldehyde	67.31	Naphthalene	3,803.12	Acrylonitrile	0.02
Dichloromethane	41.31	Manganese, PM	3,755.20	Carbon Tetrachloride	0.01
Ethylene glycol	36.52	Arsenic, PM	3,671.47	Tetrachloroethylene	0.01
Hydrochloric acid	24.34	Xylenes	3,520.63	Chloroform	<0.01

Table 17-8. 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)**
New Brunswick, New Jersey (Middlesex County) - NBNJ					
Toluene	776.52	Acrolein	445,148.01	Formaldehyde	0.28
Xylenes	593.79	1,3-Butadiene	20,000.36	Acetaldehyde	0.28
Benzene	263.33	Formaldehyde	17,862.97	Acrylonitrile	0.05
Hexane	227.61	Manganese, PM	12,571.41	1,3-Butadiene	0.03
Formaldehyde	175.06	Acetaldehyde	11,968.98	Benzene	0.02
Ethylbenzene	146.78	Benzene	8,777.75	Trichloroethylene	0.01
Acetaldehyde	107.72	Naphthalene	6,872.93	Carbon Tetrachloride	0.01
Ethylene glycol	49.05	Titanium tetrachloride	6,385.00	Tetrachloroethylene	0.00
1,3-Butadiene	40.00	Nickel, PM	6,175.26	Chloroform	0.00
Glycol ethers, gas	37.20	Xylenes	5,937.95	Ethylbenzene	0.00
Paterson, New Jersey (Passaic County) - PANJ					
Toluene	358.91	Acrolein	154,681.77		
Xylenes	286.81	1,3-Butadiene	8,754.09		
Benzene	115.84	Formaldehyde	6,341.18		
Hexane	71.05	Acetaldehyde	4,613.84		
Ethylbenzene	63.19	Benzene	3,861.24		
Formaldehyde	62.14	Xylenes	2,868.11		
Acetaldehyde	41.52	Naphthalene	2,419.97		
Ethylene glycol	29.87	Arsenic, PM	1,099.65		
1,3-Butadiene	17.51	Lead, PM	797.37		
Glycol ethers, gas	13.40	Glycol ethers, gas	670.22		

Observations from Table 17-7 include the following:

- Benzene is the highest emitted pollutant with a cancer URE in all four New Jersey counties, followed by ethylbenzene, formaldehyde, and acetaldehyde (although not necessarily in that order).

- Benzene, formaldehyde, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for all four New Jersey counties, although not necessarily in that order.

- Seven of the 10 highest emitted pollutants in Morris, Middlesex, and Passaic Counties also have the highest toxicity-weighted emissions while eight of the highest emitted pollutants in Union County also have the highest toxicity-weighted emissions.

- Formaldehyde is the pollutant with the highest cancer risk approximations for CHNJ, ELNJ, and NBNJ. This pollutant also appears at or near the top of both emissions-based lists. Acetaldehyde, benzene, and 1,3-butadiene also appear on all three lists for these sites. Conversely, carbon tetrachloride and acrylonitrile appear on neither emissions-based list for the New Jersey sites but appear among the pollutants with the highest cancer risk approximations for each site.

Observations from Table 17-8 include the following:

- Toluene, xylenes, and benzene are the highest emitted pollutants with noncancer RfCs for all four New Jersey counties.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for all four counties but is not among the highest emitted pollutants for any of the New Jersey counties. Although acrolein was sampled for at all four 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.

- Behind acrolein, 1,3-butadiene and formaldehyde have the highest noncancer toxicity-weighted emissions for three of the four New Jersey counties. For Union County (ELNJ), nickel has the second highest noncancer toxicity-weighted emissions, followed by 1,3-butadiene and formaldehyde.

- The number of pollutants in common between the highest emitted pollutants and those with the highest toxicity-weighted emissions ranged from four (Union County) to six (Passaic and Morris Counties).

- Formaldehyde and acetaldehyde 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 among the pollutants with the highest emissions and toxicity-weighted emissions for all four counties. Benzene and 1,3-butadiene also appear on all three lists for these sites.

17.6 Summary of the 2011 Monitoring Data for the New Jersey Monitoring Sites

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

- *Seventeen pollutants failed at least one screen for CHNJ; 16 failed screens for ELNJ; 18 failed screens for NBNJ; and 10 failed screens for PANJ.*

- *Formaldehyde and acetaldehyde had the highest annual average concentrations for CHNJ, ELNJ, and NBNJ. Annual average concentrations could not be calculated for PANJ.*

- *The annual average acetaldehyde concentration for ELNJ is the highest annual average among NMP sites sampling this pollutant. The maximum concentration of formaldehyde measured across the program was measured at NBNJ.*

- *Several of the pollutants for which a trends analysis was performed exhibit slight increasing trends from 2010 to 2011 for the New Jersey sites.*

18.0 Sites in New York

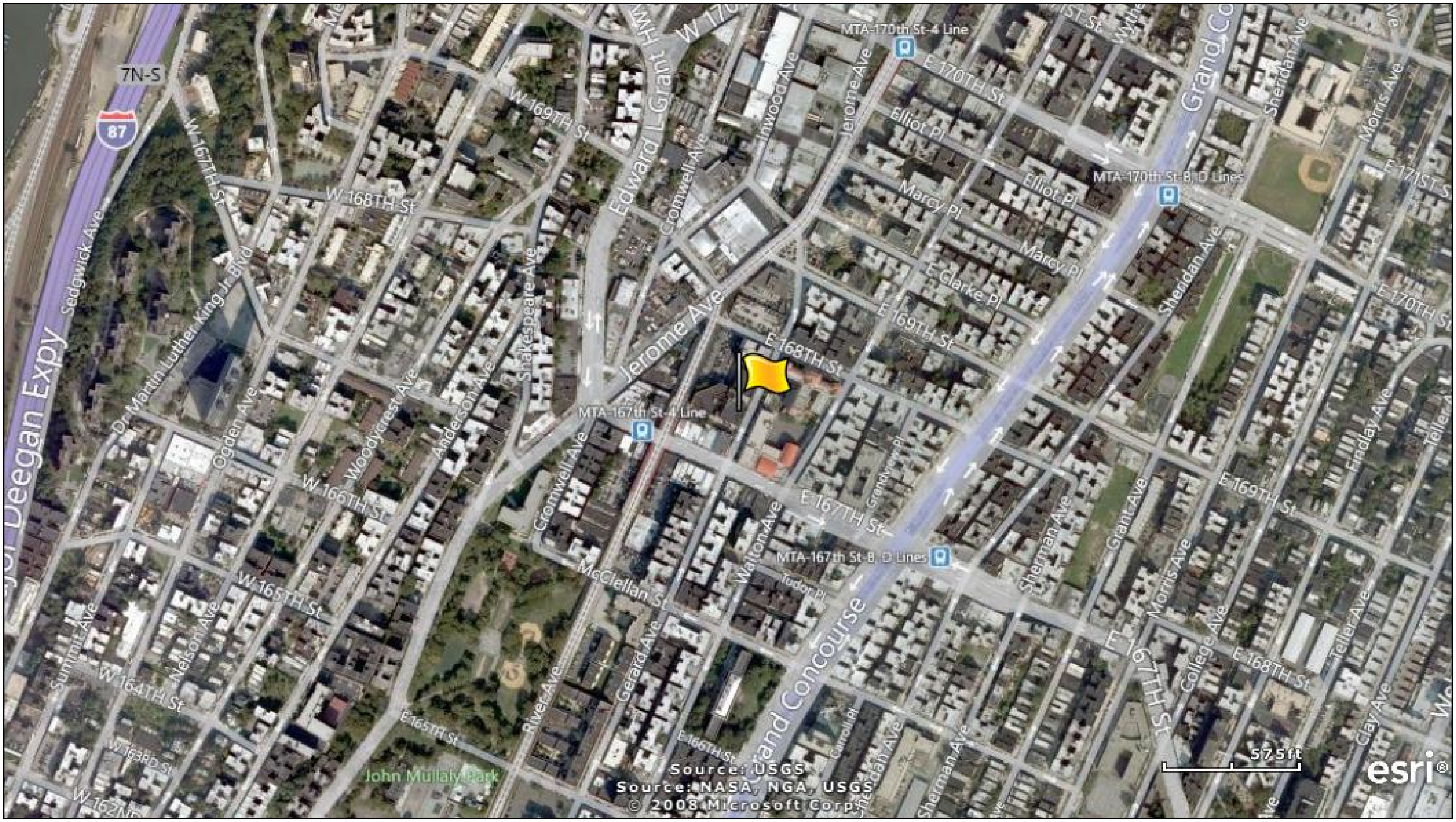
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS sites in New York, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data 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.

18.1 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.

The New York monitoring sites are located in New York City (MONY) and Rochester (ROCH). Figures 18-1 and 18-3 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban locations. Figures 18-2 and 18-4 identify nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figures 18-2 and 18-4. 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 18-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 18-1. New York City, New York (MONY) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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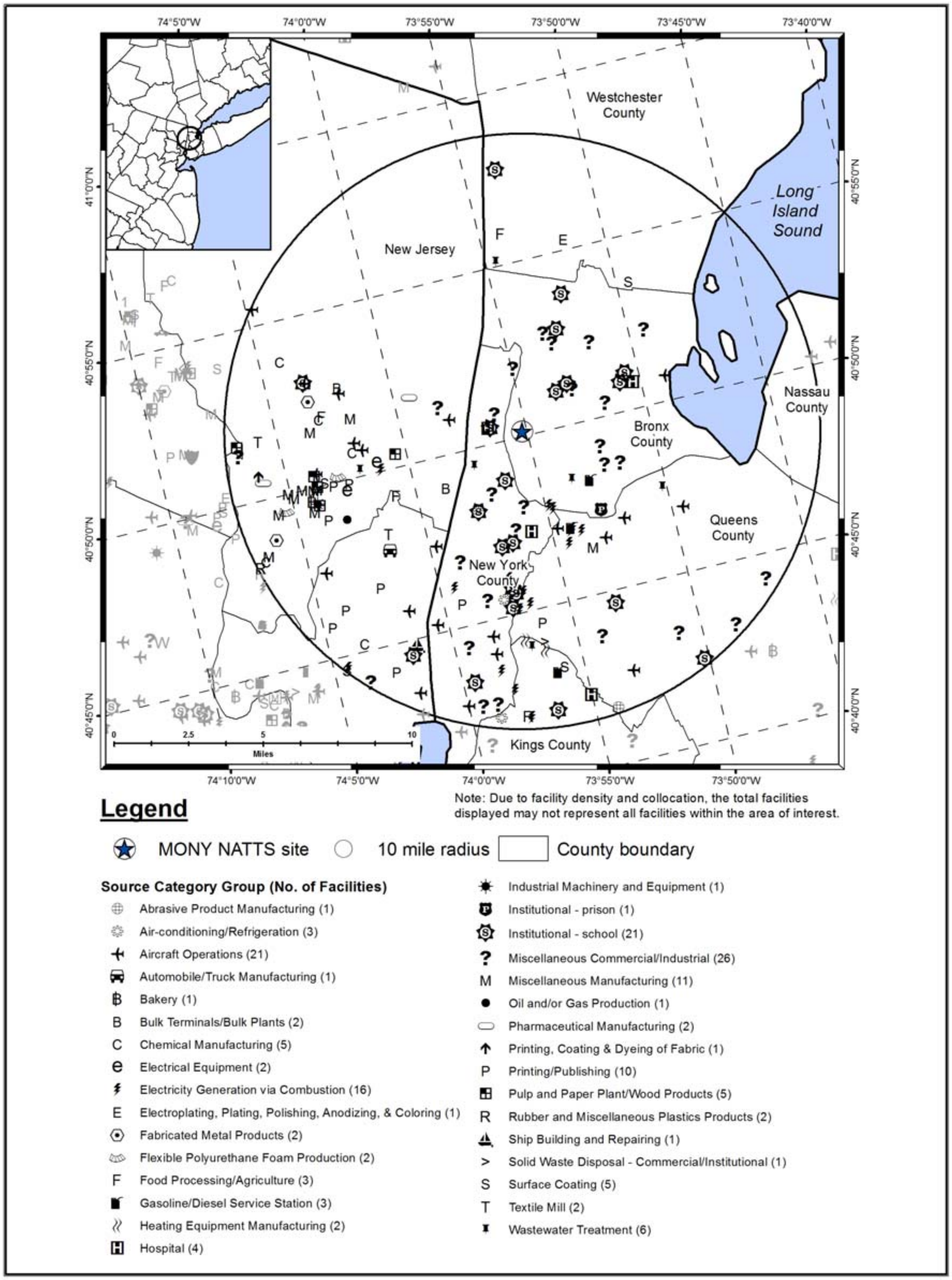
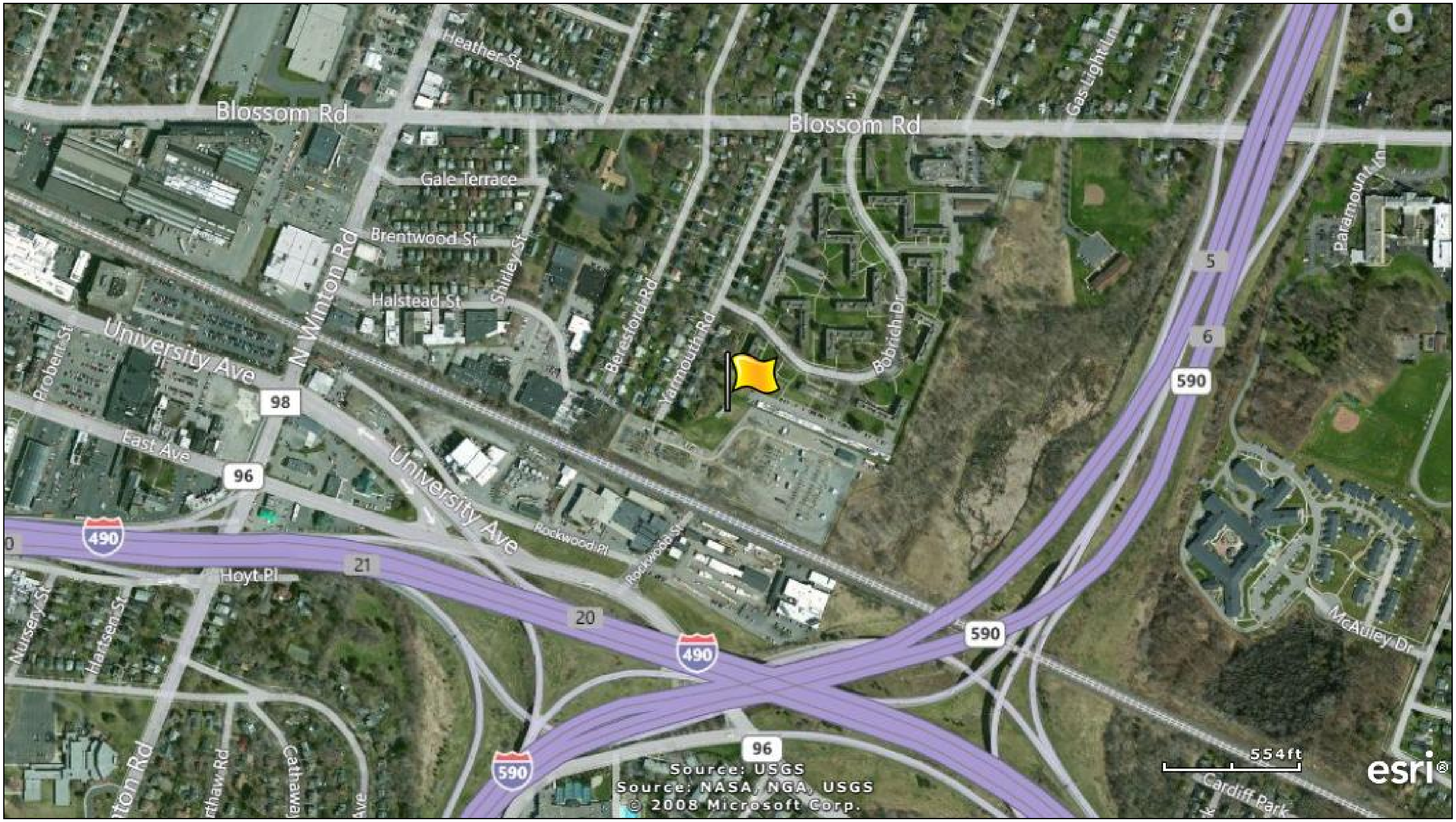
Figure 18-2. NEI Point Sources Located Within 10 Miles of MONY



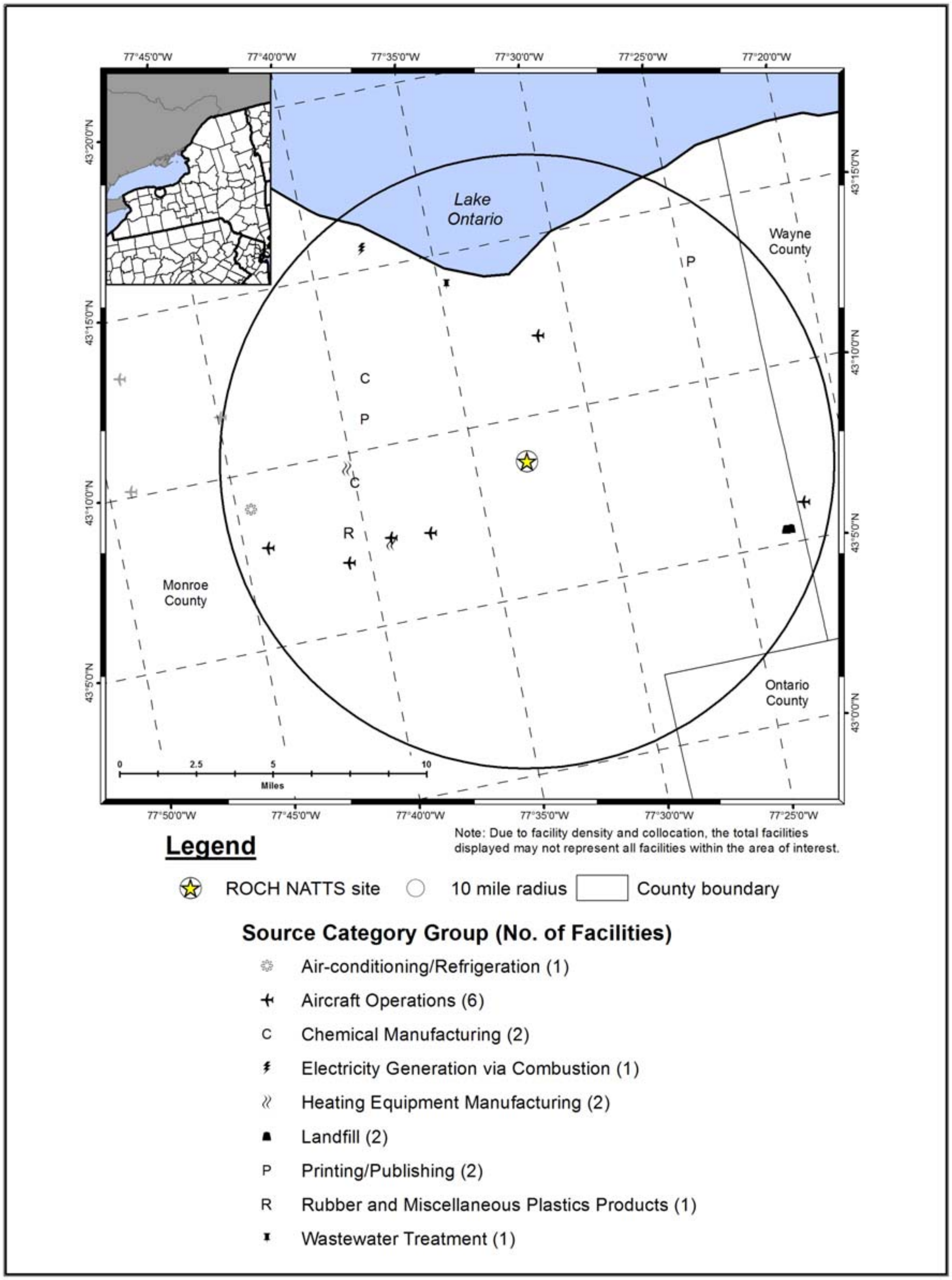
Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 18-3. Rochester, New York (ROCH) Monitoring Site



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

Figure 18-4. NEI Point Sources Located Within 10 Miles of ROCH



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 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]
MONY	36-005-0080	New York	Bronx	New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (New York Div)	40.83606, -73.92009	Residential	Urban/City Center	Carbonyl Compounds, VOCs, Meteorological Parameters, Black carbon, PM_{10} Speciation, $PM_{2.5}$.
ROCH	36-055-1007	Rochester	Monroe	Rochester, NY MSA	43.146198, -77.54813	Residential	Urban/City Center	CO, SO_2, VOCs, Carbonyl compounds, O_3, Meteorological parameters, Black Carbon, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

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 previous location. MONY is located less than three-quarters of a mile south of I-95, one-half mile east of I-87 and east of 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 18-1. 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. Figure 18-2 shows the numerous point sources that are located within 10 miles of the site. The bulk of the emissions sources are located to the south and west of the site. The source categories with the highest number of emissions sources surrounding MONY include aircraft operations, which include airports as well as small runways, heliports, or landing pads; electricity generation via combustion; schools; and printing and publishing. The point source closest to MONY is a medical school.

ROCH is located on the east side of Rochester, in western New York, at a power substation. Rochester is approximately halfway between Syracuse and Buffalo, and Lake Ontario lies to the north. Although the area north and west of the site is primarily residential, as shown in Figure 18-3, 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 18-4 shows, the relatively few point sources within a 10-mile radius of ROCH are located primarily on the west side of the 10-mile radius. The aircraft operations source category is the category with the highest number of emissions sources surrounding ROCH, although there are also landfills, chemical manufacturers, printing and publishing facilities, and heating equipment manufacturers nearby, to name a few.

Table 18-2 presents additional site-characterizing information, including indicators of mobile source activity, for the New York monitoring sites. Table 18-2 includes county-level population and vehicle registration information. Table 18-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site’s residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 18-2 also contains traffic volume information for each site. Finally, Table 18-2 presents the county-level daily VMT for Bronx and Monroe Counties.

Table 18-2. Population, Motor Vehicle, and Traffic Information for the New York Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
MONY	1,392,002	246,748	0.18	5,684,739	1,007,684	91,465	9,698,000
ROCH	745,625	550,992	0.74	650,600	480,772	86,198	17,772,000

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the New York State DMV (NYS DMV, 2011)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2010 data from the New York State DOT (NYS DOT, 2010)
[5] County-level VMT reflects 2009 data from the New York State DOT (NYS DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 18-2 include the following:

- Bronx County has the ninth highest county-level population among counties with NMP sites, but the 10-mile radius population for MONY is the highest among all NMP sites.

- County-level vehicle ownership for Bronx County is in the middle of the range among NMP sites. Although the 10-mile ownership estimate is one of the highest estimates among NMP sites, given the large population living within 10 miles of MONY, the vehicle-per-person ratio is very low (0.18), which is the lowest vehicle-per-person ratio calculated. This may seem surprising given the high population, but may be explained by the use of mass transportation systems.

- The population surrounding ROCH is lower than the population surrounding MONY. However, the county-level vehicle ownership for ROCH is double the vehicle ownership near MONY. The same is not true of the 10-mile ownership estimates. The county-level and 10-mile population and vehicle ownership data for ROCH are in the middle of the range compared to other NMP sites.

- The traffic volume near MONY and ROCH are not that different from each other. Compared to other NMP sites, the traffic volumes near MONY and ROCH rank 17th and 18th, respectively. 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 sites.

18.2 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.

18.2.1 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. 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 (Bair, 1992).

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. While the lake acts as a moderating influence on the city's temperatures, both in the summer and the winter, 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 than farther inland. Spring and summer tend to be sunny while cloudy conditions are prevalent in the fall and winter (Bair, 1992 and NOAA, 2012).

18.2.2 Meteorological Conditions in 2011

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). The closest weather stations are located at Central Park (near MONY) and Greater Rochester International Airport (near ROCH), WBAN 94728 and 14768, 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 York Monitoring Sites

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)
New York City, New York - MONY									
Central Park 94728 (40.78, 73.97)	4.35 miles 199° (SSW)	Sample Day	62.6 ± 4.5	55.4 ± 4.2	42.4 ± 4.9	49.4 ± 4.0	64.6 ± 4.1	1015.6 ± 1.9	5.2 ± 0.6
		2011	63.1 ± 1.8	56.1 ± 1.7	43.6 ± 2.0	50.2 ± 1.6	65.5 ± 1.7	1015.5 ± 0.8	5.0 ± 0.2
Rochester, New York - ROCH									
Greater Rochester Intl. Airport 14768 (43.12, -77.68)	6.46 miles 240° (WSW)	Sample Day	56.4 ± 5.0	48.6 ± 4.6	39.0 ± 4.4	44.0 ± 4.2	72.0 ± 2.7	1015.8 ± 1.8	7.5 ± 0.8
		2011	57.8 ± 2.0	49.7 ± 1.9	40.1 ± 1.8	45.1 ± 1.7	71.8 ± 1.1	1015.3 ± 0.8	7.2 ± 0.3

[1] Sample day averages are highlighted 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 the entire year for 2011. Also included in Table 18-3 is the 95 percent confidence interval for each parameter. Table 18-3 shows that meteorological conditions near MONY on sample days were representative of average weather conditions experienced throughout the year. Conditions on sample days near ROCH appear slightly cooler than conditions experienced throughout the year, although the difference is not statistically significant.

18.2.3 Back Trajectory Analysis

Figure 18-5 is the composite back trajectory map for days on which samples were collected at the MONY monitoring site in 2011. Included in Figure 18-5 are four back trajectories per sample day. Figure 18-6 is the corresponding cluster analysis. Similarly, Figure 18-7 is the composite back trajectory map for days on which samples were collected at ROCH and Figure 18-8 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 18-5 through 18-8 represents 100 miles.

Figure 18-5. 2011 Composite Back Trajectory Map for MONY

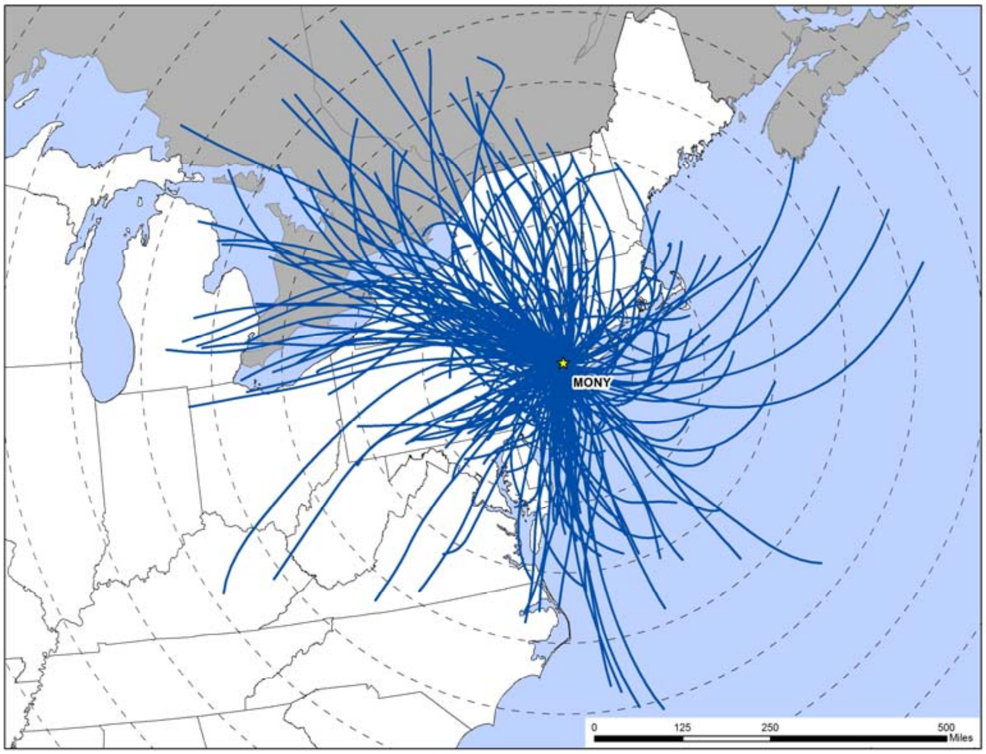


Figure 18-6. Back Trajectory Cluster Map for MONY

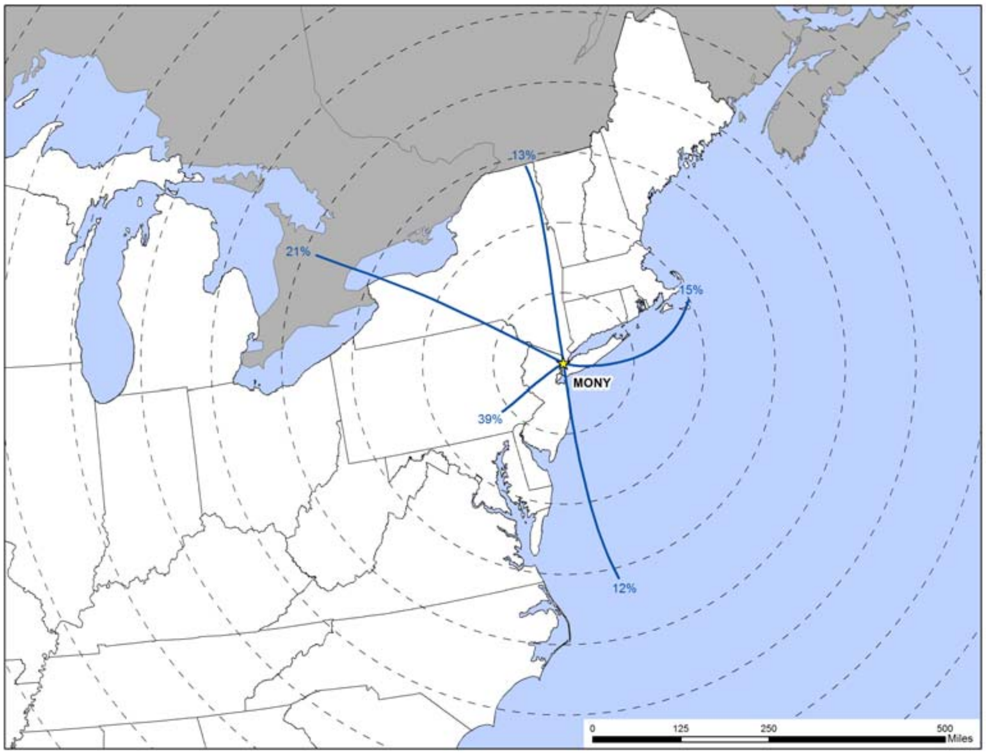


Figure 18-7. 2011 Composite Back Trajectory Map for ROCH

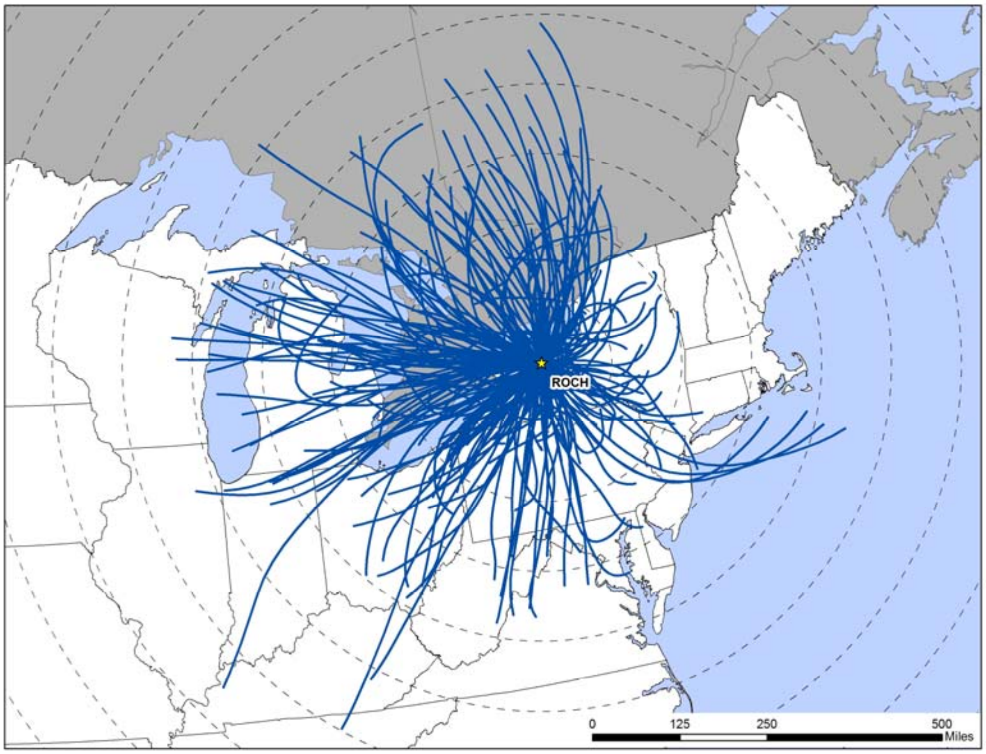
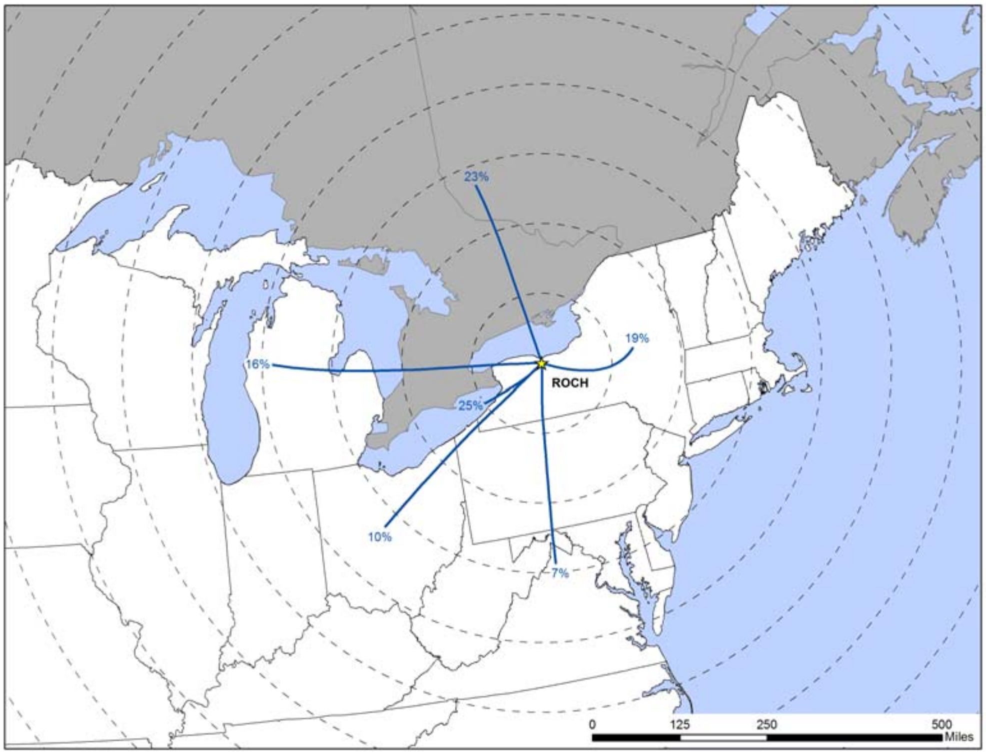


Figure 18-8. Back Trajectory Cluster Map for ROCH



Observations from Figures 18-5 and 18-6 for MONY include the following:

- Back trajectories originated from a variety of directions at MONY. Back trajectories most frequently originated to the northwest of MONY.

- The 24-hour air shed domain for MONY is similar in size to other NMP sites. Although the farthest away a back trajectory originated was over Ontario, Canada, or less than 650 miles away, the average trajectory length was 254 miles and 93 percent of trajectories originated within 400 miles of the site.

- The cluster analysis shows that approximately 20 percent of back trajectories originated to the northwest of MONY over the Great Lakes and Canada. Twelve percent originated over the offshore waters of the Mid-Atlantic states. Shorter back trajectories, generally 200 miles in length or less, originating between these two cluster trajectories are represented by the short cluster trajectory originating over southeast Pennsylvania. This cluster trajectory also includes a few longer trajectories originating over Kentucky, West Virginia, and Virginia. Another 15 percent of back trajectories originated to the east of MONY over the Atlantic Ocean and 13 percent of back trajectories originated to the north of the site, primarily over northern New York, Vermont, and Quebec, Canada.

Observations from Figures 18-7 and 18-8 for ROCH include the following:

- Back trajectories originated from a variety of directions at ROCH, although relatively few originated from the northeast of ROCH.

- The 24-hour air shed domain for ROCH was comparable in size to MONY and other NMP sites. The farthest away a trajectory originated was over western Kentucky, or approximately 650 miles away. However, the average trajectory length was 252 miles and 86 percent of back trajectories originated within 400 miles of the site.

- The cluster analysis shows that nearly 50 percent of back trajectories originated from a direction with a westerly component. These back trajectories are represented by three cluster trajectories in Figure 18-8: 1) longer trajectories originating towards Lake Michigan (16 percent), 2) longer trajectories originating towards Ohio (10 percent), and 3) relatively short trajectories (< 200 miles in length) originating from nearly any direction with a westerly component (25 percent). This third cluster also includes a few shorter trajectories originating to the south of ROCH.

- Nearly one-quarter of back trajectories originated over Ontario and Quebec, Canada. Nearly 20 percent of back trajectories originated from a direction with an easterly component. This cluster trajectory also includes the longer trajectories originating offshore, east of Long Island, New York. Seven percent of trajectories originated to the south of ROCH over West Virginia, Virginia, and Maryland.

18.2.4 Wind Rose Comparison

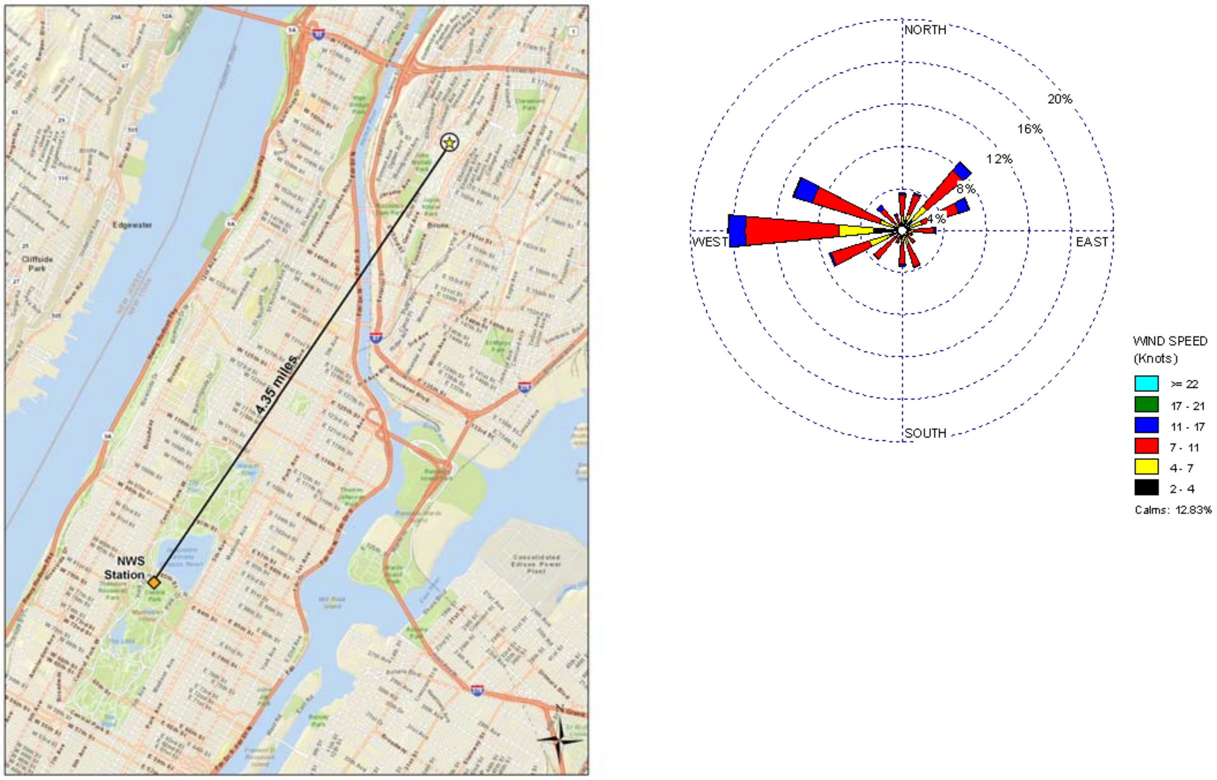
Hourly surface wind data from the weather stations at Central Park (for MONY) and Greater Rochester International Airport (for ROCH) were uploaded into a wind rose software program to produce customized wind roses, as described in Section 3.5.2.2. A wind rose shows the frequency of wind directions using “petals” positioned around a 16-point compass, and uses different colors to represent wind speeds.

Figure 18-9 presents a map showing the distance between the NWS station and MONY, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 18-9 also presents three different wind roses for the MONY monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 18-10 presents the distance map and three wind roses for ROCH.

Observations from Figure 18-9 for MONY include the following:

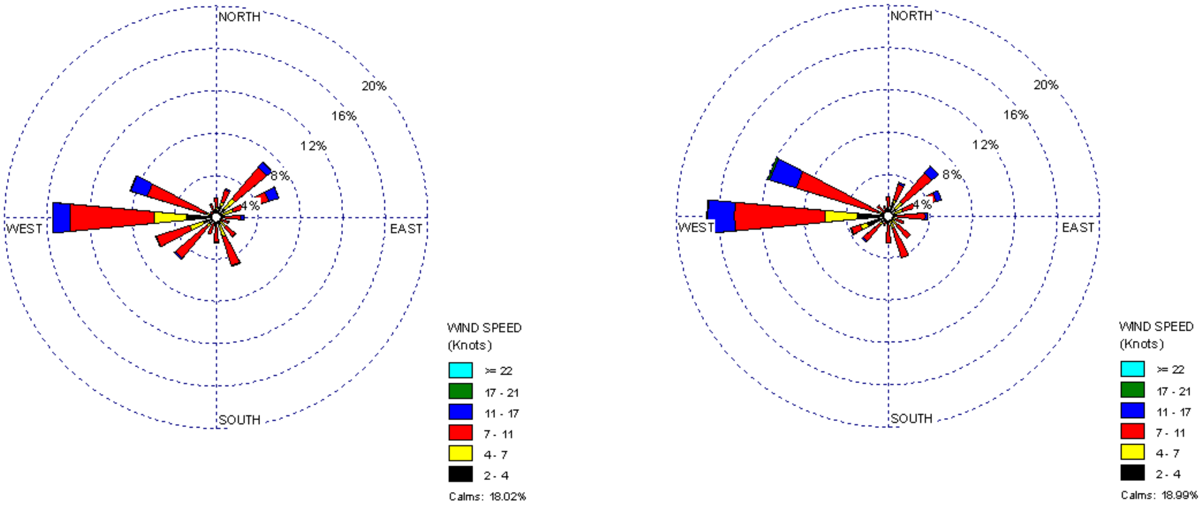
- The weather station at Central Park is located 4.35 miles south-southwest of MONY.
- The historical wind rose shows that winds from the west and west-northwest account for greater than 25 percent of wind observations. Winds from the northeast and east-northeast account for another 15 percent of observations. Calm winds (≤2 knots) were observed for nearly 13 percent of the hourly measurements near MONY.
- The 2011 full-year wind rose shares many similarities with the historical wind rose, such as the prominence of winds from the west. However, the percentage of calm winds increased for 2011 and the percentages of each of the primary wind directions decreased slightly.
- The sample day wind patterns resemble the wind patterns on the 2011 full-year and historical wind roses, indicating that wind conditions on sample days were similar to those experienced throughout 2011 and historically. However, some differences include an even higher percentage of calm winds (nearly 19 percent) and fewer observations from the west-southwest.

Figure 18-9. Wind Roses for the Central Park Weather Station near MONY



Distance between MONY and NWS Station

2001-2010 Historical Wind Rose



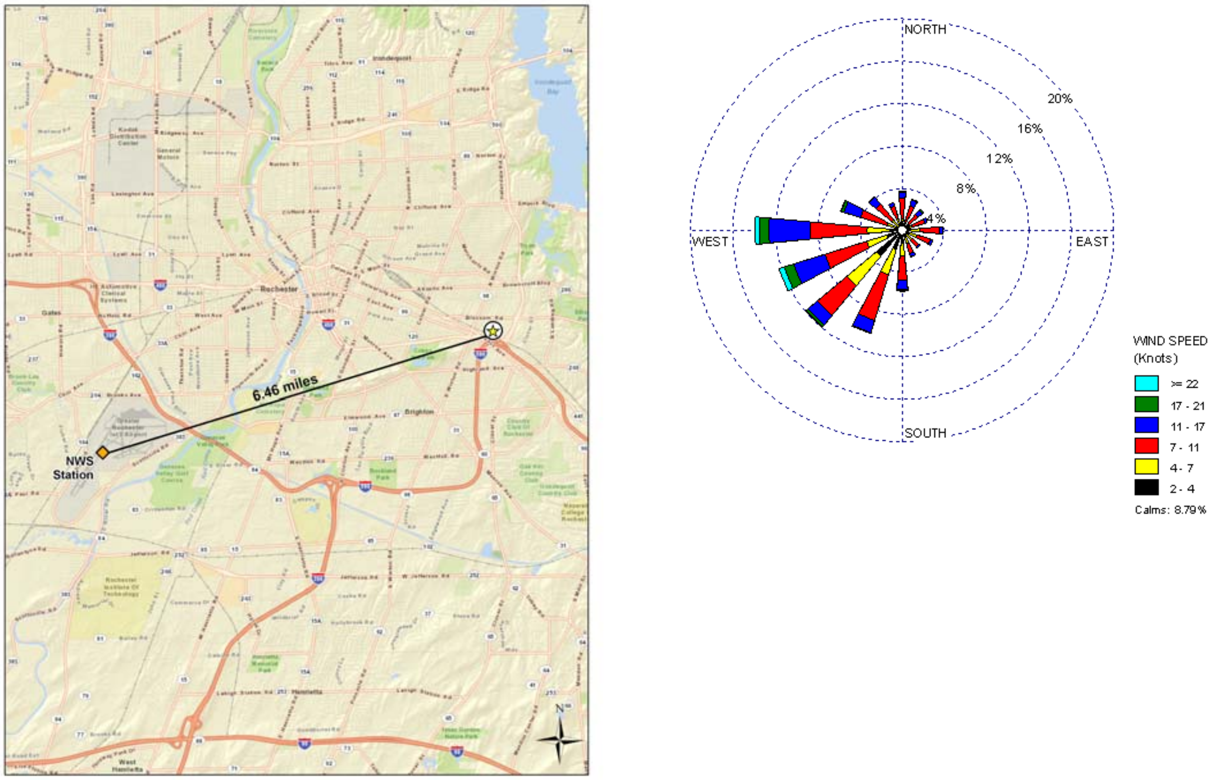
2011 Wind Rose

Sample Day Wind Rose

Figure 18-10. Wind Roses for the Greater Rochester International Airport Weather Station near ROCH

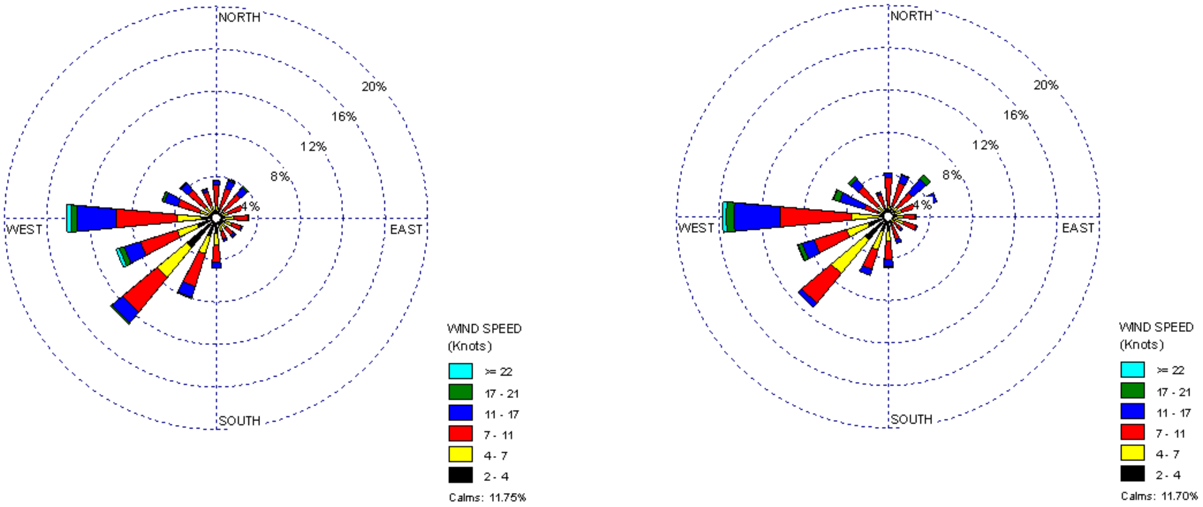
Distance between ROCH and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose



Observations from Figure 18-10 for ROCH include the following:

- The Rochester International Airport weather station is located approximately 6.5 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 nine 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 2011 wind rose are similar to the historical wind patterns for ROCH, although south-southwesterly and west-southwesterly winds were observed less frequently and a higher percentage of calm winds were observed (nearly 12 percent).

- The sample day wind patterns are similar to those shown on the full-year wind rose, although the percentages differ somewhat.

18.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the New York monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 18-4 presents the results of the preliminary risk-based screening process for the New York monitoring sites. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. MONY and ROCH both sampled for hexavalent chromium and PAHs.

Table 18-4. 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
New York City, New York - MONY						
Naphthalene	0.029	60	60	100.00	52.17	52.17
Acenaphthene	0.011	22	60	36.67	19.13	71.30
Fluorene	0.011	20	60	33.33	17.39	88.70
Fluoranthene	0.011	8	60	13.33	6.96	95.65
Hexavalent Chromium	0.000083	3	60	5.00	2.61	98.26
Acenaphthylene	0.011	1	50	2.00	0.87	99.13
Benzo(a)pyrene	0.00057	1	59	1.69	0.87	100.00
Total		115	409	28.12		
Rochester, New York - ROCH						
Naphthalene	0.029	46	58	79.31	47.42	47.42
Acenaphthene	0.011	22	58	37.93	22.68	70.10
Fluorene	0.011	20	58	34.48	20.62	90.72
Fluoranthene	0.011	9	58	15.52	9.28	100.00
Total		97	232	41.81		

Observations from Table 18-4 include the following:

- For MONY, seven pollutants, of which three are NATTS MQO Core Analytes, failed screens. The risk-based screening process identified four of the pollutants that failed at least one screen as pollutants of interest. Hexavalent chromium and benzo(a)pyrene were added as pollutants of interest for MONY because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of the total failed screens.

- For ROCH, only four pollutants failed screens. The risk-based screening process identified all of the pollutants that failed a screen as pollutants of interest. This is because it took the combined percentages of failed screens to reach the 95 percent criteria specified in Section 3.2. Hexavalent chromium and benzo(a)pyrene were added as pollutants of interest for ROCH because they are NATTS MQO Core Analytes, even though they did not fail any screens. These two pollutants are not shown in Table 18-4 but are shown in subsequent tables in the sections that follow.

- For both sites, naphthalene, acenaphthene, fluorene, and fluoranthene are the four pollutants that failed the most screens. Aside from naphthalene, these pollutants failed nearly the same number of screens for these sites.

- Naphthalene failed the majority of screens for each site. Naphthalene accounts for 47 percent of failed screens for ROCH and 52 percent of failed screens for MONY.

18.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the New York sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for each site to illustrate how the sites’ concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site. Additional site-specific statistical summaries for MONY and ROCH are provided in Appendices M and O.

18.4.1 2011 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 of 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 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 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)
New York City, New York - MONY						
Acenaphthene	60/60	2.28 ± 0.39	11.51 ± 3.31	16.36 ± 3.22	5.81 ± 1.49	8.99 ± 1.80
Benzo(a)pyrene	59/60	0.29 ± 0.06	0.11 ± 0.03	0.12 ± 0.06	0.28 ± 0.08	0.20 ± 0.04
Fluoranthene	60/60	4.75 ± 0.75	7.03 ± 1.89	9.72 ± 1.95	4.97 ± 1.27	6.62 ± 0.89
Fluorene	60/60	4.39 ± 0.65	11.62 ± 3.36	15.27 ± 2.87	6.60 ± 1.42	9.47 ± 1.55
Hexavalent Chromium	60/61	0.06 ± 0.01	0.04 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.04 ± 0.01
Naphthalene	60/60	108.37 ± 23.45	130.27 ± 29.50	170.41 ± 34.78	133.59 ± 33.66	135.66 ± 15.50
Rochester, New York - ROCH						
Acenaphthene	58/58	1.83 ± 0.69	13.74 ± 6.91	27.43 ± 7.09	5.55 ± 2.69	12.29 ± 3.55
Benzo(a)pyrene	42/58	0.08 ± 0.06	0.05 ± 0.03	0.08 ± 0.07	0.15 ± 0.04	0.09 ± 0.03
Fluoranthene	58/58	1.35 ± 0.42	6.76 ± 4.56	12.01 ± 3.64	2.37 ± 0.57	5.68 ± 1.76
Fluorene	58/58	2.06 ± 0.55	11.19 ± 6.11	21.41 ± 5.63	4.59 ± 1.77	9.92 ± 2.81
Hexavalent Chromium	41/56	0.01 ± <0.01	0.01 ± 0.01	0.01 ± <0.01	0.01 ± 0.01	0.01 ± <0.01
Naphthalene	58/58	31.28 ± 5.74	53.56 ± 14.95	103.28 ± 24.56	56.69 ± 10.08	61.85 ± 10.12

Observations from Table 18-5 include the following:

- The annual average concentration of naphthalene is the highest annual average among the pollutants of interest for both New York sites. The annual average naphthalene concentration for MONY is more than twice the annual average for ROCH.

- For both sites, the third quarter average concentration of naphthalene is greater than the other quarterly averages. For ROCH, the eight highest concentrations of naphthalene (those greater than 100 ng/m^3) were all measured in July or August. For MONY, the maximum naphthalene concentration (330 ng/m^3) was measured on December 5, 2011, although a similar concentration was also measured on July 20, 2011 (318 ng/m^3). The seven concentrations greater than 200 ng/m^3 measured at MONY were spread across all four quarters of 2011. This indicates a relatively high-level of variability within the measurements for MONY. This is also supported by the relatively large confidence intervals calculated for the quarterly averages.

- For both New York sites, concentrations of acenaphthene, fluoranthene, and fluorene were highest during the warmer months of the year. However, the confidence intervals calculated for these sites indicate that there is a high level of variability in the measurements. For example, acenaphthene concentrations for ROCH range from 0.34 ng/m^3 to 50.3 ng/m^3 with a median concentration of 5.49 ng/m^3. The 15 highest concentrations were measured at ROCH between June and September while 13 of the 15 lowest concentrations were measured between January and March or November and December.

- Conversely, benzo(a)pyrene measurements tended to be measured during the colder months of the year, particularly for MONY. The single non-detect of benzo(a)pyrene and the measurements less than 0.1 ng/m^3 were measured at MONY between April and October while all but one of the concentrations greater than 0.25 ng/m^3 were measured between January and March or October and December.

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 MONY and ROCH from those tables include the following:

- MONY and ROCH appear in Tables 4-11 seven times, appearing among the top 10 for each PAH with the exception of ROCH's annual average concentration of naphthalene.

- MONY has the second highest annual average concentration of benzo(a)pyrene, the third highest annual average concentration naphthalene, the fourth highest concentration of fluorene, and the fifth highest concentration of acenaphthene among NMP sites sampling PAHs.

- ROCH has the second highest annual average concentrations of acenaphthene and fluorene and the ninth highest annual average concentration of benzo(a)pyrene among NMP sites sampling PAHs.

- MONY has the fourth highest annual average concentration of hexavalent chromium among sites sampling this pollutant, while the annual average for ROCH ranks lower (19th).

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzo(a)pyrene, hexavalent chromium, and naphthalene were created for each site. Figures 18-11 through 18-13 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.

Figure 18-11. Program vs. Site-Specific Average Benzo(a)pyrene Concentrations

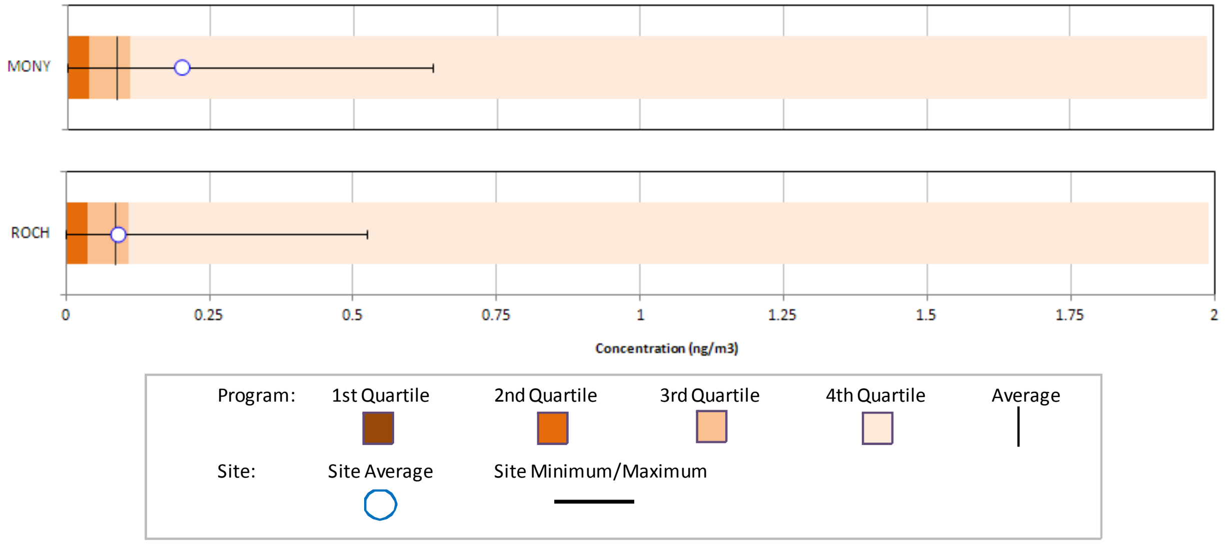


Figure 18-12. Program vs. Site-Specific Average Hexavalent Chromium Concentrations

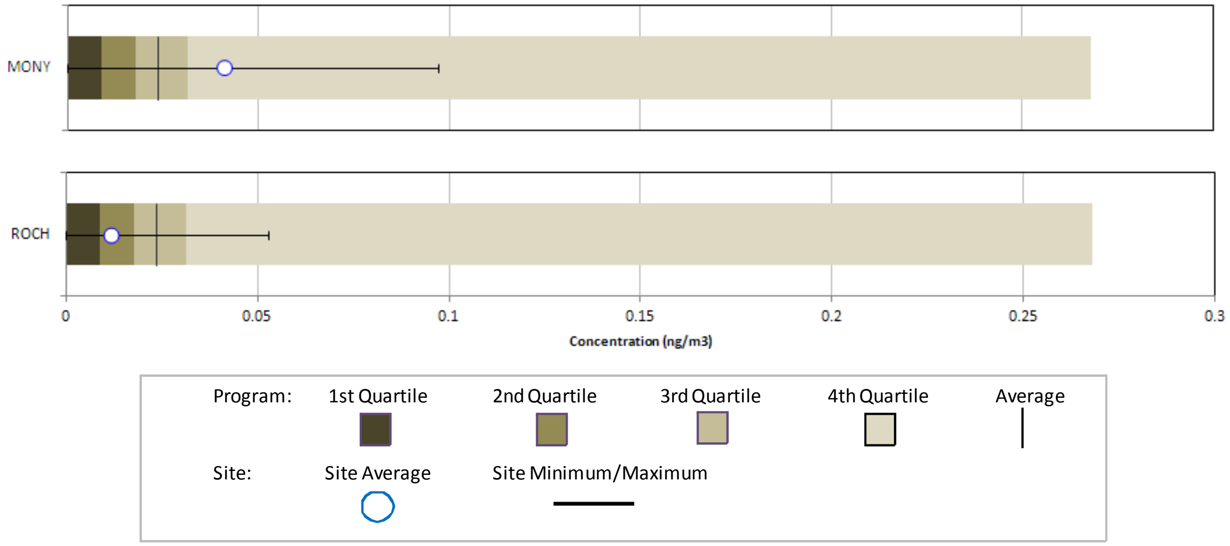
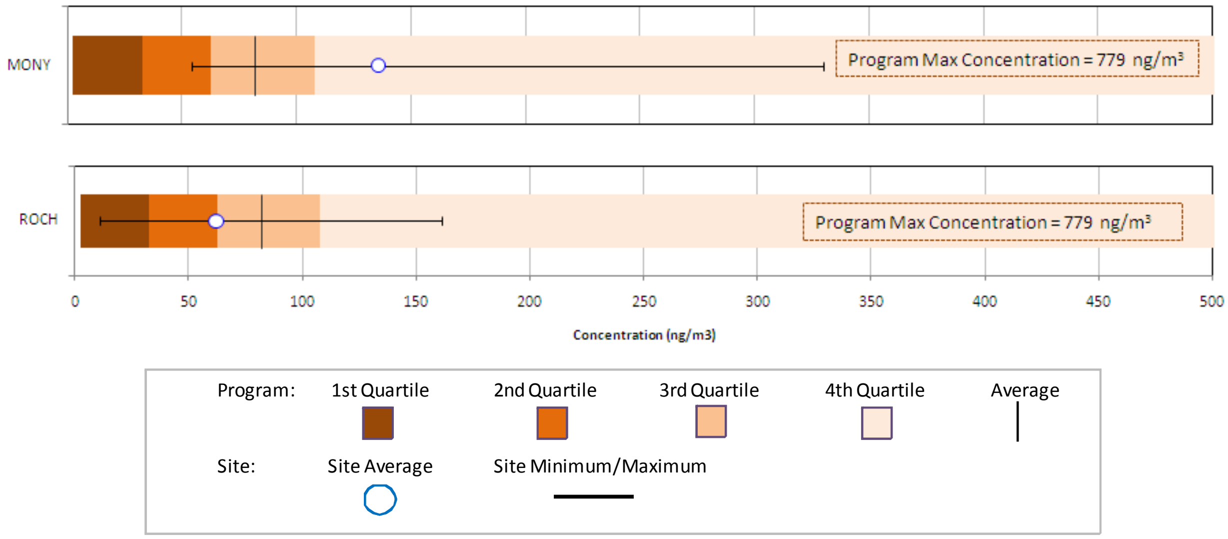


Figure 18-13. Program vs. Site-Specific Average Naphthalene Concentrations



Observations from Figures 18-11 through 18-13 include the following:

- Figure 18-11 presents the box plots for benzo(a)pyrene. Note that the program-level first quartile for this pollutant is zero and is not visible on the box plots. The box plots show that the annual average concentration for MONY is greater the annual average concentration for ROCH, although both are greater than the program-level average concentration (but just barely for ROCH). Although the range of measurements is slightly greater for MONY than ROCH, the maximum concentrations of benzo(a)pyrene for both sites are considerably less than the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at ROCH while a single non-detect was measured at MONY.

- Figure 18-12 presents the box plots for hexavalent chromium. The range of measurements for MONY is roughly twice the range of measurements for ROCH. The annual average concentration for MONY is greater than the program-level average concentration and third quartile while the annual average for ROCH is less than the program-level median concentration. Several non-detects of hexavalent chromium were measured at ROCH while a single non-detect was measured at MONY.

- Figure 18-13 presents the box plots for naphthalene. Note that the program-level maximum concentration (779 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 has been reduced to 500 ng/m^3. Figure 18-13 shows that the annual average naphthalene concentration for MONY is twice the annual average concentration for ROCH. While the annual average for ROCH is similar to the program-level median concentration, the annual average for MONY is greater than the program-level third quartile. The maximum naphthalene concentration measured at MONY is twice the maximum concentration measured at ROCH, although both are less than the program-level maximum concentration. There were no non-detects of naphthalene measured at either site. The minimum concentration of naphthalene measured at MONY (53.9 ng/m^3) is the highest minimum concentration among sites sampling this pollutant.

18.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. Although ROCH has sampled hexavalent chromium under the NMP since 2007, sampling did not begin until late in the year, which does not allow for the statistical metrics to be calculated. As a result, a trends analysis was not performed because there would be fewer than 5 years of statistical metrics provided. In addition, sampling for PAHs at ROCH did not begin until 2008. The MONY site began sampling under the NMP in 2010. Thus, a trends analysis was not conducted for either site.

18.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

18.5.2 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
New York City, New York - MONY						
Acenaphthene	0.000088	--	60/60	8.99 ± 1.80	0.79	--
Benzo(a)pyrene	0.00176	--	59/60	0.20 ± 0.04	0.35	--
Fluoranthene	0.000088	--	60/60	6.62 ± 0.89	0.58	--
Fluorene	0.000088	--	60/60	9.47 ± 1.55	0.83	--
Hexavalent Chromium	0.012	0.0001	60/61	0.04 ± 0.01	0.49	<0.01
Naphthalene	0.000034	0.003	60/60	135.66 ± 15.50	4.61	0.05
Rochester, New York - ROCH						
Acenaphthene	0.000088	--	58/58	12.29 ± 3.55	1.08	--
Benzo(a)pyrene	0.00176	--	42/58	0.09 ± 0.03	0.16	--
Fluoranthene	0.000088	--	58/58	5.68 ± 1.76	0.50	--
Fluorene	0.000088	--	58/58	9.92 ± 2.81	0.87	--
Hexavalent Chromium	0.012	0.0001	41/56	0.01 ± <0.01	0.14	<0.01
Naphthalene	0.000034	0.003	58/58	61.85 ± 10.12	2.10	0.02

-- = a Cancer URE or Noncancer RfC is not available

Observations for the New York sites from Table 18-6 include the following:

- Naphthalene has the highest annual average concentration for both sites.
- Naphthalene also has the highest cancer risk approximations for both sites (4.61 in-a-million) for MONY and 2.10 in-a-million for ROCH). For MONY, this is the only pollutant of interest with a cancer risk approximation greater than 1-in-a-million. For ROCH, acenaphthene also has a cancer risk approximation greater than 1 in-a-million (1.08 in-a-million).
- None of the pollutants of interest for either New York monitoring site have noncancer hazard approximations greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants.

18.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 18-7 and 18-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 18-6. Table 18-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 18-6.

The pollutants listed in Tables 18-7 and 18-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 18.3, both New York sites sampled PAHs and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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 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)**
New York City, New York (Bronx County) - MONY					
Benzene	225.51	Benzene	1.76E-03	Naphthalene	4.61
Ethylbenzene	171.25	Formaldehyde	1.36E-03	Fluorene	0.83
Formaldehyde	104.61	Naphthalene	7.97E-04	Acenaphthene	0.79
Acetaldehyde	62.07	1,3-Butadiene	6.86E-04	Fluoranthene	0.58
Naphthalene	23.44	Ethylbenzene	4.28E-04	Hexavalent Chromium	0.49
1,3-Butadiene	22.86	POM, Group 3	3.35E-04	Benzo(a)pyrene	0.35
Dichloromethane	12.53	Hexavalent Chromium, PM	3.18E-04		
POM, Group 2b	2.17	Arsenic, PM	2.23E-04		
Tetrachloroethylene	1.28	POM, Group 2b	1.91E-04		
POM, Group 1a	0.93	Acetaldehyde	1.37E-04		
Rochester, New York (Monroe County) - ROCH					
Benzene	397.57	Benzene	3.10E-03	Naphthalene	2.10
Ethylbenzene	198.79	Formaldehyde	2.57E-03	Acenaphthene	1.08
Formaldehyde	197.58	1,3-Butadiene	1.59E-03	Fluorene	0.87
Acetaldehyde	106.73	POM, Group 3	1.36E-03	Fluoranthene	0.50
1,3-Butadiene	53.16	Naphthalene	1.02E-03	Benzo(a)pyrene	0.16
Dichloromethane	47.06	Hexavalent Chromium, PM	7.52E-04	Hexavalent Chromium	0.14
Naphthalene	29.93	Arsenic, PM	5.79E-04		
POM, Group 2b	6.47	POM, Group 2b	5.70E-04		
Tetrachloroethylene	1.62	Ethylbenzene	4.97E-04		
POM, Group 6	0.67	POM, Group 5a	3.51E-04		

Table 18-8. 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)**
New York City, New York (Bronx County) - MONY					
Methanol	808.80	Acrolein	999,876.74	Naphthalene	0.05
Toluene	801.90	1,3-Butadiene	11,427.60	Hexavalent Chromium	<0.01
Xylenes	456.53	Formaldehyde	10,674.18		
Benzene	225.51	Naphthalene	7,813.40		
Hexane	197.82	Benzene	7,517.03		
Ethylene glycol	194.12	Acetaldehyde	6,896.87		
Ethylbenzene	171.25	Xylenes	4,565.34		
Formaldehyde	104.61	Cadmium, PM	3,703.33		
Acetaldehyde	62.07	Arsenic, PM	3,455.69		
Hydrochloric acid	55.88	Hydrochloric acid	2,793.99		
Rochester, New York (Monroe County) - ROCH					
Toluene	944.15	Acrolein	641,820.42	Naphthalene	0.02
Xylenes	669.05	1,3-Butadiene	26,578.28	Hexavalent Chromium	<0.01
Methanol	479.68	Formaldehyde	20,160.87		
Benzene	397.57	Benzene	13,252.21		
Hexane	220.52	Acetaldehyde	11,858.72		
Hydrochloric acid	200.68	Hydrochloric acid	10,033.82		
Ethylbenzene	198.79	Naphthalene	9,976.12		
Formaldehyde	197.58	Arsenic, PM	8,971.06		
Acetaldehyde	106.73	Chlorine	7,563.24		
Ethylene glycol	104.78	Manganese, PM	7,454.48		

Observations from Table 18-7 include the following:

- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in Bronx and Monroe Counties.

- Benzene and formaldehyde are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for both New York counties.

- Seven 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 has the highest cancer risk approximation for both sites, appears on both emissions-based lists. Hexavalent chromium appears among the pollutants with the highest toxicity-weighted emissions for both counties, but is not among the highest emitted.

- Emissions of several POM Groups rank among the highest emitted pollutants as well as the highest toxicity-weighted emissions for both New York counties. POM, Group 2b appears on both emissions-based lists for both counties and includes several PAHs sampled for at these sites, including acenaphthene, fluoranthene, and fluorene. POM, Group 5a has one of the highest toxicity-weighted emissions for Monroe County and includes benzo(a)pyrene. POM, Group 6, which ranks 10th for quntity emitted for Monroe County, includes benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene.

Observations from Table 18-8 include the following:

- Methanol, toluene, and xylenes are the highest emitted pollutants with noncancer RfCs in both Bronx and Monroe Counties, although not necessarily in that order.

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

- Five 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. Hexavalent chromium does not appear on either emissions-based list for either New York county. None of the other pollutants of interest for either site have noncancer RfCs.

18.6 Summary of the 2011 Monitoring Data for MONY and ROCH

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

- *Seven pollutants failed screens for MONY while four pollutants failed screens for ROCH. The same four pollutants were identified as pollutants of interest via the risk-based screening process for MONY and ROCH.*

- *Naphthalene had the highest annual average concentration among the pollutants of interest for both sites.*

- *For both sites, concentrations of acenaphthene, fluoranthene, and fluorene were highest during the warmer months of the year while concentrations of benzo(a)pyrene were highest during the colder months of the year.*

19.0 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.

19.1 Site Characterization

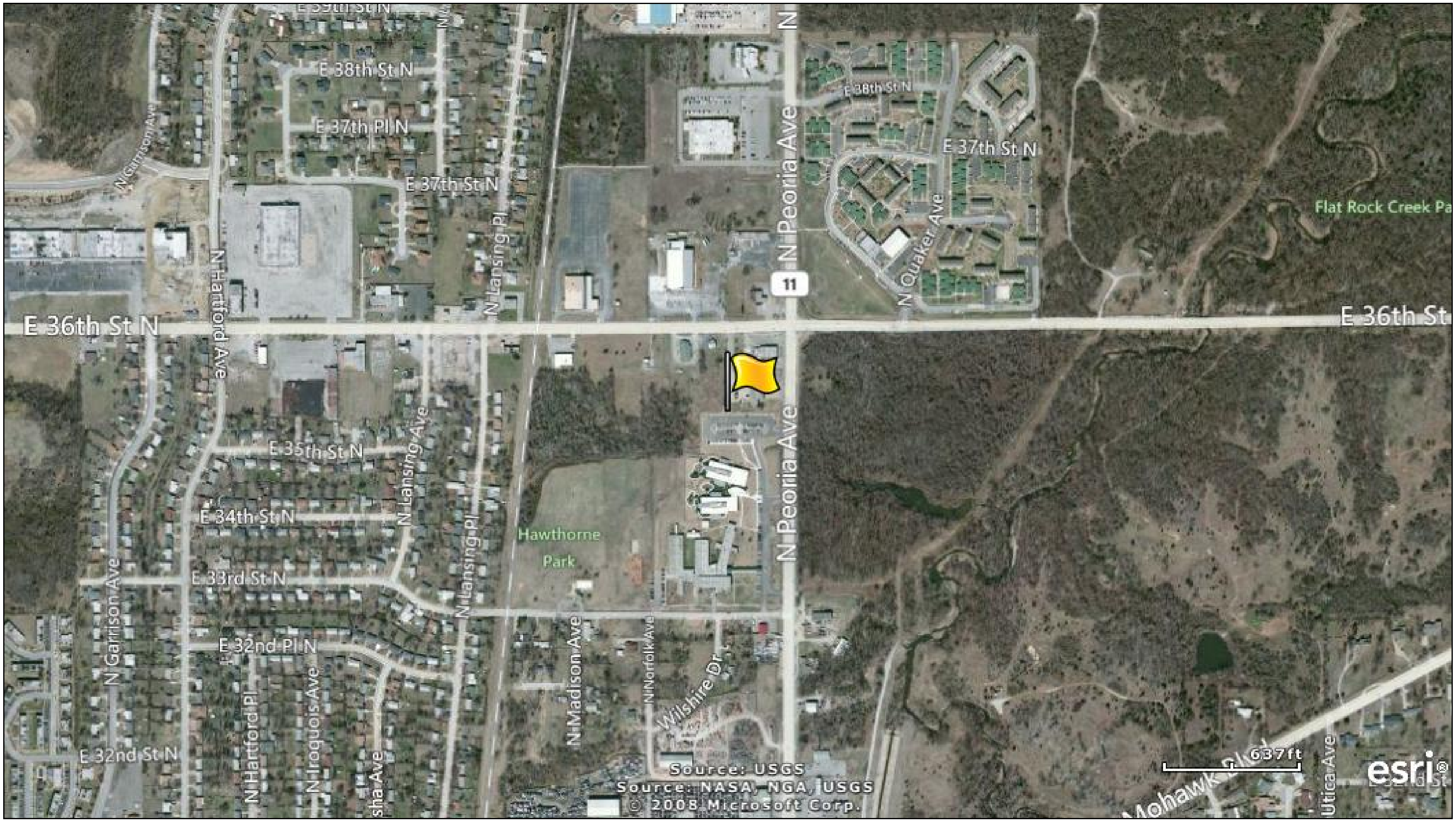
This section characterizes the Oklahoma monitoring sites by providing geographical and physical information about the locations of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist 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; one site is located in Oklahoma City (OCOK) and another is located just outside Oklahoma City in Midwest City (MWOK).

Figures 19-1 and 19-2 are composite satellite images retrieved from ArcGIS Explorer showing the Tulsa monitoring sites in their urban locations. Figure 19-3 identifies nearby point source emissions locations by source category, as reported in the 2008 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 radii are still visible on the map, but have been grayed out in order to show emissions sources just outside the boundary. Figures 19-4 through 19-8 are the composite satellite maps and emissions source maps for the Pryor Creek and Oklahoma City sites. Table 19-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 19-1. Tulsa, Oklahoma (TOOK) Monitoring Site

Figure 19-2. Tulsa, Oklahoma (TMOK) Monitoring Site



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

Figure 19-3. NEI Point Sources Located Within 10 Miles of TMOK and TOOK

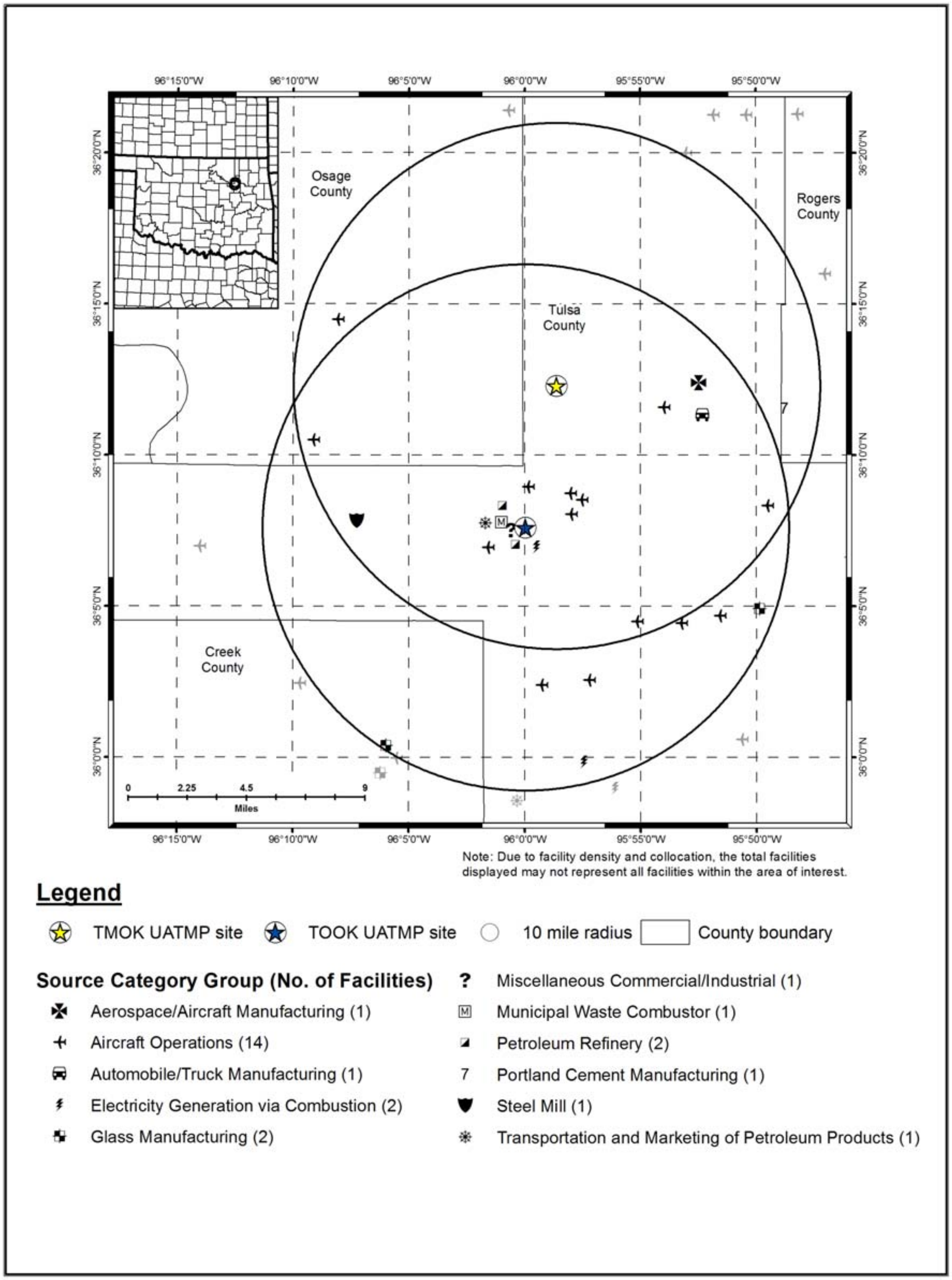
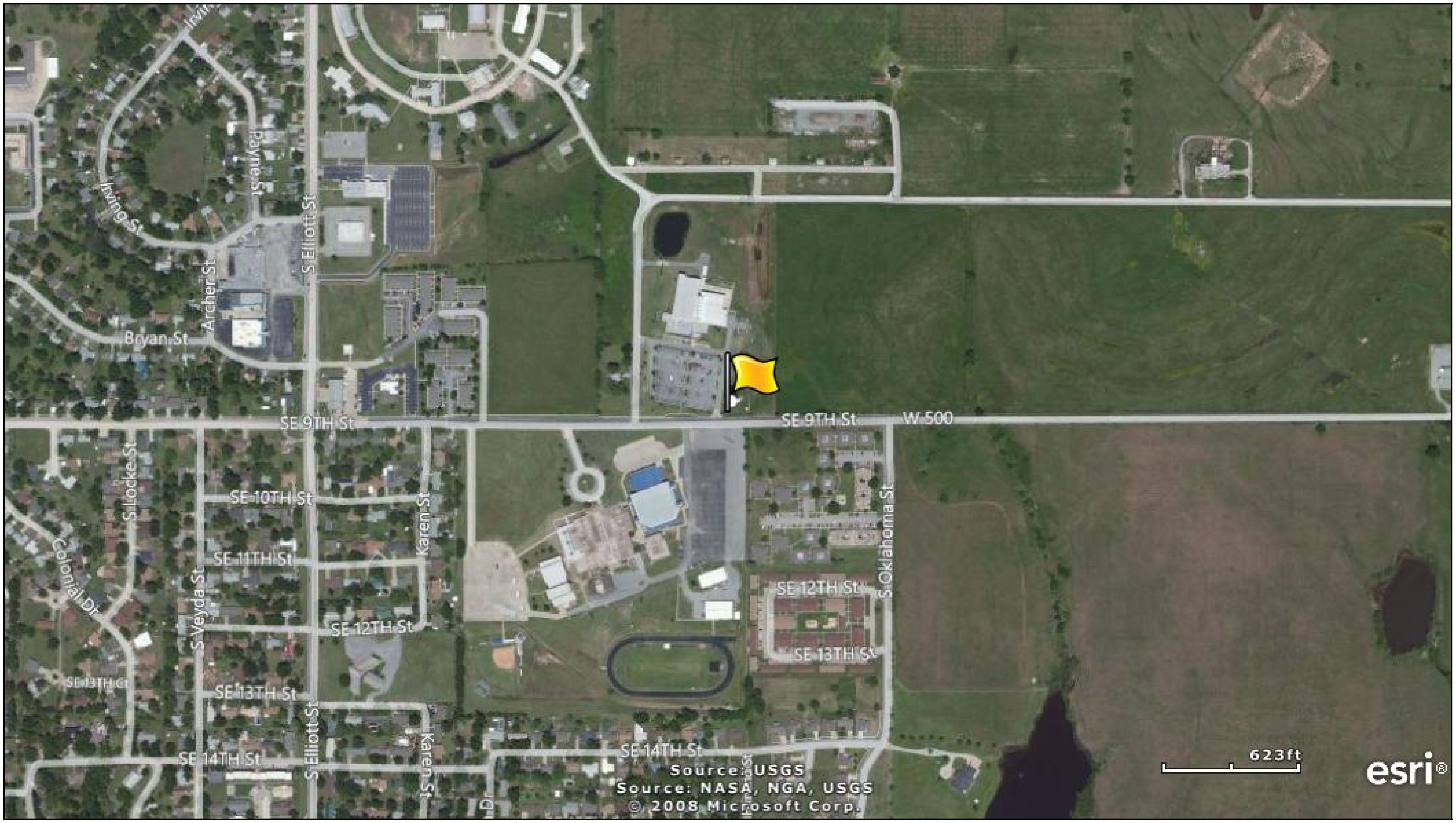
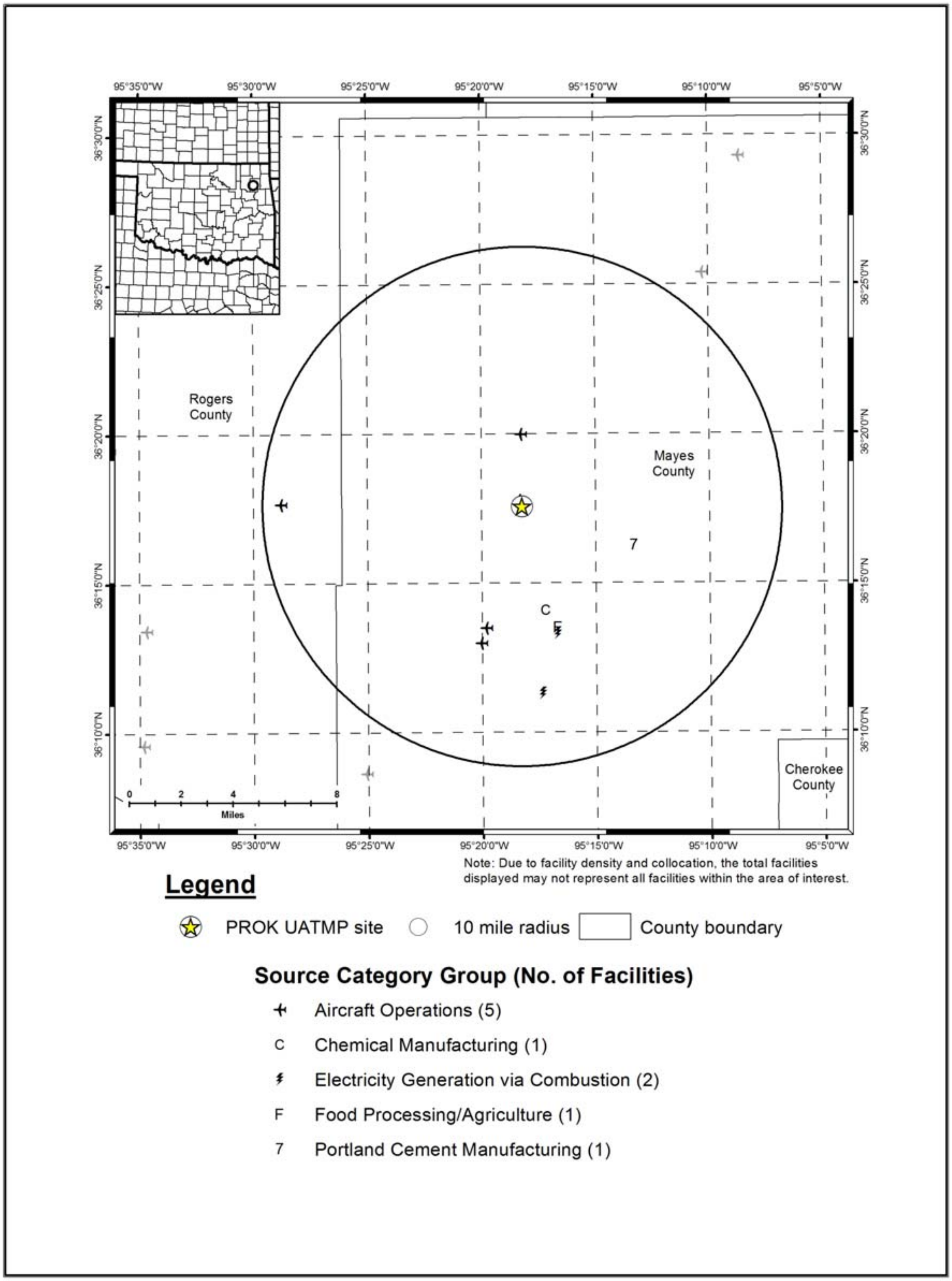

Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 19-4. Pryor Creek, Oklahoma (PROK) Monitoring Site



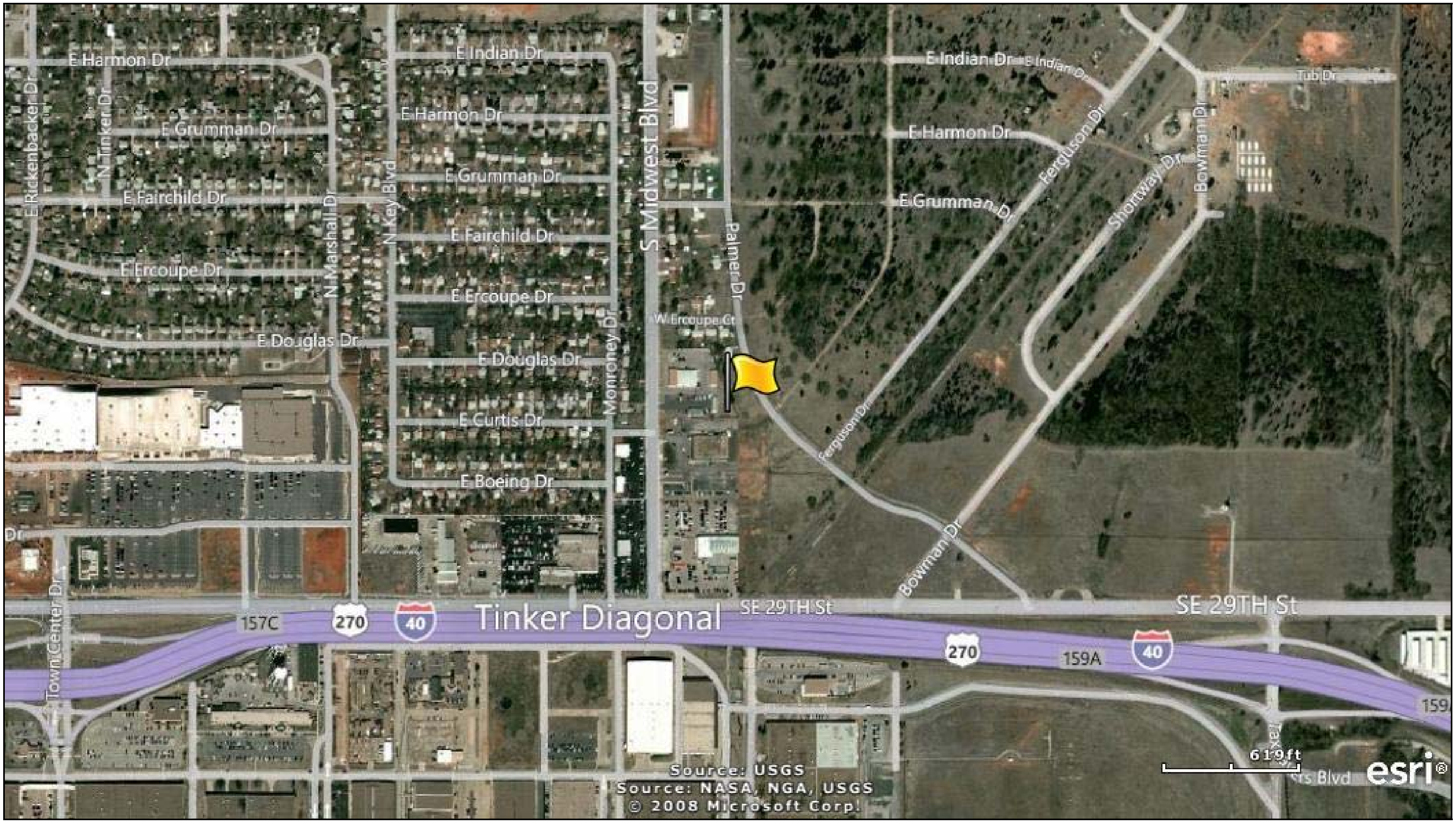
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 19-5. 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 19-6. Midwest City, Oklahoma (MWOK) Monitoring Site



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

Figure 19-7. Oklahoma City, Oklahoma (OCOK) Monitoring Site

Figure 19-8. NEI Point Sources Located Within 10 Miles of MWOK and OCOK

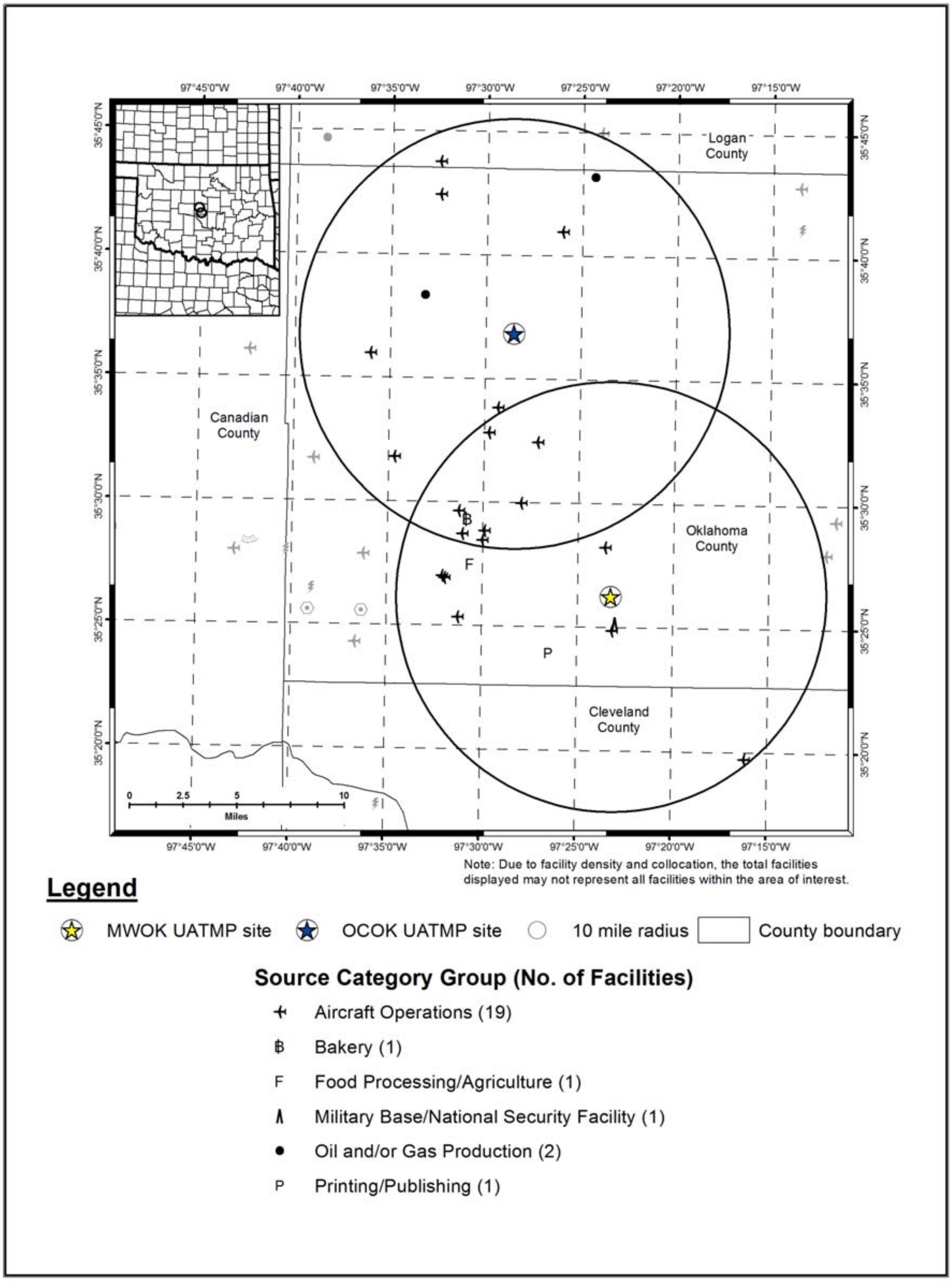


Table 19-1. Geographical Information for the Oklahoma Monitoring Sites

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 and H_2S.
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.
PROK	40-097-0187	Pryor Creek	Mayes	Not in an MSA	36.292941, -95.303409	Industrial	Suburban	None.
MWOK	40-109-0041	Midwest City	Oklahoma	Oklahoma City, OK MSA	35.437641, -97.387254	Commercial	Urban/City Center	None.
OCOK	40-109-1037	Oklahoma City	Oklahoma	Oklahoma City, OK MSA	35.614131, -97.475083	Residential	Suburban	SO_2, NO, NO_2, NO_x, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, and $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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. As shown in Figure 19-1, an oil refinery is located just south of the site. Another refinery is located to the northwest of the site, on the other side of I-244. A rail yard is located on the opposite side of I-244.

TMOK is located in north Tulsa on the property of Fire Station Number 24. As shown in Figure 19-2, 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 19-3 shows that the Tulsa sites are located approximately 5 miles apart, with TMOK to the north and TOOK to the south. Most of the emissions sources are clustered around TOOK, while there are no point sources within a couple miles of TMOK. The source category with the greatest number of sources surrounding the Tulsa sites is the aircraft operations source category, which includes airports as well as small runways, heliports, or landing pads. Point sources closest to TOOK include petroleum refineries, a municipal waste combustor, 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 19-4. The monitoring site is located due north (and downwind) of an industrial park located a few miles to the south. Figure 19-5 shows that there are relatively few emissions sources surrounding PROK and that the aircraft operations source category has the greatest number of emissions sources near the site. An aircraft operations facility is located a quarter mile north of PROK but is located under the site symbol in Figure 19-5. The aforementioned industrial park is represented in Figure 19-5 by the chemical manufacturing and food processing/agriculture facilities located to the south of PROK.

The MWOK monitoring site is located in Midwest City, southeast of Oklahoma City. The site is located in a commercial area on South Midwest Boulevard just north of I-40. This site is located at a school enrollment center just north of Tinker Air Force Base, the northern portion of which can be seen just south of I-40 in Figure 19-6. Residential areas are located to the northwest and north, while an extension of Tinker AFB is located to the east.

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 19-7.

Figure 19-8 shows that MWOK 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 (west and northwest of MWOK and south of OCOK). The source category with the greatest number of sources surrounding the two sites is the aircraft operations source category. The point source closest to MWOK is the military base; the source closest to OCOK is a heliport.

Table 19-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Oklahoma monitoring sites. Table 19-2 includes county-level population and vehicle registration information. Table 19-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 19-2 also contains traffic volume information for each site. Finally, Table 19-2 presents the county-level daily VMT for Tulsa, Mayes, and Oklahoma Counties.

Table 19-2. Population, Motor Vehicle, and Traffic Information for the Oklahoma Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
TOOK	610,599	603,926	0.99	453,918	448,957	63,000	20,348,926
TMOK				327,223	323,647	12,600	
PROK	41,389	39,968	0.97	30,326	29,285	15,100	1,656,458
MWOK	732,371	832,160	1.14	376,168	427,423	40,900	27,190,328
OCOK				378,154	429,679	40,900	

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Oklahoma Tax Commission (OKTC, 2011)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data from the Oklahoma DOT (OK DOT, 2011)
[5] County-level VMT reflects 2011 data from the Oklahoma DOT (OK DOT, 2012)

Observations from Table 19-2 include the following:

- The Mayes County population is significantly lower than the populations for Tulsa and Oklahoma County. This is also true of the 10-mile populations. Compared to other NMP monitoring sites, the Tulsa and Oklahoma City populations are in the middle of the range, while Pryor Creek's population is on the low end.

- The Mayes County vehicle registration is also significantly lower than vehicle registration for Tulsa and Oklahoma Counties. Similar observations can be made for the 10-mile vehicle registration estimates. These observations are expected given the rural nature of the area surrounding PROK compared to the urban location of the Tulsa and Oklahoma City sites. Compared to other NMP monitoring sites, the vehicle ownership estimates follow a similar pattern as the populations.

- The county-level registration-to-population ratios range from 0.97 vehicles per person for PROK to 1.14 vehicles per person for MWOK and OCOK.

- 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 TMOK and PROK are in the bottom third among NMP sites while the traffic for TOOK is in the middle of the range. Although the traffic counts are the same for MWOK and OCOK, the counts represent different locations. The following list provides the roadways or intersections from which the traffic data were obtained: TOOK – I-244, north of the split with US-75; TMOK – East 36th Street North near North Peoria Avenue; PROK – Highway 69, south of Graham Avenue (Highway 20); MWOK – I-40, west of Tinker Air Force Base; OCOK – Highway 77 north of Highway 44 (before the bend at West 33rd Street).

- County-level VMT is greatest for Oklahoma County and ranks 11th compared to other NMP sites. VMT is the smallest for Mayes County and is among the smallest VMT compared to other sites.

19.2 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.

19.2.1 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 very warm summers and cool winters. Precipitation is generally concentrated in the spring and summer months, with spring as the wettest season, 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. A southerly wind prevails for much of the year, bringing warm, moist air northward from the Gulf of Mexico. 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 county; tornadoes are more prevalent here than any other region in the U.S. (Bair, 1992; NCDC, 2013; and NOAA, 2013b).

19.2.2 Meteorological Conditions in 2011

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). 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 MWOK) 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 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 for 2011. Also included in Table 19-3 is the 95 percent confidence interval for each parameter. As shown in Table 19-3, average meteorological conditions on sample days were representative of average weather conditions throughout the year for most of the Oklahoma monitoring sites. The differences are greatest for MWOK, where sample days appear slightly warmer than conditions experienced throughout the year, but the difference is not statistically significant. Sampling was discontinued at MWOK at the end of November 2011 in order to move the instruments to a new sampling location, which likely explains these differences.

19.2.3 Back Trajectory Analysis

Figure 19-9 is the composite back trajectory map for days on which samples were collected at the TOOK monitoring site in 2011. Included in Figure 19-9 are four back trajectories per sample day. Figure 19-10 is the corresponding cluster analysis. Similarly, Figures 19-11 through 19-18 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 19-9 through 19-18 represents 100 miles.

Table 19-3. Average Meteorological Conditions near the Oklahoma Monitoring Sites

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)
Tulsa, Oklahoma - TOOK									
Richard Lloyd Jones Jr. Airport 53908 (36.04, -95.98)	6.12 miles 172° (S)	Sample Day	74.5 ± 5.3	62.7 ± 5.2	47.0 ± 4.5	53.9 ± 4.3	60.8 ± 2.9	1015.8 ± 2.1	6.2 ± 0.9
		2011	74.1 ± 2.2	62.1 ± 2.1	46.8 ± 1.8	53.6 ± 1.7	61.6 ± 1.3	1015.8 ± 0.7	5.6 ± 0.3
Tulsa, Oklahoma - TMOK									
Tulsa International Airport 13968 (36.20, -95.89)	4.81 miles 96° (E)	Sample Day	73.4 ± 5.4	62.7 ± 5.2	46.1 ± 4.3	53.4 ± 4.2	58.8 ± 3.1	1014.7 ± 2.1	9.1 ± 1.1
		2011	73.3 ± 2.2	62.5 ± 2.1	46.0 ± 1.8	53.3 ± 1.7	59.2 ± 1.4	1014.6 ± 0.7	8.4 ± 0.4
Pryor Creek, Oklahoma - PROK									
Claremore Regional Airport 53940 (36.29, -95.47)	8.66 miles 270° (W)	Sample Day	70.4 ± 5.2	58.8 ± 5.1	45.9 ± 4.3	51.6 ± 4.3	66.4 ± 2.9	NA	7.5 ± 1.0
		2011	71.0 ± 2.1	59.7 ± 2.0	46.9 ± 1.8	52.6 ± 1.7	66.7 ± 1.3	NA	6.8 ± 0.4
Midwest City, Oklahoma - MWOK									
Tinker AFB/Airport 13919 (35.42, -97.39)	1.57 miles 178° (S)	Sample Day	76.3 ± 5.5	64.4 ± 5.3	47.0 ± 4.5	54.6 ± 4.3	57.8 ± 3.6	1013.7 ± 2.0	11.3 ± 1.2
		2011	74.6 ± 2.2	63.0 ± 2.1	45.8 ± 1.8	53.5 ± 1.7	58.5 ± 1.6	1014.6 ± 0.8	10.3 ± 0.4
Oklahoma City, Oklahoma - OCOK									
Wiley Post Airport 03954 (35.53, -97.65)	10.68 miles 240° (WSW)	Sample Day	74.5 ± 5.6	63.1 ± 5.4	44.5 ± 4.3	52.8 ± 4.2	55.7 ± 3.4	1014.4 ± 2.2	11.9 ± 1.3
		2011	74.5 ± 2.2	63.1 ± 2.2	44.4 ± 1.7	52.8 ± 1.7	55.8 ± 1.6	1014.3 ± 0.8	10.9 ± 0.4

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

NA = Sea level pressure was not recorded at the Claremore Regional Airport

Figure 19-9. 2011 Composite Back Trajectory Map for TOOK

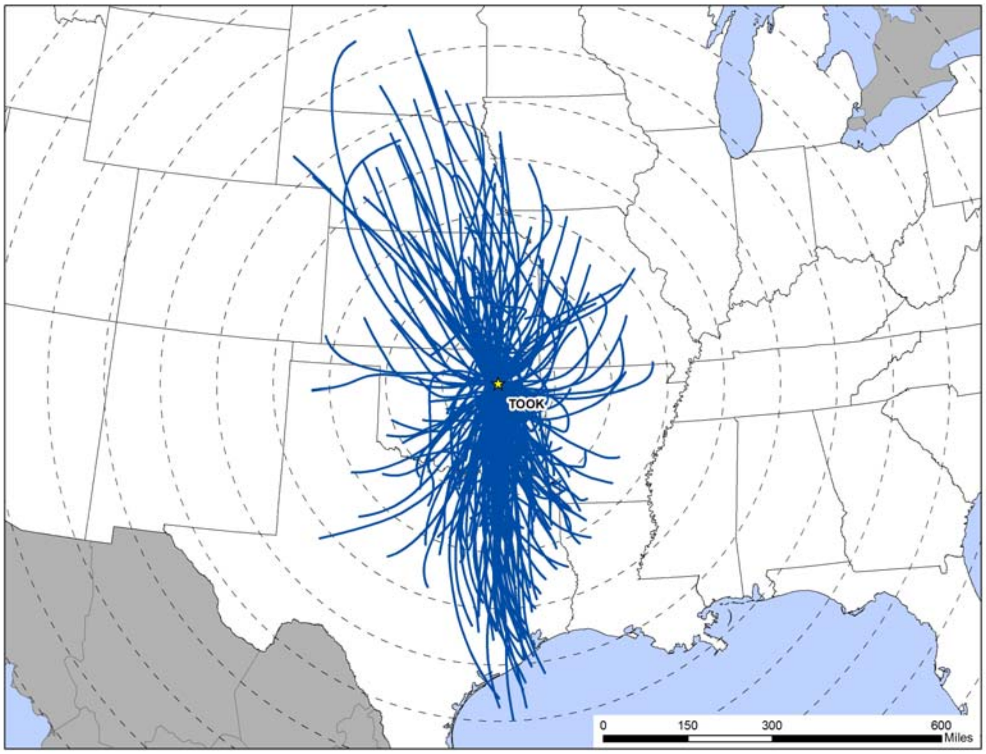


Figure 19-10. Back Trajectory Cluster Map for TOOK

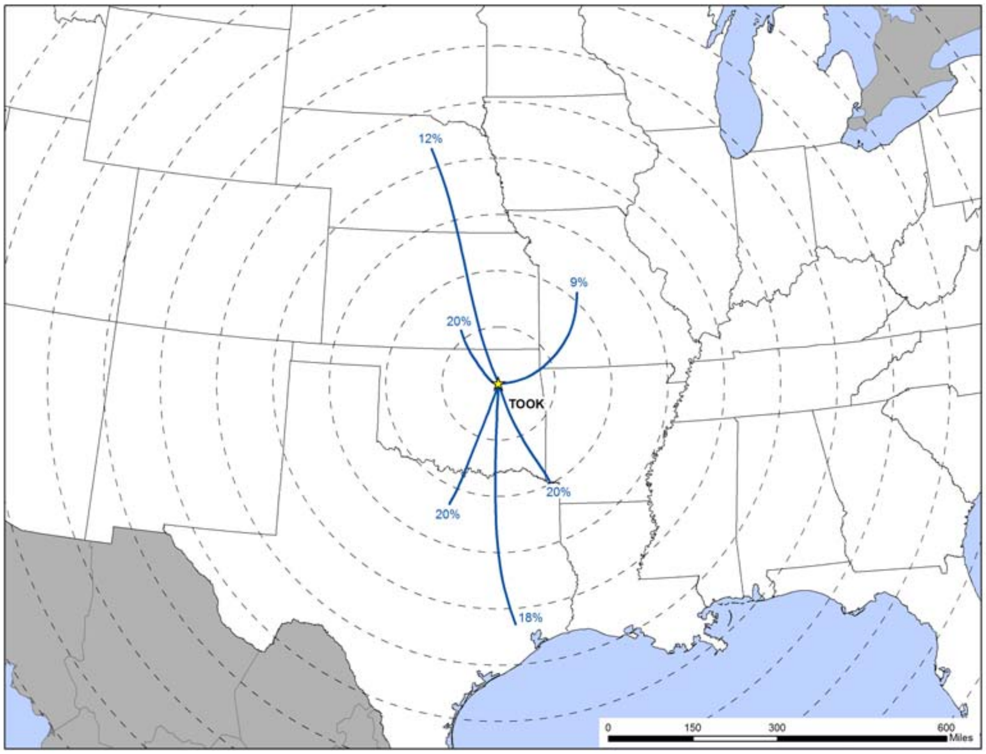


Figure 19-11. 2011 Composite Back Trajectory Map for TMOK

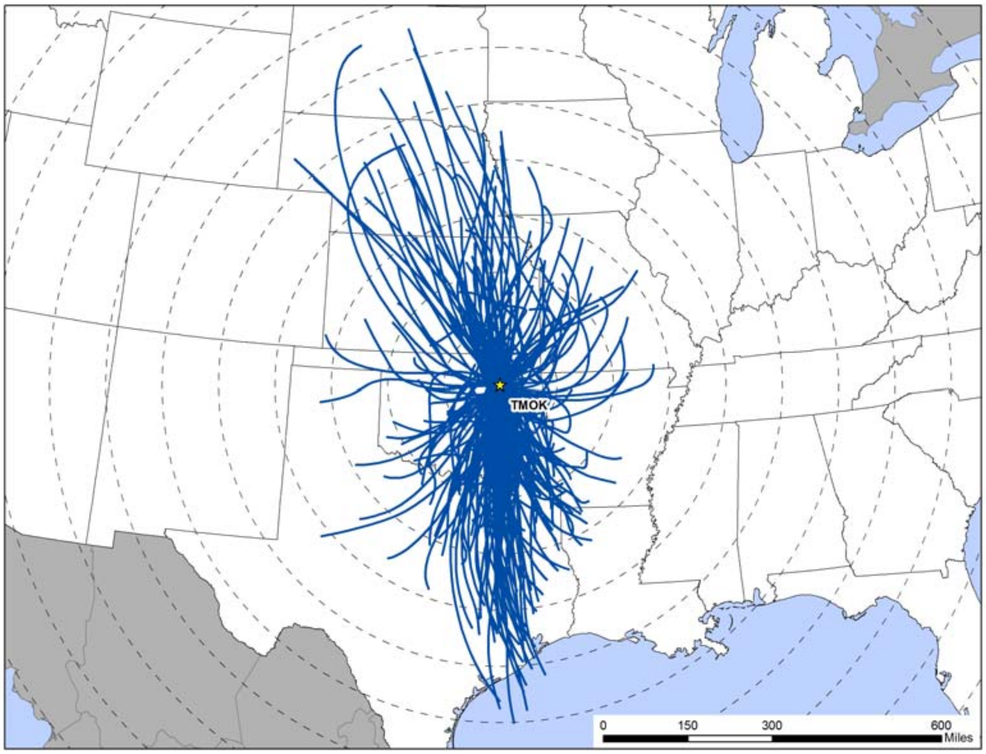


Figure 19-12. Back Trajectory Cluster Map for TMOK

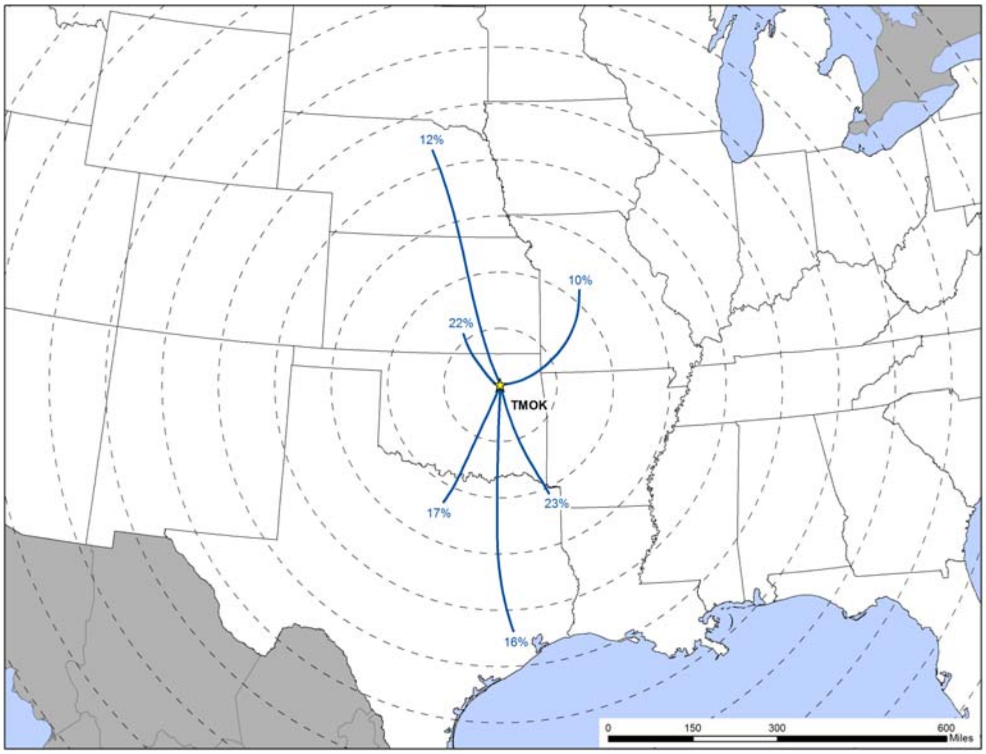


Figure 19-13. 2011 Composite Back Trajectory Map for PROK

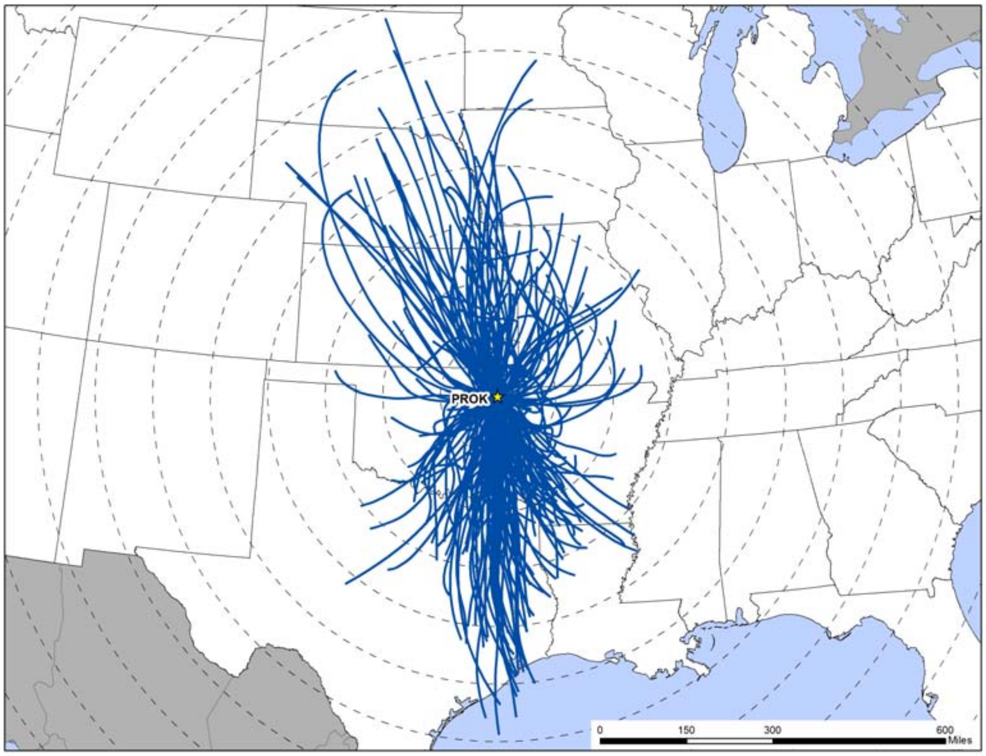


Figure 19-14. Back Trajectory Cluster Map for PROK

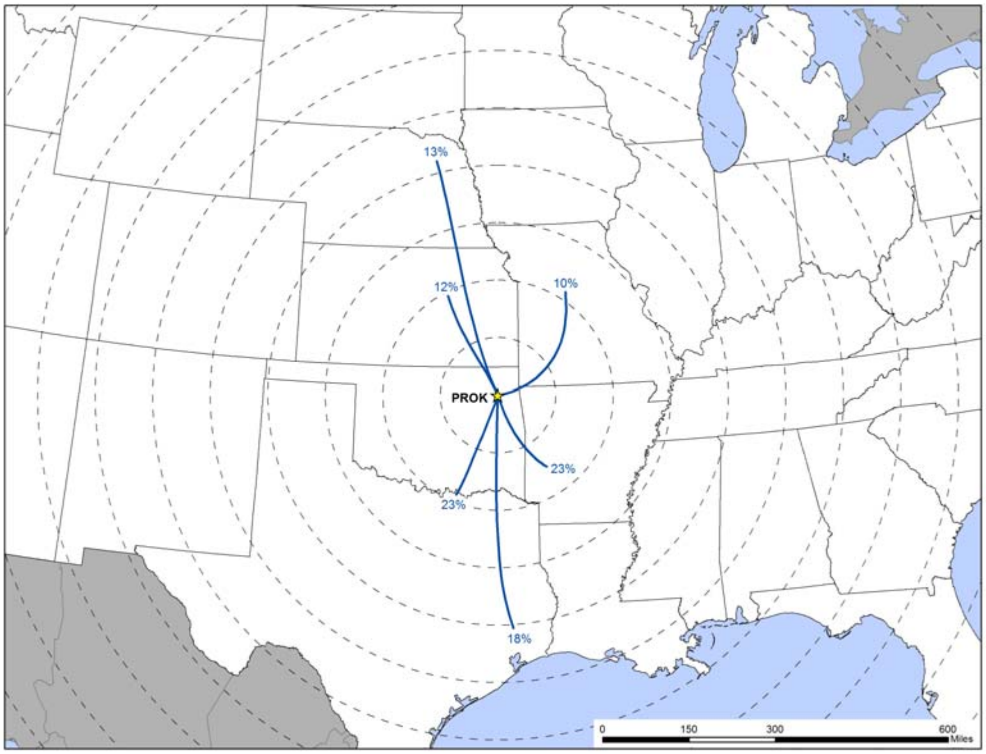


Figure 19-15. 2011 Composite Back Trajectory Map for MWOK

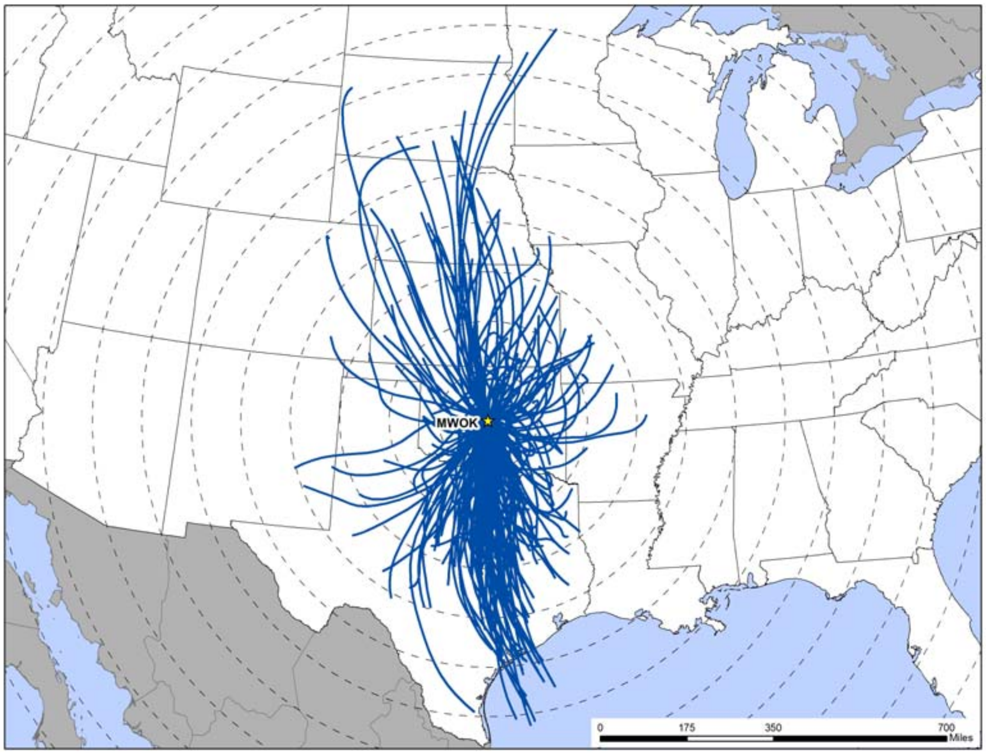


Figure 19-16. Back Trajectory Cluster Map for MWOK

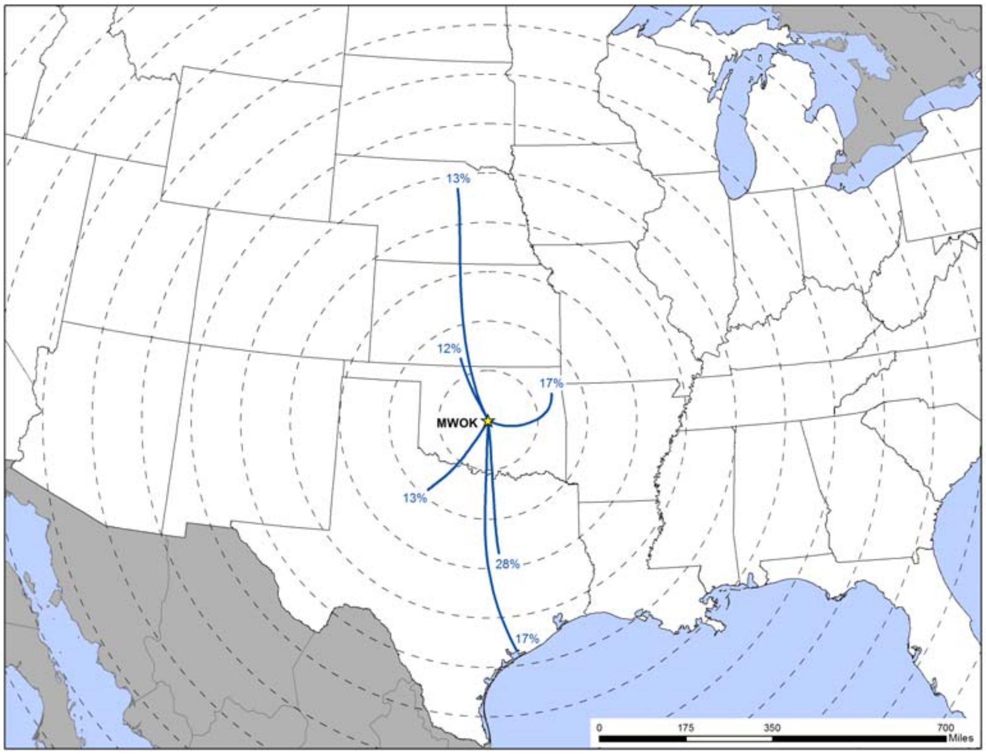


Figure 19-17. 2011 Composite Back Trajectory Map for OCOK

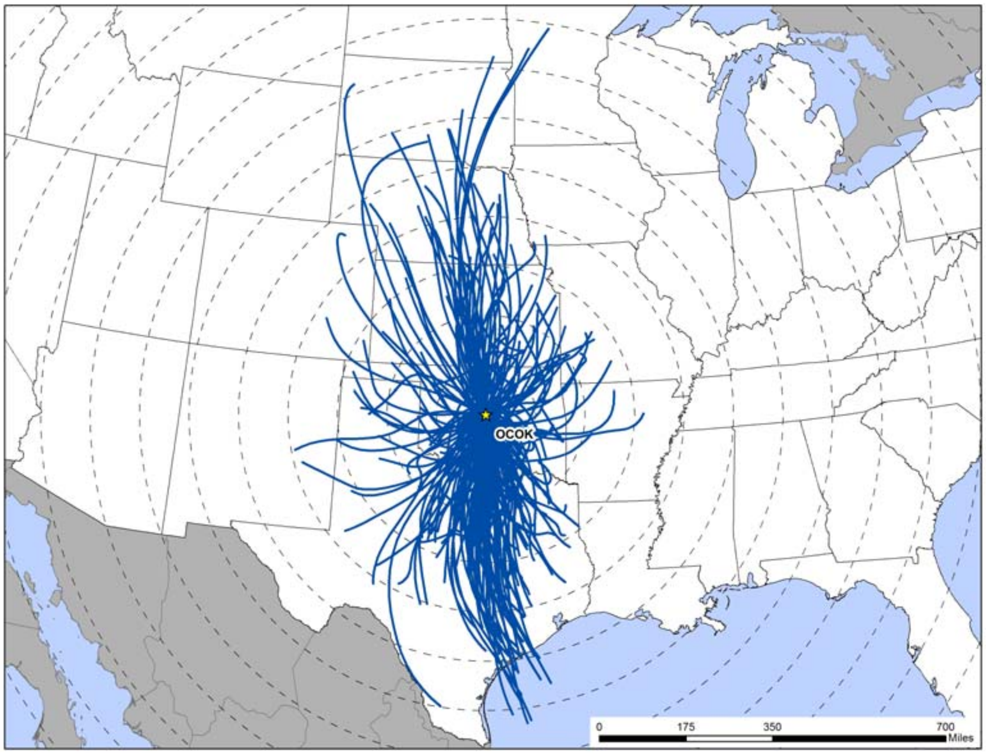
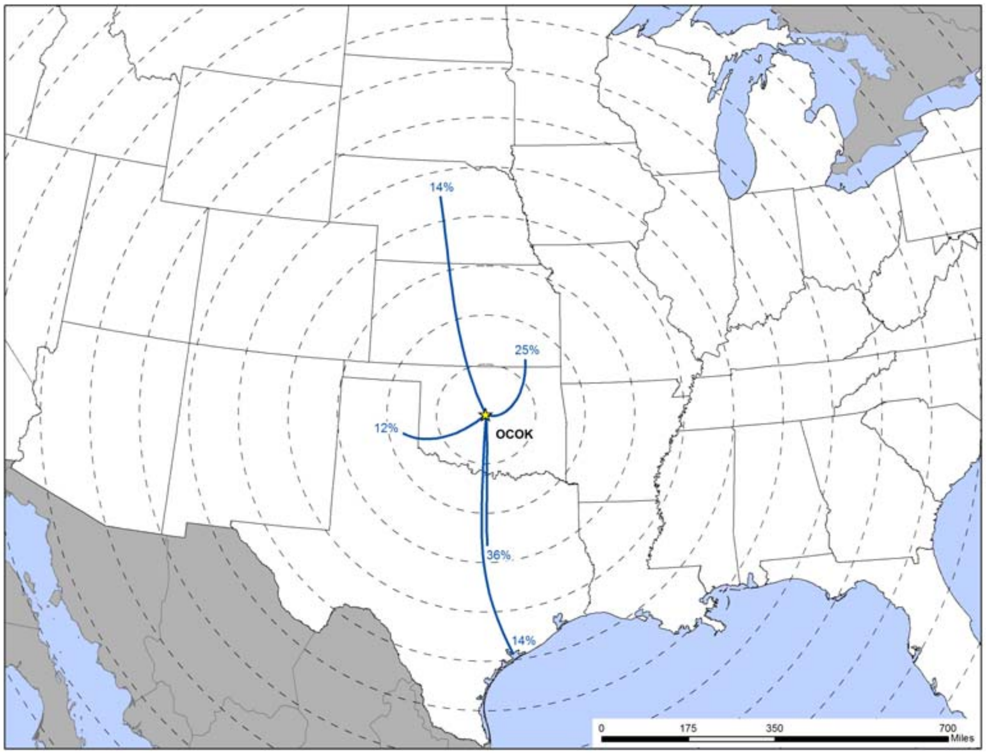


Figure 19-18. Back Trajectory Cluster Map for OCOK



Observations from Figures 19-9 through 19-18 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 domains for the Oklahoma City and Midwest City sites were among the largest compared to other NMP sites, ranking second and third, respectively, based on average trajectory length. The farthest away a back trajectory originated was over northern Minnesota, or approximately 800 miles away, with an average trajectory length of nearly 300 miles. The air shed domains for TOOK, TMOK, and PROK round out the top 10 sites based on air shed domain size compared to other NMP sites. For these sites, the farthest away a back trajectory originated was over north-central South Dakota, or greater than 650 miles away. The average trajectory length for these sites ranged from 268 miles (PROK) to 277 miles (TOOK).

- Each of the sites exhibits a strong 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.

- For the Tulsa and Pryor Creek sites, greater than 60 percent of back trajectories originated from the southeast to southwest, generally over eastern Texas. Another one-third of trajectories originated generally from the west to northwest to north of the sites, but of varying lengths. The remaining back trajectories originated from the northeast to east, generally over the state of Missouri.

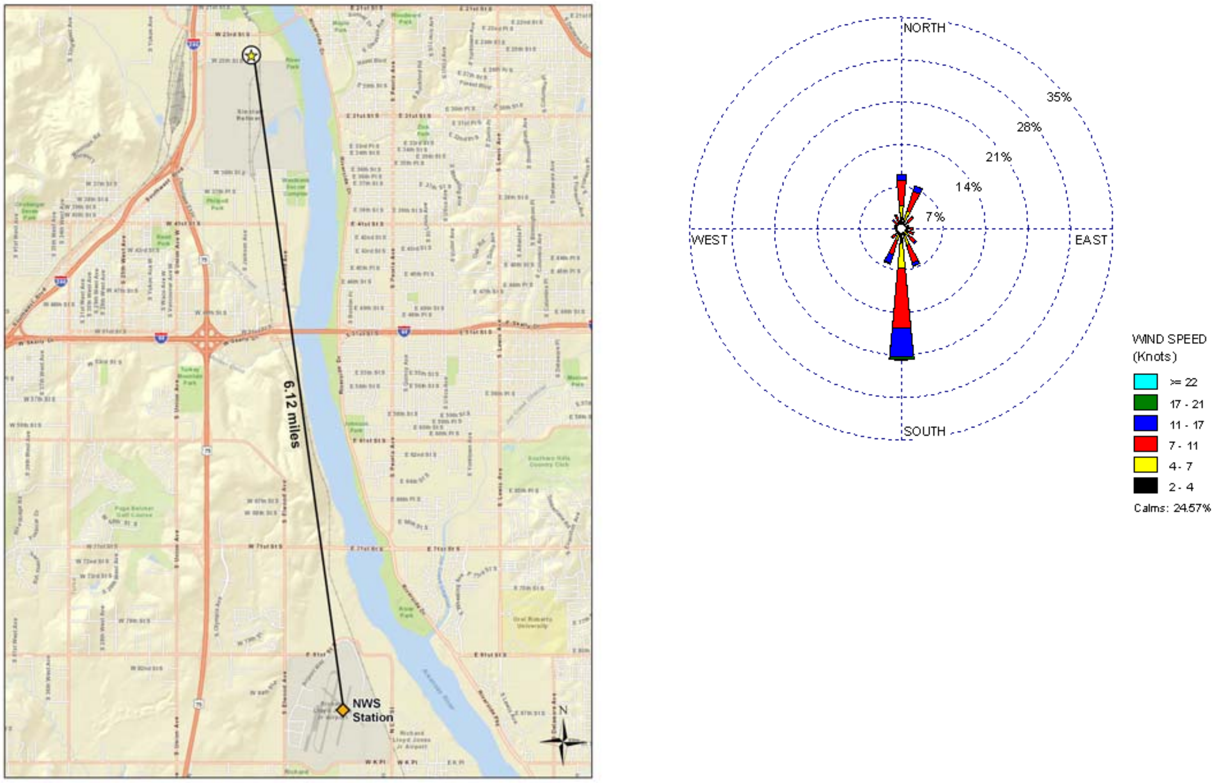
- The cluster analysis maps for the Oklahoma City and Midwest City sites are similar to each other and to the cluster maps for the Tulsa and Pryor Creeks sites in cluster distribution patterns. One difference between the cluster maps for OCOK and MWOK is the number of cluster trajectories. Back trajectories originating over the panhandles of Texas and Oklahoma are represented by a single cluster for OCOK (12 percent). For MWOK, the back trajectories originating over the panhandle of Texas are represented by their own cluster trajectory (13 percent), while those originating over the panhandle of Oklahoma are included with shorter, northward-originating trajectories as well as others originating within the state of Oklahoma. These are represented by the cluster trajectory originating just north of the Kansas-Oklahoma border (12 percent).

19.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS weather stations at Richard Lloyd Jones Junior Airport (for TOOK), Tulsa International Airport (for TMOK), Claremore Regional Airport (for PROK), Wiley Post Airport (for OCOK), and Tinker Air Force Base (for MWOK) 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.

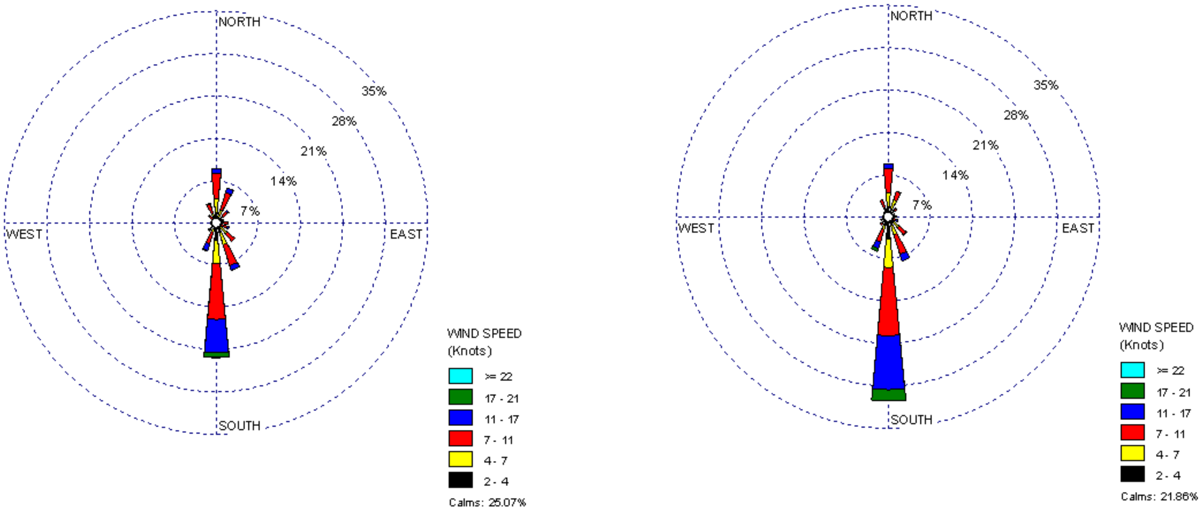
Figure 19-19 presents a map showing the distance between the NWS station and TOOK, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 19-19 also presents three different wind roses for the TOOK monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 19-20 through 19-23 present the distance map and wind roses for the remaining Oklahoma sites.

Figure 19-19. Wind Roses for the Richard Lloyd Jones Jr. Airport Weather Station near TOOK



Distance between TOOK and NWS Station

2001-2010 Historical Wind Rose

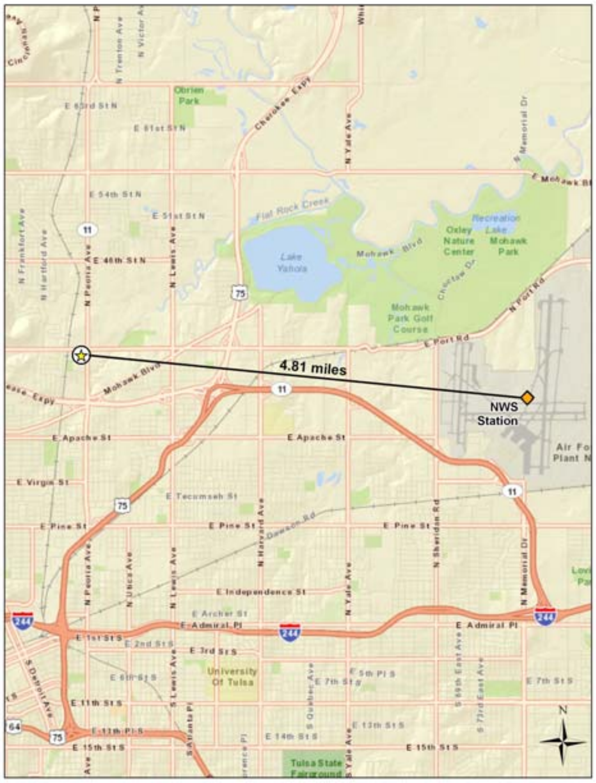


2011 Wind Rose

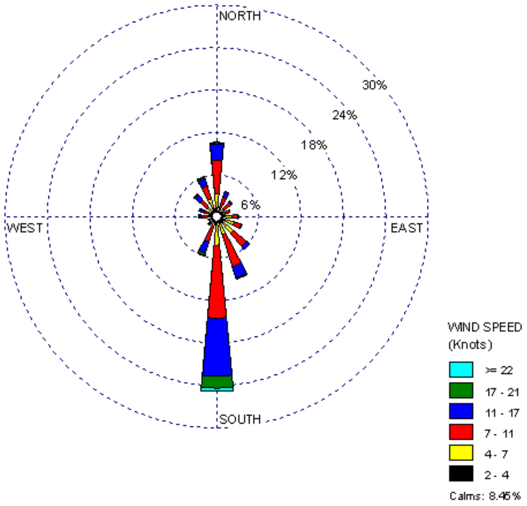
Sample Day Wind Rose

Figure 19-20. Wind Roses for the Tulsa International Airport Weather Station near TMOK

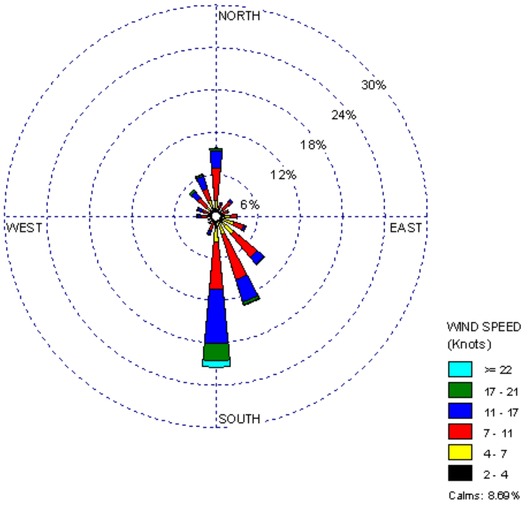
Distance between TMOK and NWS Station



2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

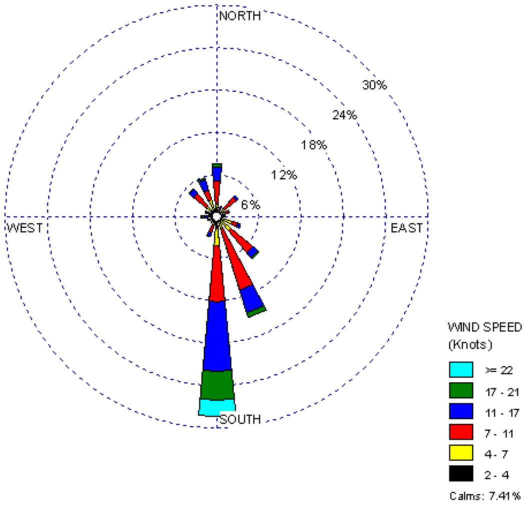
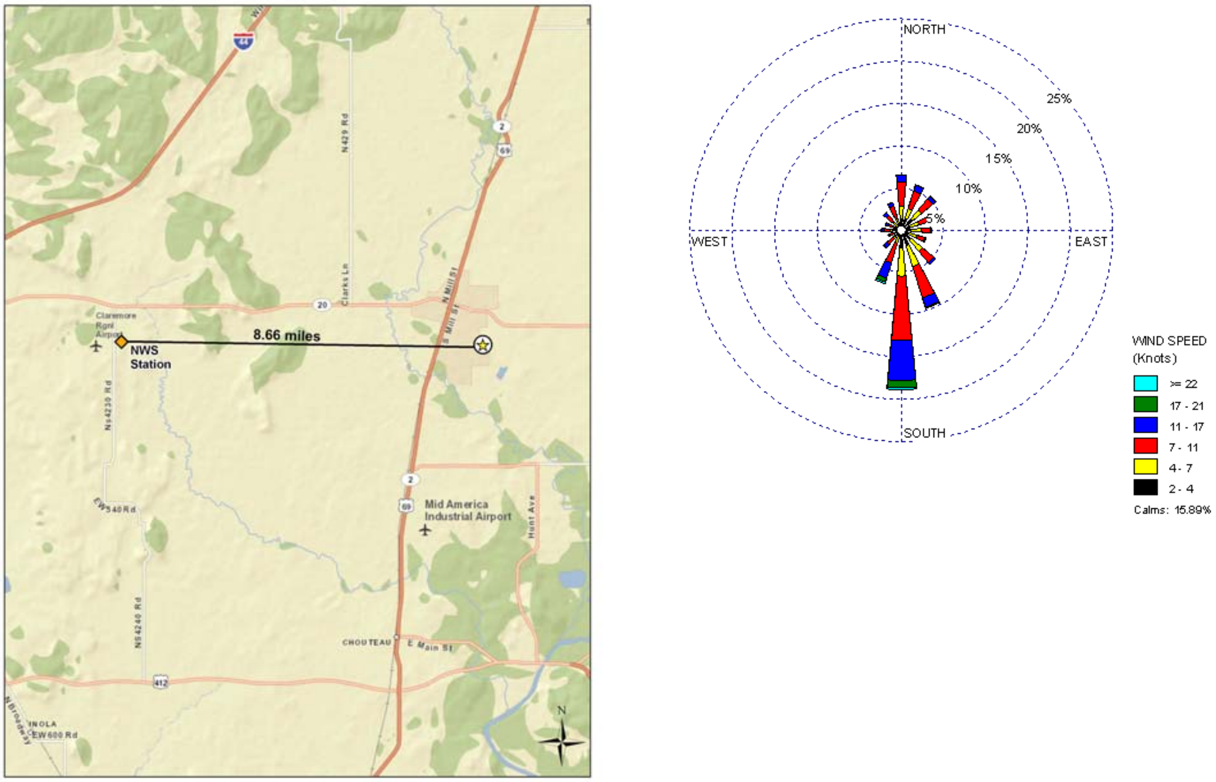
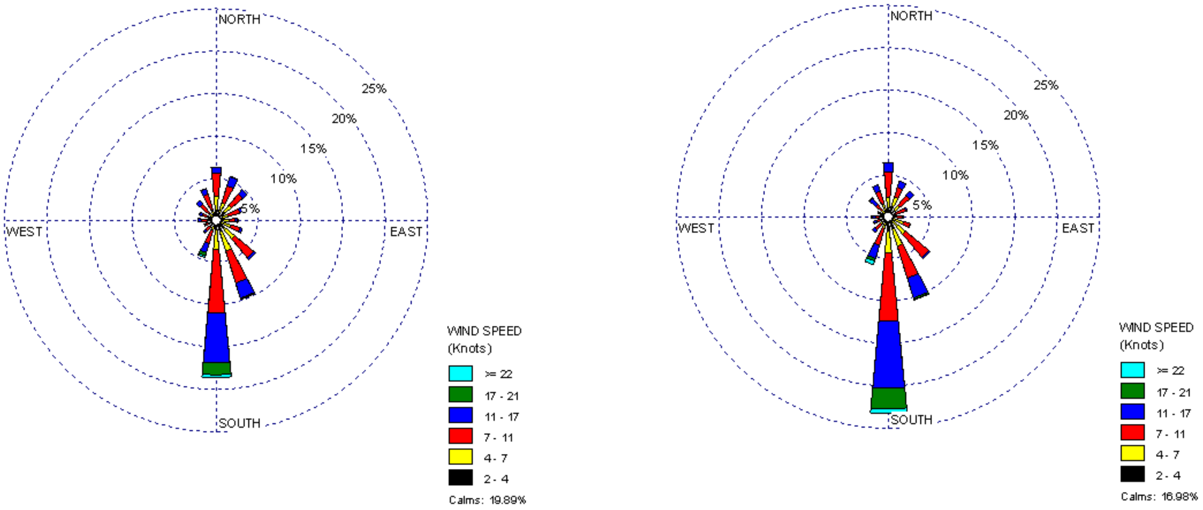


Figure 19-21. Wind Roses for the Claremore Regional Airport Weather Station near PROK



Distance between PROK and NWS Station

2003-2010 Historical Wind Rose

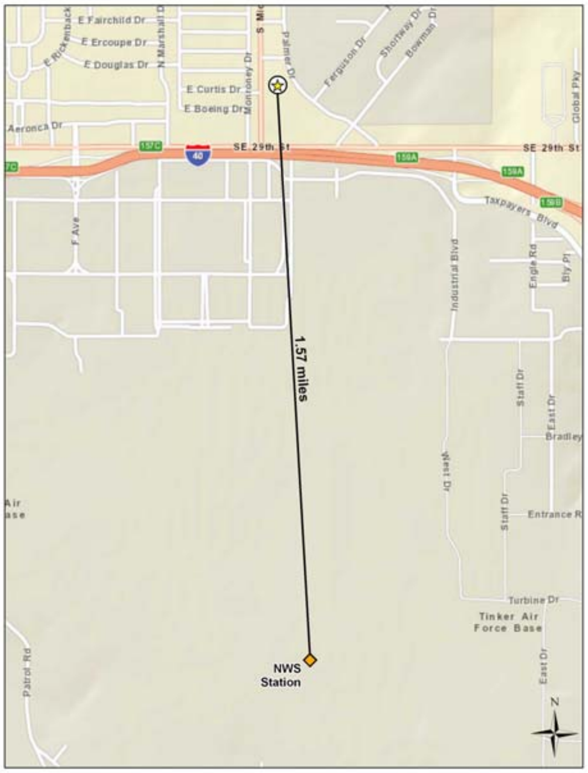


2011 Wind Rose

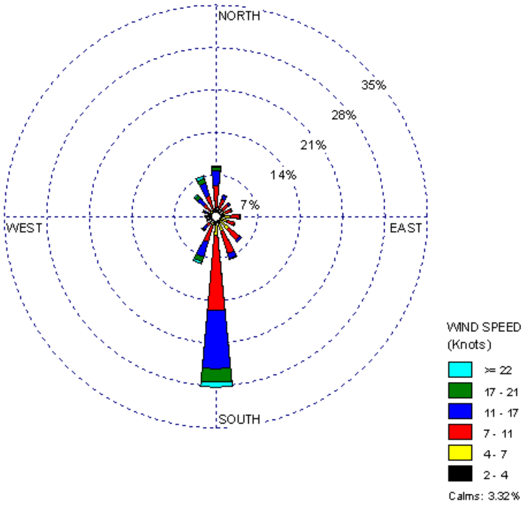
Sample Day Wind Rose

Figure 19-22. Wind Roses for the Tinker Air Force Base Airport Weather Station near MWOK

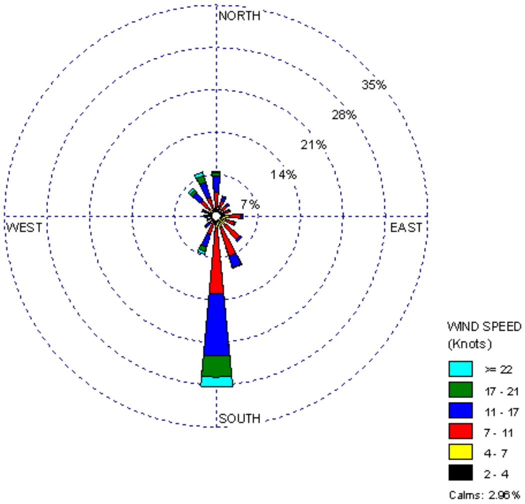
Distance between MWOK and NWS Station



2006-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

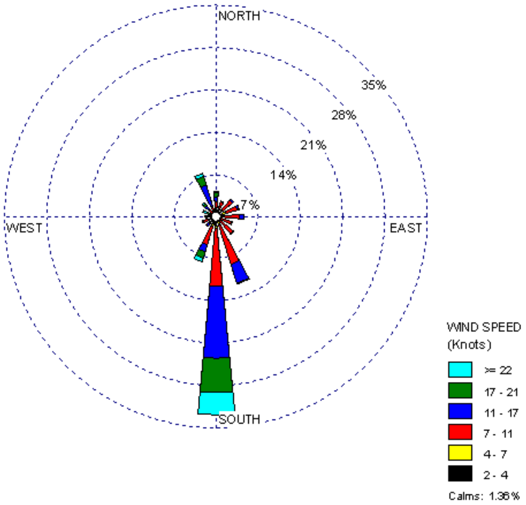
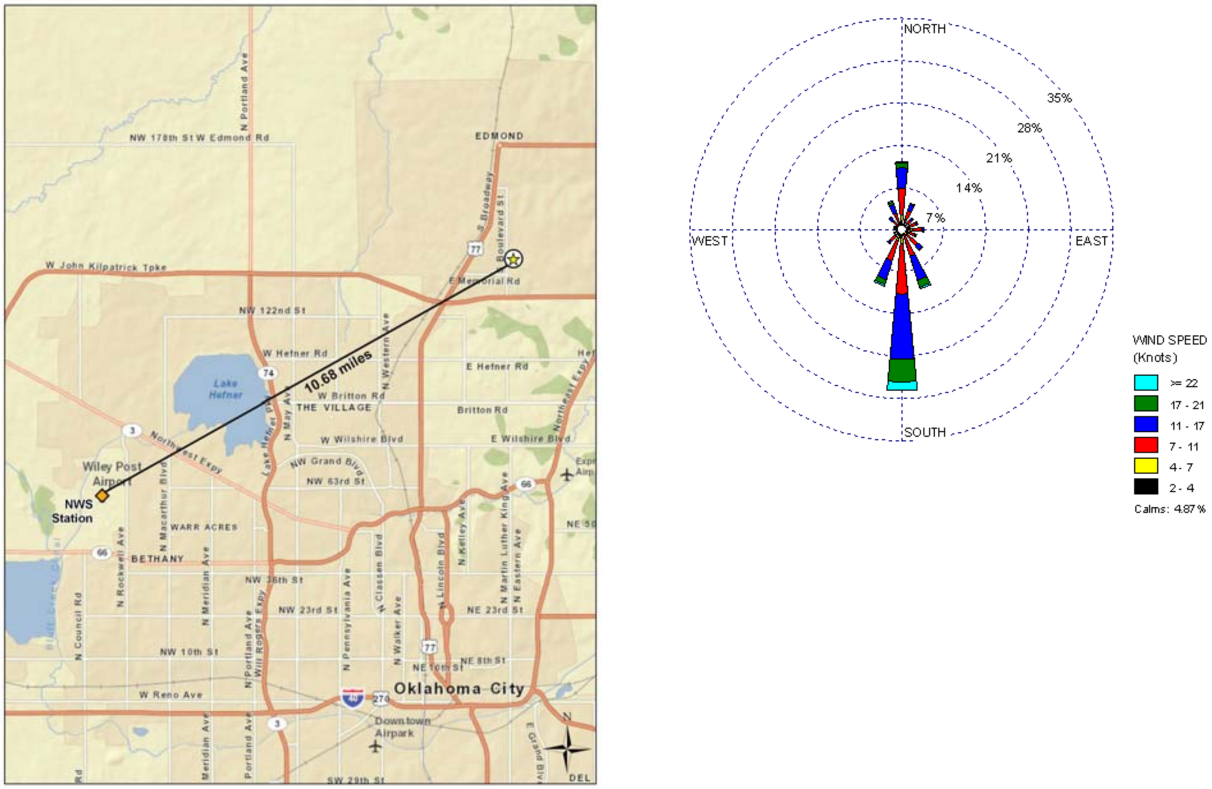
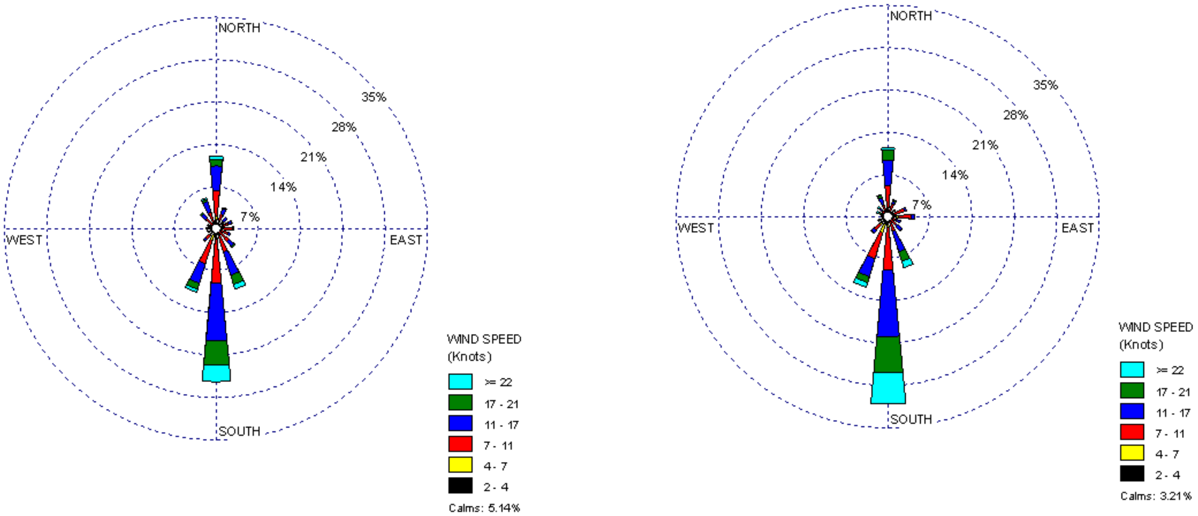


Figure 19-23. Wind Roses for the Wiley Post Airport Weather Station near OCOK



Distance between OCOK and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

Observations from Figures 19-19 through 19-23 include the following:

- The distance maps show that the distances between the sites and the weather stations varies from 1.6 miles between Tinker Air Force Base and MWOK 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 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 one-fifth to one-quarter of the 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 three percent at the Tinker Air Force Base (MWOK) to as high as 25 percent at the Richard Lloyd Jones Jr. Airport (TOOK). Further, 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 while winds from the west or east were rarely observed near each site.

- For TOOK, the 2011 wind patterns are similar to the historical wind patterns, as are the sample day wind patterns, although a higher percentage of southerly winds were observed 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 2011 wind patterns resemble the historical wind patterns, although there was a slightly higher percentage of southeasterly and south-southeasterly winds observed in 2011. The sample day wind patterns are similar to the full-year wind patterns, although a higher percentage of southerly winds were observed on sample days. These similarities indicate that conditions on sample days were representative of conditions experienced throughout the year and historically.

- For PROK, the historical wind rose includes eight years worth of data. The 2011 wind patterns are nearly identical to the historical wind patterns. The one difference is the slightly reduced number of south-southwesterly wind observations for 2011, which are reflected in the higher calm rate. The sample day wind rose for PROK is similar to the historical and full-year wind roses, although a higher percentage of southerly winds were observed on sample days. These similarities indicate that conditions on sample days were representative of conditions experienced throughout the year and historically.

- For MWOK, the historical wind rose includes only five years worth of data. The 2011 wind patterns resemble the historical wind patterns, although there were slightly fewer south-southwesterly wind observations and slightly more northwesterly winds observations in 2011. The sample day wind patterns resemble the historical and the full-year wind patterns roses, although there are a few subtle differences. The sample day wind rose has a higher percentage of southerly winds, as well as a higher percentage of south-southeasterly winds. The calm rate for sample days (1.36 percent) is roughly half the calm rate on the full-year wind rose (2.96 percent), although both are low percentages.

- For OCOK, the wind patterns shown on the 2011 wind rose are nearly identical to the historical wind patterns. The sample day wind rose for OCOK is similar to both the historical and full-year wind roses, but there was a slightly higher percentage of southerly winds observed in 2011 and a slightly reduced calm rate. However, the similarities indicate that conditions on sample days were representative of those experienced over the entire year and historically.

19.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the Oklahoma monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 19-4 presents the results of the preliminary risk-based screening process for each Oklahoma monitoring site. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. The five Oklahoma sites sampled for VOCs, carbonyl compounds, and metals (TSP).

Table 19-4. 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						
Benzene	0.13	57	57	100.00	10.94	10.94
Carbon Tetrachloride	0.17	57	57	100.00	10.94	21.88
Acetaldehyde	0.45	56	56	100.00	10.75	32.63
Formaldehyde	0.077	56	56	100.00	10.75	43.38
Manganese (TSP)	0.005	56	56	100.00	10.75	54.13
Arsenic (TSP)	0.00023	55	56	98.21	10.56	64.68
1,3-Butadiene	0.03	51	52	98.08	9.79	74.47
p-Dichlorobenzene	0.091	43	51	84.31	8.25	82.73
Ethylbenzene	0.4	39	57	68.42	7.49	90.21
Nickel (TSP)	0.0021	18	56	32.14	3.45	93.67
Propionaldehyde	0.8	7	56	12.50	1.34	95.01
Cadmium (TSP)	0.00056	6	56	10.71	1.15	96.16
1,2-Dichloroethane	0.038	6	6	100.00	1.15	97.31
Hexachloro-1,3-butadiene	0.045	5	5	100.00	0.96	98.27
Acrylonitrile	0.015	3	3	100.00	0.58	98.85
1,2-Dibromoethane	0.0017	2	2	100.00	0.38	99.23
Cobalt (TSP)	0.01	1	56	1.79	0.19	99.42
Lead (TSP)	0.015	1	56	1.79	0.19	99.62
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.19	99.81
Xylenes	10	1	57	1.75	0.19	100.00
Total		521	852	61.15		
Tulsa, Oklahoma - TMOK						
Acetaldehyde	0.45	61	61	100.00	11.94	11.94
Formaldehyde	0.077	61	61	100.00	11.94	23.87
Benzene	0.13	60	60	100.00	11.74	35.62
Carbon Tetrachloride	0.17	60	60	100.00	11.74	47.36
Manganese (TSP)	0.005	58	58	100.00	11.35	58.71
Arsenic (TSP)	0.00023	56	58	96.55	10.96	69.67
1,3-Butadiene	0.03	49	51	96.08	9.59	79.26
Ethylbenzene	0.4	36	60	60.00	7.05	86.30
p-Dichlorobenzene	0.091	24	47	51.06	4.70	91.00
Acrylonitrile	0.015	10	10	100.00	1.96	92.95
1,2-Dichloroethane	0.038	10	10	100.00	1.96	94.91
Nickel (TSP)	0.0021	10	58	17.24	1.96	96.87
Propionaldehyde	0.8	8	61	13.11	1.57	98.43
Hexachloro-1,3-butadiene	0.045	3	3	100.00	0.59	99.02
Cadmium (TSP)	0.00056	1	58	1.72	0.20	99.22

Table 19-4. 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
Chloromethylbenzene	0.02	1	1	100.00	0.20	99.41
Cobalt (TSP)	0.01	1	58	1.72	0.20	99.61
1,2-Dibromoethane	0.0017	1	1	100.00	0.20	99.80
Lead (TSP)	0.015	1	58	1.72	0.20	100.00
Total		511	834	61.27		
Pryor Creek, Oklahoma - PROK						
Acetaldehyde	0.45	58	58	100.00	13.74	13.74
Formaldehyde	0.077	58	58	100.00	13.74	27.49
Benzene	0.13	56	56	100.00	13.27	40.76
Carbon Tetrachloride	0.17	56	56	100.00	13.27	54.03
Arsenic (TSP)	0.00023	51	56	91.07	12.09	66.11
Manganese (TSP)	0.005	48	56	85.71	11.37	77.49
p-Dichlorobenzene	0.091	36	47	76.60	8.53	86.02
1,3-Butadiene	0.03	30	33	90.91	7.11	93.13
1,2-Dichloroethane	0.038	17	17	100.00	4.03	97.16
Hexachloro-1,3-butadiene	0.045	4	4	100.00	0.95	98.10
Acrylonitrile	0.015	3	3	100.00	0.71	98.82
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.47	99.29
Bromomethane	0.5	1	34	2.94	0.24	99.53
Ethylbenzene	0.4	1	56	1.79	0.24	99.76
Xylenes	10	1	56	1.79	0.24	100.00
Total		422	592	71.28		
Midwest City, Oklahoma - MWOK						
Acetaldehyde	0.45	56	56	100.00	13.43	13.43
Benzene	0.13	56	56	100.00	13.43	26.86
Carbon Tetrachloride	0.17	56	56	100.00	13.43	40.29
Formaldehyde	0.077	56	56	100.00	13.43	53.72
Manganese (TSP)	0.005	52	56	92.86	12.47	66.19
Arsenic (TSP)	0.00023	48	56	85.71	11.51	77.70
1,3-Butadiene	0.03	36	40	90.00	8.63	86.33
p-Dichlorobenzene	0.091	26	50	52.00	6.24	92.57
1,2-Dichloroethane	0.038	9	9	100.00	2.16	94.72
Acrylonitrile	0.015	5	5	100.00	1.20	95.92
Ethylbenzene	0.4	5	56	8.93	1.20	97.12
Hexachloro-1,3-butadiene	0.045	4	4	100.00	0.96	98.08
Nickel (TSP)	0.0021	4	56	7.14	0.96	99.04
1,2-Dibromoethane	0.0017	1	1	100.00	0.24	99.28
cis-1,3-Dichloropropene	0.25	1	1	100.00	0.24	99.52

Table 19-4. Risk-Based Screening Results for the Oklahoma Monitoring Sites (Continued)

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
trans-1,3-Dichloropropene	0.25	1	1	100.00	0.24	99.76
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.24	100.00
Total		417	560	74.46		
Oklahoma City, Oklahoma - OCOK						
Benzene	0.13	61	61	100.00	13.35	13.35
Acetaldehyde	0.45	60	60	100.00	13.13	26.48
Formaldehyde	0.077	60	60	100.00	13.13	39.61
Carbon Tetrachloride	0.17	59	61	96.72	12.91	52.52
Arsenic (TSP)	0.00023	56	61	91.80	12.25	64.77
Manganese (TSP)	0.005	56	61	91.80	12.25	77.02
1,3-Butadiene	0.03	37	41	90.24	8.10	85.12
p-Dichlorobenzene	0.091	16	39	41.03	3.50	88.62
1,2-Dichloroethane	0.038	14	14	100.00	3.06	91.68
Ethylbenzene	0.4	13	61	21.31	2.84	94.53
Acrylonitrile	0.015	9	9	100.00	1.97	96.50
Propionaldehyde	0.8	7	60	11.67	1.53	98.03
Hexachloro-1,3-butadiene	0.045	4	4	100.00	0.88	98.91
Cadmium (TSP)	0.00056	2	61	3.28	0.44	99.34
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.44	99.78
1,2-Dibromoethane	0.0017	1	1	100.00	0.22	100.00
Total		457	656	69.66		

Observations from Table 19-4 include the following:

- Twenty pollutants failed at least one screen for TOOK; 19 pollutants failed screens for TMOK; 15 pollutants failed screens for PROK; 17 pollutants failed screens for MWOK; and 16 pollutants failed screens for OCOK.

- The risk-based screening process identified 11 pollutants of interest for TOOK, of which eight are NATTS MQO Core Analytes. Cadmium and lead were added to the pollutants of interest for TOOK because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of the total failed screens. Five additional pollutants (beryllium, chloroform, tetrachloroethylene, trichloroethylene, and vinyl chloride) were added to the pollutants of interest for TOOK because they are NATTS MQO Core Analytes, even though they did not fail any screens. These five pollutants do not appear in Table 19-4 but are shown in subsequent tables in the sections that follow.

- The risk-based screening process identified 12 pollutants of interest for TMOK, of which eight are NATTS MQO Core Analytes. Cadmium and lead were added to the pollutants of interest for TMOK because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of the total failed screens. Five additional pollutants (beryllium, chloroform, tetrachloroethylene, trichloroethylene, and vinyl chloride) were added to the pollutants of interest for TMOK because they are NATTS MQO Core Analytes, even though they did not fail any screens. These five pollutants do not appear in Table 19-4 but are shown in subsequent tables in the sections that follow.

- The risk-based screening process identified nine pollutants of interest for PROK, of which seven are NATTS MQO Core Analytes. An additional eight pollutants (beryllium, cadmium, chloroform, lead, nickel, tetrachloroethylene, trichloroethylene, and vinyl chloride) were added to the pollutants of interest for PROK because they are NATTS MQO Core Analytes, even though they did not fail any screens. These six pollutants do not appear in Table 19-4 but are shown in subsequent tables in the sections that follow.

- The risk-based screening process identified 11 pollutants of interest for MWOK, of which seven are NATTS MQO Core Analytes. Nickel was added to the pollutants of interest for MWOK because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of the total failed screens. An additional seven pollutants (beryllium, cadmium, chloroform, lead, tetrachloroethylene, trichloroethylene, and vinyl chloride) were added to the pollutants of interest for MWOK because they are NATTS MQO Core Analytes, even though they did not fail any screens. These seven pollutants do not appear in Table 19-4 but are shown in subsequent tables in the sections that follow.

- The risk-based screening process identified 11 pollutants of interest for OCOK, of which seven are NATTS MQO Core Analytes. Cadmium was added to the pollutants of interest for OCOK because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of the total failed screens. Seven additional pollutants (beryllium, chloroform, lead, nickel, tetrachloroethylene, trichloroethylene, and vinyl chloride) were added to the pollutants of interest for OCOK because they are NATTS MQO Core Analytes, even though they did not fail any screens. These pollutants do not appear in Table 19-4 but are shown in subsequent tables in the sections that follow.

- Acetaldehyde, benzene, and formaldehyde each failed 100 percent of screens for each site.

- TOOK and TMOK failed the fourth and fifth highest number of screens among all NMP sites, although the other Oklahoma sites ranked 10th (OCOK), 11th (PROK), and 12th (MWOK), as shown in Table 4-8.

19.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Oklahoma monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for each of the Oklahoma sites are provided in Appendices J, L, and N.

19.4.1 2011 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 of 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 19-5, 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 19-5. 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	56/56	NA	2.27 ± 0.46	4.49 ± 0.95	2.11 ± 0.49	2.75 ± 0.41
Benzene	57/57	4.03 ± 2.22	4.39 ± 3.01	3.81 ± 1.53	2.33 ± 0.80	3.59 ± 0.98
1,3-Butadiene	52/57	0.11 ± 0.04	0.05 ± 0.02	0.09 ± 0.02	0.12 ± 0.05	0.09 ± 0.02
Carbon Tetrachloride	57/57	0.47 ± 0.06	0.68 ± 0.15	0.64 ± 0.03	0.68 ± 0.06	0.63 ± 0.05
Chloroform	17/57	0.03 ± 0.03	0.04 ± 0.05	0.04 ± 0.04	0.06 ± 0.04	0.04 ± 0.02
p-Dichlorobenzene	51/57	0.11 ± 0.02	0.06 ± 0.03	0.29 ± 0.06	0.16 ± 0.02	0.15 ± 0.03
Ethylbenzene	57/57	0.52 ± 0.16	0.42 ± 0.08	0.69 ± 0.24	1.03 ± 0.37	0.68 ± 0.13
Formaldehyde	56/56	NA	4.22 ± 1.16	5.61 ± 1.21	2.16 ± 0.40	3.74 ± 0.57
Propionaldehyde	56/56	NA	0.49 ± 0.12	0.77 ± 0.18	0.37 ± 0.08	0.51 ± 0.07
Tetrachloroethylene	47/57	0.12 ± 0.05	0.13 ± 0.09	0.14 ± 0.09	0.11 ± 0.04	0.12 ± 0.03
Trichloroethylene	8/57	<0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.02	0.01 ± 0.01
Vinyl Chloride	3/57	0	<0.01 ± <0.01	<0.01 ± <0.01	0	<0.01 ± <0.01
Arsenic (TSP)[a]	56/56	0.77 ± 0.15	0.70 ± 0.14	0.77 ± 0.10	0.82 ± 0.25	0.76 ± 0.08
Beryllium (TSP)[a]	56/56	0.02 ± <0.01	0.03 ± 0.01	0.03 ± 0.01	0.02 ± 0.01	0.03 ± <0.01
Cadmium (TSP)[a]	56/56	0.34 ± 0.16	0.39 ± 0.21	0.18 ± 0.04	0.35 ± 0.22	0.31 ± 0.08
Lead (TSP)[a]	56/56	5.91 ± 1.94	6.41 ± 2.21	5.43 ± 1.20	5.75 ± 1.98	5.87 ± 0.87
Manganese (TSP)[a]	56/56	21.84 ± 5.42	29.22 ± 7.69	37.56 ± 8.63	29.53 ± 13.51	30.09 ± 4.58
Nickel (TSP)[a]	56/56	1.49 ± 0.31	1.69 ± 0.41	2.06 ± 0.32	1.70 ± 0.52	1.75 ± 0.19

[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 19-5. 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	61/61	1.51 ± 0.27	2.00 ± 0.43	4.05 ± 0.67	1.89 ± 0.45	2.40 ± 0.34
Acrylonitrile	10/60	0.01 ± 0.02	0.16 ± 0.18	0.02 ± 0.03	0.11 ± 0.22	0.08 ± 0.07
Benzene	60/60	1.34 ± 0.31	1.14 ± 0.30	1.54 ± 0.37	1.41 ± 0.48	1.35 ± 0.18
1,3-Butadiene	51/60	0.10 ± 0.03	0.04 ± 0.03	0.13 ± 0.04	0.14 ± 0.07	0.10 ± 0.02
Carbon Tetrachloride	60/60	0.50 ± 0.07	0.61 ± 0.06	0.65 ± 0.04	0.64 ± 0.06	0.60 ± 0.03
Chloroform	28/60	0.04 ± 0.02	0.05 ± 0.03	0.15 ± 0.11	0.06 ± 0.04	0.07 ± 0.03
p-Dichlorobenzene	47/60	0.08 ± 0.03	0.05 ± 0.04	0.11 ± 0.03	0.10 ± 0.03	0.08 ± 0.02
1,2-Dichloroethane	10/60	0	0.03 ± 0.02	0.01 ± 0.02	0.04 ± 0.03	0.02 ± 0.01
Ethylbenzene	60/60	0.48 ± 0.14	0.40 ± 0.11	0.63 ± 0.13	0.68 ± 0.26	0.55 ± 0.09
Formaldehyde	61/61	2.15 ± 0.38	4.44 ± 1.35	6.04 ± 1.31	2.81 ± 0.58	3.93 ± 0.62
Tetrachloroethylene	40/60	0.08 ± 0.03	0.04 ± 0.03	0.07 ± 0.03	0.09 ± 0.03	0.07 ± 0.02
Trichloroethylene	10/60	0.02 ± 0.02	0.02 ± 0.02	0.01 ± 0.02	0.01 ± 0.02	0.01 ± 0.01
Vinyl Chloride	1/60	0	<0.01 ± <0.01	0	0	<0.01 ± <0.01
Arsenic (TSP)[a]	58/58	0.61 ± 0.16	0.59 ± 0.12	0.58 ± 0.12	0.75 ± 0.24	0.63 ± 0.08
Beryllium (TSP)[a]	58/58	0.01 ± <0.01	0.02 ± 0.01	0.02 ± <0.01	0.01 ± <0.01	0.02 ± <0.01
Cadmium (TSP)[a]	58/58	0.27 ± 0.05	0.20 ± 0.03	0.17 ± 0.04	0.24 ± 0.08	0.22 ± 0.03
Lead (TSP)[a]	58/58	5.08 ± 1.16	4.76 ± 1.12	4.72 ± 0.89	5.13 ± 2.00	4.91 ± 0.64
Manganese (TSP)[a]	58/58	14.93 ± 5.09	24.93 ± 6.60	23.30 ± 5.19	18.29 ± 7.30	20.52 ± 3.06
Nickel (TSP)[a]	58/58	1.21 ± 0.30	1.58 ± 0.38	1.56 ± 0.33	1.33 ± 0.52	1.42 ± 0.19

[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 19-5. 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)
Pryor Creek, Oklahoma - PROK						
Acetaldehyde	58/58	1.35 ± 0.21	1.52 ± 0.32	2.43 ± 0.38	1.38 ± 0.26	1.68 ± 0.18
Benzene	56/56	0.75 ± 0.10	0.60 ± 0.11	0.70 ± 0.27	0.67 ± 0.14	0.68 ± 0.08
1,3-Butadiene	33/56	0.04 ± 0.03	0.01 ± 0.01	0.03 ± 0.02	0.05 ± 0.03	0.04 ± 0.01
Carbon Tetrachloride	56/56	0.55 ± 0.05	0.63 ± 0.06	0.66 ± 0.05	0.65 ± 0.06	0.62 ± 0.03
Chloroform	15/56	0.01 ± 0.02	0.06 ± 0.06	0.01 ± 0.02	0.05 ± 0.03	0.03 ± 0.02
p-Dichlorobenzene	47/56	0.07 ± 0.03	0.07 ± 0.05	0.54 ± 0.21	0.17 ± 0.02	0.20 ± 0.07
1,2-Dichloroethane	17/56	0.01 ± 0.02	0.02 ± 0.03	0.01 ± 0.02	0.06 ± 0.02	0.03 ± 0.01
Formaldehyde	58/58	2.38 ± 0.35	4.52 ± 1.65	5.96 ± 1.43	2.43 ± 0.73	3.84 ± 0.67
Tetrachloroethylene	28/56	0.06 ± 0.02	0.02 ± 0.02	0.01 ± 0.01	0.05 ± 0.02	0.03 ± 0.01
Trichloroethylene	2/56	0	0	0.01 ± 0.02	<0.01 ± 0.01	<0.01 ± <0.01
Vinyl Chloride	3/56	0	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Arsenic (TSP) [a]	56/56	0.57 ± 0.14	0.45 ± 0.10	0.53 ± 0.16	0.59 ± 0.14	0.54 ± 0.07
Beryllium (TSP) [a]	56/56	0.02 ± 0.01	0.04 ± 0.02	0.03 ± 0.01	0.02 ± 0.01	0.03 ± 0.01
Cadmium (TSP) [a]	56/56	0.23 ± 0.07	0.13 ± 0.04	0.13 ± 0.03	0.14 ± 0.03	0.16 ± 0.02
Lead (TSP) [a]	56/56	3.16 ± 0.72	2.46 ± 0.60	2.57 ± 0.62	2.58 ± 0.52	2.69 ± 0.30
Manganese (TSP) [a]	56/56	8.28 ± 2.76	11.95 ± 3.87	15.28 ± 5.10	9.41 ± 2.23	11.31 ± 1.88
Nickel (TSP) [a]	56/56	0.75 ± 0.17	0.89 ± 0.24	0.88 ± 0.14	0.64 ± 0.14	0.79 ± 0.09

[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 19-5. 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 ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Midwest City, Oklahoma - MWOK						
Acetaldehyde	56/56	1.52 ± 0.44	1.66 ± 0.27	2.98 ± 0.39	NA	2.03 ± 0.24
Acrylonitrile	5/56	0.01 ± 0.02	0.02 ± 0.02	0	NA	0.01 ± 0.01
Benzene	56/56	0.84 ± 0.16	0.64 ± 0.09	0.69 ± 0.11	NA	0.73 ± 0.07
1,3-Butadiene	40/56	0.09 ± 0.05	0.04 ± 0.02	0.04 ± 0.02	NA	0.06 ± 0.02
Carbon Tetrachloride	56/56	0.49 ± 0.07	0.62 ± 0.06	0.66 ± 0.06	NA	0.60 ± 0.03
Chloroform	23/56	0.04 ± 0.02	0.05 ± 0.03	0.01 ± 0.02	NA	0.04 ± 0.01
p-Dichlorobenzene	50/56	0.09 ± 0.02	0.09 ± 0.03	0.10 ± 0.03	NA	0.09 ± 0.01
1,2-Dichloroethane	9/56	0	0.03 ± 0.02	0	NA	0.01 ± 0.01
Ethylbenzene	56/56	0.23 ± 0.09	0.18 ± 0.03	0.25 ± 0.04	NA	0.25 ± 0.04
Formaldehyde	56/56	2.61 ± 0.47	3.85 ± 0.96	5.99 ± 0.97	NA	4.05 ± 0.53
Tetrachloroethylene	40/56	0.25 ± 0.19	0.13 ± 0.08	0.08 ± 0.09	NA	0.15 ± 0.06
Trichloroethylene	1/56	0.01 ± 0.02	0	0	NA	<0.01 ± <0.01
Vinyl Chloride	1/56	0	0	<0.01 ± <0.01	NA	<0.01 ± <0.01
Arsenic (TSP) [a]	56/56	0.39 ± 0.08	0.42 ± 0.06	0.32 ± 0.06	NA	0.40 ± 0.04
Beryllium (TSP) [a]	56/56	0.01 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	NA	0.02 ± <0.01
Cadmium (TSP) [a]	56/56	0.11 ± 0.02	0.18 ± 0.06	0.08 ± 0.02	NA	0.12 ± 0.02
Lead (TSP) [a]	56/56	2.33 ± 0.34	2.79 ± 0.50	2.35 ± 0.50	NA	2.48 ± 0.22
Manganese (TSP) a	56/56	9.17 ± 2.63	15.24 ± 3.98	16.17 ± 4.43	NA	13.26 ± 1.94
Nickel (TSP) a	56/56	0.93 ± 0.24	1.54 ± 0.63	1.26 ± 0.30	NA	1.20 ± 0.21

[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 19-5. 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 - OCOK						
Acetaldehyde	60/60	1.44 ± 0.27	2.50 ± 0.79	3.69 ± 0.50	1.86 ± 0.37	2.41 ± 0.33
Acrylonitrile	9/61	0.02 ± 0.04	0.23 ± 0.20	0.01 ± 0.02	0.02 ± 0.04	0.07 ± 0.05
Benzene	61/61	0.75 ± 0.11	0.70 ± 0.15	1.12 ± 0.79	0.93 ± 0.21	0.88 ± 0.21
1,3-Butadiene	41/61	0.04 ± 0.03	0.01 ± 0.01	0.64 ± 1.21	0.08 ± 0.04	0.20 ± 0.31
Carbon Tetrachloride	61/61	0.46 ± 0.11	0.61 ± 0.08	0.65 ± 0.05	0.61 ± 0.06	0.58 ± 0.04
Chloroform	13/61	0.03 ± 0.02	0.02 ± 0.02	0.01 ± 0.01	0.02 ± 0.02	0.02 ± 0.01
p-Dichlorobenzene	39/61	0.04 ± 0.02	0.01 ± 0.02	0.10 ± 0.03	0.07 ± 0.02	0.06 ± 0.01
1,2-Dichloroethane	14/61	0	0.03 ± 0.03	0.01 ± 0.01	0.09 ± 0.09	0.03 ± 0.02
Ethylbenzene	61/61	0.23 ± 0.05	0.25 ± 0.07	0.38 ± 0.06	0.38 ± 0.11	0.31 ± 0.04
Formaldehyde	60/60	2.01 ± 0.36	5.70 ± 2.56	5.82 ± 0.91	2.46 ± 0.61	4.06 ± 0.80
Tetrachloroethylene	40/61	0.11 ± 0.06	0.04 ± 0.03	0.05 ± 0.03	0.13 ± 0.05	0.08 ± 0.02
Trichloroethylene	1/61	0	0	0	0.01 ± 0.01	<0.01 ± <0.01
Vinyl Chloride	3/61	0	0	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Arsenic (TSP) [a]	61/61	0.47 ± 0.10	0.48 ± 0.11	0.36 ± 0.07	0.57 ± 0.22	0.47 ± 0.07
Beryllium (TSP) [a]	61/61	0.02 ± 0.01	0.02 ± 0.01	0.02 ± <0.01	0.01 ± <0.01	0.02 ± <0.01
Cadmium (TSP) [a]	61/61	0.15 ± 0.07	0.15 ± 0.09	0.08 ± 0.05	0.12 ± 0.03	0.13 ± 0.03
Lead (TSP) [a]	61/61	2.87 ± 0.54	2.78 ± 0.48	2.15 ± 0.34	2.68 ± 0.73	2.61 ± 0.26
Manganese (TSP) [a]	61/61	12.42 ± 3.49	16.94 ± 4.71	16.28 ± 4.79	10.35 ± 2.51	14.04 ± 2.01
Nickel (TSP) [a]	61/61	0.85 ± 0.15	1.03 ± 0.20	0.79 ± 0.12	0.70 ± 0.10	0.84 ± 0.08

[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 19-5 include the following:

- Formaldehyde has the highest annual average concentration by mass for each site, followed by acetaldehyde and benzene, with one exception. The annual average concentration of benzene is greater than the annual average concentration of acetaldehyde for TOOK.

- The annual average concentrations of formaldehyde range from 3.74 ± 0.57 µg/m^3 for TOOK to 4.06 ± 0.80 µg/m^3 for OCOK, although the annual averages for MWOK and OCOK are nearly identical. The annual average concentration of acetaldehyde ranged from 1.68 ± 0.18 µg/m^3 for PROK to 2.75 ± 0.41 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 relatively large confidence intervals associated with these averages indicate that, in most cases, the differences are not statistically significant.

- The annual average concentration of benzene is highest for TOOK and TMOK. These are the only two Oklahoma sites for which the annual average is greater than 1 µg/m^3. However, the annual average for TOOK (3.59 ± 0.98 µg/m^3) is nearly three times the annual average for TMOK (1.35 ± 0.18 µg/m^3).

- The annual average concentration of manganese is the highest of the TSP metals for each site, followed by lead and nickel. The annual average manganese concentrations range from 11.31 ± 1.88 µg/m^3 for PROK to 30.09 ± 4.58 µg/m^3 for TOOK.

- Concentrations of the TSP metals tended to be higher at TOOK and TMOK than PROK, OCOK, and MWOK.

Observations for TOOK from Table 19-5 include the following:

- The first, second, and third quarter average concentrations of benzene for TOOK have relatively large confidence intervals associated with them, particularly the second quarter. The maximum benzene concentration was measured on April 3, 2011 (23.8 µg/m^3) and is nearly twice the next highest concentration of benzene (12.6 µg/m^3), measured on January 15, 2011. The April 3rd measurement is also the maximum concentration of benzene measured across the program. Of the four concentrations of benzene greater than 10 µg/m^3 measured at TOOK, two were measured in the first quarter and one each in the second and third quarters. Of the 27 concentrations of benzene greater than 4 µg/m^3 measured across the program, 19 were measured at TOOK. No other NMP site had more than two benzene measurements greater than 4 µg/m^3 (OCOK had one). Similar observations for the benzene measurements collected at TOOK were made in the 2010 NMP report.

- Concentrations of *p*-dichlorobenzene were highest in the third quarter of 2011 at TOOK. A review of the data shows that the four highest concentrations of this pollutant were measured in July 2011 and of the 15 concentrations greater than 0.2 µg/m^3, 12 were measured between July and September.

- The fourth quarter average concentration of ethylbenzene is higher than the other quarterly averages. A review of the data shows that six of the seven highest concentrations measured at TOOK were measured during the fourth quarter of 2011, including the only two concentrations greater than 2 µg/m^3.

- Although the third quarter average concentration of manganese is greater than the fourth quarter average, the fourth quarter has a larger confidence interval associated with it. A review of the data shows that the maximum concentration of manganese was measured at TOOK on October 6, 2011 (104 ng/m^3). The second highest concentration was measured on the previous sample day, September 30, 2011 (64.5 ng/m^3). Of the 14 manganese concentrations greater than 40 ng/m^3, nine were measured during the third quarter of 2011, while only one was measured during the fourth quarter. Thus, manganese concentrations were generally higher during the third quarter, while a single outlier is driving the fourth quarter average concentration.

- TOOK does not have first quarter averages for the carbonyl compounds due to complications at the site during this time frame.

Observations for TMOK from Table 19-5 include the following:

- Each of the quarterly average concentrations of acrylonitrile has a confidence interval greater than the average itself, particularly the second and fourth quarters. A review of the data shows that concentrations of acrylonitrile spanned an order of magnitude, ranging from 0.109 µg/m^3 to 1.69 µg/m^3. Two concentrations greater than 1 µg/m^3 were measured at TMOK, one in June and one in December. The December 29, 2011 measurement (1.69 µg/m^3) is the maximum acrylonitrile concentration measured among all NMP sites sampling VOCs (while the June 14, 2011 measurement ranked seventh across the program). However, acrylonitrile was detected only 10 times at TMOK, leading to the substitution of many zeros for non-detects in the calculations.

- The third quarter average chloroform concentration is two to three times higher than the other quarterly average concentrations. A review of the data shows that five of the six concentrations greater than 2 µg/m^3 were measured during the third quarter of 2011. In addition, the third quarter has the fewest non-detects of chloroform (6), while the number of non-detects in the other quarters range from seven (first quarter) to 10 (fourth quarter).

- Each of the quarterly average concentrations of manganese has a relatively large confidence interval associated with it, particularly the fourth quarter average. A review of the data shows that the maximum concentration of manganese was measured at TMOK on October 6, 2011 (65.6 ng/m^3), which is the same day the maximum manganese concentration was measured at TOOK. The next highest concentration measured during the fourth quarter was considerably less (25.1 ng/m^3).

A manganese measurement greater than 40 ng/m^3 was measured in three of the four calendar quarters. The second quarter of 2011 has the greatest number of concentrations greater than 30 ng/m^3 (5), followed by four in the third quarter and one each in the first and fourth quarters. This explains the relatively high-level of variability shown in the quarterly averages.

Observations for PROK from Table 19-5 include the following:

- The third quarter average concentration of *p*-dichlorobenzene is more than seven times higher than the other quarterly averages. A review of the data shows that the only two measurements greater than 1 µg/m^3 were both measured in July. These two measurements account for half of the *p*-dichlorobenzene concentrations greater than 1 µg/m^3 measured across all NMP sites sampling VOCs. The eight highest concentrations of *p*-dichlorobenzene measured at PROK (those greater than 0.35 µg/m^3) were measured during the third quarter.

- The third quarter average manganese concentration is greater than the other quarterly averages and has a relatively large confidence interval associated with it. The maximum manganese concentration (43.8 ng/m^3) was measured on September 30, 2011, which is the day the second and third highest manganese concentrations were measured at TOOK and TMOK, respectively. The second highest manganese concentration measured at PROK was half as high (23.0 ng/m^3), but also measured during the third quarter.

Observations for MWOK from Table 19-5 include the following:

- The annual average concentration of formaldehyde for MWOK is nearly identical to the annual average concentration for OCOK, which has the highest annual average concentration of formaldehyde among the Oklahoma monitoring sites. The maximum concentration of formaldehyde was measured at MWOK on August 25, 2011 (7.10 µg/m^3), although the five highest concentrations were all measured in July or August. Twelve of the 17 concentrations greater than 5 µg/m^3 were measured during the third quarter, with four in the second quarter and one in the fourth quarter.

- The first quarter average concentration of tetrachloroethylene is two and three times greater than the second and third quarter averages, respectively, and 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 March 4, 2011 (1.45 µg/m^3). This concentration is the only measurement greater than 1 µg/m^3 measured at MWOK and is nearly three times higher than the next highest tetrachloroethylene concentration (0.571 µg/m^3). This measurement is also the ninth highest tetrachloroethylene concentration measured across all NMP sites sampling VOCs.

- There are no fourth quarter average concentrations in Table 19-5 for MWOK because sampling was discontinued at this site at the end of November.

Observations for OCOK from Table 19-5 include the following:

- The second quarter acrylonitrile average for OCOK is higher than the other quarterly averages and has a relatively large confidence interval associated with it. The maximum concentration of acrylonitrile was measured on May 9, 2011 (1.27 µg/m^3) and is nearly twice the next highest concentration (0.644 µg/m^3) measured on June 20, 2011. The May 9th measurement is the ninth highest concentration measured among sites sampling VOCs and OCOK is one of only five sites to measure an acrylonitrile concentration greater than 1 µg/m^3 (TMOK is one of the other four). However, acrylonitrile was detected only nine times at OCOK, leading to the substitution of many zeros for non-detects in the calculations, which explains the relatively large confidence intervals for each quarterly average.

- The third quarter average concentrations of benzene and 1,3-butadiene are higher than the other quarterly averages and have relatively large confidence intervals, particularly for 1,3-butadiene. The maximum concentration of each pollutant was measured on September 18, 2011. The benzene concentration for this date (6.81 µg/m^3) is nearly four times higher than the next highest concentration measured at OCOK and the eighth highest benzene concentration measured across the program. The 1,3-butadiene concentration for this date (9.51 µg/m^3) is nearly forty times higher than the next highest concentration measured at OCOK. This 1,3-butadiene concentration is not only the maximum concentration measured across the program, but is more than three times higher than the next highest concentration measured across the program (2.68 µg/m^3, measured at NBIL).

- OCOK has the highest annual average concentration of formaldehyde among the Oklahoma sites. The maximum formaldehyde concentration measured at OCOK was measured on May 9, 2011 (19.6 µg/m^3) and is the third highest concentration of formaldehyde measured among NMP sites sampling carbonyl compounds. The second and third quarter average concentrations are significantly greater than the other quarterly averages. Although the second and third quarter averages are similar to each other, the second quarter average has a relatively large confidence interval associated with it, indicating that outlier(s) may be affecting the average concentration. The three highest formaldehyde concentrations measured at OCOK were measured between April 27, 2011 and May 9, 2011 and range from 9.10 µg/m^3 to 19.6 µg/m^3. Of the 20 formaldehyde concentrations greater than 5 µg/m^3, only one was measured outside of the second or third quarter. The range of formaldehyde concentrations for the second quarter is 1.06 µg/m^3 to 19.6 µg/m^3 with a median concentration of 4.55 µg/m^3. The range of formaldehyde concentrations for the third quarter is 2.90 µg/m^3 to 8.59 µg/m^3 with a median concentration of 6.07 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 Oklahoma sites include the following:

- The Oklahoma sites appear in Tables 4-9 through 4-12 a total of 57 times. However, because they are the only sites sampling TSP metals, all five sites appear for each metal, accounting for 30 of the appearances.

- TOOK has the highest annual average of concentration of benzene among all NMP sites sampling this pollutant. Similar findings were observed in the 2010 NMP report. The annual average for TMOK ranks fourth.

- The annual average concentrations for four of the five Oklahoma sites ranked among the highest annual average concentrations of *p*-dichlorobenzene, with PROK ranking the highest at third. OCOK, the only site that does not appear in Table 4-9 for *p*-dichlorobenzene, ranks 12th.

- OCOK ranks third highest for 1,2-dichloroethane and 1,3-butadiene. TOOK ranks third highest for ethylbenzene and MWOK ranks third highest for hexachloro-1,3-butadiene.

- All five Oklahoma sites appear in Table 4-10 for their annual average concentrations of formaldehyde, ranking third through seventh among sites sampling carbonyl compounds. TOOK ranks fourth for acetaldehyde while OCOK and TMOK rank seventh and eighth, respectively.

- Of the six TSP metals shown in Table 4-12, TOOK has the highest annual average concentration of five of them among the Oklahoma sites. The only exception is for beryllium, where PROK ranks highest and TOOK ranks second.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, lead, and manganese were created for the Oklahoma sites. Figures 19-24 through 19-30 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.

Figure 19-24. Program vs. Site-Specific Average Acetaldehyde Concentrations

Figure 19-25. Program vs. Site-Specific Average Arsenic (TSP) Concentrations

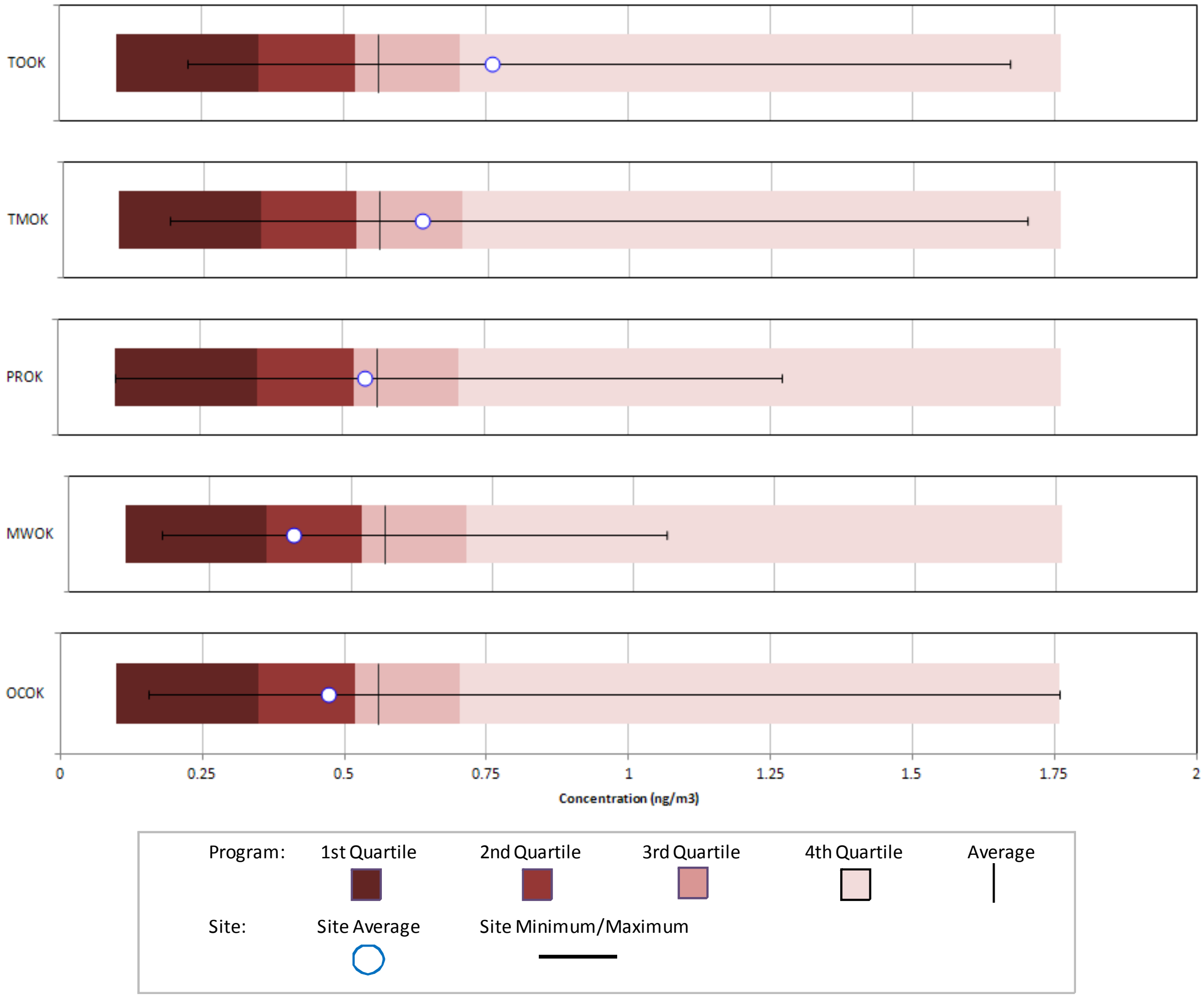


Figure 19-26. Program vs. Site-Specific Average Benzene Concentrations

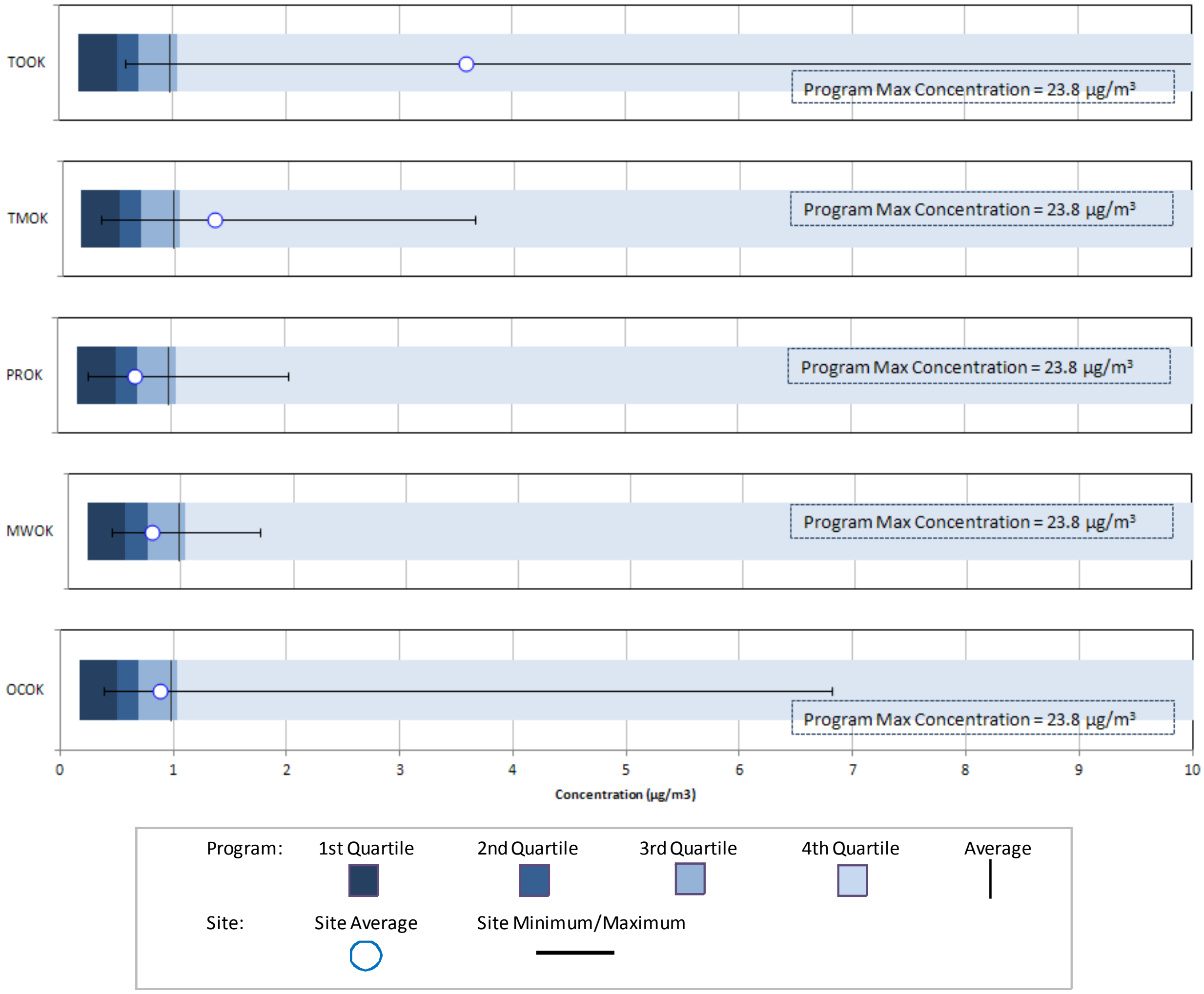


Figure 19-27. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

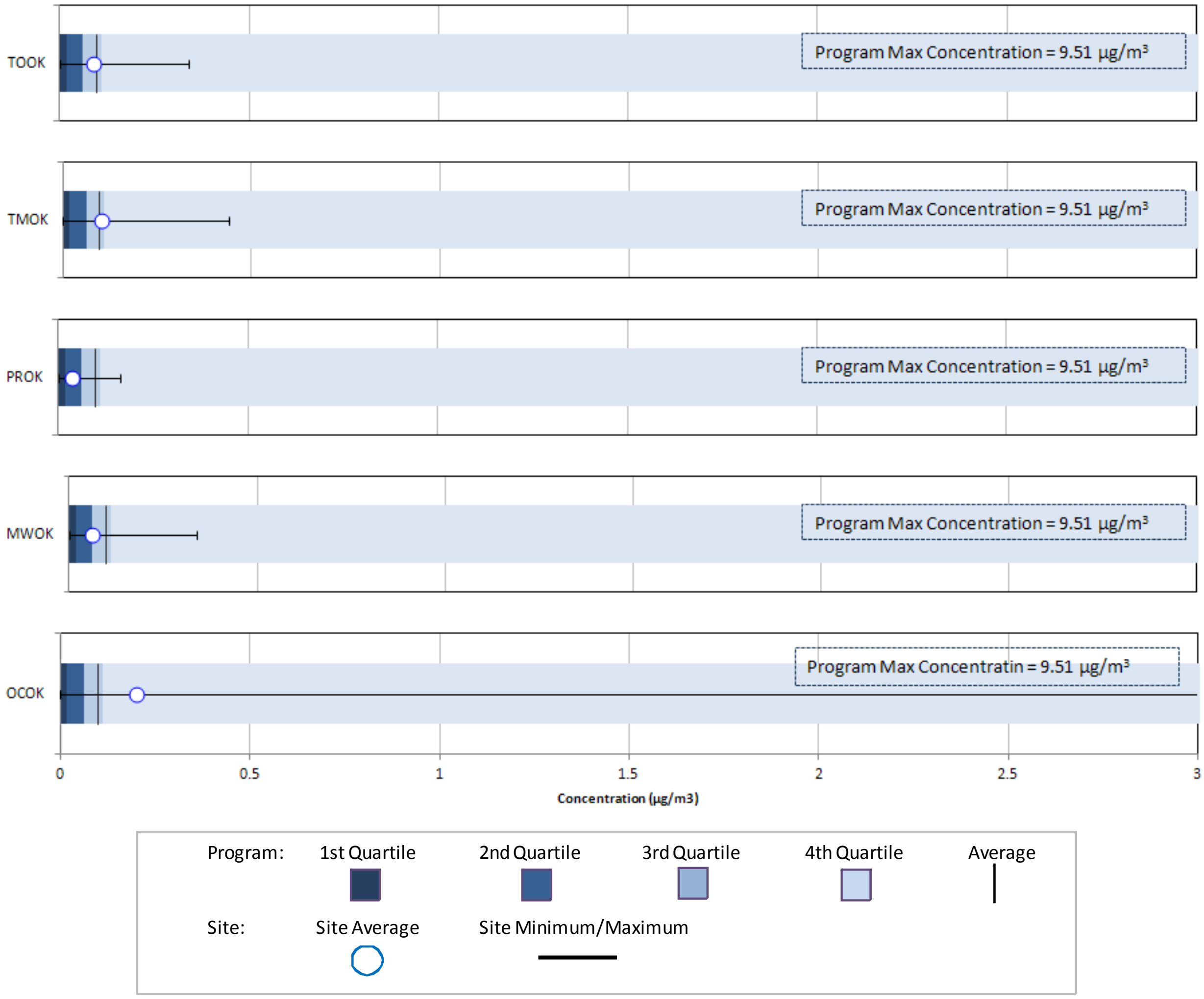


Figure 19-28. Program vs. Site-Specific Average Formaldehyde Concentrations

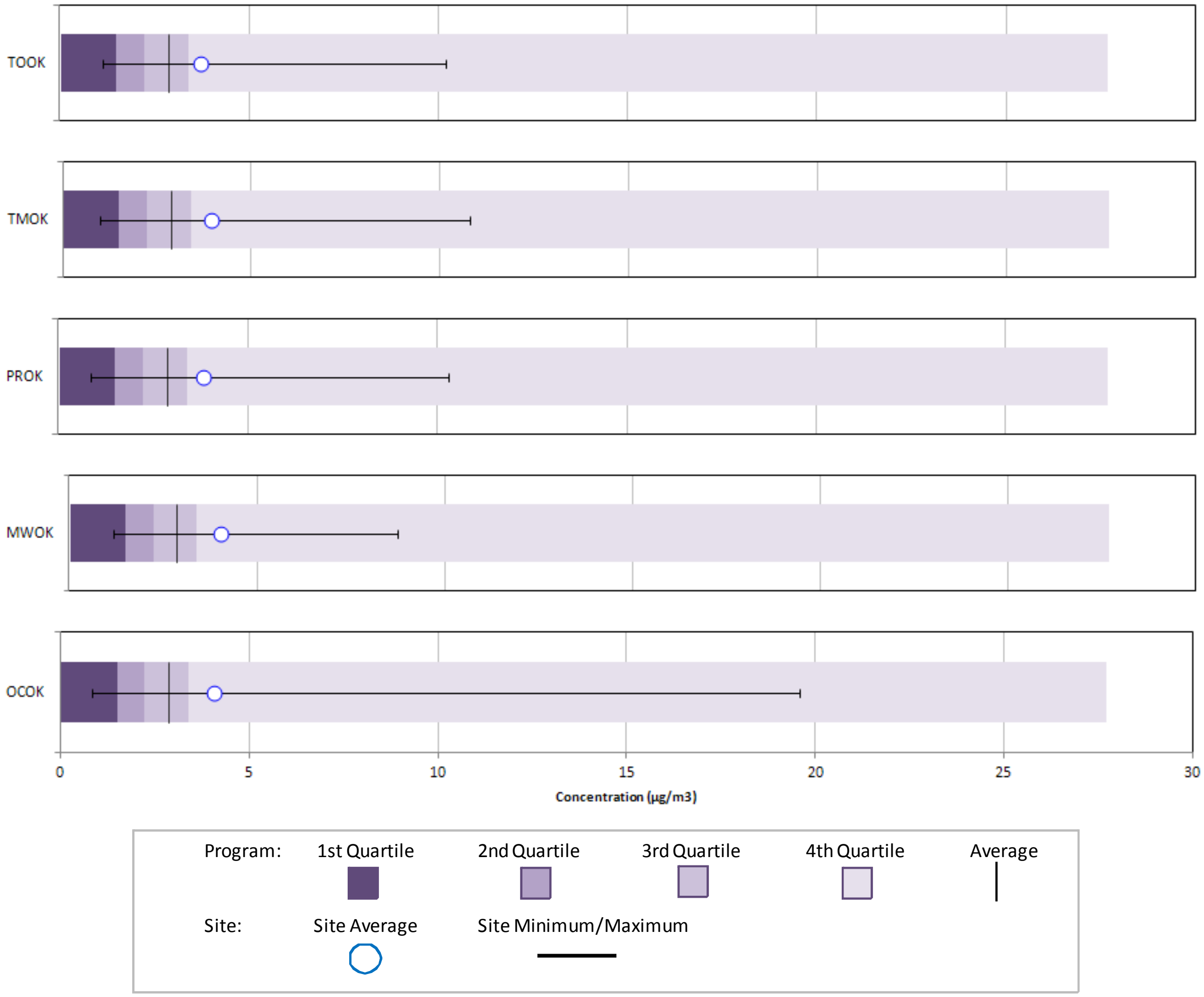


Figure 19-29. Program vs. Site-Specific Average Lead (TSP) Concentrations

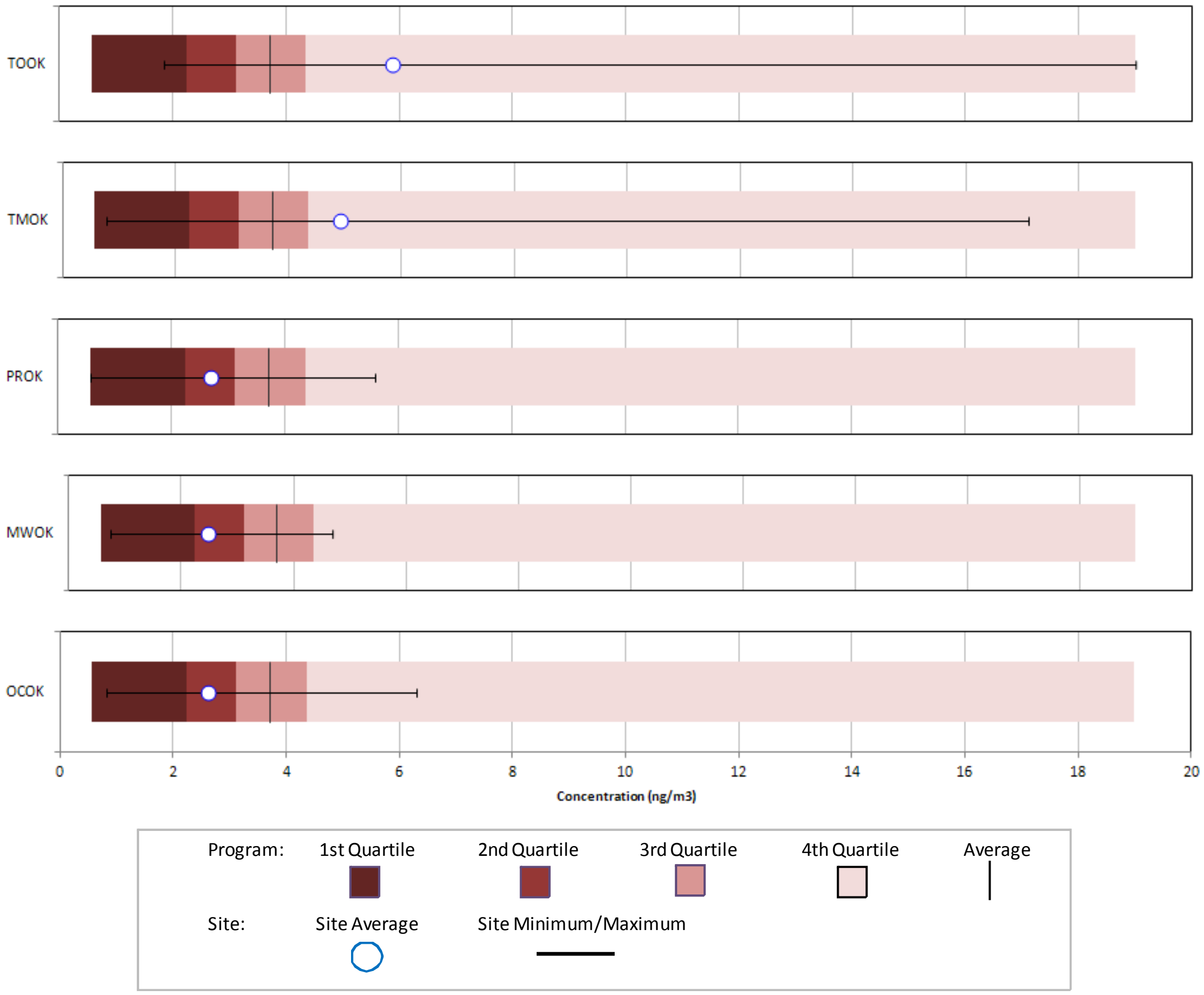
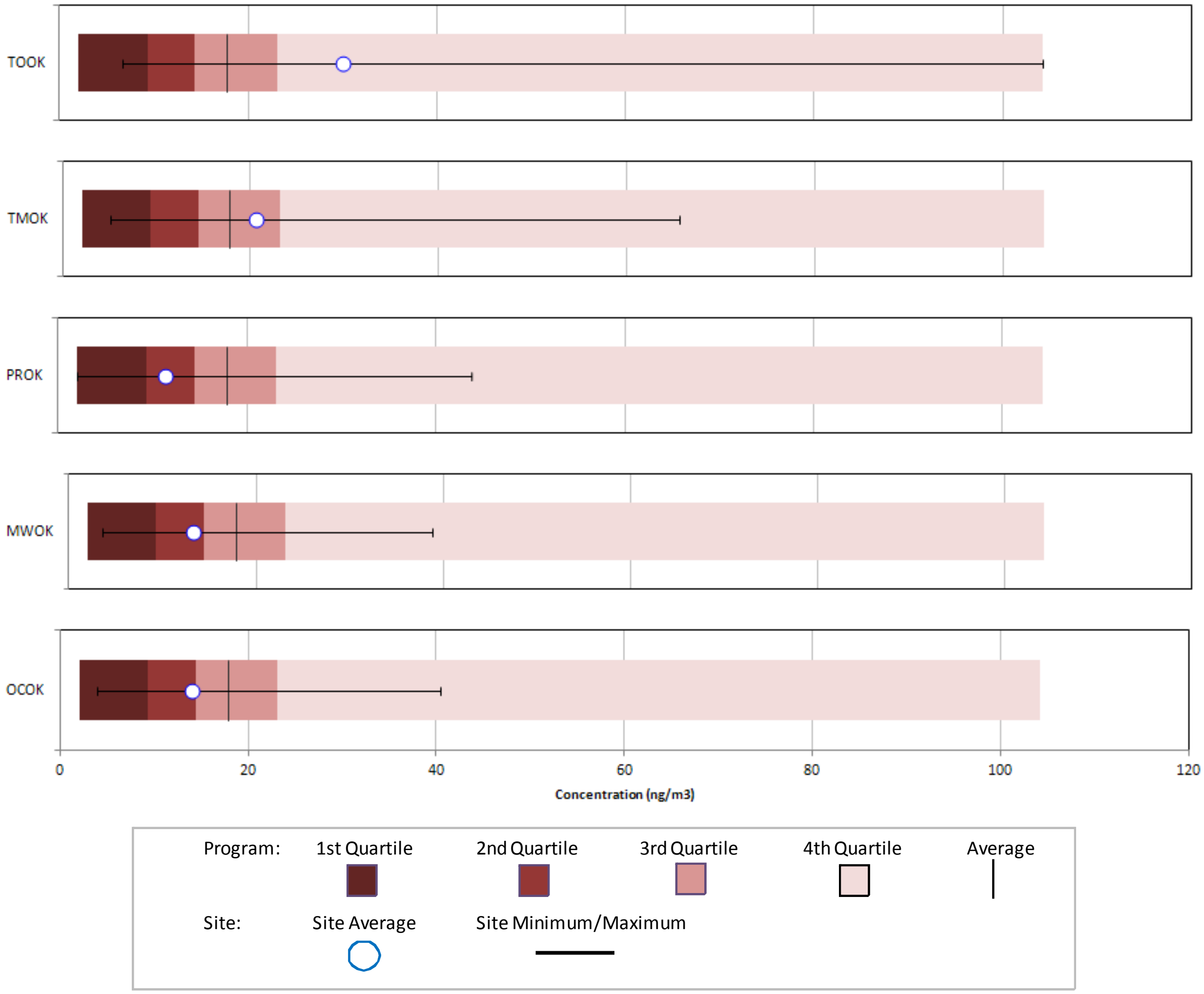


Figure 19-30. Program vs. Site-Specific Average Manganese (TSP) Concentrations



Observations from Figures 19-24 through 19-30 include the following:

- Figure 19-24 shows that 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 MWOK is similar to the program-level average while the annual average for PROK is less than the program-level average and equivalent to the program-level median concentration. The range of acetaldehyde concentrations is largest for TOOK and smallest for PROK. There were no non-detects of acetaldehyde reported for the Oklahoma sites or across the program.

- Because the Oklahoma sites are the only sites sampling TSP metals, Figure 19-25 compares the individual Oklahoma site data against the combined Oklahoma data. Figure 19-25 shows that the annual average arsenic (TSP) concentration is greatest for TOOK and least for MWOK. This figure also shows that the range of measurements of arsenic is largest for OCOK, where the maximum arsenic (TSP) concentration was measured, although similar concentrations were also measured at TOOK and TMOK. The minimum arsenic concentration measured among the five sites sampling TSP metals was measured at PROK.

- Figure 19-26 presents the box plots for benzene. Note that the program-level maximum concentration (23.8 µg/m^3) is not shown directly on each 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 10 µg/m^3. Figure 19-26 shows that the annual average concentration of benzene for TOOK and TMOK are greater than the program-level average while the annual average concentration of benzene for PROK, MWOK, and OCOK are less than the program-level average. The annual average benzene concentration for TOOK is at least twice the other sites' annual averages. The maximum benzene concentration measured at TOOK is the maximum benzene concentration measured across the program. There were no non-detects of benzene measured at the Oklahoma sites.

- Figure 19-27 presents the box plots for 1,3-butadiene. Similar to the box plots for benzene, the program-level maximum concentration (9.51 µg/m^3) is not shown directly on the box plots as the scale has been reduced to 3 µg/m^3 to allow for the observation of data points at the lower end of the concentration range. The maximum concentration of 1,3-buadiene measured across the program was measured at OCOK. The annual average 1,3-butadiene concentration for OCOK is twice the program-level average concentration, while the annual averages for TOOK and TMOK are similar to the program-level average and the annual averages for PROK and MWOK are less than the program-level average. Several non-detects of 1,3-butadiene were measured at the Oklahoma sites, as indicated by the minimum concentration for each site.

- Figure 19-28 shows that the annual average formaldehyde concentration for each Oklahoma site is greater than the program-level average concentration and third quartile. Although the annual average concentrations of formaldehyde did not vary significantly among the Oklahoma sites, the maximum concentration measured at OCOK is roughly twice the maximum concentration measured at the other four sites, although all are less than the maximum concentration measured across the program. There were no non-detects of formaldehyde measured at the Oklahoma sites or across the program.

- Because the Oklahoma sites are the only monitoring sites sampling TSP metals, Figure 19-29 compares the individual Oklahoma site lead data against the combined Oklahoma data. Figure 19-29 shows that the annual average lead (TSP) concentration is greatest for TOOK and TMOK and lowest for PROK, MWOK, and OCOK (note that the annual averages for these three sites are not that different from each other). This figure also shows that the range of lead measurements was greatest for TOOK and TMOK and smallest for MWOK. The maximum manganese (TSP) concentration was measured at TOOK.

- Figure 19-30 compares the individual Oklahoma site manganese data against the combined Oklahoma data. Figure 19-30 shows that the annual average manganese (TSP) concentration is highest for TOOK and lowest for PROK. Figure 19-30 also shows that the range of manganese measurements was greatest for TOOK and smallest for MWOK.

19.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. TOOK has sampled TSP metals, carbonyl compounds, and VOCs since 2006; thus, Figures 19-31 through 19-37 present the annual statistical metrics for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, lead, and manganese, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 19-31. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at TOOK

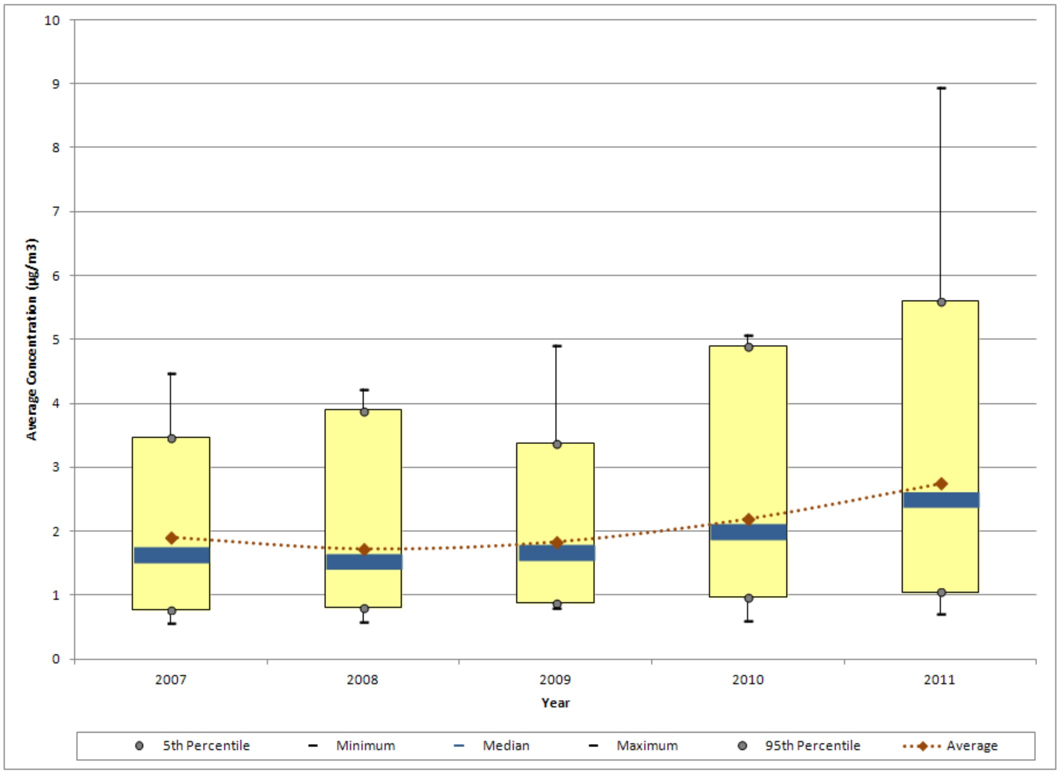


Figure 19-32. Annual Statistical Metrics for Arsenic (TSP) Concentrations Measured at TOOK

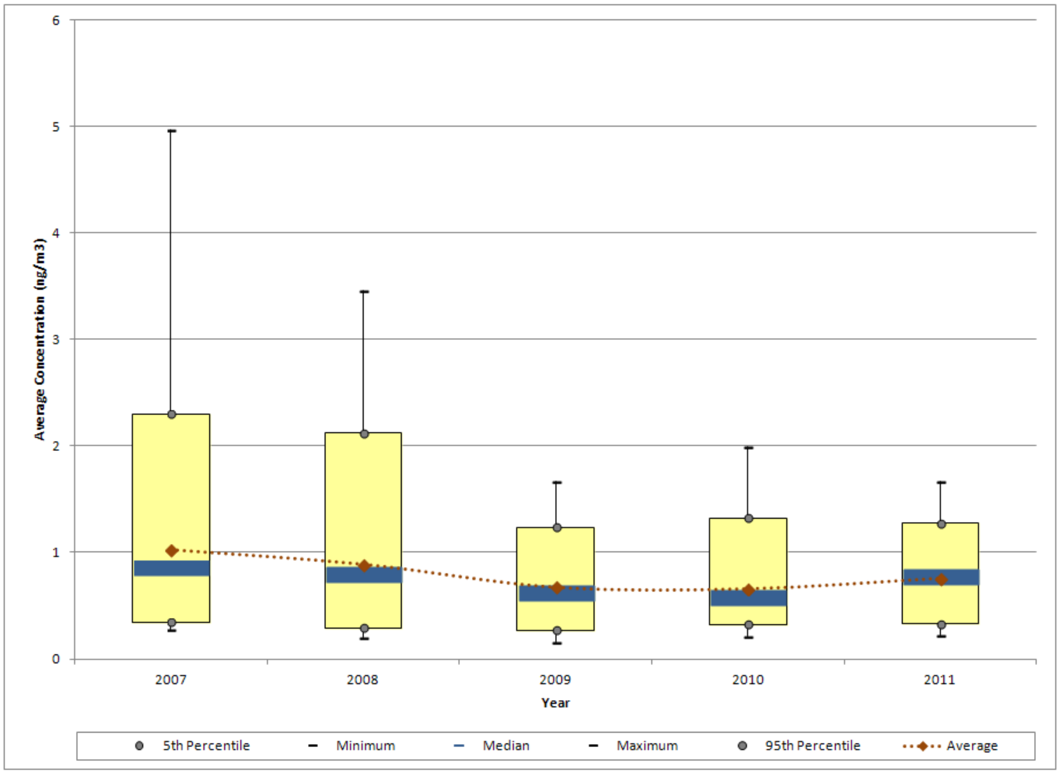


Figure 19-33. Annual Statistical Metrics for Benzene Concentrations Measured at TOOK

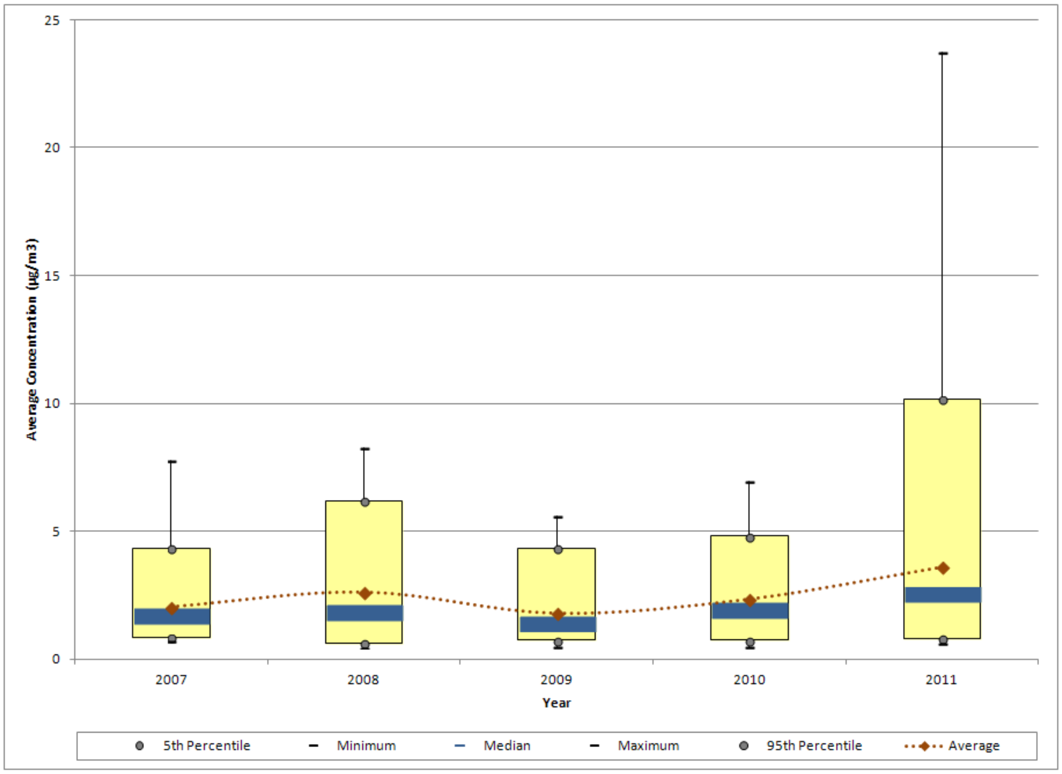


Figure 19-34. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at TOOK

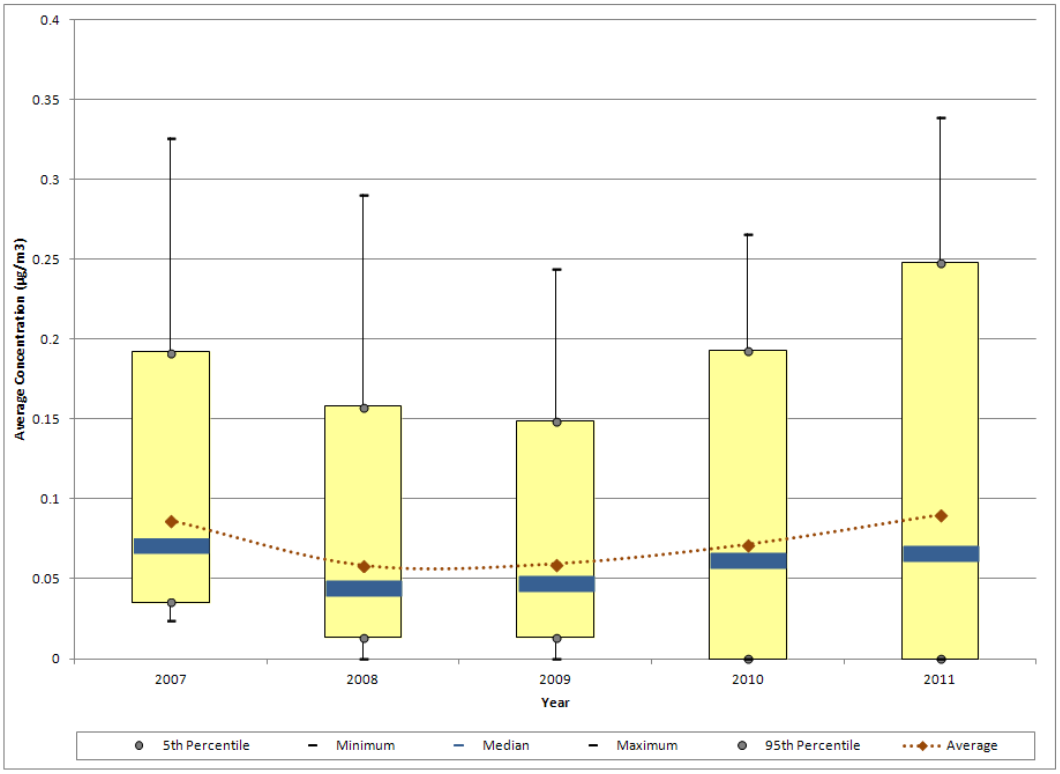


Figure 19-35. Annual Statistical Metrics for Formaldehyde Concentrations Measured at TOOK

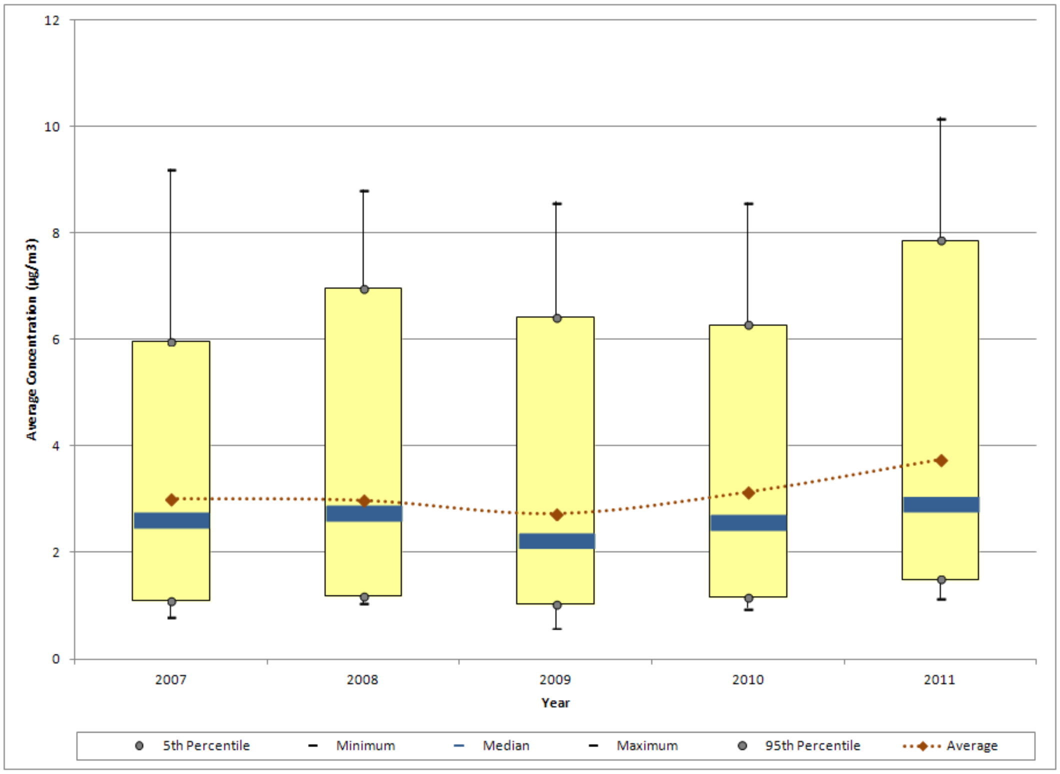


Figure 19-36. Annual Statistical Metrics for Lead (TSP) Concentrations Measured at TOOK

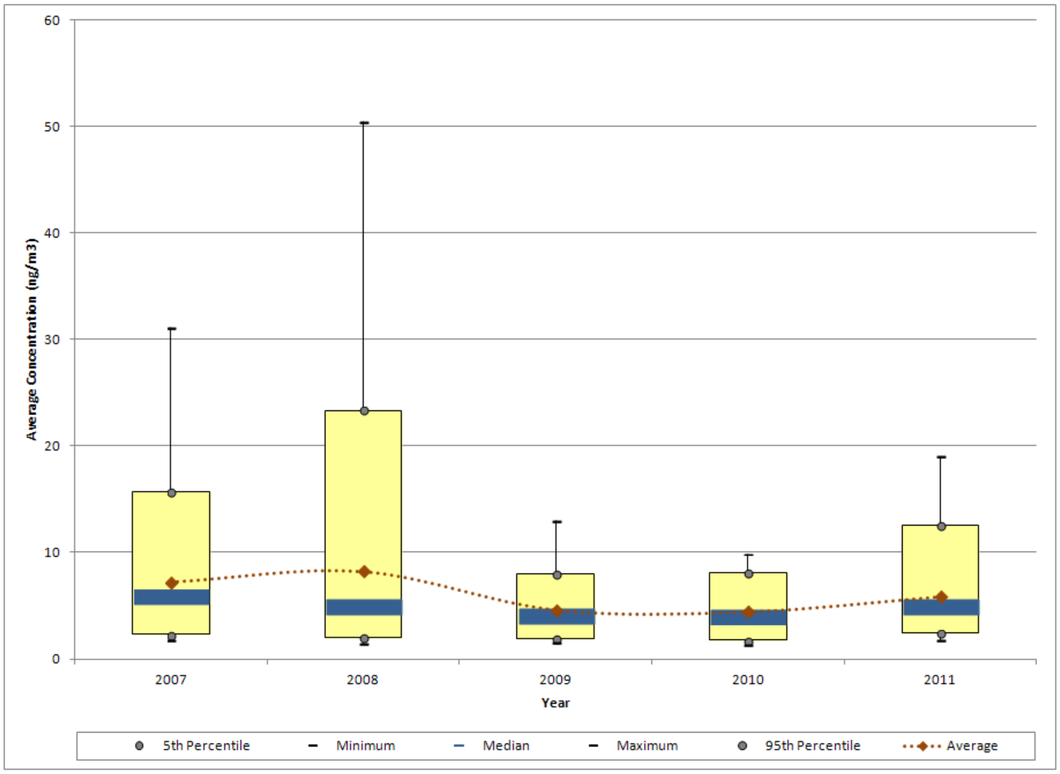
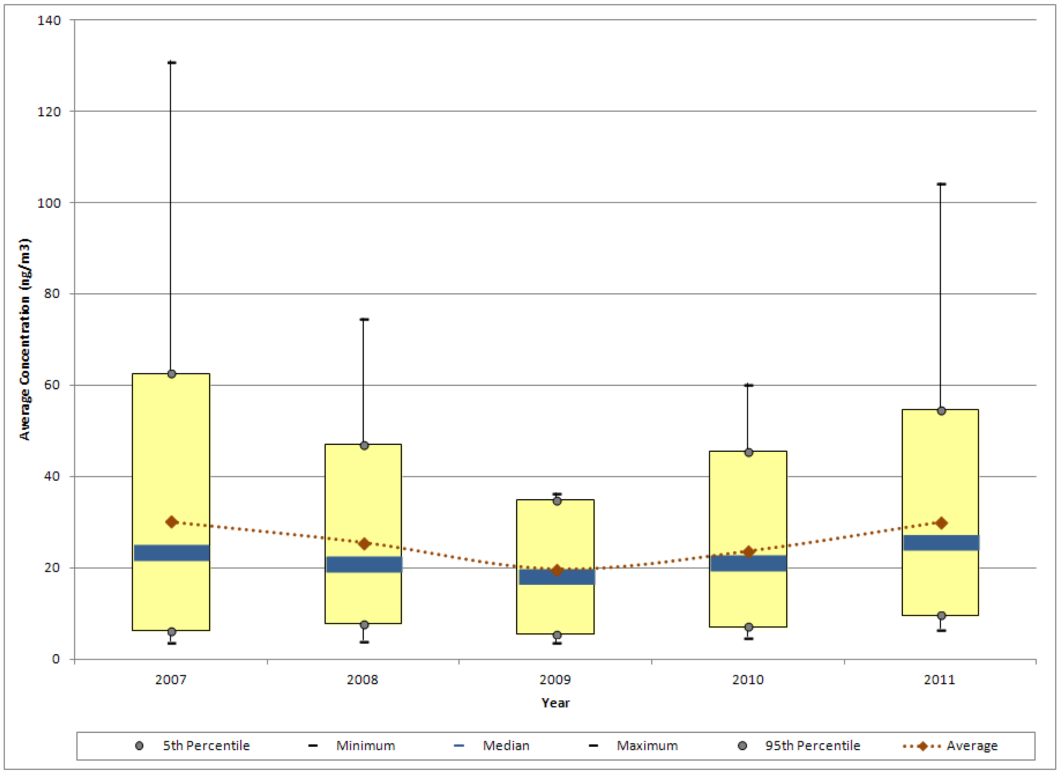


Figure 19-37. Annual Statistical Metrics for Manganese (TSP) Concentrations Measured at TOOK



Observations from Figure 19-31 for acetaldehyde measurements at TOOK include the following:

- Although TOOK began sampling carbonyl compounds in January 2006, equipment complications at the onset of sampling resulted in fewer than 85 percent valid samples in 2006; thus, Figure 19-31 excludes data from 2006 per the criteria specified in Section 3.5.4.

- The maximum concentration of acetaldehyde was measured in 2011 (8.95 µg/m^3). The five highest concentrations were all measured in 2011. Of the 16 acetaldehyde concentrations greater than 4 µg/m^3 measured at TOOK, half were measured in 2011, five were measured in 2010, and one was measured in each of the other years shown.

- The average concentration exhibits an increasing trend since 2009. Nearly all of the statistical metrics shown have been increasing since 2009.

- The minimum concentration measured for each year shown is greater than zero, indicating that there were no non-detects of acetaldehyde reported over the years at TOOK.

Observations from Figure 19-32 for arsenic (TSP) measurements 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 19-32 excludes data from 2006 per the criteria specified in Section 3.5.4.

- 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 average and median concentrations exhibit a decreasing trend from 2007 to 2009. The average concentration of arsenic did not change significantly from 2009 to 2010 while the median decreased slightly. Although a slight increase in the average and median concentrations is shown for 2011, the maximum and 95th percentiles actually decreased and the median for 2011 is actually slightly greater than the average concentration.

- The minimum concentration measured for each year shown is greater than zero, indicating that there were no non-detects of arsenic reported over the years at TOOK.

Observations from Figure 19-33 for benzene measurements at TOOK include the following:

- Although TOOK began sampling VOCs in January 2006, equipment complications at the onset of sampling resulted in fewer than 85 percent valid samples in 2006; thus, Figure 19-33 excludes data from 2006.

- The maximum concentration of benzene was measured in 2011 (23.8 µg/m^3). The four highest concentrations were all 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 previous years.

- The average benzene concentration has fluctuated over the years. After a substantial decrease from 2008 to 2009, most of the statistical parameters increased for 2010, an increase that continued into 2011.

- The difference between the average and median concentrations nearly tripled from 2010 to 2011. This is a further indication of the increasing variability of the 2011 benzene measurements. The median represents the mid-point of the dataset, which increased by more than 0.5 µg/m^3 from 2010 to 2011. The average, which is influenced more by outliers, such as the maximum concentration measured in 2011, increased by more than 1.25 µg/m^3 from 2010 to 2011.

- The minimum concentration measured for each year shown is greater than zero, indicating that there were no non-detects of benzene reported over the years at TOOK.

Observations from Figure 19-34 for 1,3-butadiene measurements at TOOK include the following:

- Similar to other pollutants, the maximum concentration of 1,3-butadiene was measured in 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 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 for 2011.

- The minimum concentration for 2007 is greater than zero, indicating that non-detects of 1,3-butadiene were not reported. For 2008 and 2009, the minimum concentration shown is zero, indicating that at least one non-detect was measured during those years. For 2010 and 2011, both the minimum concentration and 5th percentile are zero, indicating that additional non-detects were reported. The percentage of non-detects for 2010 and 2011 is less than nine percent.

Observations from Figure 19-35 for formaldehyde measurements at TOOK include the following:

- The maximum concentration of formaldehyde (10.1 µg/m^3) was measured at TOOK on August 19, 2011, the same day the maximum acetaldehyde concentration was measured.

- Similar to acetaldehyde, an increasing trend is shown for formaldehyde from 2009 to 2010 and 2011. However, due to the higher level of variability in the formaldehyde measurements as a whole, the difference is not statistically significant.

- The minimum concentration measured for each year shown is greater than zero, indicating that there were no non-detects of formaldehyde reported over the years at TOOK.

Observations from Figure 19-36 for lead (TSP) measurements at TOOK include the following:

- The maximum concentration of lead was measured in 2008 (50.5 ng/m^3). Four of the five highest concentrations of lead were measured in 2008.

- Although most of the statistical parameters increased from 2007 to 2008, the median concentration actually decreased. This indicates that the higher concentrations measured in 2008 were likely driving the average concentration while a higher percentage of measurements were actually lower than in 2007.

- A significant decrease is shown for most of the statistical parameters from 2008 to 2009, with additional slight decreases for 2010.

- Nearly all of the statistical parameters increased for 2011.

- The minimum concentration measured for each year shown is greater than zero, indicating that there were no non-detects of lead reported over the years at TOOK.

Observations from Figure 19-37 for manganese (TSP) measurements at TOOK include the following:

- The maximum concentration of manganese was measured in 2007 (131 ng/m^3), although another measurement greater than 100 ng/m^3 was also measured in 2011 (104 ng/m^3).

- A steady decreasing trend in the average and median concentrations through 2009 was followed by an increasing trend for 2010 and 2011. The average concentration for 2007 is similar to the average concentration for 2011.

- The minimum concentration measured for each year shown is greater than zero, indicating that there were no non-detects of manganese reported over the years at TOOK.

19.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

19.5.2 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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.

Table 19-6. Risk Approximations for the Oklahoma Monitoring Sites

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 Hazard Approximation (HQ)
Tulsa, Oklahoma - TOOK						
Acetaldehyde	0.0000022	0.009	56/56	2.75 ± 0.41	6.04	0.31
Arsenic (TSP)[a]	0.0043	0.000015	56/56	<0.01 ± <0.01	3.27	0.05
Benzene	0.0000078	0.03	57/57	3.59 ± 0.98	28.02	0.12
Beryllium (TSP)[a]	0.0024	0.00002	56/56	<0.01 ± <0.01	0.06	<0.01
1,3-Butadiene	0.00003	0.002	52/57	0.09 ± 0.02	2.70	0.05
Cadmium (TSP)[a]	0.0018	0.00001	56/56	<0.01 ± <0.01	0.55	0.03
Carbon Tetrachloride	0.000006	0.1	57/57	0.63 ± 0.05	3.76	0.01
Chloroform	--	0.098	17/57	0.04 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	51/57	0.15 ± 0.03	1.70	<0.01
Ethylbenzene	0.0000025	1	57/57	0.68 ± 0.13	1.70	<0.01
Formaldehyde	0.000013	0.0098	56/56	3.74 ± 0.57	48.62	0.38
Lead (TSP)[a]	--	0.00015	56/56	0.01 ± <0.01	--	0.04
Manganese (TSP)[a]	--	0.00005	56/56	0.03 ± <0.01	--	0.60
Nickel (TSP)[a]	0.00048	0.00009	56/56	<0.01 ± <0.01	0.84	0.02
Propionaldehyde	--	0.008	56/56	0.51 ± 0.07	--	0.06
Tetrachloroethylene	0.00000026	0.04	47/57	0.12 ± 0.03	0.03	<0.01
Trichloroethylene	0.0000048	0.002	8/57	0.01 ± 0.01	0.05	0.01
Vinyl Chloride	0.0000088	0.1	3/57	<0.01 ± <0.01	0.01	<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 19-5.

Table 19-6. 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 Hazard Approximation (HQ)
Tulsa, Oklahoma - TMOK						
Acetaldehyde	0.0000022	0.009	61/61	2.40 ± 0.34	5.28	0.27
Acrylonitrile	0.000068	0.002	10/60	0.08 ± 0.07	5.36	0.04
Arsenic (TSP)[a]	0.0043	0.000015	58/58	<0.01 ± <0.01	2.73	0.04
Benzene	0.0000078	0.03	60/60	1.35 ± 0.18	10.54	0.05
Beryllium (TSP)[a]	0.0024	0.00002	58/58	<0.01 ± <0.01	0.04	<0.01
1,3-Butadiene	0.00003	0.002	51/60	0.10 ± 0.02	3.07	0.05
Cadmium (TSP) [a]	0.0018	0.00001	58/58	<0.01 ± <0.01	0.39	0.02
Carbon Tetrachloride	0.000006	0.1	60/60	0.60 ± 0.03	3.61	0.01
Chloroform	--	0.098	28/60	0.07 ± 0.03	--	<0.01
p-Dichlorobenzene	0.000011	0.8	47/60	0.08 ± 0.02	0.91	<0.01
1,2-Dichloroethane	0.000026	2.4	10/60	0.02 ± 0.01	0.47	<0.01
Ethylbenzene	0.0000025	1	60/60	0.55 ± 0.09	1.37	<0.01
Formaldehyde	0.000013	0.0098	61/61	3.93 ± 0.62	51.15	0.40
Lead (TSP)[a]	--	0.00015	58/58	<0.01 ± <0.01	--	0.03
Manganese (TSP)[a]	--	0.00005	58/58	0.02 ± <0.01	--	0.41
Nickel (TSP)[a]	0.00048	0.00009	58/58	<0.01 ± <0.01	0.68	0.02
Tetrachloroethylene	0.00000026	0.04	40/60	0.07 ± 0.02	0.02	<0.01
Trichloroethylene	0.0000048	0.002	10/60	0.01 ± 0.01	0.06	0.01
Vinyl Chloride	0.0000088	0.1	1/60	<0.01 ± <0.01	<0.01	<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 19-5.

Table 19-6. 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 Hazard Approximation (HQ)
Pryor Creek, Oklahoma - PROK						
Acetaldehyde	0.0000022	0.009	58/58	1.68 ± 0.18	3.70	0.19
Arsenic (TSP) [a]	0.0043	0.000015	56/56	<0.01 ± <0.01	2.32	0.04
Benzene	0.0000078	0.03	56/56	0.68 ± 0.08	5.28	0.02
Beryllium (TSP)[a]	0.0024	0.00002	56/56	<0.01 ± <0.01	0.07	<0.01
1,3-Butadiene	0.00003	0.002	33/56	0.04 ± 0.01	1.07	0.02
Cadmium (TSP)[a]	0.0018	0.00001	56/56	<0.01 ± <0.01	0.28	0.02
Carbon Tetrachloride	0.000006	0.1	56/56	0.62 ± 0.03	3.73	0.01
Chloroform	--	0.098	15/56	0.03 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	47/56	0.20 ± 0.07	2.20	<0.01
1,2-Dichloroethane	0.000026	2.4	17/56	0.03 ± 0.01	0.73	<0.01
Formaldehyde	0.000013	0.0098	58/58	3.84 ± 0.67	49.86	0.39
Lead (TSP)[a]	--	0.00015	56/56	<0.01 ± <0.01	--	0.02
Manganese (TSP)[a]	--	0.00005	56/56	0.01 ± <0.01	--	0.23
Nickel (TSP)[a]	0.00048	0.00009	56/56	<0.01 ± <0.01	0.38	0.01
Tetrachloroethylene	0.00000026	0.04	28/56	0.03 ± 0.01	0.01	<0.01
Trichloroethylene	0.0000048	0.002	2/56	<0.01 ± <0.01	0.01	<0.01
Vinyl Chloride	0.0000088	0.1	3/56	<0.01 ± <0.01	0.01	<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 19-5.

Table 19-6. 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 Hazard Approximation (HQ)
Midwest City, Oklahoma - MWOK						
Acetaldehyde	0.0000022	0.009	56/56	2.03 ± 0.24	4.47	0.23
Acrylonitrile	0.000068	0.002	5/56	0.01 ± 0.01	0.76	0.01
Arsenic (TSP)[a]	0.0043	0.000015	56/56	<0.01 ± <0.01	1.71	0.03
Benzene	0.0000078	0.03	56/56	0.73 ± 0.07	5.73	0.02
Beryllium (TSP)[a]	0.0024	0.00002	56/56	<0.01 ± <0.01	0.05	<0.01
1,3-Butadiene	0.00003	0.002	40/56	0.06 ± 0.02	1.81	0.03
Cadmium (TSP)[a]	0.0018	0.00001	56/56	<0.01 ± <0.01	0.22	0.01
Carbon Tetrachloride	0.000006	0.1	56/56	0.60 ± 0.03	3.60	0.01
Chloroform	--	0.098	23/56	0.04 ± 0.01	--	<0.01
p-Dichlorobenzene	0.000011	0.8	50/56	0.09 ± 0.01	0.99	<0.01
1,2-Dichloroethane	0.000026	2.4	9/56	0.01 ± 0.01	0.39	<0.01
Ethylbenzene	0.0000025	1	56/56	0.25 ± 0.04	0.61	<0.01
Formaldehyde	0.000013	0.0098	56/56	4.05 ± 0.53	52.69	0.41
Lead (TSP)[a]	--	0.00015	56/56	<0.01 ± <0.01	--	0.02
Manganese (TSP)[a]	--	0.00005	56/56	0.01 ± <0.01	--	0.27
Nickel (TSP)[a]	0.00048	0.00009	56/56	<0.01 ± <0.01	0.58	0.01
Tetrachloroethylene	0.00000026	0.04	40/56	0.15 ± 0.06	0.04	<0.01
Trichloroethylene	0.0000048	0.002	1/56	<0.01 ± <0.01	0.01	<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 19-5.

Table 19-6. 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 Hazard Approximation (HQ)
Oklahoma City, Oklahoma - OCOK						
Acetaldehyde	0.0000022	0.009	60/60	2.41 ± 0.33	5.30	0.27
Acrylonitrile	0.000068	0.002	9/61	0.07 ± 0.05	4.74	0.03
Arsenic (TSP)[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	2.02	0.03
Benzene	0.0000078	0.03	61/61	0.88 ± 0.21	6.85	0.03
Beryllium (TSP)[a]	0.0024	0.00002	61/61	<0.01 ± <0.01	0.04	<0.01
1,3-Butadiene	0.00003	0.002	41/61	0.20 ± 0.31	6.03	0.10
Cadmium (TSP)[a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.23	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.58 ± 0.04	3.50	0.01
Chloroform	--	0.098	13/61	0.02 ± 0.01	--	<0.01
p-Dichlorobenzene	0.000011	0.8	39/61	0.06 ± 0.01	0.62	<0.01
1,2-Dichloroethane	0.000026	2.4	14/61	0.03 ± 0.02	0.81	<0.01
Ethylbenzene	0.0000025	1	61/61	0.31 ± 0.04	0.78	<0.01
Formaldehyde	0.000013	0.0098	60/60	4.06 ± 0.80	52.80	0.41
Lead (TSP)[a]	--	0.00015	61/61	<0.01 ± <0.01	--	0.02
Manganese (TSP)[a]	--	0.00005	61/61	0.01 ± <0.01	--	0.28
Nickel (TSP)[a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.40	0.01
Tetrachloroethylene	0.00000026	0.04	40/61	0.08 ± 0.02	0.02	<0.01
Trichloroethylene	0.0000048	0.002	1/61	<0.01 ± <0.01	0.01	<0.01
Vinyl Chloride	0.0000088	0.1	3/61	<0.01 ± <0.01	0.01	<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 19-5.

Observations from Table 19-6 include the following:

- Formaldehyde has the highest annual average concentration by mass 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 Oklahoma monitoring sites. Formaldehyde cancer risk approximations range from 48.62 in-a-million for TOOK to 52.80 in-a-million for OCOK. The cancer risk approximations for OCOK and MWOK rank third and fourth highest among all cancer risk approximations program-wide. Benzene cancer risk approximations range from 5.28 in-a-million for PROK to 28.02 in-a-million for TOOK. The benzene cancer risk approximation for TOOK is the highest benzene cancer risk approximation program-wide.

- Among the metals, arsenic has the highest cancer risk approximations for all of the Oklahoma monitoring sites, ranging from 1.71 in-a-million for MWOK to 3.27 in-a-million for TOOK.

- 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, manganese, and acetaldehyde have the highest noncancer hazard approximations for each site (albeit less than 1.0).

19.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 19-7 and 19-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 19-6. Table 19-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 19-6.

Table 19-7. 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	398.15	Benzene	3.11E-03	Formaldehyde	48.62
Ethylbenzene	236.92	Formaldehyde	2.58E-03	Benzene	28.02
Formaldehyde	198.13	1,3-Butadiene	1.57E-03	Acetaldehyde	6.04
Acetaldehyde	105.13	Hexavalent Chromium, PM	1.11E-03	Carbon Tetrachloride	3.76
1,3-Butadiene	52.47	Naphthalene	8.02E-04	Arsenic	3.27
Tetrachloroethylene	41.33	Ethylbenzene	5.92E-04	1,3-Butadiene	2.70
Naphthalene	23.57	POM, Group 2b	3.16E-04	Ethylbenzene	1.70
Dichloromethane	5.51	Acetaldehyde	2.31E-04	*p*-Dichlorobenzene	1.70
POM, Group 2b	3.59	POM, Group 3	2.30E-04	Nickel	0.84
Nickel, PM	0.40	Nickel, PM	1.90E-04	Cadmium	0.55
Tulsa, Oklahoma (Tulsa County) - TMOK					
Benzene	398.15	Benzene	3.11E-03	Formaldehyde	51.15
Ethylbenzene	236.92	Formaldehyde	2.58E-03	Benzene	10.54
Formaldehyde	198.13	1,3-Butadiene	1.57E-03	Acrylonitrile	5.36
Acetaldehyde	105.13	Hexavalent Chromium, PM	1.11E-03	Acetaldehyde	5.28
1,3-Butadiene	52.47	Naphthalene	8.02E-04	Carbon Tetrachloride	3.61
Tetrachloroethylene	41.33	Ethylbenzene	5.92E-04	1,3-Butadiene	3.07
Naphthalene	23.57	POM, Group 2b	3.16E-04	Arsenic	2.73
Dichloromethane	5.51	Acetaldehyde	2.31E-04	Ethylbenzene	1.37
POM, Group 2b	3.59	POM, Group 3	2.30E-04	*p*-Dichlorobenzene	0.91
Nickel, PM	0.40	Nickel, PM	1.90E-04	Nickel	0.68

Table 19-7. 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	37.28	Arsenic, PM	2.29E-03	Formaldehyde	49.86
Formaldehyde	24.25	Hexavalent Chromium, PM	9.45E-04	Benzene	5.28
Ethylbenzene	17.46	Nickel, PM	5.62E-04	Carbon Tetrachloride	3.73
Acetaldehyde	12.40	Formaldehyde	3.15E-04	Acetaldehyde	3.70
1,3-Butadiene	3.72	Benzene	2.91E-04	Arsenic	2.32
Naphthalene	2.04	1,3-Butadiene	1.11E-04	*p*-Dichlorobenzene	2.20
Chloromethylbenzene	1.60	Beryllium, PM	8.46E-05	1,3-Butadiene	1.07
Nickel, PM	1.17	Cadmium, PM	8.35E-05	1,2-Dichloroethane	0.73
Dichloromethane	1.03	Chloromethylbenzene	7.85E-05	Nickel	0.38
Arsenic, PM	0.53	Naphthalene	6.93E-05	Cadmium	0.28
Midwest City, Oklahoma (Oklahoma County) - MWOK					
Benzene	447.79	Benzene	3.49E-03	Formaldehyde	52.69
Ethylbenzene	275.02	Formaldehyde	3.26E-03	Benzene	5.73
Formaldehyde	250.63	1,3-Butadiene	1.79E-03	Acetaldehyde	4.47
Acetaldehyde	137.04	Naphthalene	9.96E-04	Carbon Tetrachloride	3.60
1,3-Butadiene	59.70	Ethylbenzene	6.88E-04	1,3-Butadiene	1.81
Naphthalene	29.28	Hexavalent Chromium, PM	6.16E-04	Arsenic	1.71
Dichloromethane	15.08	POM, Group 2b	3.97E-04	*p*-Dichlorobenzene	0.99
Tetrachloroethylene	10.79	Acetaldehyde	3.01E-04	Acrylonitrile	0.76
POM, Group 2b	4.51	POM, Group 3	2.64E-04	Ethylbenzene	0.61
Bis(2-ethylhexyl)phthalate (DEHP), gas	0.49	Arsenic, PM	1.85E-04	Nickel	0.58

Table 19-7. 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	447.79	Benzene	3.49E-03	Formaldehyde	52.80
Ethylbenzene	275.02	Formaldehyde	3.26E-03	Benzene	6.85
Formaldehyde	250.63	1,3-Butadiene	1.79E-03	1,3-Butadiene	6.03
Acetaldehyde	137.04	Naphthalene	9.96E-04	Acetaldehyde	5.30
1,3-Butadiene	59.70	Ethylbenzene	6.88E-04	Acrylonitrile	4.74
Naphthalene	29.28	Hexavalent Chromium, PM	6.16E-04	Carbon Tetrachloride	3.50
Dichloromethane	15.08	POM, Group 2b	3.97E-04	Arsenic	2.02
Tetrachloroethylene	10.79	Acetaldehyde	3.01E-04	1,2-Dichloroethane	0.81
POM, Group 2b	4.51	POM, Group 3	2.64E-04	Ethylbenzene	0.78
Bis(2-ethylhexyl)phthalate (DEHP), gas	0.49	Arsenic, PM	1.85E-04	*p*-Dichlorobenzene	0.62

Table 19-8. 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	1,180.06	Acrolein	577,473.50	Manganese	0.60
Xylenes	902.52	1,3-Butadiene	26,235.74	Formaldehyde	0.38
Methanol	402.45	Formaldehyde	20,217.32	Acetaldehyde	0.31
Benzene	398.15	Manganese, PM	18,832.62	Benzene	0.12
Hexane	293.67	Benzene	13,271.68	Propionaldehyde	0.06
Ethylbenzene	236.92	Lead, PM	13,200.35	Arsenic	0.05
Formaldehyde	198.13	Acetaldehyde	11,681.56	1,3-Butadiene	0.05
Acetaldehyde	105.13	Xylenes	9,025.21	Lead	0.04
1,3-Butadiene	52.47	Naphthalene	7,857.87	Cadmium	0.03
Ethylene glycol	50.77	Cobalt , PM	5,351.77	Nickel	0.02
Tulsa, Oklahoma (Tulsa County) - TMOK					
Toluene	1,180.06	Acrolein	577,473.50	Manganese	0.41
Xylenes	902.52	1,3-Butadiene	26,235.74	Formaldehyde	0.40
Methanol	402.45	Formaldehyde	20,217.32	Acetaldehyde	0.27
Benzene	398.15	Manganese, PM	18,832.62	1,3-Butadiene	0.05
Hexane	293.67	Benzene	13,271.68	Benzene	0.05
Ethylbenzene	236.92	Lead, PM	13,200.35	Arsenic	0.04
Formaldehyde	198.13	Acetaldehyde	11,681.56	Acrylonitrile	0.04
Acetaldehyde	105.13	Xylenes	9,025.21	Lead	0.03
1,3-Butadiene	52.47	Naphthalene	7,857.87	Cadmium	0.02
Ethylene glycol	50.77	Cobalt , PM	5,351.77	Nickel	0.02

Table 19-8. 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					
Hydrochloric acid	145.18	Acrolein	91,374.65	Formaldehyde	0.39
Toluene	89.08	Chlorine	61,006.67	Manganese	0.23
Xylenes	72.70	Cyanide Compounds, gas	43,619.17	Acetaldehyde	0.19
Benzene	37.28	Arsenic, PM	35,508.85	Arsenic	0.04
Cyanide Compounds, gas	34.90	Nickel, PM	13,015.34	Benzene	0.02
Hydrofluoric acid	26.35	Manganese, PM	8,604.28	Lead	0.02
Formaldehyde	24.25	Hydrochloric acid	7,259.15	1,3-Butadiene	0.02
Methanol	23.55	Cyanide Compounds, PM	7,154.96	Cadmium	0.02
Hexane	22.30	Cadmium, PM	4,636.70	Nickel	0.01
Ethylbenzene	17.46	Lead, PM	4,369.13	Carbon Tetrachloride	0.01
Midwest City, Oklahoma (Oklahoma County) - MWOK					
Toluene	1,373.20	Acrolein	875,997.95	Formaldehyde	0.41
Xylenes	1,058.17	1,3-Butadiene	29,851.09	Manganese	0.27
Methanol	468.16	Formaldehyde	25,574.80	Acetaldehyde	0.23
Benzene	447.79	Acetaldehyde	15,226.70	1,3-Butadiene	0.03
Hexane	337.57	Benzene	14,926.42	Arsenic	0.03
Ethylbenzene	275.02	Xylenes	10,581.67	Benzene	0.02
Formaldehyde	250.63	Naphthalene	9,759.95	Lead	0.02
Acetaldehyde	137.04	Arsenic, PM	2,874.57	Nickel	0.01
Ethylene glycol	61.51	Lead, PM	2,417.07	Cadmium	0.01
1,3-Butadiene	59.70	Propionaldehyde	2,079.24	Carbon Tetrachloride	0.01

Table 19-8. 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	1,373.20	Acrolein	875,997.95	Formaldehyde	0.41
Xylenes	1,058.17	1,3-Butadiene	29,851.09	Manganese	0.28
Methanol	468.16	Formaldehyde	25,574.80	Acetaldehyde	0.27
Benzene	447.79	Acetaldehyde	15,226.70	1,3-Butadiene	0.10
Hexane	337.57	Benzene	14,926.42	Acrylonitrile	0.03
Ethylbenzene	275.02	Xylenes	10,581.67	Arsenic	0.03
Formaldehyde	250.63	Naphthalene	9,759.95	Benzene	0.03
Acetaldehyde	137.04	Arsenic, PM	2,874.57	Lead	0.02
Ethylene glycol	61.51	Lead, PM	2,417.07	Cadmium	0.01
1,3-Butadiene	59.70	Propionaldehyde	2,079.24	Nickel	0.01

The pollutants listed in Tables 19-7 and 19-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 19.3, the Oklahoma sites sampled VOCs, carbonyl compounds, and TSP metals. 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, as discussed in previous sections. A more in-depth discussion of this analysis is provided in Section 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 19-7 include the following:

- Benzene is the highest emitted pollutant with a cancer URE in Mayes, Oklahoma, and Tulsa Counties, followed by ethylbenzene and formaldehyde in Oklahoma and Tulsa Counties and formaldehyde and ethylbenzene in Mayes County. The emissions of these pollutants in Mayes County are an order of magnitude lower than the emissions for Oklahoma and Tulsa Counties.

- The pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Oklahoma and Tulsa Counties are benzene, formaldehyde, and 1,3-butadiene. The pollutants with the highest toxicity-weighted emissions for Mayes County are arsenic, hexavalent chromium, and nickel.

- Eight of the highest emitted pollutants in Tulsa County also have the highest toxicity-weighted emissions. Six of the highest emitted pollutants in Mayes County also have the highest toxicity-weighted emissions. Seven of the highest emitted pollutants in Oklahoma County also have the highest toxicity-weighted emissions.

- Formaldehyde and benzene have the highest cancer risk approximations among the Oklahoma sites' pollutants of interest. These pollutants appear on both emissions-based lists for all five sites. Conversely, carbon tetrachloride, another pollutant with relatively high cancer risk approximations, does not appear on either emissions-based list.

- While hexavalent chromium is among the pollutants with the highest toxicity-weighted emissions for each county, it is not among the highest emitted pollutants. This indicates that lower emissions can translate to higher risk levels.

- The toxicity-weighted pollutants listed for Mayes County are considerably different than for the other two counties. There are five metals listed for Mayes County while the other counties only have two each. In addition, there are no POM Groups listed for Mayes County, while POM, Groups 2b and 3 appear for Oklahoma and Tulsa Counties.

Observations from Table 19-8 include the following:

- Toluene, xylenes, and methanol are the highest emitted pollutants with noncancer RfCs in Oklahoma and Tulsa Counties. Hydrochloric acid, toluene, and xylenes are the highest emitted pollutants with noncancer RfCs in Mayes County. Note that the quantity emitted is much higher in Tulsa and Oklahoma Counties than 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.

- Two of the highest emitted pollutants in Mayes County also have the highest toxicity-weighted emissions; five of the highest emitted pollutants in Tulsa and Oklahoma Counties also have the highest toxicity-weighted emissions.

- Five of the 10 pollutants with the highest noncancer toxicity-weighted emissions in Mayes County were metals. Cyanide compounds, gaseous and particulate, account for two more.

- 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 11th for toxicity-weighted emissions for Mayes County and therefore does not appear in Table 19-8 in that column. Manganese appears among the pollutants with the highest toxicity-weighted emissions for Tulsa and Mayes Counties but ranks 14th for toxicity-weighted emissions for Oklahoma County. There are no metals listed among the highest emitted pollutants for any of the three counties.

- It is important to note that for the metals, the emissions-based lists are PM_{10} while the Oklahoma sites sampled TSP metals.

19.6 Summary of the 2011 Monitoring Data for the Oklahoma Monitoring Sites

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

- ❖ *Twenty pollutants failed at least one screen for TOOK; 19 pollutants failed screens for TMOK; 15 pollutants failed screens for PROK; 17 pollutants failed screens for MWOK; and 16 pollutants failed screens for OCOK.*

- *Formaldehyde had the highest annual average concentration by mass for each site. Among the TSP metals, the annual average concentration of manganese was the highest for each site.*

- *TOOK had the highest annual average of concentration of benzene among all NMP sites sampling this pollutant. Annual averages of formaldehyde for all five Oklahoma sites rank among the highest annual average concentrations of formaldehyde program-wide.*

- *Concentrations of several of the NATTS MQO Core Analytes exhibit increasing trends at TOOK.*

20.0 Site in Rhode Island

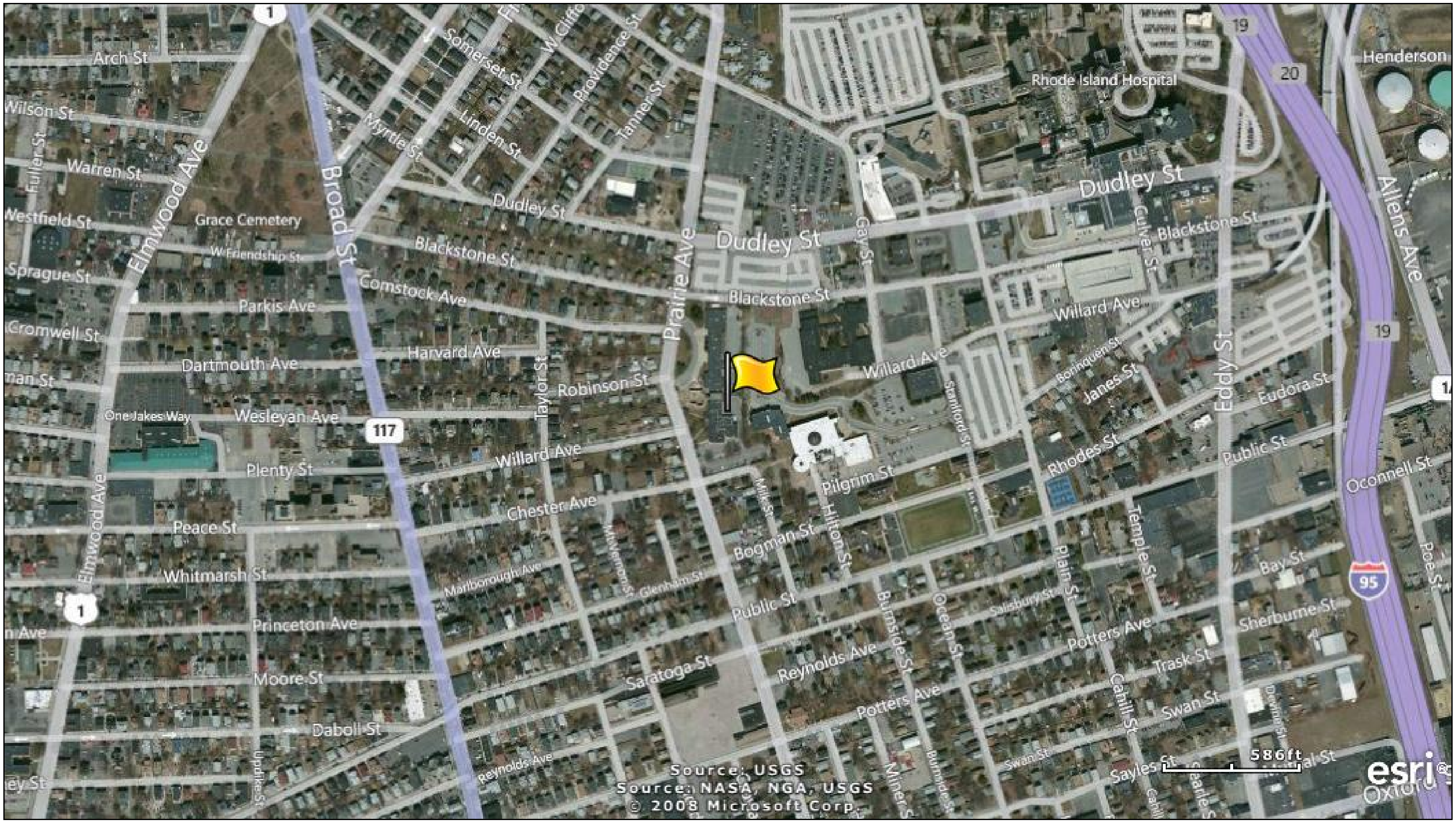
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Rhode Island, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the 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.

20.1 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 20-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its urban location. Figure 20-2 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 20-2. 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 20-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 20-1. Providence, Rhode Island (PRRI) Monitoring Site



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

Figure 20-2. NEI Point Sources Located Within 10 Miles of PRRI

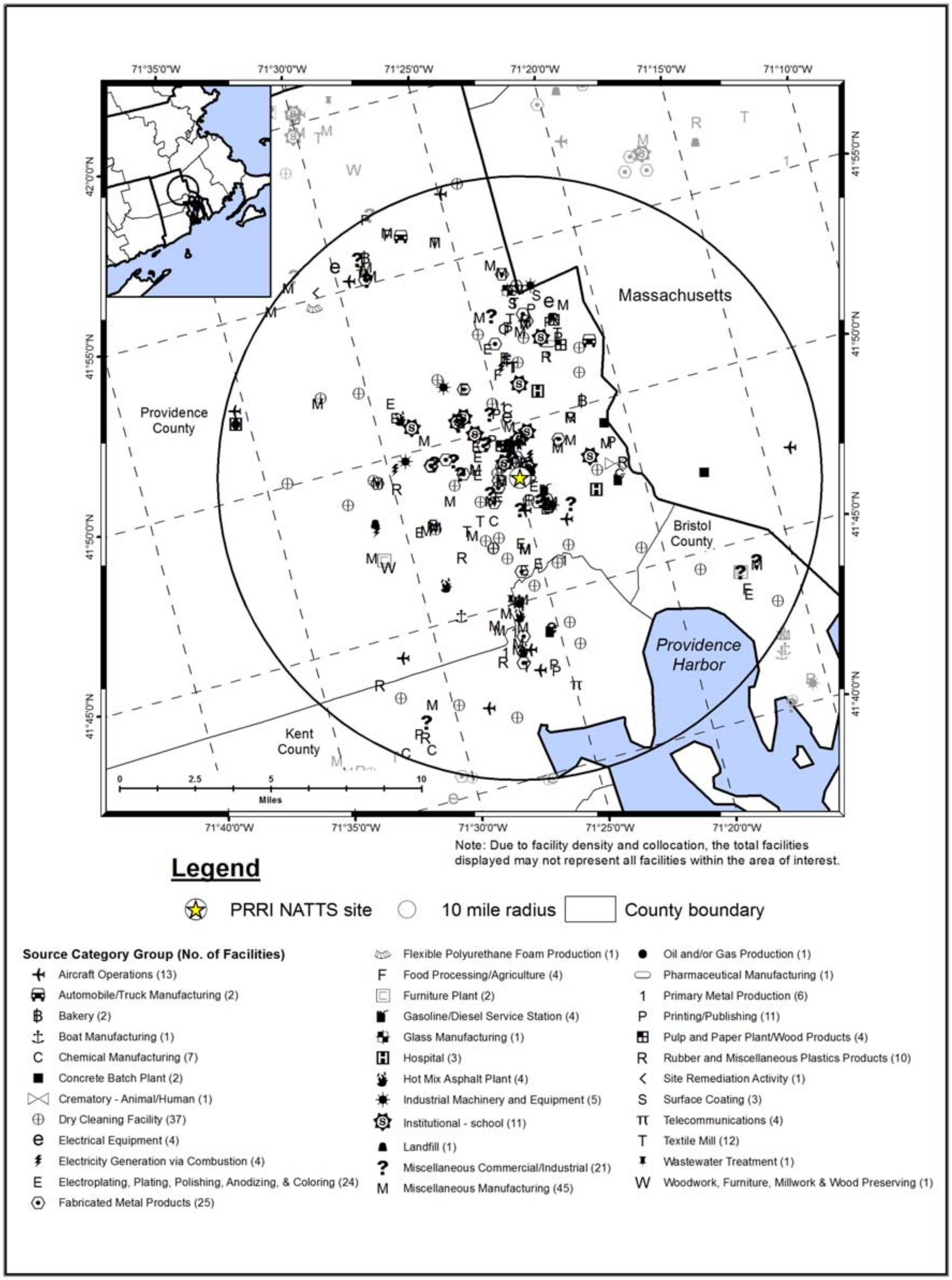


Table 20-1. Geographical Information for the Rhode Island Monitoring Site

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-New Bedford-Fall River, RI-MA MSA	41.807949, -71.415	Residential	Urban/City Center	PAMS, VOCs, Carbonyl Compounds, Meteorological parameters, PM_{10}, PM_{10} Speciation, Black Carbon, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Germanium.

[1] Data for additional pollutants are reported to AQS for PRRI (EPA, 2012c); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

Figure 20-1 shows that the areas to the west and south of PRRI are residential, but areas to the north and east are commercial. A hospital lies to the northeast of the site, just north of Dudley Street. About 1/2 mile to the east I-95 runs north-south, then turns northwestward, entering downtown Providence. Narragansett Bay and the Port of Providence are a few tenths of a mile farther to the east, just on the other side of I-95. Figure 20-2 shows that a large number of point sources are located within 10 miles of PRRI, especially to the north of the site. Many of these sources seem to parallel I-95. The source categories with the greatest number of point sources within 10 miles of PRRI include dry cleaners; fabricated metals products facilities; electroplating, plating, polishing, anodizing, and coloring facilities; and aircraft operations, which includes airports as well as small runways, heliports, or landing pads.

Table 20-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Rhode Island monitoring site. Table 20-2 includes a 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 20-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 20-2 also contains traffic volume information for PRRI. County-level VMT data were not readily available for Providence County.

Table 20-2. Population, Motor Vehicle, and Traffic Information for the Rhode Island Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
PRRI	626,709	485,837	0.78	657,586	509,773	136,800	--

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects a ratio based on 2010 state-level vehicle registration data from the FHWA and the 2010 county-level proportion of the state population data (FHWA, 2011 and Census Bureau, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2009 data from the Rhode Island DOT (RI DOT, 2009)
[5] County-level VMT was not available for this site.
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 20-2 include the following:

- Providence County's population is in the middle of the range compared to other counties with NMP sites, as is the 10-mile population.
- The estimated county-level vehicle registration is in the middle of the range compared to other counties with NMP sites, as is the 10-mile ownership estimate.
- The vehicle-per-person ratio is in the bottom third compared to other NMP sites.
- The traffic volume experienced near PRRI is the ninth highest compared to other NMP monitoring sites. The traffic estimate provided is for I-95 near the I-195 interchange.

20.2 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.

20.2.1 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. Precipitation in Providence is well distributed throughout the year. Weather is fairly variable as frequent storm systems affect the New England region (Bair, 1992).

20.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest PRRI were retrieved for 2011 (NCDC, 2011). The closest weather station is located at Theodore F. Green State Airport (WBAN 14765). Additional information about the T.F. Green weather station, such as the distance between the site and the weather station, 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 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 20-3 is the 95 percent confidence interval for each parameter. As shown in Table 20-3, average meteorological conditions on sample days appear slightly cooler than average weather conditions throughout the year, although the differences are not statistically significant. This is likely the result of several make-up samples collected during the first quarter of the year.

20.2.3 Back Trajectory Analysis

Figure 20-3 is the composite back trajectory map for days on which samples were collected at the PRRI monitoring site in 2011. Included in Figure 20-3 are four back trajectories per sample day. Figure 20-4 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 20-3 and 20-4 represents 100 miles.

Table 20-3. Average Meteorological Conditions near the Rhode Island Monitoring Site

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)
Providence, Rhode Island - PRRI									
Theodore F. Green State Airport 14765 (41.72, -71.43)	6.01 miles 173° (S)	Sample Day	59.5 ± 4.3	51.3 ± 4.1	40.2 ± 4.7	46.4 ± 4.0	69.0 ± 3.8	1014.9 ± 2.0	7.6 ± 0.7
		2011	60.9 ± 1.8	52.6 ± 1.8	41.9 ± 1.9	47.7 ± 1.7	69.9 ± 1.5	1015.4 ± 0.8	7.0 ± 0.3

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

Figure 20-3. 2011 Composite Back Trajectory Map for PRRI

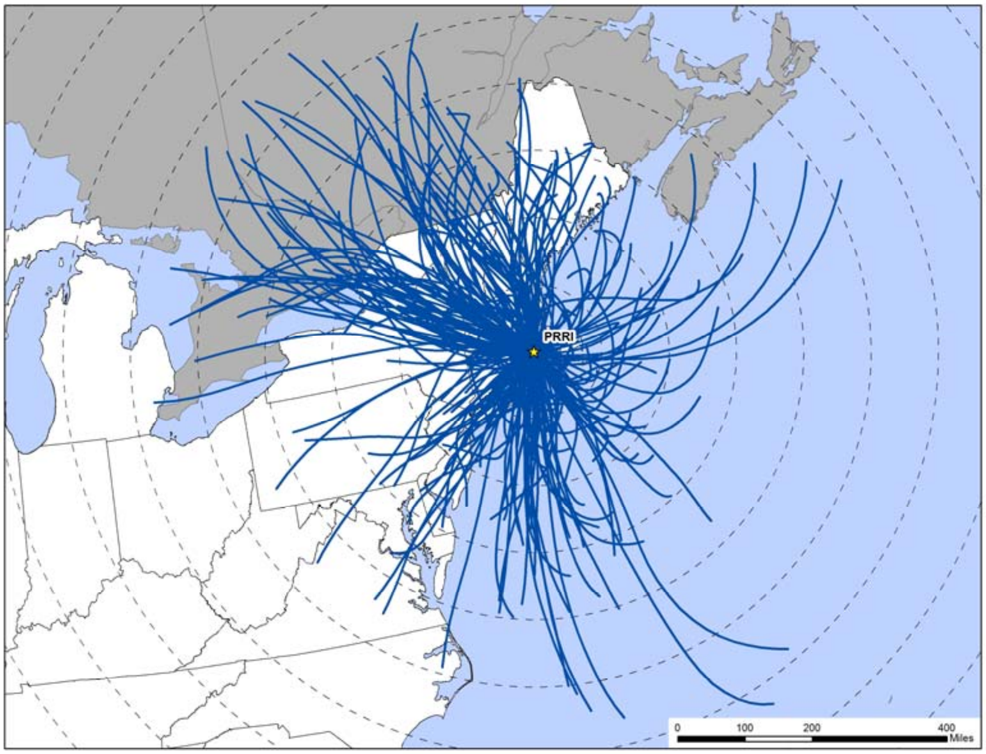
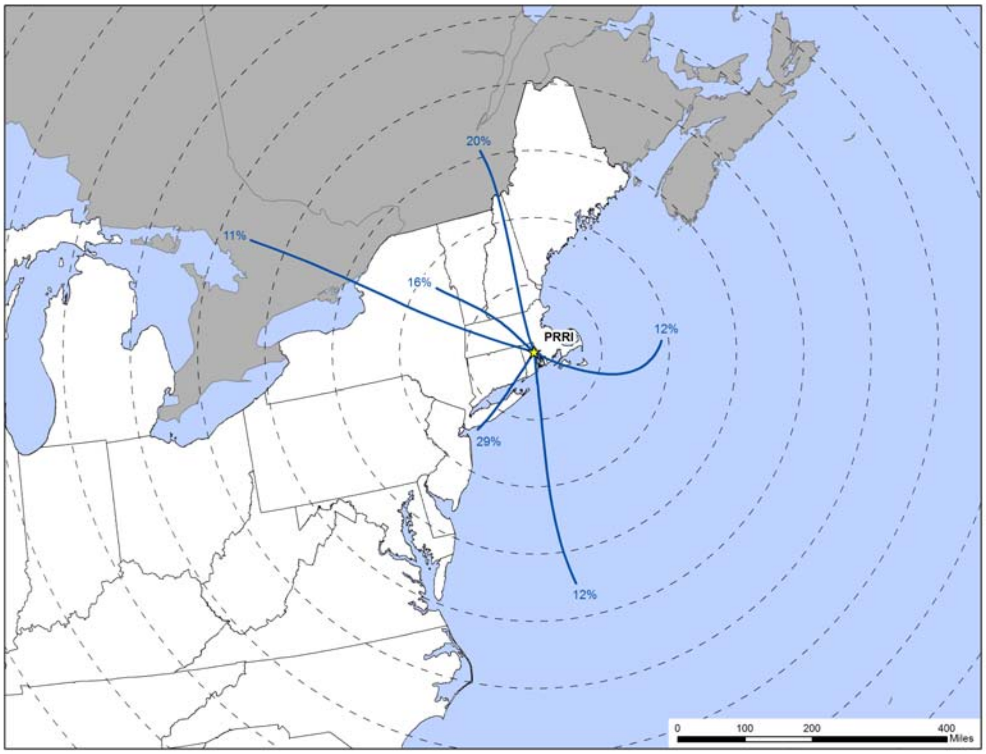


Figure 20-4. Back Trajectory Cluster Map for PRRI



Observations from Figures 20-3 and 20-4 for PRRI include the following:

- Back trajectories originated from a variety of directions at PRRI, although the majority of back trajectories originated from the northwest to north and south-southeast to south-southwest.

- The airshed domain for PRRI was among the larger in size compared to other NMP sites, based on the average trajectory length. The average trajectory length was 265 miles long, although the farthest away a back trajectory originated was off the North Carolina coast and over the Atlantic Ocean, or greater than 600 miles away. However, 87 percent of back trajectories originating within 450 miles of the site.

- The cluster analysis shows that nearly 50 percent of back trajectories originated from the west, northwest, and north, although of differing lengths, as represented by three cluster trajectories. One originates over south Ontario, Canada (11 percent) and represents longer trajectories originating over the Great Lakes region. The short cluster trajectory originating over New York (16 percent) represents back trajectories originating over northern New York, Vermont, and New Hampshire as well as shorter northward originating trajectories. The cluster trajectory originating to the north (20 percent) represents longer trajectories originating over Quebec, Canada, as well as shorter back trajectories originating over Maine and the Gulf of Maine. Twenty-nine percent of back trajectories originated to the southwest of PRRI, although this cluster trajectory also represents short back trajectories (generally 100-200 miles in length) originating from the south to southwest to west of the site. Twelve percent of back trajectories originated over the offshore waters of the Mid-Atlantic states, while another 12 percent originated from a direction with an easterly component.

20.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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.

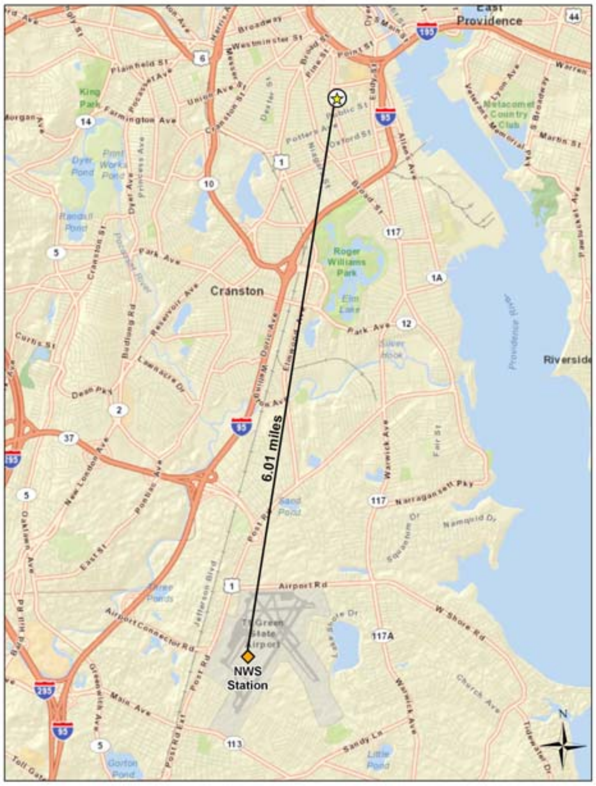
Figure 20-5 presents a map showing the distance between the NWS station and PRRI, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 20-5 also presents three different wind roses for the PRRI monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 20-5 for PRRI include the following:

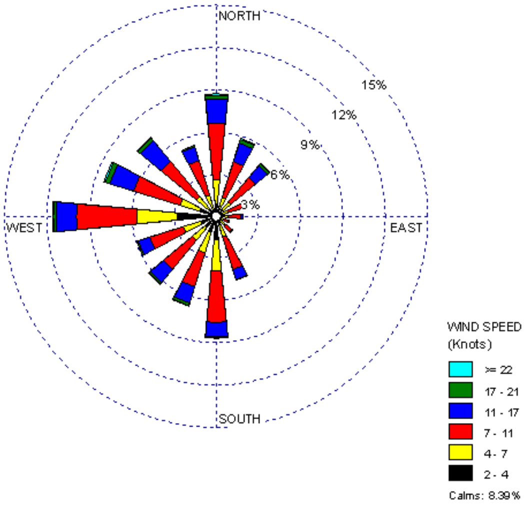
- The NWS weather station at T.F. Green Airport is located approximately 6 miles south of PRRI.
- The historical wind rose shows that while westerly winds were observed the most (approximately 12 percent of observations), winds from the western quadrants, due north, and due south are common near PRRI. Calm winds (≤ 2 knots) account for less than nine percent of the hourly measurements.
- The wind patterns shown on the 2011 wind rose are similar to the historical wind patterns, with winds from the western quadrants, due north, and due south prevalent near PRRI, although there are some slight differences in the percentages. Also, the calm rate for 2011 is nearly 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 north and due south, although the percentages vary for some directions. The sample day calm rate is similar to the full-year calm rate. These similarities indicate that conditions on sample days were generally representative of conditions experienced throughout the year and historically.

Figure 20-5. Wind Roses for the T.F. Green State Airport Weather Station near PRRI

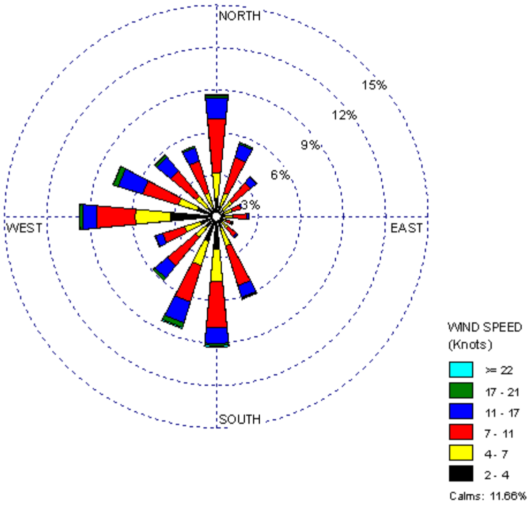
Distance between PRRI and NWS Station



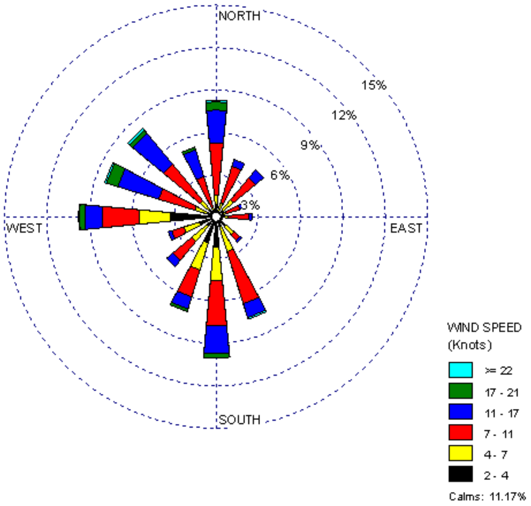
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



20.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Rhode Island monitoring site in order to allow 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." 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 20-4 presents the results of the preliminary risk-based screening process for PRRI. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for PRRI are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. PRRI sampled for PAHs and hexavalent chromium.

Table 20-4. 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	57	57	100.00	86.36	86.36
Fluorene	0.011	4	57	7.02	6.06	92.42
Acenaphthene	0.011	3	57	5.26	4.55	96.97
Fluoranthene	0.011	1	57	1.75	1.52	98.48
Hexavalent Chromium	0.000083	1	52	1.92	1.52	100.00
Total		66	280	23.57		

Observations from Table 20-4 include the following:

- Five pollutants failed screens for PRRI. Naphthalene failed 100 percent of its screens and accounted for 86 percent of PRRI's total failed screens.

- Naphthalene, fluorene, and acenaphthene were identified as the pollutants of interest for PRRI based on the risk-based screening process. Hexavalent chromium was added to the pollutants of interest for PRRI because is it a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of failed screens. Benzo(a)pyrene was added to the pollutants of interest for PRRI because it is also a NATTS MQO Core

Analyte, even though it did not fail any screens. Benzo(a)pyrene is not shown in Table 20-4 but is shown in subsequent tables in the sections that follow.

20.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for PRRI, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for PRRI are provided in Appendices M and O.

20.4.1 2011 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 of 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 20-5, 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 20-5. 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						
Acenaphthene	57/57	1.39 ± 0.30	4.35 ± 1.60	6.61 ± 2.06	2.33 ± 0.79	3.65 ± 0.83
Benzo(a)pyrene	56/57	0.20 ± 0.07	0.17 ± 0.06	0.10 ± 0.03	0.16 ± 0.06	0.16 ± 0.03
Fluorene	57/57	2.78 ± 0.50	5.97 ± 2.25	8.13 ± 2.24	3.13 ± 0.74	4.97 ± 0.96
Hexavalent Chromium	52/57	0.02 ± 0.01	0.02 ± 0.01	0.03 ± 0.02	0.02 ± 0.01	0.02 ± 0.01
Naphthalene	57/57	84.66 ± 22.05	70.92 ± 20.09	108.89 ± 38.22	100.52 ± 32.64	91.41 ± 14.27

Observations for PRRI from Table 20-5 include the following:

- The annual average concentration of naphthalene is significantly higher than the annual averages of the other pollutants of interest.

- Although the third and fourth quarter average concentrations of naphthalene are higher than the other quarterly averages, the associated confidence intervals indicate that there is a high level of variability associated with the naphthalene concentrations. Naphthalene measurements range from 29.7 ng/m^3 to 277 ng/m^3, with a median concentration of 78.5 ng/m^3. Of the six concentrations of naphthalene greater than 150 ng/m^3, one was measured in February, one in July, two in August, and two in November. The minimum concentration of naphthalene was also measured in November.

- Concentrations of acenaphthene and fluorene are highest during the warmer months of the year, as indicated by the second and third quarter averages, although they have relatively high levels of variability associated with them. The 11 concentrations of fluorene greater than 7 ng/m^3 were all measured between May and August, while the 20 concentrations less than 3 ng/m^3 were measured between January and April or October and December. A similar trend is exhibited by the acenaphthene measurements.

- Although the annual average benzo(a)pyrene concentration is relatively low compared to the other pollutants of interest for PRRI, this annual average is the fourth highest annual average benzo(a)pyrene concentration among sites sampling PAHs, as shown in Table 4-11.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots were created for benzo(a)pyrene, hexavalent chromium, and naphthalene for PRRI. Figures 20-6 through 20-8 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 20-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

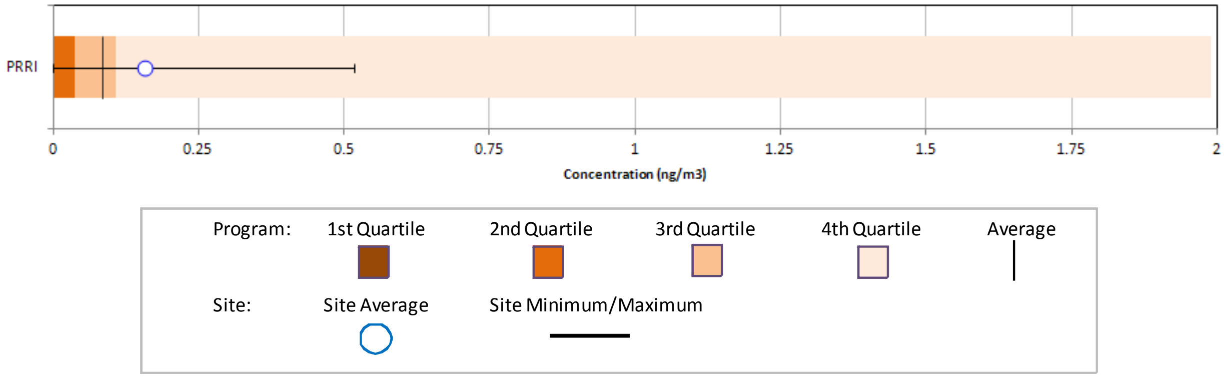


Figure 20-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

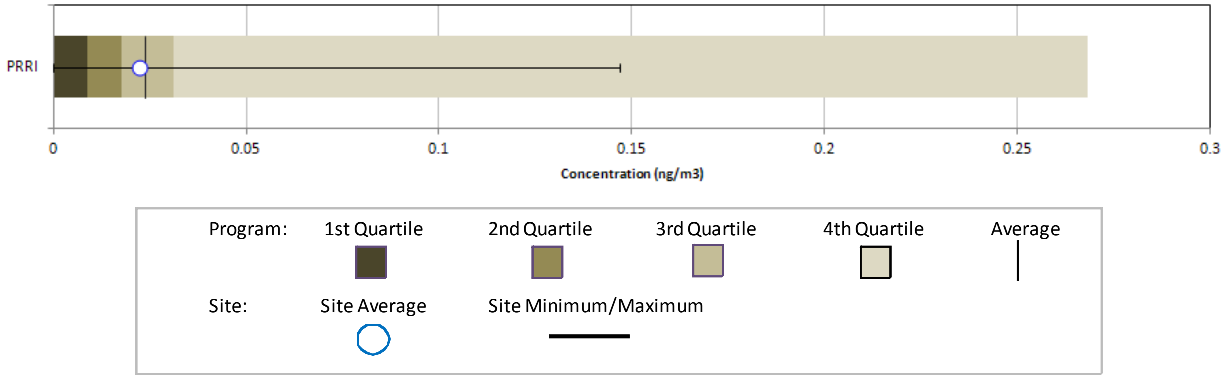
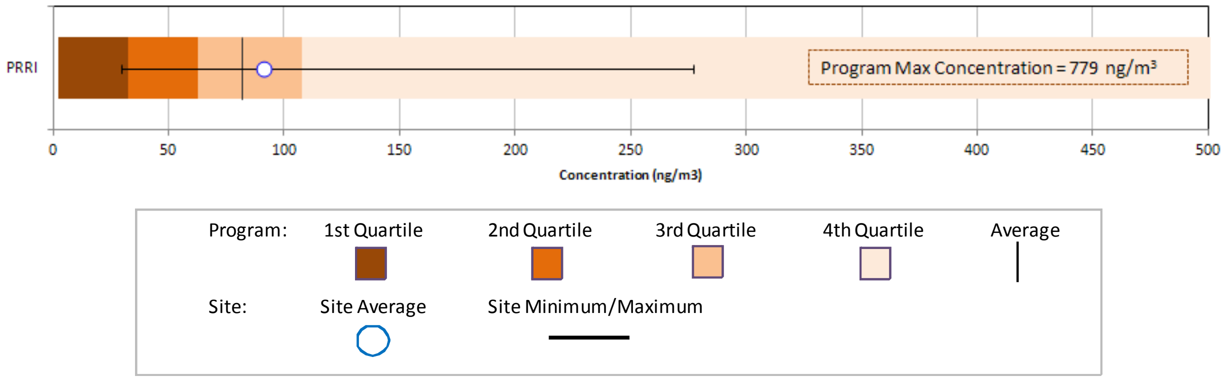


Figure 20-8. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 20-6 through 20-8 include the following:

- Figure 20-6 is the box plot for benzo(a)pyrene. Note that the program-level first quartile for this pollutant is zero and is not visible on the box plot. This box plot shows that the annual average concentration for PRRI is greater than the program-level average concentration. The maximum concentration measured at PRRI is considerably less than the maximum concentration measured across the program. A single non-detect of benzo(a)pyrene was measured at PRRI.

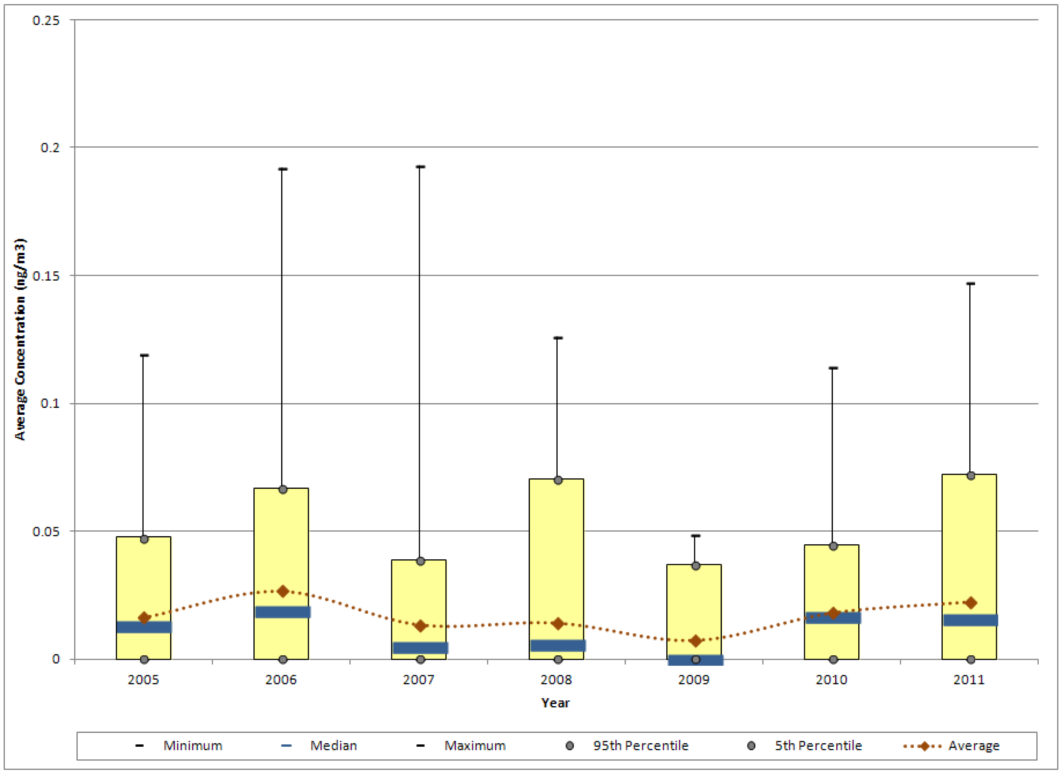
- Figure 20-7 is the box plot for hexavalent chromium. The annual average concentration of hexavalent chromium for PRRI is just less than the program-level average but greater than program-level median concentration. The maximum concentration measured at PRRI is less than the program-level maximum concentration, although the maximum hexavalent chromium concentration for PRRI is the ninth highest concentration measured among NMP sites sampling this pollutant. There were five non-detects of hexavalent chromium measured at PRRI.

- Figure 20-8 is the box plot for naphthalene. Note that the program-level maximum concentration (779 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 500 ng/m^3. Figure 20-8 shows that the annual average naphthalene concentration for PRRI is greater than the program-level average concentration. The maximum naphthalene concentration measured at PRRI is less than the maximum concentration measured at the program-level while the minimum concentration measured at PRRI is just less than the program-level first quartile. There were no non-detects of naphthalene measured at PRRI.

20.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. PRRI has sampled hexavalent chromium under the NMP since 2005. Thus, Figure 20-9 presents the annual statistical metrics for hexavalent chromium for PRRI. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. A trends analysis was not performed for the PAHs because PAH sampling did not begin at PRRI until 2008.

Figure 20-9. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at PRRI



Observations from Figure 20-9 for hexavalent chromium measurements at PRRI include the following:

- The maximum hexavalent chromium concentration was measured on August 28, 2007 (0.193 ng/m^3), although a similar concentration was also measured on July 4, 2006 (0.192 ng/m^3). The third highest concentration was measured in 2011 (July 20, 2011, 0.147 ng/m^3).

- The average concentration of hexavalent chromium has fluctuated over the years of sampling, with the average at a maximum in 2006 (0.027 ng/m^3) and a minimum in 2009 (0.007 ng/m^3). However, an increasing trend is shown over the last two year years of sampling.

- 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 nine percent in 2011 to as high as 65 percent in 2009. This explains why the median concentration is also zero for 2009.

20.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

20.5.2 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
Providence, Rhode Island - PRRI						
Acenaphthene	0.000088	--	57/57	3.65 ± 0.83	0.32	--
Benzo(a)pyrene	0.00176	--	56/57	0.16 ± 0.03	0.28	--
Fluorene	0.000088	--	57/57	4.97 ± 0.96	0.44	--
Hexavalent Chromium	0.012	0.0001	52/57	0.02 ± 0.01	0.27	<0.01
Naphthalene	0.000034	0.003	57/57	91.41 ± 14.27	3.11	0.03

-- = a Cancer URE or Noncancer RfC is not available

Observations for PRRI from Table 20-6 include the following:

- As discussed in the previous section, naphthalene has the highest annual average concentration among the pollutants of interest for PRRI, followed by fluorene and acenaphthene.

- The cancer risk approximation for naphthalene (3.11 in-a-million) is the highest cancer risk approximation among the pollutants of interest for PRRI and the only cancer risk approximation greater than 1-in-a-million.

- Only two of the five pollutants of interest for PRRI have noncancer RfCs (hexavalent chromium and naphthalene).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.

20.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 20-7 and 20-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 20-6. Table 20-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations, also calculated from annual averages provided in Table 20-6.

The pollutants listed in Tables 20-7 and 20-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. The cancer risk and noncancer hazard approximations based on the site's annual averages are limited to those pollutants for which each respective site sampled. As discussed in Section 20.3, PRRI sampled for PAHs and hexavalent chromium only. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Table 20-7. 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	204.49	Formaldehyde	2.03E-03	Naphthalene	3.11
Formaldehyde	155.91	Benzene	1.60E-03	Fluorene	0.44
Ethylbenzene	96.49	POM, Group 3	1.18E-03	Acenaphthene	0.32
Acetaldehyde	84.05	1,3-Butadiene	9.05E-04	Benzo(a)pyrene	0.28
1,3-Butadiene	30.18	Naphthalene	5.93E-04	Hexavalent Chromium	0.27
Tetrachloroethylene	27.44	POM, Group 2b	4.37E-04		
Naphthalene	17.46	Hexavalent Chromium, PM	3.47E-04		
Dichloromethane	8.03	POM, Group 5a	2.51E-04		
Trichloroethylene	6.19	Ethylbenzene	2.41E-04		
POM, Group 2b	4.97	Arsenic, PM	1.98E-04		

Table 20-8. 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	576.48	Acrolein	335,397.31	Naphthalene	0.03
Xylenes	398.70	Formaldehyde	15,908.87	Hexavalent Chromium	<0.01
Methanol	368.54	1,3-Butadiene	15,090.50		
Benzene	204.49	Acetaldehyde	9,339.31		
Formaldehyde	155.91	Benzene	6,816.26		
Hexane	128.27	Naphthalene	5,818.50		
Ethylbenzene	96.49	Xylenes	3,986.98		
Acetaldehyde	84.05	Nickel, PM	3,977.28		
Ethylene glycol	38.49	Trichloroethylene	3,096.76		
1,3-Butadiene	30.18	Arsenic, PM	3,072.81		

Observations from Table 20-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Providence County.
- Formaldehyde is also 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 fifth highest toxicity-weighted emissions.
- POM, Group 2b is the tenth highest emitted "pollutant" in Providence County and ranks sixth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at PRRI including acenaphthene, fluoranthene, and fluorene, all of which failed at least one screen for PRRI.
- POM, Group 5a ranks eighth for toxicity-weighted emissions. POM, Group 5a includes benzo(a)pyrene, another pollutant of interest for PRRI. POM, Group 5a is not among the highest emitted "pollutants" in Providence County.
- Hexavalent chromium, which is also one of the pollutants of interest for PRRI, has the seventh highest toxicity-weighted emissions for Providence County, but does not appear among the highest emitted pollutants.

Observations from Table 20-8 include the following:

- Toluene, xylenes, 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.
- While 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 with noncancer RfCs for PRRI.

20.6 Summary of the 2011 Monitoring Data for PRRI

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

- *Five pollutants failed at least one screen for PRRI, with naphthalene accounting for the majority of the failed screens.*

- *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for PRRI.*

- *Concentrations of hexavalent chromium have an increasing trend for the most recent years of sampling at PRRI.*

21.0 Site in South Carolina

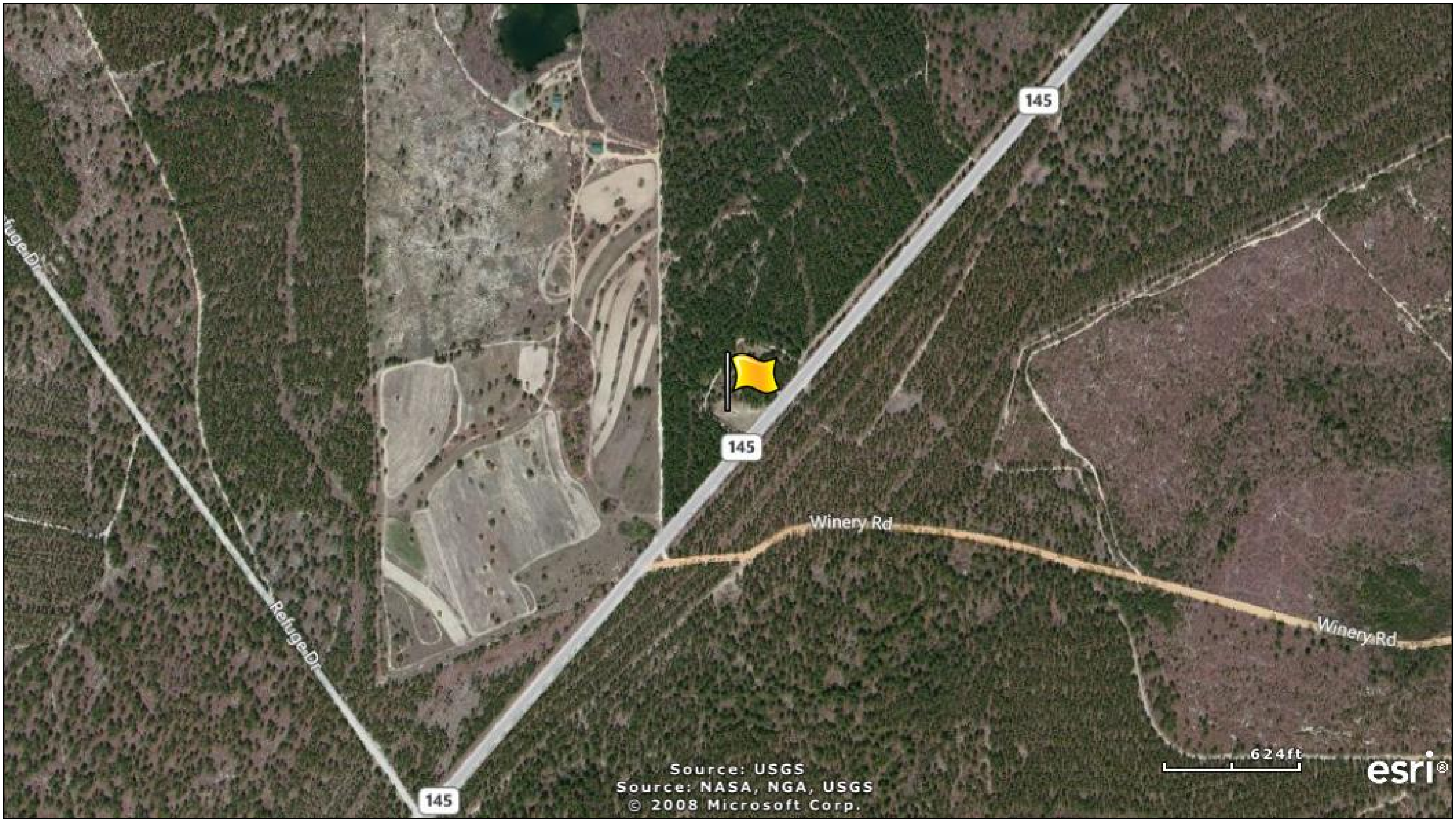
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in South Carolina, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in 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.

21.1 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.

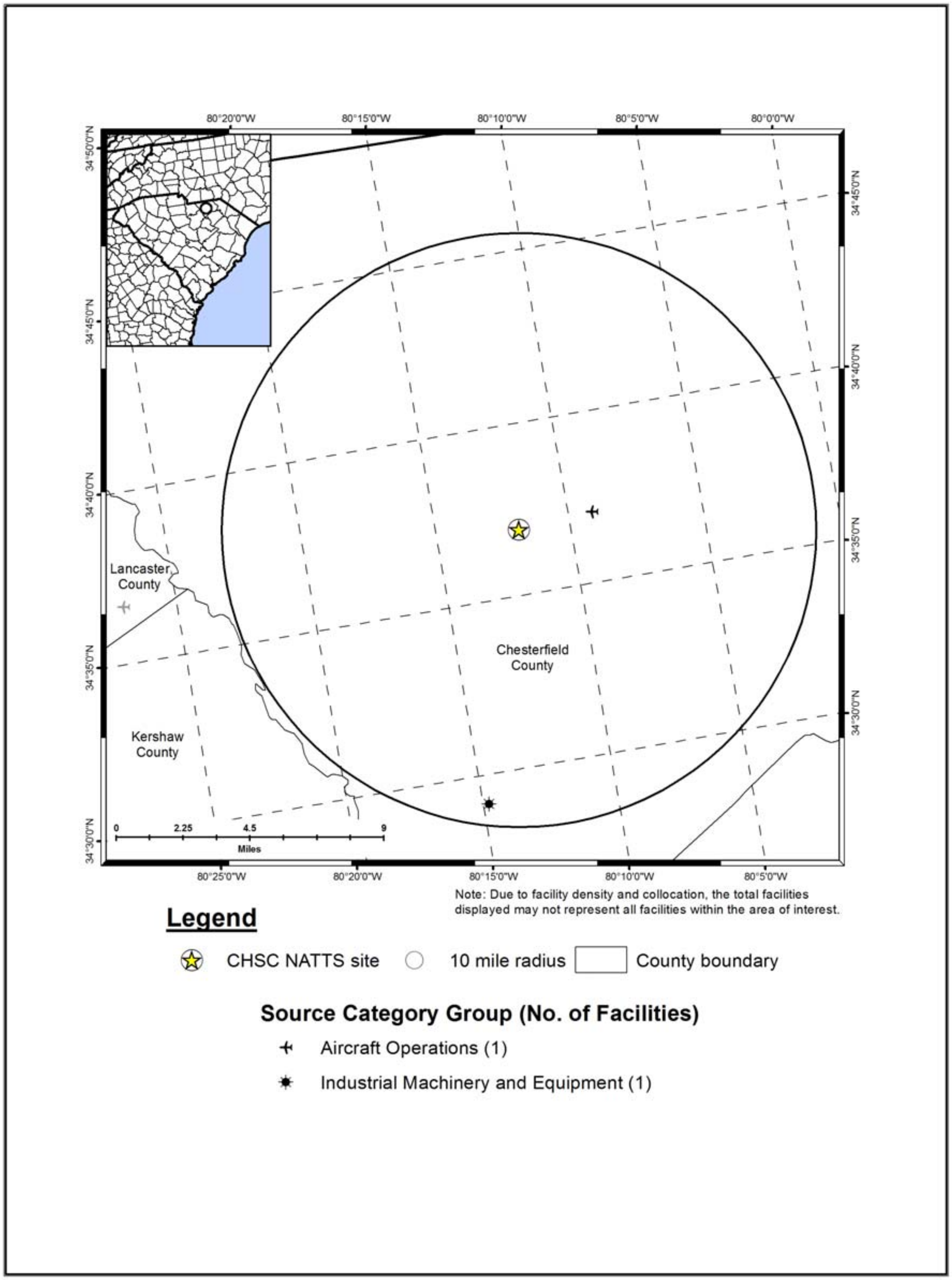
CHSC is located in central Chesterfield County, South Carolina. Figure 21-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its rural location. Figure 21-2 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI for 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. Chesterfield, South Carolina (CHSC) Monitoring Site



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

Figure 21-2. NEI Point Sources Located Within 10 Miles of CHSC



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 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	45-021-0001	Not in a city	Chesterfield	Not in an MSA	34.615367, -80.198789	Forest	Rural	TSP, TSP Metals, VOCs, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Carbonyl Compounds, Hexachlorobutadiene.

[1] Data for additional pollutants are reported to AQS for CHSC (EPA, 2012c); 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 15 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 21-1 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 21-2 shows that few point sources are located within 10 miles of CHSC, the closest of which is the Wild Irish Rose Airport.

Table 21-2 presents additional site-characterizing information, including indicators of mobile source activity, for the South Carolina monitoring site. Table 21-2 includes county-level population and vehicle registration information. Table 21-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 21-2 also contains traffic volume information for CHSC. Finally, Table 21-2 presents the daily VMT for Chesterfield County.

Table 21-2. Population, Motor Vehicle, and Traffic Information for the South Carolina Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
CHSC	46,557	40,792	0.88	5,538	4,852	550	1,276,517

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the South Carolina DMV (SC DMV, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data from the South Carolina DOT (SC DOT, 2012a)
[5] County-level VMT reflects 2011 data from the South Carolina DOT (SC DOT, 2012b)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 21-2 include the following:

- Chesterfield County's population is among the lowest compared to other counties with NMP sites. This site's 10-mile population is the second lowest among NMP sites, behind only CAMS 85 (in Texas). Similar rankings were found for both the county-level and 10-mile vehicle ownerships.

- The vehicle-per-person ratio is in the middle of the range among NMP sites.

- The traffic volume experienced near CHSC ranks among the 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).

21.2 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.

21.2.1 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. Chesterfield County leads the state in the average number of sleet and freezing rain events per year (Bair, 1992 and SC SCO, 2013).

21.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2011 (NCDC, 2011). 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 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 South Carolina Monitoring Site

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)
Chesterfield, South Carolina - CHSC									
Monroe Airport 53872 (35.02, -80.62)	35.81 miles 311° (NW)	Sample Day	71.4 ± 4.1	61.4 ± 3.9	49.6 ± 4.5	55.3 ± 3.7	69.1 ± 3.6	1017.6 ± 1.6	4.8 ± 0.6
		2011	72.3 ± 1.6	61.7 ± 1.6	50.4 ± 1.7	55.6 ± 1.4	70.2 ± 1.3	1017.7 ± 0.7	4.8 ± 0.3

[1] Sample day averages are highlighted 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 the entire year. 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 were representative of average weather conditions throughout the year.

21.2.3 Back Trajectory Analysis

Figure 21-3 is the composite back trajectory map for days on which samples were collected at the CHSC monitoring site in 2011. 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.

Observations from Figures 21-3 and 21-4 for CHSC include the following:

- Back trajectories originated from a variety of directions at CHSC.
- The 24-hour air shed domain for CHSC was similar in size to other NMP monitoring sites. The farthest away a back trajectory originated was over central Michigan, or greater than 600 miles away. However, the average trajectory length was 206 miles and 81 percent of back trajectories originated within 300 miles of the site.
- The cluster analysis shows that 38 percent of back trajectories originated from the southwest to west to northwest of CHSC, primarily over western North and South Carolina and northern Georgia. Although most of these back trajectories originated less than 300 miles away from the site, a few longer back trajectories originating to the west of the site are also included. Eleven percent of back trajectories also originated from the northwest of CHSC but of longer length (greater than 300 miles away). Another 26 percent of back trajectories originated to the north to northeast of CHSC, varying between 300 and 600 miles in length. Nearly 20 percent of back trajectories are represented by the short cluster originating near the coast of South Carolina. These back trajectories originated to the northeast, east, and southeast of CHSC, over eastern North and South Carolina and their offshore waters. Fewer than 10 percent of back trajectories originated farther south, over the offshore waters of Georgia and Florida.

Figure 21-3. 2011 Composite Back Trajectory Map for CHSC

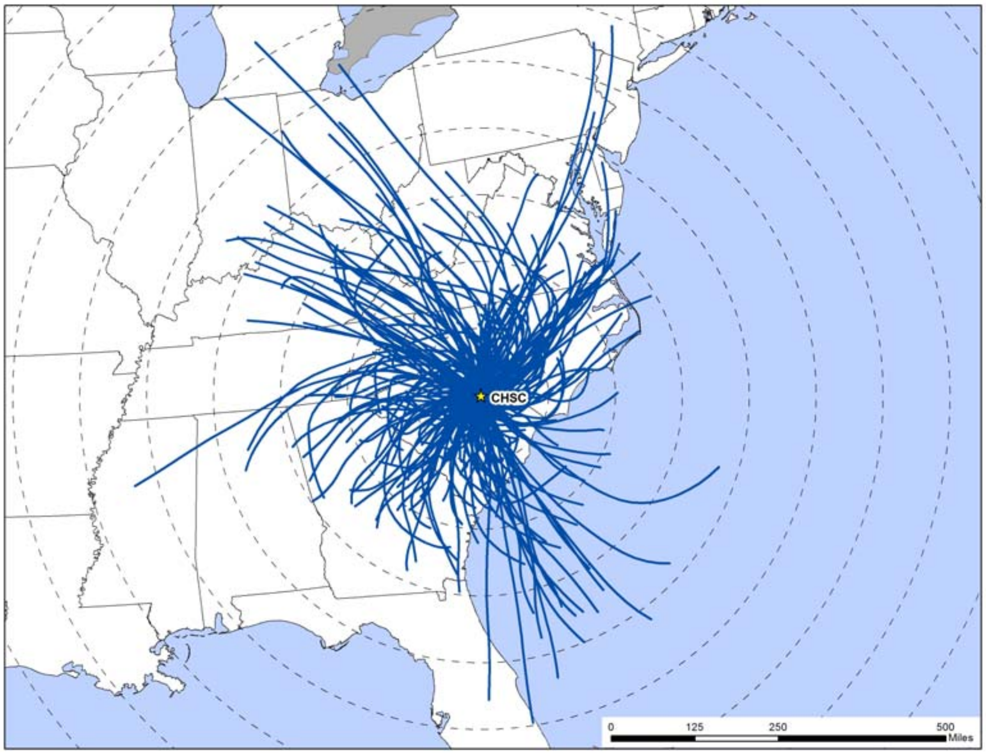


Figure 21-4. Back Trajectory Cluster Map for CHSC

21.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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 21-5 presents a map showing the distance between the NWS station and CHSC, 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 CHSC monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 21-5 for CHSC include the following:

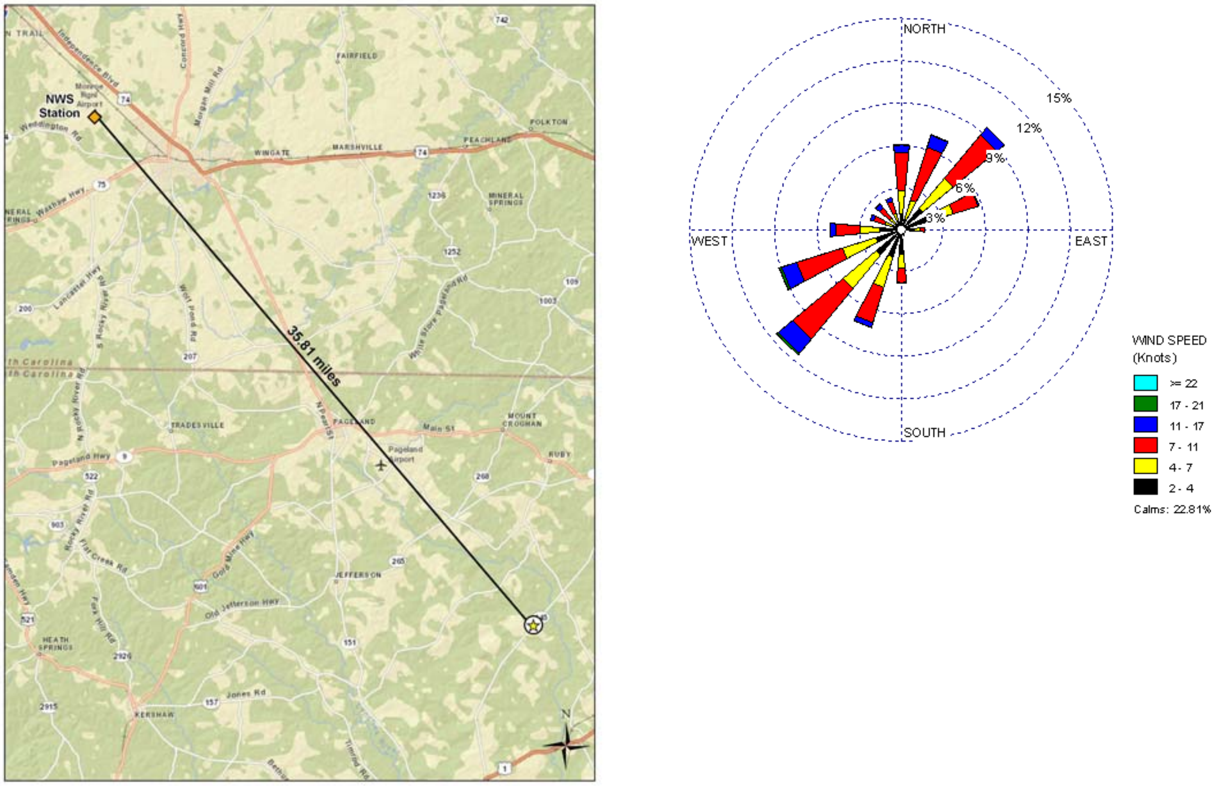
- The Monroe Airport weather station is located across the North Carolina/South Carolina border, approximately 36 miles northwest of CHSC.

- 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 2011 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 2011 were similar to what is expected climatologically near this site.

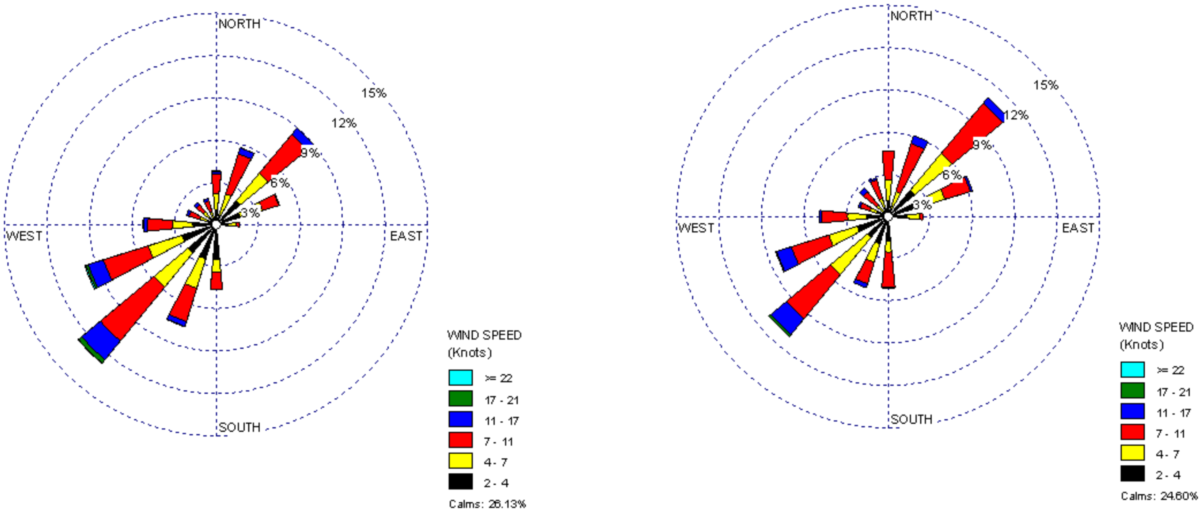
- The sample day wind patterns for 2011 also resemble the historical and full-year wind patterns. However, there were fewer observations from the southwest quadrant and more observations from the northeast quadrant compared to the full-year wind rose.

Figure 21-5. Wind Roses for the Monroe Airport Weather Station near CHSC



Distance between CHSC and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

21.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the South Carolina monitoring site in order to allow 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.” 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 21-4 presents the results of the preliminary risk-based screening process for CHSC. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for the monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. CHSC sampled hexavalent chromium and PAHs.

Table 21-4. Risk-Based Screening Results for the South Carolina Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Chesterfield, South Carolina - CHSC						
Naphthalene	0.029	3	60	5.00	100.00	100.00
Total		3	60	5.00		

Observations from Table 21-4 include the following:

- Naphthalene was the only pollutant to fail screens for CHSC. This pollutant was detected in all 60 valid samples collected at CHSC and failed three screens, or approximately 5 percent of screens.

- This site has the third lowest number of failed screens (3) among all NMP sites.

- Benzo(a)pyrene and hexavalent chromium were added to CHSC’s pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens. These pollutants are not shown in Table 21-4 but are shown in subsequent tables in the sections that follow.

21.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for CHSC, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for CHSC are provided in Appendices M and O.

21.4.1 2011 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 of 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 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 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						
Benzo(a)pyrene	7/60	0.02 ± 0.03	0	0.03 ± 0.05	0.01 ± 0.01	0.01 ± 0.02
Hexavalent Chromium	29/60	<0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01	<0.01 ± <0.01	0.01 ± <0.01
Naphthalene	60/60	25.11 ± 15.57	12.38 ± 2.45	14.37 ± 3.96	13.81 ± 3.82	16.42 ± 4.13

Observations for CHSC from Table 21-5 include the following:

- The annual average concentration of naphthalene is three orders of magnitude higher than the annual average concentrations of hexavalent chromium and benzo(a)pyrene.
- Compared to other NMP sites, CHSC has the second lowest annual average concentration for each of these pollutants, second only to UNVT for each.
- Benzo(a)pyrene was infrequently detected at CHSC. This pollutant was detected twice in the first quarter, was not detected at all during the second quarter, was detected once in the third quarter, and was detected three times in the fourth quarter of 2011.
- Although hexavalent chromium was detected in all four quarters of 2011, it was detected in fewer than half of the samples collected (29 out of 60). The measurements ranged from 0.0023 ng/m^3 to 0.0244 ng/m^3, with two-thirds of the concentrations measured during the second (10) and third (10) quarters of 2011.
- Naphthalene was detected in every sample collected at CHSC. The first quarter average concentration is roughly twice the other quarterly averages and has a relatively large confidence interval associated with it. The maximum naphthalene concentration was measured on March 10, 2011 (122 ng/m^3) and is more than twice the next highest measurement (49.3 ng/m^3), measured on the following sample day. The concentrations measured at CHSC ranged from 4.54 ng/m^3 to 122 ng/m^3, with a median concentration of 11.75 ng/m^3.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzo(a)pyrene, hexavalent chromium, and naphthalene were created for CHSC. Figures 21-6 through 21-8 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 21-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

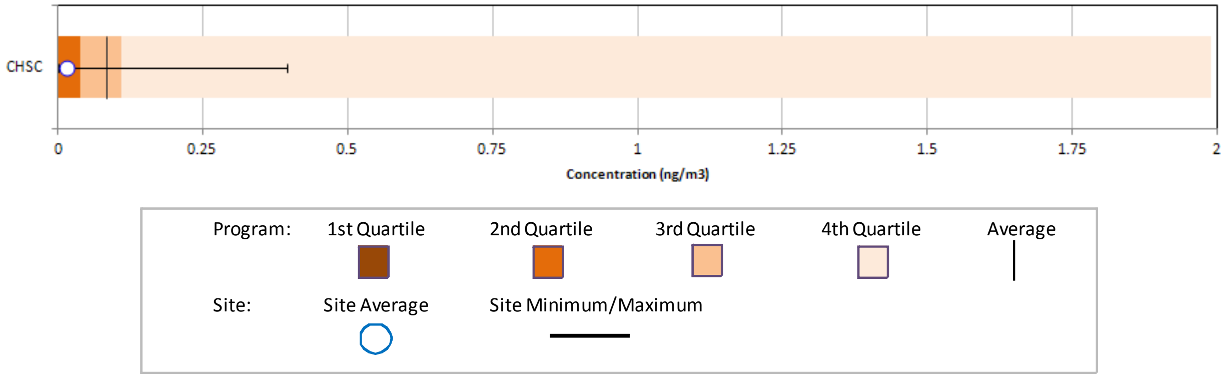


Figure 21-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

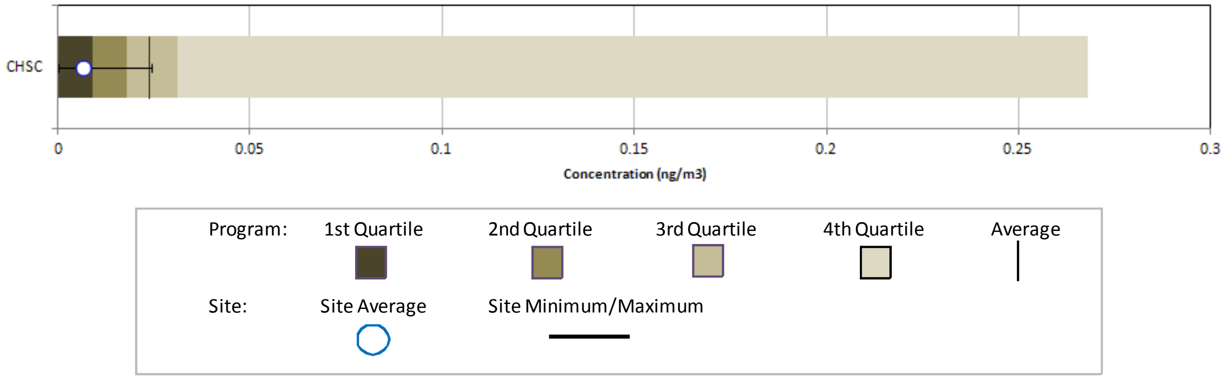
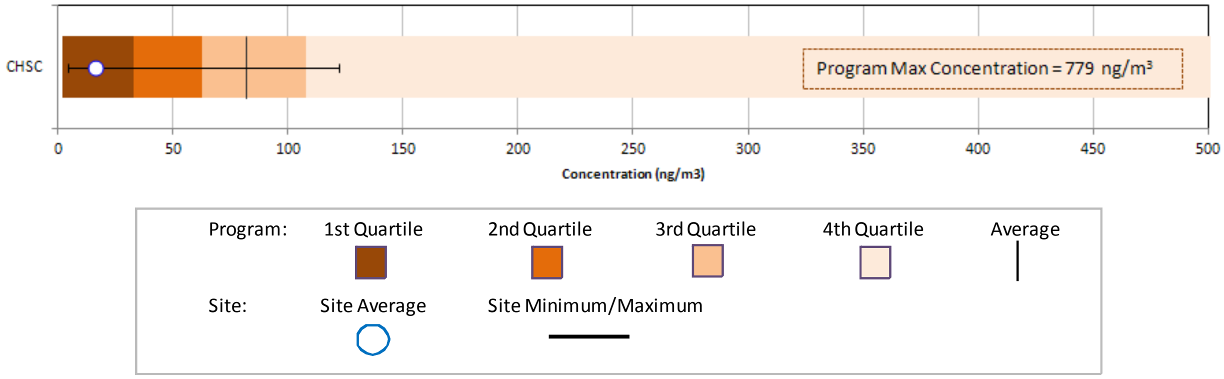


Figure 21-8. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 21-6 through 21-8 include the following:

- Figure 21-6 is the box plot for benzo(a)pyrene. Note that the first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average concentration for CHSC is less than both the program-level average and median concentrations. Figure 21-6 also shows that the maximum concentration measured at CHSC is considerably less than the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at CHSC.

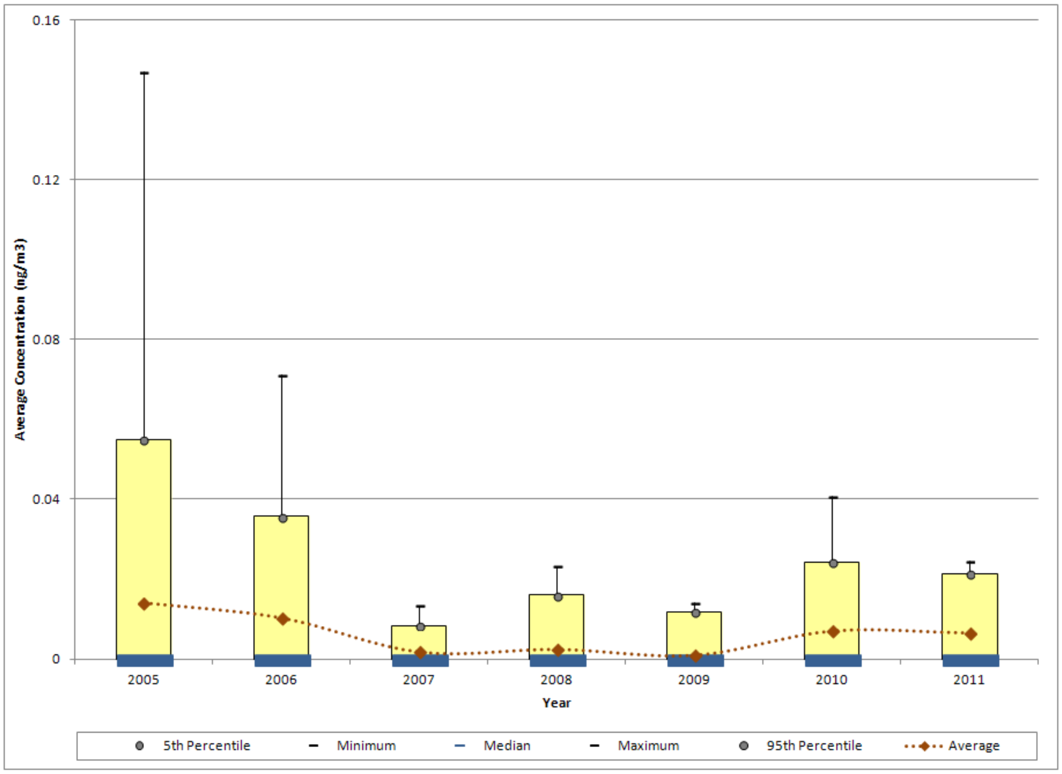
- Figure 21-7 is the box plot for hexavalent chromium and shows that the annual average concentration of hexavalent chromium for CHSC is less than the program-level first quartile (25th percentile). Further, the maximum concentration measured at CHSC is just greater than the program-level average concentration. More than half of the measurements of hexavalent chromium for CHSC were non-detects.

- Figure 21-8 is the box plot for naphthalene. Note that the program-level maximum concentration (779 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 500 ng/m^3. Figure 21-8 shows that the annual naphthalene average for CHSC is less than the program-level first quartile. The maximum naphthalene concentration measured at CHSC is considerably less than the program-level maximum concentration. There were no non-detects of naphthalene measured at CHSC 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 selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. CHSC has sampled hexavalent chromium under the NMP since 2005. Thus, Figure 21-9 presents the annual statistical metrics for hexavalent chromium for CHSC. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. PAHs are excluded from this analysis because sampling for PAHs did not begin until 2008.

Figure 21-9. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at CHSC



Observations from Figure 21-9 for hexavalent chromium measurements at CHSC include the following:

- Sampling for hexavalent chromium at CHSC began in January 2005.

- The maximum concentration of hexavalent chromium was measured on March 23, 2005 (0.147 ng/m^3). The maximum concentration of hexavalent chromium measured in subsequent time periods was considerably lower (by at least half). The eight highest concentrations of hexavalent chromium were all measured in 2005 and 2006.

- The minimum, 5th percentile, and median concentrations are zero for each year shown, indicating that at least 50 of the measurements collected at CHSC were non-detects. The percentage of non-detects has varied from 52 percent (2011) to 91 percent (2009).

- The maximum concentration, 95th percentile, and average concentration of hexavalent chromium decreased significantly through 2007. Little change is shown in the average concentration between 2007 and 2009. The range of concentrations measured nearly tripled from 2009 to 2010; thus, the average concentration exhibits an increase from 2009 to 2010, with little change in the average concentration from 2010 to 2011.

21.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

21.5.2 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
Chesterfield, South Carolina - CHSC						
Benzo(a)pyrene	0.00176	--	7/60	0.01 ± 0.02	0.03	--
Hexavalent Chromium	0.012	0.0001	29/60	0.01 ± <0.01	0.08	<0.01
Naphthalene	0.000034	0.003	60/60	16.42 ± 4.13	0.56	0.01

-- = a Cancer URE or Noncancer RfC is not available

Observations for CHSC from Table 21-6 include the following:

- The cancer risk approximations for the pollutants of interest for CHSC are all less than 1 in-a-million, with the highest cancer risk approximation calculated for naphthalene (0.56 in-a-million).
- The noncancer hazard approximations for the pollutants of interest are very low (0.01 or less), indicating that no adverse health effects are expected from these individual pollutants. Because benzo(a)pyrene has no RfC, a noncancer hazard approximation could not be calculated.

21.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 21-7 and 21-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from annual averages provided in Table 21-6. Table 21-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from the annual averages provided in Table 21-6.

Table 21-7. 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	28.92	Benzene	2.26E-04	Naphthalene	0.56
Ethylbenzene	14.89	Formaldehyde	1.71E-04	Hexavalent Chromium	0.08
Formaldehyde	13.15	1,3-Butadiene	9.52E-05	Benzo(a)pyrene	0.03
Acetaldehyde	7.77	Hexavalent Chromium, PM	7.65E-05		
1,3-Butadiene	3.17	Naphthalene	5.11E-05		
Naphthalene	1.50	Ethylbenzene	3.72E-05		
Trichloroethylene	0.47	POM, Group 2b	2.81E-05		
Dichloromethane	0.40	POM, Group 3	2.20E-05		
POM, Group 2b	0.32	POM, Group 5a	1.92E-05		
Ethylene oxide	0.07	Acetaldehyde	1.71E-05		

Table 21-8. 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	78.42	Acrolein	42,691.89	Naphthalene	0.01
Xylenes	60.74	Cyanide Compounds, gas	1,852.73	Hexavalent Chromium	<0.01
Benzene	28.92	1,3-Butadiene	1,586.49		
Methanol	28.81	Formaldehyde	1,341.80		
Hexane	19.60	Benzene	963.86		
Ethylbenzene	14.89	Acetaldehyde	863.64		
Formaldehyde	13.15	Xylenes	607.44		
Acetaldehyde	7.77	Naphthalene	500.57		
Methyl isobutyl ketone	6.32	Lead, PM	432.31		
Ethylene glycol	3.86	Manganese, PM	287.58		

The pollutants listed in Tables 21-7 and 21-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. The cancer risk and noncancer hazard approximations based on the site's annual averages are limited to those pollutants for which the site sampled. As discussed in Section 21.3, CHSC sampled for PAHs and hexavalent chromium only. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 21-7 include the following:

- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in Chesterfield County.
- Benzene, formaldehyde, and 1,3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Chesterfield County.
- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Chesterfield County.
- Naphthalene appears on all three lists, with the sixth highest emissions, the fifth highest toxicity-weighted emissions, and highest cancer risk approximation among the pollutants of interest for CHSC.
- Hexavalent chromium ranks fourth for its toxicity-weighted emissions, but is not among the highest emitted pollutants.
- Several POM Groups appear among the pollutants with the highest emissions and toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at CHSC including acenaphthylene, fluoranthene, and perylene. POM, Group 5a includes benzo(a)pyrene, which is one of CHSC's pollutants of interest. POM, Group 5a ranks ninth for toxicity weighted emissions but is not among the highest emitted. POM, Group 3 does not include any pollutants sampled for at CHSC.

Observations from Table 21-8 include the following:

- Toluene, xylenes, and benzene 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, cyanide compounds (gaseous), and 1,3-butadiene.

- Four of the highest emitted pollutants in Chesterfield County also have the highest toxicity-weighted emissions.

- Naphthalene does not appear among the highest emitted pollutants with a noncancer toxicity factor, but ranks eighth among the pollutants with the highest toxicity-weighted emissions. Hexavalent chromium does not appear on either emissions-based list. These are the only two pollutants of interest with noncancer RfCs for CHSC.

21.6 Summary of the 2011 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 third lowest number of failed screens (3) among all NMP sites.*

- ❖ *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for CHSC; however, it was second lowest compared to other NMP sites sampling naphthalene.*

- ❖ *Concentrations of hexavalent chromium increased from 2009 to 2010 and then held steady for 2011.*

22.0 Sites in South Dakota

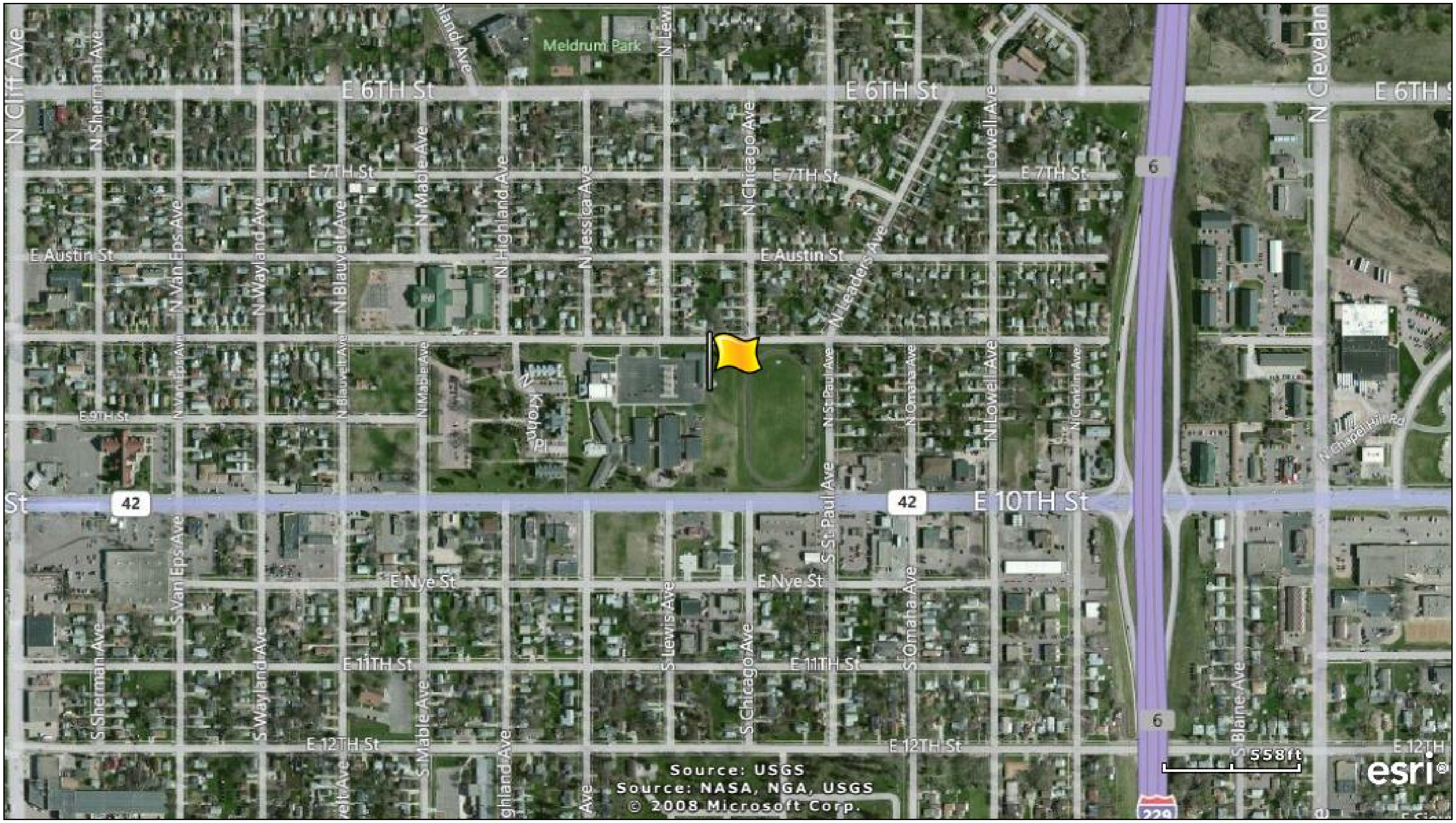
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP sites in South Dakota, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the 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.

22.1 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.

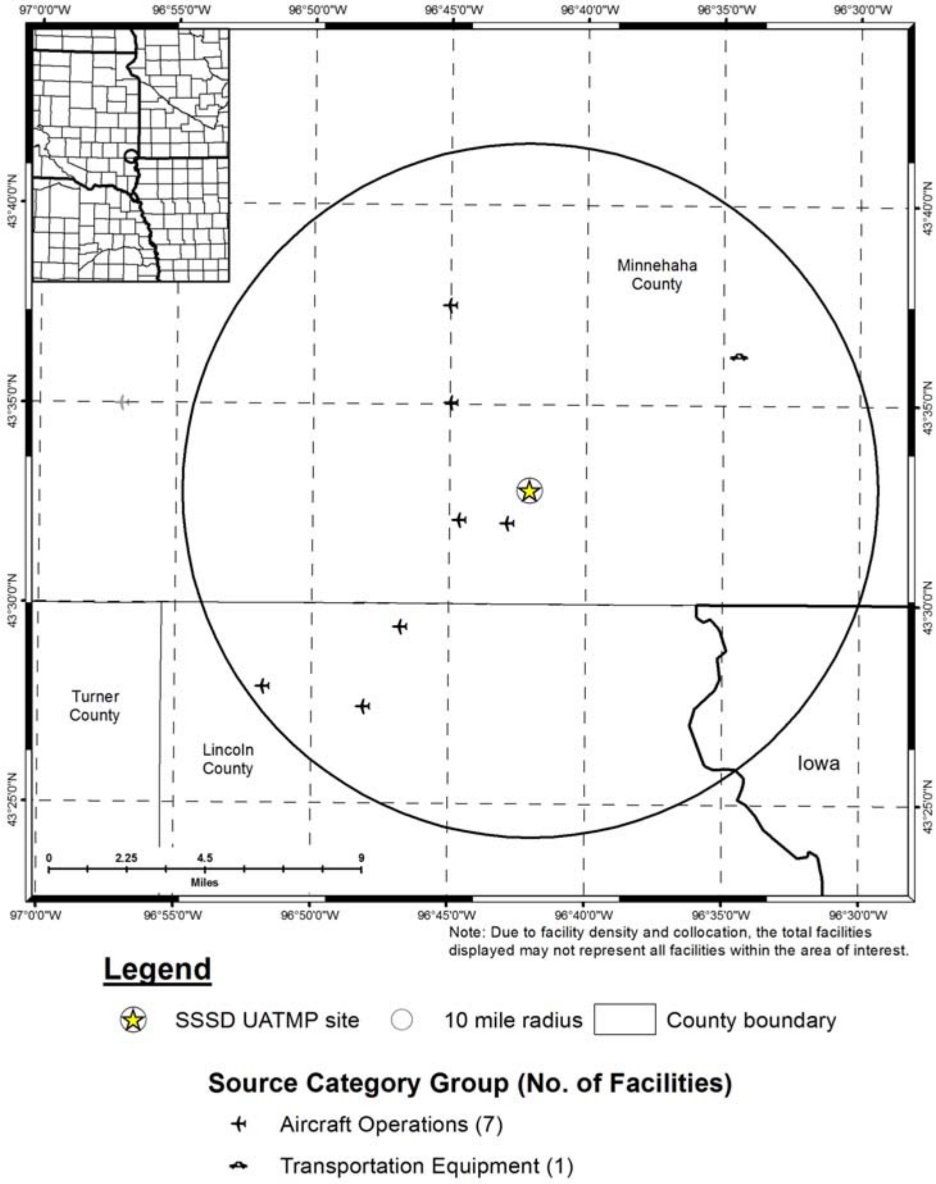
There are two South Dakota monitoring sites. One monitoring site is located in Sioux Falls, South Dakota (SSSD) while the other is located in Union County (UCSD). Figures 22-1 and 22-3 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 22-2 and 22-4 identify nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figures 22-2 and 22-4. 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 each 10-mile radius are still visible on the maps, but have been grayed out in order to show emissions sources just outside the boundaries. Table 22-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 22-1. Sioux Falls, South Dakota (SSSD) Monitoring Site



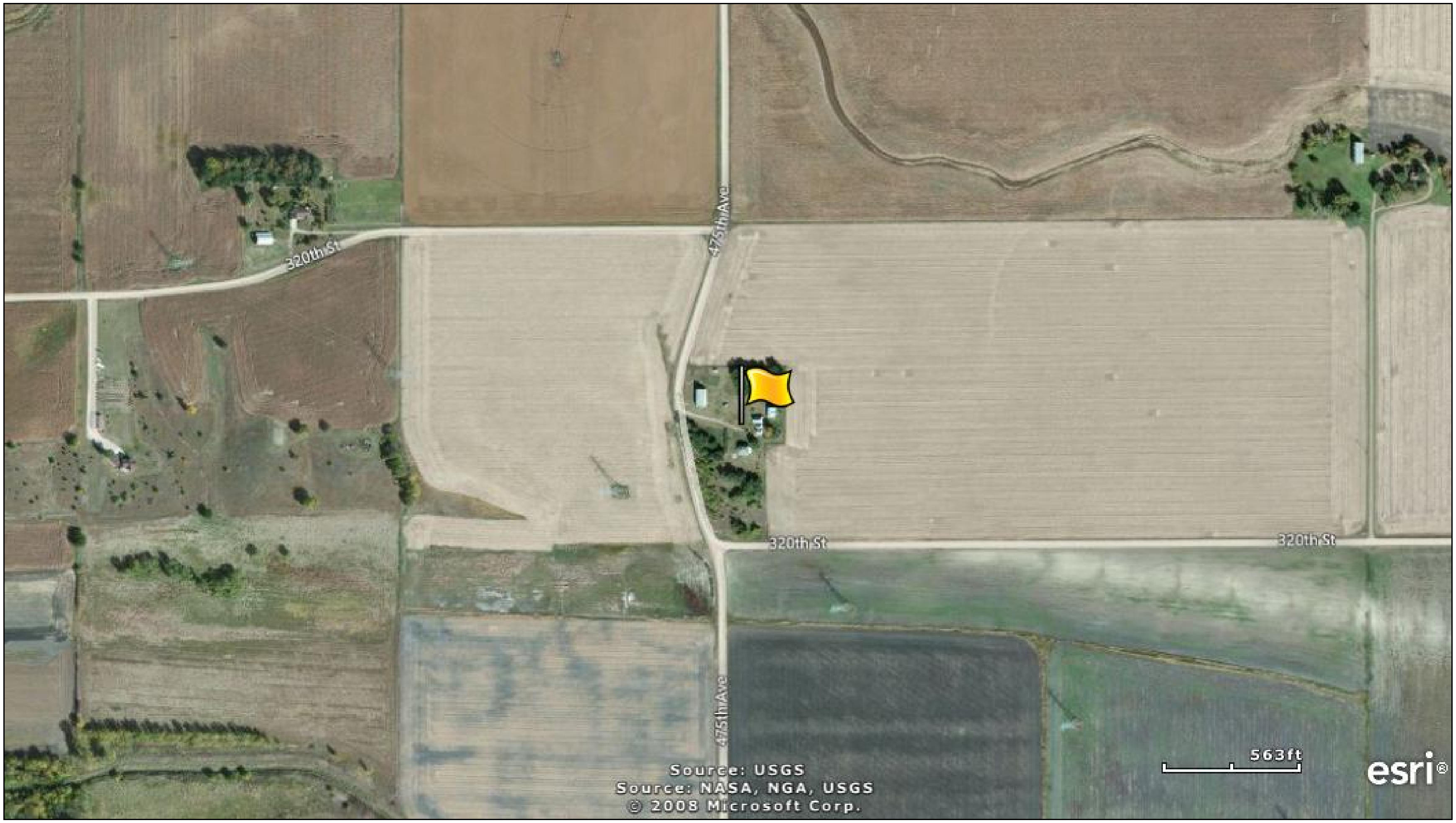
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 22-2. NEI Point Sources Located Within 10 Miles of SSSD



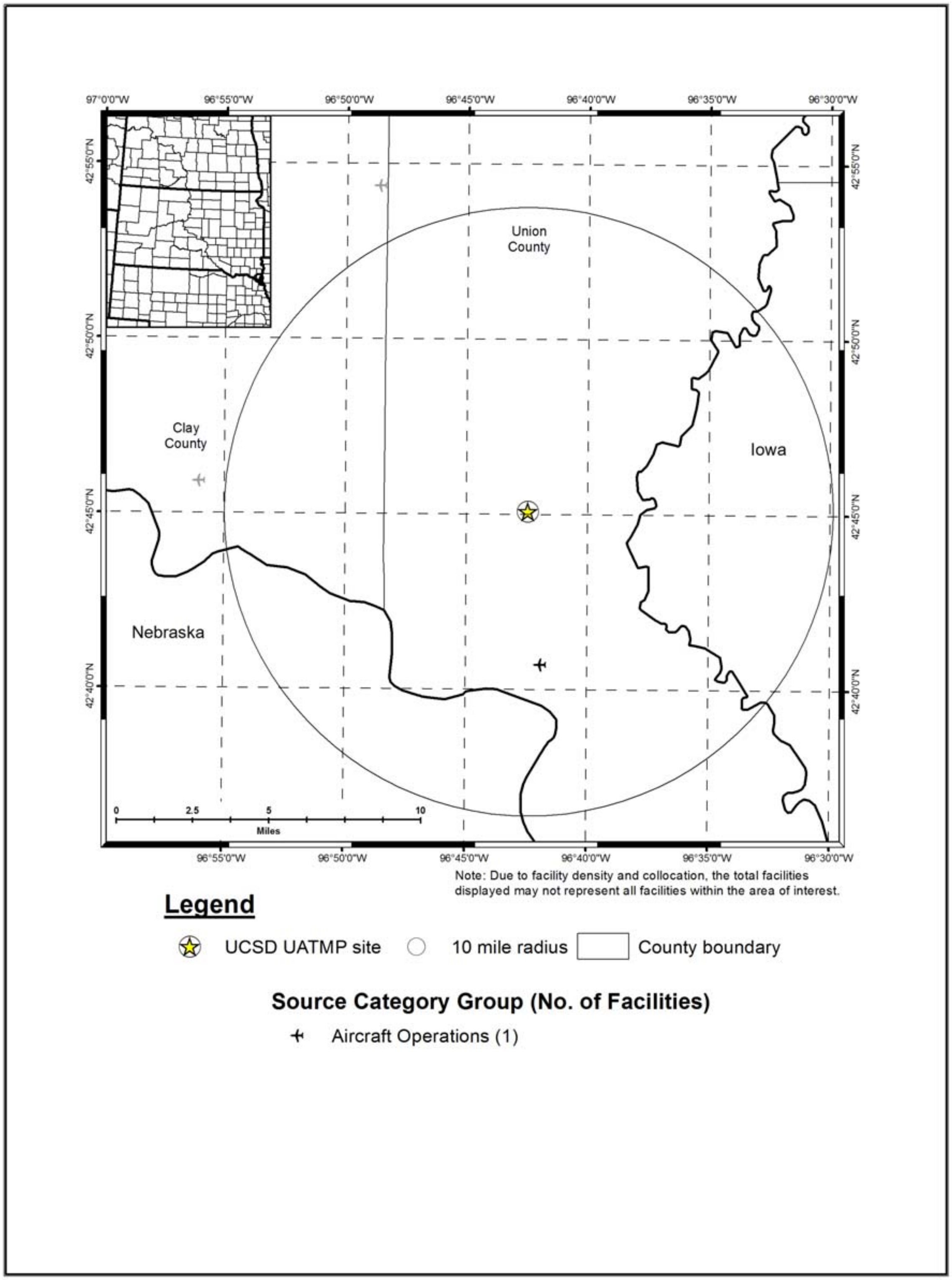
Note: Due to facility density and collocation, the total facilities displayed may not represent all facilities within the area of interest.

Figure 22-3. Union County, South Dakota (UCSD) Monitoring Site



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

Figure 22-4. NEI Point Sources Located Within 10 Miles of UCSD



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

Table 22-1. Geographical Information for the South Dakota 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]
SSSD	46-099-0008	Sioux Falls	Minnehaha	Sioux Falls, SD MSA	43.54792, -96.700769	Commercial	Urban/City Center	SO_2, NO, NO_2, NO_x, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, and $PM_{2.5}$ Speciation.
UCSD	46-127-0001	Not in a City	Union	Sioux City, IA-NE-SD MSA	42.751518, -96.707208	Agricultural	Rural	CO, SO_2, NO, NO_2, NO_x, Meteorological parameters, PM_{10}, and $PM_{2.5}$.

[1] Data for additional pollutants are reported to AQS for SSSD and UCSD (EPA, 2012c); 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 eastern 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 1/2 mile from the intersection of Highway 42 (East 10th Street) and I-229, as shown in Figure 22-1. As Figure 22-2 shows, few emissions sources are located within 10 miles of SSSD. There are only two source categories shown in Figure 22-2, the aircraft operations category, which includes airports as well as small runways, heliports, or landing pads, and the transportation equipment category. The emissions source closest to SSSD is a hospital heliport.

UCSD is located in Union County, the southeastern-most county of the state, where the South Dakota state border follows the Missouri River and comes to a point near Sioux City, Iowa at the Nebraska and Iowa borders. The UCSD monitoring site is located in a rural and agricultural area in the town of Brule, north of Elk Point and west of Vermillion. As shown in Figure 22-3, the monitoring site is located on a residential property surrounded by agricultural fields. Interstate-29 runs northwest-southeast through the center of Union County and lies less than 1.5 miles west of UCSD. Figure 22-4 shows that there is a single point source located within 10 miles of the site. However, UCSD is south of a proposed power plant and oil refinery. The purpose of monitoring at UCSD is to collect air quality data before, during, and after the construction of the proposed power plant and oil refinery (SD DENR, 2011).

Table 22-2 presents additional site-characterizing information, including indicators of mobile source activity, for the South Dakota monitoring sites. Table 22-2 includes county-level population and vehicle registration information. Table 22-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 22-2 also contains traffic volume information for each site. Finally, Table 22-2 presents the county-level daily VMT for Minnehaha and Union Counties.

Table 22-2. Population, Motor Vehicle, and Traffic Information for the South Dakota Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
SSSD	171,752	210,914	1.23	186,954	229,582	18,700	3,751,886
UCSD	14,651	25,419	1.73	5,577	9,676	156	808,049

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the South Dakota Department of Revenue (SD DOR, 2012)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data for SSSD and 2007 data for UCSD from the South Dakota DOT (SD DOT, 2007 and 2011)
[5] County-level VMT reflects 2011 data from the South Dakota DOT (SD DOT, 2012)

Observations from Table 22-2 include the following:

- Although SSSD's county-level population is an order of magnitude higher than the county-level population for UCSD, both county-level populations are in the bottom third compared to other counties with NMP sites, with UCSD ranking last. The 10-mile population for each site is also on the low side compared to other NMP sites, particularly for UCSD.

- SSSD's county-level vehicle registration is an order of magnitude higher than the county-level vehicle registration for UCSD, but both of the county-level vehicle registrations are on the low side compared to other counties with NMP sites. Union County's vehicle registration is the lowest of all NMP counties, while Minnehaha County is in the bottom third. The 10-mile vehicle ownership estimates for SSSD and UCSD rank slightly higher among NMP sites than county-level vehicle ownerships.

- The vehicle-per-person ratios for UCSD and SSSD are among the highest compared to other NMP sites, ranking first and second, respectively. This indicates that residents likely own multiple vehicles.

- The traffic volume for SSSD is two orders of magnitude higher than the traffic volume for UCSD. The traffic near UCSD is the second lowest among all NMP sites, behind only BRCO. Traffic data for SSSD are provided for East 10th Avenue between South Mable Avenue and South Highland Avenue; traffic data for UCSD are provided for 475th Avenue near 317th Street.

- The daily VMT for Minnehaha County is more than four times the VMT for Union County. The daily VMT for Union County is the lowest among NMP sites (where VMT was available). The VMT for Minnehaha County ranks tenth lowest among counties with NMP sites (where VMT was available).

22.2 Meteorological Characterization

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

22.2.1 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. On average, a south wind blows in the summer and fall and a northwest wind blows in the winter and 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 and to divert water from the Big Sioux River and Skunk Creek around the city (Bair, 1992).

Sioux City is located just north of the Missouri River where the Iowa border meets the Nebraska and South Dakota borders. The climate near Sioux City is generally continental in nature, with warm summers and cold, relatively dry winters. Precipitation is concentrated in the spring and summer months. Wind direction varies with season, with southeasterly to southerly winds in spring and summer, and northwesterly winds in fall and winter (Bair, 1992).

22.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). The closest weather stations are located at Joe Foss Field Airport (near SSSD) and Sioux Gateway Airport (near UCSD), WBAN 14944 and 14943, respectively. Additional information about these weather stations, such as the distance between the sites and the weather stations, 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. Average Meteorological Conditions near the South Dakota Monitoring Sites

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)
Sioux Falls, South Dakota - SSSD									
Joe Foss Field Airport 14944 (43.58, -96.75)	3.20 miles 309° (NW)	Sample Day	56.3 ± 5.9	46.8 ± 5.7	37.0 ± 5.5	42.1 ± 5.3	71.8 ± 3.0	1014.3 ± 2.1	8.6 ± 1.0
		2011	55.9 ± 2.4	46.4 ± 2.3	36.1 ± 2.2	41.5 ± 2.1	70.4 ± 1.2	1015.3 ± 0.8	8.2 ± 0.4
Union County, South Dakota - UCSD									
Sioux Gateway/Col. Bud Day Field Airport 14943 (42.39, -96.38)	29.45 miles 148° (SSE)	Sample Day	60.1 ± 6.0	49.0 ± 5.7	38.8 ± 5.4	43.9 ± 5.2	71.1 ± 3.1	1014.9 ± 2.3	8.6 ± 0.9
		2011	59.5 ± 2.4	48.7 ± 2.3	37.9 ± 2.2	43.4 ± 2.1	69.5 ± 1.2	1015.4 ± 0.8	8.3 ± 0.4

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

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 the entire year. Also included in Table 22-3 is the 95 percent confidence interval for each parameter. As shown in Table 22-3, average meteorological conditions on sample days were representative of average weather conditions throughout the year for both sites.

22.2.3 Back Trajectory Analysis

Figure 22-5 is the composite back trajectory map for days on which samples were collected at the SSSD monitoring site in 2011. Included in Figure 22-5 are four back trajectories per sample day. Figure 22-6 is the corresponding cluster analysis. Similarly, Figure 22-7 is the composite back trajectory map for days on which samples were collected at UCSD and Figure 22-8 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 22-5 through 22-8 represents 100 miles.

Observations from Figures 22-5 and 22-6 for SSSD include the following:

- Back trajectories originated from a variety of directions at the SSSD site, but rarely from due north.

- The 24-hour air shed domain for SSSD is among the larger air sheds compared to the other NMP monitoring sites. The farthest away a back trajectory originated was southwest Montana, or greater than 700 miles away, although the average back trajectory length was nearly 282 miles and 88 percent of back trajectories originated within 450 miles of the site.

- The cluster analysis shows that back trajectories originating from the southwest to northwest of SSSD account for one-quarter of the back trajectories. Another one-quarter of back trajectories originated to the northwest to north of SSSD, primarily over North Dakota. The shorter cluster (34 percent) originating to the southeast of SSSD represents shorter trajectories (< 300 miles) originating from a variety of directions, although primarily over the state of Iowa. Eight percent of trajectories originated from the south of SSSD over Kansas and Missouri and another eight percent originated to the northeast of SSSD.

Figure 22-5. 2011 Composite Back Trajectory Map for SSSD

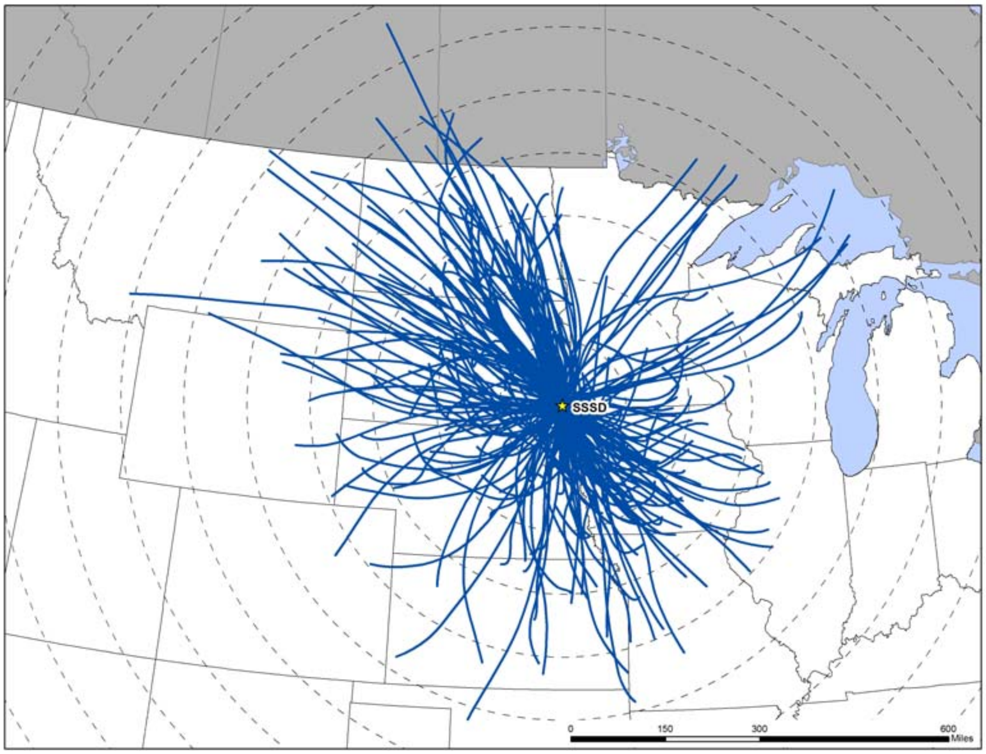


Figure 22-6. Back Trajectory Cluster Map for SSSD

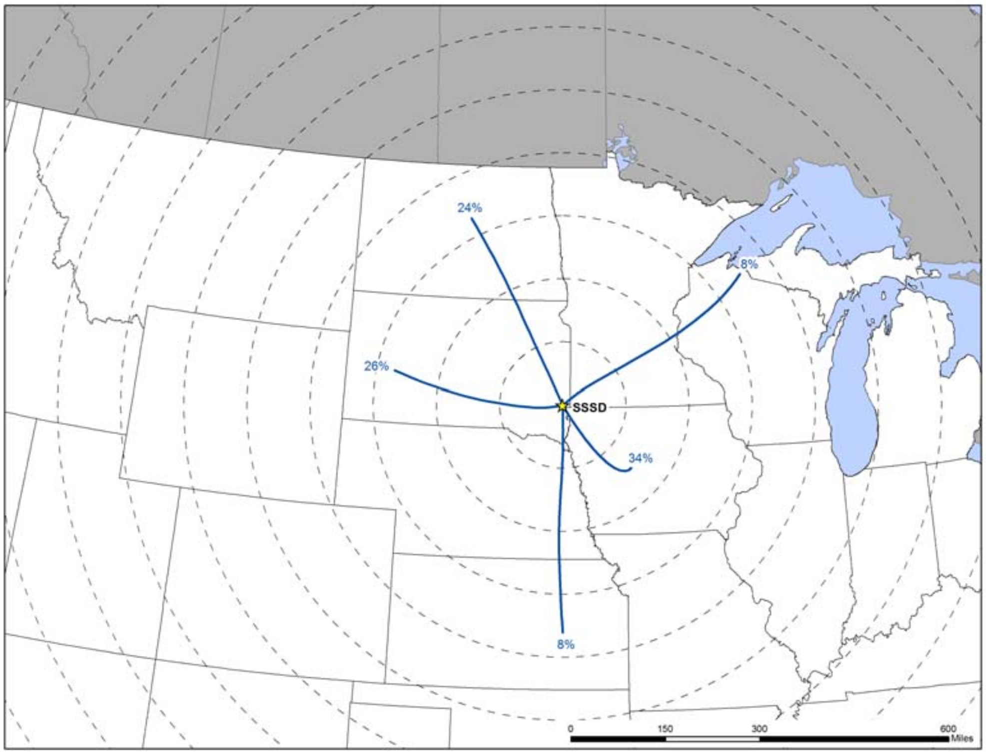


Figure 22-7. 2011 Composite Back Trajectory Map for UCSD

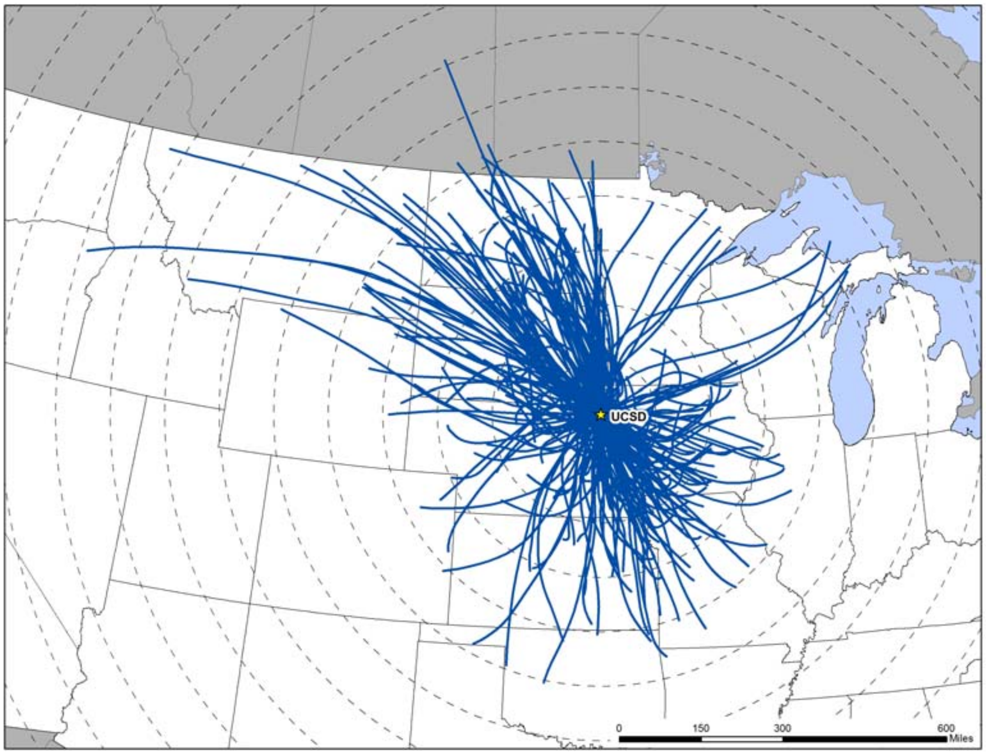
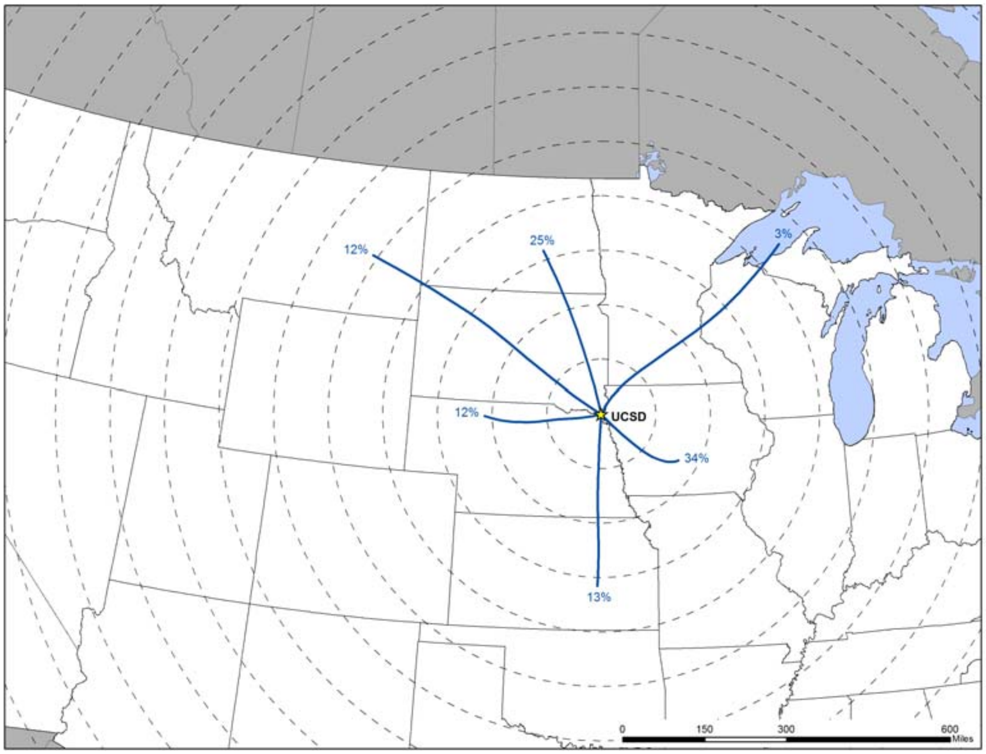


Figure 22-8. Back Trajectory Cluster Map for UCSD



Observations from Figures 22-7 and 22-8 for UCSD include the following:

- Back trajectories originated from a variety of directions at the UCSD monitoring site, with the longest back trajectories originating to the northwest of UCSD.

- The 24-hour air shed domain for UCSD was larger in size compared to SSSD and most other NMP sites. Two back trajectories originated farther than 900 miles away (one over northwest Montana and one over northeast Oregon. The average back trajectory length was greater than 300 miles; this is the only NMP site for which this is true. However, 85 percent of the trajectories originated within 450 miles of the site.

- The cluster analysis for UCSD shows that nearly 50 percent of back trajectories originated to the west to northwest to north of the site, although these back trajectories are represented by three cluster trajectories. One cluster trajectory (12 percent) includes back trajectories originating to the west of UCSD over central and western North and South Dakota and of relatively short length (<350 miles). Another cluster trajectory (12 percent) includes back trajectories originating from the northwest, primarily over Montana, and are relatively long (> 400 miles) in length. The third cluster trajectory (25 percent) includes mostly shorter trajectories originating to the northwest to north of UCSD and over North Dakota and northern South Dakota. Roughly one-third of back trajectories (34 percent) originated to the east and southeast over Iowa and Missouri. These were generally less than 300 miles in length. Another 13 percent of back trajectories originated to the south of UCSD and finally, three percent originated northeastward over Minnesota, Lake Superior, and the Upper Peninsula of Michigan.

22.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS weather stations at Joe Foss Field (for SSSD) and Sioux Gateway (for UCSD) Airports 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 22-9 presents a map showing the distance between the NWS station and SSSD, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 22-9 also presents three different wind roses for the SSSD monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 22-10 presents the distance map and three wind roses for UCSD.

Observations from Figure 22-9 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 3 percent). Calm winds were observed for approximately 11 percent of the observations. The strongest winds tend to be from the south or the northwest quadrant.

- The 2011 wind patterns are very similar to the historical wind patterns, indicating that wind conditions in 2011 near SSSD are similar to historical wind conditions.

- The sample day wind rose also resembles the historical and full-year wind roses, but does exhibit some differences. The sample day wind rose has a higher percentage of winds from the southeast quadrant and fewer from the northwest quadrant. In addition, winds greater than 22 knots were observed with easterly winds as well as winds from the southeast to south, and northwest to north-northwest.

Observations from Figure 22-10 for UCSD include the following:

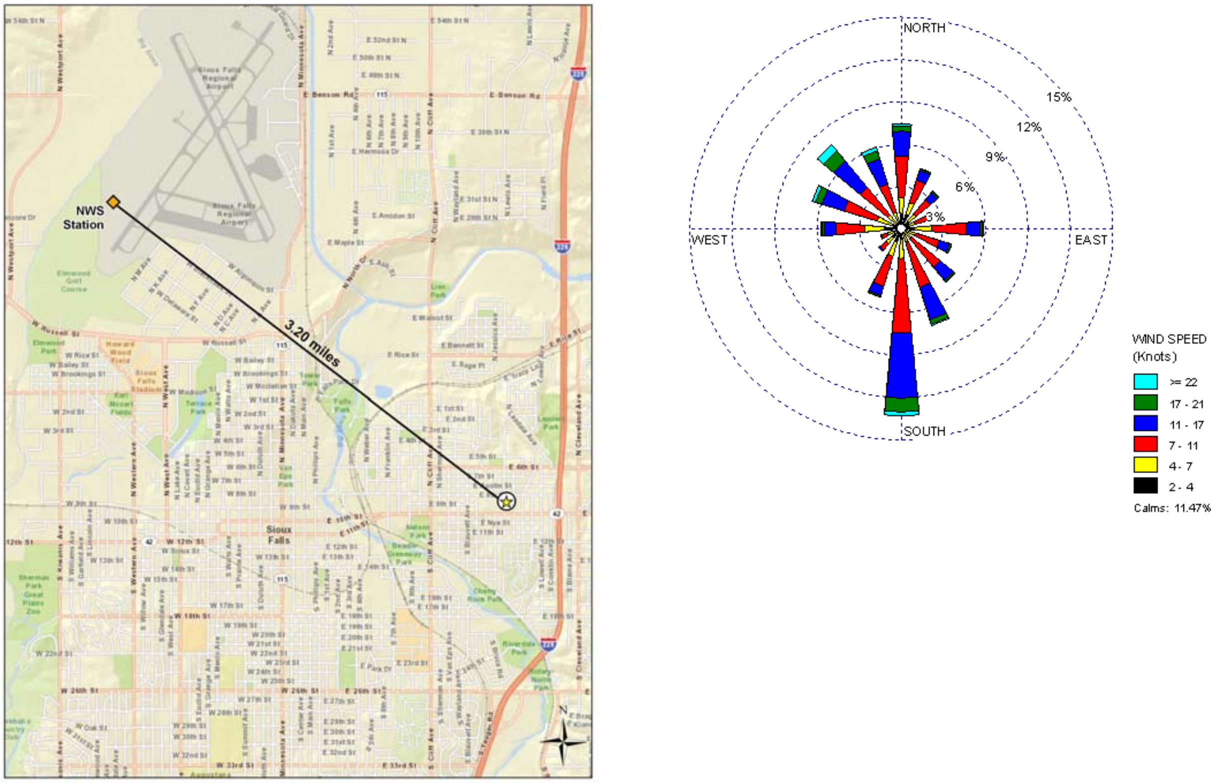
- The Sioux Gateway Airport weather station is located approximately 29 miles south-southeast of UCSD, across the state border in Sioux City, Iowa. The weather station is located less than a mile from the Missouri River.

- The historical wind rose shows that winds from the southeast and northwest quadrants were observed the most near UCSD. Calm winds were observed for less than eight percent of the observations. The strongest winds tend to be from the south or the northwest quadrant.

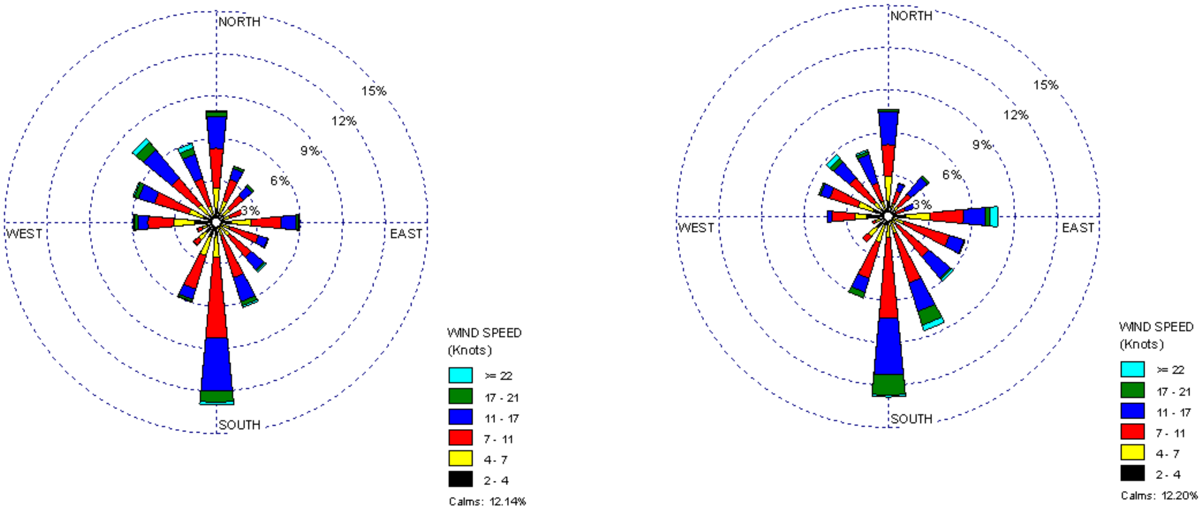
- The 2011 wind patterns are similar to the historical wind patterns, although the calm rate is slightly higher for 2011 (approximately 10 percent).

- The sample day wind patterns resemble the historical and full-year wind patterns, but have a higher percentage of east-southeasterly and southeasterly wind observations.

Figure 22-9. Wind Roses for the Joe Foss Field Airport Weather Station near SSSD

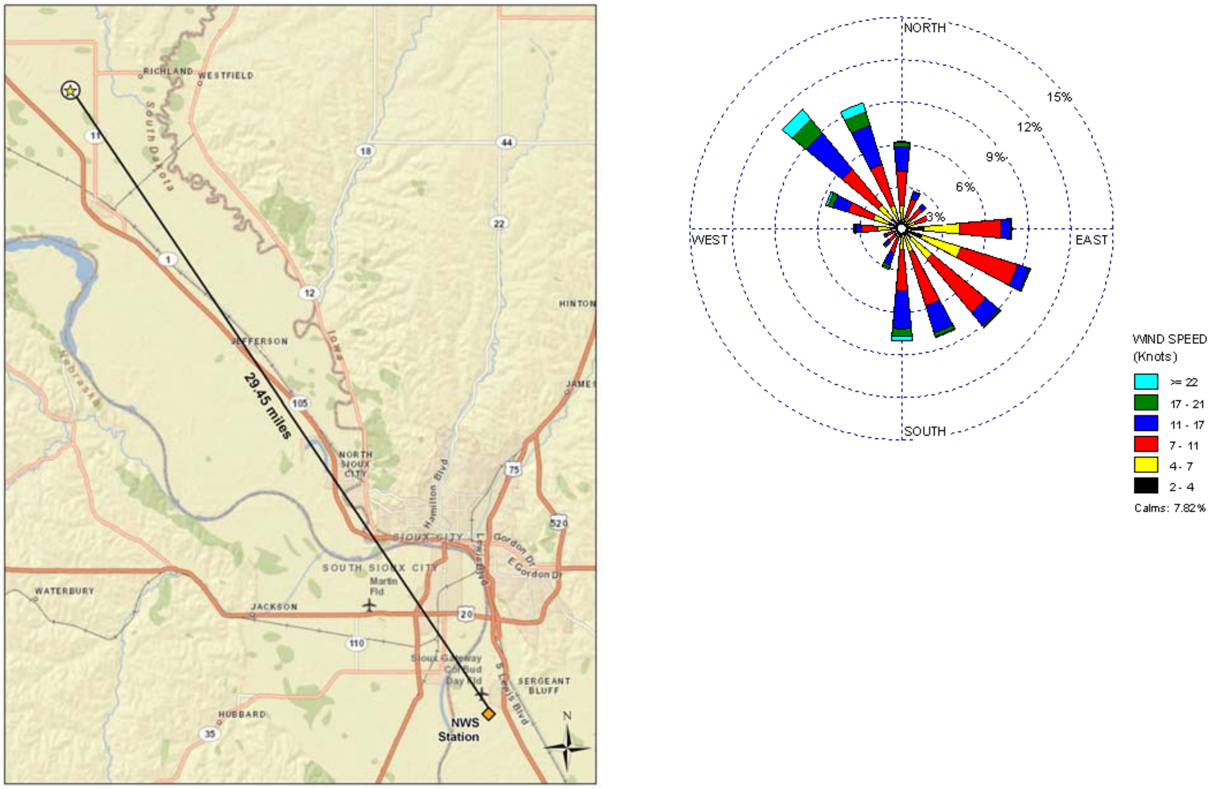

Distance between SSSD and NWS Station

2001-2010 Historical Wind Rose


2011 Wind Rose

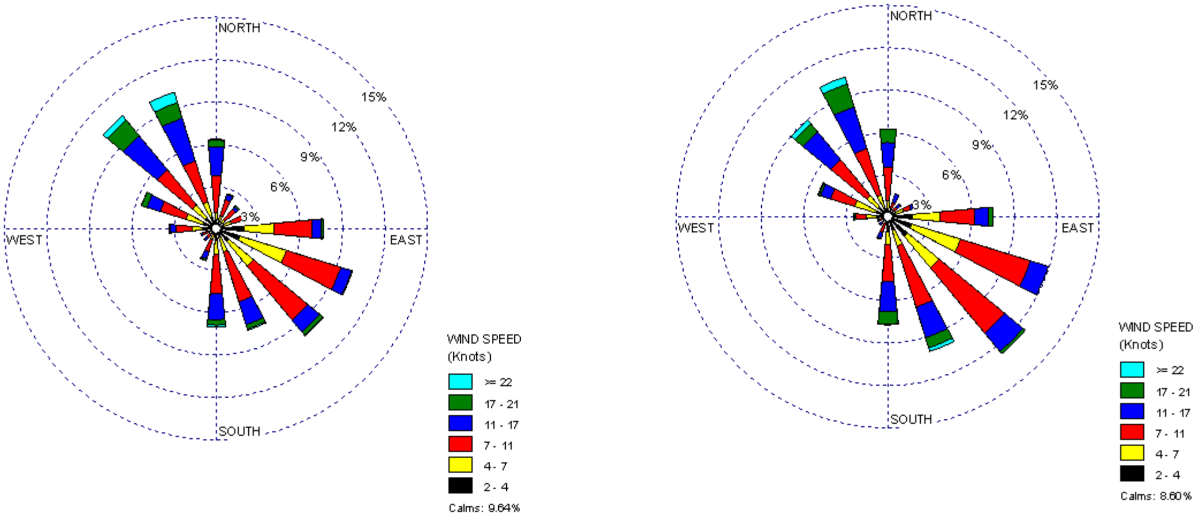
Sample Day Wind Rose

Figure 22-10. Wind Roses for the Sioux Gateway Airport Weather Station near UCSD



Distance between UCSD and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

22.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the South Dakota monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 22-4 presents the results of the preliminary risk-based screening process for the South Dakota monitoring sites. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. SSSD and UCSD sampled for VOCs, SNMOCs, and carbonyl compounds.

Table 22-4. Risk-Based Screening Results for the South Dakota Monitoring Sites

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	60	60	100.00	18.81	18.81
Acetaldehyde	0.45	59	59	100.00	18.50	37.30
Formaldehyde	0.077	59	59	100.00	18.50	55.80
Carbon Tetrachloride	0.17	55	59	93.22	17.24	73.04
1,3-Butadiene	0.03	41	44	93.18	12.85	85.89
1,2-Dichloroethane	0.038	17	17	100.00	5.33	91.22
Acrylonitrile	0.015	13	13	100.00	4.08	95.30
Ethylbenzene	0.4	6	60	10.00	1.88	97.18
Hexachloro-1,3-butadiene	0.045	3	3	100.00	0.94	98.12
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.63	98.75
Chloromethylbenzene	0.02	1	1	100.00	0.31	99.06
p-Dichlorobenzene	0.091	1	19	5.26	0.31	99.37
Dichloromethane	7.7	1	43	2.33	0.31	99.69
Propionaldehyde	0.8	1	59	1.69	0.31	100.00
Total		319	498	64.06		

Table 22-4. Risk-Based Screening Results for the South Dakota Monitoring Sites (Continued)

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Union County, South Dakota - UCSD						
Formaldehyde	0.077	61	61	100.00	20.33	20.33
Acetaldehyde	0.45	60	61	98.36	20.00	40.33
Benzene	0.13	56	56	100.00	18.67	59.00
Carbon Tetrachloride	0.17	54	56	96.43	18.00	77.00
Acrylonitrile	0.015	32	32	100.00	10.67	87.67
1,2-Dichloroethane	0.038	18	18	100.00	6.00	93.67
Hexachloro-1,3-butadiene	0.045	5	5	100.00	1.67	95.33
1,3-Butadiene	0.03	4	5	80.00	1.33	96.67
Ethylbenzene	0.4	3	56	5.36	1.00	97.67
1,2-Dibromoethane	0.0017	2	2	100.00	0.67	98.33
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.67	99.00
Trichloroethylene	0.2	2	4	50.00	0.67	99.67
p-Dichlorobenzene	0.091	1	11	9.09	0.33	100.00
Total		300	369	81.30		

Observations from Table 22-4 include the following:

- Fourteen pollutants failed at least one screen for SSSD; of these, five are NATTS MQO Core Analytes. Thirteen pollutants failed screens for UCSD, of which six are also NATTS MQO Core Analytes. Of the pollutants failing screens, the sites share 11 pollutants in common in Table 22-4.

- For SSSD, seven pollutants (of which five are NATTS MQO Core Analytes) were identified as pollutants of interest by the risk-based screening process. Chloroform, tetrachloroethylene, trichloroethylene, and vinyl chloride were added to SSSD's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens. These pollutants are not shown in Table 22-4 but are shown in subsequent tables in the sections that follow.

- For UCSD, seven pollutants (of which four are NATTS MQO Core Analytes) were identified as pollutants of interest by the risk-based screening process. Trichloroethylene and 1,3-butadiene were added to the pollutants of interest for UCSD because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of the total failed screens. Chloroform, tetrachloroethylene, and vinyl chloride were added to UCSD's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens. These three pollutants are not shown in Table 22-4 but are shown in subsequent tables in the sections that follow.

- Formaldehyde and benzene were detected in every valid sample collected at UCSD and SSSD and failed 100 percent of screens. Other pollutants, such as acrylonitrile, 1,2-dichloroethane, and hexachloro-1,3-butadiene also failed 100 percent of screens for each site but were detected 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 the South Dakota sites sampled both VOCs (TO-15) and SNMOCs, the TO-15 results were used for the 12 pollutants these methods have in common.

22.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the South Dakota monitoring sites. Where applicable, the following calculations and data analyses were performed: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the South Dakota monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for SSSD and UCSD are provided in Appendices J through L.

22.4.1 2011 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each 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 of 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 sites 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 Dakota 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)
Sioux Falls, South Dakota - SSSD						
Acetaldehyde	59/59	1.90 ± 0.68	1.31 ± 0.23	1.56 ± 0.36	1.51 ± 0.23	1.57 ± 0.21
Acrylonitrile	13/60	0.02 ± 0.05	0.06 ± 0.04	0.05 ± 0.04	0	0.03 ± 0.02
Benzene	60/60	0.69 ± 0.10	0.60 ± 0.12	0.56 ± 0.09	0.67 ± 0.13	0.63 ± 0.05
1,3-Butadiene	44/60	0.03 ± 0.01	0.03 ± 0.02	0.04 ± 0.02	0.07 ± 0.02	0.04 ± 0.01
Carbon Tetrachloride	59/60	0.32 ± 0.11	0.65 ± 0.05	0.64 ± 0.04	0.57 ± 0.07	0.54 ± 0.05
Chloroform	28/60	0.02 ± 0.02	0.04 ± 0.03	0.04 ± 0.03	0.07 ± 0.02	0.04 ± 0.01
1,2-Dichloroethane	17/60	0.01 ± 0.02	0.02 ± 0.02	0.01 ± 0.01	0.06 ± 0.02	0.02 ± 0.01
Formaldehyde	59/59	0.98 ± 0.30	2.53 ± 0.71	2.50 ± 0.38	2.05 ± 0.45	2.01 ± 0.28
Tetrachloroethylene	46/60	0.08 ± 0.03	0.09 ± 0.03	0.06 ± 0.03	0.09 ± 0.03	0.08 ± 0.01
Trichloroethylene	3/60	<0.01 ± 0.01	0	0	<0.01 ± 0.01	<0.01 ± <0.01
Vinyl Chloride	1/60	<0.01 ± <0.01	0	0	0	<0.01 ± <0.01
Union County, South Dakota - UCSD						
Acetaldehyde	61/61	1.26 ± 0.24	1.30 ± 0.25	2.71 ± 0.87	3.85 ± 0.74	2.33 ± 0.40
Acrylonitrile	32/56	0.25 ± 0.03	0.34 ± 0.03	NA	0	0.17 ± 0.04
Benzene	56/56	0.50 ± 0.06	0.39 ± 0.06	NA	0.39 ± 0.06	0.40 ± 0.03
1,3-Butadiene	5/56	<0.01 ± <0.01	<0.01 ± <0.01	NA	0.01 ± 0.01	<0.01 ± <0.01
Carbon Tetrachloride	56/56	0.47 ± 0.08	0.59 ± 0.09	NA	0.63 ± 0.05	0.58 ± 0.04
Chloroform	14/56	0.03 ± 0.02	0.01 ± 0.01	NA	0.04 ± 0.02	0.02 ± 0.01
1,2-Dichloroethane	18/56	0.01 ± 0.02	0.02 ± 0.02	NA	0.06 ± 0.02	0.03 ± 0.01
Formaldehyde	61/61	0.97 ± 0.19	1.66 ± 0.42	1.72 ± 0.34	1.60 ± 0.57	1.50 ± 0.21
Hexachloro-1,3-butadiene	5/56	0	0.02 ± 0.03	NA	0.02 ± 0.03	0.01 ± 0.01

Table 22-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the South Dakota Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (µg/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Tetrachloroethylene	23/56	0.05 ± 0.02	0.03 ± 0.02	NA	0.03 ± 0.02	0.03 ± 0.01
Trichloroethylene	4/56	0.06 ± 0.08	0.01 ± 0.02	NA	0	0.02 ± 0.02
Vinyl Chloride	3/56	<0.01 ± <0.01	<0.01 ± <0.01	NA	0	<0.01 ± <0.01

Observations for SSSD from Table 22-5 include the following:

- The pollutants with the highest annual average concentrations by mass are formaldehyde (2.01 ± 0.28 µg/m^3) and acetaldehyde (1.57 ± 0.21 µg/m^3). These are the only two pollutants of interest with an annual average greater than 1.0 µg/m^3.

- The first quarter acetaldehyde average is higher than the other quarterly averages and has a relatively large confidence interval associated with it. The maximum acetaldehyde concentration was measured on March 10, 2011 (5.83 µg/m^3). This concentration is one of only two acetaldehyde concentrations greater than 3 µg/m^3 measured at SSSD (the second was measured in September). Of the 10 acetaldehyde concentrations greater than or equal to 2 µg/m^3 measured at SSSD, six were measured during the first quarter of 2011.

- Several of the VOC pollutants of interest have large confidence intervals relative to their quarterly and annual averages. Most of these pollutants were detected in fewer than half of the valid samples collected. For example, the confidence interval for the first quarter average of acrylonitrile is greater than the average itself. This quarterly average includes one measured detection of acrylonitrile (0.373 µg/m^3, measured on March 22, 2011) and 14 non-detects. The other 12 measured detections of acrylonitrile were from samples collected across the second and third quarters (there were no measured detections of acrylonitrile in the fourth quarter of the year). 1,2-Dichloroethane is another example. This pollutant was detected 17 times in samples collected in 2011. Two were measured during the first quarter, three in the second, two in the third, and 10 in the fourth. These quarterly averages are a result of many zeros substituted for non-detects combined with relatively low measurements. For 1,2-dichloroethane, the concentrations ranged from 0.0446 µg/m^3 to 0.11 µg/m^3.

Observations for UCSD from Table 22-5 include the following:

- The pollutants with the highest annual average concentrations by mass are acetaldehyde (2.33 ± 0.40 µg/m^3) and formaldehyde (1.50 ± 0.21 µg/m^3). These are the only two pollutants of interest with an annual average greater than 1.0 µg/m^3.

- For acetaldehyde, the third and fourth quarter averages are two and three times higher than the first and second quarter averages. A review of the data shows that the maximum concentration of acetaldehyde was measured on August 31, 2011 (6.93 µg/m^3). Two additional concentrations greater than 6 µg/m^3 were also measured in October and November. All 16 concentrations greater than 3 µg/m^3 were measured between August 31 and December 31, 2011. Conversely, all eight measurements less than 1 µg/m^3 were measured between January and April. Formaldehyde does not follow a similar trend.

- Third quarter averages for the VOCs could not be calculated because sampler issues resulted in several canister samples outside pressure limits.

- With the exception of benzene, acrylonitrile, and carbon tetrachloride, many of the VOCs were detected in fewer than half of the valid samples collected.

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 SSSD and UCSD from those tables include the following:

- None of the annual average concentrations of the pollutants of interest for SSSD appear in Tables 4-9 through 4-12.

- UCSD has the second highest annual average concentration of acrylonitrile among NMP sites sampling VOCs, as shown in Table 4-9. This site has the fourth highest number of failed screens for this pollutant among all sites sampling VOCs.

- UCSD also appears in Table 4-9 for hexachloro-1,3-butadiene, vinyl chloride, trichloroethylene, and 1,2-dichloroethane. However, these pollutants were detected in one-third or less of the valid samples collected.

- The annual average concentration of acetaldehyde for UCSD ranks ninth among NMP sites sampling carbonyl compounds. By comparison, the annual average formaldehyde concentration for UCSD ranks 23rd compared to other NMP sites.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde were created for both SSSD and UCSD. Figures 22-11 through 22-14 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.

Figure 22-11. Program vs. Site-Specific Average Acetaldehyde Concentrations

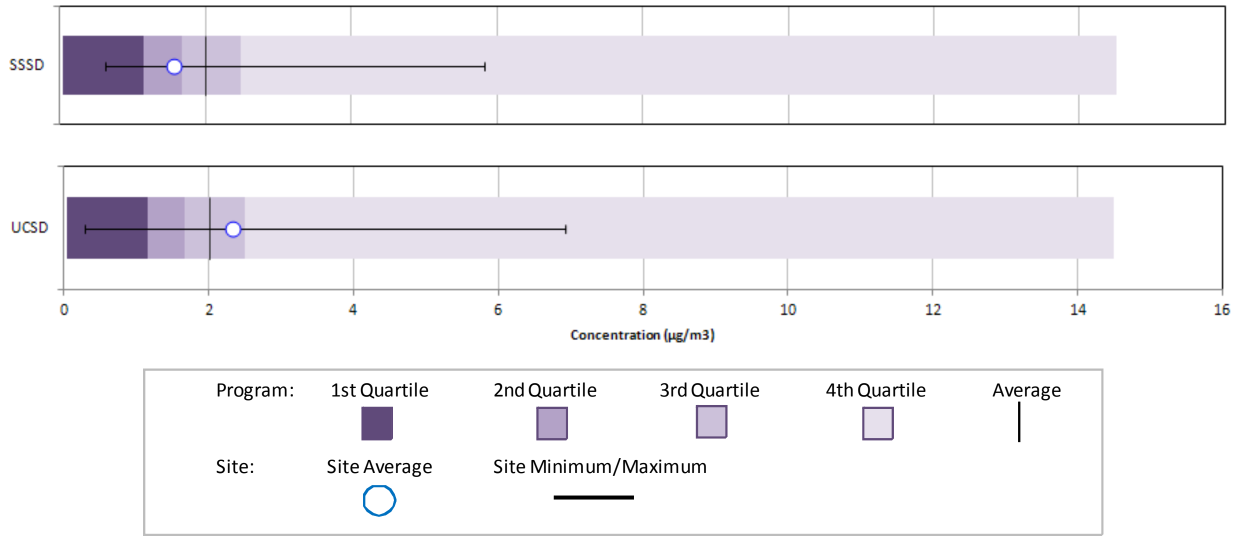


Figure 22-12. Program vs. Site-Specific Average Benzene Concentrations

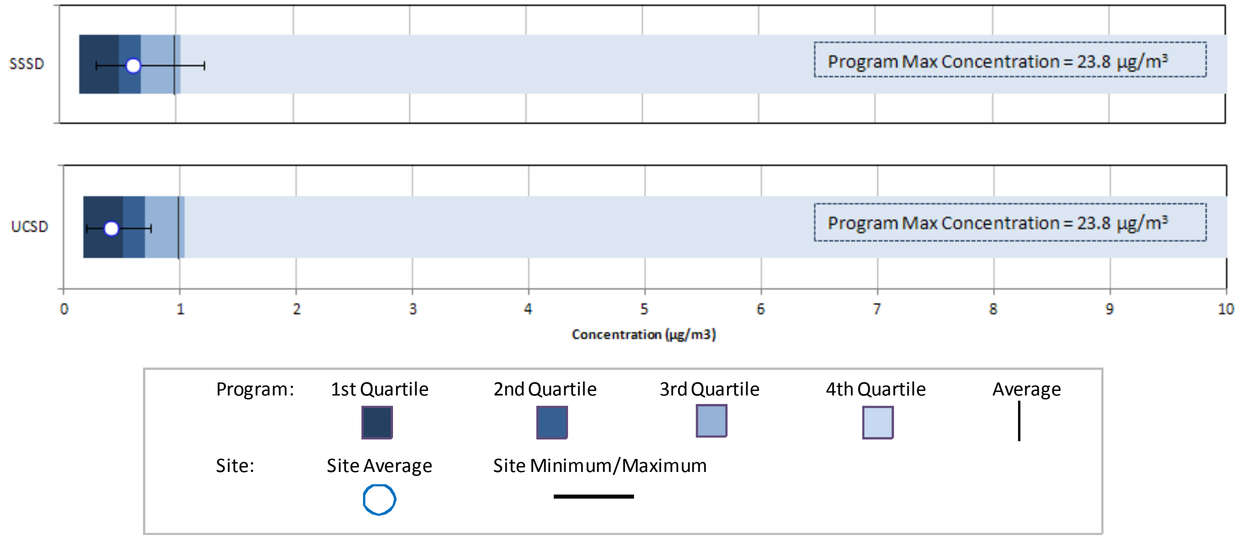


Figure 22-13. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

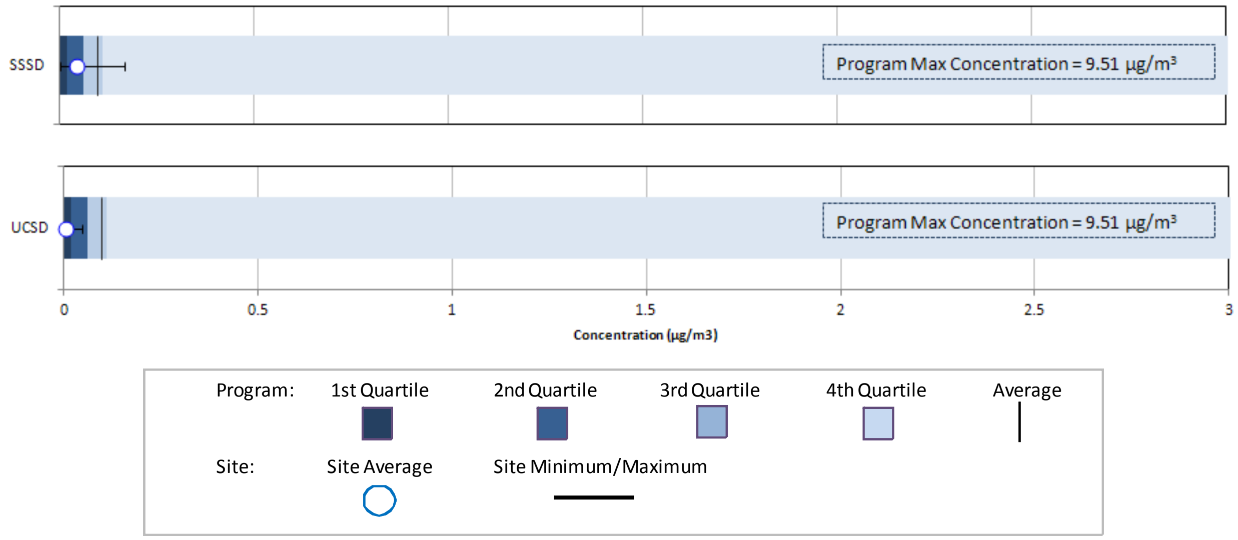
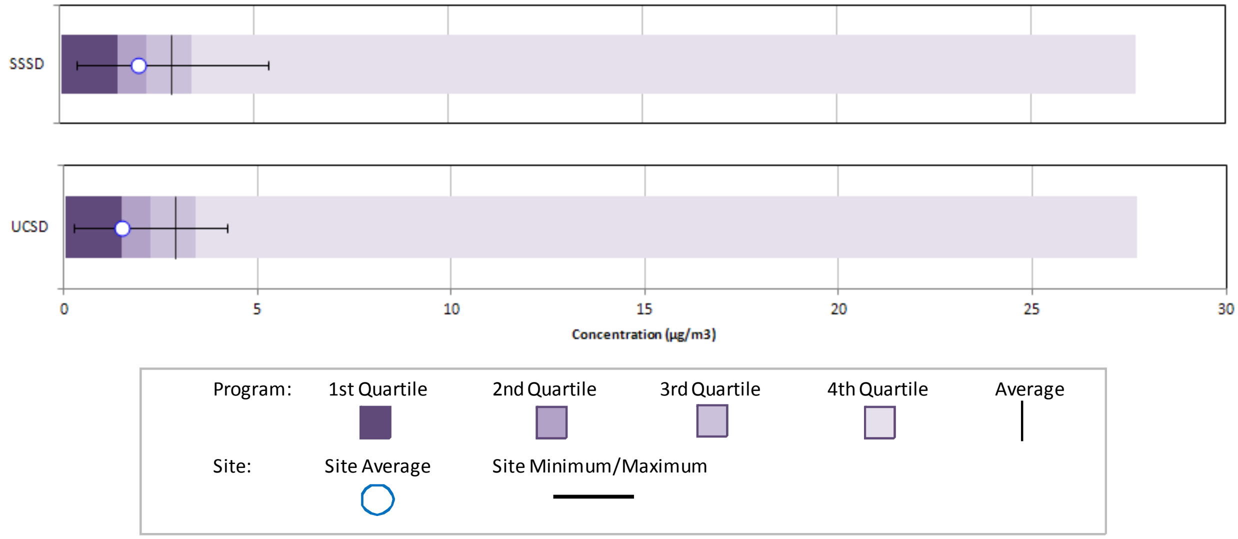


Figure 22-14. Program vs. Site-Specific Average Formaldehyde Concentrations



Observations from Figures 22-11 through 22-14 include the following:

- Figure 22-11 shows that the annual average acetaldehyde concentration for UCSD is greater than the program-level average while the annual average for SSSD is less than the program-level average and median concentrations. The range of concentrations measured is larger at UCSD than at SSSD, although the maximum concentration measured at both sites is less than the maximum concentration measured across the program. There were no non-detects of acetaldehyde measured at either site or across the program.

- The program-level maximum benzene concentration (23.8 µg/m^3) is not shown directly on the box plots in Figure 22-12 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 has been reduced to 10 µg/m^3. This figure shows that the annual average benzene concentrations for both sites are less than the program-level average and median concentrations of benzene. Further, the annual average for UCSD is less than the program-level first quartile (25th percentile) and the maximum benzene concentration measured at this site is just less than the program-level median concentration. UCSD has the lowest annual average benzene concentration among NMP sites sampling this pollutant. There were no non-detects of benzene measured at either site or across the program.

- Similar to the benzene graph, the program-level maximum 1,3-butadiene concentration (9.51 $\mu g/m^3$) is not shown directly on the box plots in Figure 22-13 as the scale has been reduced to 3 $\mu g/m^3$ to allow for the observation of data points at the lower end of the concentration range. This figure shows that the annual average 1,3-butadiene concentrations for both sites are less than the program-level average and median concentrations. The annual average for UCSD is actually an order of magnitude less than the program-level median concentration. Further, the maximum 1,3-butadiene measured at UCSD is also less than the program-level median concentration. This site has lowest annual average 1,3-butadiene concentration among NMP sites sampling this pollutant.

- Figure 22-14 shows that although the annual average formaldehyde concentration for SSSD is greater than the annual average for UCSD, the annual averages for both sites are less than the program-level average and median concentrations. The annual average for UCSD is equivalent to the program-level first quartile. The maximum formaldehyde concentration measured at each site is considerably less than the maximum concentration measured across the program. There were no non-detects of formaldehyde measured at either site.

22.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. Sampling at SSSD began in 2008 after a re-location from a previous sampling site. Sampling at UCSD under the NMP began in 2009 and was completed at the end of 2011. Thus, a trends analysis was not performed for either site.

22.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the South Dakota monitoring sites. Refer to Sections 3.3 and 3.5.5 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 Dakota 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 to 14 days); intermediate (exposures of 15 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 2011.

22.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the South Dakota 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 Dakota 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 Hazard Approximation (HQ)
Sioux Falls, South Dakota - SSSD						
Acetaldehyde	0.0000022	0.009	59/59	1.57 ± 0.21	3.46	0.17
Acrylonitrile	0.000068	0.002	13/60	0.03 ± 0.02	2.33	0.02
Benzene	0.0000078	0.03	60/60	0.63 ± 0.05	4.92	0.02
1,3-Butadiene	0.00003	0.002	44/60	0.04 ± 0.01	1.33	0.02
Carbon Tetrachloride	0.000006	0.1	59/60	0.54 ± 0.05	3.26	0.01
Chloroform	--	0.098	28/60	0.04 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	17/60	0.02 ± 0.01	0.62	<0.01
Formaldehyde	0.000013	0.0098	59/59	2.01 ± 0.28	26.08	0.20
Tetrachloroethylene	0.00000026	0.04	46/60	0.08 ± 0.01	0.02	<0.01
Trichloroethylene	0.0000048	0.002	3/60	<0.01 ± <0.01	0.01	<0.01
Vinyl Chloride	0.0000088	0.1	1/60	<0.01 ± <0.01	<0.01	<0.01
Union County, South Dakota - UCSD						
Acetaldehyde	0.0000022	0.009	61/61	2.33 ± 0.40	5.12	0.26
Acrylonitrile	0.000068	0.002	32/56	0.17 ± 0.04	11.77	0.09
Benzene	0.0000078	0.03	56/56	0.40 ± 0.03	3.11	0.01
1,3-Butadiene	0.00003	0.002	5/56	<0.01 ± <0.01	0.09	<0.01
Carbon Tetrachloride	0.000006	0.1	56/56	0.58 ± 0.04	3.47	0.01
Chloroform	--	0.098	14/56	0.02 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	18/56	0.03 ± 0.01	0.69	<0.01
Formaldehyde	0.000013	0.0098	61/61	1.50 ± 0.21	19.53	0.15
Hexachloro-1,3-butadiene	0.000022	0.09	5/56	0.01 ± 0.01	0.28	<0.01
Tetrachloroethylene	0.00000026	0.04	23/56	0.03 ± 0.01	0.01	<0.01
Trichloroethylene	0.0000048	0.002	4/56	0.02 ± 0.02	0.08	0.01
Vinyl Chloride	0.0000088	0.1	3/56	<0.01 ± <0.01	0.01	<0.01

-- = a Cancer URE or Noncancer RfC is not available

Observations from Table 22-6 for SSSD include the following:

- The pollutants with the highest annual average concentrations for SSSD are formaldehyde, acetaldehyde, and benzene.

- Formaldehyde, benzene, and acetaldehyde have the highest cancer risk approximations among this site's pollutants of interest, although formaldehyde's cancer risk approximation is an order of magnitude higher than the cancer risk approximations for the other pollutants.

- None of the noncancer hazard approximations were greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants.

Observations from Table 22-6 for UCSD include the following:

- The pollutants with the highest annual average concentrations for UCSD are acetaldehyde, formaldehyde, and carbon tetrachloride.

- Formaldehyde has the highest cancer risk approximation for UCSD, followed by acrylonitrile. The cancer risk approximation for acrylonitrile (11.77 in-a-million) is the second highest cancer risk approximation for this pollutant. Although acrylonitrile has a much lower annual average concentration than formaldehyde, the cancer risk approximations are both greater than 10 in-a-million, indicating the relative toxicity of this pollutant.

- None of the noncancer hazard approximations for the pollutants of interest for UCSD were greater than 1.0, indicating that no adverse health effects are expected from these individual pollutants.

22.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 22-7 and 22-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 22-6. Table 22-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazards approximations (HQ), also calculated from annual averages provided in Table 22-6.

Table 22-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the South Dakota 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)**
Sioux Falls, South Dakota (Minnehaha County) - SSSD					
Benzene	84.66	Formaldehyde	7.40E-04	Formaldehyde	26.08
Formaldehyde	56.95	Benzene	6.60E-04	Benzene	4.92
Ethylbenzene	54.47	1,3-Butadiene	3.72E-04	Acetaldehyde	3.46
Acetaldehyde	36.84	Naphthalene	2.11E-04	Carbon Tetrachloride	3.26
1,3-Butadiene	12.38	POM, Group 3	1.94E-04	Acrylonitrile	2.33
Naphthalene	6.21	Hexavalent Chromium, PM	1.48E-04	1,3-Butadiene	1.33
Dichloromethane	1.65	Ethylbenzene	1.36E-04	1,2-Dichloroethane	0.62
POM, Group 2b	1.34	POM, Group 2b	1.18E-04	Tetrachloroethylene	0.02
POM, Group 6	0.12	Acetaldehyde	8.10E-05	Trichloroethylene	0.01
POM, Group 1a	0.12	POM, Group 5a	5.09E-05	Vinyl Chloride	<0.01
Union County, South Dakota (Union County) - UCSD					
Benzene	15.98	Formaldehyde	1.67E-04	Formaldehyde	19.53
Formaldehyde	12.81	Benzene	1.25E-04	Acrylonitrile	11.77
Ethylbenzene	10.98	1,3-Butadiene	6.36E-05	Acetaldehyde	5.12
Acetaldehyde	8.37	Naphthalene	3.90E-05	Carbon Tetrachloride	3.47
1,3-Butadiene	2.12	Ethylbenzene	2.74E-05	Benzene	3.11
Naphthalene	1.15	POM, Group 2b	2.04E-05	1,2-Dichloroethane	0.69
POM, Group 2b	0.23	Acetaldehyde	1.84E-05	Hexachloro-1,3-butadiene	0.28
Dichloromethane	0.13	POM, Group 3	1.71E-05	1,3-Butadiene	0.09
POM, Group 6	0.02	Hexavalent Chromium, PM	1.56E-05	Trichloroethylene	0.08
POM, Group 1a	0.01	Arsenic, PM	1.05E-05	Vinyl Chloride	0.01

Table 22-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the South Dakota 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)**
Sioux Falls, South Dakota (Minnehaha County) - SSSD					
Toluene	247.74	Acrolein	148,988.96	Formaldehyde	0.20
Xylenes	232.25	1,3-Butadiene	6,191.87	Acetaldehyde	0.17
Methanol	104.42	Formaldehyde	5,811.72	1,3-Butadiene	0.02
Benzene	84.66	Acetaldehyde	4,093.12	Benzene	0.02
Formaldehyde	56.95	Benzene	2,821.95	Acrylonitrile	0.02
Ethylbenzene	54.47	Xylenes	2,322.48	Carbon Tetrachloride	0.01
Hexane	49.47	Naphthalene	2,068.40	Tetrachloroethylene	<0.01
Acetaldehyde	36.84	Lead, PM	871.54	Trichloroethylene	<0.01
Ethylene glycol	13.66	Arsenic, PM	550.67	Chloroform	<0.01
1,3-Butadiene	12.38	Propionaldehyde	461.12	1,2-Dichloroethane	<0.01
Union County, South Dakota (Union County) - UCSD					
Toluene	49.76	Acrolein	33,649.12	Acetaldehyde	0.26
Xylenes	48.01	Formaldehyde	1,307.04	Formaldehyde	0.15
Benzene	15.98	1,3-Butadiene	1,060.53	Acrylonitrile	0.09
Formaldehyde	12.81	Acetaldehyde	930.04	Benzene	0.01
Ethylbenzene	10.98	Cyanide Compounds, gas	603.39	Trichloroethylene	0.01
Hexane	8.85	Benzene	532.80	Carbon Tetrachloride	0.01
Acetaldehyde	8.37	Xylenes	480.09	1,3-Butadiene	<0.01
Methanol	8.23	Naphthalene	382.14	Tetrachloroethylene	<0.01
1,3-Butadiene	2.12	Arsenic, PM	162.43	Chloroform	<0.01
1,1,1-Trichloroethane	1.31	Propionaldehyde	119.46	Hexachloro-1,3-butadiene	<0.01

The pollutants listed in Tables 22-7 and 22-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 22.3, SSSD and UCSD sampled for VOCs, SNMOCs, and carbonyl compounds. 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, as discussed in previous sections. A more in-depth discussion of this analysis is provided in Section 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 22-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Minnehaha and Union Counties. The emissions are higher in Minnehaha County than in Union County, although both counties have relatively low emissions of these pollutants. Union County has the lowest emissions of these three pollutants among all counties with NMP sites.

- Formaldehyde, benzene, and 1,3-butaidene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for both counties.

- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Minnehaha County. The same seven pollutants appear on both emissions-based lists for Union County.

- Formaldehyde is the pollutant with the highest cancer risk approximation for SSSD; this pollutant also appears on both emissions-based lists. This is also true for acetaldehyde, benzene, and 1,3-butadiene. Conversely, several pollutants, including carbon tetrachloride and acrylonitrile, appear on neither emissions-based list but are among the pollutants with the highest cancer risk approximations for SSSD.

- Formaldehyde has the highest cancer risk approximation for UCSD and appears on both emissions-based lists. Conversely, acrylonitrile, which has the second highest cancer risk approximation for UCSD, appears on neither emissions-based list.

Observations from Table 22-8 include the following:

- Toluene and xylenes are the highest emitted pollutants with noncancer RfCs in both Minnehaha and Union Counties. The emissions of these pollutants were an order of magnitude higher in Minnehaha County than in Union County.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties. Although acrolein was sampled for at SSSD and UCSD, 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 or Union Counties.

- Five of the highest emitted pollutants also have the highest toxicity-weighted emissions for Minnehaha County. The same five pollutants appear on both emissions-based lists for Union County.

- Formaldehyde and acetaldehyde, which have the highest noncancer hazard approximations for SSSD and UCSD, appear on both emissions-based lists. Benzene and 1,3-butadiene also appear on all three lists for each South Dakota monitoring site while acrylonitrile appears on neither emissions-based list.

22.6 Summary of the 2011 Monitoring Data for SSSD and UCSD

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

- ❖ *Fourteen pollutants failed at least one screen for SSSD and 13 pollutants failed at least one screen for UCSD.*

- ❖ *For both sites, formaldehyde and acetaldehyde are the only pollutants for which the annual average concentrations were greater than 1 µg/m*^{3}.

- ❖ *UCSD has the second highest annual average concentration of acrylonitrile among NMP sites sampling VOCs. Conversely, UCSD has the lowest annual average concentrations of benzene and 1,3-butadiene among sites sampling these pollutants.*

23.0 Sites in Texas

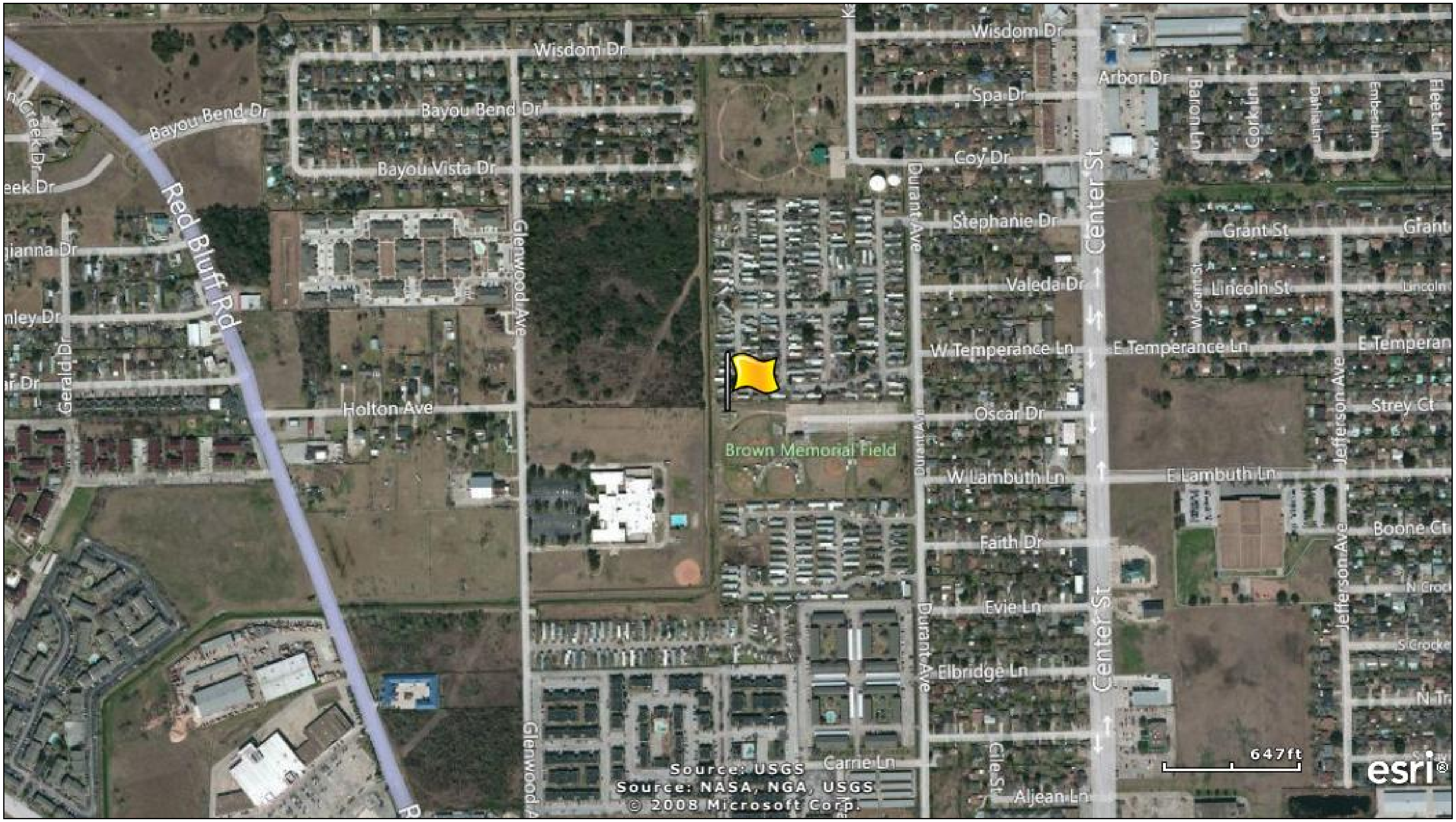
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS sites in Texas, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data 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.

23.1 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.

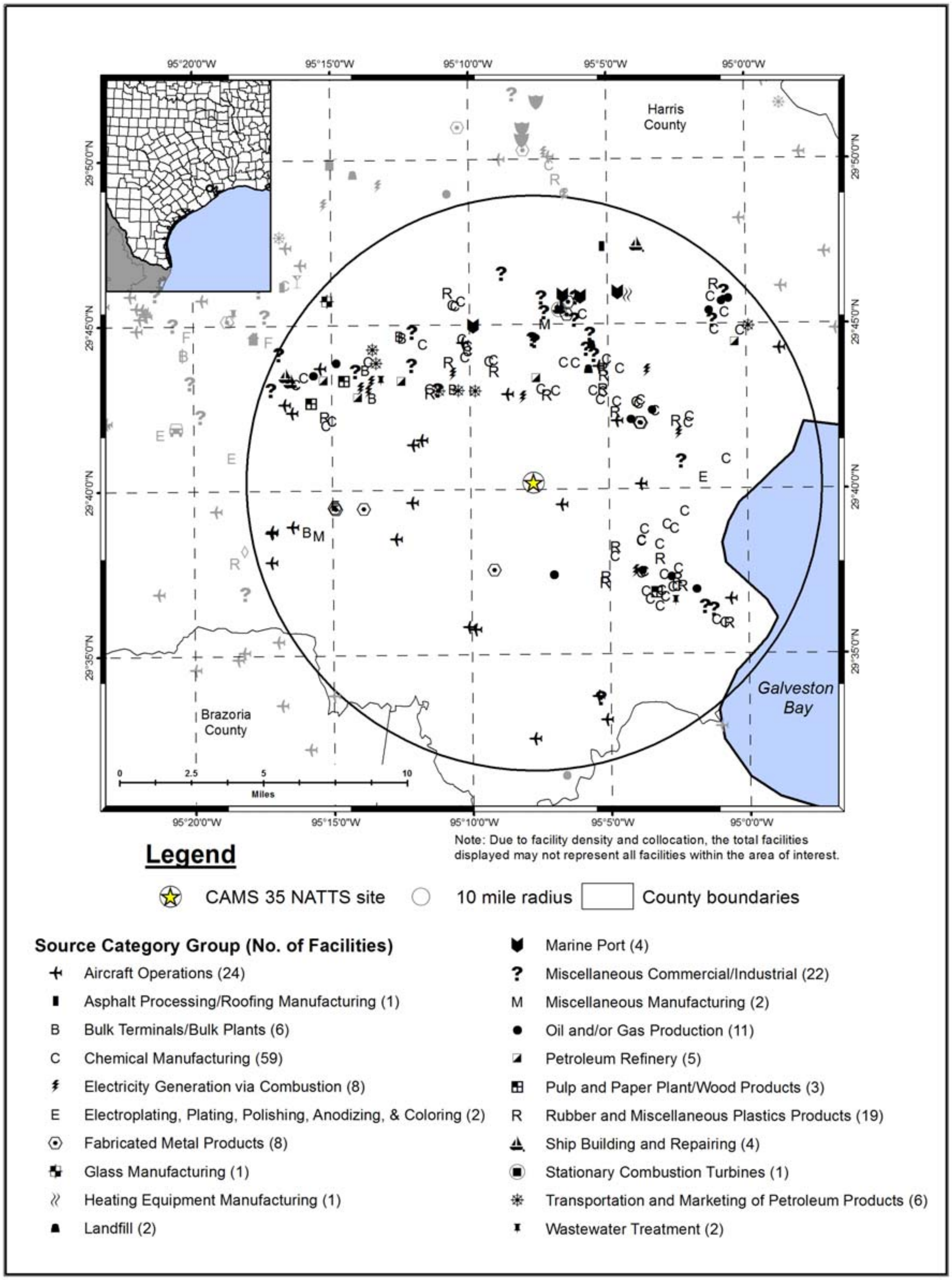
The CAMS 35 monitoring site is located in the Houston-Sugarland-Baytown, Texas MSA and CAMS 85 is part of the Marshall, Texas MSA. Figures 23-1 and 23-3 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 23-2 and 23-4 identify nearby point source emissions locations by source category for each site, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figures 23-2 and 23-4. 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 23-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 23-1. Deer Park, Texas (CAMS 35) Monitoring Site



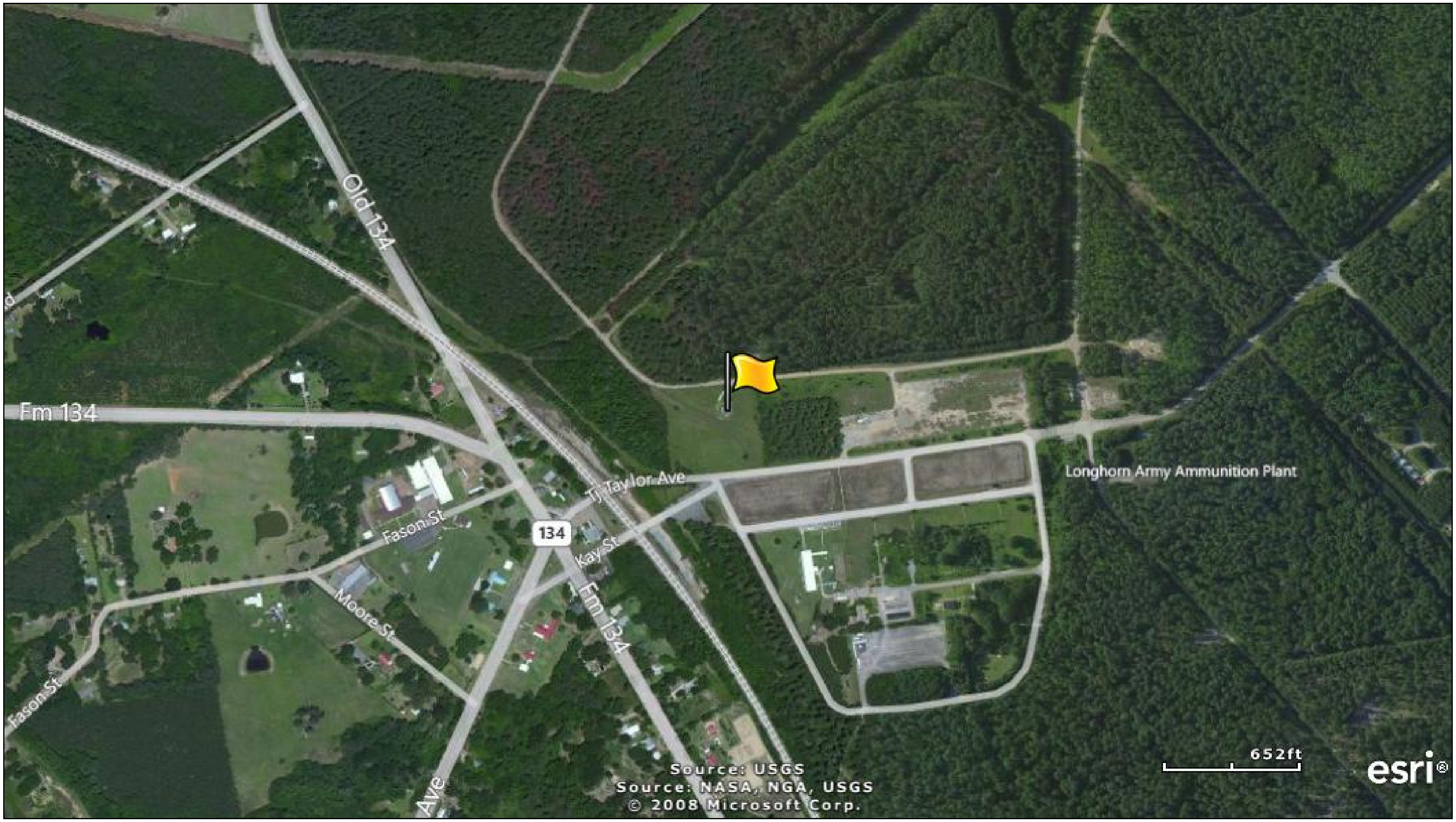
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 23-2. NEI Point Sources Located Within 10 Miles of CAMS 35



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

Figure 23-3. Karnack, Texas (CAMS 85) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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Figure 23-4. NEI Point Sources Located Within 10 Miles of CAMS 85

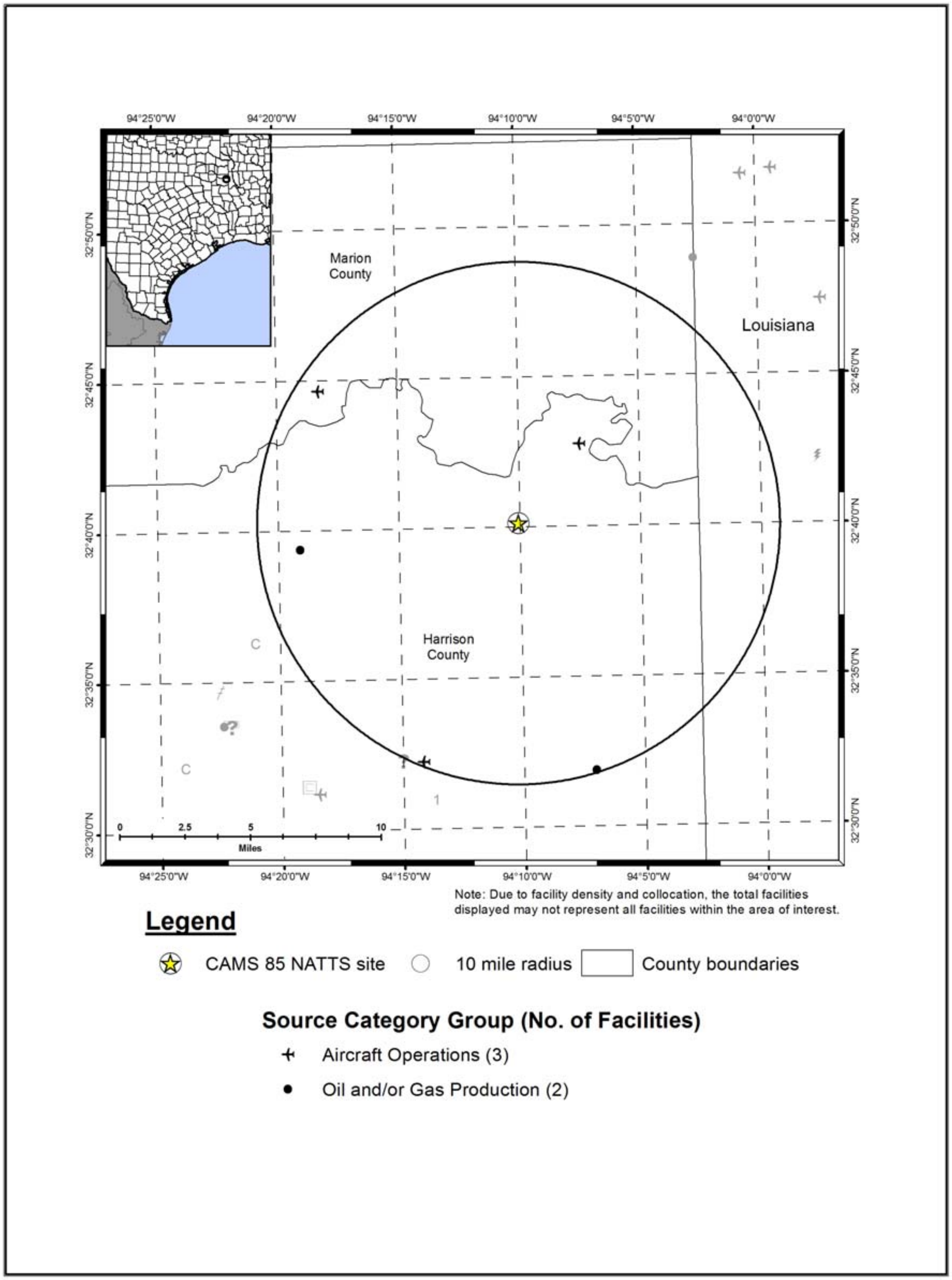


Table 23-1. Geographical Information for the Texas Monitoring Sites

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-Sugar Land-Baytown, TX MSA	29.670046, -95.128485	Residential	Suburban	Haze, CO, NO_y, NO, NO_2, NO_x, PAMS, NMOCs, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM Coarse, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation, SO_2, SVOCs.
CAMS 85	48-203-0002	Karnack	Harrison	Marshall, TX MSA	32.669004, -94.167449	Agricultural	Rural	SVOCs, NO_2, NO, NO_x, PAMS, NMOCs, Carbonyl Compounds, VOCs, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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 23-1. Major thoroughfares are near the site, including Beltway 8 (1.5 miles to the west) and Highway 225 (nearly 3 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 oil refineries. As Figure 23-2 shows, the point source located closest to the CAMS 35 monitoring site is a heliport at San Jacinto College in Pasadena. However, 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 (59) surrounding CAMS 35 is chemical manufacturing. Other source categories with a number of sources around CAMS 35 include aircraft operations, which include airports as well as small runways, heliports, or landing pads; rubber and miscellaneous plastics products; and oil and gas production.

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 from 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 23-3. The surrounding area is rural and agricultural. As Figure 23-4 shows, there are few point sources within 10 miles of CAMS 85 and these sources fall into two source categories: aircraft operations and oil and gas production. The closest source to CAMS 85 is the Fly-N-Fish Lodge Airport.

Table 23-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Texas monitoring sites. Table 23-2 includes county-level population and vehicle registration information. Table 23-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 23-2 also contains traffic volume information for each site. Finally, Table 23-2 presents the county-level daily VMT for Harris and Harrison Counties.

Table 23-2. Population, Motor Vehicle, and Traffic Information for the Texas Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
CAMS 35	4,180,894	3,164,173	0.76	698,184	528,398	31,043	56,650,489
CAMS 85	66,296	70,585	1.06	2,264	2,410	1,250	2,578,700

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Texas Department of Motor Vehicles (TX DMV, 2012)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2010 data for CAMS 85 from the Texas DOT and 2004 data for CAMS 35 from Harris County Public Infrastructure Department (TX DOT, 2011 and HCPID, 2012)
[5] County-level VMT reflects 2011 data from the Texas DOT (TX DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 23-2 include the following:

- The population and vehicle ownership counts are significantly higher for CAMS 35 than CAMS 85. 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 10-mile populations for both CAMS 35 and CAMS 85 do not reflect the magnitude of the county-level populations, indicating that these sites are not located near the centers of highest population density. The 10-mile population for CAMS 35 is in the middle of the range compared to other NMP sites, while the 10-mile population for CAMS 85 is the lowest among all NMP sites. The estimated 10-mile vehicle ownerships for each site exhibit similar rankings.

- The vehicle-per-person ratio for CAMS 85 is higher than for CAMS 35. Compared to other sites, the ratio for CAMS 85 is in the top third while the ratio for CAMS 35 is in the bottom third.

- The traffic volume passing CAMS 35 is significantly 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.

23.2 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.

23.2.1 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. 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 (Bair, 1992 and TAMU, 2013).

23.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2011 (NCDC, 2011). 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 23-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 23-3. Average Meteorological Conditions near the Texas Monitoring Sites

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)
Deer Park, Texas - CAMS 35									
William P. Hobby Airport 12918 (29.65, -95.28)	8.85 miles 258° (WSW)	Sample Day	80.1 ± 3.8	70.6 ± 3.6	56.8 ± 4.0	62.7 ± 3.4	65.8 ± 3.1	1016.7 ± 1.5	7.2 ± 0.8
		2011	81.2 ± 1.5	71.7 ± 1.4	58.6 ± 1.5	64.0 ± 1.3	67.1 ± 1.3	1016.3 ± 0.6	7.1 ± 0.3
Karnack, Texas - CAMS 85									
Shreveport Regional Airport 13957 (32.45, -93.82)	24.46 miles 127° (SE)	Sample Day	77.9 ± 4.8	66.4 ± 4.6	51.0 ± 4.0	57.6 ± 3.8	62.5 ± 3.4	1016.2 ± 1.6	6.9 ± 0.8
		2011	79.4 ± 1.9	68.0 ± 1.8	52.7 ± 1.5	59.1 ± 1.4	62.6 ± 1.4	1015.7 ± 0.6	6.7 ± 0.3

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

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. Although the differences are not statistically significant, the average temperature and moisture parameters for both sites are slightly higher for all of 2011 than they are for sample days alone.

23.2.3 Back Trajectory Analysis

Figure 23-5 is the composite back trajectory map for days on which samples were collected at the CAMS 35 monitoring site in 2011. Included in Figure 23-5 are four back trajectories per sample day. Figure 23-6 is the corresponding cluster analysis. Figure 23-7 is the composite back trajectory map for days on which samples were collected at CAMS 85 and Figure 23-8 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 23-5 through 23-8 represents 100 miles.

Observations from Figures 23-5 and 23-6 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 among the largest in size compared to other NMP monitoring sites. The average trajectory length was 278 miles, which is the fifth highest average trajectory length among NMP sites. Two back trajectories originated greater than 800 miles away, over central Nebraska. Approximately 82 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 northwest to northeast (25 percent). The short cluster trajectory originating near the Louisiana border (21 percent) represents back trajectories originating primarily over east Texas and Louisiana as well as relatively short trajectories originating from other directions and generally within 300 miles of CAMS 35.

Figure 23-5. 2011 Composite Back Trajectory Map for CAMS 35

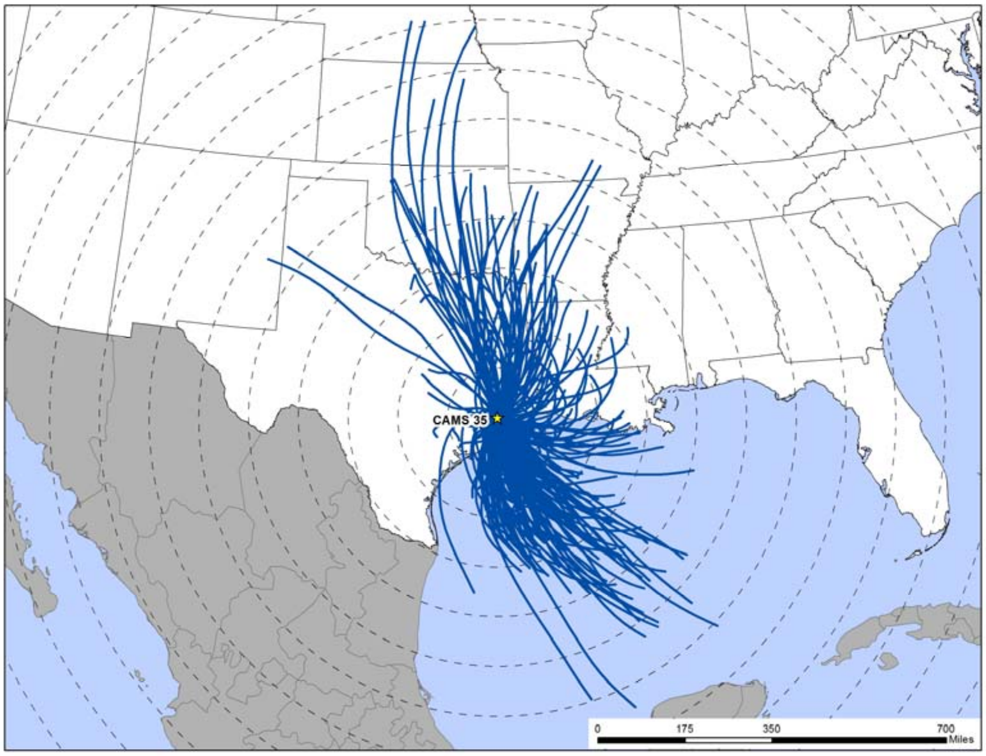


Figure 23-6. Back Trajectory Cluster Map for CAMS 35

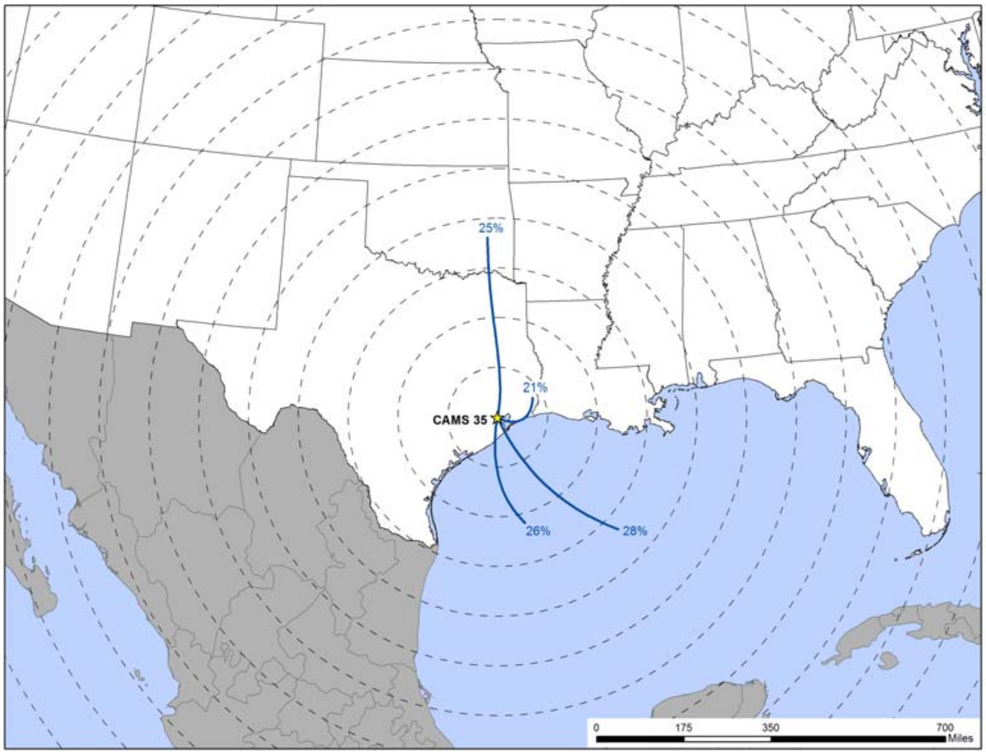


Figure 23-7. 2011 Composite Back Trajectory Map for CAMS 85

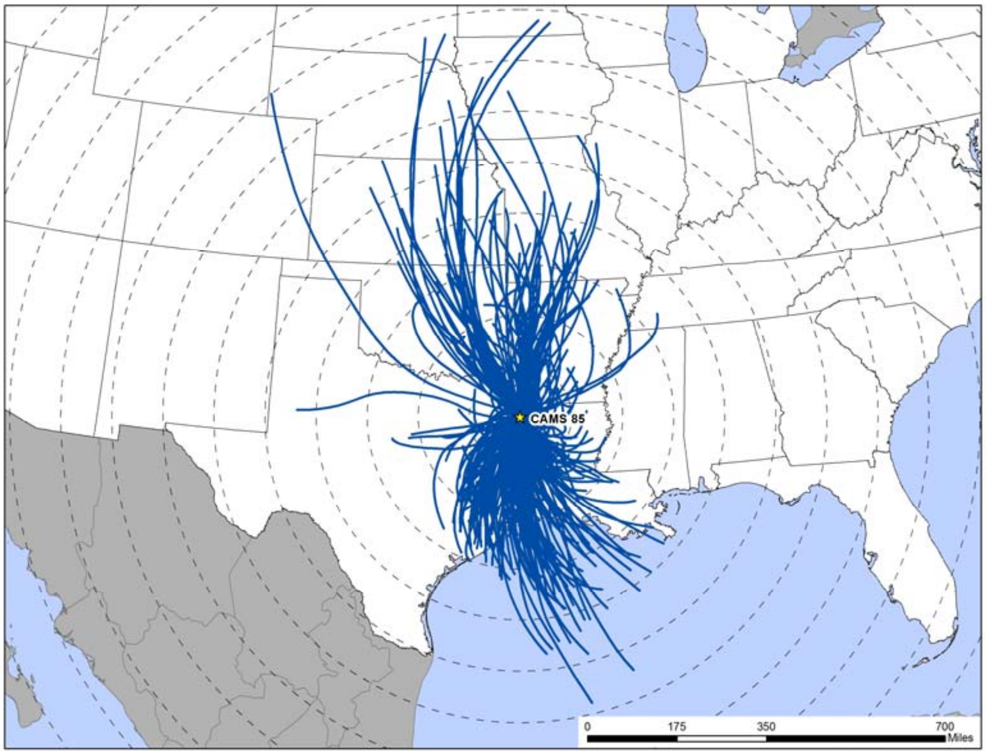
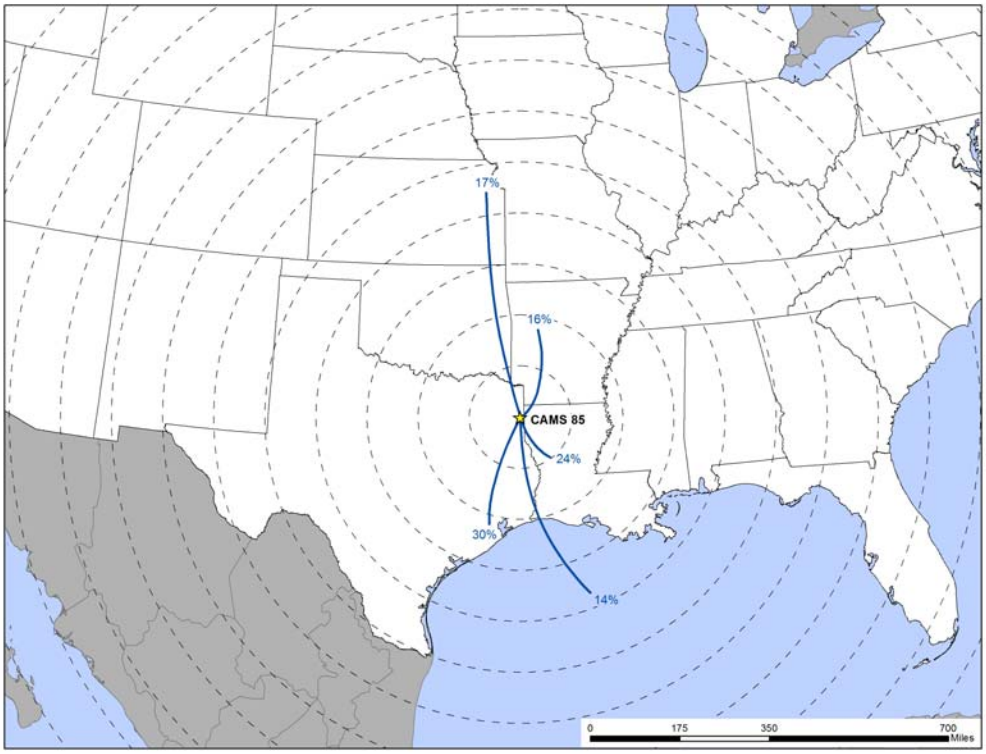


Figure 23-8. Back Trajectory Cluster Map for CAMS 85



Observations from Figures 23-7 and 23-8 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 composite map for CAMS 85 resembles the composite map for CAMS 35 in the direction of trajectory origin.

- The 24-hour air shed domain for CAMS 85 is slightly smaller in size compared to CAMS 35 but is similar in size to many other NMP monitoring sites. The farthest away a trajectory originated was 800 miles away, near the Wyoming/Nebraska border. However, the average trajectory length is 260 miles and most trajectories (86 percent) originated less than 400 miles from CAMS 85.

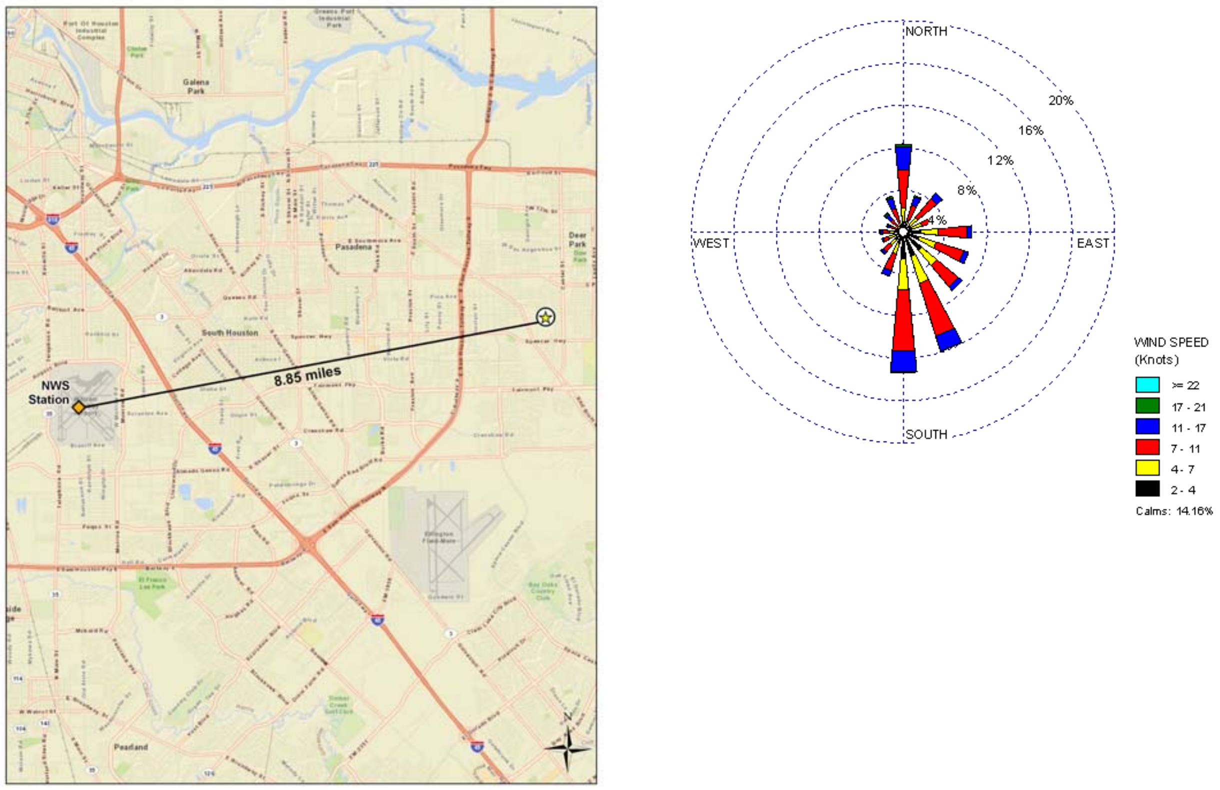
- The cluster analysis for CAMS 85 shows that that 44 percent of back trajectories originated to the south of the site, as indicated by the short cluster (30 percent) representing back trajectories originating over East Texas and the longer cluster (14 percent) originating over the Gulf of Mexico. Another common trajectory origin is from the southeast over Louisiana (24 percent). Additionally, 33 percent of back trajectories originated to the northwest to northeast of the site, as indicated by the short cluster (16 percent) representing relatively short back trajectories originating over Arkansas and the longer cluster (17 percent) originating over the central Plains.

23.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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.

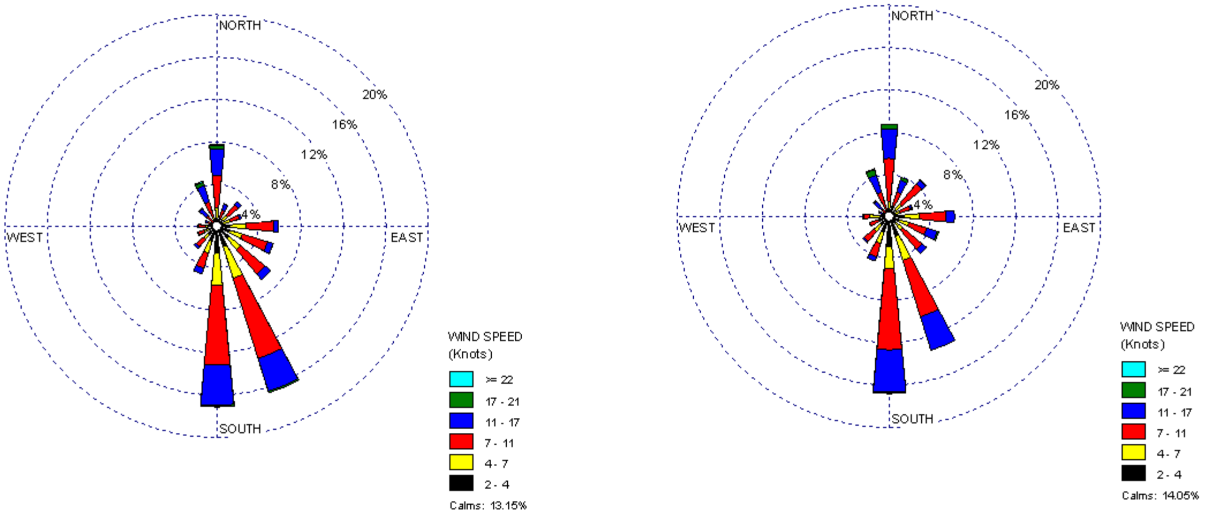
Figure 23-9 presents a map showing the distance between the NWS station and CAMS 35, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 23-9 also presents three different wind roses for the CAMS 35 monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figure 23-10 presents the distance map and three wind roses for CAMS 85.

Figure 23-9. Wind Roses for the William P. Hobby Airport Weather Station near CAMS 35



Distance between CAMS 35 and NWS Station

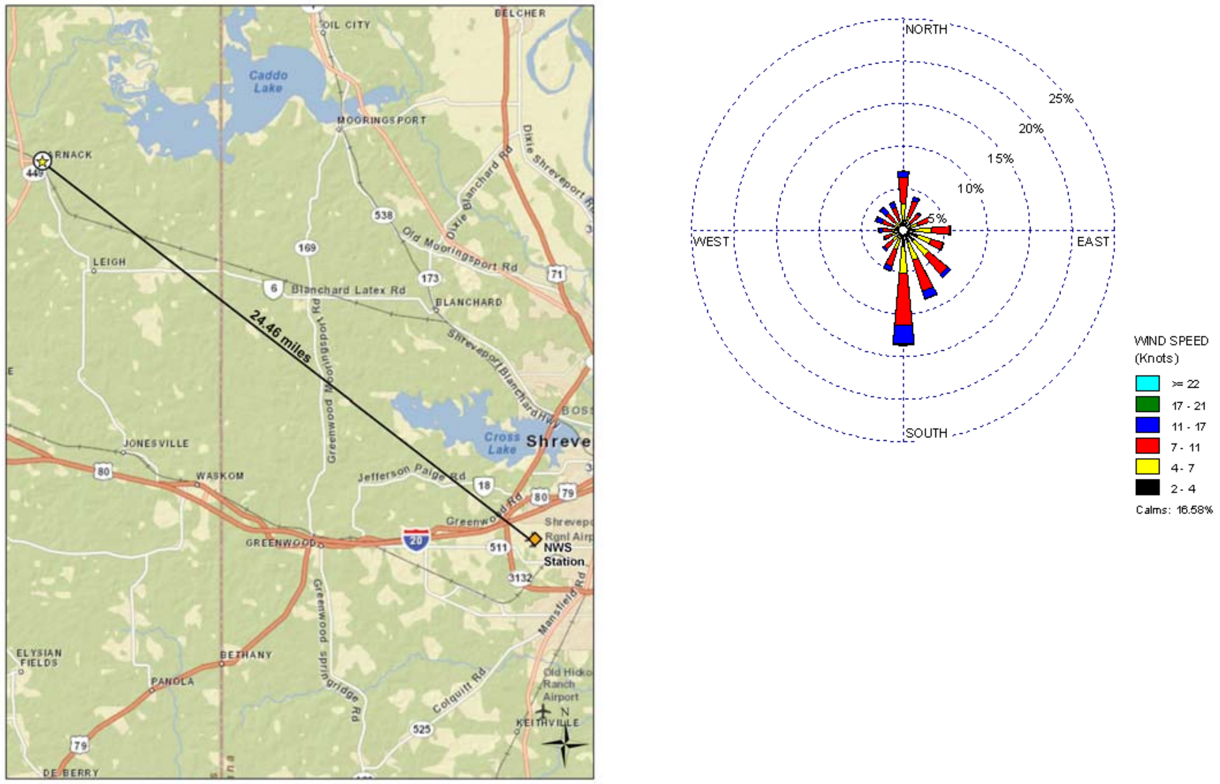
2001-2010 Historical Wind Rose



2011 Wind Rose

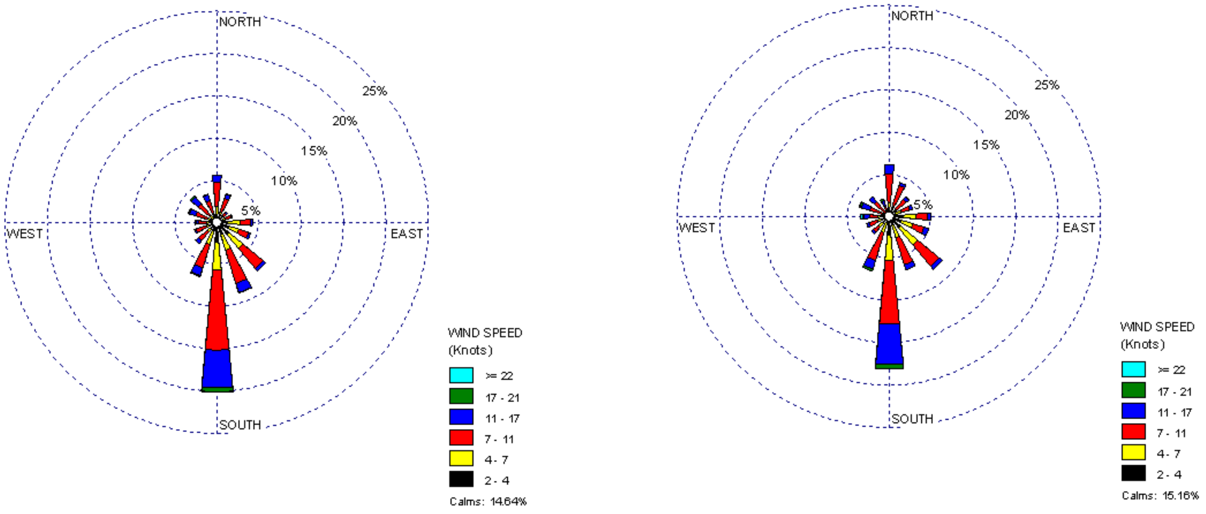
Sample Day Wind Rose

Figure 23-10. Wind Roses for the Shreveport Regional Airport Weather Station near CAMS 85



Distance between CAMS 85 and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

Observations from Figure 23-9 for CAMS 35 include the following:

- The Hobby Airport weather station is located approximately 8.9 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 often. Calm winds (≤2 knots) were observed for approximately 14 percent of the wind measurements.
- Winds from the southeast quadrant were frequently observed in 2011 as well, but the number of south-southeasterly and southerly wind observations was higher in 2011 than historically. This is also true for the sample day wind rose.

Observations from Figure 23-10 for CAMS 85 include the following:

- The Shreveport Regional Airport weather station is located across the Texas-Louisiana border, approximately 24.5 miles southeast of CAMS 85.
- The wind patterns on the historical wind rose for CAMS 85 resemble 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. Northerly winds were also observed fairly often. Calm winds were observed for approximately 17 percent of the wind measurements.
- The wind patterns shown on the 2011 wind rose are similar to the historical wind patterns, although the number of southerly winds increased from roughly 13 percent to 20 percent. A similar trend is shown for the CAMS 35 wind rose.
- The sample day wind patterns resemble the full-year wind patterns, indicating that wind conditions on sample days were representative of those experienced throughout 2011.

23.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the Texas monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 23-4 presents the results of the preliminary risk-based screening process for CAMS 35 and CAMS 85. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. CAMS 35 sampled for hexavalent chromium and PAHs while CAMS 85 sampled for hexavalent chromium only.

Table 23-4. Risk-Based Screening Results for the Texas Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Deer Park, Texas - CAMS 35						
Naphthalene	0.029	53	58	91.38	70.67	70.67
Fluorene	0.011	7	58	12.07	9.33	80.00
Acenaphthene	0.011	6	58	10.34	8.00	88.00
Hexavalent Chromium	0.000083	6	60	10.00	8.00	96.00
Fluoranthene	0.011	3	58	5.17	4.00	100.00
Total		75	292	25.68		
Karnack, Texas - CAMS 85						
Hexavalent Chromium	0.000083	0	50	0.00	0.00	0.00
Total		0	50	0.00		

Observations from Table 23-4 include the following:

- Five pollutants, including two NATTS MQO Core Analytes, failed at least one screen for CAMS 35. Naphthalene contributed to 71 percent of the total number of failed screens for CAMS 35.

- Naphthalene, fluorene, acenaphthene, and hexavalent chromium were initially identified as pollutants of interest for CAMS 35. Benzo(a)pyrene was added to the pollutants of interest for CAMS 35 because it is a NATTS MQO Core Analyte, even though it did not fail any screens. Benzo(a)pyrene is not shown in Table 23-4 but is shown in subsequent tables in the sections that follow.

- Hexavalent chromium is the only pollutant sampled for at CAMS 85. This pollutant did not fail any screens during the 2011 monitoring effort. However, because it is a NATTS MQO Core Analyte, and because it is the only pollutant sampled for at this site, hexavalent chromium is the pollutant of interest for CAMS 85.

23.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Texas monitoring sites. Where applicable, the following calculations and data analyses were performed: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Texas monitoring sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for the sites to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for CAMS 35 and CAMS 85 are provided in Appendices M and O.

23.4.1 2011 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for each Texas 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 of 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 Texas monitoring sites 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 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						
Acenaphthene	58/58	2.45 ± 0.72	4.94 ± 1.58	14.08 ± 7.24	3.76 ± 0.77	6.58 ± 2.30
Benzo(a)pyrene	23/58	0.02 ± 0.02	0.01 ± 0.01	0.02 ± 0.01	0.04 ± 0.02	0.02 ± 0.01
Fluorene	58/58	3.05 ± 0.76	5.57 ± 2.08	17.00 ± 9.06	4.42 ± 0.83	7.84 ± 2.85
Hexavalent Chromium	60/60	0.04 ± 0.01	0.05 ± 0.01	0.06 ± 0.01	0.04 ± 0.01	0.05 ± 0.01
Naphthalene	58/58	81.21 ± 27.31	52.65 ± 18.88	113.19 ± 35.95	126.77 ± 49.62	94.14 ± 18.02
Karnack, Texas - CAMS 85						
Hexavalent Chromium	50/61	0.02 ± 0.01	0.03 ± <0.01	0.02 ± 0.01	0.01 ± 0.01	0.02 ± <0.01

Observations from Table 23-5 include the following:

- Naphthalene's annual average concentration is significantly higher than the annual averages for the other pollutants of interest for CAMS 35.

- Although naphthalene concentrations appear to be higher during the second half of the year, the confidence intervals indicate that concentrations of this pollutant have a considerable amount of variability associated with them. The maximum concentration of naphthalene was measured at CAMS 35 on November 11, 2011 (299 ng/m^3), and additional concentrations greater than 200 ng/m^3 were also measured in August (2), November (1), and December (1). While concentrations greater than 100 ng/m^3 were measured in each quarter of 2011, most were measured during the second half of the year (four in the first quarter, one in the second, seven in the third, and seven in the fourth).

- The third quarter average concentrations for acenaphthene and fluorene were significantly higher than the other quarterly averages and have relatively large confidence intervals associated with them. Concentrations of acenaphthene ranged from 1.02 ng/m^3 to 52.9 ng/m^3, with the five highest concentrations all measured in August. All 13 concentrations greater than 6 ng/m^3 were measured between June and September. Conversely, the nine concentrations of acenaphthene less than 2 ng/m^3 were all measured in January, February, or December. A similar trend is exhibited by fluorene.

- Benzo(a)pyrene was detected in fewer than half of the valid PAH samples collected at CAMS 35. Measured detections ranged from 0.0196 ng/m^3 to 0.151 ng/m^3, with only one measurement greater than 0.1 ng/m^3.

- Concentrations of hexavalent chromium were higher at CAMS 35 than at CAMS 85. The hexavalent chromium concentrations ranged from 0.0019 ng/m^3 to 0.159 ng/m^3 at CAMS 35, with a total of three measurements greater than 0.1 ng/m^3. Hexavalent chromium concentrations ranged from a few non-detects to 0.0522 ng/m^3 at CAMS 85. Hexavalent chromium was detected in 100 percent of the valid samples collected at CAMS 35, while the detection rate was lower at CAMS 85 (82 percent).

- The annual average concentration of hexavalent chromium for CAMS 35 for 2011 is similar to the annual average for 2010. This same is not true for CAMS 85. In 2010, CAMS 85 had the highest annual average concentration of hexavalent chromium (0.31 ± 0.16 ng/m^3) among all NMP sites sampling this pollutant and was six times higher than the annual average concentration for the Deer Park site. For 2011, the annual average concentration of hexavalent chromium for CAMS 85 is an order of magnitude lower (0.02 ± <0.01 ng/m^3). This may be attributable to the use of stainless steel filter holders used in the sampler which may have contaminated the samples. Changing to a Teflon® filter holder has resulted in a decrease in hexavalent chromium concentrations at CAMS 85. The filter holder was exchanged at the end of 2010.

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 CAMS 35 and CAMS 85 from those tables include the following:

- CAMS 35 appears in Table 4-11 three times. The annual average fluorene concentration for CAMS 35 ranks fifth highest among sites sampling PAHs. CAMS 35 also ranks sixth for acenaphthene and seventh for naphthalene.

- As shown in Table 4-12, the annual average hexavalent chromium concentration for CAMS 35 is the second highest annual average hexavalent chromium concentration among NMP sites sampling this pollutant, behind only PXSS. The annual average hexavalent chromium concentration for CAMS 85 ranks tenth highest among NMP sites.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzo(a)pyrene, hexavalent chromium, and naphthalene were created for CAMS 35. A box plot for hexavalent chromium was also created for CAMS 85. Figures 23-11 through 23-13 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.

Figure 23-11. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

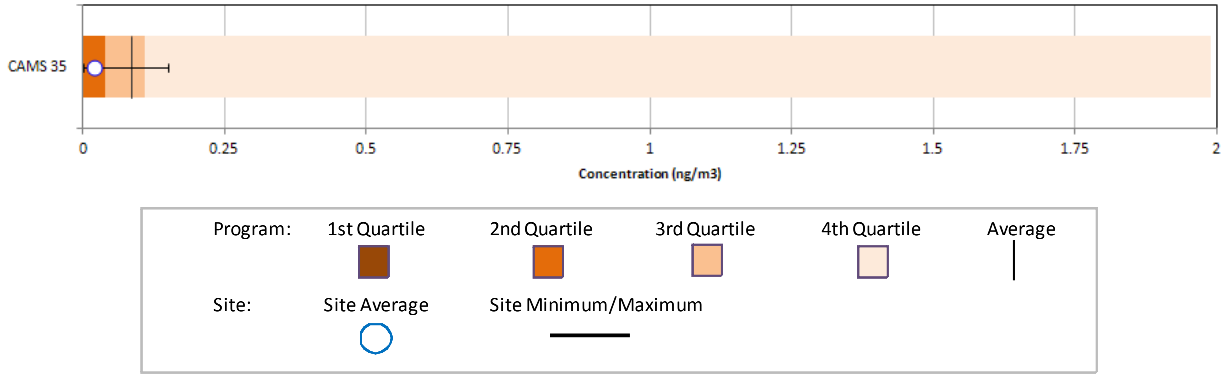


Figure 23-12. Program vs. Site-Specific Average Hexavalent Chromium Concentrations

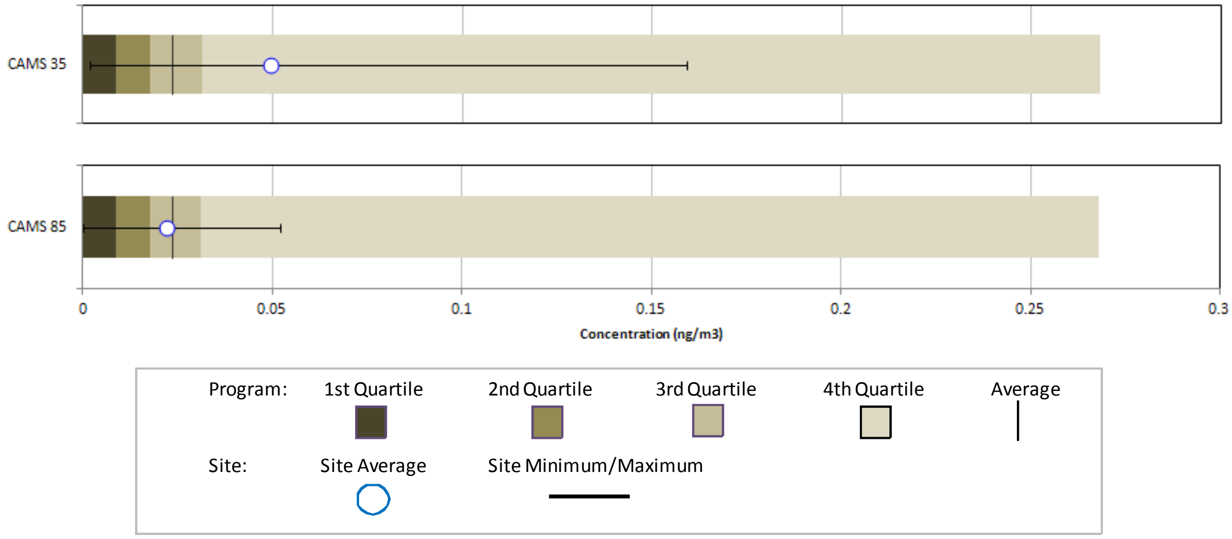
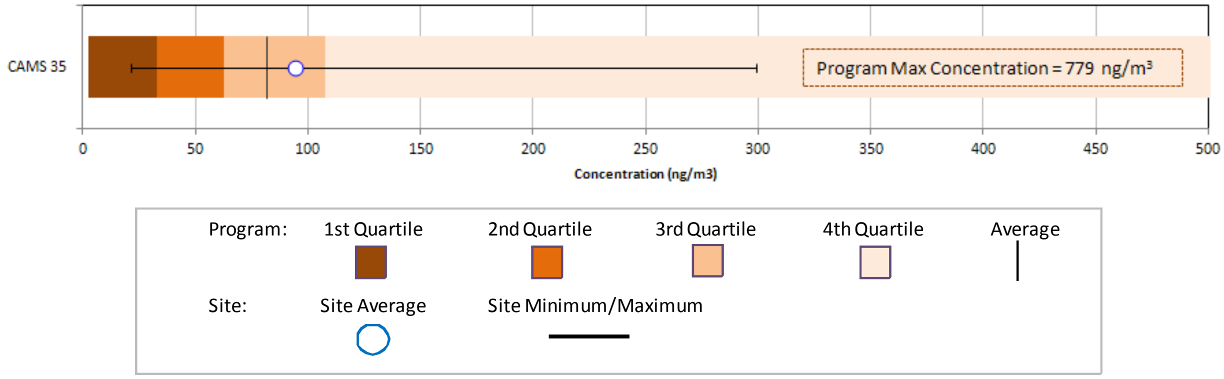


Figure 23-13. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 23-11 through 23-13 include the following:

- Figure 23-11 is the box plot for benzo(a)pyrene for CAMS 35. Note that the first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average concentration for CAMS 35 is less than both the program-level average and median concentrations. Figure 23-11 also shows that the maximum concentration measured at CAMS 35 is considerably less than the maximum concentration measured across the program. More than half of the measurements of benzo(a)pyrene were non-detects at CAMS 35, as discussed in the previous section.

- Figure 23-12 for hexavalent chromium shows both sites, as both CAMS 35 and CAMS 85 sampled this pollutant. The annual average concentration for CAMS 35 is greater than the program-level third quartile (75th percentile). The annual average concentration for CAMS 85 is less than the program-level average but greater than the program-level median concentration. The concentration range measured at CAMS 35 is more than three times the concentration range for CAMS 85, although the maximum concentration measured at both sites is less than the maximum concentration measured across the program. There were no non-detects of hexavalent chromium measured at CAMS 35 while 11 non-detects were reported for CAMS 85.

- Figure 23-13 is the box plot for naphthalene for CAMS 35. Note that the program-level maximum concentration (779 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 500 ng/m^3. Figure 23-13 shows that the annual average naphthalene concentration for CAMS 35 is greater than the program-level average concentration. The maximum naphthalene concentration measured at CAMS 35 is significantly less than the program-level maximum concentration. There were no non-detects of naphthalene measured at CAMS 35 or across the program.

23.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. CAMS 35 has not sampled PAHs continuously for 5 years as part of the NMP and both sites began sampling hexavalent chromium under the NMP in 2010. Therefore, a trends analysis was not conducted.

23.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the Texas monitoring sites. Refer to Sections 3.3 and 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

23.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Texas 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
Deer Park, Texas - CAMS 35						
Acenaphthene	0.000088	--	58/58	6.58 ± 2.30	0.58	--
Benzo(a)pyrene	0.00176	--	23/58	0.02 ± 0.01	0.04	--
Fluorene	0.000088	--	58/58	7.84 ± 2.85	0.69	--
Hexavalent Chromium	0.012	0.0001	60/60	0.05 ± 0.01	0.59	<0.01
Naphthalene	0.000034	0.003	58/58	94.14 ± 18.02	3.20	0.03
Karnack, Texas - CAMS 85						
Hexavalent Chromium	0.012	0.0001	50/61	0.02 ± <0.01	0.26	<0.01

-- = a Cancer URE or Noncancer RfC is not available

Observations from Table 23-6 include the following:

- The cancer risk approximation for naphthalene for CAMS 35 is 3.20 in-a-million, based on the annual average. This is the only cancer risk approximation greater than 1.0 in-a-million for CAMS 35.
- The cancer risk approximation for hexavalent chromium for CAMS 85 (0.26 in-a-million) is half the cancer risk approximation for hexavalent chromium for CAMS 35 (0.59 in-a-million), although both are less than 1 in-a-million.
- The noncancer hazard approximations for CAMS 35 and CAMS 85, where they could be calculated, are less than 1.0, indicating that 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, Tables 23-7 and 23-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 23-6. Table 23-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 23-6.

Table 23-7. 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	1,418.35	Formaldehyde	1.64E-02	Naphthalene	3.20
Formaldehyde	1,260.11	1,3-Butadiene	1.34E-02	Fluorene	0.69
Ethylbenzene	827.79	Benzene	1.11E-02	Hexavalent Chromium	0.59
Acetaldehyde	699.55	Hexavalent Chromium, PM	1.04E-02	Acenaphthene	0.58
1,3-Butadiene	446.24	Naphthalene	4.83E-03	Benzo(a)pyrene	0.04
Methyl *tert* butyl ether	168.21	Nickel, PM	4.62E-03		
Naphthalene	142.12	Arsenic, PM	2.26E-03		
Propylene oxide	85.80	Ethylbenzene	2.07E-03		
Dichloromethane	77.80	Acetaldehyde	1.54E-03		
Tetrachloroethylene	23.32	POM, Group 2b	1.44E-03		
Karnack, Texas (Harrison County) - CAMS 85					
Formaldehyde	108.38	Hexavalent Chromium, PM	6.35E-03	Hexavalent Chromium	0.26
Benzene	64.37	Formaldehyde	1.41E-03		
Acetaldehyde	55.52	Ethylene oxide	8.72E-04		
Ethylbenzene	37.76	Benzene	5.02E-04		
1,3-Butadiene	15.22	1,3-Butadiene	4.57E-04		
Naphthalene	13.37	Naphthalene	4.54E-04		
Ethylene oxide	9.90	Nickel, PM	3.29E-04		
Dichloromethane	3.67	Arsenic, PM	1.34E-04		
Chloromethylbenzene	1.31	Acetaldehyde	1.22E-04		
Carbon tetrachloride	1.08	Ethylbenzene	9.44E-05		

Table 23-8. 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	4,428.76	Acrolein	4,253,301.87	Naphthalene	0.03
Xylenes	3,249.06	1,3-Butadiene	223,117.95	Hexavalent Chromium	<0.01
Methanol	2,707.58	Formaldehyde	128,583.14		
Hexane	1,559.23	Nickel, PM	106,919.25		
Benzene	1,418.35	Acetaldehyde	77,728.16		
Formaldehyde	1,260.11	Titanium tetrachloride	77,037.49		
Ethylbenzene	827.79	Hexamethylene-1,6-diisocyanate, gas	62,970.00		
Acetaldehyde	699.55	Chlorine	57,589.67		
1,3-Butadiene	446.24	Naphthalene	47,373.42		
Styrene	359.89	Benzene	47,278.41		
Karnack, Texas (Harrison County) - CAMS 85					
Toluene	155.11	Acrolein	647,128.44	Hexavalent Chromium	<0.01
Xylenes	142.12	Hexamethylene-1,6-diisocyanate, gas	31,490.00		
Formaldehyde	108.38	Manganese, PM	23,210.90		
Benzene	64.37	Chlorine	22,445.25		
Ethylene glycol	63.56	Formaldehyde	11,059.67		
Acetaldehyde	55.52	Cyanide Compounds, PM	9,776.20		
Hexane	53.09	Nickel, PM	7,623.51		
Methanol	48.73	1,3-Butadiene	7,611.02		
Chloromethane	40.86	Acetaldehyde	6,168.54		
Ethylbenzene	37.76	Hexavalent Chromium, PM	5,294.84		

The pollutants listed in Tables 23-7 and 23-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 23.3, both Texas monitoring sites sampled hexavalent chromium; CAMS 35 also sampled for PAHs. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 23-7 include the following:

- 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 formaldehyde, 1,3-butadiene, and benzene. The pollutants with the highest toxicity-weighted emissions for Harrison County are hexavalent chromium, formaldehyde, and ethylene oxide.

- Six of the highest emitted pollutants in Harris County also have the highest toxicity-weighted emissions while seven of the highest emitted pollutants in Harrison County also have 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. Although hexavalent chromium, which has the third highest cancer risk approximation for CAMS 35, ranks fourth for toxicity-weighted emissions, this pollutant is not one of the highest emitted in Harris County.

- POM, Group 2b ranks tenth for toxicity-weighted emissions in Harris County. POM, Group 2b includes several PAHs sampled for at CAMS 35 including acenaphthene and fluorene, both pollutants of interest for CAMS 35. Benzo(a)pyrene, another pollutant of interest for CAMS 35, is part of POM, Group 5a, which does not appear on either emissions-based list for Harris County.

- Hexavalent chromium, the only pollutant of interest for CAMS 85, is the pollutant with the highest toxicity-weighted emissions for Harrison County, but is not among the 10 highest emitted (its emissions rank 13th).

Observations from Table 23-8 include the following:

- Toluene, xylenes, and methanol are the highest emitted pollutants with noncancer RfCs in Harris County. Toluene, xylenes, and formaldehyde are the highest emitted pollutants in Harrison County. The magnitude of the emissions is significantly higher in Harris County than Harrison County.

- The pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for both counties is acrolein.

- Four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Harris County while only two of the highest emitted pollutants also have the highest toxicity-weighted emissions for Harrison County.

- Hexamethylene-1,6-diisocyante gas appears among the pollutants with the highest toxicity-weighted emissions for both sites. This pollutant only appears among the pollutants with the highest toxicity-weighted emissions for one additional NMP site (CELA).

- Naphthalene ranks ninth for toxicity-weighted emissions in Harris County but is not one of the highest emitted pollutants with a noncancer RfC. Hexavalent chromium does not appear on either emissions-based list for Harris County. These are the only two pollutants of interest for CAMS 35 with noncancer toxicity factors.

- Hexavalent chromium ranks tenth for toxicity-weighted emissions in Harrison County but is not one of the highest emitted (with a noncancer RfC).

23.6 Summary of the 2011 Monitoring Data for CAMS 35 and CAMS 85

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

- ❖ *Five pollutants failed at least one screen for CAMS 35, with naphthalene accounting for 71 percent of the total failed screens. Hexavalent chromium, the only pollutant sampled for at CAMS 85, did not fail any screens.*

- ❖ *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for CAMS 35.*

- ❖ *Concentrations of acenaphthene and fluorene were highest during the summer months at CAMS 35.*

- ❖ *Concentrations of hexavalent chromium measured at CAMS 85 decreased significantly from 2010 to 2011. This is a result of replacing the stainless steel filter holder in the sampler with a Teflon® filter holder.*

24.0 Site in Utah

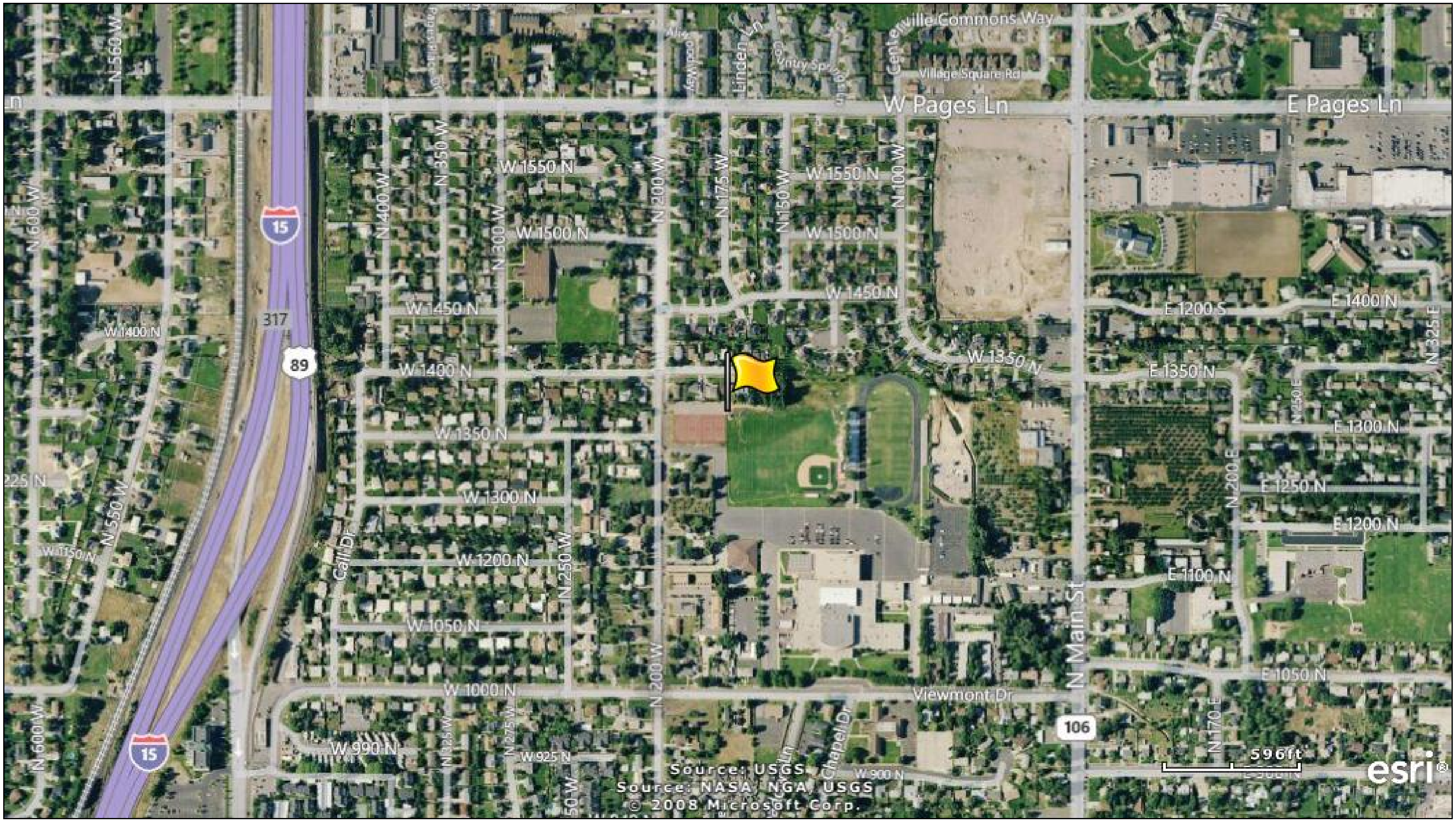
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Utah, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data analyses 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.

24.1 Site Characterization

This section characterizes the BTUT 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.

BTUT is located in Bountiful, in northern Utah. Figure 24-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its urban location. Figure 24-2 identifies nearby point source emissions locations by source category, as reported in the 2008 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. Table 24-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 24-1. Bountiful, Utah (BTUT) Monitoring Site



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

Figure 24-2. NEI Point Sources Located Within 10 Miles of BTUT

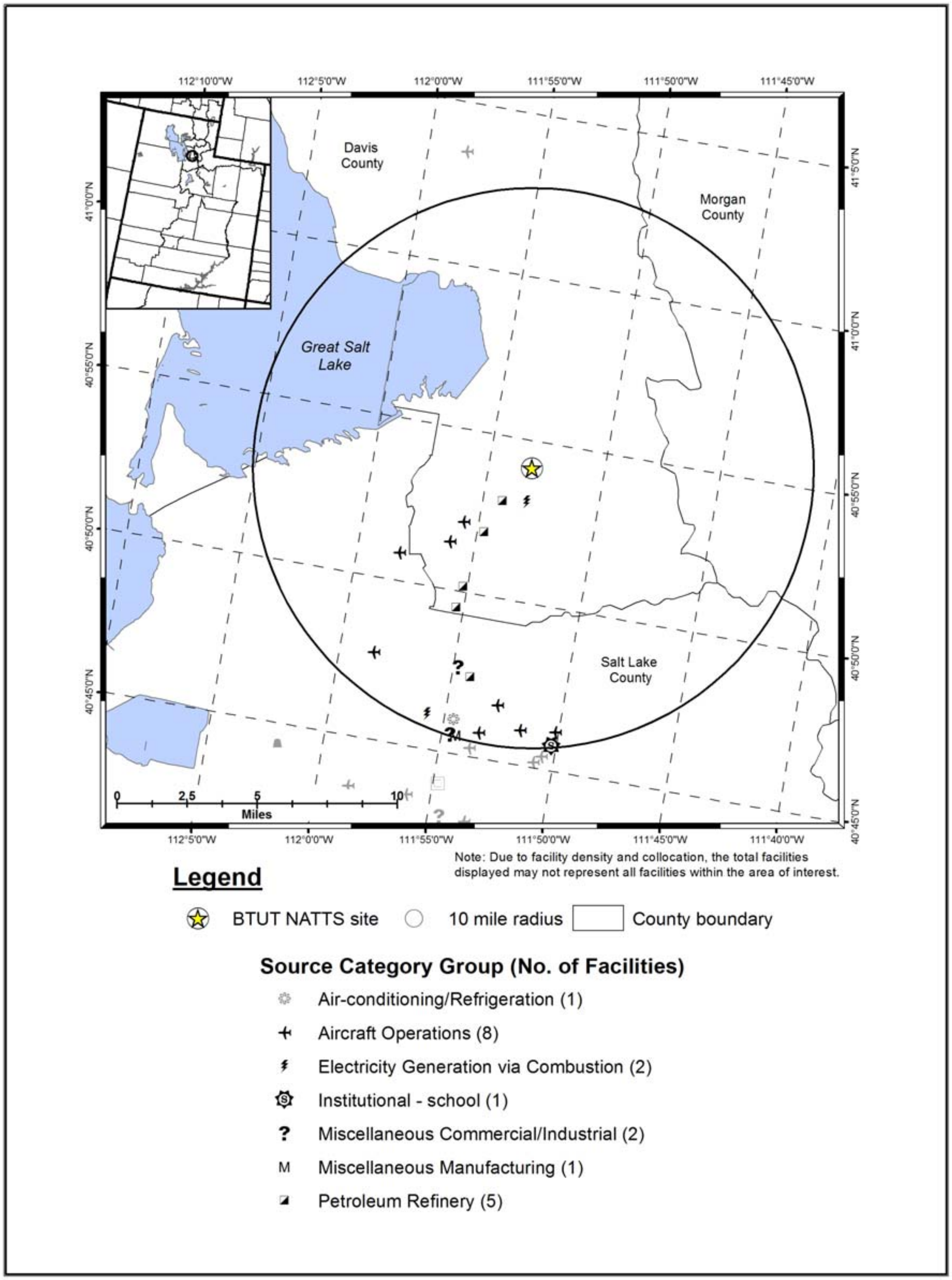


Table 24-1. Geographical Information for the Utah Monitoring Site

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, PAMS, O_3, Meteorological parameters, PM_{10}, $PM_{2.5}$, and $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for BTUT (EPA, 2012c); 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 24-1 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 24-2 shows that all of the point sources near BTUT are located to the south of the site. 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 aircraft operations, which include airports as well as small runways, heliports, or landing pads, and petroleum refineries. The source closest to BTUT generates electricity via combustion.

Table 24-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Utah monitoring site. Table 24-2 includes county-level population and vehicle registration information. Table 24-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 24-2 also contains traffic volume information for BTUT. Finally, Table 24-2 presents the county-level daily VMT for Davis County.

Table 24-2. Population, Motor Vehicle, and Traffic Information for the Utah Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
BTUT	311,811	239,582	0.77	268,749	206,495	113,955	6,866,779

[1]County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2]County-level vehicle registration reflects 2011 data from the Utah Tax Commission (UT TC, 2011)
[3]10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4]AADT reflects 2010 data from the Utah DOT (UT DOT, 2010)
[5]County-level VMT reflects 2011 data from the Utah DOT (UT DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 24-2 include the following:

- Davis County's population is in the mid-to-low end of the range, as is its 10-mile population, compared to counties with NMP sites. The county-level vehicle registration and 10-mile ownership estimate rankings are similar to the population rankings.

- The vehicle-per-person ratio (0.78) is in the bottom third of the range compared to other NMP sites.

- The traffic volume experienced near BTUT is in the top third compared to other NMP monitoring sites. The traffic estimate provided is for the intersection of I-15 with US-89, just west of the site.

- The daily VMT for Davis County is on the mid-to-low end compared to counties with NMP sites (where VMT was available).

24.2 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.

24.2.1 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, with spring as the wettest season, and sunshine prevails across the area during much of the year. 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. Surrounding mountains protect the valley from winter storm systems moving in from the southwest or north, preventing cold air outbreaks. The Great Salt Lake tends to have a moderating influence on the area's temperature. 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 (Bair, 1992 and WRCC, 2013).

24.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest BTUT were retrieved for 2011 (NCDC, 2011). The closest weather station 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 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 appear cooler than average weather conditions experienced throughout the year, although the differences are not statistically significant. This is likely due to a number of make-up samples collected in November and December of 2011.

24.2.3 Back Trajectory Analysis

Figure 24-3 is the composite back trajectory map for days on which samples were collected at the BTUT monitoring site in 2011. Included in Figure 24-3 are four back trajectories per sample day. Figure 24-4 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 24-3 and 24-4 represents 100 miles.

Table 24-3. Average Meteorological Conditions near the Utah Monitoring Site

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)
Bountiful, Utah - BTUT									
Salt Lake City International 24127 (40.79, -111.97)	8.98 miles 217° (SW)	Sample Day	58.8 ± 5.1	49.2 ± 4.5	31.7 ± 2.9	40.6 ± 3.3	57.2 ± 4.3	1016.1 ± 2.1	6.6 ± 0.8
		2011	61.4 ± 2.1	51.6 ± 1.9	33.2 ± 1.2	42.3 ± 1.4	55.5 ± 1.8	1015.6 ± 0.9	6.7 ± 0.3

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

Figure 24-3. 2011 Composite Back Trajectory Map for BTUT

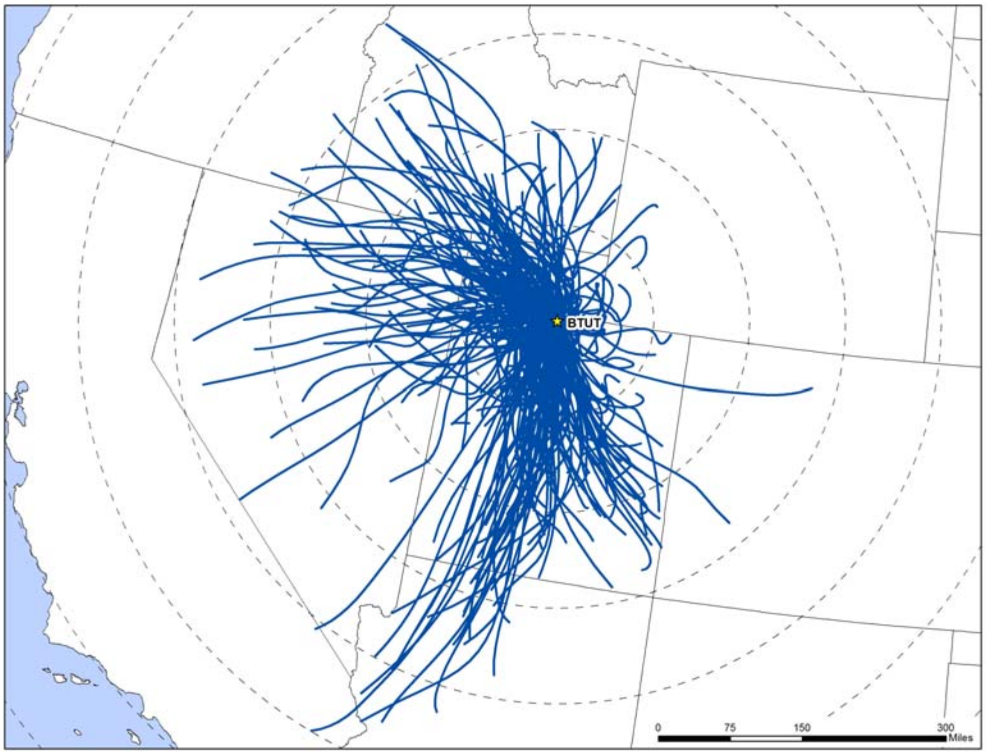
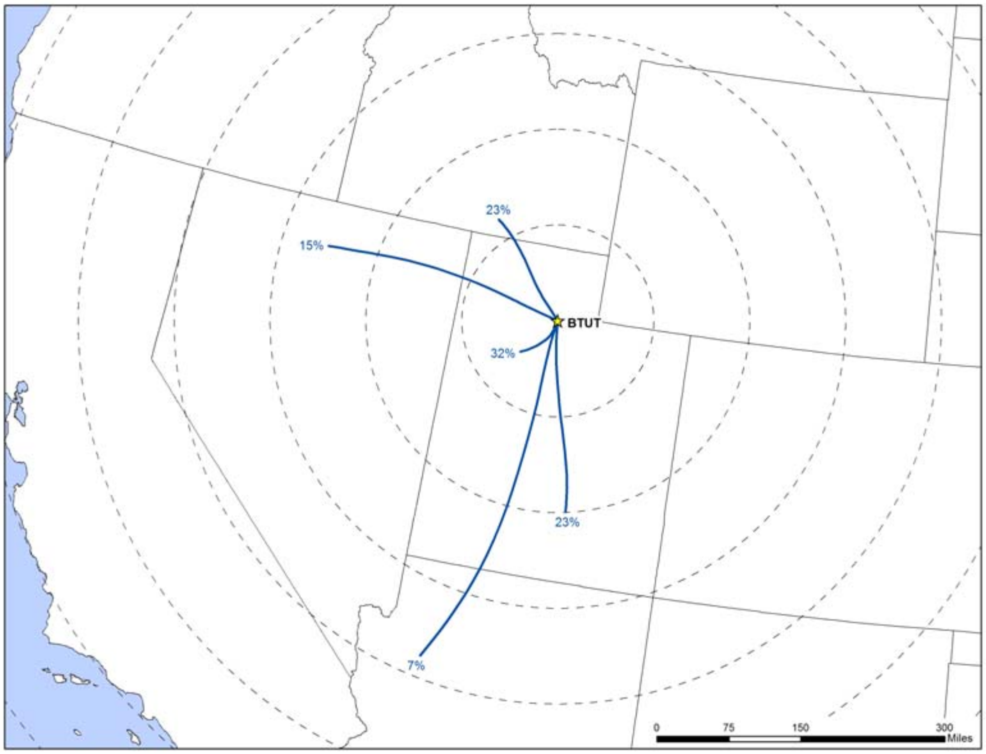


Figure 24-4. Back Trajectory Cluster Map for BTUT



Observations from Figures 24-3 and 24-4 include the following:

- Back trajectories originated from a variety of directions at BTUT. 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 monitoring sites. The farthest away a back trajectory originated was over the Mojave Desert, or just less than 500 miles away. However, the average trajectory length was 176 miles and nearly 87 percent of back trajectories originated within 300 miles of the site.

- The cluster analysis shows that nearly one-third of back trajectories are represented by the short cluster trajectory originating just southwest of the site. This cluster represents back trajectories originating within roughly 150 miles of BTUT and over the northern half of Utah. Thirty percent of back trajectories originated to the south of BTUT, although of varying distances, as indicated by the shorter cluster trajectory (23 percent), which represents back trajectories originating over the southern half of Utah, and the longer cluster trajectory (7 percent), which represents longer back trajectories originating primarily over northern Arizona. Back trajectories also originated to the west, northwest, and north of BTUT, and are also represented by two cluster trajectories; one representing shorter back trajectories originating primarily over southern Idaho, and one representing longer back trajectories originating to the west and northwest of BTUT over northeast Nevada and southwest Idaho.

24.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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 24-5 presents a map showing the distance between the NWS station and BTUT, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 24-5 also presents three different wind roses for the BTUT monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

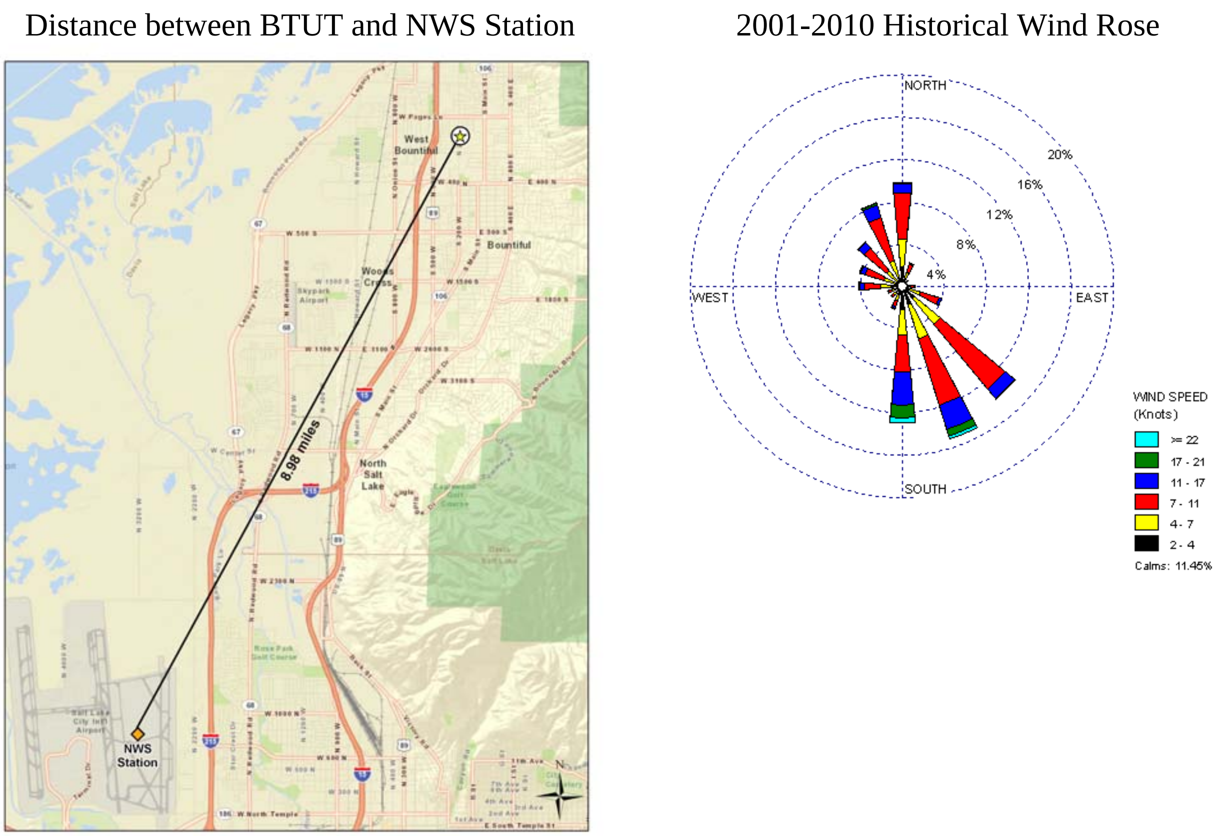
Observations from Figure 24-5 for BTUT include the following:

- The Salt Lake City International Airport weather station is located approximately 9 miles southwest of BTUT.
- The historical wind rose shows that southeasterly, south-southeasterly, and southerly winds were prevalent near BTUT, accounting for approximately 40 percent of the wind observations. Winds from the north-northwest and north were also common. Calm winds (≤2 knots) were observed for approximately 11 percent of the hourly measurements from 2001-2010. The strongest wind speeds were observed with south-southeasterly and southerly winds.
- The wind patterns shown on the 2011 wind rose are similar to the historical wind patterns, indicating that wind conditions in 2011 were similar to wind conditions experienced historically near BTUT.
- The wind patterns shown on the sample day wind rose resemble the 2011 wind patterns, indicating that conditions on sample days were representative of those experienced over the entire year (and historically).

24.3 Pollutants of Interest

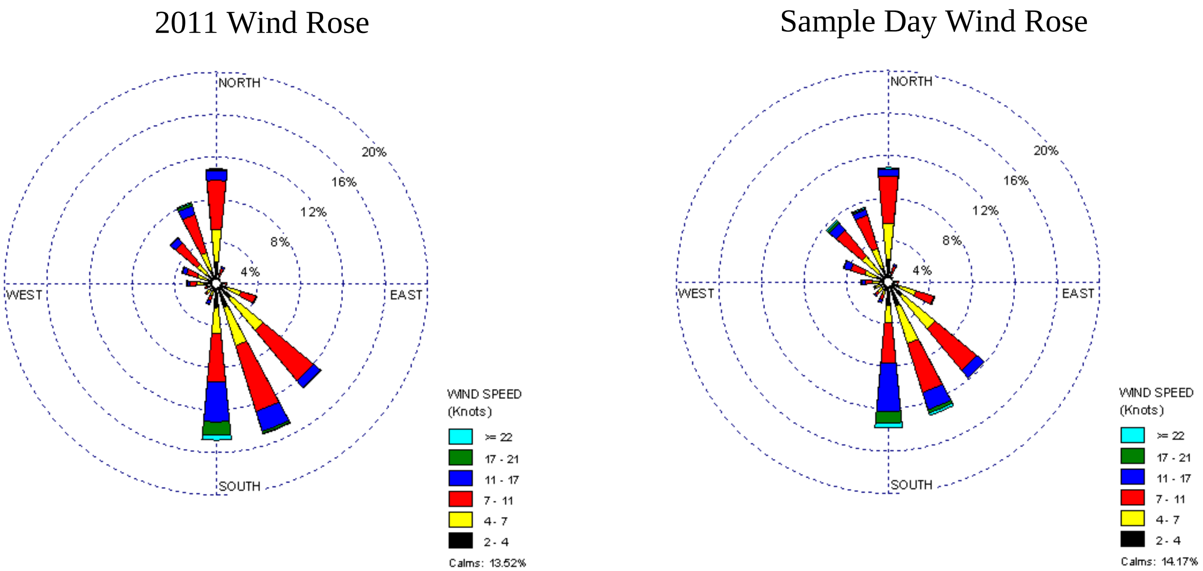
Site-specific “pollutants of interest” were determined for the BTUT monitoring site in order to allow analysts and readers to focus on a subset of pollutants through the context of risk. Each pollutant’s preprocessed daily measurement was compared to its associated risk screening value. If the concentration was greater than the risk screening value, then the concentration “failed the screen.” 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. In addition, if any of the NATTS MQO Core Analytes measured by the BTUT monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Figure 24-5. Wind Roses for the Salt Lake City International Airport Weather Station near BTUT



Distance between BTUT and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

Table 24-4 presents the results of the preliminary risk-based screening process for BTUT. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for the monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. 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 24-4. Risk-Based Screening Results for the Utah Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Bountiful, Utah - BTUT						
Acetaldehyde	0.45	60	60	100.00	11.76	11.76
Benzene	0.13	60	60	100.00	11.76	23.53
Carbon Tetrachloride	0.17	60	60	100.00	11.76	35.29
Formaldehyde	0.077	60	60	100.00	11.76	47.06
1,3-Butadiene	0.03	48	49	97.96	9.41	56.47
Arsenic (PM$_{10}$)	0.00023	43	58	74.14	8.43	64.90
Manganese (PM$_{10}$)	0.005	38	60	63.33	7.45	72.35
Naphthalene	0.029	38	62	61.29	7.45	79.80
Ethylbenzene	0.4	25	60	41.67	4.90	84.71
1,2-Dichloroethane	0.038	15	15	100.00	2.94	87.65
Nickel (PM$_{10}$)	0.0021	14	60	23.33	2.75	90.39
Dichloromethane	7.7	13	60	21.67	2.55	92.94
Acrylonitrile	0.015	7	7	100.00	1.37	94.31
p-Dichlorobenzene	0.091	6	29	20.69	1.18	95.49
Hexachloro-1,3-butadiene	0.045	6	6	100.00	1.18	96.67
Propionaldehyde	0.8	6	60	10.00	1.18	97.84
Cadmium (PM$_{10}$)	0.00056	4	60	6.67	0.78	98.63
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	0.78	99.41
Hexavalent Chromium	0.000083	1	53	1.89	0.20	99.61
Lead (PM$_{10}$)	0.015	1	60	1.67	0.20	99.80
Xylenes	10	1	60	1.67	0.20	100.00
Total		510	1,003	50.85		

Observations from Table 24-4 include the following:

- Twenty-one pollutants, of which 12 are NATTS MQO Core Analytes, failed at least one screen for BTUT.

- The risk-based screening process identified 16 pollutants of interest for BTUT, of which nine are NATTS MQO Core Analytes. Three pollutants (cadmium, hexavalent chromium, and lead) were added to BTUT's pollutants of interest because they are

NATTS MQO Core Analytes, even though they did not contribute to 95 percent of the total failed screens. Six additional pollutants were added to BTUT's pollutants of interest because they are also NATTS MQO Core Analytes, even though they did not fail any screens: beryllium, benzo(a)pyrene, chloroform, tetrachloroethylene, trichloroethylene, and vinyl chloride. These six pollutants are not shown in Table 24-4 but are shown in subsequent tables in the sections that follow.

- Nearly 50 percent of measured detections failed screens (of the pollutants that failed at least one screen) for BTUT.
- 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.

24.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for BTUT, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for this site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for BTUT are provided in Appendix J through Appendix O.

24.4.1 2011 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 of 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 24-5, where applicable. Note that concentrations of the PAHs, metals, 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 24-5. 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	60/60	3.30 ± 1.06	1.33 ± 0.28	2.12 ± 0.50	1.94 ± 0.43	2.19 ± 0.35
Acrylonitrile	7/60	NA	0.03 ± 0.04	0.02 ± 0.03	0	0.02 ± 0.01
Benzene	60/60	NA	0.79 ± 0.14	1.03 ± 0.22	1.44 ± 0.30	1.14 ± 0.15
1,3-Butadiene	49/60	NA	0.04 ± 0.03	0.05 ± 0.02	0.17 ± 0.04	0.10 ± 0.02
Carbon Tetrachloride	60/60	NA	0.60 ± 0.06	0.64 ± 0.07	0.64 ± 0.07	0.61 ± 0.03
Chloroform	29/60	NA	0.03 ± 0.03	0.03 ± 0.03	0.10 ± 0.02	0.06 ± 0.02
p-Dichlorobenzene	29/60	NA	0.01 ± 0.02	0.02 ± 0.03	0.05 ± 0.01	0.05 ± 0.02
1,2-Dichloroethane	15/60	NA	0.02 ± 0.02	0.01 ± 0.02	0.05 ± 0.02	0.03 ± 0.01
Dichloromethane	60/60	NA	6.18 ± 3.94	96.53 ± 117.86	1.92 ± 1.84	53.90 ± 50.64
Ethylbenzene	60/60	NA	0.27 ± 0.05	0.37 ± 0.05	0.55 ± 0.11	0.47 ± 0.13
Formaldehyde	60/60	8.37 ± 3.63	3.01 ± 1.10	4.42 ± 1.56	2.13 ± 0.23	4.49 ± 1.15
Hexachloro-1,3-butadiene	6/60	NA	0.02 ± 0.03	0	0.01 ± 0.01	0.01 ± 0.01
Propionaldehyde	60/60	0.67 ± 0.20	0.32 ± 0.06	0.47 ± 0.09	0.36 ± 0.08	0.46 ± 0.07
Tetrachloroethylene	41/60	NA	0.05 ± 0.03	0.06 ± 0.03	0.14 ± 0.04	0.10 ± 0.02
Trichloroethylene	11/60	NA	0	0	0.04 ± 0.02	0.02 ± 0.01

[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 24-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Utah Monitoring Site (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)
Vinyl Chloride	1/60	NA	0	0	0	<0.01 ± <0.01
Arsenic (PM_{10})[a]	58/60	0.71 ± 0.62	0.36 ± 0.20	0.43 ± 0.09	0.87 ± 0.50	0.59 ± 0.19
Benzo(a)pyrene[a]	20/62	0.06 ± 0.06	0	0.02 ± 0.01	0.10 ± 0.05	0.04 ± 0.02
Beryllium (PM_{10})[a]	53/60	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	0.01 ± <0.01
Cadmium (PM_{10})[a]	60/60	0.15 ± 0.13	0.07 ± 0.03	0.09 ± 0.02	0.27 ± 0.15	0.14 ± 0.05
Hexavalent Chromium[a]	53/61	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.02	0.02 ± 0.01	0.02 ± <0.01
Lead (PM_{10})[a]	60/60	4.14 ± 3.27	2.26 ± 1.25	2.62 ± 0.58	5.15 ± 2.16	3.51 ± 0.98
Manganese (PM_{10})[a]	60/60	4.76 ± 1.88	6.39 ± 3.04	10.17 ± 1.90	8.64 ± 2.80	7.58 ± 1.27
Naphthalene[a]	62/62	54.33 ± 21.23	25.28 ± 5.96	46.19 ± 9.36	62.83 ± 18.12	47.39 ± 7.88
Nickel (PM_{10})[a]	60/60	1.98 ± 0.81	0.98 ± 0.23	1.80 ± 0.74	2.19 ± 0.83	1.73 ± 0.35

[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 BTUT from Table 24-5 include the following:

- The pollutants with the highest annual average concentrations by mass are dichloromethane, formaldehyde, acetaldehyde, and benzene, consistent with the last few years of sampling. The annual average for dichloromethane is significantly higher than the annual averages of the other pollutants.

- Dichloromethane has the highest annual average for BTUT, but also has a very large confidence interval associated it, as do the quarterly averages. This indicates the likely presence of outliers. The concentrations of dichloromethane at BTUT range from 0.313 µg/m^3 to 1,214 µg/m^3. One measurement of this pollutant is greater than 1,000 µg/m^3, three are greater than 500 µg/m^3, six are greater than 75.0 µg/m^3, and 12 are greater than 10 µg/m^3. The top six measurements are the six highest concentrations of dichloromethane measured across the program. However, the median concentration of dichloromethane for BTUT is 0.919 µg/m^3, as over half of the measurements are less than 1 µg/m^3.

- There are no first quarter averages for the VOCs because sampler issues during this time resulted in canisters with pressures outside of the tolerance limits.

- The first quarter average concentrations of the three carbonyl compound pollutants of interest are higher than the other quarterly averages and have relatively large confidence intervals. A review of the data shows that the highest concentrations of all three pollutants were measured in February and March. The maximum concentration of formaldehyde (19.9 µg/m^3) was measured at BTUT on March 4, 2011, which is the day the second highest concentrations of acetaldehyde and propionaldehyde were measured. This formaldehyde concentration is the second highest formaldehyde concentration measured across the program. The maximum concentrations of acetaldehyde (7.06 µg/m^3) and propionaldehyde (1.44 µg/m^3) were measured at BTUT on February 26, 2011, which is the day the second highest concentration of formaldehyde was measured. This propionaldehyde concentration is the highest propionaldehyde concentration measured across the program (although a concentration of similar magnitude was also measured at TOOK).

- In addition to the first quarter, the second and third quarter average concentrations of formaldehyde also have relatively large confidence intervals associated with them. BTUT is the site with the highest number of formaldehyde measurements greater than 5 µg/m^3 (15), which were measured in February (5), March (3), June (3), and July (4).

- Many of the VOC pollutants of interest are highest during the fourth quarter of 2011, as illustrated by the quarterly averages. The highest concentrations of these pollutants were measured in January, November, or December, or were detected most frequently during these months. For example, 1,2-dichloroethane was detected 11 times (out of a total of 15) during the fourth quarter and trichloroethylene was not detected outside the first or fourth quarters. Of the eight benzene concentrations greater than 2 µg/m^3, all but one was measured in January, November, or December. Similarly, of the 15 ethylbenzene concentrations greater than 0.5 µg/m^3, all but one was measured in the first or fourth quarter of 2011. The 19 highest concentrations of 1,3-butadiene were also measured in the first or fourth quarters of 2011.

- Concentrations of naphthalene and benzo(a)pyrene appear highest in the colder months of the year. The ten highest concentrations of naphthalene (those greater than 90 ng/m^3) were all measured in the first and fourth quarters of 2011. Although benzo(a)pyrene was detected in only 20 samples, 14 of these were measured during the first and fourth quarters of 2011, with the highest concentrations measured during these quarters.

- This trend continues for some of the metals. The maximum concentrations of arsenic, cadmium, and lead were all measured on January 15, 2011, with additional “higher” concentrations measured in November and December. The arsenic concentration measured on this date for BTUT is the maximum arsenic concentration measured among sites sampling metals. A similar trend was noted in the 2010 NMP report. This is not true for manganese, beryllium, or nickel.

- Concentrations of hexavalent chromium ranged from 0.0055 ng/m^3 to 0.13 ng/m^3. The maximum concentration of hexavalent chromium was measured at BTUT on July 2, 2011, and is twice the next highest concentration (0.06 ng/m^3, measured on January 21, 2011).

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 13 times for the program-level pollutants of interest.
- BTUT does not rank higher than eighth among the program-level VOC pollutants of interest shown in Table 4-9.
- BTUT has the highest annual average concentration of formaldehyde and tenth highest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds, as shown in Table 4-10.
- 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 in the top five for each of the PM_{10} metals shown in Table 4-12. It is important, however, to note that only nine sites sampled PM_{10} metals. BTUT does not appear in Table 4-12 for hexavalent chromium.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde, arsenic, benzene, benzo(a)pyrene, 1,3-butadiene, formaldehyde, hexavalent chromium, lead, manganese, and naphthalene were created for BTUT. Figures 24-6 through 24-15 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, median, average, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 24-6. Program vs. Site-Specific Average Acetaldehyde Concentration

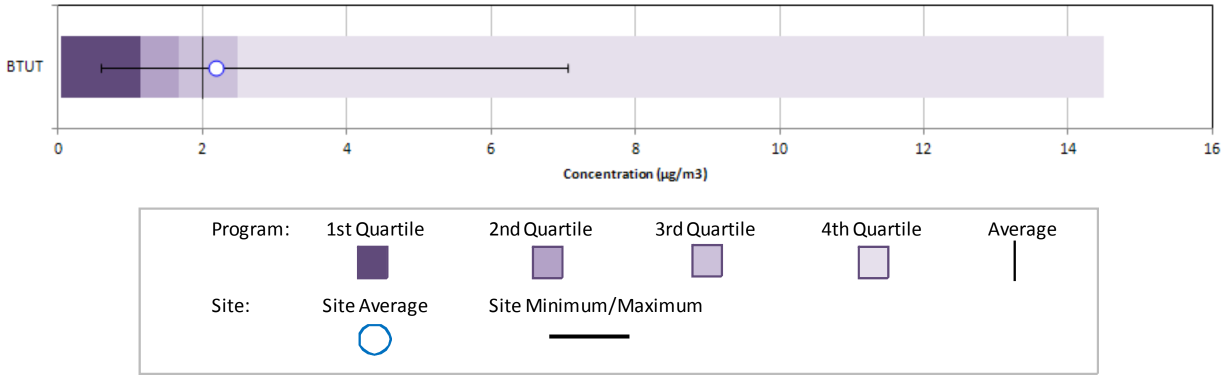


Figure 24-7. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

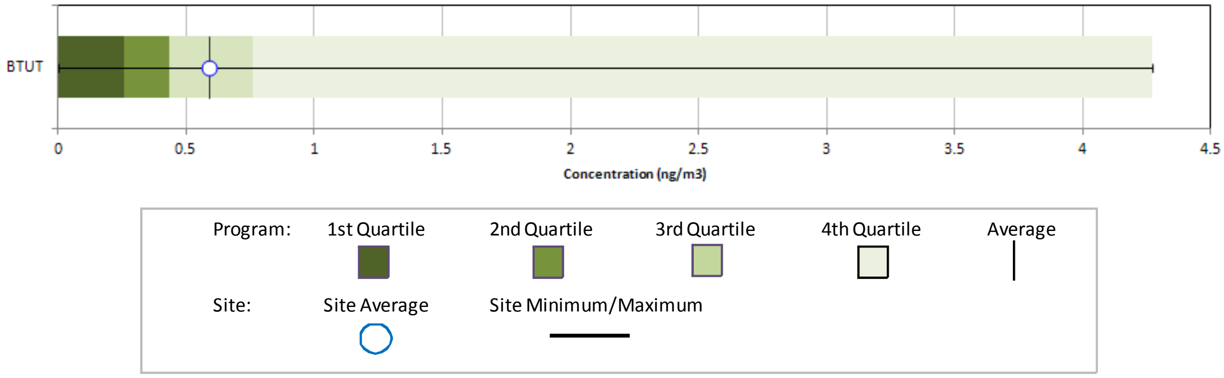


Figure 24-8. Program vs. Site-Specific Average Benzene Concentration

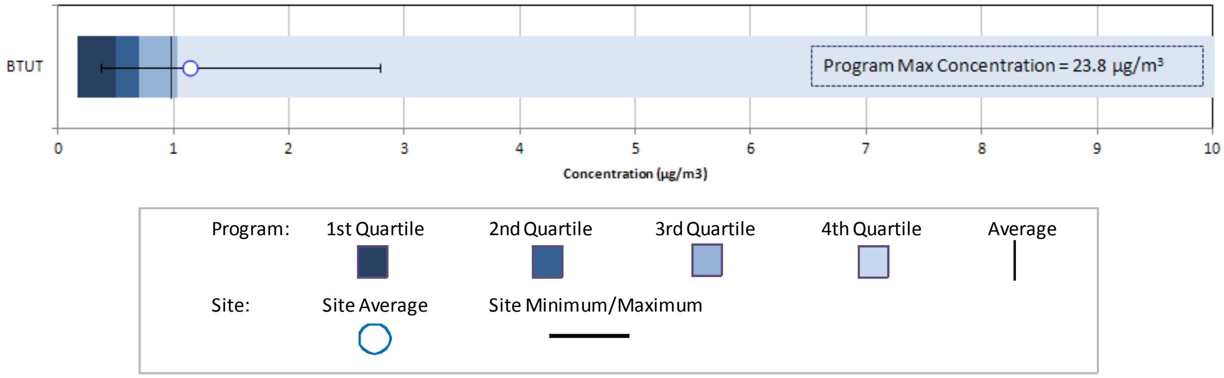


Figure 24-9. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

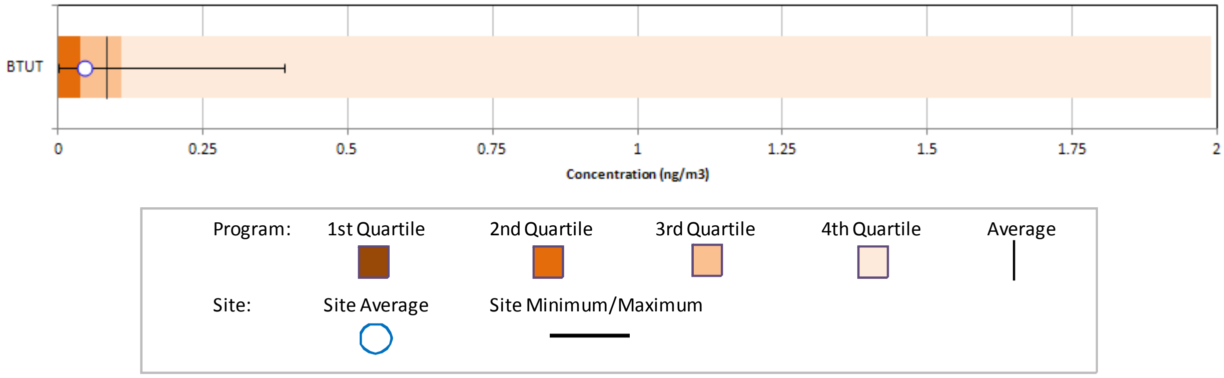


Figure 24-10. Program vs. Site-Specific Average 1,3-Butadiene Concentration

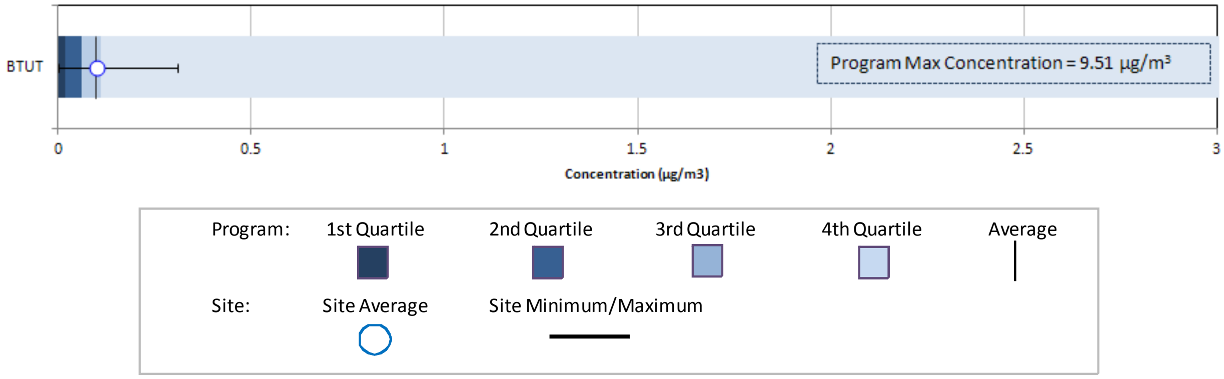


Figure 24-11. Program vs. Site-Specific Average Formaldehyde Concentration

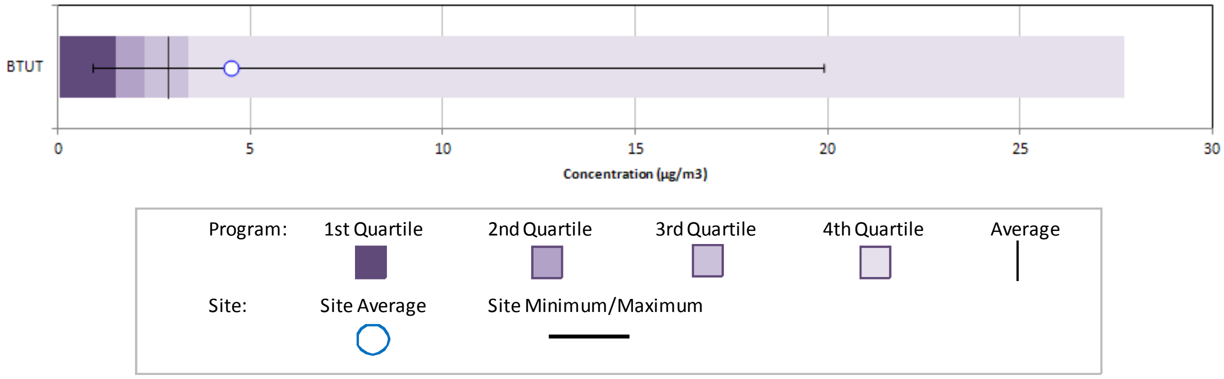


Figure 24-12. Program vs. Site-Specific Average Hexavalent Chromium Concentration

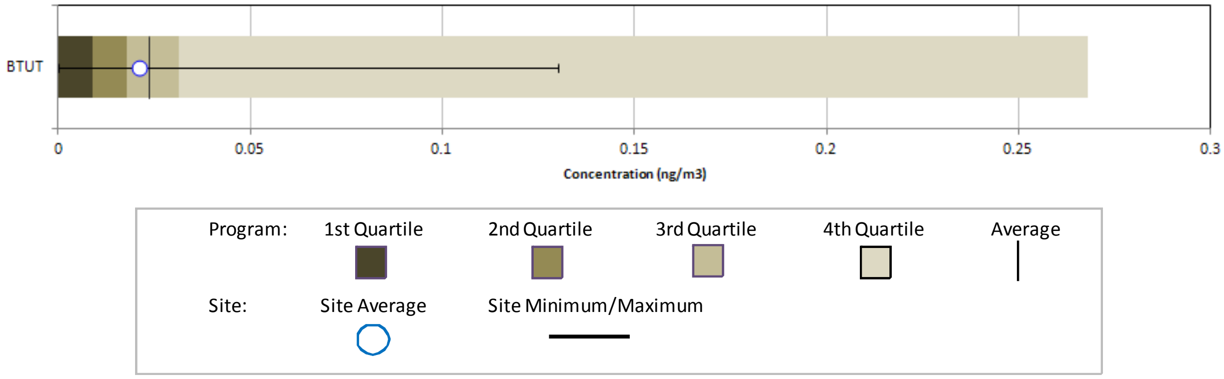


Figure 24-13. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

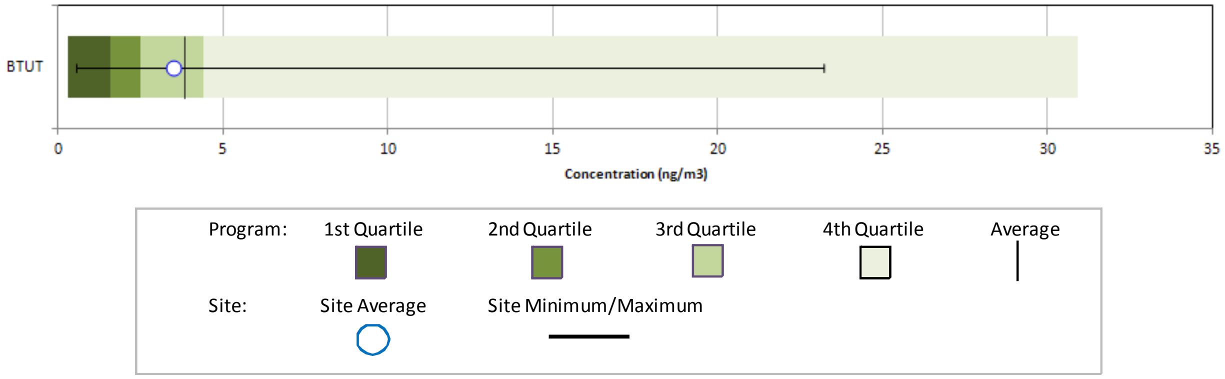


Figure 24-14. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

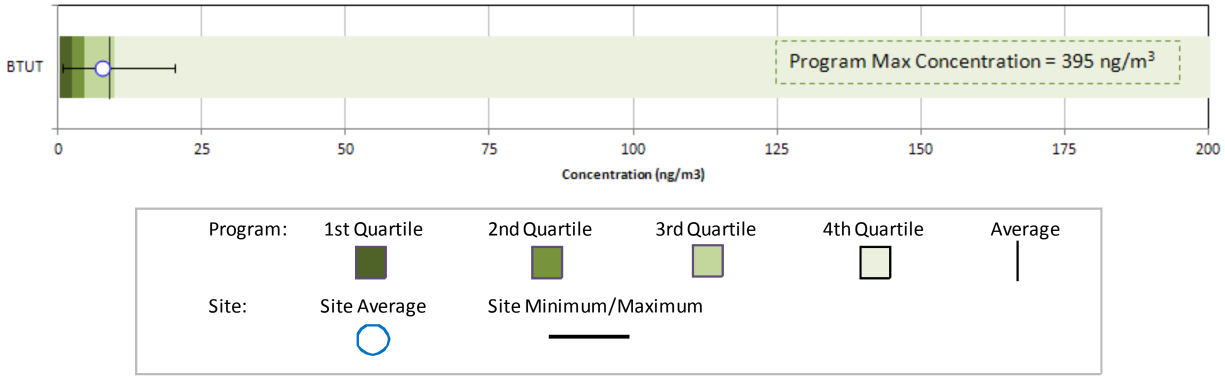
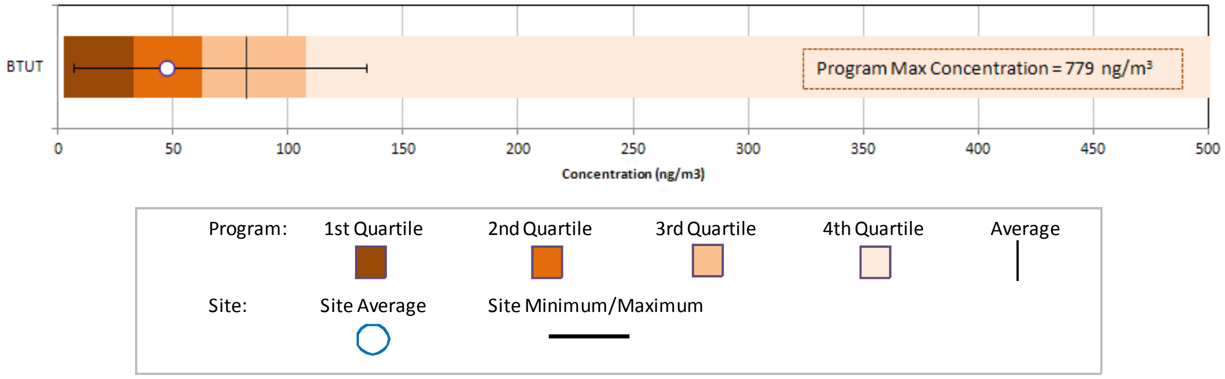


Figure 24-15. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 24-6 through 24-14 include the following:

- Figure 24-6 shows that the annual average acetaldehyde concentration for BTUT is just greater than the program-level average concentration. The maximum concentration measured at BTUT is 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 24-7 shows that the maximum concentration of arsenic (PM_{10}) across the program was measured at BTUT. Yet, the annual average arsenic concentration is equivalent to the program-level average arsenic concentration. Two non-detects of arsenic were measured at BTUT.

- Figure 24-8 is the box plot for benzene. Note that the program-level maximum benzene concentration (23.8 $\mu g/m^3$) 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 has been reduced to 10 $\mu g/m^3$. Figure 24-8 shows that the annual average concentration for BTUT is greater than the program-level average concentration and third quartile (75th percentile). The maximum concentration of benzene measured at BTUT is considerably less than the maximum concentration measured across the program. There were no non-detects of benzene measured at BTUT or across the program.

- Figure 24-9 is the box plot for benzo(a)pyrene. Note that the program-level first quartile for this pollutant is zero and is not visible on this box plot. The box plot shows that the annual average concentration for BTUT is less than the program-level average concentration but greater than the program-level median concentration. Figure 24-9 also shows that the maximum concentration measured at BTUT is considerably less than the maximum concentration measured across the program. A number of non-detects of benzo(a)pyrene were measured at BTUT.

- Similar to the box plot for benzene, the program-level maximum 1,3-butadiene concentration (9.51 $\mu g/m^3$) is not shown directly on the box plot in Figure 24-10; thus, the scale has been reduced to 3 $\mu g/m^3$ in order to allow for the observation of data points at the lower end of the concentration range. Figure 24-10 for 1,3-butadiene shows that the annual average concentration for BTUT is similar to the program-level average concentration and that both are just less than the program-level third quartile. The maximum concentration of 1,3-butadiene measured at BTUT is considerably less than the maximum concentration measured across the program. Several non-detects of 1,3-butadiene were measured at BTUT.

- Figure 24-11 shows that BTUT's annual average formaldehyde concentration is greater than the program-level average and greater than the program-level third quartile. Although the maximum concentration of formaldehyde measured at BTUT is not the maximum measured across the program, it is the second highest formaldehyde concentration measured among NMP sites sampling carbonyl compounds. There were no non-detects of formaldehyde measured at BTUT or across the program.

- Figure 24-12 is the box plot for hexavalent chromium. The annual average concentration for BTUT is less than the program-level average but greater than the program-level median concentration. The maximum concentration measured at BTUT is less than the program-level maximum concentration. There were a few non-detects of hexavalent chromium measured at BTUT.

- Figure 24-13 shows that the annual average concentration of lead (PM_{10}) for BTUT is less than the program-level average concentration. Although the maximum concentration measured at BTUT is less than the program-level maximum concentration, it is the third highest lead concentration measured among NMP sites sampling metals. There were no non-detects of lead measured at BTUT or across the program.

- Figure 24-14 is the box plot for manganese (PM_{10}). The program-level maximum manganese concentration (395 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 200 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. Figure 24-14 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 considerably less than the program-level maximum concentration. Although difficult to discern in Figure 24-14, there were no non-detects of manganese measured at BTUT.

- Figure 24-15 is the box plot for naphthalene. The program-level maximum naphthalene concentration (779 ng/m^3) is not shown directly on the box plot in Figure 24-15 as the scale has been reduced to 500 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. Figure 24-15 shows that the annual average naphthalene concentration for BTUT is less than both the program-level average and median concentrations. Of the 23 sites sampling PAHs, the annual average concentration of naphthalene for BTUT ranks 19th. 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.

24.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. BTUT has sampled carbonyl compounds, VOCs, metals, and SNMOCs as part of the NMP since 2003. BTUT has also sampled hexavalent chromium since 2005. Thus, Figures 24-16 through 24-23 present the annual statistical metrics for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, lead, and manganese for BTUT, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. Sampling for PAHs at BTUT did not begin until 2008; thus, a trends analysis was not conducted for the PAHs because this method does not meet the 5 consecutive year criteria.

Figure 24-16. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at BTUT

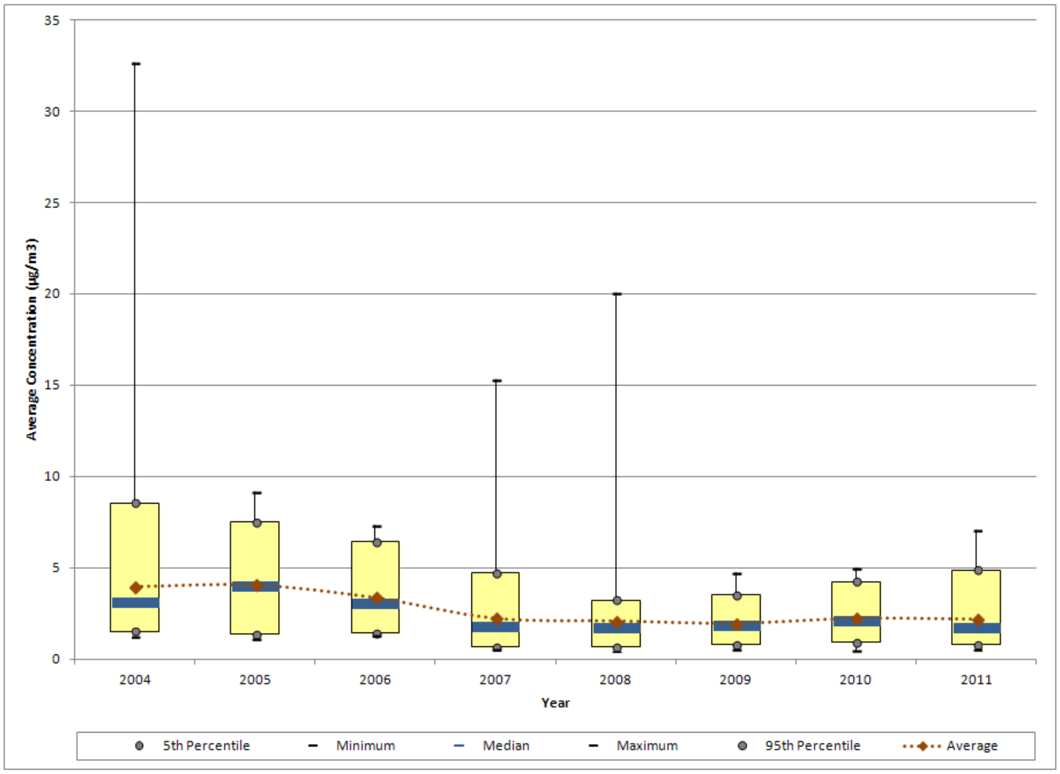


Figure 24-17. Annual Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at BTUT

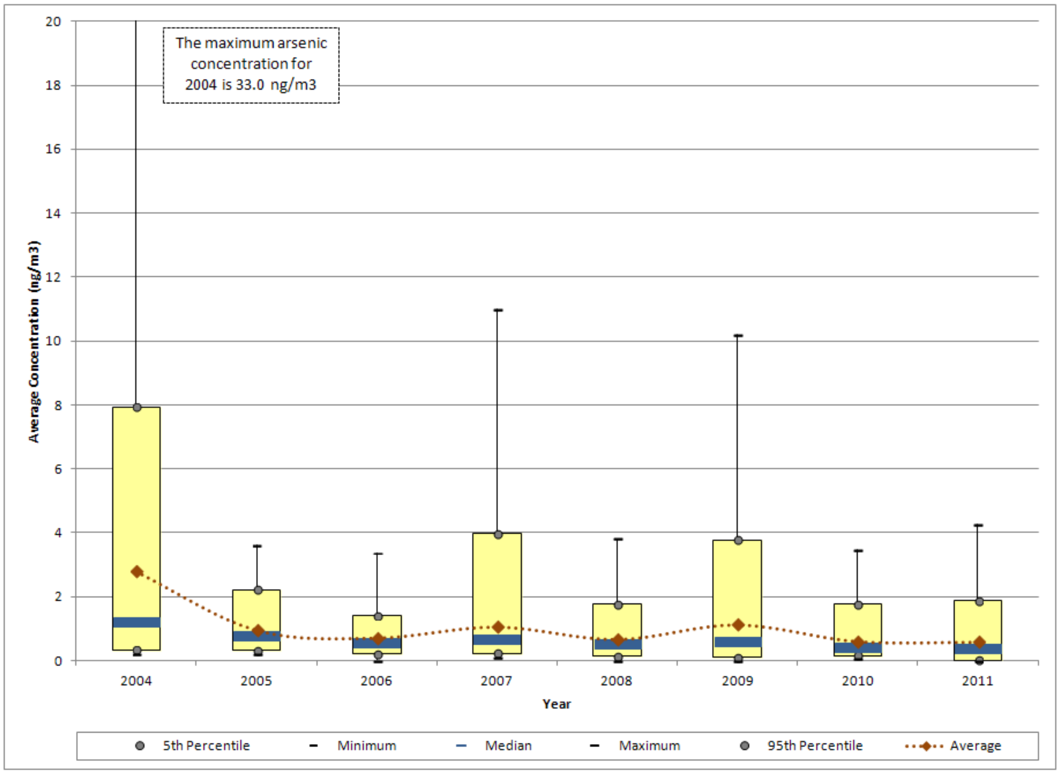


Figure 24-18. Annual Statistical Metrics for Benzene Concentrations Measured at BTUT

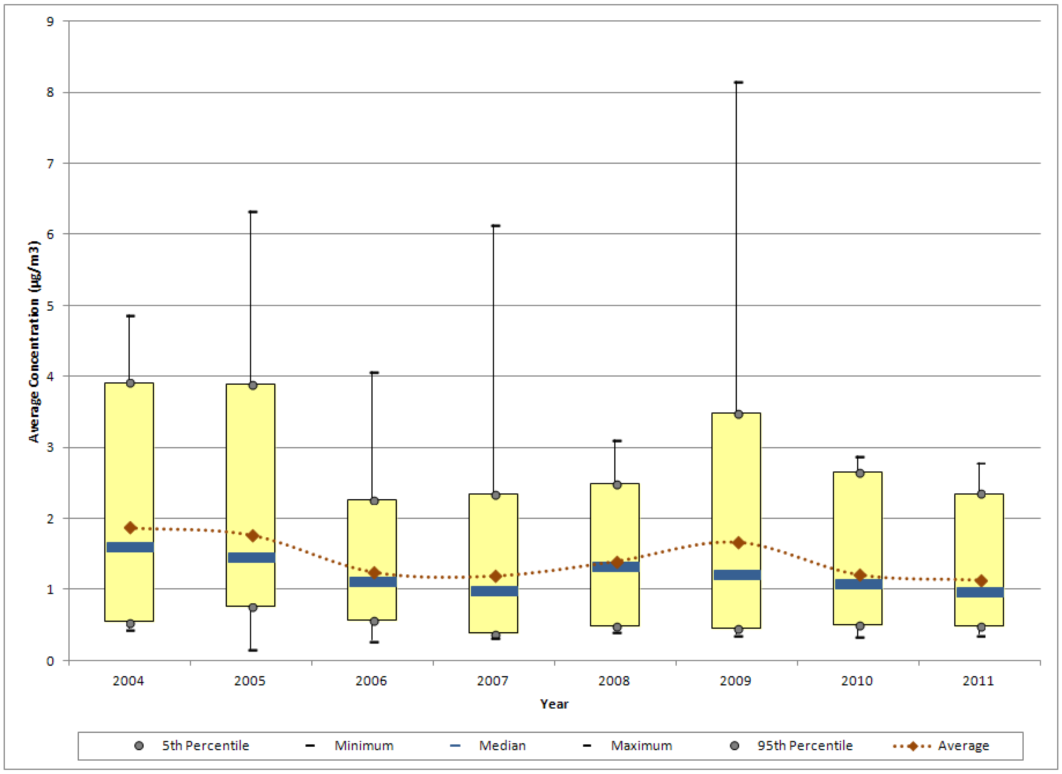


Figure 24-19. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at BTUT

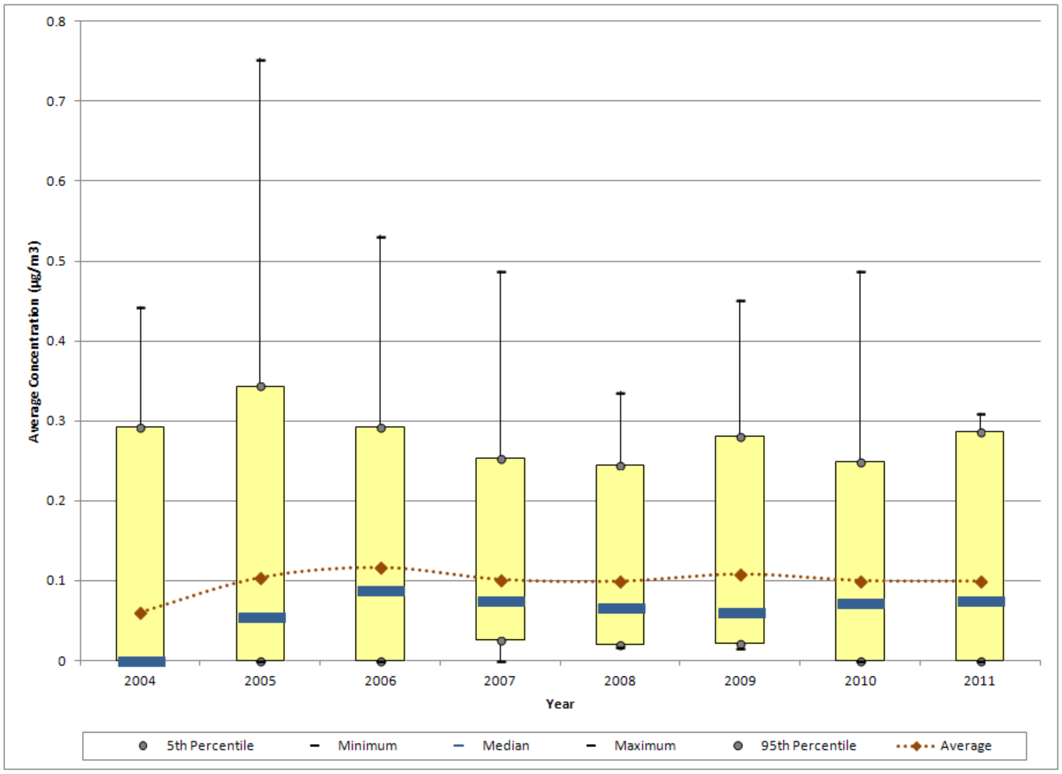


Figure 24-20. Annual Statistical Metrics for Formaldehyde Concentrations Measured at BTUT

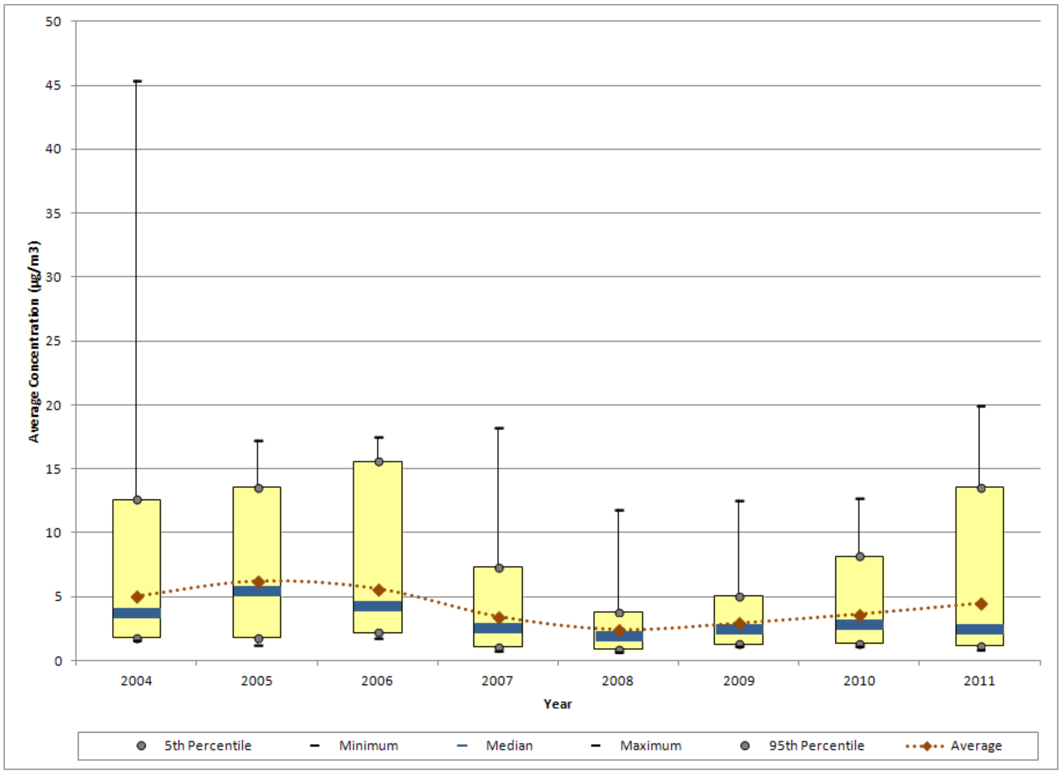


Figure 24-21. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at BTUT

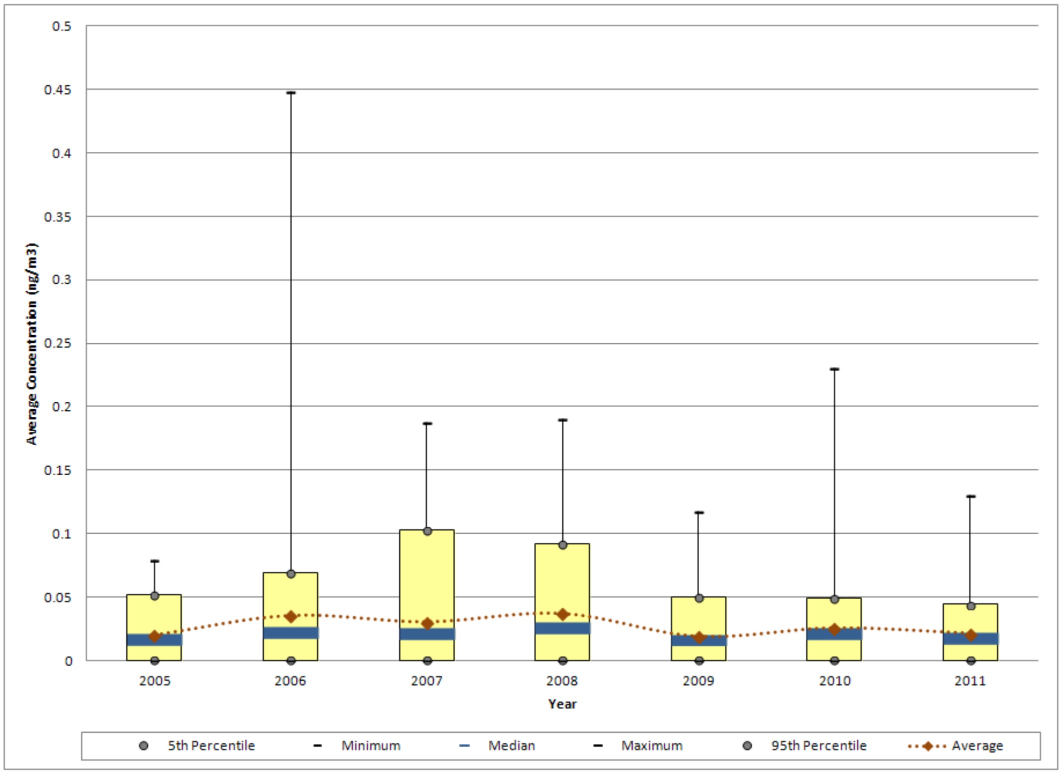


Figure 24-22. Annual Statistical Metrics for Lead (PM_{10}) Concentrations Measured at BTUT

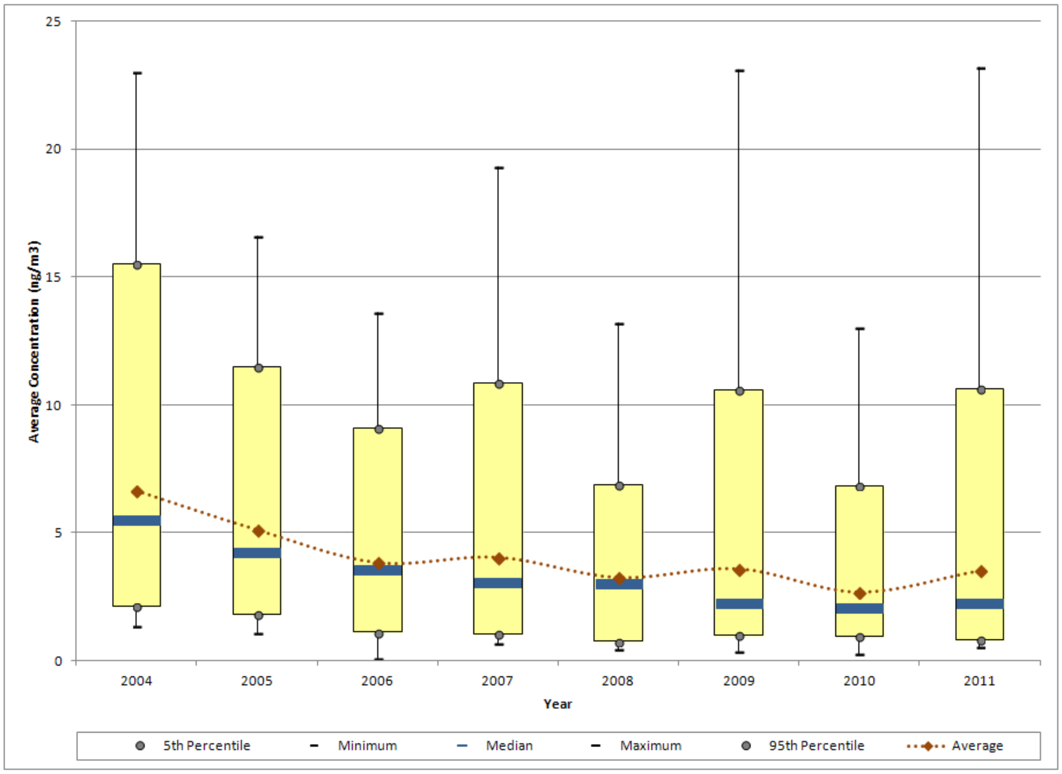
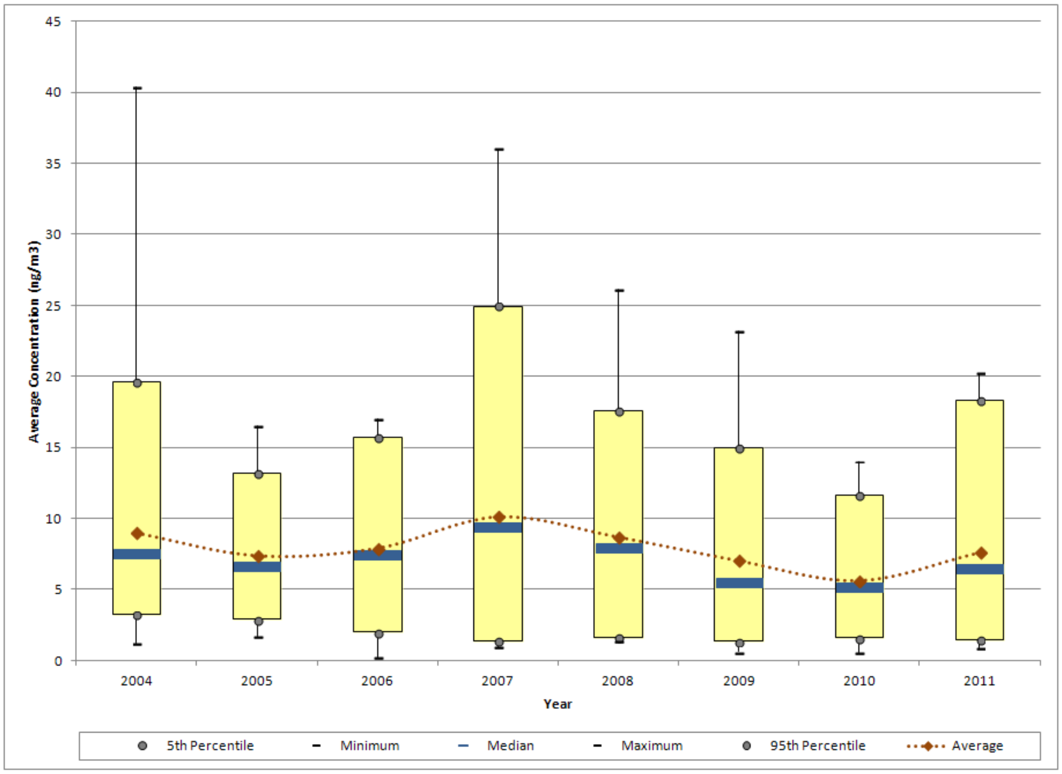


Figure 24-23. Annual Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at BTUT



Observations from Figure 24-16 for acetaldehyde measurements include the following:

- Although sampling for carbonyl compounds at BTUT began in 2003, sampling did not begin until July, which does not yield enough samples for the statistical metrics to be calculated, based on the criteria specified in Section 3.5.4. Thus, Figure 24-16 begins with 2004.

- The maximum acetaldehyde concentration was measured in 2004 (32.7 µg/m^3). The second highest concentration of acetaldehyde measured at BTUT is the maximum shown for 2008 (20.0 µg/m^3). All acetaldehyde concentrations greater than 8 µg/m^3 were measured prior to 2009.

- The average concentration exhibits a steady decreasing trend beginning with 2006 and continuing through 2009, after which the average concentration held steady around 2 µg/m^3.

- Even with the second highest concentration measured (20.0 µg/m^3), nearly all of the statistical metrics exhibit a decrease from 2007 to 2008. The second highest concentration measured in 2008 (4.17 µg/m^3) was considerably less than the maximum concentration and only five acetaldehyde concentrations greater than 3 µg/m^3 were measured that year, which is the least of any year of sampling.

- There have been no non-detects of acetaldehyde measured at BTUT.

Observations from Figure 24-17 for arsenic measurements include the following:

- Although sampling for PM$_{10}$ metals at BTUT began in 2003, sampling did not begin until July, which does not yield enough samples for the statistical metrics to be calculated, based on the criteria specified in Section 3.5.4. Thus, Figure 24-17 begins with 2004.

- The maximum arsenic concentration was measured in 2004. The maximum concentration measured (33.0 ng/m^3) 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 12 highest concentrations of arsenic (those greater than 5 ng/m^3) were measured in 2004. Of these 12, eight were measured in the first quarter of the calendar year and four were measured during the fourth quarter of the calendar year, supporting the tendency discussed in Section 24.4.1.

- The average concentration of arsenic decreased significantly from 2004 to 2005, a trend that continued into 2006. After 2004, the average arsenic concentration has fluctuated between 0.59 ng/m^3 (2011) to 1.13 ng/m^3 (2009). The statistical parameters for 2007 and 2009 are being driven primarily by a single "high" measurement. If 2007 and 2009 are excluded, the averages then range from 0.59 ng/m^3 to 0.71 ng/m^3. If the maximum concentrations measured in 2007 and 2009 were removed, the average concentrations from 2005 to 2011 would all be less than 1 ng/m^3. The maximum concentrations for 2007 and 2009 were both measured in January.

- Non-detects of arsenic were not measured for half of the years of sampling. For those years with non-detects, the greatest percentage were measured in 2011 (5 percent).

Observations from Figures 24-18 for benzene include the following:

- Although sampling for VOCs at BTUT began in 2003, sampling did not begin until July, which does not yield enough samples for the statistical metrics to be calculated, based on the criteria specified in Section 3.5.4. Thus, Figure 24-18 begins with 2004.

- 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.

- The average and median concentrations have a decreasing trend through 2007. An increasing trend in the average is then shown through 2009, after which another decreasing trend follows. The average benzene concentration ranges from 1.14 µg/m^3 (2011) to 1.87 µg/m^3 (2004).

- Although the average concentration increased for 2009, the median concentration decreased. This average is being driven by the higher concentrations measured in 2009, as discussed above.

- There have been no non-detects of benzene measured at BTUT.

Observations from Figures 24-19 for 1,3-butadiene 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.

- The minimum, 5th percentile, and median concentrations are all zero for the 2004, indicating that at least 50 percent 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 and then the 5th percentile. 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.

- The average concentration has changed little over the years of sampling and ranges from 0.10 µg/m^3 to 0.12 µg/m^3 between 2005 and 2011.

Observations from Figure 24-20 for formaldehyde measurements include the following:

- The maximum formaldehyde concentration was measured in 2004 (45.4 µg/m^3), on the same day as the highest acetaldehyde concentration, August 31, 2004. 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 an increase from 2004 to 2005. The median, or midpoint concentration, increased by 2 µg/m^3 from 2004 to 2005, indicating that concentrations ran higher in 2005 than 2004 rather than being driven by an outlier, as in 2004. As an illustration, there were 11 concentrations greater than 5 µg/m^3 in 2004 compared to 31 in 2005.

- After 2005, the average concentration began to decrease, reaching a minimum for 2008. A steady increasing trend in the average formaldehyde concentration, as well as most other statistical parameters, is shown after 2008.

- Although the maximum, 95th percentile, and average concentrations increased for 2011, the median actually decreased. Although the concentrations on the upper end of the range are higher than they had been in recent years of sampling, the number of concentrations on the lower end of the range is also higher for 2011. The number of measurements less than 2.5 µg/m^3 for 2011 (30) is the second highest, behind only 2008 (37).

- There have been no non-detects of formaldehyde measured at BTUT.

Observations from Figure 24-21 for hexavalent chromium measurements include the following:

- The maximum hexavalent chromium concentration was measured on July 4, 2006 (0.45 ng/m^3). The next highest concentration, measured in 2010, is roughly half as high.

- The minimum and 5th percentile are both zero for each year of sampling, indicating the presence of non-detects. The number of non-detects has varied over the years, ranging from eight percent (2006) to 38 percent (2009). The decrease exhibited by most of the statistical metrics from 2008 to 2009 may result, at least in part, from the increase in non-detects (up from 10 percent 2008), and thus, zeros substituted into the calculations.

- The average hexavalent chromium concentration has fluctuated over the years of sampling, ranging from 0.019 ng/m^3 for 2009 to 0.037 ng/m^3 for 2008.

Observations from Figure 24-22 for lead measurements include the following:

- Although the maximum concentration of lead was measured in 2011 (23.2 ng/m^3), similar concentrations were also measured in 2004 and 2009.

- The statistical metrics shown in Figure 24-22 reflect a relatively high level of variability in the lead concentrations measured at BTUT. One indicator of this is the difference between the average and median concentrations. This difference is at a minimum for 2008 (0.22 ng/m^3) and at a maximum for 2009 (1.33 ng/m^3), with a difference for half of the years of sampling greater than 1 ng/m^3.

- The average and median concentrations have an overall decreasing trend over the period of sampling, although this is difficult to discern in Figure 24-22 due to the fluctuations in the maximum concentrations and 95th percentiles.

Observations from Figure 24-23 for manganese measurements 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). Concentrations greater than 20 ng/m^3 have been measured in 2004, 2007, 2008, 2009, and 2011.

- The average concentration decreased from 2004 to 2005, after which an increase is shown through 2007, although these changes are not statistically significant. However, a significant decrease in manganese concentrations is shown from 2008 through 2010. The median concentration follows a similar trend.

- With the exception of the 5th percentile, all of the statistical metrics exhibit an increase for 2011. The number of concentrations greater than 10 ng/m^3 increased from six in 2010 to 18 in 2011.

24.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

24.5.2 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
Bountiful, Utah - BTUT						
Acetaldehyde	0.0000022	0.009	60/60	2.19 ± 0.35	4.83	0.24
Acrylonitrile	0.000068	0.002	7/60	0.02 ± 0.01	1.10	0.01
Arsenic (PM_{10})[a]	0.0043	0.000015	58/60	<0.01 ± <0.01	2.52	0.04
Benzene	0.0000078	0.03	60/60	1.14 ± 0.15	8.90	0.04
Benzo(a)pyrene[a]	0.00176	--	20/62	<0.01 ± <0.01	0.08	--
Beryllium (PM_{10})[a]	0.0024	0.00002	53/60	<0.01 ± <0.01	0.03	<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 24-5.

Table 24-6. Risk Approximations for the Utah Monitoring Site (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 Hazard Approximation (HQ)
1,3-Butadiene	0.00003	0.002	49/60	0.10 ± 0.02	2.98	0.05
Cadmium (PM$_{10}$)[a]	0.0018	0.00001	60/60	<0.01 ± <0.01	0.25	0.01
Carbon Tetrachloride	0.000006	0.1	60/60	0.61 ± 0.03	3.68	0.01
Chloroform	--	0.098	29/60	0.06 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	29/60	0.05 ± 0.02	0.50	<0.01
1,2-Dichloroethane	0.000026	2.4	15/60	0.03 ± 0.01	0.72	<0.01
Dichloromethane	0.00000013	0.6	60/60	53.90 ± 50.64	7.01	0.09
Ethylbenzene	0.0000025	1	60/60	0.47 ± 0.13	1.17	<0.01
Formaldehyde	0.000013	0.0098	60/60	4.49 ± 1.15	58.42	0.46
Hexachloro-1,3-butadiene	0.000022	0.09	6/60	0.01 ± 0.01	0.22	<0.01
Hexavalent Chromium[a]	0.012	0.0001	53/61	<0.01 ± <0.01	0.26	<0.01
Lead (PM$_{10}$)[a]	--	0.00015	60/60	<0.01 ± <0.01	--	0.02
Manganese (PM$_{10}$)[a]	--	0.00005	60/60	0.01 ± <0.01	--	0.15
Naphthalene[a]	0.000034	0.003	62/62	0.05 ± 0.01	1.61	0.02
Nickel (PM$_{10}$)[a]	0.00048	0.00009	60/60	<0.01 ± <0.01	0.83	0.02
Propionaldehyde	--	0.008	60/60	0.46 ± 0.07	--	0.06
Tetrachloroethylene	0.00000026	0.04	41/60	0.10 ± 0.02	0.03	<0.01
Trichloroethylene	0.0000048	0.002	11/60	0.02 ± 0.01	0.07	0.01
Vinyl Chloride	0.0000088	0.1	1/60	<0.01 ± <0.01	<0.01	<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 24-5.

Observations for BTUT from Table 24-6 include the following:

- The pollutants with the highest annual average concentrations are dichloromethane, formaldehyde, acetaldehyde, and benzene, as discussed in Section 24.4.1.

- The pollutants with the highest cancer risk approximations are formaldehyde, benzene, dichloromethane, and acetaldehyde. The cancer risk approximation for formaldehyde is eight times greater than the cancer risk approximation for dichloromethane, even with an annual average concentration of dichloromethane nearly 12 times greater than the annual average concentration of formaldehyde. This is an indication of the toxicity potential of formaldehyde vs. dichloromethane.

- 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 (0.46), which is the second highest noncancer hazard approximation calculated among the site-specific pollutants of interest with noncancer toxicity factors.

24.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 24-7 and 24-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 24-6. Table 24-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 24-6.

The pollutants listed in Tables 24-7 and 24-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 24.3, BTUT sampled for VOCs, carbonyl compounds, SNMOCs, metals (PM_{10}), PAHs, and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Table 24-7. 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	174.72	Benzene	1.36E-03	Formaldehyde	58.42
Ethylbenzene	80.37	Formaldehyde	9.97E-04	Benzene	8.90
Formaldehyde	76.71	1,3-Butadiene	6.17E-04	Dichloromethane	7.01
Acetaldehyde	44.32	Naphthalene	3.46E-04	Acetaldehyde	4.83
1,3-Butadiene	20.55	Ethylbenzene	2.01E-04	Carbon Tetrachloride	3.68
Naphthalene	10.19	POM, Group 3	1.87E-04	1,3-Butadiene	2.98
Dichloromethane	2.66	POM, Group 2b	1.40E-04	Arsenic	2.52
POM, Group 2b	1.59	Hexavalent Chromium, PM	1.31E-04	Naphthalene	1.61
POM, Group 1a	0.20	Acetaldehyde	9.75E-05	Ethylbenzene	1.17
POM, Group 6	0.14	POM, Group 5a	7.17E-05	Acrylonitrile	1.10

Table 24-8. 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	403.75	Acrolein	215,538.97	Formaldehyde	0.46
Xylenes	329.01	1,3-Butadiene	10,275.13	Acetaldehyde	0.24
Benzene	174.72	Formaldehyde	7,827.57	Manganese	0.15
Methanol	171.92	Benzene	5,823.93	Dichloromethane	0.09
Hexane	100.56	Acetaldehyde	4,924.23	Propionaldehyde	0.06
Ethylbenzene	80.37	Naphthalene	3,395.03	1,3-Butadiene	0.05
Formaldehyde	76.71	Xylenes	3,290.06	Arsenic	0.04
Acetaldehyde	44.32	Lead, PM	1,295.06	Benzene	0.04
Ethylene glycol	22.52	Arsenic, PM	736.79	Lead	0.02
1,3-Butadiene	20.55	Propionaldehyde	619.63	Nickel	0.02

Observations from Table 24-7 include the following:

- Benzene, ethylbenzene, and formaldehyde 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 benzene, formaldehyde, 1,3-butadiene.

- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions.

- Formaldehyde and benzene, which have the highest and second highest cancer risk approximations for BTUT, appear near the top of both emissions-based lists. Acetaldehyde, 1,3-butadiene, naphthalene, and ethylbenzene also appear on all three lists in Table 24-7. Dichloromethane, which has the third highest cancer risk approximation for BTUT, ranks seventh for emissions in Davis County but does not have one of the highest toxicity-weighted emissions (it ranks 19th). Carbon tetrachloride, which has the fifth highest cancer risk approximation for BTUT, appears on neither emissions-based list.

- POM, Group 2b is the eighth highest emitted "pollutant" in Davis County and ranks seventh 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 failed screens for BTUT.

- POM, Group 5a ranks tenth for toxicity-weighted emissions in Davis County. POM, Group 5a includes benzo(a)pyrene, which is one of BTUT's pollutants of interest. POM, Group 5a is not one of the highest emitted pollutants in Davis County and is not among the pollutants with the highest cancer risk approximations for BTUT.

Observations from Table 24-8 include the following:

- Toluene, xylenes, and benzene 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.

- Five 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 fifth (respectively) for toxicity-weighted emissions and seventh and eighth (respectively) for total emissions. Dichloromethane, which has the fourth highest noncancer hazard approximation, appears on neither emissions-based list.

24.6 Summary of the 2011 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; of these, 12 were NATTS MQO Core Analytes.*

- *Dichloromethane had the highest annual average concentration among the pollutants of interest for BTUT, followed by formaldehyde, acetaldehyde, and benzene.*

- *The annual average formaldehyde concentration for BTUT is the highest annual average among NMP sites sampling carbonyl compounds.*

- *Formaldehyde concentrations at BTUT have been increasing in the last few years of sampling while benzene concentrations have decreased in the last few years. There is an overall decreasing trend in concentrations of lead at BTUT.*

25.0 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.

25.1 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 is located farther south in Rutland, Vermont. Figures 25-1 and 25-2 are the composite satellite images retrieved from ArcGIS Explorer showing the Burlington monitoring sites in their urban and rural locations. Figure 25-3 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the sites are included in the facility counts provided in Figure 25-3. 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 25-4 and 25-5 are the composite satellite image and emissions sources map for the Rutland site. Table 25-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

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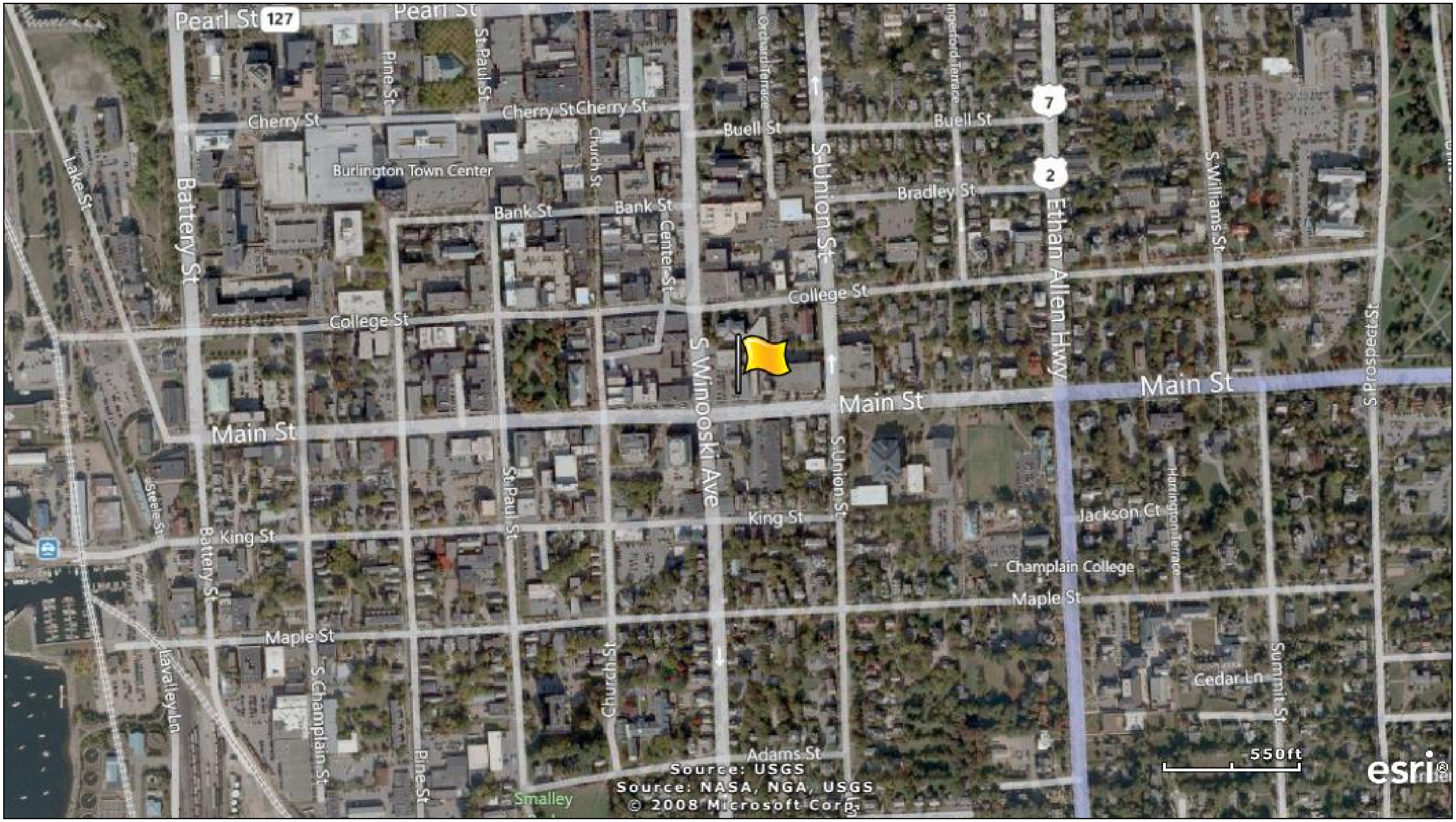
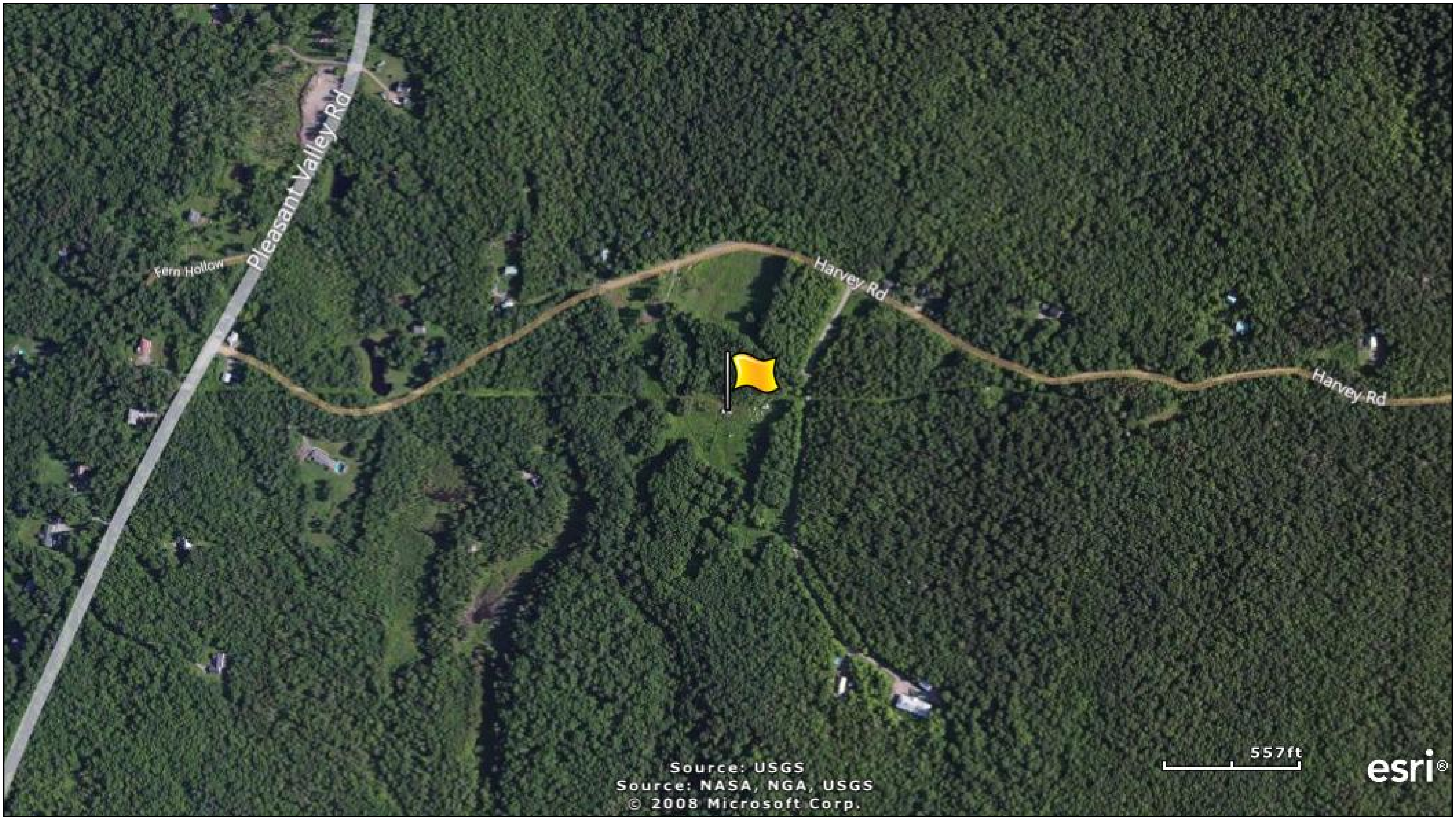
Figure 25-1. Burlington, Vermont (BURVT) Monitoring Site



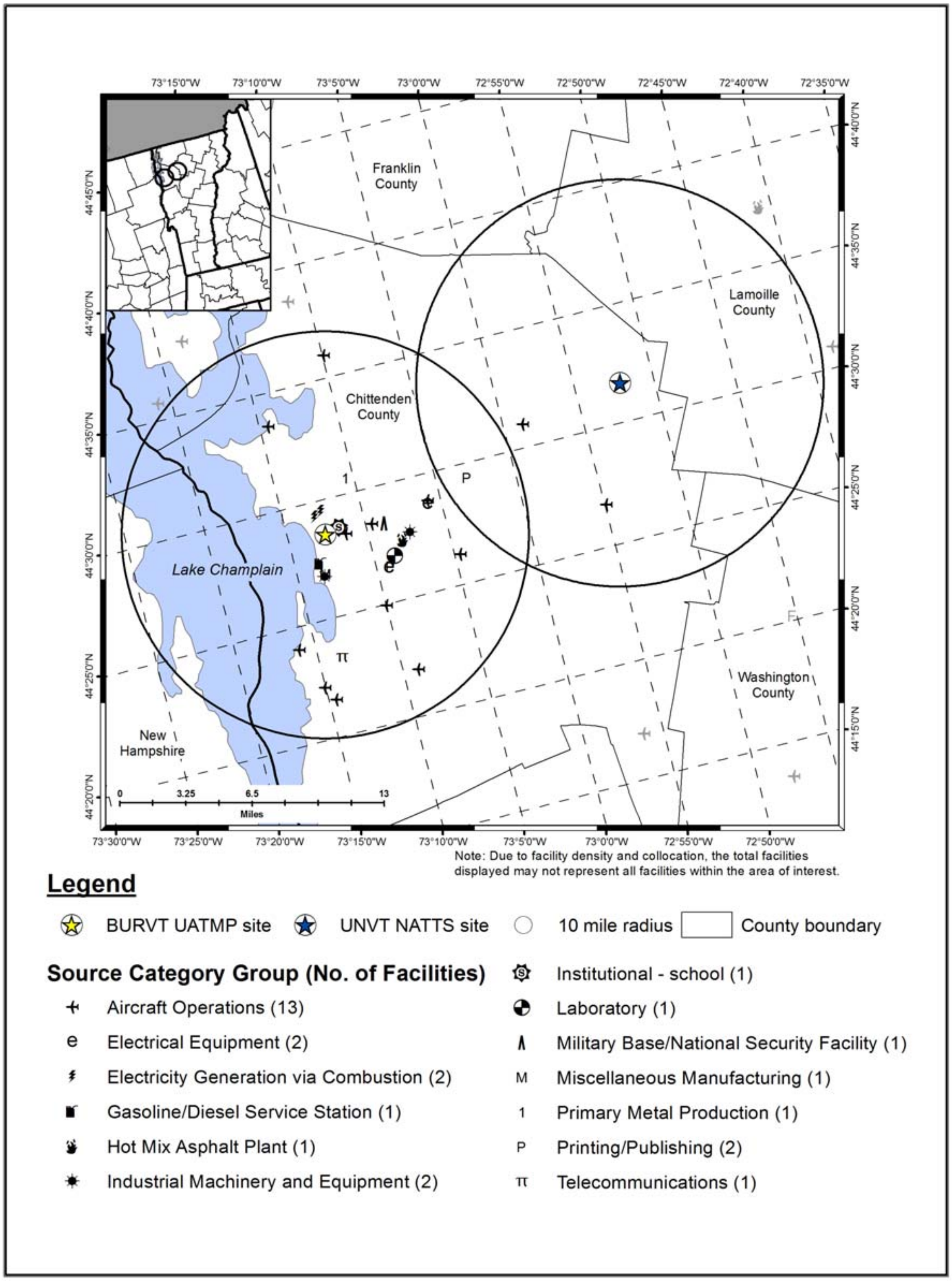
Source: USGS
Source: NASA, NGA, USGS
© 2008 Microsoft Corp.

Figure 25-2. Underhill, Vermont (UNVT) Monitoring Site



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

Figure 25-3. NEI Point Sources Located Within 10 Miles of BURVT and UNVT



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

Figure 25-4. Rutland, Vermont (RUVT) Monitoring Site

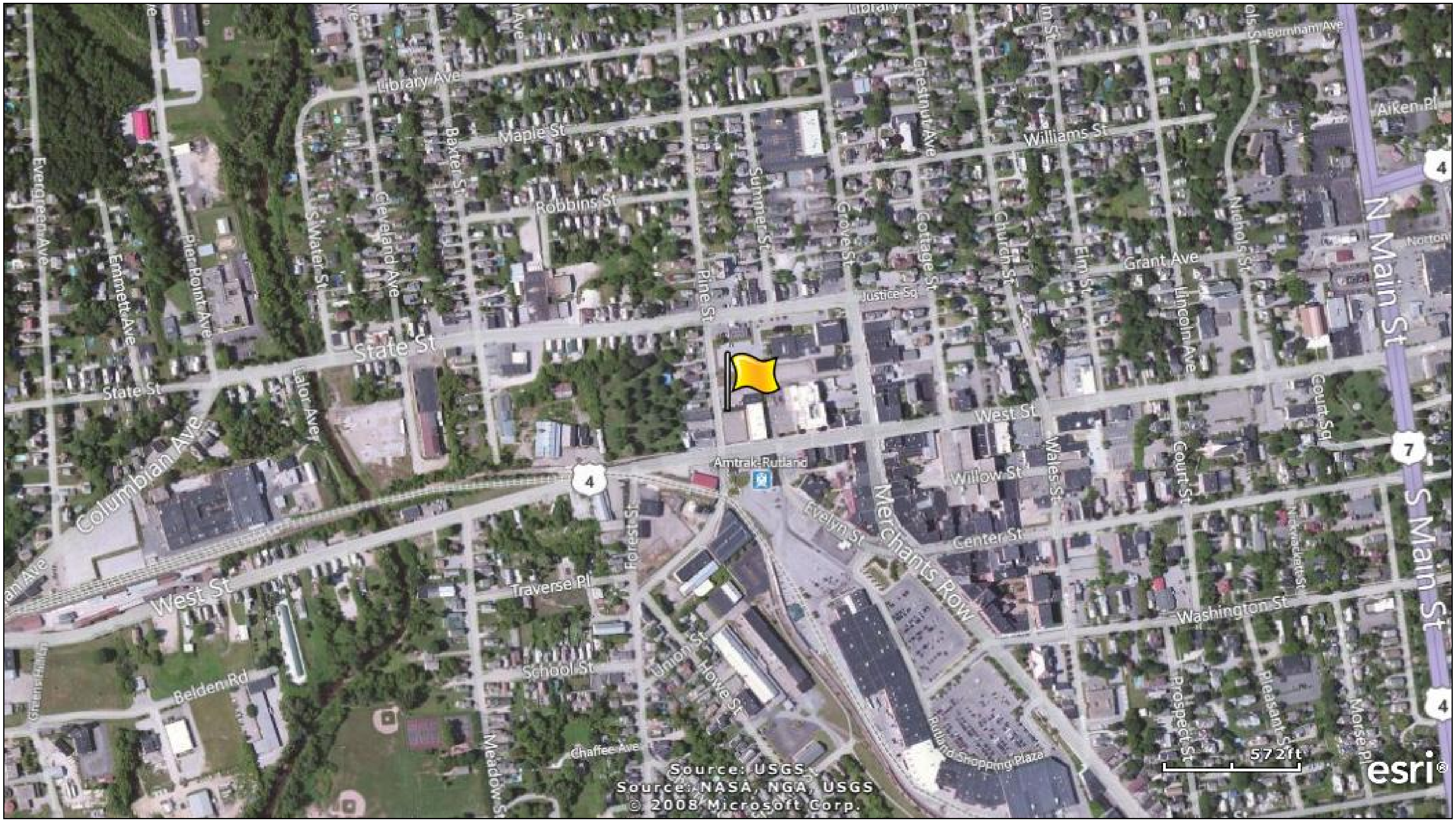
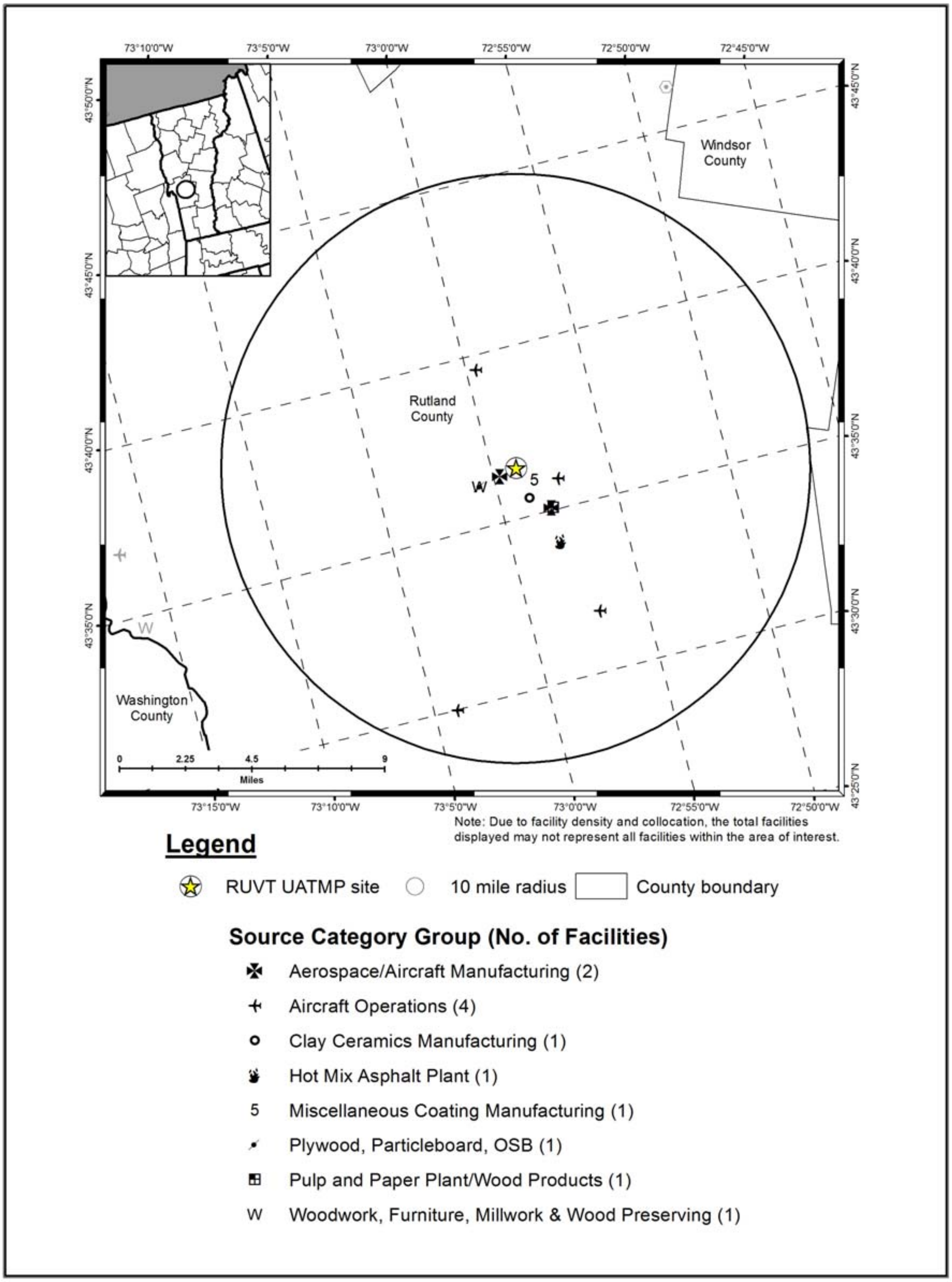


Figure 25-5. NEI Point Sources Located Within 10 Miles of RUVT



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

Table 25-1. 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	44.476202, -73.210383	Commercial	Urban/City Center	CO, NO, NO_2, NO_x, Carbonyl compounds, Meteorological parameters, PM_{10}, $PM_{2.5}$.
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, Carbonyl compounds, Meteorological parameters, PM_{10}, $PM_{2.5}$.
UNVT	50-007-0007	Underhill	Chittenden	Burlington-South Burlington, VT MSA	44.52839, -72.86884	Forest	Rural	Haze, Sulfate, SO_2, O_3, Meteorological parameters, PM_{10}, PM Coarse, $PM_{2.5}$, and $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for these sites (EPA, 2012c); 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 are commercial while the areas to the east are residential, as shown in Figure 25-1. 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 a few miles to the south. Figure 25-2 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.

As Figure 25-3 shows, UNVT and BURVT are located approximately 16 miles apart. 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 aircraft operations source category, which includes airports as well as small runways, heliports, or landing pads. The sources closest to BURVT are a medical school/hospital, an airport, 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 25-4. 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 north junction of Route 4 and Route 7 is approximately 1/2 mile east of the site. Figure 25-5 shows that most of the emissions sources near RUVT are located along Route 4 and Route 7, just south of the monitoring site. The source categories with the greatest number of sources include aircraft operations and aerospace/aircraft manufacturing. The source closest to RUVT is an aerospace/aircraft manufacturer.

Table 25-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Vermont monitoring sites. Table 25-2 includes county-level population and vehicle registration information. Table 25-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within each monitoring site's residing county. In addition, the population within 10 miles of each site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was then determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 25-2 also contains traffic volume information for each site. Finally, Table 25-2 presents the county-level daily VMT for Chittenden and Rutland Counties.

Table 25-2. Population, Motor Vehicle, and Traffic Information for the Vermont Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
BURVT	157,491	169,767	1.08	120,787	130,202	14,000	4,027,945
UNVT				33,622	36,243	1,110	
RUVT	61,289	70,900	1.16	34,662	40,098	7,200	1,766,027

[1] County-level population estimates reflect 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)

[2] County-level vehicle registration reflects 2012 data from the Vermont DMV (VT DMV, 2012)

[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)

[4] AADT reflects 2007 and 2011 data for BURVT and UNVT, respectively, from the Chittenden County Regional Planning Commission (CCRPC, 2007 and 2011) and 2010 data for RUVT from Vermont Agency of Transportation (VTrans, 2011)

[5] County-level VMT reflects 2010 data from the Vermont Agency of Transportation (Vtrans, 2010)

BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 25-2 include the following:

- The population for Chittenden County is more than twice the population of Rutland County. The populations for both counties are in the bottom third compared to other counties with NMP sites. UNVT's 10-mile population is the lowest among the three Vermont sites, although it is similar to the 10-mile population surrounding RUVT. The 10-mile populations for BURVT and UNVT show that BURVT is near the center of population for Chittenden County while UNVT is not.

- Although similar patterns are shown in the vehicle ownership data, the number of vehicles registered in each county is higher than the population counts, leading to relatively large vehicle-per-person ratios. This indicates that some people own more than one vehicle.

- The traffic volume is highest near BURVT and lowest near UNVT among the Vermont sites. The traffic estimates near these sites are in the bottom third compared to the traffic near other NMP sites. The traffic estimate for BURVT is provided for Main Street between South Union Street and South Willard Street; Pleasant Valley Road, north of Harvey Road for UNVT; and US-4 Business between Merchants Row and Grove Street for RUVT.

- 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 monitoring sites (where VMT data were available).

25.2 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.

25.2.1 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 much 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. Precipitation is evenly distributed throughout the year. 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 (Bair, 1992; NCDC, 2013; NOAA, 2013c).

25.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather stations nearest the Vermont monitoring sites were retrieved for 2011 (NCDC, 2011). 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 25-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

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 the entire year for 2011. 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 at UNVT were representative of average weather conditions throughout the year. Temperatures on sample days at BURVT and RUVT appear slightly warmer than those for all of 2011, although the differences are not statistically significant.

25.2.3 Back Trajectory Analysis

Figure 25-6 is the composite back trajectory map for days on which samples were collected at the BURVT monitoring site in 2011. Included in Figure 25-6 are four back trajectories per sample day. Figure 25-7 is the corresponding cluster analysis. Similarly, Figures 25-8 through 25-11 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 25-6 through 25-11 represents 100 miles.

Table 25-3. Average Meteorological Conditions near the Vermont Monitoring Sites

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)
Burlington, Vermont - BURVT									
Burlington Intl. Airport 14742 (44.48, -73.16)	2.38 miles 87° (E)	Sample Day	57.4 ± 7.3	48.9 ± 6.7	39.1 ± 6.7	44.4 ± 6.2	71.9 ± 4.7	1015.5 ± 3.1	6.4 ± 1.1
		2011	55.9 ± 2.2	47.9 ± 2.0	38.2 ± 2.0	43.5 ± 1.9	71.7 ± 1.2	1014.9 ± 0.8	6.3 ± 0.3
Rutland, Vermont - RUVT									
Rutland State Airport 94737 (43.53, -72.95)	5.60 miles 149° (SSE)	Sample Day	56.6 ± 6.1	48.9 ± 5.8	39.1 ± 6.2	44.4 ± 5.5	71.4 ± 4.4	NA	6.6 ± 1.0
		2011	54.8 ± 2.0	46.4 ± 1.9	36.4 ± 2.0	41.9 ± 1.8	70.3 ± 1.2	NA	6.1 ± 0.3
Underhill, Vermont - UNVT									
Morrisville-Stowe State Airport 54771 (44.53, -72.61)	11.84 miles 78° (E)	Sample Day	54.1 ± 4.7	44.9 ± 4.2	36.5 ± 4.4	41.2 ± 4.0	74.9 ± 2.7	1015.9 ± 1.8	3.2 ± 0.5
		2011	54.7 ± 2.2	45.1 ± 2.0	36.7 ± 2.1	41.3 ± 1.9	75.1 ± 1.1	1015.6 ± 0.8	3.0 ± 0.2

[1] Sample day averages are highlighted 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 25-6. 2011 Composite Back Trajectory Map for BURVT

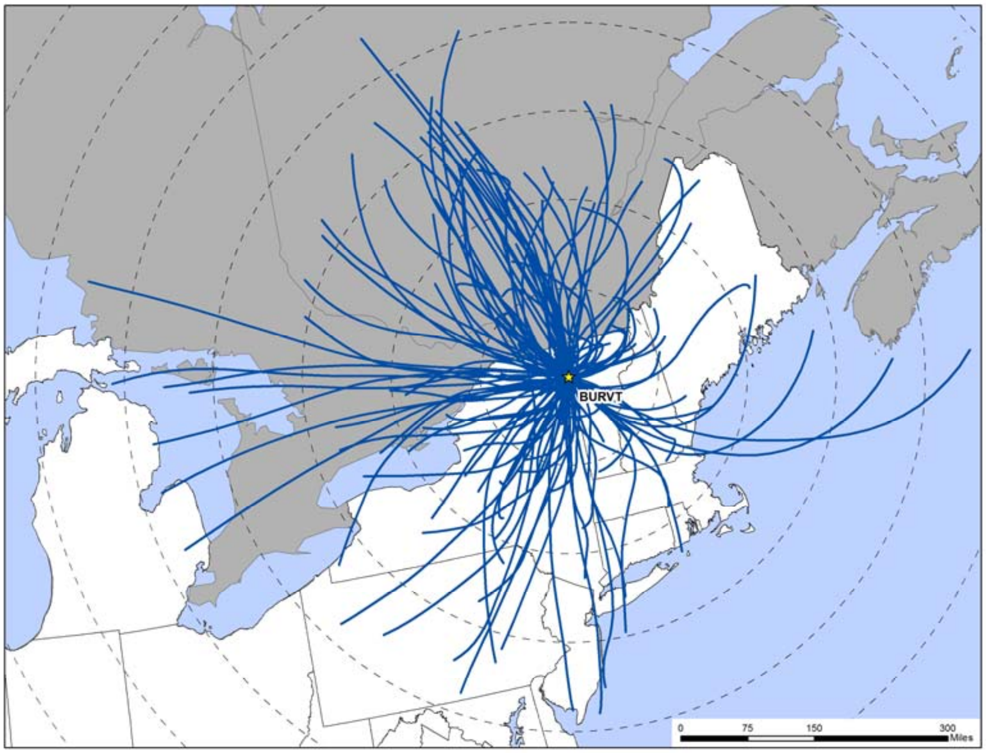


Figure 25-7. Back Trajectory Cluster Map for BURVT

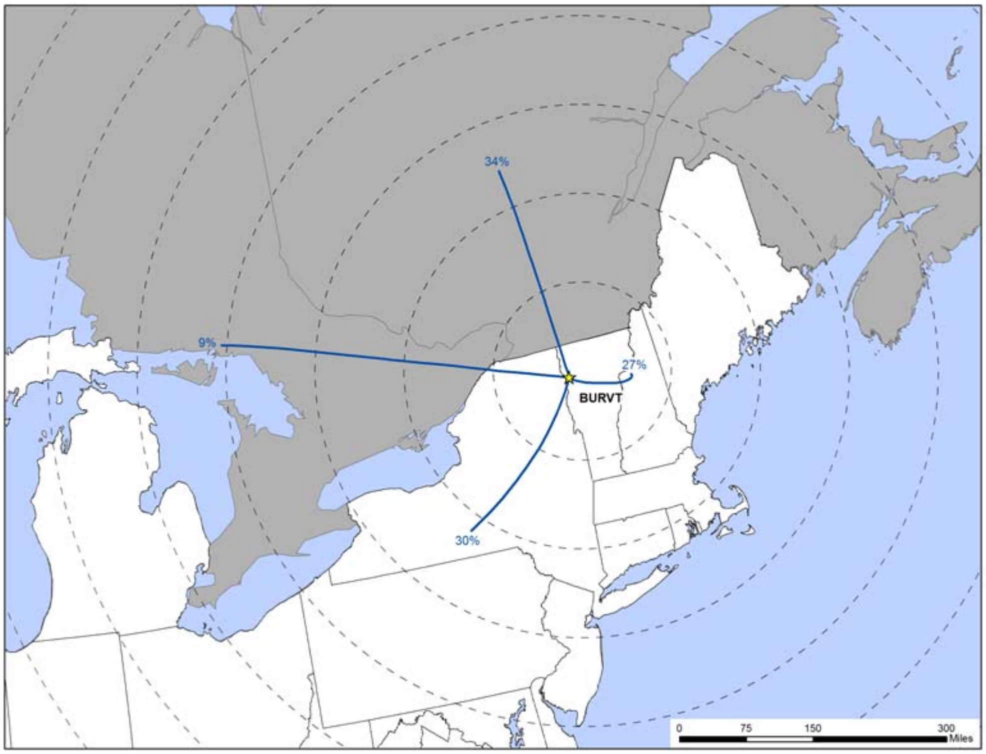


Figure 25-8. 2011 Composite Back Trajectory Map for RUVT

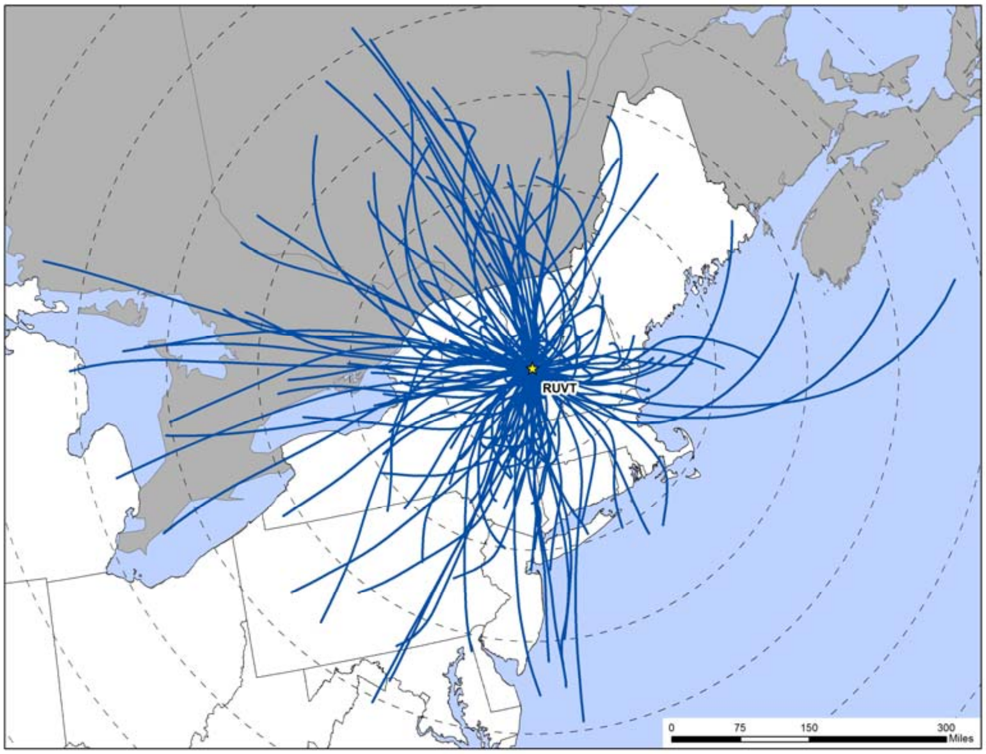


Figure 25-9. Back Trajectory Cluster Map for RUVT

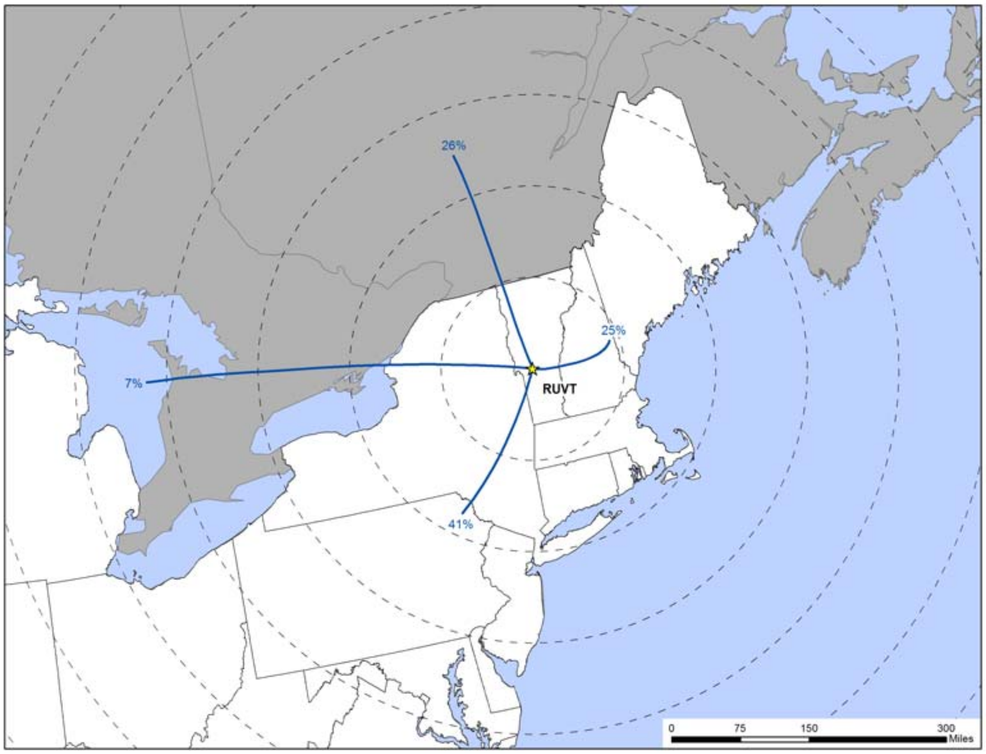


Figure 25-10. 2011 Composite Back Trajectory Map for UNVT

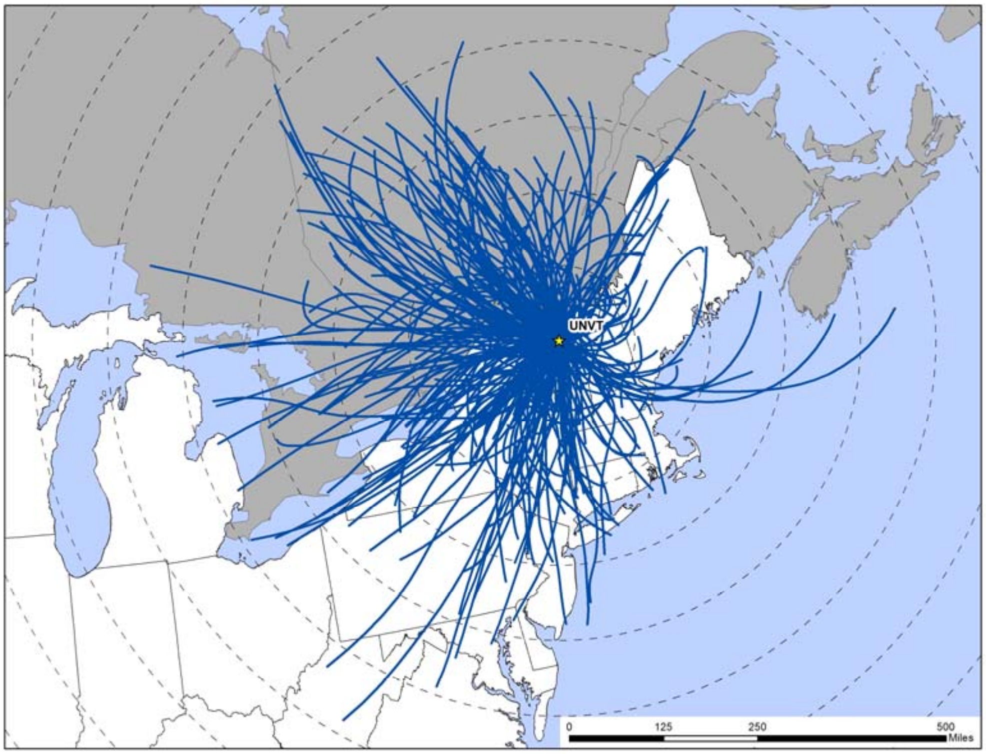
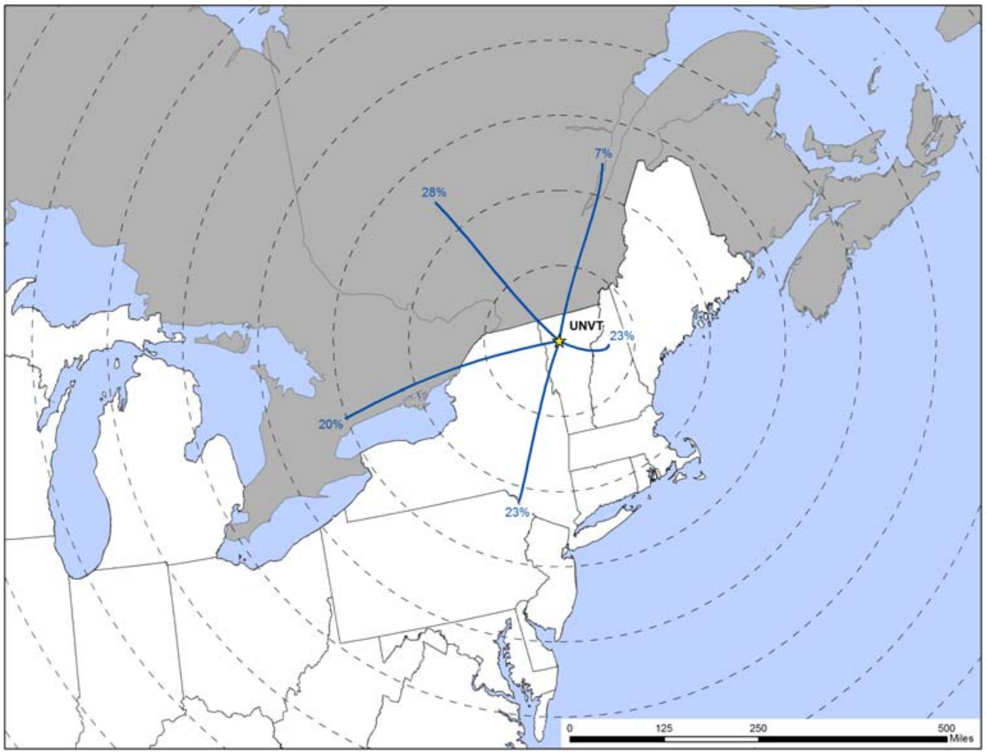


Figure 25-11. Back Trajectory Cluster Map for UNVT



Observations from Figures 25-6 through 25-11 for the Vermont monitoring sites include the following:

- The composite back trajectories maps for the Vermont sites are similar to each other, which is not unexpected given their relatively close proximity to each other. However, BURVT and RUVT sampled on a 1-in-12 schedule, yielding roughly half as many sample days for these sites as UNVT.

- The composite back trajectory maps show that the majority of back trajectories originated from a direction with a westerly component.

- For BURVT and RUVT, the farthest away a back trajectory originated was over south-central Ontario, Canada, or greater than 500 miles away. For UNVT, the farthest away a back trajectory originated was central West Virginia, or nearly 600 miles away. The average trajectory length varied from 220 miles for RUVT to 231 miles for BURVT and UNVT. Most back trajectories (roughly 90 percent) originated within 400 miles of each site.

- The cluster analyses for BURVT and RUVT are fairly similar to each other directionally, although the percentages vary. For BURVT, 34 percent of back trajectories originated to the north of the site, generally over Quebec, Canada. For RUVT, this percentage is 26 percent. Between 7 and 9 percent of back trajectories originated to the west of the sites over the Greater Lakes region and southern Ontario, Canada. For BURVT, 30 percent of back trajectories originated from the southwest quadrant, including south and west, primarily over New York and Pennsylvania. For RUVT, this percentage is higher, at 41 percent. The cluster trajectory originating to the east of the sites and representing about one-quarter of the back trajectories, includes longer back trajectories originating over the Atlantic Ocean, shorter trajectories originating over New Hampshire, as well as trajectories originating from other directions but generally less than 100 miles in length.

- The back trajectories for UNVT are represented by five cluster trajectories rather than four in Figure 25-11. Twenty-eight percent of back trajectories originated to the northwest of UNVT and another seven percent originated to the north to northeast of UNVT. These back trajectories are combined in the cluster analyses for BURVT and RUVT. Twenty percent of back trajectories originated to the southwest to west of UNVT over the Great Lakes region and southern Ontario, Canada. Just less than one-quarter of back trajectories originated to the south to southwest of UNVT over the Northeast and Mid-Atlantic states. The same percentage of back trajectories is represented by the short cluster trajectory originating over New Hampshire. Similar to the other two Vermont sites, this cluster trajectory represents longer back trajectories originating over the Atlantic Ocean, shorter trajectories originating over the New England states, as well as back trajectories originating from other directions but generally less than 100 miles in length.

25.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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 25-12 presents a map showing the distance between the NWS station and BURVT, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 25-12 also presents three different wind roses for the BURVT monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction in 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Figures 25-13 and 25-14 present the three wind roses and distance maps for the RUVT and UNVT monitoring sites.

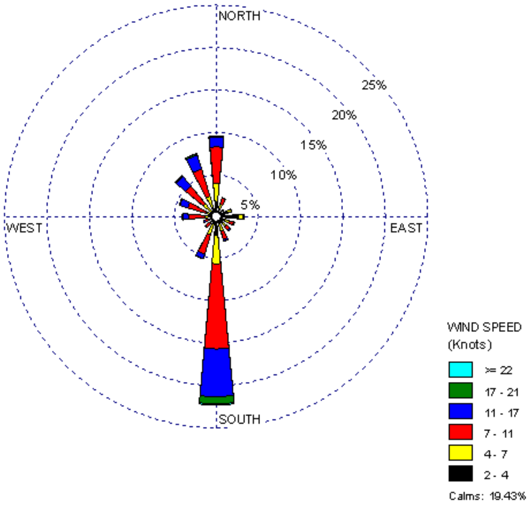
Observations from Figure 25-12 for BURVT include the following:

- The Burlington International Airport weather station is located approximately 2.8 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 19 percent of measurements. Winds from the northwest quadrant, including north, account for another 30 percent of the wind observations. Winds from the eastern quadrants are rarely observed.
- The wind patterns shown on the 2011 wind rose are similar to the historical wind patterns, indicating that conditions observed during 2011 were similar to those observed over the last 10 years.
- The sample day wind rose shows that wind conditions on sample days were similar to those experienced throughout 2011, although northwesterly to northerly winds accounted for a higher percentage of the hourly wind measurements.

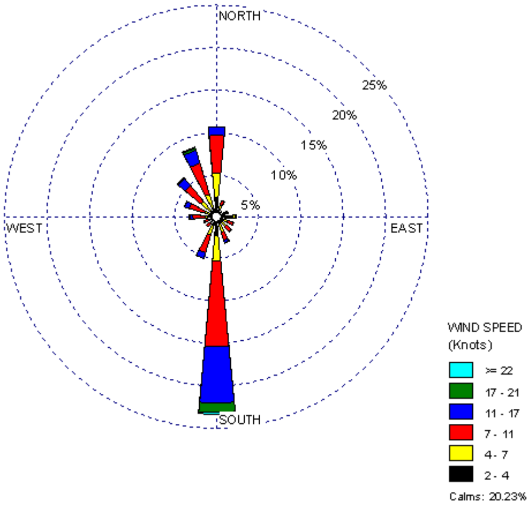
Figure 25-12. Wind Roses for the Burlington International Airport Weather Station near BURVT

Distance between BURVT and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

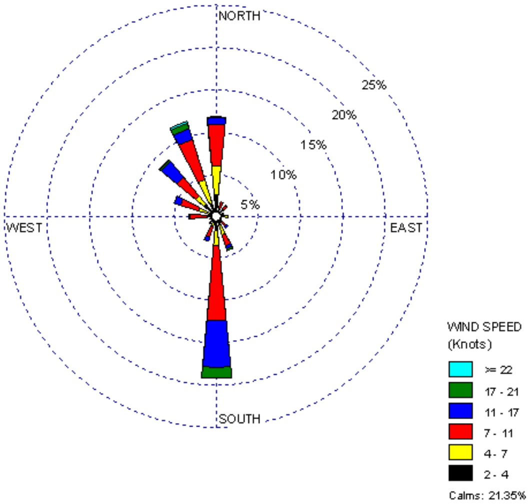
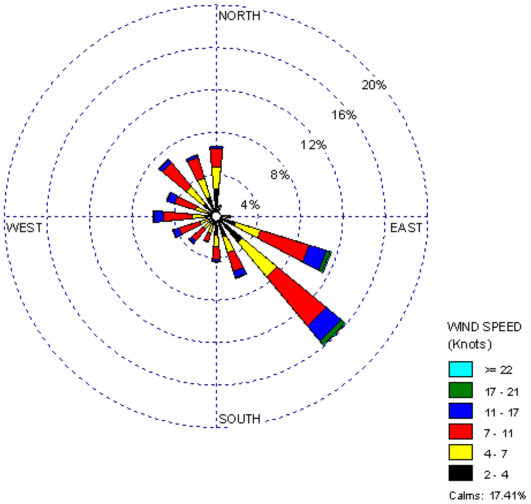


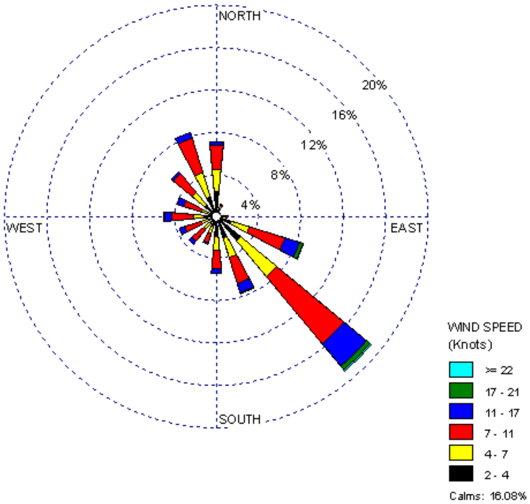
Figure 25-13. Wind Roses for the Rutland State Airport Weather Station near RUVT

Distance between RUVT and NWS Station

2003-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose

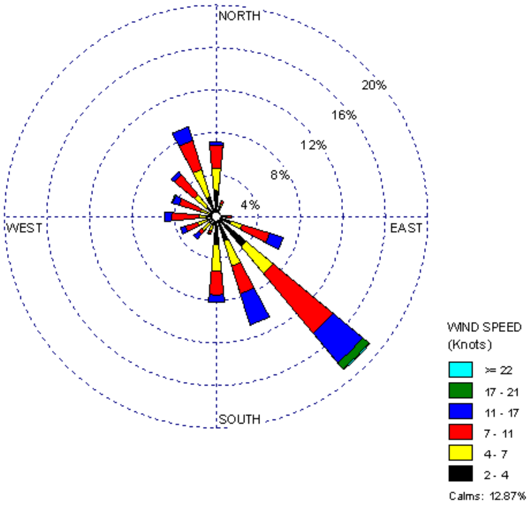
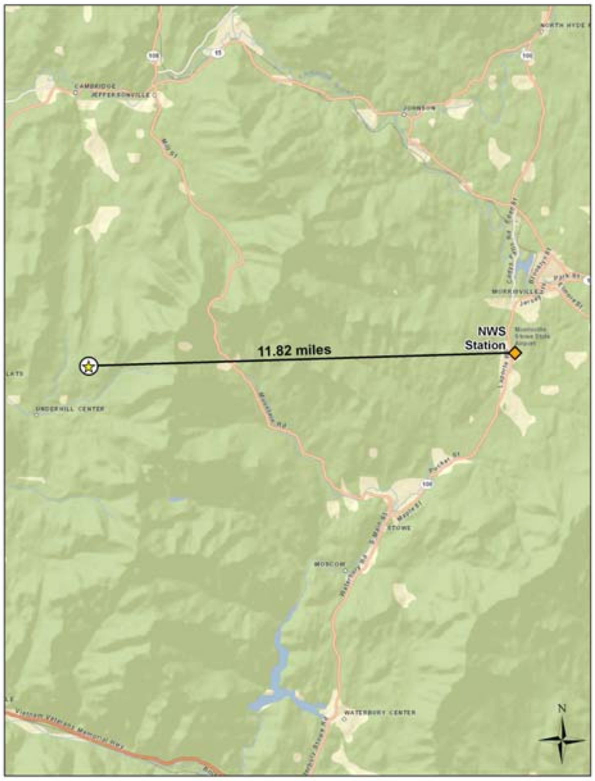
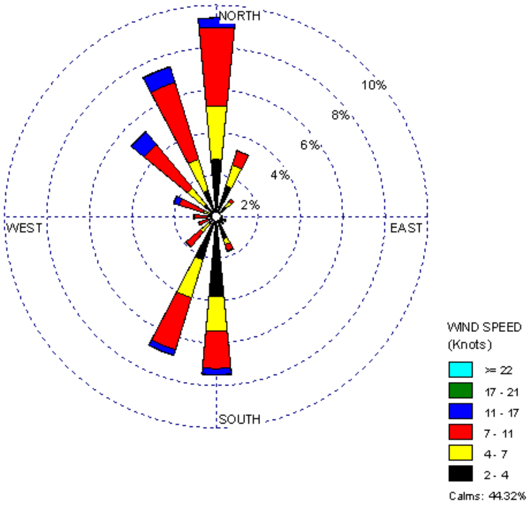


Figure 25-14. Wind Roses for the Morrisville-Stowe State Airport Weather Station near UNVT

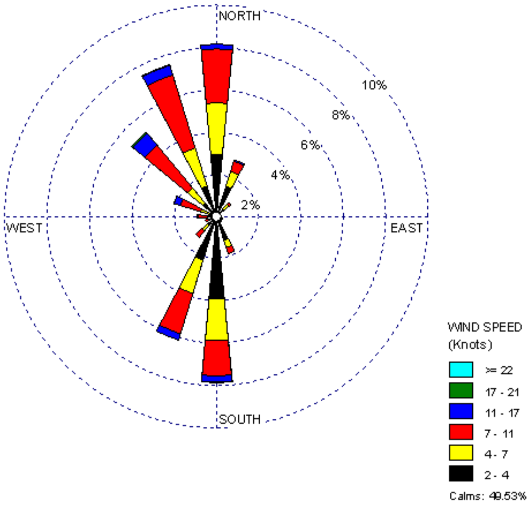
Distance between UNVT and NWS Station



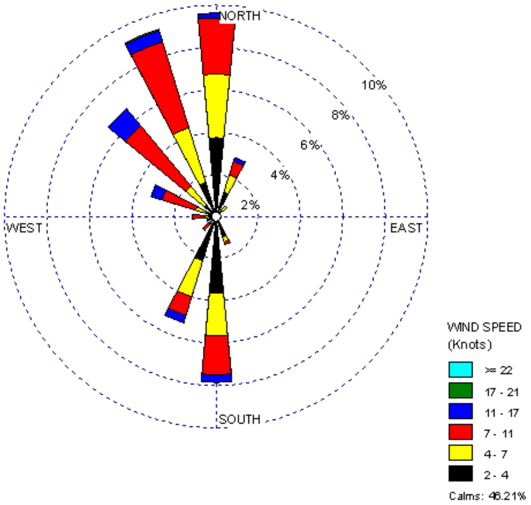
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



Observations from Figure 25-13 for RUVT include the following:

- The Rutland State Airport weather station is located approximately 5.6 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 over a quarter of the hourly measurements. Winds from the southwest and northwest quadrants were also observed while winds from the northeast quadrant were almost never observed. Calm winds were observed for 17 percent of the hourly measurements.
- The wind patterns shown on the 2011 wind rose are similar to the historical wind patterns, although a higher percentage of winds from the southeast and fewer east-southeasterly winds were observed in 2011.
- The sample day wind rose exhibits similar wind patterns as the historical and full-year wind roses, but with even fewer east-southeasterly winds and more south-southeasterly and southerly wind observations.

Observations from Figure 25-14 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 2011 wind rose are similar to the historical wind patterns, although calm winds account for almost 50 percent of the observations.
- The sample day wind rose shows that wind conditions on sample days were similar to those experienced throughout 2011, although winds from the northwest to north account for a greater percentage of wind measurements on sample days.

25.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the Vermont monitoring sites in order to allow 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. In addition, if any of the NATTS MQO Core Analytes measured by each monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 25-4 presents the results of the preliminary risk-based screening process for the Vermont monitoring sites. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for each monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. BURVT and RUVT sampled for VOCs only while UNVT sampled for VOCs, hexavalent chromium, PAHs, and metals (PM_{10}).

Table 25-4. Risk-Based Screening Results for the Vermont Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Burlington, Vermont - BURVT						
Benzene	0.13	30	30	100.00	24.39	24.39
1,3-Butadiene	0.03	30	30	100.00	24.39	48.78
Carbon Tetrachloride	0.17	30	30	100.00	24.39	73.17
p-Dichlorobenzene	0.091	7	27	25.93	5.69	78.86
1,2-Dichloroethane	0.038	7	7	100.00	5.69	84.55
Hexachloro-1,3-butadiene	0.045	5	6	83.33	4.07	88.62
Acrylonitrile	0.015	4	4	100.00	3.25	91.87
Ethylbenzene	0.4	4	30	13.33	3.25	95.12
1,1,2,2-Tetrachloroethane	0.017	4	4	100.00	3.25	98.37
Bromomethane	0.5	1	22	4.55	0.81	99.19
1,2-Dibromoethane	0.0017	1	1	100.00	0.81	100.00
Total		123	191	64.40		
Rutland, Vermont - RUVT						
Benzene	0.13	30	30	100.00	31.25	31.25
Carbon Tetrachloride	0.17	30	30	100.00	31.25	62.50
1,3-Butadiene	0.03	25	25	100.00	26.04	88.54
1,2-Dichloroethane	0.038	4	4	100.00	4.17	92.71
Ethylbenzene	0.4	4	30	13.33	4.17	96.88
Acrylonitrile	0.015	2	2	100.00	2.08	98.96
Hexachloro-1,3-butadiene	0.045	1	1	100.00	1.04	100.00
Total		96	122	78.69		

Table 25-4. Risk-Based Screening Results for the Vermont Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Underhill, Vermont - UNVT						
Benzene	0.13	60	60	100.00	33.52	33.52
Carbon Tetrachloride	0.17	58	60	96.67	32.40	65.92
Arsenic (PM_{10})	0.00023	23	54	42.59	12.85	78.77
1,2-Dichloroethane	0.038	12	12	100.00	6.70	85.47
Acrylonitrile	0.015	6	6	100.00	3.35	88.83
1,3-Butadiene	0.03	5	13	38.46	2.79	91.62
Naphthalene	0.029	4	60	6.67	2.23	93.85
Hexachloro-1,3-butadiene	0.045	3	4	75.00	1.68	95.53
Manganese (PM_{10})	0.005	3	57	5.26	1.68	97.21
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	1.12	98.32
Bromomethane	0.5	1	28	3.57	0.56	98.88
p-Dichlorobenzene	0.091	1	10	10.00	0.56	99.44
Nickel (PM_{10})	0.0021	1	57	1.75	0.56	100.00
Total		179	423	42.32		

Observations from Table 25-4 include the following:

- A total of 11 pollutants, including three NATTS MQO Core Analytes, failed screens for BURVT. Seven pollutants, including the same three NATTS MQO Core Analytes, failed screens for RUVT. The seven pollutants failing screens for RUVT also failed at least one screen for BURVT. Thirteen pollutants, of which seven are NATTS MQO Core Analytes, failed screens for UNVT.

- The preliminary risk-based screening process identified nine pollutants of interest for BURVT. Even though the 95 percent criteria is met by ethylbenzene, 1,1,2,2-tetrachloroethane contributed equally to the number of failed screens (4), thus, this pollutant was also designated as a pollutant of interest, as discussed in Section 3.2. Four additional pollutants (chloroform, tetrachloroethylene, and trichloroethylene, and vinyl chloride) were added as pollutants of interest for BURVT because they are NATTS MQO Core Analytes, even though these pollutants did not fail any screens. These pollutants are not shown in Table 25-4 but are shown in subsequent tables in the sections that follow.

- The preliminary risk-based screening process identified five pollutants of interest for RUVT (benzene, carbon tetrachloride, 1,3-butadiene, 1,2-dichloroethane, and ethylbenzene). Three additional pollutants (chloroform, tetrachloroethylene, and trichloroethylene) were added as pollutants of interest because they are NATTS MQO Core Analytes, even though these pollutants did not fail any screens. These pollutants are not shown in Table 25-4 but are shown in subsequent tables in the sections that follow. Vinyl chloride is also a NATTS MQO Core Analyte, but because this pollutant was not detected at RUVT, it was not added to the pollutants of interest.

- The preliminary risk-based screening process identified nine pollutants of interest for UNVT (six VOCs, two metals, and one PAH). Nickel was added to UNVT's pollutants of interest because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of UNVT's total failed screens. Nine additional pollutants (three PM_{10} metals, four VOCs, one PAH, and hexavalent chromium) were added as pollutants of interest for UNVT because they are NATTS MQO Core Analytes, even though these pollutants did not fail any screens. These pollutants are not shown in Table 25-4 but are shown in subsequent tables in the sections that follow.

- Benzene, carbon tetrachloride, 1,3-butadiene, and 1,2-dichloroethane were identified as pollutants of interest for each of the Vermont monitoring sites.

25.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Vermont sites, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically for each site to illustrate how the sites' concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites. Additional site-specific statistical summaries for BURVT, RUVT, and UNVT are provided in Appendices J, M, N, and O.

25.4.1 2011 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 of 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 25-5, where applicable. Note that concentrations of the PAHs, metals, and hexavalent chromium 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 25-5. 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						
Acrylonitrile	4/30	0.01 ± 0.03	0.03 ± 0.06	0.05 ± 0.11	0	0.02 ± 0.03
Benzene	30/30	0.99 ± 0.18	0.61 ± 0.13	0.75 ± 0.19	0.79 ± 0.15	0.78 ± 0.09
1,3-Butadiene	30/30	0.11 ± 0.03	0.09 ± 0.03	0.10 ± 0.03	0.10 ± 0.03	0.10 ± 0.01
Carbon Tetrachloride	30/30	0.49 ± 0.08	0.58 ± 0.10	0.65 ± 0.04	0.62 ± 0.07	0.59 ± 0.04
Chloroform	17/30	0.05 ± 0.05	0.07 ± 0.05	0.08 ± 0.07	0.08 ± 0.05	0.07 ± 0.02
p-Dichlorobenzene	27/30	0.07 ± 0.03	0.08 ± 0.03	0.07 ± 0.03	0.06 ± 0.01	0.07 ± 0.01
1,2-Dichloroethane	7/30	0	0.02 ± 0.03	0.01 ± 0.02	0.04 ± 0.03	0.02 ± 0.01
Ethylbenzene	30/30	0.28 ± 0.06	0.25 ± 0.08	0.35 ± 0.09	0.32 ± 0.08	0.30 ± 0.04
Hexachloro-1,3-butadiene	6/30	0.03 ± 0.05	0.01 ± 0.03	0.01 ± 0.02	0.02 ± 0.03	0.02 ± 0.01
1,1,2,2-Tetrachloroethane	4/30	0.01 ± 0.02	0	0.01 ± 0.02	0.01 ± 0.02	0.01 ± 0.01
Tetrachloroethylene	23/30	0.11 ± 0.06	0.06 ± 0.06	0.18 ± 0.21	0.13 ± 0.06	0.12 ± 0.05
Trichloroethylene	2/30	0	0.01 ± 0.01	0	0.01 ± 0.01	<0.01 ± <0.01
Vinyl Chloride	1/30	0	0	<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 pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Table 25-5. 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						
Benzene	30/30	0.98 ± 0.21	0.70 ± 0.39	0.71 ± 0.06	1.26 ± 0.38	0.89 ± 0.16
1,3-Butadiene	25/30	0.11 ± 0.05	0.05 ± 0.03	0.07 ± 0.02	0.17 ± 0.08	0.09 ± 0.03
Carbon Tetrachloride	30/30	0.54 ± 0.02	0.60 ± 0.07	0.60 ± 0.12	0.68 ± 0.08	0.61 ± 0.04
Chloroform	9/30	0	0.05 ± 0.05	0.07 ± 0.07	0.05 ± 0.06	0.04 ± 0.03
1,2-Dichloroethane	4/30	0	0.02 ± 0.03	0	0.02 ± 0.03	0.01 ± 0.01
Ethylbenzene	30/30	0.25 ± 0.06	0.25 ± 0.06	0.33 ± 0.02	0.38 ± 0.13	0.30 ± 0.04
Tetrachloroethylene	23/30	0.09 ± 0.03	0.14 ± 0.12	0.09 ± 0.06	0.14 ± 0.03	0.12 ± 0.04
Trichloroethylene	2/30	0	<0.01 ± 0.01	0	<0.01 ± 0.01	<0.01 ± <0.01
Underhill, Vermont - UNVT						
Acrylonitrile	6/60	<0.01 ± 0.01	<0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.02	0.01 ± 0.01
Benzene	60/60	0.59 ± 0.11	0.33 ± 0.03	0.31 ± 0.06	0.43 ± 0.06	0.42 ± 0.04
1,3-Butadiene	13/60	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	<0.01 ± <0.01	0.01 ± <0.01
Carbon Tetrachloride	60/60	0.46 ± 0.09	0.54 ± 0.09	0.63 ± 0.04	0.64 ± 0.05	0.57 ± 0.04
Chloroform	17/60	0.03 ± 0.02	0.03 ± 0.03	0.01 ± 0.02	0.03 ± 0.02	0.03 ± 0.01
1,2-Dichloroethane	12/60	<0.01 ± 0.01	0.02 ± 0.02	0	0.04 ± 0.02	0.02 ± 0.01
Hexachloro-1,3-butadiene	4/60	0.01 ± 0.02	0.01 ± 0.02	0.01 ± 0.01	<0.01 ± 0.01	0.01 ± 0.01
Tetrachloroethylene	19/60	0.03 ± 0.02	0.01 ± 0.01	0.02 ± 0.02	0.02 ± 0.02	0.02 ± 0.01
Trichloroethylene	1/60	0	0	0	<0.01 ± <0.01	<0.01 ± <0.01
Vinyl Chloride	1/60	0	<0.01 ± <0.01	0	0	<0.01 ± <0.01
Arsenic (PM$_{10}$)[a]	55/58	0.23 ± 0.10	0.19 ± 0.08	NA	0.31 ± 0.12	0.25 ± 0.06
Benzo(a)pyrene [a]	13/60	0.04 ± 0.03	0.01 ± 0.01	0	0.01 ± 0.01	0.01 ± 0.01
Beryllium (PM$_{10}$) [a]	46/58	0.01 ± <0.01	0.01 ± <0.01	NA	<0.01 ± <0.01	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 pollutants below the blue line are presented in ng/m^3 for ease of viewing.

Table 25-5. 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)
Cadmium (PM_{10}) [a]	58/58	0.07 ± 0.03	0.05 ± 0.01	NA	0.08 ± 0.03	0.07 ± 0.01
Hexavalent Chromium [a]	17/60	<0.01 ± <0.01	0.01 ± 0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Lead (PM_{10}) [a]	58/58	1.50 ± 0.64	0.94 ± 0.27	NA	1.88 ± 0.54	1.46 ± 0.29
Manganese (PM_{10}) [a]	58/58	1.37 ± 0.42	2.06 ± 0.70	NA	2.00 ± 0.63	1.84 ± 0.32
Naphthalene [a]	60/60	27.87 ± 12.64	6.43 ± 1.53	5.44 ± 1.68	13.23 ± 4.58	13.37 ± 3.96
Nickel (PM_{10}) [a]	58/58	0.45 ± 0.29	0.33 ± 0.09	NA	0.74 ± 0.15	0.53 ± 0.10

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 BURVT and RUVT from Table 25-5 include the following:

- BURVT and RUVT sampled VOCs on a 1-in-12 day schedule.

- For both sites, the pollutants with the highest annual average concentrations are benzene, carbon tetrachloride, and ethylbenzene, although all of the annual average concentrations for the pollutants of interest for both sites are less than 1 µg/m^3.

- Several of the VOCs listed for BURVT were detected relatively few times, resulting in relatively large confidence intervals for the quarterly and annual averages, some of which are greater than the averages themselves. Examples include acrylonitrile, 1,2-dichloroethane, hexachloro-1,3-butadiene, and 1,1,2,2-tetrachloroethane. This is also true from some of RUVT's pollutants of interest.

- The first quarter benzene average for BURVT is higher than the other quarterly averages. A review of the data shows that the maximum concentration of benzene was measured on February 2, 2011 (1.38 µg/m^3). Of the five benzene concentrations greater than 1 µg/m^3 measured at BURVT, three were measured in the first quarter of 2011 (with one each measured in the third and fourth quarter).

- The third quarter average concentration of tetrachloroethylene for BURVT is greater than the other quarterly averages and has a confidence interval that is greater than the averages itself. A review of the data shows that the maximum concentration of tetrachloroethylene was measured on September 24, 2011 (0.75 µg/m^3), which is more than twice the next highest concentration (0.31 µg/m^3, measured on October 6, 2011). All other measurements of tetrachloroethylene are 0.20 µg/m^3 or less.

- Several of the quarterly averages of benzene for RUVT have relatively large confidence intervals associated with them. Concentrations of benzene measured at RUVT range from 0.311 µg/m^3 to 2.07 µg/m^3. The maximum benzene concentration was measured on June 17, 2011 and is the only concentration of benzene greater than 1 µg/m^3 measured in the second quarter. A total of eight benzene concentrations greater than 1 µg/m^3 were measured at RUVT, with two measured in the first quarter, one (the maximum) was measured in the second, and five were measured in the fourth quarter.

- Although the second and fourth quarter average concentrations of tetrachloroethylene are the same for RUVT, the second quarter average has a larger confidence interval associated with it. A review of the data shows that the three highest concentrations of tetrachloroethylene were measured in April, May, and June. These are three of only four measurements greater than 0.20 µg/m^3 measured at this site (with the fourth being measured in October).

Observations for UNVT from Table 25-5 include the following:

- UNVT sampled VOCs, PAHs, PM_{10} metals, and hexavalent chromium on a 1-in-6 day schedule.

- Carbon tetrachloride and benzene have highest annual average concentrations. Similar to BURVT and RUVT, all of the annual average concentrations for the pollutants of interest for UNVT are less than 1 µg/m^3.

- Of the metals, manganese and lead have the highest annual average concentrations. For the PAHs, naphthalene has the highest annual average concentration.

- The first quarter benzene average for UNVT is higher than the other quarterly averages, although the differences are not statistically significant. The maximum concentration of benzene was measured on February 27, 2011 (1.31 µg/m^3) and is the only benzene measurement greater than 1 µg/m^3. The second highest benzene concentration measured at UNVT was collected on the following sample day and was half as high (0.755 µg/m^3). Of the 16 measurements greater than 0.5 µg/m^3, 11 were measured during the first quarter, one was measured in third quarter, and four were measured during the fourth quarter.

- Similar to the other Vermont sites, several of the VOCs listed for UNVT were detected relatively few times, resulting in relatively large confidence intervals for the quarterly and annual averages. Examples include acrylonitrile, 1,2-dichloroethane, and hexachloro-1,3-butadiene.

- Third quarter averages for the PM_{10} metals are not provided in Table 25-5. This is a result of flooding and damage to the metals sampler as well as the Vermont Department of Conservation laboratory in the wake of Hurricane Irene at the end of August 2011. While a few missed samples are noted for all methods sampled at UNVT, metals were the most affected because individual samples were lost in the flood at the laboratory.

- Concentrations of naphthalene at UNVT tended to be higher during the colder months of the year. The maximum concentration of naphthalene was measured at UNVT on January 27, 2011 (85.8 ng/m^3). The three highest concentrations of naphthalene were measured at UNVT in January and February and of the 15 highest concentrations (those greater than 15 ng/m^3), 10 were measured during the first quarter of the year and the other five were measured during the fourth quarter of 2011.

- The first quarter benzo(a)pyrene average for UNVT is higher than the other quarterly averages and has a relatively large confidence interval associated with it. The maximum concentration of this pollutant (0.162 ng/m^3) was measured on January 21, 2011 and is one of only three concentrations greater than 0.1 ng/m^3 measured at UNVT. These three measurements were made on the same days as the highest naphthalene concentrations.

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 second highest annual average concentration of hexachloro-1,3-butadiene and the tenth highest annual average concentration of *p*-dichlorobenzene among NMP sites sampling VOCs.

- RUVT appears once in Table 4-9. RUVT has the tenth highest annual average concentration of benzene among NMP sites sampling VOCs.

- UNVT appears only in Table 4-12 for PM_{10} metals. However, because only nine NMP sites sampled PM_{10} metals, all nine sites appear in Table 4-12. UNVT ranks eighth or ninth for each of the six program-wide metal pollutants of interest.

- Compared to other NMP sites, UNVT has some of the lowest annual average concentrations for each of the program-wide pollutants of interest. For the VOCs, UNVT ranks no higher than 16th. For the PAHs and hexavalent chromium, UNVT ranks last for each pollutant.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzene and 1,3-butadiene were created for BURVT, RUVT, and UNVT. Box plots were also created for arsenic, benzo(a)pyrene, hexavalent chromium, manganese, lead, and naphthalene for UNVT. Figures 25-15 through 25-22 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.

Figure 25-15. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

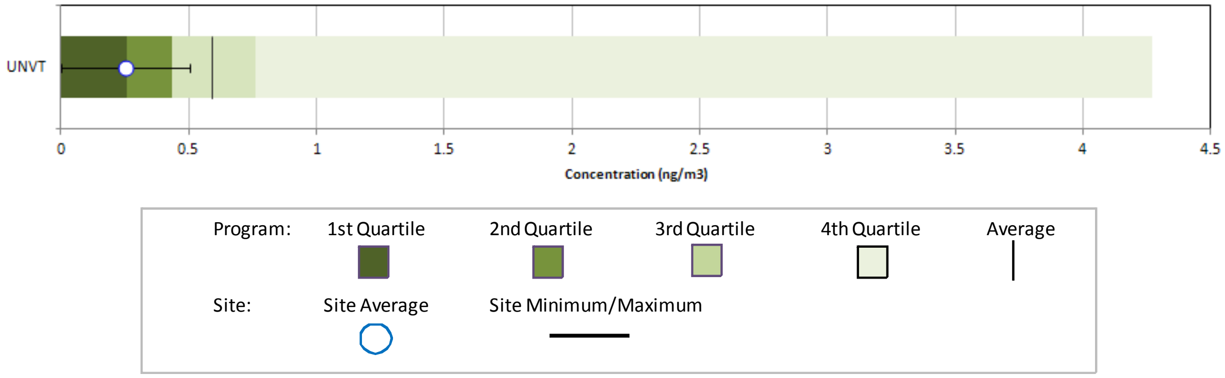


Figure 25-16. Program vs. Site-Specific Average Benzene Concentrations

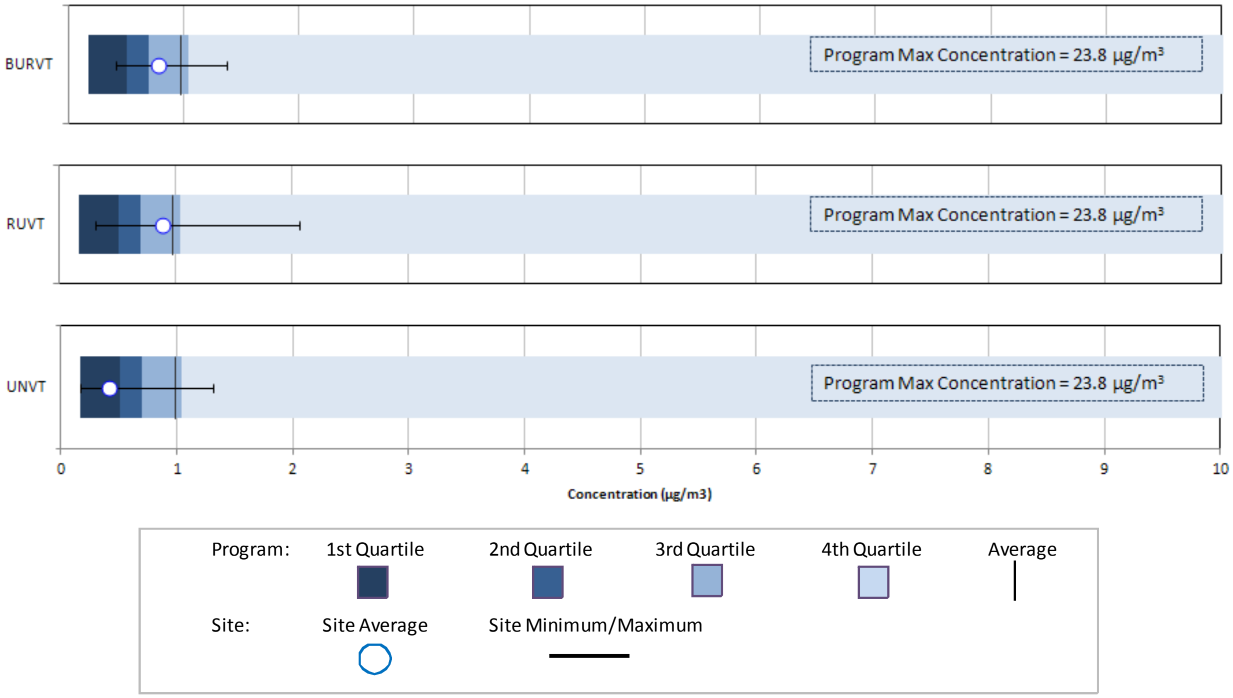


Figure 25-17. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

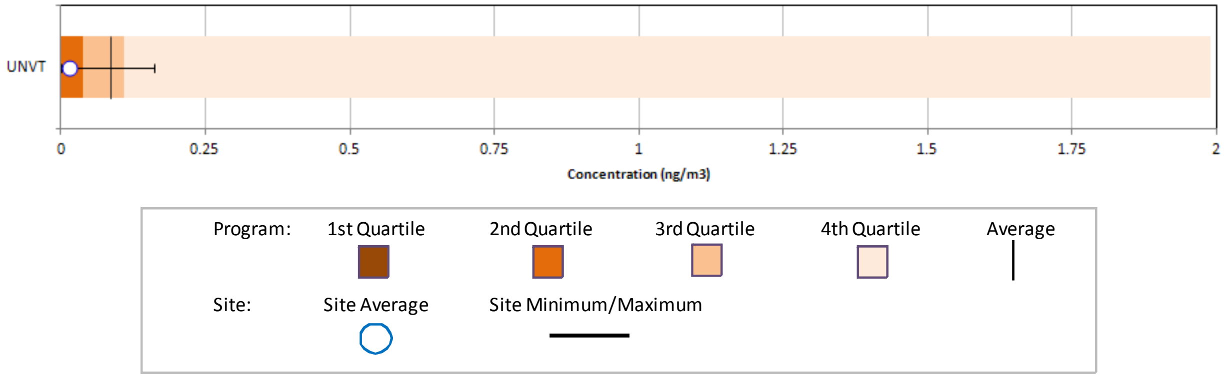


Figure 25-18. Program vs. Site-Specific Average 1,3-Butadiene Concentrations

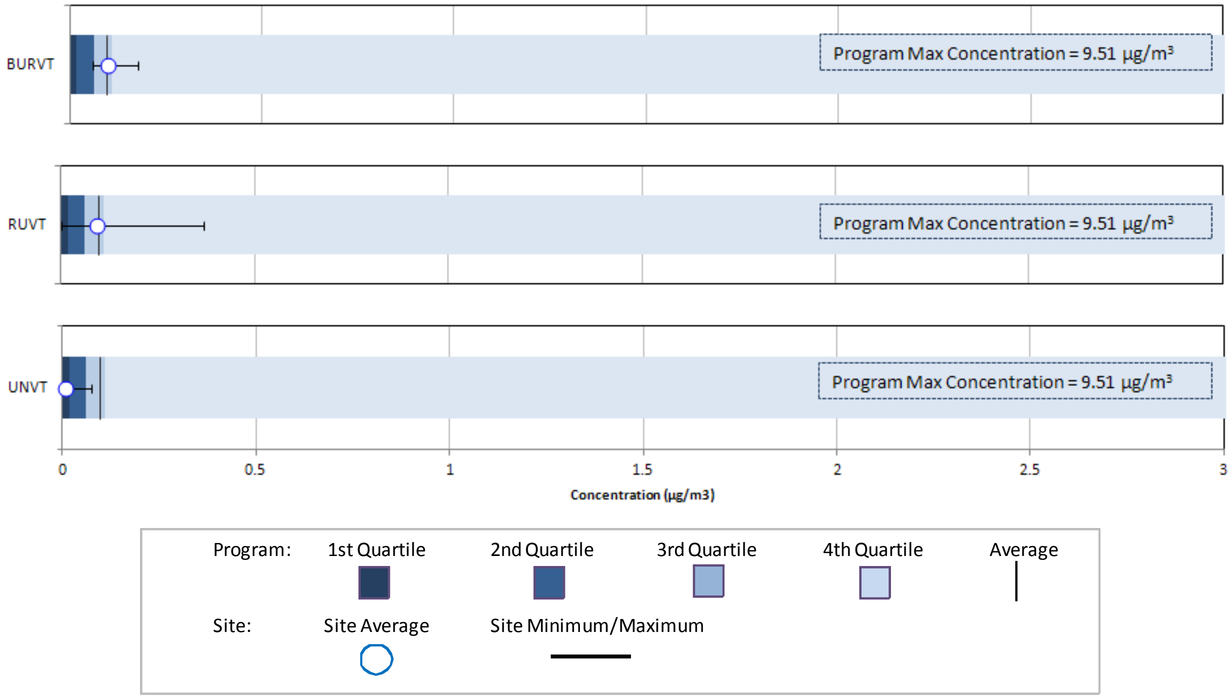


Figure 25-19. Program vs. Site-Specific Average Hexavalent Chromium Concentration

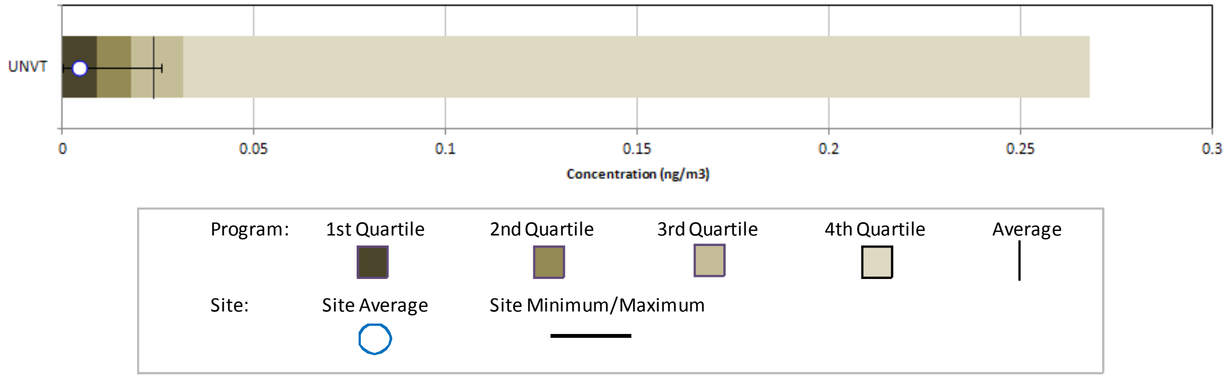


Figure 25-20. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

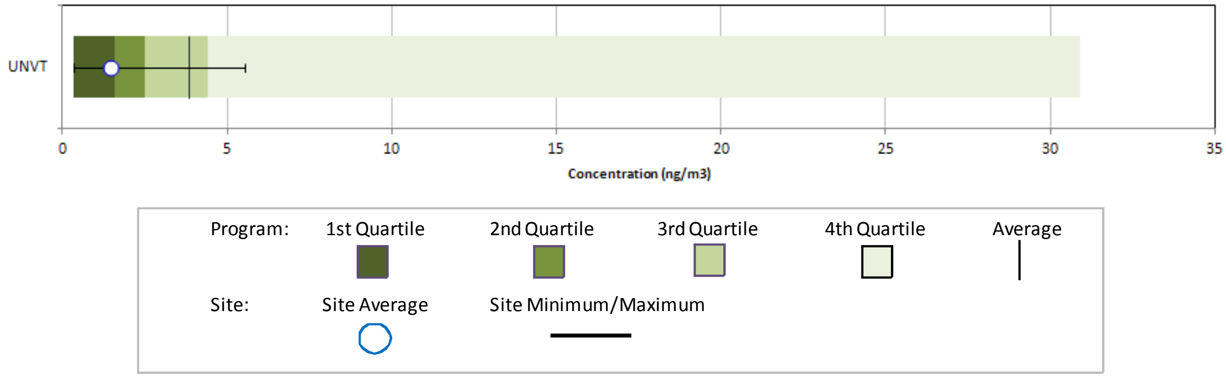


Figure 25-21. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

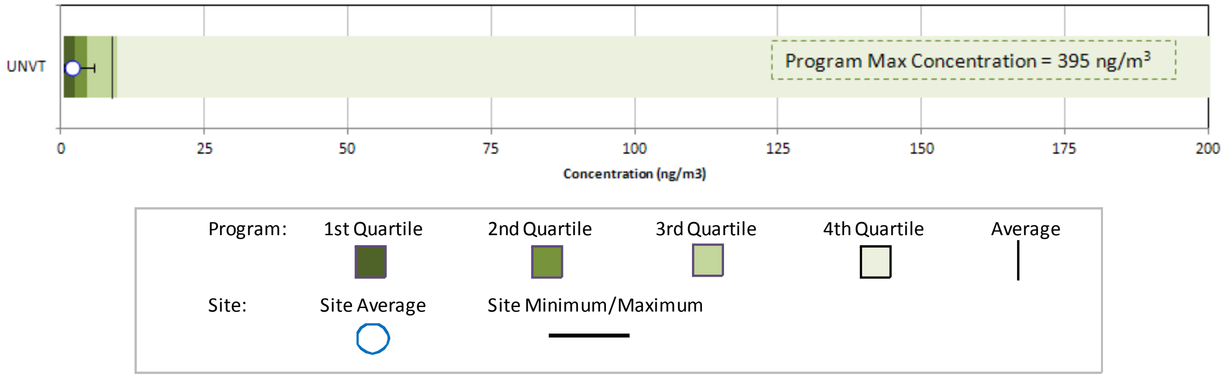
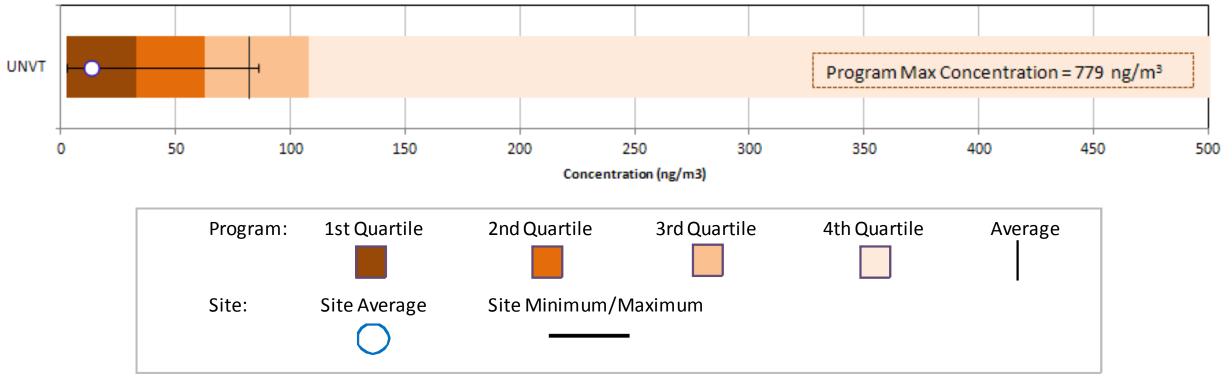


Figure 25-22. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 25-15 through 25-22 include the following:

- Figure 25-15 shows that UNVT's annual average arsenic (PM_{10}) concentration is roughly equivalent to the program-level first quartile (25th percentile). The annual average concentration of arsenic for UNVT is the lowest annual average concentration among NMP sites sampling this pollutant. The maximum arsenic concentration measured at UNVT is less than the program-level average concentration. A few non-detects of arsenic were measured at UNVT.

- Figure 25-16 for benzene shows all three Vermont sites. Note that the program-level maximum concentration (23.8 $\mu g/m^3$) 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 has been reduced to 10 $\mu g/m^3$. This figure shows that the annual average concentration of benzene is highest for RUVT and lowest for UNVT and that all three annual averages are less than the program-level average benzene concentration. Figure 25-16 also shows that UNVT's annual average benzene concentration is less than the program-level average, median, and first quartile concentrations (and is the second lowest among all NMP sites sampling benzene). The range of benzene measurements is smallest for BURVT and largest for RUVT, although there were no non-detects of benzene measured at the Vermont sites. Note that the minimum benzene concentration across the program was measured at UNVT.

- Figure 25-17 is the box plot for benzo(a)pyrene for UNVT. Note that the first quartile for this pollutant is zero and is not visible on the box plot. This box plot shows that the annual average concentration for UNVT is less than the program-level average and median concentrations. The maximum concentration measured at UNVT is considerably less than the maximum concentration measured across the program. Nearly 80 percent of the measurements at UNVT were non-detects.

- Figure 25-18 for 1,3-butadiene also shows all three sites. Similar to the benzene box plots, the program-level maximum concentration (9.51 µg/m^3) is not shown directly on the box plots as the scale has been reduced to 3 µg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. The annual average concentration for BURVT is similar to the annual average for RUVT, even though the range of measurements is higher for RUVT, and both are roughly equivalent to the program-level average concentration. The annual average for UNVT is an order of magnitude lower than the other two Vermont sites. The maximum concentration measured at each site is considerably less than the maximum 1,3-butadiene concentration measured across the program. Five non-detects of 1,3-butadiene were measured at RUVT and 80 percent of the measurements were non-detects for UNVT. Conversely, the minimum concentration of 1,3-butadiene measured at BURVT is equivalent to the program-level median concentration.

- Figure 25-19 is the box plot for hexavalent chromium for UNVT. This figure shows that the annual average concentration of hexavalent chromium for UNVT is less than the program-level first quartile and is the lowest annual average hexavalent chromium concentration among NMP sites sampling this pollutant. The maximum concentration measured at UNVT is just greater than the program-level average concentration. Nearly 70 percent of the measurements of hexavalent chromium were non-detects.

- Figure 25-20 is the box plot for lead (PM_{10}) for UNVT. This figure shows that the annual average concentration of lead for UNVT is just less than the program-level first quartile and is the lowest annual average lead concentration among NMP sites sampling this pollutant. The maximum concentration measured at UNVT is the lowest maximum concentration among NMP sites sampling lead. The minimum concentration measured at UNVT is the lowest minimum concentration among NMP sites sampling lead.

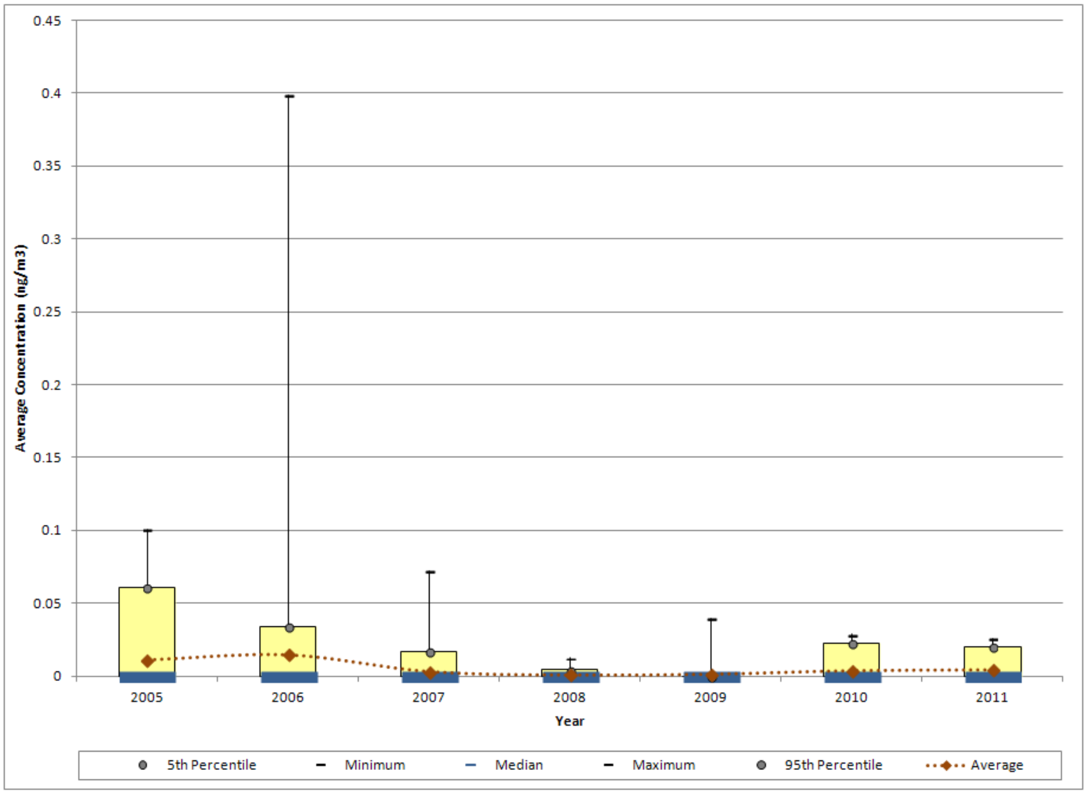
- Figure 25-21 is the box plot for manganese (PM_{10}) for UNVT. Note that the program-level maximum concentration (395 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 200 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. This figure shows that, similar to other metals, the annual average concentration of manganese (PM_{10}) for UNVT is less than the program-level first quartile. The annual average concentration of manganese for UNVT is the lowest annual average concentration among NMP sites sampling this pollutant. There were no non-detects of manganese measured at UNVT.

- Figure 25-22 is the box plot for naphthalene for UNVT. Note that the program-level maximum concentration (799 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 ng/m^3 in order to allow for the observation of data points at the lower end of the concentration range. The annual average for UNVT is less than the program-level first quartile and ranks lowest among all sites sampling this pollutant. The maximum naphthalene concentration measured at UNVT is less than the program-level third quartile and just greater than the program-level average concentration. It is also the lowest maximum concentration among NMP sites sampling naphthalene.

25.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. UNVT has sampled hexavalent chromium under the NMP since 2005. Thus, Figure 25-23 presents the annual statistical metrics for hexavalent chromium for UNVT. The statistical metrics presented for calculating trends include the substitution of zeros for non-detects. Sampling of the other methods did not begin until 2008 and thus does not meet the 5-consecutive year criterion.

Figure 25-23. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at UNVT



Observations from Figure 25-23 for hexavalent chromium measurements at UNVT include the following:

- The maximum hexavalent chromium concentration was measured at UNVT on June 16, 2006 (0.399 ng/m^3). The next highest hexavalent chromium concentration was measured on April 22, 2005 (0.101 ng/m^3). All other measurements of this pollutant are less than 0.1 ng/m^3.

- For all time frames shown, the minimum, 5th percentile, and median concentrations are zero, indicating that at least 50 percent of the measurements are non-detects. The percentage of non-detects has varied over the years of sampling, from as low as 63 percent in 2006 to as high as 95 percent in 2009.

- The second highest concentration measured in 2006 is an order of magnitude less than the maximum concentration measured that year. The 95th percentile decreased by almost half from 2005 to 2006. Both are an indication that the maximum concentration is driving the average concentration measured at UNVT for 2006. If this measurement were removed from the calculations, Figure 25-23 would show a decreasing trend beginning with 2006.

- The average concentration decreased from 2006 to 2007 and again in 2008. Fewer than 10 percent of the samples collected in 2008 and 2009 had measurable levels of hexavalent chromium, which explains why even the average and 95th percentile are nearly zero for these years. The number of non-detects decreased for 2010 and 2011 to between 70 and 80 percent, allowing the average concentration to increase. The average concentrations for 2010 and 2011 are around 0.004 ng/m^3.

25.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

25.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Vermont 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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.

Observations from Table 25-6 include the following:

- For BURVT, benzene and carbon tetrachloride have the highest annual average concentrations. These two pollutants also have the highest cancer risk approximations for BURVT (6.08 in-a-million and 3.52 in-a-million, respectively).
- Similar to BURVT, benzene and carbon tetrachloride have the highest annual average concentrations for RUVT. These two pollutants also have the highest cancer risk approximations for RUVT (6.94 in-a-million and 3.65 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 (3.41 in-a-million and 3.25 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.

Table 25-6. Risk Approximations for the Vermont Monitoring Sites

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 Hazard Approximation (HQ)
Burlington, Vermont - BURVT						
Acrylonitrile	0.000068	0.002	4/30	0.02 ± 0.03	1.60	0.01
Benzene	0.0000078	0.03	30/30	0.78 ± 0.09	6.08	0.03
1,3-Butadiene	0.00003	0.002	30/30	0.10 ± 0.01	2.98	0.05
Carbon Tetrachloride	0.000006	0.1	30/30	0.59 ± 0.04	3.52	0.01
Chloroform	--	0.098	17/30	0.07 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	27/30	0.07 ± 0.01	0.77	<0.01
1,2-Dichloroethane	0.000026	2.4	7/30	0.02 ± 0.01	0.47	<0.01
Ethylbenzene	0.0000025	1	30/30	0.30 ± 0.04	0.75	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	6/30	0.02 ± 0.01	0.41	<0.01
1,1,2,2-Tetrachloroethane	0.000058	--	4/30	0.01 ± 0.01	0.41	--
Tetrachloroethylene	0.00000026	0.04	23/30	0.12 ± 0.05	0.03	<0.01
Trichloroethylene	0.0000048	0.002	2/30	<0.01 ± <0.01	0.02	<0.01
Vinyl Chloride	0.0000088	0.1	1/30	<0.01 ± <0.01	0.01	<0.01
Rutland, Vermont - RUVT						
Benzene	0.0000078	0.03	30/30	0.89 ± 0.16	6.94	0.03
1,3-Butadiene	0.00003	0.002	25/30	0.09 ± 0.03	2.80	0.05
Carbon Tetrachloride	0.000006	0.1	30/30	0.61 ± 0.04	3.65	0.01
Chloroform	--	0.098	9/30	0.04 ± 0.03	--	<0.01
1,2-Dichloroethane	0.000026	2.4	4/30	0.01 ± 0.01	0.29	<0.01
Ethylbenzene	0.0000025	1	30/30	0.30 ± 0.04	0.76	<0.01
Tetrachloroethylene	0.00000026	0.04	23/30	0.12 ± 0.04	0.03	<0.01
Trichloroethylene	0.0000048	0.002	2/30	<0.01 ± <0.01	0.01	<0.01
Vinyl Chloride	0.0000088	0.1	0/30	<0.01 ± <0.01	<0.01	<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 25-5.

Table 25-6. Risk Approximations for the Vermont 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 Hazard Approximation (HQ)
Underhill, Vermont - UNVT						
Acrylonitrile	0.000068	0.002	6/60	0.01 ± 0.01	0.41	<0.01
Arsenic (PM$_{10}$)[a]	0.0043	0.000015	54/57	<0.01 ± <0.01	1.09	0.02
Benzene	0.0000078	0.03	60/60	0.42 ± 0.04	3.25	0.01
Benzo(a)pyrene [a]	0.00176	--	13/60	<0.01 ± <0.01	0.03	--
Beryllium (PM$_{10}$) [a]	0.0024	0.00002	45/57	<0.01 ± <0.01	0.01	<0.01
1,3-Butadiene	0.00003	0.002	13/60	0.01 ± <0.01	0.21	<0.01
Cadmium (PM$_{10}$) [a]	0.0018	0.00001	57/57	<0.01 ± <0.01	0.12	0.01
Carbon Tetrachloride	0.000006	0.1	60/60	0.57 ± 0.04	3.41	0.01
Chloroform	--	0.098	17/60	0.03 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	12/60	0.02 ± 0.01	0.40	<0.01
Hexachloro-1,3-butadiene	0.000022	0.09	4/60	0.01 ± 0.01	0.14	<0.01
Hexavalent Chromium [a]	0.012	0.0001	17/60	<0.01 ± <0.01	0.05	<0.01
Lead (PM$_{10}$) [a]	--	0.00015	57/57	<0.01 ± <0.01	--	0.01
Manganese (PM$_{10}$) [a]	--	0.00005	57/57	<0.01 ± <0.01	--	0.04
Naphthalene [a]	0.000034	0.003	60/60	0.01 ± <0.01	0.45	<0.01
Nickel (PM$_{10}$) [a]	0.00048	0.00009	57/57	<0.01 ± <0.01	0.25	0.01
Tetrachloroethylene	0.00000026	0.04	19/60	0.02 ± 0.01	0.01	<0.01
Trichloroethylene	0.0000048	0.002	1/60	<0.01 ± <0.01	<0.01	<0.01
Vinyl Chloride	0.0000088	0.1	1/60	<0.01 ± <0.01	<0.01	<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 25-5.

25.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 25-7 and 25-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million) for the Vermont monitoring sites, as calculated from the annual averages provided in Table 25-6. Table 25-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 25-6.

The pollutants listed in Tables 25-7 and 25-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 25.3, UNVT sampled for VOCs, PAHs, metals (PM_{10}), and hexavalent chromium; BURVT and RUVT sampled for VOCs only. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, 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 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	117.39	Benzene	9.16E-04	Benzene	6.08
Formaldehyde	57.01	Formaldehyde	7.41E-04	Carbon Tetrachloride	3.52
Ethylbenzene	42.71	1,3-Butadiene	3.90E-04	1,3-Butadiene	2.98
Acetaldehyde	30.61	Hexavalent Chromium, PM	2.57E-04	Acrylonitrile	1.60
1,3-Butadiene	12.99	POM, Group 3	2.46E-04	*p*-Dichlorobenzene	0.77
Dichloromethane	7.10	Arsenic, PM	2.44E-04	Ethylbenzene	0.75
Naphthalene	6.54	Naphthalene	2.22E-04	1,2-Dichloroethane	0.47
POM, Group 2b	1.69	POM, Group 2b	1.49E-04	1,1,2,2-Tetrachloroethane	0.41
POM, Group 6	0.20	POM, Group 5a	1.24E-04	Hexachloro-1,3-butadiene	0.41
POM, Group 1a	0.12	Ethylbenzene	1.07E-04	Tetrachloroethylene	0.03
Underhill, Vermont (Chittenden County) - UNVT					
Benzene	117.39	Benzene	9.16E-04	Carbon Tetrachloride	3.41
Formaldehyde	57.01	Formaldehyde	7.41E-04	Benzene	3.25
Ethylbenzene	42.71	1,3-Butadiene	3.90E-04	Arsenic	1.09
Acetaldehyde	30.61	Hexavalent Chromium, PM	2.57E-04	Naphthalene	0.45
1,3-Butadiene	12.99	POM, Group 3	2.46E-04	Acrylonitrile	0.41
Dichloromethane	7.10	Arsenic, PM	2.44E-04	1,2-Dichloroethane	0.40
Naphthalene	6.54	Naphthalene	2.22E-04	Nickel	0.25
POM, Group 2b	1.69	POM, Group 2b	1.49E-04	1,3-Butadiene	0.21
POM, Group 6	0.20	POM, Group 5a	1.24E-04	Hexachloro-1,3-butadiene	0.14
POM, Group 1a	0.12	Ethylbenzene	1.07E-04	Cadmium	0.12

Table 25-7. 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	54.68	Benzene	4.26E-04	Benzene	6.94
Formaldehyde	24.42	Formaldehyde	3.17E-04	Carbon Tetrachloride	3.65
Ethylbenzene	20.01	1,3-Butadiene	1.94E-04	1,3-Butadiene	2.80
Acetaldehyde	14.97	POM, Group 3	1.38E-04	Ethylbenzene	0.76
1,3-Butadiene	6.47	Hexavalent Chromium, PM	1.24E-04	1,2-Dichloroethane	0.29
Naphthalene	3.14	Naphthalene	1.07E-04	Tetrachloroethylene	0.03
POM, Group 2b	0.93	POM, Group 2b	8.17E-05	Trichloroethylene	0.01
Dichloromethane	0.47	POM, Group 5a	6.57E-05	Vinyl Chloride	0.00
POM, Group 6	0.12	Ethylbenzene	5.00E-05		
POM, Group 1a	0.06	Acetaldehyde	3.29E-05		

Table 25-8. 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	221.14	Acrolein	552,694.88	1,3-Butadiene	0.05
Xylenes	170.08	Manganese, PM	67,632.70	Benzene	0.03
Benzene	117.39	Chlorine	13,450.30	Acrylonitrile	0.01
Methanol	88.67	1,3-Butadiene	6,493.30	Carbon Tetrachloride	0.01
Formaldehyde	57.01	Formaldehyde	5,817.27	Tetrachloroethylene	<0.01
Ethylbenzene	42.71	Benzene	3,912.93	Trichloroethylene	<0.01
Hexane	41.71	Arsenic, PM	3,782.88	Chloroform	<0.01
Hydrochloric acid	41.61	Acetaldehyde	3,400.90	Ethylbenzene	<0.01
Acetaldehyde	30.61	Cyanide Compounds, gas	2,550.52	Hexachloro-1,3-butadiene	<0.01
1,3-Butadiene	12.99	Naphthalene	2,180.85	*p*-Dichlorobenzene	<0.01
Underhill, Vermont (Chittenden County) - UNVT					
Toluene	221.14	Acrolein	552,694.88	Manganese	0.04
Xylenes	170.08	Manganese, PM	67,632.70	Arsenic	0.02
Benzene	117.39	Chlorine	13,450.30	Benzene	0.01
Methanol	88.67	1,3-Butadiene	6,493.30	Lead	0.01
Formaldehyde	57.01	Formaldehyde	5,817.27	Cadmium	0.01
Ethylbenzene	42.71	Benzene	3,912.93	Nickel	0.01
Hexane	41.71	Arsenic, PM	3,782.88	Carbon Tetrachloride	0.01
Hydrochloric acid	41.61	Acetaldehyde	3,400.90	Naphthalene	<0.01
Acetaldehyde	30.61	Cyanide Compounds, gas	2,550.52	1,3-Butadiene	<0.01
1,3-Butadiene	12.99	Naphthalene	2,180.85	Acrylonitrile	<0.01

Table 25-8. 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	121.10	Acrolein	74,401.74	1,3-Butadiene	0.05
Xylenes	77.74	1,3-Butadiene	3,234.62	Benzene	0.03
Benzene	54.68	Formaldehyde	2,492.15	Carbon Tetrachloride	0.01
Methanol	37.29	Cyanide Compounds, gas	2,311.36	Tetrachloroethylene	<0.01
Formaldehyde	24.42	Benzene	1,822.62	Trichloroethylene	<0.01
Ethylbenzene	20.01	Acetaldehyde	1,663.70	Chloroform	<0.01
Hexane	17.83	Naphthalene	1,045.42	Ethylbenzene	<0.01
Acetaldehyde	14.97	Xylenes	777.44	1,2-Dichloroethane	<0.01
1,3-Butadiene	6.47	Arsenic, PM	462.98	Vinyl Chloride	<0.01
Styrene	5.25	Lead, PM	399.93		

Observations from Table 25-7 include the following:

- Benzene, formaldehyde, and ethylbenzene are the highest emitted pollutants with cancer UREs in Chittenden and Rutland Counties, although the emissions in Chittenden County were nearly twice those in Rutland County.

- Benzene, formaldehyde, and 1.3-butadiene are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for both counties.

- Six 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 and carbon tetrachloride have the highest cancer risk approximations for all three sites. Benzene topped both emissions-based lists for both counties, while carbon tetrachloride appeared on neither emissions-based list for either county. 1,3-Butadiene also appears on all three lists for each site. Ethylbenzene appears on all three lists for BURVT and RUVT but is not a pollutant of interest for UNVT. Naphthalene also appears on all three lists for UNVT.

- Arsenic has the third highest cancer risk approximation and ranks sixth for toxicity-weighted emissions, but is not one of the highest emitted.

- Benzo(a)pyrene is part of POM, Group 5a and is one of UNVT's pollutants of interest. POM, Group 5a has the ninth highest toxicity-weighted emissions but is not among the highest emitted in Chittenden County.

- POM, Group 2b ranks eighth for both quantity emitted and its toxicity-weighted emissions in Chittenden County. POM, Group 2b includes several PAHs sampled for at UNVT including acenaphthylene, fluoranthene, and perylene. None of the PAHs included in POM, Group 2b failed screens for UNVT. POM, Groups 1a, 3, and 6 also appear in Table 25-7, but only POM, Group 6 includes PAHs sampled for at UNVT (benzo(a)anthracene, for example), but none of these pollutants failed screens.

Observations from Table 25-8 include the following:

- Toluene, xylenes, and benzene are the highest emitted pollutants with noncancer RfCs in Chittenden and Rutland Counties, although the emissions in Chittenden County were nearly 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.

- Four 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 and 1,3-butadiene appear on both emissions-based lists.

- Although very low, manganese and arsenic have the highest noncancer hazard approximations for UNVT. While these pollutants rank second and seventh among the toxicity-weighted emissions for Chittenden County, respectively, neither pollutant appears among the highest emitted.

25.6 Summary of the 2011 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; seven pollutants failed screens for RUVT; and 13 pollutants failed screens for UNVT.*

- ❖ *None of the annual average concentrations of the pollutants of interest for the Vermont monitoring sites were greater than 1 µg/m^3.*

- ❖ *The annual average concentrations for several of UNVT's pollutants of interest were the lowest annual averages among all NMP sites sampling those pollutants.*

26.0 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.

26.1 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. Figure 26-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its urban location. Figure 26-2 identifies nearby point source emissions locations by source category, as reported in the 2008 NEI for point sources. Note that only sources within 10 miles of the site are included in the facility counts provided in Figure 26-2. 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 26-1 provides supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 26-1. Richmond, Virginia (RIVA) Monitoring Site

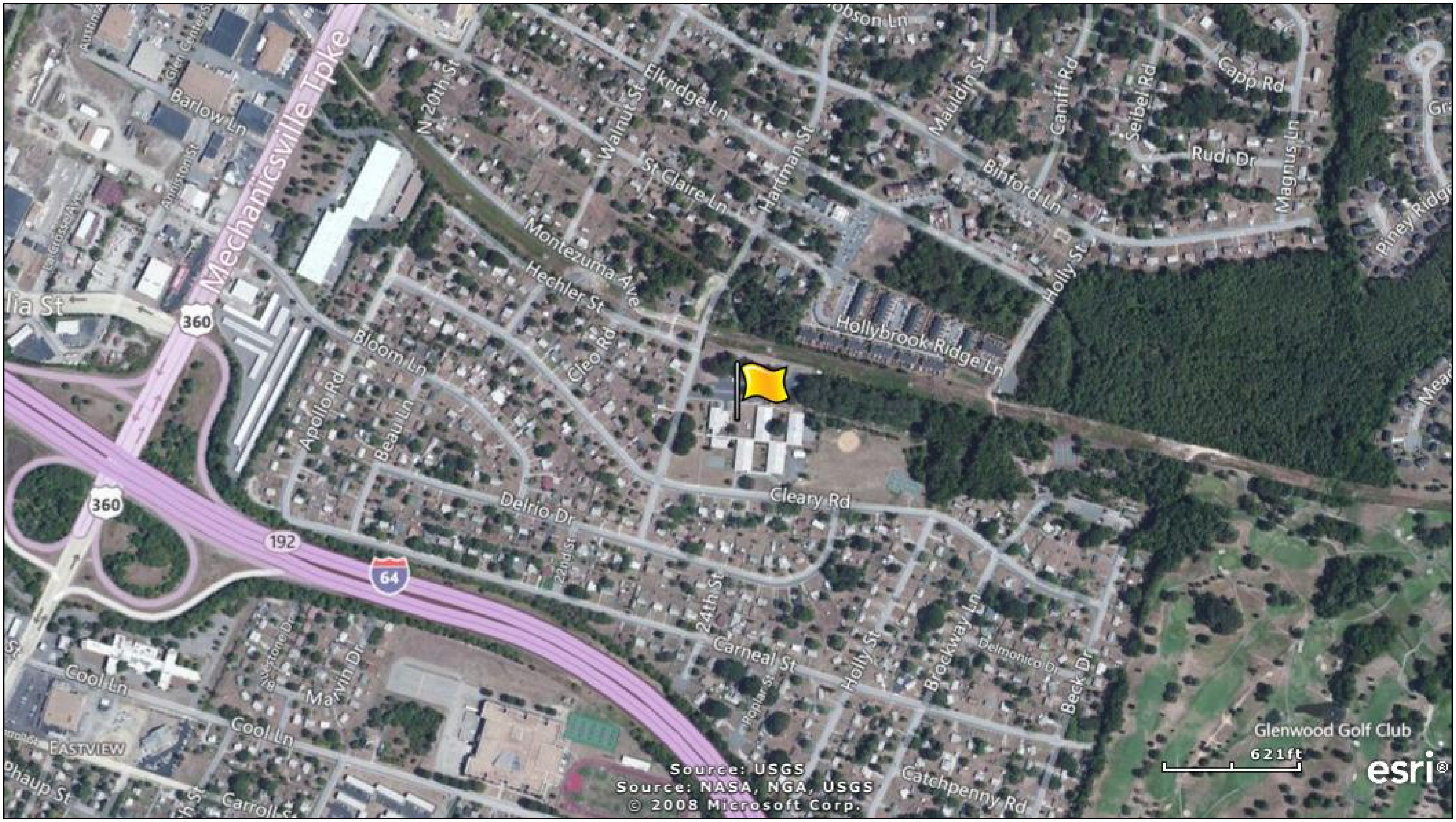


Figure 26-2. NEI Point Sources Located Within 10 Miles of RIVA

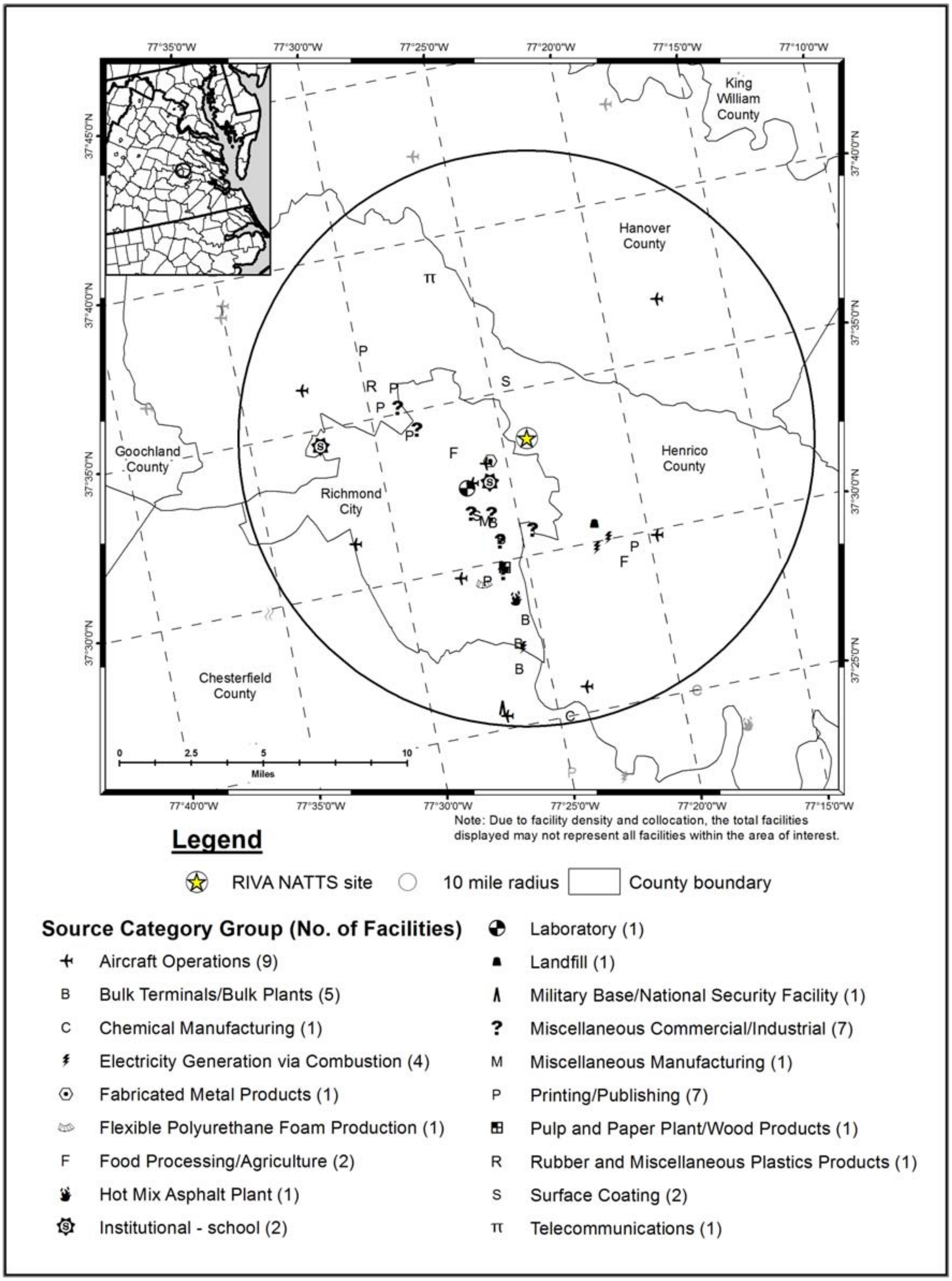


Table 26-1. Geographical Information for the Virginia Monitoring Site

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	Richmond	Henrico	Richmond, VA MSA	37.55655, -77.400411	Residential	Suburban	TSP Metals, SO_2, NO_y, NO, NO_2, NO_x, PAMS, NMOCs, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Metals, PM Coarse, $PM_{2.5}$, and $PM_{2.5}$ Speciation, CO, Tetrahydrofuran.

[1] Data for additional pollutants are reported to AQS for this site (EPA, 2012c); 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 less than 1/4 mile from I-64. The I-64 interchange with Mechanicsville Turnpike (360) is less than 1/2 mile southwest of the site, as shown in Figure 26-1. Beyond the residential areas surrounding the school property are a golf course to the southeast, a high school to the south (on the southside of I-64), and commercial areas to the west. As Figure 26-2 shows, RIVA is located near several point sources, most of which are located to the southeast and south of the site and within the city of Richmond. The sources closest to RIVA are a fabricated metal products 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 aircraft operations, which include airports as well as small runways, heliports, or landing pads; printing and publishing facilities; bulk terminals and bulk plants; and facilities generating electricity via combustion.

Table 26-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Virginia monitoring site. Table 26-2 includes county-level population and vehicle registration information. Table 26-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 26-2 also contains traffic volume information for RIVA. Finally, Table 26-2 presents the county-level daily VMT for Henrico County.

Table 26-2. Population, Motor Vehicle, and Traffic Information for the Virginia Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
RIVA	310,445	354,721	1.14	476,219	544,138	73,000	8,246,774

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Revenue Division of the County of Henrico (Henrico County, 2012)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data from the Virginia DOT (VA DOT, 2011)
[5] County-level VMT reflects 2011 data from the Virginia DOT (VA DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 26-2 include the following:

- RIVA's county-level population is in the lower third of the range compared to other counties with NMP sites while its 10-mile population is in the middle of the range among NMP sites.

- The county-level and 10-mile vehicle ownerships are in the middle of the range compared to other NMP sites.

- The vehicle-per-person ratio is among the higher ratios compared to other NMP sites.

- The traffic volume experienced near RIVA is in the middle of the range compared to other NMP monitoring sites. The traffic volume provided is for the interchange of US-360 (Mechanicsville Turnpike) and I-64.

- The daily VMT for Henrico County is in the middle of the range compared to other counties with NMP sites (where VMT data are available).

26.2 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.

26.2.1 Climate Summary

The city of Richmond is located in east-central Virginia, east of the Blue Ridge Mountains and west of the Chesapeake Bay. 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 (Bair, 1992).

26.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2011 (NCDC, 2011). 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 26-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

Table 26-3. Average Meteorological Conditions near the Virginia Monitoring Site

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)
Richmond, Virginia - RIVA									
Richmond International Airport 13740 (37.51, -77.32)	5.16 miles 118° (ESE)	Sample Day	69.8 ± 4.2	60.0 ± 4.0	47.2 ± 4.8	53.6 ± 3.9	66.8 ± 3.9	1016.9 ± 1.7	6.4 ± 0.8
		2011	70.6 ± 1.7	60.6 ± 1.7	47.9 ± 1.8	54.1 ± 1.6	66.7 ± 1.4	1017.0 ± 0.7	6.2 ± 0.3

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

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 the entire year. Also included in Table 26-3 is the 95 percent confidence interval for each parameter. As shown in Table 26-3, average meteorological conditions on sample days were representative of average weather conditions throughout the year.

26.2.3 Back Trajectory Analysis

Figure 26-3 is the composite back trajectory map for days on which samples were collected at the RIVA monitoring site in 2011. Included in Figure 26-3 are four back trajectories per sample day. Figure 26-4 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 26-3 and 26-4 represents 100 miles.

Observations from Figures 26-3 and Figure 26-4 for RIVA include the following:

- Back trajectories originated from a variety of directions near RIVA, although a large number of them originated to the northwest.

- The 24-hour air shed domain for RIVA was similar in size to many other NMP monitoring sites. The farthest away a trajectory originated was over the Upper Peninsula of Michigan, or over 700 miles away. However, the average trajectory length is 242 miles and most back trajectories (87 percent) originated within 400 miles of the site.

- The cluster analysis shows that 28 percent of back trajectories originated from the northwest of RIVA over Michigan, Ohio, and Indiana. Seventeen percent originated from the southwest to west and includes back trajectories of varying lengths. The cluster trajectory originating over eastern North Carolina (36 percent) represents back trajectories originating from the east, southeast, and south, primarily over eastern North Carolina but also over the offshore waters of Virginia, North Carolina, and South Carolina. Another 19 percent of back trajectories originated from the north-northwest, north, and northeast of the site.

Figure 26-3. 2011 Composite Back Trajectory Map for RIVA

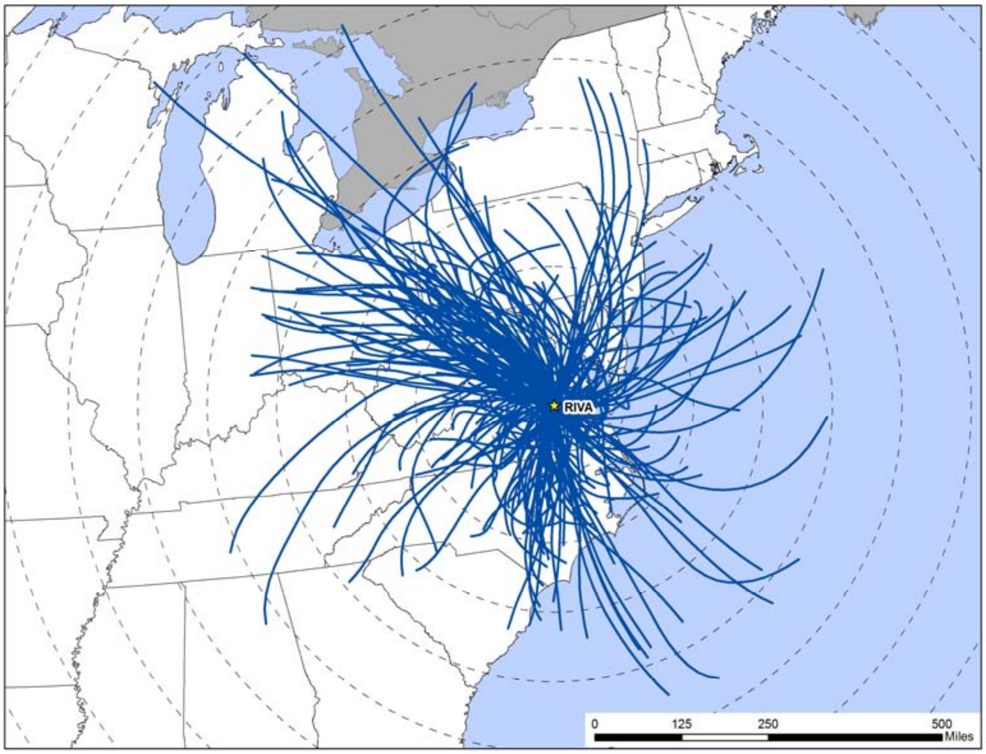


Figure 26-4. Back Trajectory Cluster Map for RIVA

26.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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 26-5 presents a map showing the distance between the NWS station and RIVA, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location. Figure 26-5 also presents three different wind roses for the RIVA monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Observations from Figure 26-5 for RIVA include the following:

- The Richmond International weather station is located approximately 5.1 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 quadrant were observed the least. Calm winds (≤ 2 knots) were observed for approximately 15 percent of the hourly wind measurements.

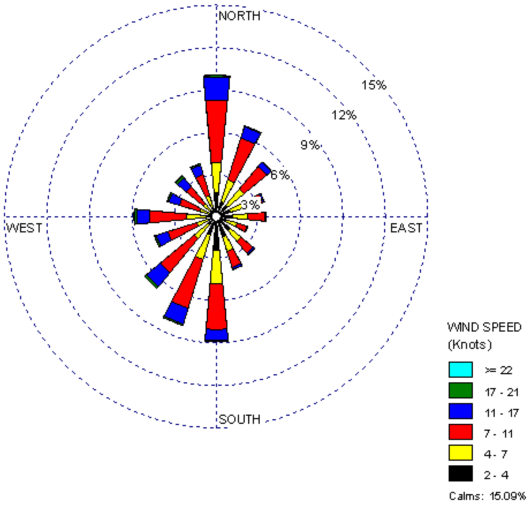
- The 2011 wind rose resembles the historical wind rose in some ways but exhibits differences as well. Southerly and south-southwesterly winds were more prominent in 2011, although northerly winds were still frequently observed.

- Northerly winds prevailed on sample days near RIVA, although southerly winds still accounted for greater than 10 percent of the wind observations. A higher percentage of winds from the northwest quadrant were observed on sample days compared to the entire year and historically. There were also fewer wind observations from the southwest quadrant on sample days compared to the entire year and historically.

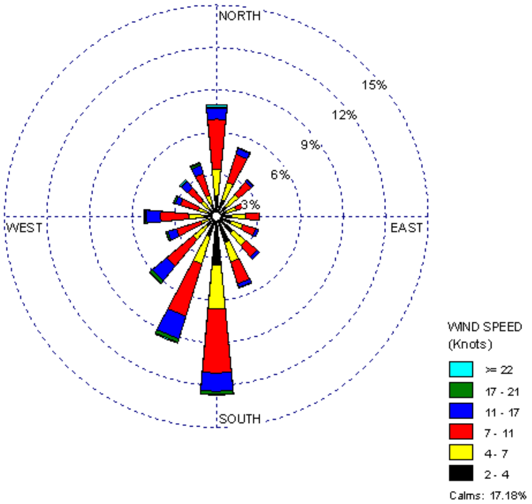
Figure 26-5. Wind Roses for the Richmond International Airport Weather Station near RIVA

Distance between RIVA and NWS Station

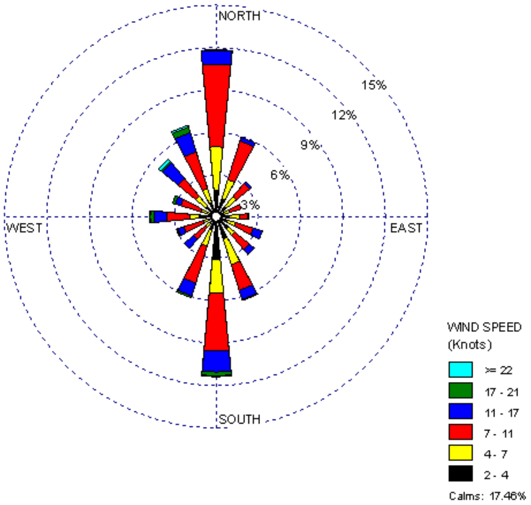
2001-2010 Historical Wind Rose



2011 Wind Rose



Sample Day Wind Rose



26.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Virginia monitoring site in order to allow 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." 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 26-4 presents the results of the preliminary risk-based screening process for RIVA. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens for the monitoring site are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. RIVA sampled for PAHs and hexavalent chromium.

Table 26-4. Risk-Based Screening Results for the Virginia Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Richmond, Virginia - RIVA						
Naphthalene	0.029	54	61	88.52	94.74	94.74
Acenaphthene	0.011	1	61	1.64	1.75	96.49
Benzo(a)pyrene	0.00057	1	30	3.33	1.75	98.25
Fluorene	0.011	1	61	1.64	1.75	100.00
Total		57	213	26.76		

Observations from Table 26-4 include the following:

- Although four PAHs failed screens for RIVA, naphthalene contributed to roughly 95 percent of the total failed screens, while the other pollutants accounted for a single failed screen each.
- The risk-based screening process identified all four PAHs failing screens as the pollutants of interest for RIVA. This is because two of the pollutants contribute to the minimum 95 percent criteria discussed in Section 3.2, but because benzo(a)pyrene and fluorene contributed equally to the number of failed screens as acenaphthene,

these pollutants were also designated as pollutants of interest. Hexavalent chromium was also added to the pollutants of interest for RIVA because it is a NATTS MQO Core Analyte, even though it did not fail any screens. This pollutant is not shown in Table 26-4 but is shown in subsequent tables in the sections that follow.

26.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for RIVA, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for RIVA are provided in Appendices M and O.

26.4.1 2011 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 of 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 26-5, 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 26-5. 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)
Richmond, Virginia - RIVA						
Acenaphthene	61/61	1.17 ± 0.21	4.53 ± 1.59	4.66 ± 1.14	2.05 ± 0.79	3.13 ± 0.64
Benzo(a)pyrene	30/61	0.12 ± 0.07	0.01 ± 0.01	0.08 ± 0.15	0.10 ± 0.06	0.08 ± 0.04
Fluorene	61/61	2.18 ± 0.34	4.83 ± 1.57	4.92 ± 1.11	2.69 ± 0.66	3.68 ± 0.58
Hexavalent Chromium	48/61	0.01 ± <0.01	0.01 ± <0.01	0.02 ± 0.01	0.01 ± <0.01	0.01 ± <0.01
Naphthalene	61/61	72.80 ± 20.97	76.51 ± 22.49	70.33 ± 15.69	93.27 ± 26.43	78.10 ± 10.38

Observations for RIVA from Table 26-5 include the following:

- The annual average concentration of naphthalene is significantly higher than the annual average concentrations of the remaining pollutants of interest.

- The quarterly averages of naphthalene have a relatively high-level of variability associated with them, as indicated by the confidence intervals. The maximum concentration measured at RIVA was measured on May 9, 2011 (175 ng/m^3), although 17 concentrations greater than or equal to 100 ng/m^3 were measured at this site. Six of these were measured during the fourth quarter of 2011, while the other quarters have three or four each.

- The quarterly averages of acenaphthene and fluorene are higher in the warmer months of the year and lower in the colder months of the year. The maximum concentrations of both of these pollutants were measured on June 8, 2011. Of the 26 acenaphthene concentrations greater than 3 ng/m^3, 11 were measured in the second quarter of 2011 and 12 were measured during the third quarter of 2011. Conversely, all but two of the 11 concentrations less than 1 ng/m^3 were measured in the first or fourth quarters of 2011. A similar pattern is shown in the concentrations of fluorene.

- The maximum benzo(a)pyrene concentration was measured at RIVA on August 16, 2011 (1.14 ng/m^3) and is one of only seven concentrations greater than 1 ng/m^3 for this PAH measured across the program. The second highest concentration of this pollutant measured at RIVA was half as high (0.515 ng/m^3) and was measured in March. Aside from the August 16th measurement, concentrations of benzo(a)pyrene tended to be higher during the colder months of the year. Of the 30 measured detections of this pollutant, 12 were measured during the first quarter, three were measured in the second, five were measured in the third, and 10 were measured in the fourth. Conversely, of the 31 non-detects, three were measured during the first quarter, 12 were measured in the second, 11 were measured in the third, and five were measured in the fourth.

- Hexavalent chromium concentrations ranged from 0.0011 ng/m^3 to 0.0466 ng/m^3, with the five highest concentrations all measured during the third quarter of 2011.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for benzo(a)pyrene, hexavalent chromium, and naphthalene were created for RIVA. Figures 26-6 through 26-8 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 26-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

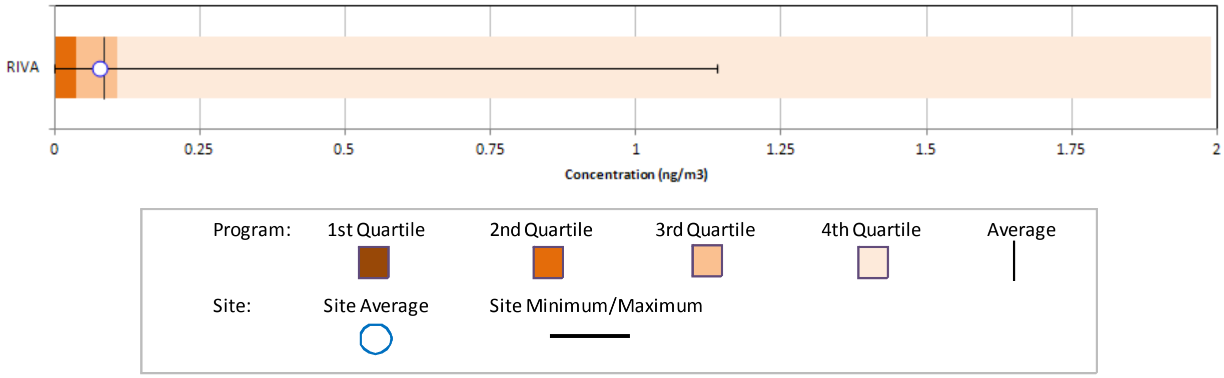


Figure 26-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

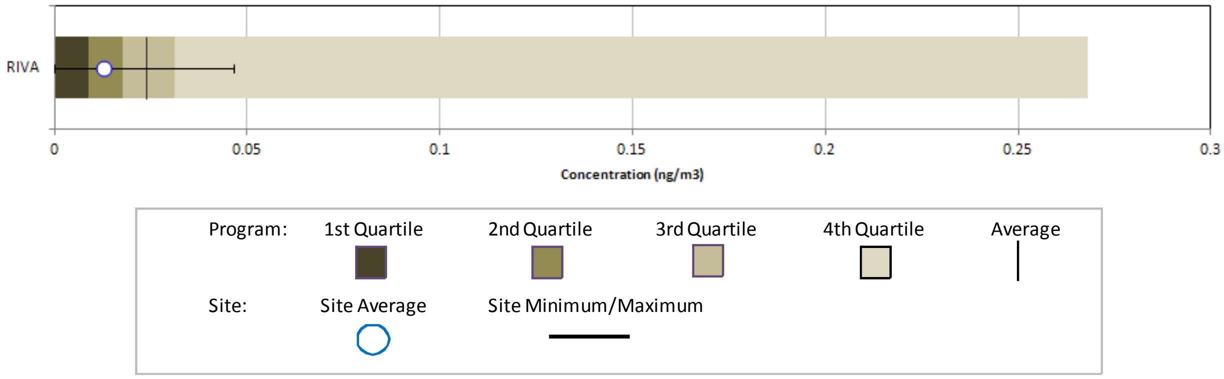
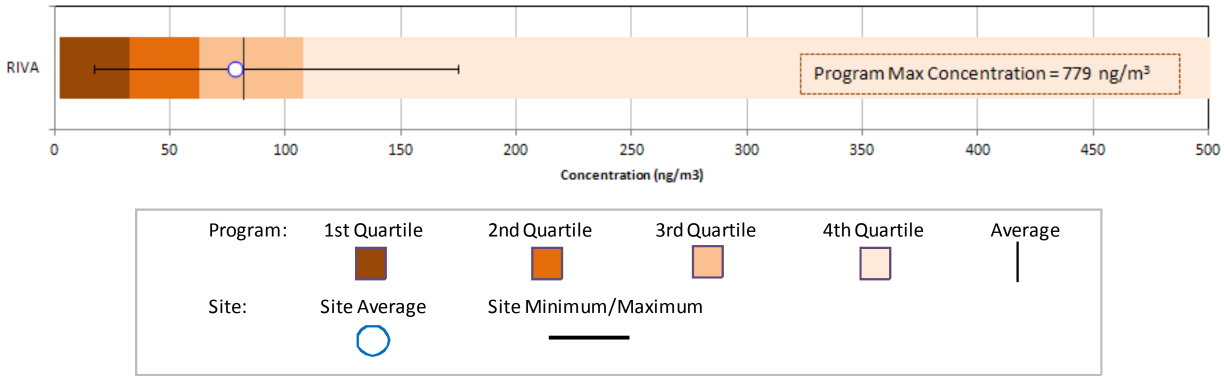


Figure 26-8. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 26-6 through 26-8 include the following:

- Figure 26-6 is the box plot for benzo(a)pyrene. Note that the first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average concentration for RIVA is just less than the program-level average concentration. Figure 26-6 also shows that the maximum concentration measured at RIVA is less than the maximum concentration measured across the program. Half of the measurements of benzo(a)pyrene were non-detects.

- Figure 26-7 is the box plot for hexavalent chromium. Figure 26-7 shows that the annual average concentration of hexavalent chromium for RIVA is less than both the program-level average and median concentrations. This site has one of the lowest annual average concentrations of hexavalent chromium among NMP sites sampling this pollutant. The maximum concentration measured at RIVA is considerably less than the maximum concentration measured across the program. Several non-detects of hexavalent chromium were measured at RIVA.

- Figure 26-8 is the box plot for naphthalene. Note that the program-level maximum concentration (799 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 500 ng/m^3. Figure 26-8 shows that the annual average concentration of naphthalene for RIVA is just less 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.

26.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. RIVA did not begin sampling PAHs or hexavalent chromium under the NMP until October 2008; therefore, the trends analysis was not conducted.

26.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

26.5.2 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
Richmond, Virginia - RIVA						
Acenaphthene	0.000088	--	61/61	3.13 ± 0.64	0.28	--
Benzo(a)pyrene	0.00176	--	30/61	0.08 ± 0.04	0.14	--
Fluorene	0.000088	--	61/61	3.68 ± 0.58	0.32	--
Hexavalent Chromium	0.012	0.0001	48/61	0.01 ± <0.01	0.15	<0.01
Naphthalene	0.000034	0.003	61/61	78.10 ± 10.38	2.66	0.03

-- = a Cancer URE or Noncancer RfC is not available

Observations for RIVA from Table 26-6 include the following:

- The pollutant with the highest annual average concentration for RIVA is naphthalene, followed by fluorene and acenaphthene, although the annual average for naphthalene is significantly higher than the other annual average concentrations.

- The cancer risk approximation for naphthalene is 2.66 in-a-million. The cancer risk approximations for the remaining pollutants of interest are less than 1.0 in-a-million.

- Only two of the pollutants of interest for RIVA have noncancer toxicity factors. The noncancer hazard approximations for hexavalent chromium and naphthalene are considerably less than 1.0, indicating that no adverse health effects are expected from these individual pollutants.

26.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 26-7 and 26-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 26-6. Table 26-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 26-6.

Table 26-7. 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)**
Richmond, Virginia (Henrico County) - RIVA					
Benzene	115.26	Formaldehyde	1.18E-03	Naphthalene	2.66
Formaldehyde	90.51	Benzene	8.99E-04	Fluorene	0.32
Ethylbenzene	64.92	1,3-Butadiene	5.90E-04	Acenaphthene	0.28
Acetaldehyde	60.31	Naphthalene	3.32E-04	Hexavalent Chromium	0.15
1,3-Butadiene	19.67	POM, Group 3	2.60E-04	Benzo(a)pyrene	0.14
Naphthalene	9.77	Hexavalent Chromium, PM	2.50E-04		
Dichloromethane	2.81	POM, Group 2b	1.68E-04		
POM, Group 2b	1.91	Ethylbenzene	1.62E-04		
Tetrachloroethylene	0.38	Acetaldehyde	1.33E-04		
POM, Group 1a	0.19	Arsenic, PM	6.94E-05		

Table 26-8. 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)**
Richmond, Virginia (Henrico County) - RIVA					
Toluene	752.59	Acrolein	216,262.42	Naphthalene	0.03
Xylenes	248.81	1,3-Butadiene	9,835.00	Hexavalent Chromium	<0.01
Methanol	175.23	Formaldehyde	9,235.99		
Benzene	115.26	Acetaldehyde	6,700.91		
Formaldehyde	90.51	Benzene	3,842.01		
Hexane	75.32	Naphthalene	3,257.58		
Ethylbenzene	64.92	Xylenes	2,488.08		
Acetaldehyde	60.31	Arsenic, PM	1,076.66		
Ethylene glycol	21.10	Lead, PM	792.69		
1,3-Butadiene	19.67	Propionaldehyde	689.88		

The pollutants listed in Tables 26-7 and 26-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 26.3, RIVA sampled for PAHs and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 26-7 include the following:

- Benzene, formaldehyde, and ethylbenzene 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.
- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Henrico County.
- Naphthalene, which is the pollutant with the highest cancer risk approximation for RIVA, has the sixth highest emissions and the fourth highest toxicity-weighted emissions for Henrico County.
- POM, Group 2b is the eighth highest emitted "pollutant" in Henrico County and ranks seventh for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at RIVA including acenaphthene and fluorene.
- Hexavalent chromium does not appear among the highest emitted pollutants, but ranks sixth for the toxicity-weighted emissions.

Observations from Table 26-8 include the following:

- Toluene, xylenes, and methanol 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, 1,3-butadiene, and formaldehyde.
- 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.

- Hexavalent chromium appears on neither emissions-based list.

26.6 Summary of the 2011 Monitoring Data for RIVA

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

- *Although four pollutants failed screens for RIVA, naphthalene failed the majority of screens.*

- *The annual average concentration of naphthalene was significantly higher than the annual average concentrations of the other pollutants of interest.*

- *Benzo(a)pyrene concentrations appear higher during the colder months of the year while concentrations of acenaphthene and fluorene appear higher during the warmer months of the year.*

27.0 Site in Washington

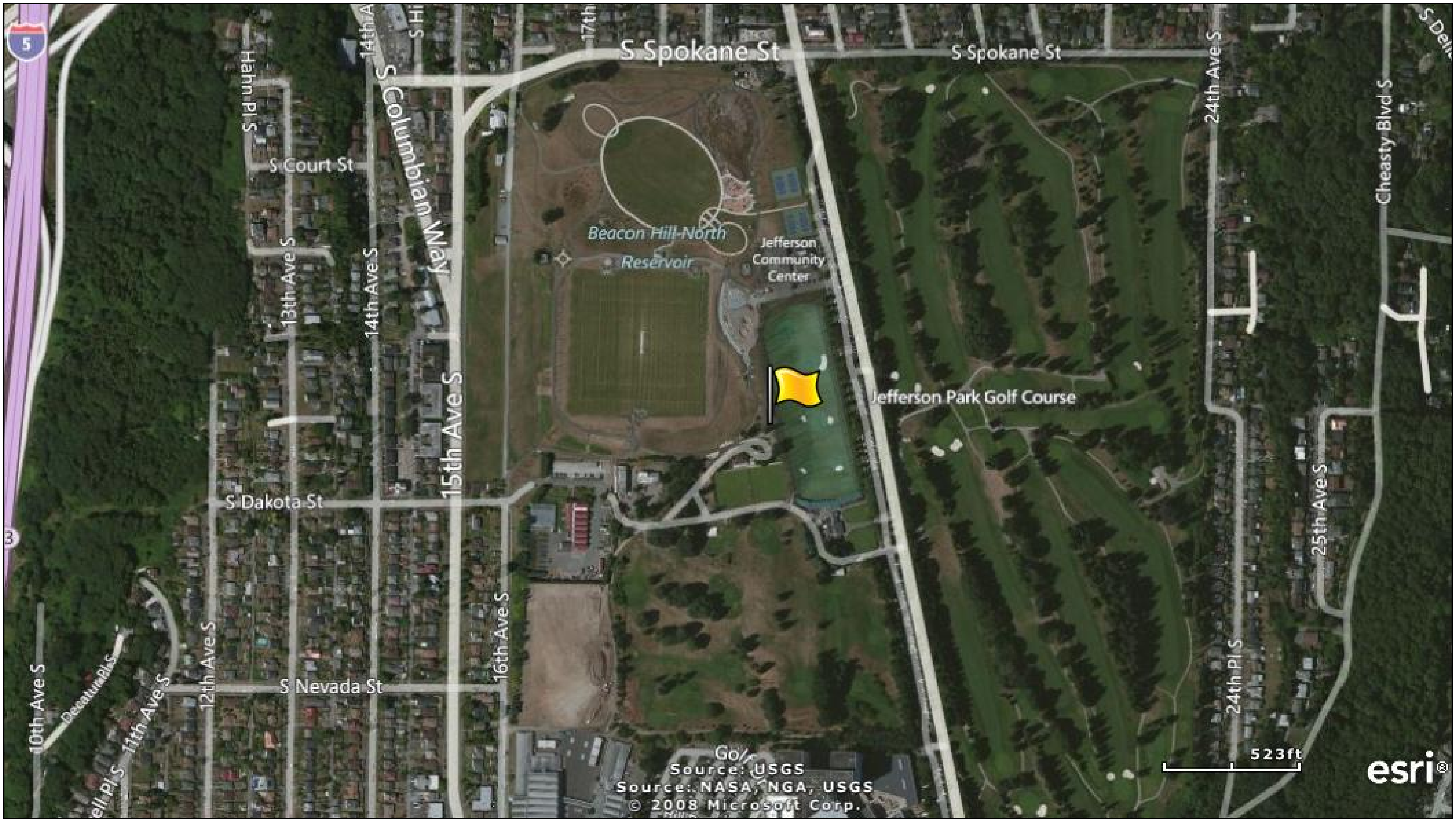
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Washington, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the 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.

27.1 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 27-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its urban location. Figure 27-2 identifies nearby point source emissions locations by source category, as reported in the 2008 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. Seattle, Washington (SEWA) Monitoring Site



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

Figure 27-2. NEI Point Sources Located Within 10 Miles of SEWA

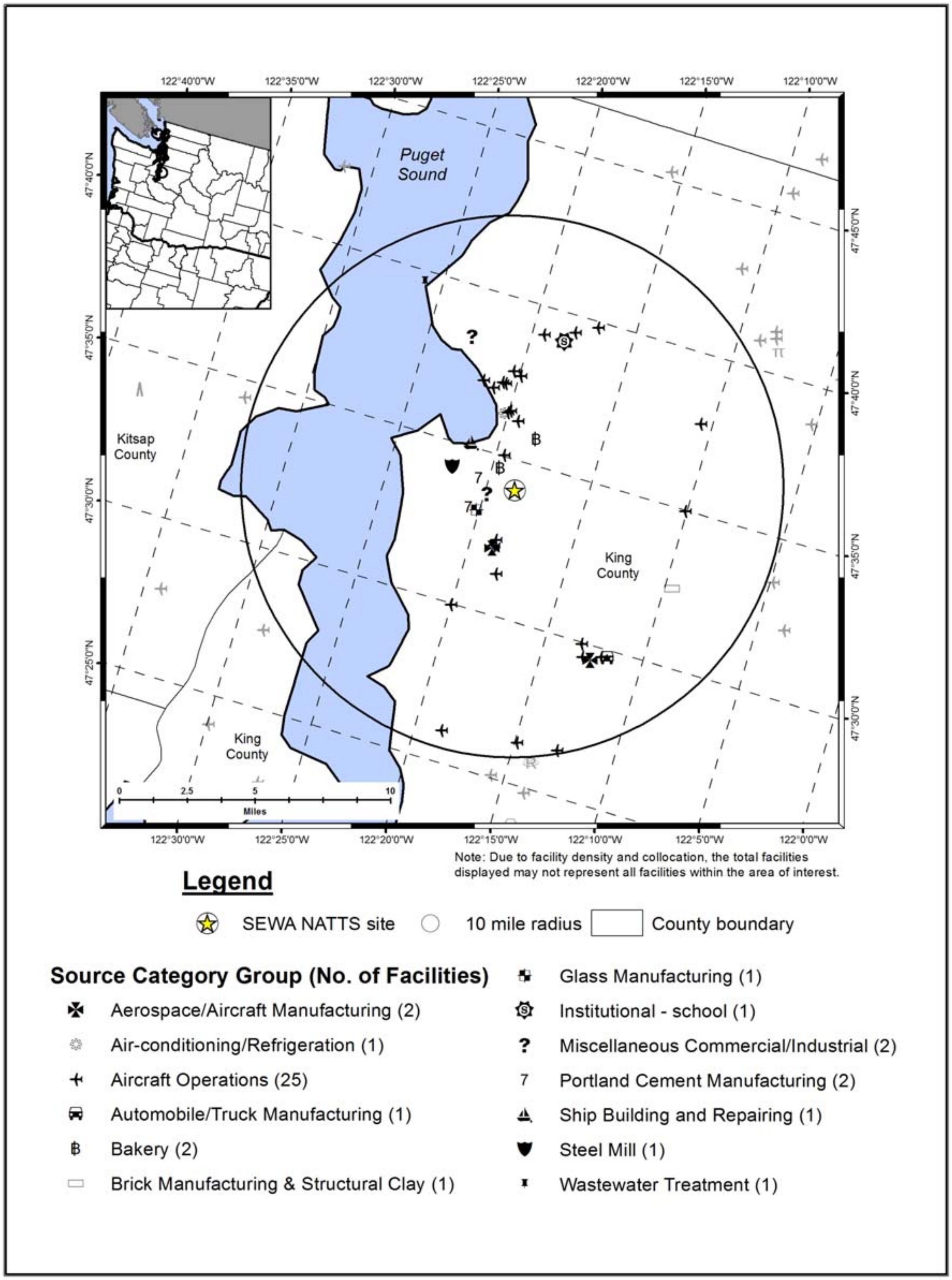


Table 27-1. Geographical Information for the Washington Monitoring Site

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 (Seattle Div)	47.568333, -122.308056	Industrial	Suburban	Haze, CO, SO_2, NO_y, NO, O_3, Meteorological parameters, PM Coarse, PM_{10}, Black Carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation.

[1] Data for additional pollutants are reported to AQS for SEWA (EPA, 2012c); 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 27-1. 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 aircraft operations source category, which includes airports, as well as small runways, heliports, or landing pads, has the greatest number of sources. The point source located closest to SEWA is a bakery.

Table 27-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Washington monitoring site. Table 27-2 includes county-level population and vehicle registration information. Table 27-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 27-2 also contains traffic volume information for SEWA. Finally, Table 27-2 presents the county-level daily VMT for King County.

Table 27-2. Population, Motor Vehicle, and Traffic Information for the Washington Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
SEWA	1,969,722	1,783,335	0.91	983,171	890,137	226,000	23,282,703

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Washington Dept of Licensing (WA DOL, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2011 data from the Washington DOT (WA DOT, 2011)
[5] County-level VMT reflects 2011 data from the Washington DOT (WA DOT, 2011)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 27-2 include the following:

- King County has the sixth highest county-level population among counties with NMP sites. The 10-mile population estimate for SEWA ranks lower but still in the top third among NMP sites.
- The county-level and 10-mile vehicle registration counts for SEWA mimick the rankings of the county-level and 10-mile populations.
- The vehicle-per-person ratio for SEWA is in the middle of the range compared to other NMP sites.
- The traffic volume experienced near SEWA is the third highest compared to other NMP monitoring sites. The traffic estimate provided is for I-5 near Spokane Street.
- The daily VMT for King County is in the top third compared to other counties with NMP sites (where VMT data were available).

27.2 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.

27.2.1 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 lower compared to many locations east of the Rocky Mountains. The winter months are the wettest and the summer months the driest. Prevailing winds are out of the southwest (Bair, 1992).

27.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest SEWA were retrieved for 2011 (NCDC, 2011). 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 27-3. These data were used to determine how meteorological conditions on sample days vary from conditions experienced throughout the year.

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 the entire year. 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 appear slightly cooler and drier than average weather conditions experienced throughout the year, although the differences are not statistically significant.

27.2.3 Back Trajectory Analysis

Figure 27-3 is the composite back trajectory map for days on which samples were collected at the SEWA monitoring site in 2011. 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.

Table 27-3. Average Meteorological Conditions near the Washington Monitoring Site

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)
Seattle, Washington - SEWA									
Boeing Field/ King County Intl Airport 24234 (47.53, -122.30)	2.66 miles 189° (S)	Sample Day	56.7 ± 2.8	49.9 ± 2.6	42.0 ± 2.3	46.0 ± 2.3	75.9 ± 2.2	1017.8 ± 1.8	4.5 ± 0.6
		2011	58.0 ± 1.2	51.4 ± 1.0	42.7 ± 0.9	47.1 ± 0.9	74.6 ± 1.1	1017.5 ± 0.7	4.4 ± 0.2

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

Figure 27-3. 2011 Composite Back Trajectory Map for SEWA

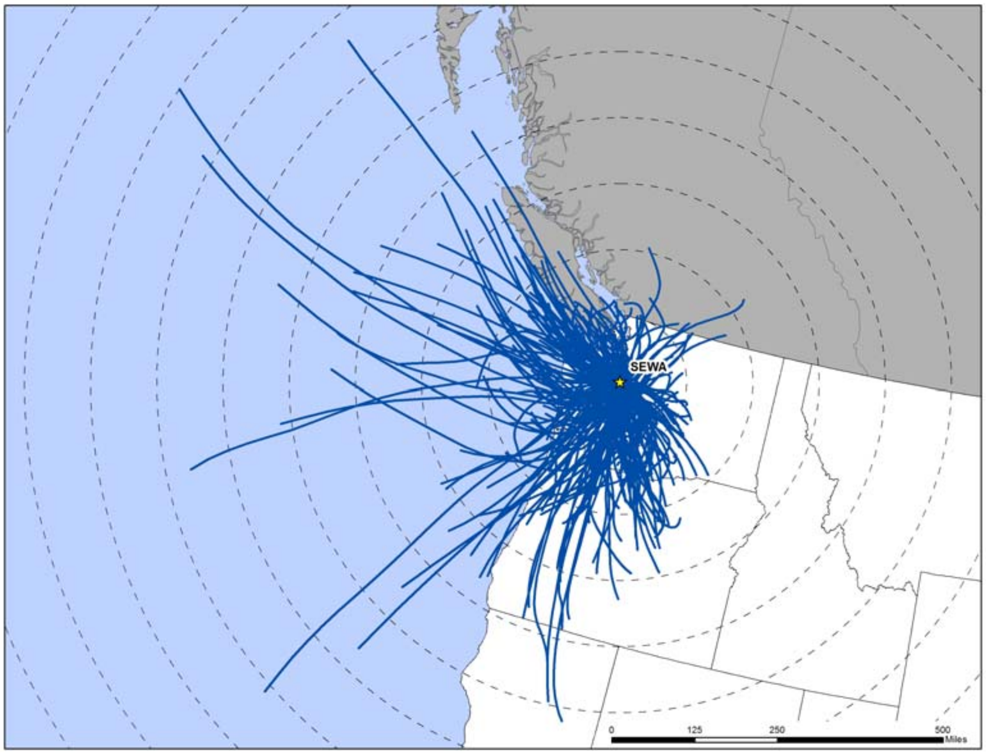
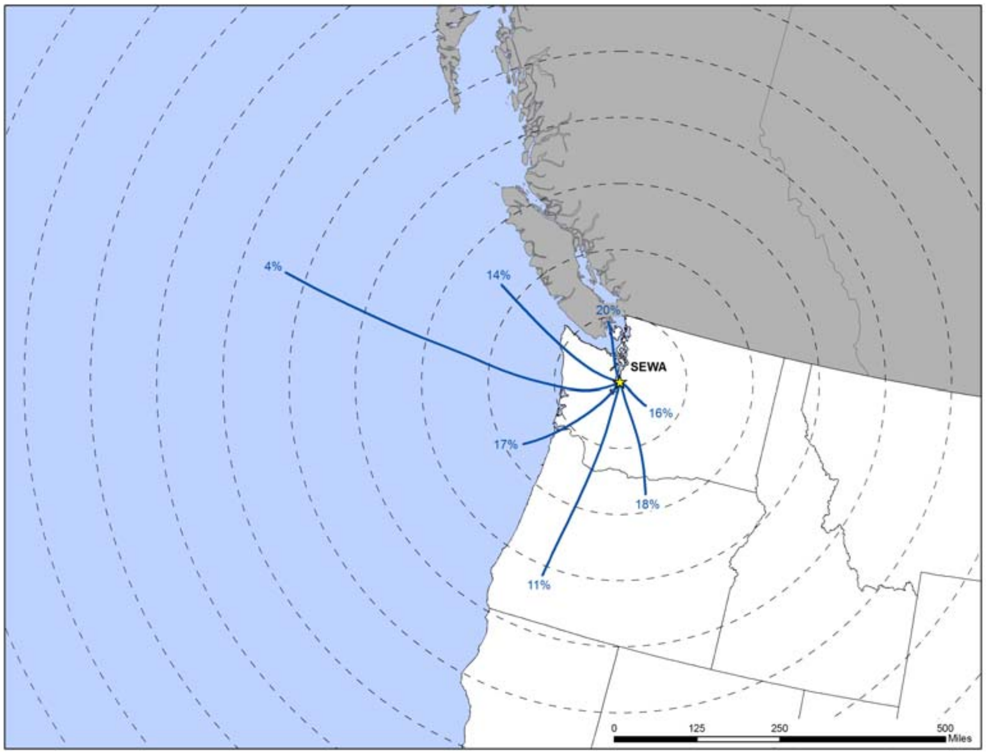


Figure 27-4. Back Trajectory Cluster Map for SEWA



Observations from Figures 27-3 and 27-4 for SEWA include the following:

- Back trajectories originated from a variety of directions from SEWA, although less frequently from the northeast quadrant.

- The 24-hour air shed domain for SEWA is somewhat smaller in size than many other NMP sites. Although the longest trajectory originated 800 miles away over the Pacific Ocean, the average trajectory length was less than 200 miles long and 86 percent of trajectories originated within 300 miles of the site.

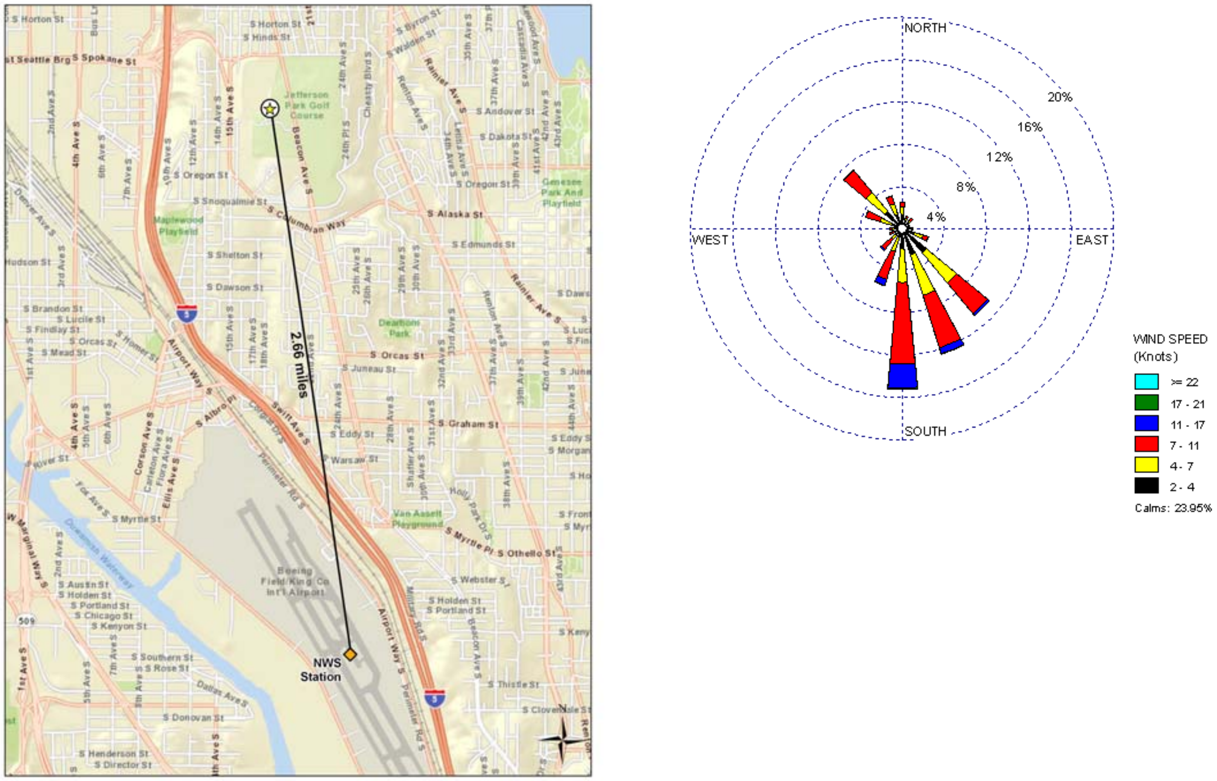
- The cluster analysis shows that 35 percent of back trajectories originated over the Pacific Ocean, but are represented by three cluster trajectories. One represents back trajectories originating well offshore (4 percent), one represents back trajectories originating over the offshore waters of southwest Washington and Oregon (17 percent), and one represents back trajectories originating south and west of Vancouver Island (14 percent). Twenty percent of back trajectories originated over northwest Washington and British Columbia, Canada, and generally less than 200 miles from the site. Another 16 percent of back trajectories originated over central Washington, 18 percent originated over south-central Washington and north-central Oregon, and 11 percent originated to the south of SEWA over western Oregon and northern California.

27.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS 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.

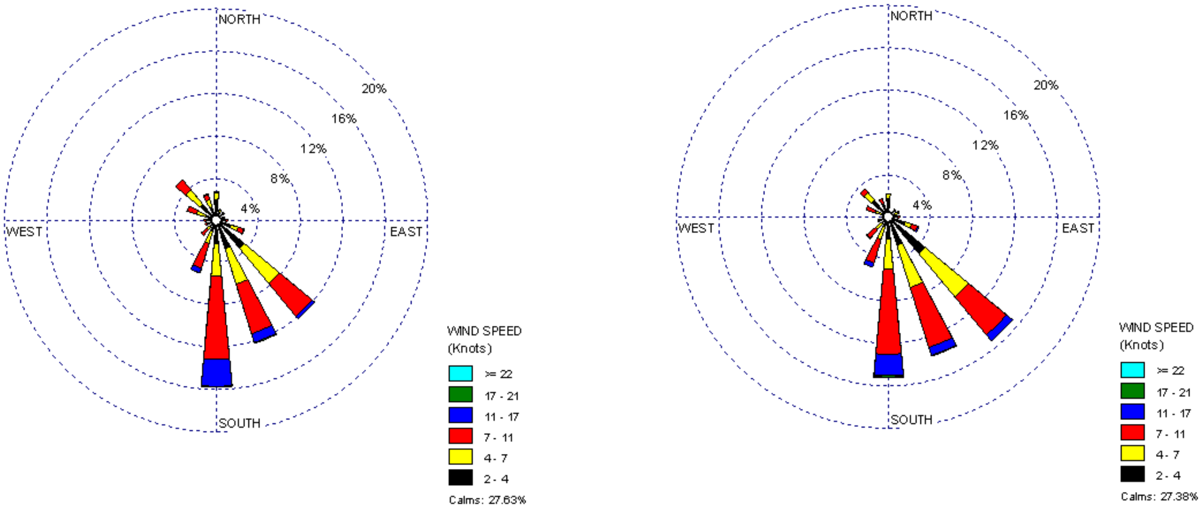
Figure 27-5 presents a map showing the distance between the NWS station and SEWA, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 27-5 also presents three different wind roses for the SEWA monitoring site. First, a historical wind rose representing 2001 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 27-5. Wind Roses for the Boeing Field/King County International Airport Weather Station near SEWA



Distance between SEWA and NWS Station

2001-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

Observations from Figure 27-5 for SEWA include the following:

- The Boeing Field/King County Airport weather station is located approximately 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 2011 wind rose are similar to the historical wind patterns, although the percentage of calm winds is slightly higher (nearly 28 percent) in 2011.
- The wind patterns shown on the sample day wind rose resemble the historical and 2011 wind patterns, indicating that conditions on sample days were representative of those experienced over the entire year and historically.

27.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the Washington monitoring site in order to allow 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.” 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 27-4 presents the results of the preliminary risk-based screening process for SEWA. The pollutants that failed at least one screen and contributed to 95 percent of the total failed screens are shaded. NATTS MQO Core Analytes are bolded. Thus, pollutants of interest are shaded and/or bolded. SEWA sampled for PM_{10} metals, VOCs, PAHs, carbonyl compounds, and hexavalent chromium.

Table 27-4. Risk-Based Screening Results for the Washington Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Seattle, Washington - SEWA						
Benzene	0.13	61	61	100.00	12.66	12.66
Carbon Tetrachloride	0.17	61	61	100.00	12.66	25.31
Formaldehyde	0.077	60	60	100.00	12.45	37.76
Acetaldehyde	0.45	58	60	96.67	12.03	49.79
Arsenic (PM$_{10}$)	0.00023	56	61	91.80	11.62	61.41
1,3-Butadiene	0.03	52	52	100.00	10.79	72.20
Naphthalene	0.029	51	60	85.00	10.58	82.78
Manganese (PM$_{10}$)	0.005	24	61	39.34	4.98	87.76
1,2-Dichloroethane	0.038	17	17	100.00	3.53	91.29
Nickel (PM$_{10}$)	0.0021	14	61	22.95	2.90	94.19
Ethylbenzene	0.4	12	61	19.67	2.49	96.68
Dichloromethane	7.7	5	61	8.20	1.04	97.72
Hexavalent Chromium	0.000083	4	59	6.78	0.83	98.55
Benzo(a)pyrene	0.00057	2	25	8.00	0.41	98.96
Cadmium (PM$_{10}$)	0.00056	2	61	3.28	0.41	99.38
Acenaphthene	0.011	1	60	1.67	0.21	99.59
Acrylonitrile	0.015	1	1	100.00	0.21	99.79
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.21	100.00
Total		482	883	54.59		

Observations from Table 27-4 for SEWA include the following:

- Eighteen pollutants failed at least one screen for SEWA, of which 12 are NATTS MQO Core Analytes.

- The risk-based screening process identified 11 pollutants of interest, of which all but two are NATTS MQO Core Analytes. Hexavalent chromium, benzo(a)pyrene, and cadmium were added to SEWA's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of the total failed screens. Six additional pollutants were added to SEWA's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens (beryllium, chloroform, lead, tetrachloroethylene, trichloroethylene, and vinyl chloride). These six pollutants are not shown in Table 27-4 but are shown in subsequent tables in the sections that follow.

- Benzene, 1,3-butadiene, carbon tetrachloride, and formaldehyde failed 100 percent of screens for SEWA. 1,2-Dichloroethane, acrylonitrile, and 1,1,2,2-tetrachloroethane also failed 100 percent of screens for SEWA, but were detected less frequently.

27.4 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: Time period-based concentration averages (quarterly and annual) are provided for the pollutants of interest for the Washington monitoring site, where the data meet the applicable criteria. Concentration averages for select pollutants are also presented graphically to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for SEWA are provided in Appendices J, L, M, N, and O.

27.4.1 2011 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 of 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 27-5, where applicable. Note that concentrations of the PAHs, metals, 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 27-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the SEWA 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)
Seattle, Washington - SEWA						
Acetaldehyde	60/60	0.80 ± 0.23	0.80 ± 0.26	1.17 ± 0.19	0.96 ± 0.12	0.94 ± 0.10
Benzene	61/61	0.88 ± 0.27	0.56 ± 0.17	0.42 ± 0.07	0.96 ± 0.21	0.71 ± 0.11
1,3-Butadiene	52/61	0.11 ± 0.06	0.04 ± 0.02	0.06 ± 0.02	0.14 ± 0.04	0.09 ± 0.02
Carbon Tetrachloride	61/61	0.55 ± 0.04	0.65 ± 0.06	0.66 ± 0.03	0.72 ± 0.05	0.65 ± 0.03
Chloroform	57/61	0.10 ± 0.01	0.14 ± 0.02	0.14 ± 0.04	0.11 ± 0.02	0.12 ± 0.01
1,2-Dichloroethane	17/61	0	0.04 ± 0.03	<0.01 ± 0.01	0.05 ± 0.02	0.02 ± 0.01
Ethylbenzene	61/61	0.30 ± 0.14	0.20 ± 0.04	0.28 ± 0.05	0.38 ± 0.08	0.30 ± 0.04
Formaldehyde	60/60	0.77 ± 0.22	0.77 ± 0.15	0.99 ± 0.16	0.82 ± 0.20	0.84 ± 0.09
Tetrachloroethylene	46/61	0.14 ± 0.07	0.03 ± 0.03	0.08 ± 0.03	0.12 ± 0.04	0.09 ± 0.02
Trichloroethylene	5/61	0.01 ± 0.02	0	0	0.01 ± 0.01	0.01 ± 0.01
Vinyl Chloride	1/61	0	0	<0.01 ± <0.01	0	<0.01 ± <0.01
Arsenic (PM_{10})[a]	61/61	0.57 ± 0.25	0.46 ± 0.17	0.50 ± 0.11	1.05 ± 0.26	0.66 ± 0.12
Benzo(a)pyrene[a]	25/60	0.08 ± 0.08	<0.01 ± <0.01	<0.01 ± 0.01	0.22 ± 0.17	0.08 ± 0.05
Beryllium (PM_{10})[a]	61/61	0.02 ± 0.02	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	0.01 ± 0.01
Cadmium (PM_{10})[a]	61/61	0.17 ± 0.13	0.07 ± 0.02	0.06 ± 0.01	0.11 ± 0.03	0.10 ± 0.03
Hexavalent Chromium[a]	59/61	0.04 ± 0.02	0.02 ± 0.01	0.02 ± 0.01	0.05 ± 0.02	0.03 ± 0.01
Lead (PM_{10})[a]	61/61	2.83 ± 1.11	2.20 ± 0.44	2.49 ± 0.29	3.84 ± 1.14	2.89 ± 0.44
Manganese (PM_{10})[a]	61/61	7.36 ± 4.65	5.57 ± 3.31	9.36 ± 5.08	9.76 ± 6.85	8.17 ± 2.57
Naphthalene[a]	60/60	82.50 ± 42.28	36.18 ± 8.84	65.76 ± 20.36	99.48 ± 29.66	72.81 ± 14.58
Nickel (PM_{10})[a]	61/61	1.19 ± 0.51	1.97 ± 1.11	3.39 ± 1.22	1.07 ± 0.22	1.90 ± 0.46

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

Observations from Table 27-5 include the following:

- The annual average concentrations for all of SEWA's pollutants of interest are less than 1.0 µg/m^3. The pollutants with the highest annual average concentrations by mass are acetaldehyde (0.94 ± 0.10 µg/m^3), formaldehyde (0.84 ± 0.09 µg/m^3), benzene (0.71 ± 0.11 µg/m^3), and carbon tetrachloride (0.65 ± 0.03 µg/m^3).

- Even though acetaldehyde and formaldehyde have the highest annual average concentrations among SEWA's pollutants of interest, these annual averages are the lowest among other NMP sites sampling carbonyl compounds, similar to previous years.

- Several of the VOCs and PAHs appear to be higher during the colder months of year. However, the confidence intervals indicate that most of these differences are not statistically significant and that there is considerable variability in the measurements.

- The fourth quarter average concentration of arsenic is greater than the other quarterly averages. A review of the data shows that of the 14 concentrations greater than 1 ng/m^3 measured at SEWA, 10 were measured during the fourth quarter. The maximum arsenic concentration was measured on December 14, 2011 (2.04 ng/m^3). The maximum concentrations of lead (9.45 ng/m^3) and manganese (48.7 ng/m^3) were also measured on this date.

- The fourth quarter average concentration of lead is also greater than the other quarterly averages of lead and both the first and fourth quarter averages have large confidence intervals associated with them. A review of the data shows that concentrations of lead range from 1.12 ng/m^3 to 9.45 ng/m^3, with a median concentration of 2.47 ng/m^3. Of the 10 concentrations greater than 3.50 ng/m^3 measured at SEWA, seven were measured during the fourth quarter and three in the first quarter of 2011.

- The quarterly averages of manganese have a high-level of variability in the measurements, as indicated by the associated confidence intervals. Concentrations of manganese range from 0.647 ng/m^3 to 48.7 ng/m^3, with a median concentration of 4.01 ng/m^3. Of the 10 concentrations greater than 15 ng/m^3 measured at SEWA, two were measured during the first quarter of 2011, one in the second quarter, three in the third quarter, and four in the fourth quarter.

- The second and third quarter average concentrations of nickel have large confidence intervals associated with them. A review of the data shows that concentrations of nickel range from 0.431 ng/m^3 to 7.97 ng/m^3. The maximum concentration of nickel was measured on August 7, 2011 and is the maximum nickel concentration measured among NMP sites sampling this pollutant. Of the 13 nickel concentrations greater than 5 ng/m^3 measured across the program, seven were measured at SEWA. All but one of the 13 concentrations greater than 3 ng/m^3 measured at SEWA were measured in the second and third quarters of 2011, explaining the relatively large confidence intervals associated with those quarterly averages.

- The first and fourth quarter average concentrations of naphthalene are greater than the other quarterly averages and the first quarter average has a large confidence interval associated with it. A review of the data shows that the maximum concentration of naphthalene was measured on January 27, 2011 (308 ng/m^3) and that two additional concentrations greater than 200 ng/m^3 were measured in November and December. All but two of the 12 concentrations greater than 100 ng/m^3 were measured in either the first or fourth quarters of 2011. Conversely, all but one of the nine concentrations less than 30 ng/m^3 were measured in the second or third quarter of 2011.

- The first and fourth quarter average concentrations of benzo(a)pyrene are greater than the other quarterly averages, particularly the fourth quarter, and both averages have relatively large confidence intervals associated with them. A review of the data shows that the maximum concentration was measured on November 29, 2011 (1.30 ng/m^3). This is one of seven concentrations of benzo(a)pyrene greater than 1 ng/m^3 measured across the program. The next highest concentration measured at SEWA is roughly half as high (0.764 ng/m^3, measured on December 14, 2011). Of the 14 benzo(a)pyrene concentrations greater than 0.1 ng/m^3, four were measured in January and February and 10 were measured in November and December.

- No samples were collected at SEWA between June 20, 2011 and July 13, 2011. However, make-up samples were collected in the latter half of July.

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:

- As shown in Table 4-12, SEWA has the highest annual average concentration of nickel among all sites sampling metals (PM_{10} and TSP) for the second year in a row.

- Recall that only nine sites sampled PM_{10} metals; as a result every site sampling PM_{10} metals appears in Table 4-12 for each metal.

- SEWA has the fourth highest concentrations of arsenic and manganese and ranks fifth highest for hexavalent chromium.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, box plots for acetaldehyde, arsenic, benzene, benzo(a)pyrene, 1,3-butadiene, formaldehyde, hexavalent chromium, lead, manganese, and naphthalene were created for SEWA. Figures 27-6 through 27-15 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.

Figure 27-6. Program vs. Site-Specific Average Acetaldehyde Concentration

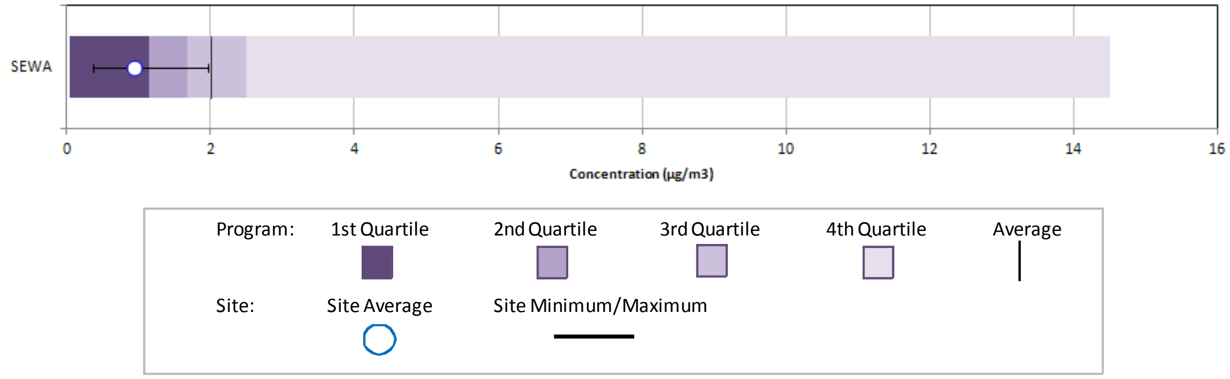


Figure 27-7. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration

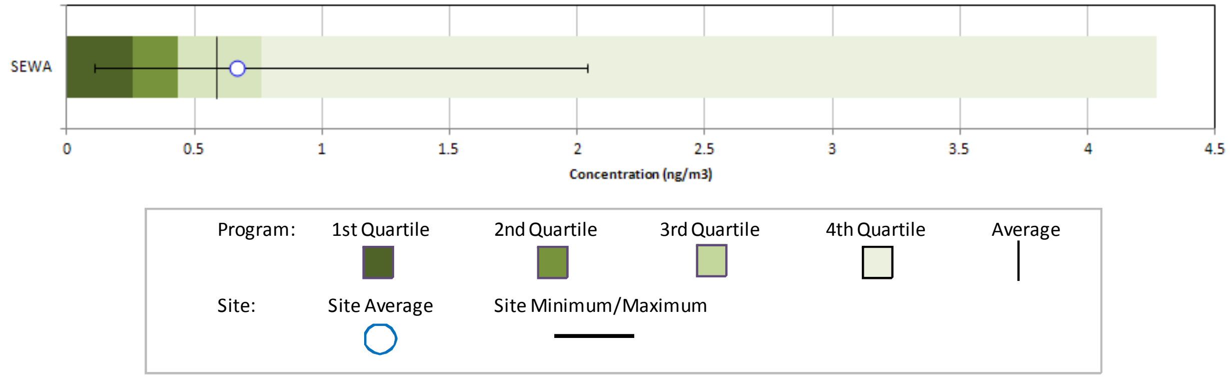


Figure 27-8. Program vs. Site-Specific Average Benzene Concentration

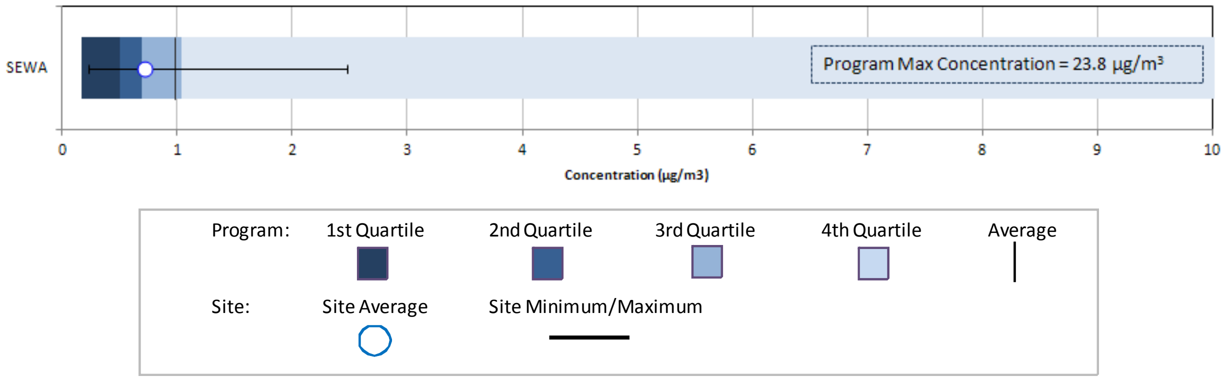


Figure 27-9. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

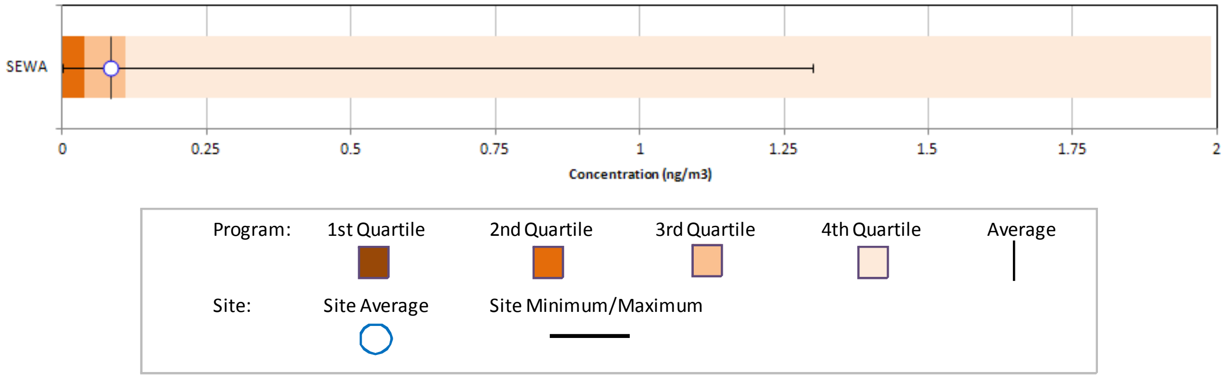


Figure 27-10. Program vs. Site-Specific Average 1,3-Butadiene Concentration

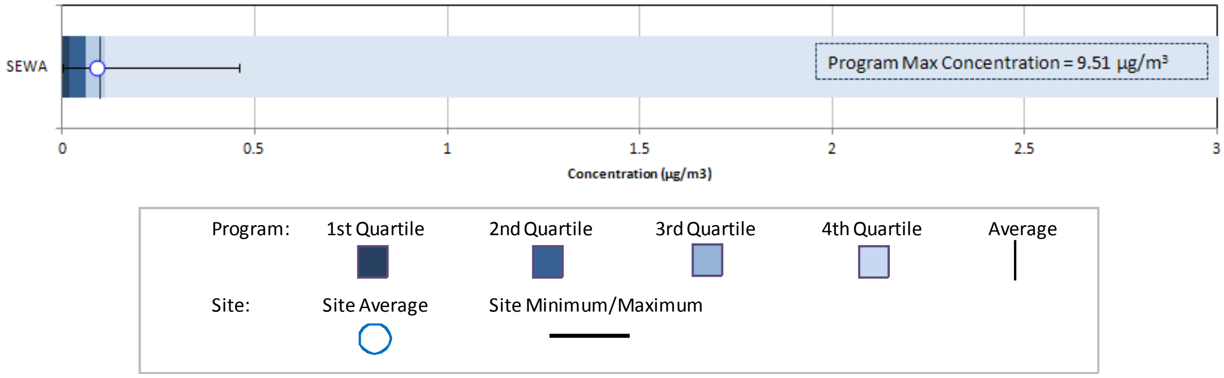


Figure 27-11. Program vs. Site-Specific Average Formaldehyde Concentration

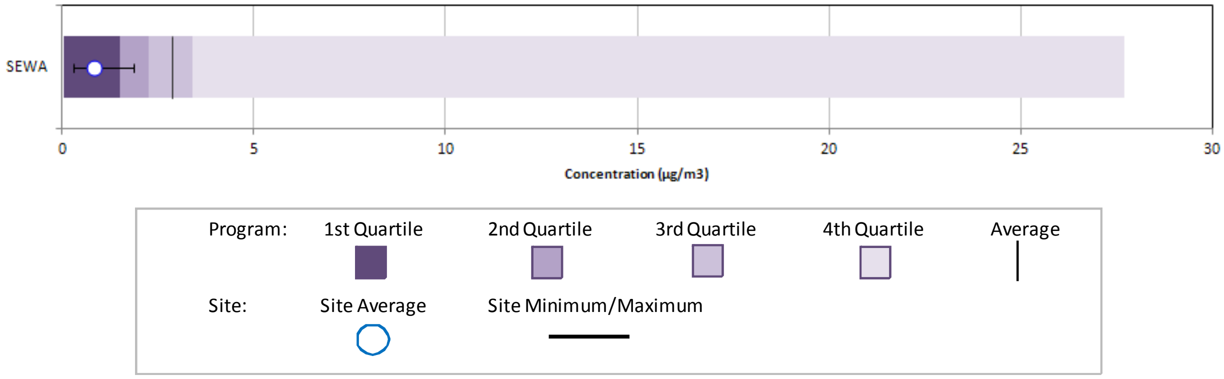


Figure 27-12. Program vs. Site-Specific Average Hexavalent Chromium Concentration

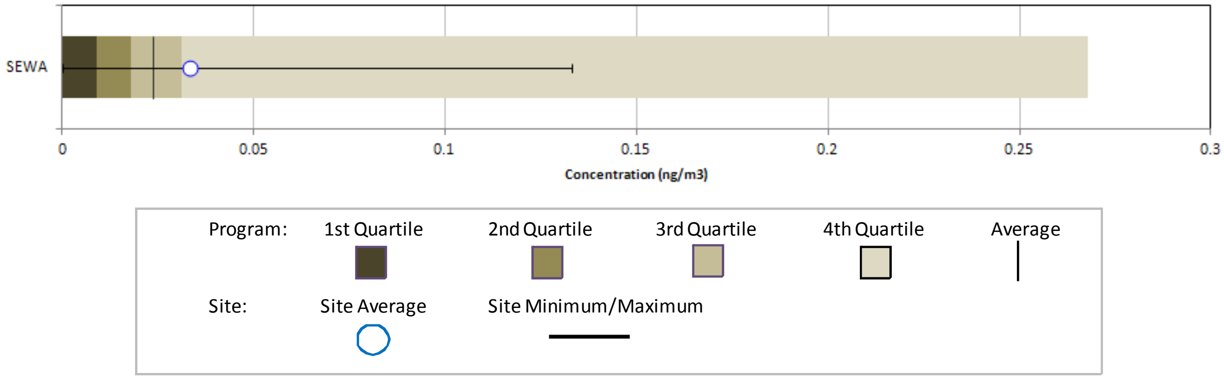


Figure 27-13. Program vs. Site-Specific Average Lead (PM_{10}) Concentration

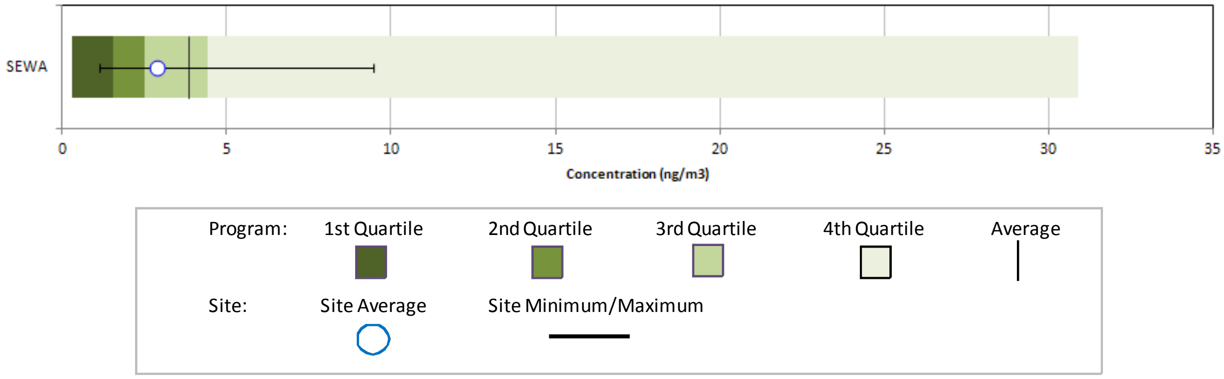


Figure 27-14. Program vs. Site-Specific Average Manganese (PM_{10}) Concentration

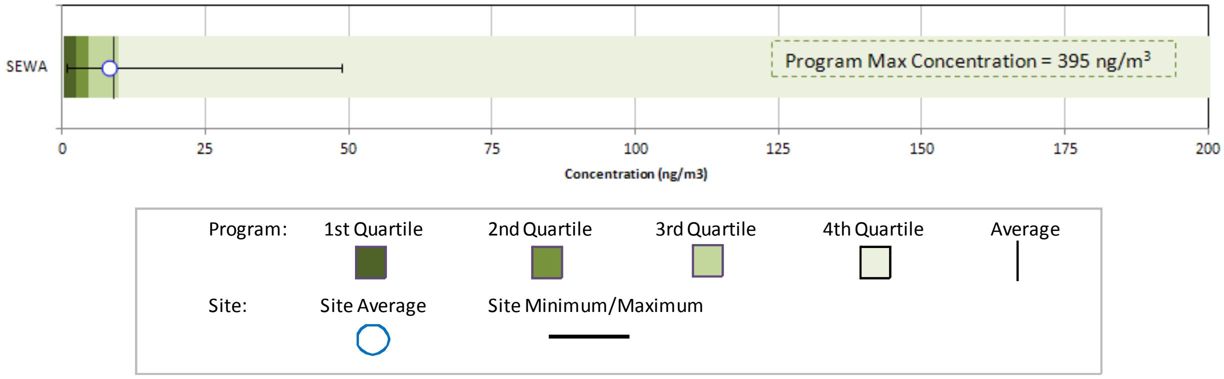
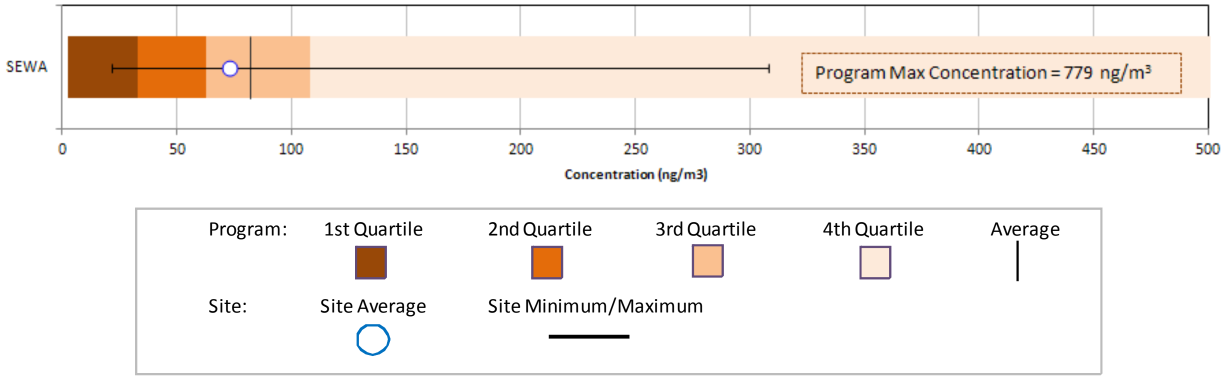


Figure 27-15. Program vs. Site-Specific Average Naphthalene Concentration



Observations from Figures 27-6 through 27-15 include the following:

- Figure 27-6 shows that SEWA's annual average acetaldehyde concentration is considerably less than the program-level average for acetaldehyde and is actually less than the program-level first quartile (25th percentile). Even the maximum acetaldehyde concentration measured at SEWA less than the program-level average concentration. This site has the lowest annual average concentration of acetaldehyde among NMP sites sampling carbonyl compounds.

- Figure 27-7 shows that SEWA's annual average arsenic (PM_{10}) concentration is greater than the program-level average concentration of arsenic (PM_{10}). The maximum arsenic concentration measured at SEWA is roughly half the maximum concentration measured across the program. There were no non-detects of arsenic measured at SEWA.

- Figure 27-8 is the box plot for benzene. Note that the program-level maximum concentration (23.8 $\mu g/m^3$) 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 has been reduced to 10 $\mu g/m^3$. Figure 27-8 shows that the annual average concentration for SEWA is less than the program-level average concentration but greater than the program-level median concentration. The maximum benzene concentration measured at SEWA is considerably less than the maximum benzene concentration measured across the program. There were no non-detects of benzene measured at SEWA or across the program.

- Figure 27-9 is the box plot for benzo(a)pyrene. Note that the first quartile for this pollutant is zero and is not visible on this box plot. This box plot shows that the annual average concentration for SEWA is roughly equivalent to the program-level average concentration. Although the maximum concentration measured at SEWA is less than the maximum concentration measured across the program, it is one of the higher measurements. Nearly 60 percent of the benzo(a)pyrene measurements at SEWA were non-detects.

- Figure 27-10 is the box plot for 1,3-butadiene. Similar to the benzene box plot, the program-level maximum concentration (9.51 $\mu g/m^3$) is not shown directly on the box plot as the scale has been reduced to 3 $\mu g/m^3$ 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 for SEWA is less than the program-level average concentration but greater than the program-level median concentration. Figure 27-10 also shows that the maximum 1,3-butadiene concentration measured at SEWA is considerably less than the maximum concentration measured across the program. A few non-detects of 1,3-butadiene were measured at SEWA.

- Figure 27-11 shows that SEWA’s annual average formaldehyde concentration is less than the program-level first quartile, similar to acetaldehyde. The maximum formaldehyde concentration measured at SEWA is less than the program-level median concentration. This site has the lowest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds and the second smallest range of concentrations.

- Figure 27-12 shows that the annual average concentration of hexavalent chromium for SEWA is greater than the program-level average concentration and the program-level third quartile. The maximum hexavalent chromium concentration measured at SEWA is less than the maximum hexavalent chromium concentration measured across the program. Two non-detects of hexavalent chromium were measured at SEWA.

- Figure 27-13 shows that the annual average concentration of lead (PM_{10}) for SEWA is less than the program-level average but just greater than the program-level median concentration. The maximum lead concentration measured at SEWA is considerably less than the maximum lead concentration measured across the program. There were no non-detects of lead measured at SEWA.

- Figure 27-14 is the box plot for manganese. The program-level maximum concentration (395 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 200 $\mu g/m^3$ 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 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 27-15 is the box plot for naphthalene. The program-level maximum concentration (779 ng/m^3) is not shown directly on the box plot as the scale has been reduced to 500 µg/m^3 in order to allow for the observation of data points at the lower end of the concentration range. Figure 27-15 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 less than the program-level maximum concentration. There were no non-detects of naphthalene measured at SEWA 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 selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. Sampling for hexavalent chromium at SEWA began in 2005 while sampling for PM_{10} metals, VOCs, and carbonyl compounds began in 2007; thus, Figures 27-16 through 27-23 present the annual statistical metrics for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, lead, and manganese, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. A trends analysis was not conducted for the PAHs because sampling for PAHs did not begin at SEWA until 2008.

Observations from Figure 27-16 for acetaldehyde measurements 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). These are the only concentrations greater than 3 µg/m^3 measured at SEWA.
- The average acetaldehyde concentration ranges from 0.80 µg/m^3 (2010) to 0.98 µg/m^3 (2009). Confidence intervals calculated indicate that the average concentrations are not statistically different, although the range of measurements is lower in more recent years.
- There have been no non-detects of acetaldehyde measured since the onset of sampling.

Figure 27-16. Annual Statistical Metrics for Acetaldehyde Concentrations Measured at SEWA

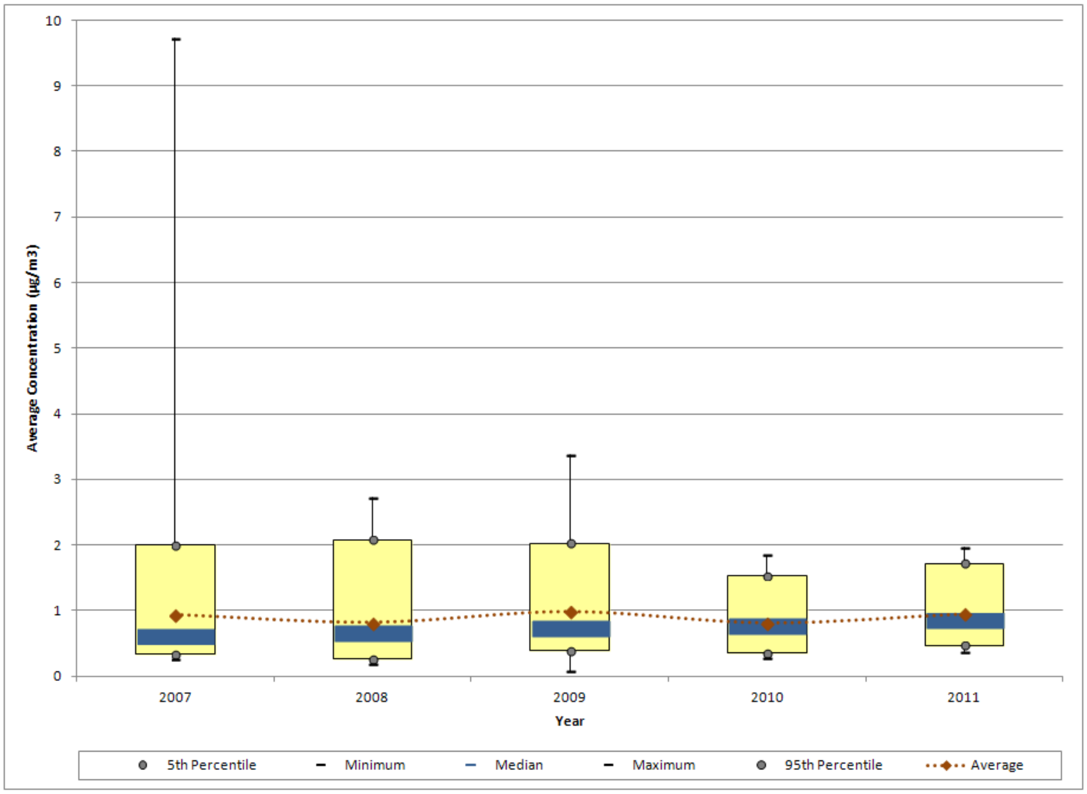


Figure 27-17. Annual Statistical Metrics for Arsenic (PM_{10}) Concentrations Measured at SEWA

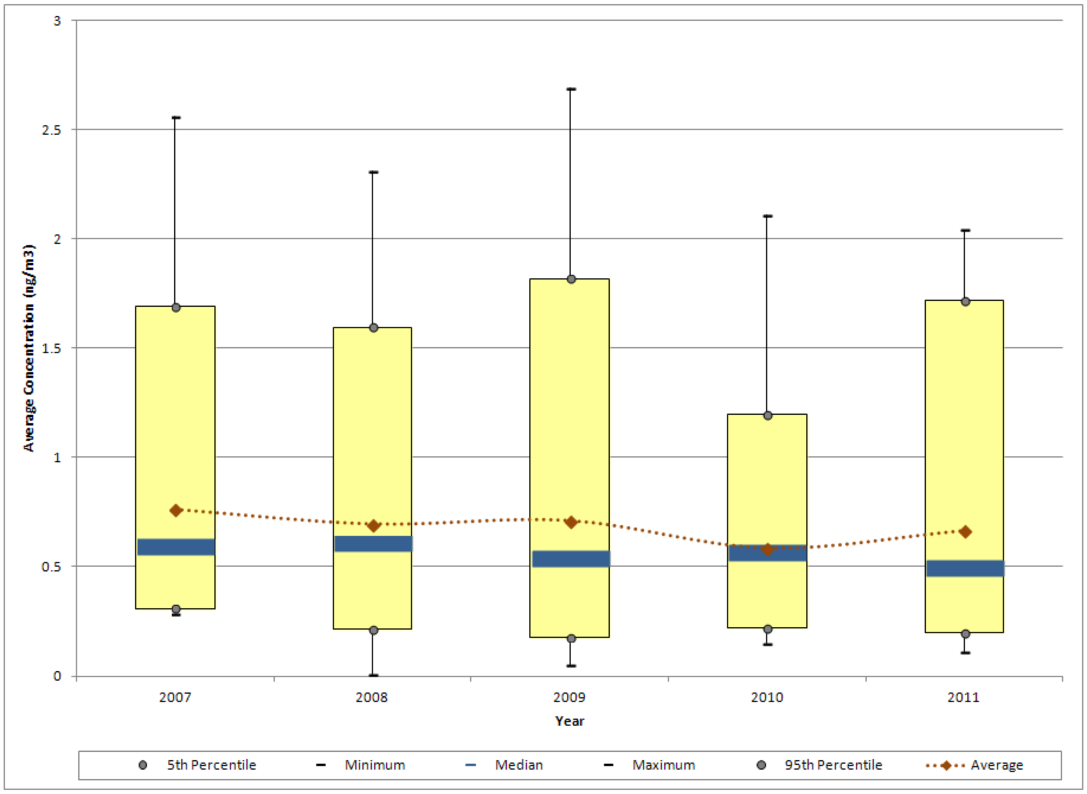


Figure 27-18. Annual Statistical Metrics for Benzene Concentrations Measured at SEWA

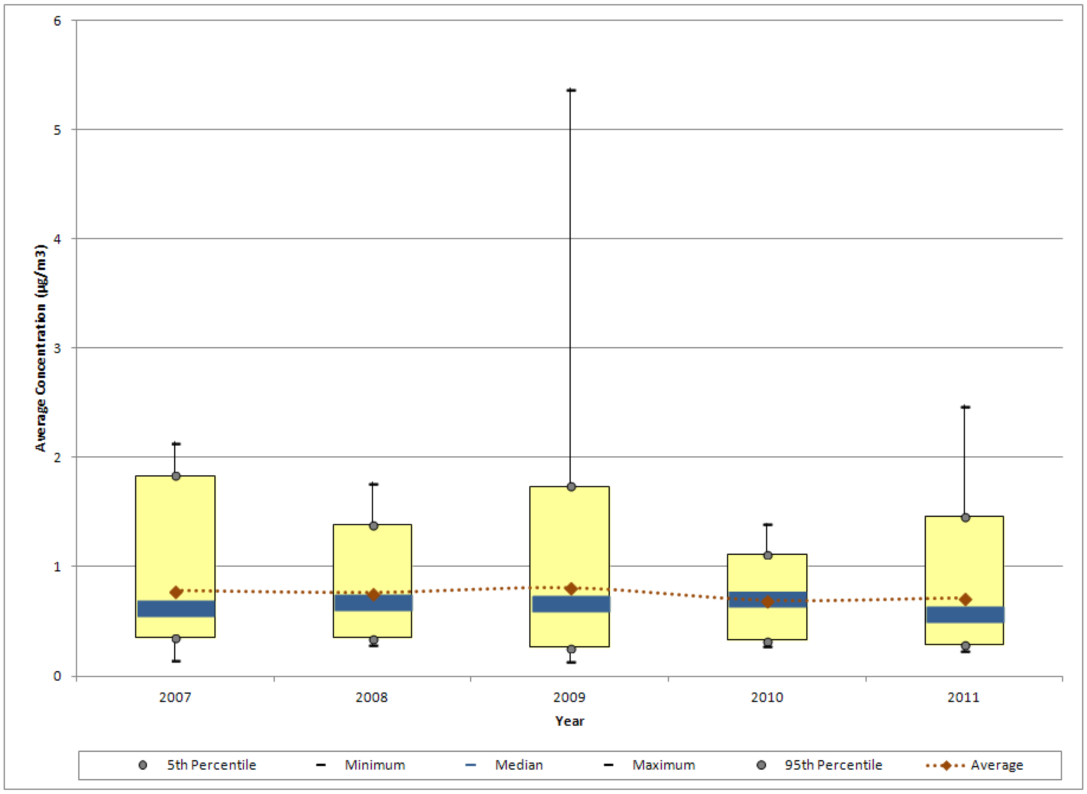


Figure 27-19. Annual Statistical Metrics for 1,3-Butadiene Concentrations Measured at SEWA

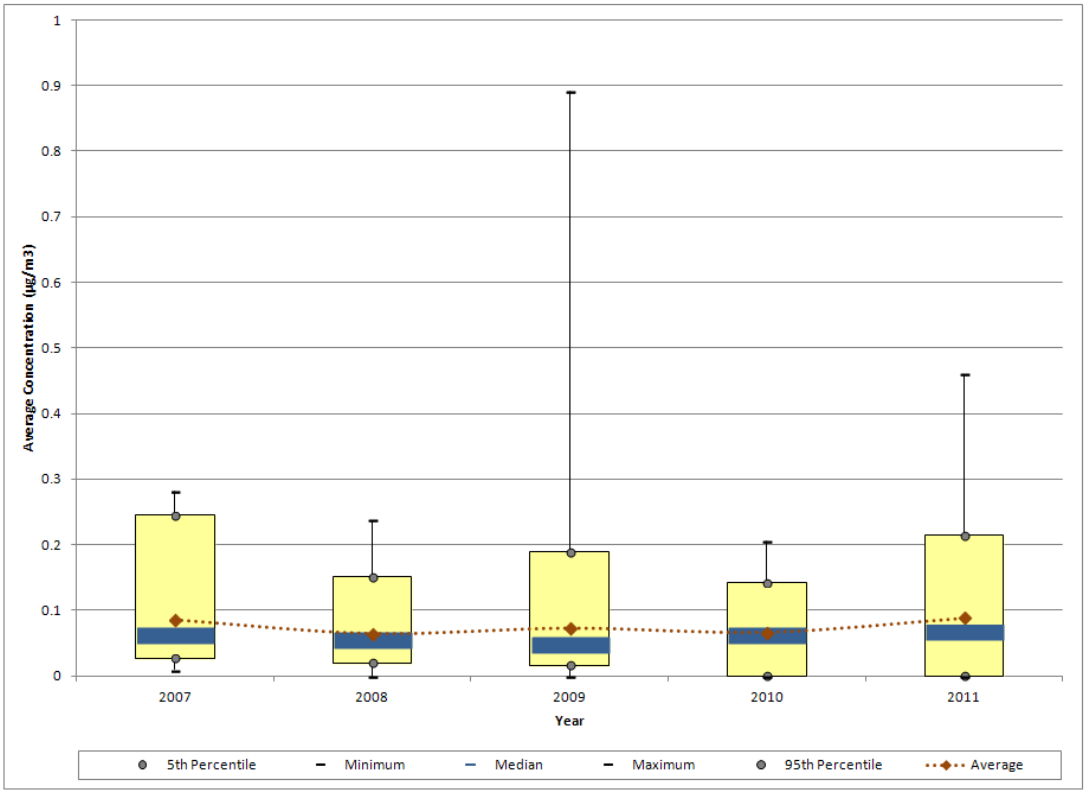


Figure 27-20. Annual Statistical Metrics for Formaldehyde Concentrations Measured at SEWA

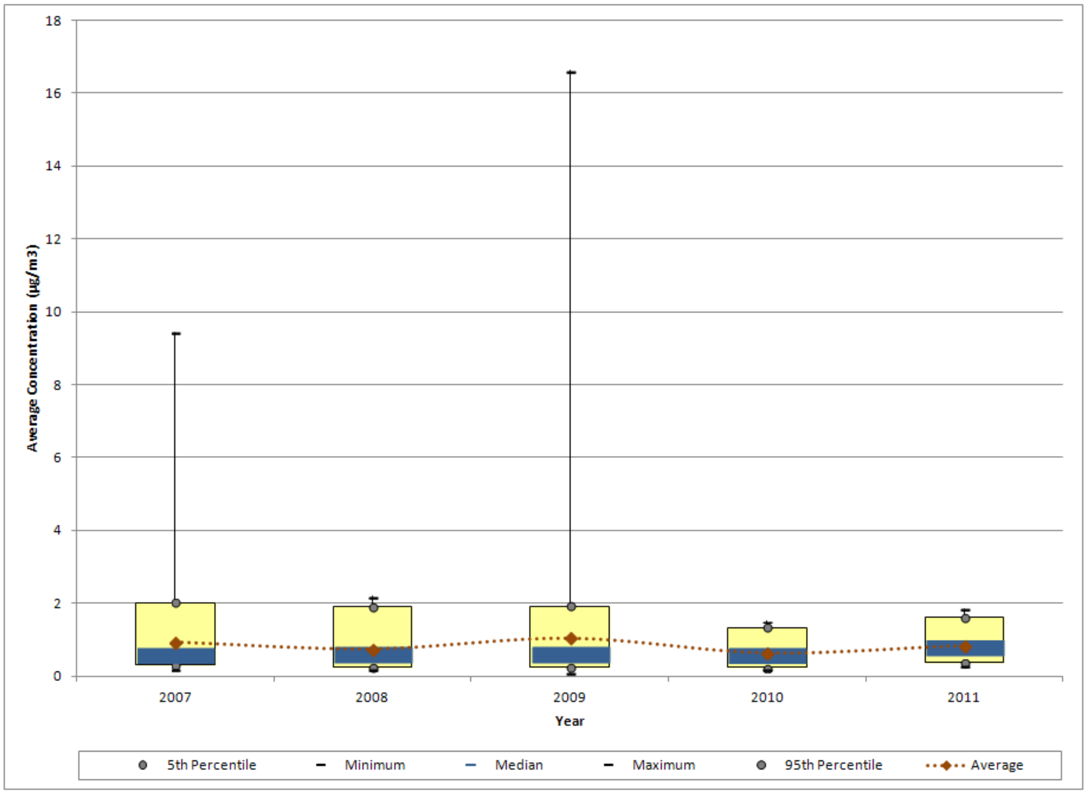


Figure 27-21. Annual Statistical Metrics for Hexavalent Chromium Concentrations Measured at SEWA

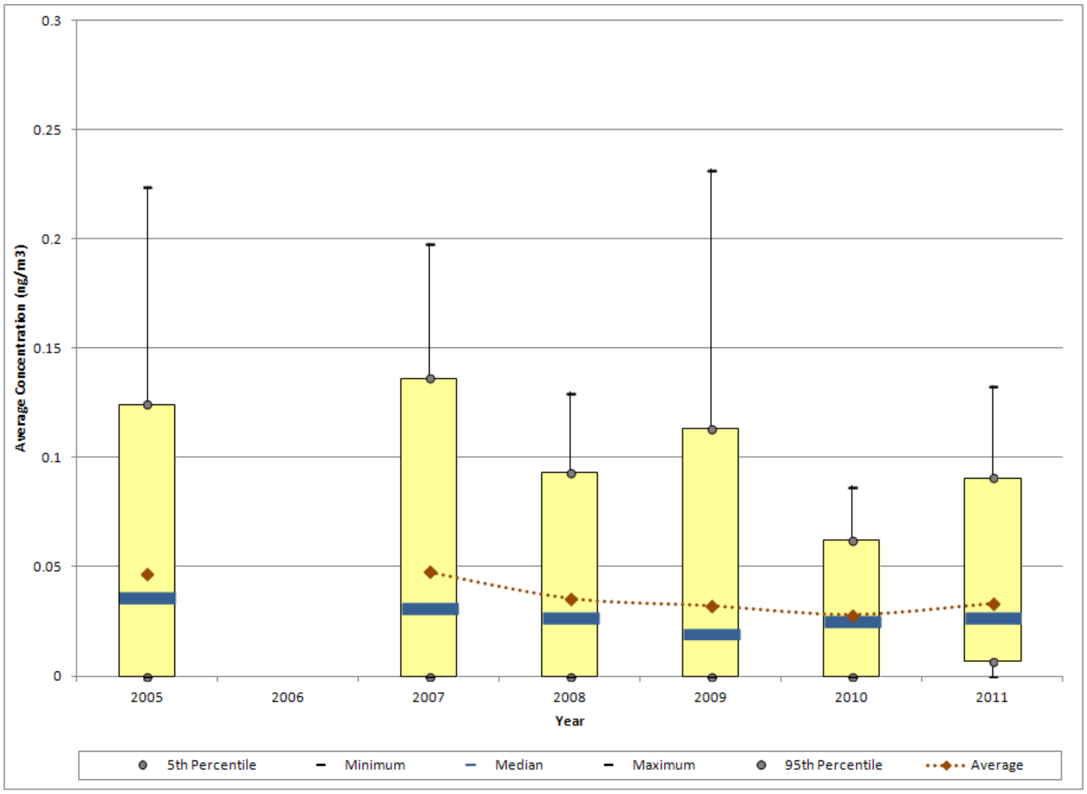


Figure 27-22. Annual Statistical Metrics for Lead (PM_{10}) Concentrations Measured at SEWA

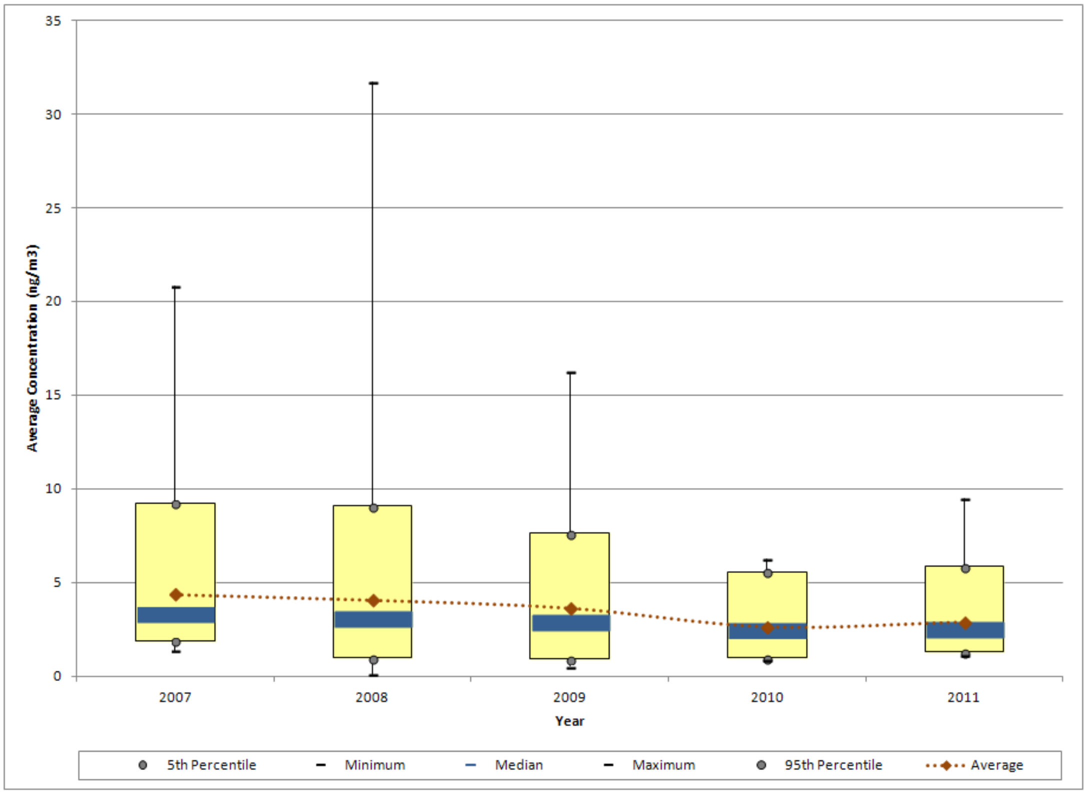
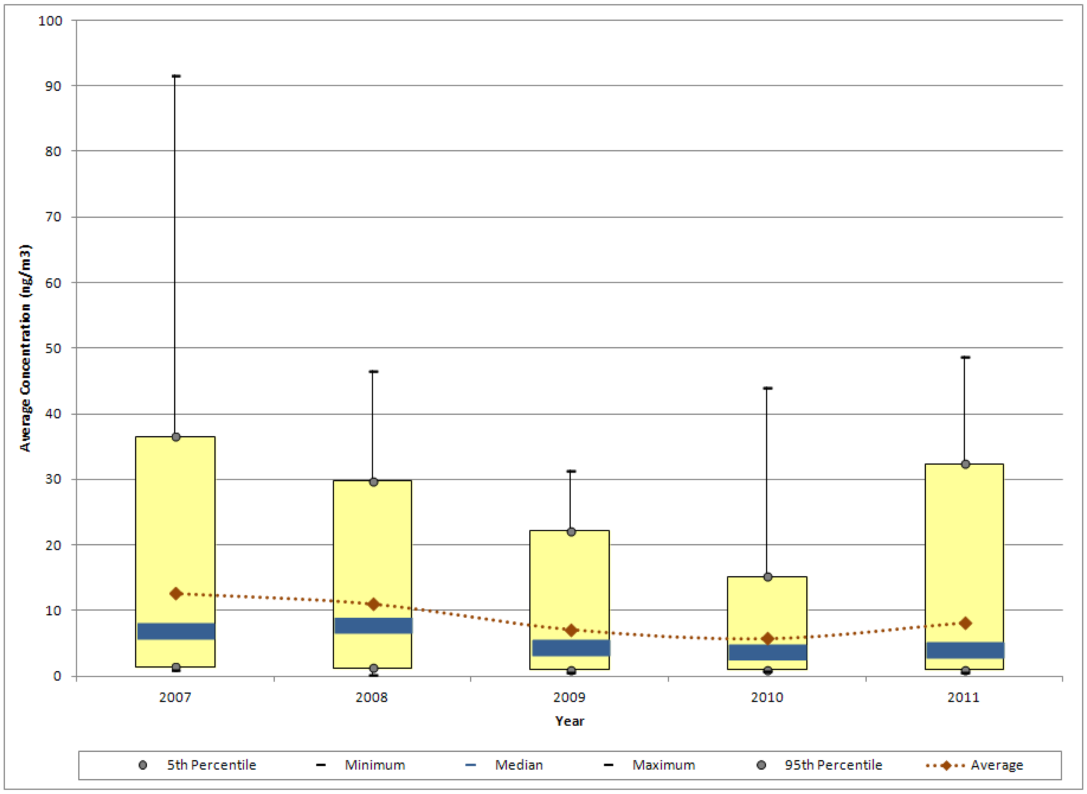


Figure 27-23. Annual Statistical Metrics for Manganese (PM_{10}) Concentrations Measured at SEWA



Observations from Figure 27-17 for arsenic (PM_{10}) measurements 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 average concentration has ranged from 0.58 ng/m^3 (2010) to 0.76 µg/m^3 (2007). The very slight decreasing trend exhibited by the average and median concentrations is not statistically significant.

- 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.

Observations from Figure 27-18 for benzene measurements 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 average concentration of benzene ranges from 0.69 µg/m^3 (2010) to 0.81 µg/m^3 (2009). If the maximum concentration measured in 2009 was removed from the calculation, the averages would vary by less than 0.1 µg/m^3.

- Most of the statistical metrics increased at least slightly from 2010 to 2011, with the exception of the median. The median decreased because the number of concentrations at the lower end of the range increased from 2010 to 2011 while the average concentration increased because it is being driven by the higher concentrations measured in 2011 (the maximum concentration increased by 1 µg/m^3 from 2010 to 2011).

- There have been no non-detects of benzene measured since the onset of sampling.

Observations from Figure 27-19 for 1,3-butadiene measurements at SEWA include the following:

- The maximum 1,3-butadiene concentration was measured at SEWA on the same day as the maximum benzene concentration was measured, January 19, 2009 (0.89 µg/m^3). 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.

- The number non-detects measured at SEWA has been increasing since the onset of sampling, from 0 percent in 2007 to 15 percent in 2011.

- Nearly all of the statistical metrics exhibit an increase from 2010 to 2011. The average concentration of 1,3-butadiene is at a maximum for 2011 (0.089 µg/m^3), although confidence intervals calculated for the average concentrations indicate that the averages are not statistically different.

Observations from Figure 27-20 for formaldehyde measurements 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 (9.43 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 level of variability in the measurements decreased significantly from 2009 to 2010. The difference between the average and median concentrations is less than 0.1 µg/m^3 for both 2010 and 2011.

- Although difficult to discern in Figure 27-20, the average concentration increased slightly from 2010 to 2011, although the average concentrations for both years are the lowest annual average concentrations of formaldehyde among all NMP sites sampling this pollutant.

- There have been no non-detects of formaldehyde measured since the onset of sampling.

Observations from Figure 27-21 for hexavalent chromium measurements at SEWA include the following:

- Although SEWA began sampling hexavalent chromium in January 2005, sampling was discontinued for an eight-month period in 2006 from March through October. There is no data provided for 2006 in Figure 27-21 because four months is not considered enough to be representative of an entire year.

- The maximum hexavalent chromium concentration shown was measured on January 19, 2009 (0.232 ng/m^3), the same day that the maximum concentration of several pollutants were measured at SEWA. A similar concentration was measured in 2005 (0.224 ng/m^3), also in January.

- The minimum and 5th percentiles are zero for each year of sampling shown except 2011, indicating the presence of non-detects. The percentage of non-detects has ranged from three percent (2011) to 21 percent (2009).

- The average concentration has a decreasing trend beginning in 2008 that continues through 2010. The median, however, reaches a minimum in 2009 rather than 2010, even with the maximum hexavalent chromium concentration measured. This is partly a result of the number of non-detects and thus, zeroes substituted into the calculation. The number of non-detects is 21 percent for 2009, which decreased to 15 percent for 2010. There were also a higher number of "lower" measurements in 2009; 18 concentrations less than 0.02 ng/m^3 were measured in 2009 as opposed to 12 in 2010.

- Nearly all of the statistical metrics exhibit increases from 2010 to 2011.

Observations from Figure 27-22 for lead (PM_{10}) measurements at SEWA include the following:

- The maximum lead concentration was measured at SEWA on February 24, 2008 (31.7 ng/m^3). Only one additional concentration measured at SEWA is greater than 20 ng/m^3 (20.8 ng/m^3 measured on July 5, 2007).

- A decreasing trend in the average and median lead concentrations is shown in Figure 27-22. Nearly all of the statistical metrics decreased from 2008 to 2009 and again for 2010. Slight increases in the statistical metrics are shown for 2011, although the difference in the average concentrations between 2010 and 2011 is not statistically significant.

- There have been no non-detects of lead measured since the onset of sampling, including in 2008, where it appears the minimum concentration is zero. For 2008, the minimum is 0.11 ng/m^3.

Observations from Figure 27-23 for manganese (PM_{10}) measurements 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 concentration measured in 2011 is just less than 50 ng/m^3.

- A steady decreasing trend in the average manganese concentration is shown through 2010.

- Most of the statistical metrics increased from 2010 to 2011. Although the 95th percentile more than doubled and the average increased by 40 percent, the median concentration changed only slightly.

- There have been no non-detects of manganese measured since the onset of sampling.

27.5 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 3.5.5 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 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 to 14 days); intermediate (exposures of 15 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 2011.

27.5.2 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 or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 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 Hazard Approximation (HQ)
Seattle, Washington - SEWA						
Acetaldehyde	0.0000022	0.009	60/60	0.94 ± 0.10	2.08	0.10
Arsenic (PM_{10})[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	2.86	0.04
Benzene	0.0000078	0.03	61/61	0.71 ± 0.11	5.56	0.02
Benzo(a)pyrene [a]	0.00176	--	25/60	<0.01 ± <0.01	0.15	--
Beryllium (PM_{10}) [a]	0.0024	0.00002	61/61	<0.01 ± <0.01	0.02	<0.01
1,3-Butadiene	0.00003	0.002	52/61	0.09 ± 0.02	2.66	0.04
Cadmium (PM_{10}) [a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.18	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.65 ± 0.03	3.90	0.01
Chloroform	--	0.098	57/61	0.12 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	17/61	0.02 ± 0.01	0.63	<0.01
Ethylbenzene	0.0000025	1	61/61	0.30 ± 0.04	0.74	<0.01
Formaldehyde	0.000013	0.0098	60/60	0.84 ± 0.09	10.95	0.09
Hexavalent Chromium [a]	0.012	0.0001	59/61	<0.01 ± <0.01	0.40	<0.01
Lead (PM_{10}) [a]	--	0.00015	61/61	<0.01 ± <0.01	--	0.02
Manganese (PM_{10}) [a]	--	0.00005	61/61	0.01 ± <0.01	--	0.16
Naphthalene [a]	0.000034	0.003	60/60	0.07 ± 0.01	2.48	0.02
Nickel (PM_{10}) [a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.91	0.02
Tetrachloroethylene	0.00000026	0.04	46/61	0.09 ± 0.02	0.02	<0.01
Trichloroethylene	0.0000048	0.002	5/61	0.01 ± 0.01	0.03	<0.01
Vinyl Chloride	0.0000088	0.1	1/61	<0.01 ± <0.01	<0.01	<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 27-5.

Observations from Table 27-6 for SEWA include the following:

- The pollutants with the highest annual averages for SEWA are acetaldehyde, formaldehyde, benzene, and carbon tetrachloride.

- 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 (0.16), indicating that no adverse health effects are expected from these individual pollutants.

27.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 27-7 and 27-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages provided in Table 27-6. Table 27-8 presents similar information, but identifies the 10 pollutants with the highest noncancer hazard approximations (HQ), also calculated from annual averages provided in Table 27-6.

The pollutants listed in Table 27-7 and 27-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. Further, 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 27.3, SEWA sampled for VOCs, carbonyl compounds, PAHs, metals (PM_{10}), and hexavalent chromium. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Table 27-7. 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	1,542.30	Benzene	1.20E-02	Formaldehyde	10.95
Formaldehyde	849.03	Formaldehyde	1.10E-02	Benzene	5.56
Ethylbenzene	654.82	POM, Group 3	8.19E-03	Carbon Tetrachloride	3.90
Acetaldehyde	430.54	1,3-Butadiene	5.70E-03	Arsenic	2.86
1,3-Butadiene	190.09	Naphthalene	3.37E-03	1,3-Butadiene	2.66
Naphthalene	99.14	POM, Group 2b	2.49E-03	Naphthalene	2.48
POM, Group 2b	28.31	Ethylbenzene	1.64E-03	Acetaldehyde	2.08
Dichloromethane	17.29	Nickel, PM	1.36E-03	Nickel	0.91
POM, Group 6	2.99	Hexavalent Chromium, PM	1.34E-03	Ethylbenzene	0.74
Nickel, PM	2.83	POM, Group 5a	1.11E-03	1,2-Dichloroethane	0.63

Table 27-8. 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	3,282.31	Acrolein	2,237,728.52	Manganese	0.16
Xylenes	2,629.14	1,3-Butadiene	95,046.24	Acetaldehyde	0.10
Benzene	1,542.30	Formaldehyde	86,635.26	Formaldehyde	0.09
Methanol	1,092.81	Benzene	51,409.86	Arsenic	0.04
Formaldehyde	849.03	Acetaldehyde	47,837.23	1,3-Butadiene	0.04
Ethylbenzene	654.82	Naphthalene	33,047.76	Naphthalene	0.02
Hexane	642.62	Nickel, PM	31,499.47	Benzene	0.02
Acetaldehyde	430.54	Xylenes	26,291.40	Nickel	0.02
1,3-Butadiene	190.09	Lead, PM	15,384.07	Lead	0.02
Ethylene glycol	142.99	Arsenic, PM	10,669.99	Cadmium	0.01

Observations from Table 27-7 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 benzene, formaldehyde, and POM, Group 3. POM, Group 3 does not include any pollutants sampled for at SEWA.

- Seven 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, ethylbenzene, and nickel also appear on all three lists.

- Carbon tetrachloride and arsenic, which rank third and fourth for cancer risk approximations for SEWA, do not appear on either emissions-based list. Acetaldehyde has the seventh highest cancer risk approximation and ranks fourth for total emissions, but ranks 11th for toxicity-weighted emissions and thus, does not appear in this column in Table 27-7.

- POM, Group 2b is the seventh highest emitted "pollutant" in King County and ranks sixth for toxicity-weighted emissions. POM, Group 2b includes several PAHs sampled for at SEWA including acenaphthene, fluorene, and perylene. Although none of the PAHs included in POM, Group 2b were identified as pollutants of interest for SEWA, acenaphthene failed one screen for SEWA.

- POM, Group 5a ranks tenth for toxicity-weighted emissions for King County. POM, Group 5a includes benzo(a)pyrene and is not one of the highest "pollutants" emitted in King County.

Observations from Table 27-8 for SEWA include the following:

- Toluene, xylenes, and benzene are the highest emitted pollutants with noncancer RfCs in King County.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for King County, followed by 1,3-butadiene and formaldehyde. 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.

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

- Manganese, which has the highest noncancer hazard approximation for SEWA, does not appear on either emissions-based list for King County. Acetaldehyde, formaldehyde, 1,3-butadiene, and benzene appear on all three lists in Table 27-8.

- Three of the four metals that appear among the highest noncancer hazard approximations for SEWA are also among the pollutants with the highest toxicity-weighted emissions (arsenic, nickel, and lead). However, none of these are among the highest emitted pollutants (with a noncancer RfC) in King County.

- Naphthalene also has one of the highest noncancer hazard approximations for SEWA and appears among the pollutants with the highest toxicity-weighted emissions but is not one of the highest emitted (with a noncancer RfC).

27.6 Summary of the 2011 Monitoring Data for SEWA

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

- ❖ *Eighteen pollutants failed at least one screen for SEWA, of which 12 are NATTS MQO Core Analytes.*

- ❖ *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 highest among NMP sites sampling metals.*

- ❖ *The average concentration for each of the pollutants for which a trends analysis was performed exhibits a slight increase from 2010 to 2011.*

28.0 Site in Wisconsin

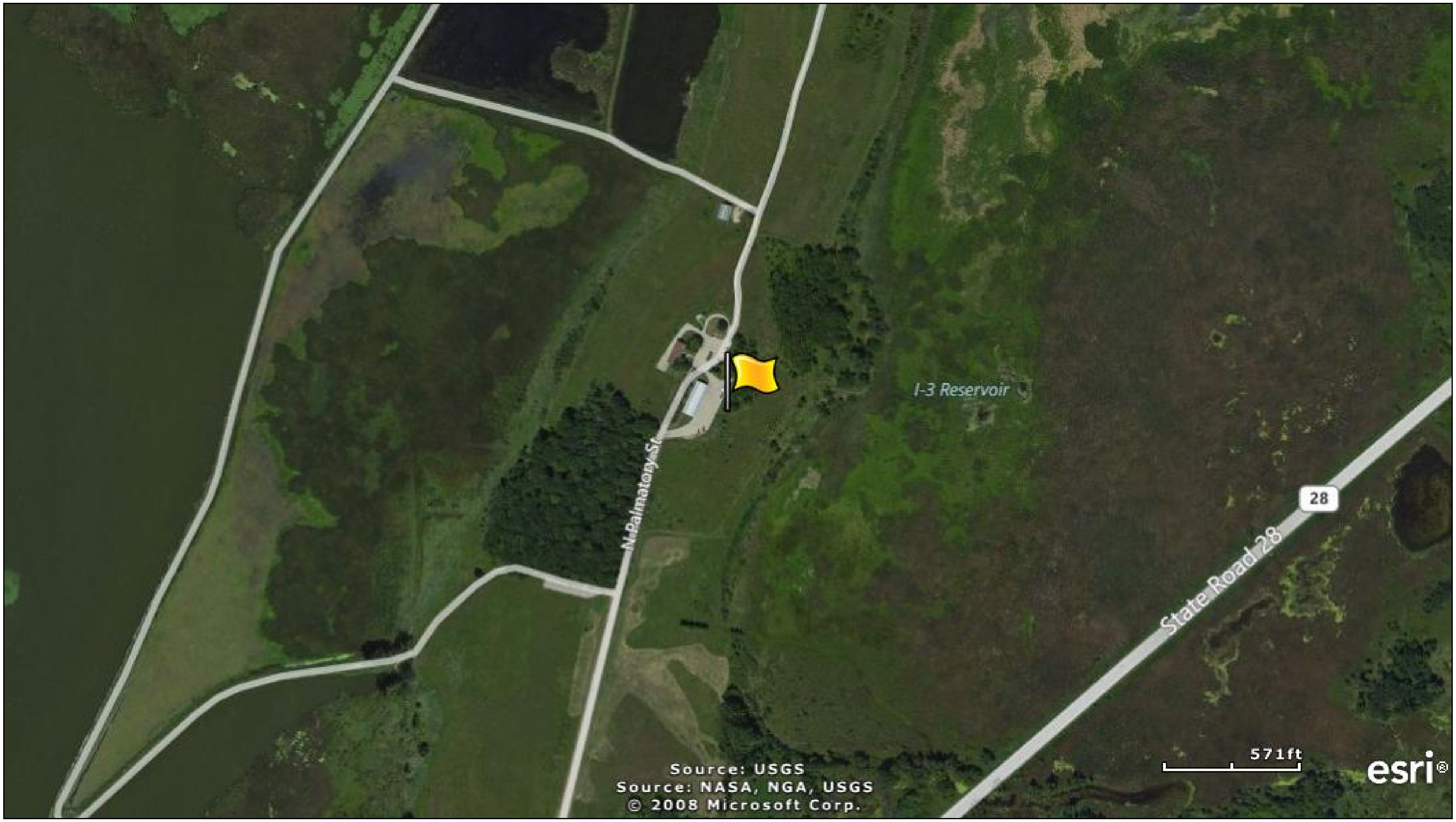
This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site in Wisconsin, and integrates these concentrations with emissions, meteorological, and risk information. Data generated by sources other than ERG are not included in the data 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.

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 HOWI site is located in Horicon, Wisconsin and is the relocated Mayville NATTS site. Figure 28-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its rural location. Figure 28-2 identifies nearby point source emissions locations by source category, as reported in the 2008 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. Horicon, Wisconsin (HOWI) Monitoring Site



Source: USGS
Source: NASA, NGA, USGS
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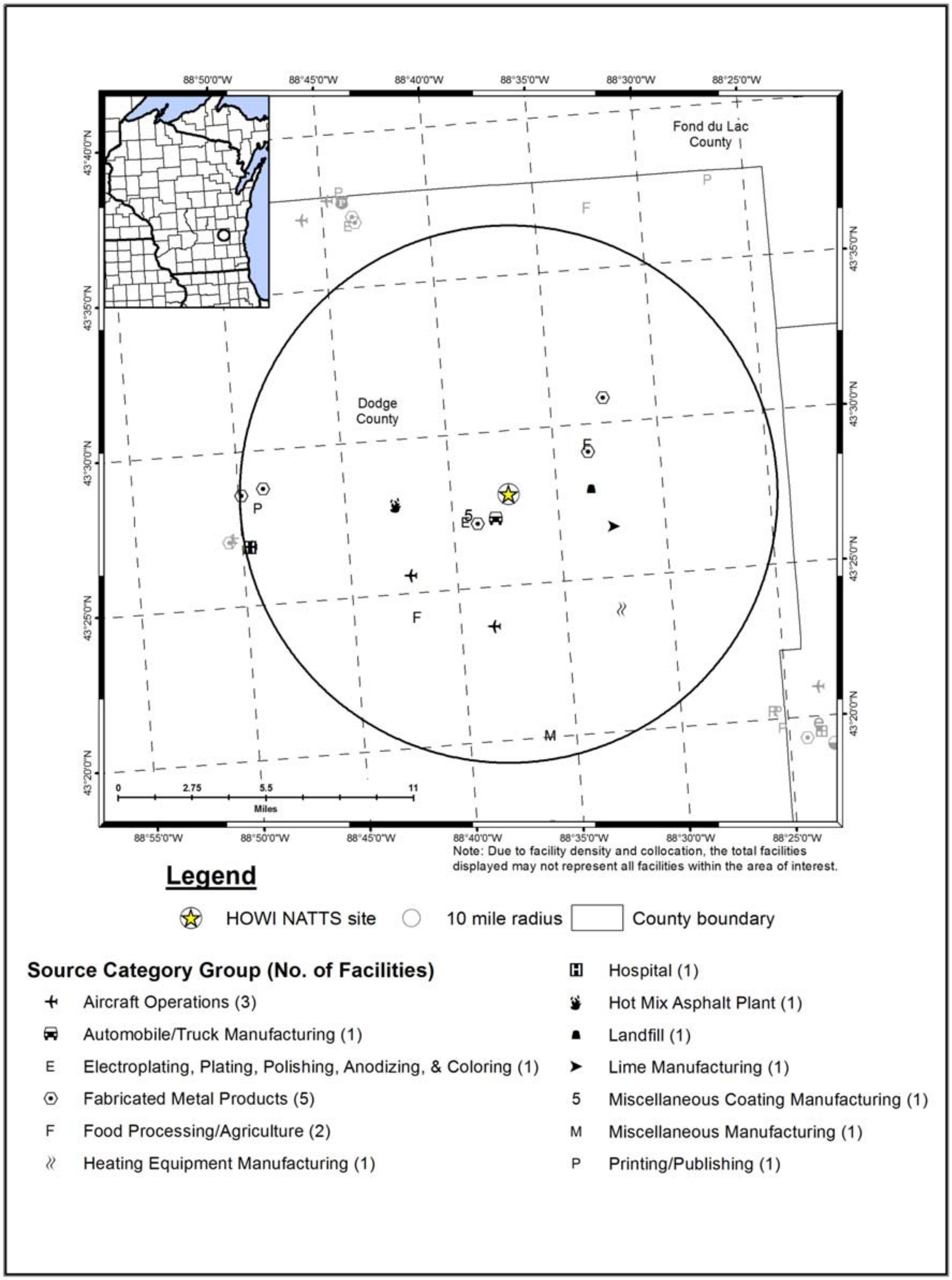
Figure 28-2. NEI Point Sources Located Within 10 Miles of HOWI



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

Table 28-1. Geographical Information for the Wisconsin 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]
HOWI	55-027-0007	Horicon	Dodge	Beaver Dam, WI MSA	43.466111, -88.621111	Agricultural	Rural	CO, SO_2, NO_y, NO, VOCs, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Metals, $PM_{2.5}$, and $PM_{2.5}$ Speciation, SVOCs, PM Coarse.

[1] Data for additional pollutants are reported to AQS for HOWI (EPA, 2012c); however, these data are not generated by ERG and are therefore not included in this report.

BOLD ITALICS = EPA-designated NATTS Site

The HOWI 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 about 46 miles northwest of Milwaukee and roughly 48 miles northeast of Madison. 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 28-1, is the closest major roadway. Figure 28-2 shows that a cluster of point sources is located just south and west of HOWI, in the town of Horicon. The closest point source to HOWI is an automobile and truck manufacturing facility. The source categories with the most emissions sources within 10 miles of HOWI are fabricated metal products facilities; aircraft operations, which include airports as well as small runways, heliports, and landing pads; and food processing/agricultural facilities.

Table 28-2 presents additional site-characterizing information, including indicators of mobile source activity, for the Wisconsin monitoring site. Table 28-2 includes county-level population and vehicle registration information. Table 28-2 also includes a county-level vehicle registration-to-population ratio, which was calculated to represent the number of vehicles per person within the monitoring site's residing county. In addition, the population within 10 miles of the site is presented, based on postal code population data estimates. An estimate of 10-mile vehicle ownership was determined by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 28-2 also contains traffic volume information for HOWI. Finally, Table 28-2 presents the county-level daily VMT for Dodge County.

Table 28-2. Population, Motor Vehicle, and Traffic Information for the Wisconsin Monitoring Site

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	Vehicles per Person (Registration: Population)	Population within 10 miles[3]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[4]	County-level Daily VMT[5]
HOWI	88,661	100,176	1.13	21,990	24,846	5,000	2,626,054

[1] County-level population estimate reflects 2011 data from the U.S. Census Bureau (Census Bureau, 2012b)
[2] County-level vehicle registration reflects 2011 data from the Wisconsin DOT (WI DOT, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] AADT reflects 2008 data from the Wisconsin DOT (WI DOT, 2008)
[5] County-level VMT reflects 2011 data from the Wisconsin DOT (WI DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 28-2 include the following:

- Dodge County's population is in the bottom-third compared to other counties with NMP sites. This is also true of its 10-mile population.
- The county-level vehicle registration is also on the low end compared to other counties with NMP sites. This is also true of its estimated 10-mile vehicle ownership.
- The vehicle-per-person ratio is slightly greater than one vehicle per person. This ratio ranks among the higher ratios for NMP sites.
- The traffic volume near HOWI is also on the low end compared to other NMP sites. The traffic estimate provided is for State Road 28 near State Road 33 on the east side of Horicon.
- The daily VMT for Dodge County is on the low side 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 Wisconsin on sample days, as well as over the course of the year.

28.2.1 Climate Summary

The town of Horicon is located in southeast Wisconsin, between the towns of West Bend and Beaver Dam, and about 40 miles west of Lake Michigan. This area is far enough inland to limit some of the moderating influences of Lake Michigan on the area's climate. This area experiences a highly variable, continental climate as weather systems frequently track across the region. Precipitation falls predominantly in the spring and summer months. Winters are cold and predominantly dry, although snowfall is common. Lake effect snows can occur with winds with a northeasterly and easterly component, although lake effect snows are often reduced this far inland. Summers tend to be mild, although southerly winds out of the Gulf of Mexico can occasionally advect warm, humid air into the area (Bair, 1992).

28.2.2 Meteorological Conditions in 2011

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2011 (NCDC, 2011). The closest weather station is located at Dodge County Airport (WBAN 04898). Additional information about the Dodge County Airport 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.

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 the entire year. 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 appear cooler and drier than average weather conditions throughout 2011, although the differences are not statistically significant.

28.2.3 Back Trajectory Analysis

Figure 28-3 is the composite back trajectory map for days on which samples were collected at the HOWI monitoring site in 2011. 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.

Table 28-3. Average Meteorological Conditions near the Wisconsin Monitoring Site

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)
Horicon, Wisconsin - HOWI									
Dodge County Airport 04898 (43.43, -88.70)	4.64 miles 229° (SW)	Sample Day	52.3 ± 5.5	44.9 ± 5.1	34.3 ± 4.6	40.0 ± 4.5	69.7 ± 3.2	NA	6.9 ± 0.9
		2011	54.5 ± 2.2	46.6 ± 2.0	36.2 ± 1.8	41.8 ± 1.8	70.7 ± 1.3	NA	6.9 ± 0.3

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

NA = Sea level pressure was not recorded at the Dodge County Airport

Figure 28-3. 2011 Composite Back Trajectory Map for HOWI

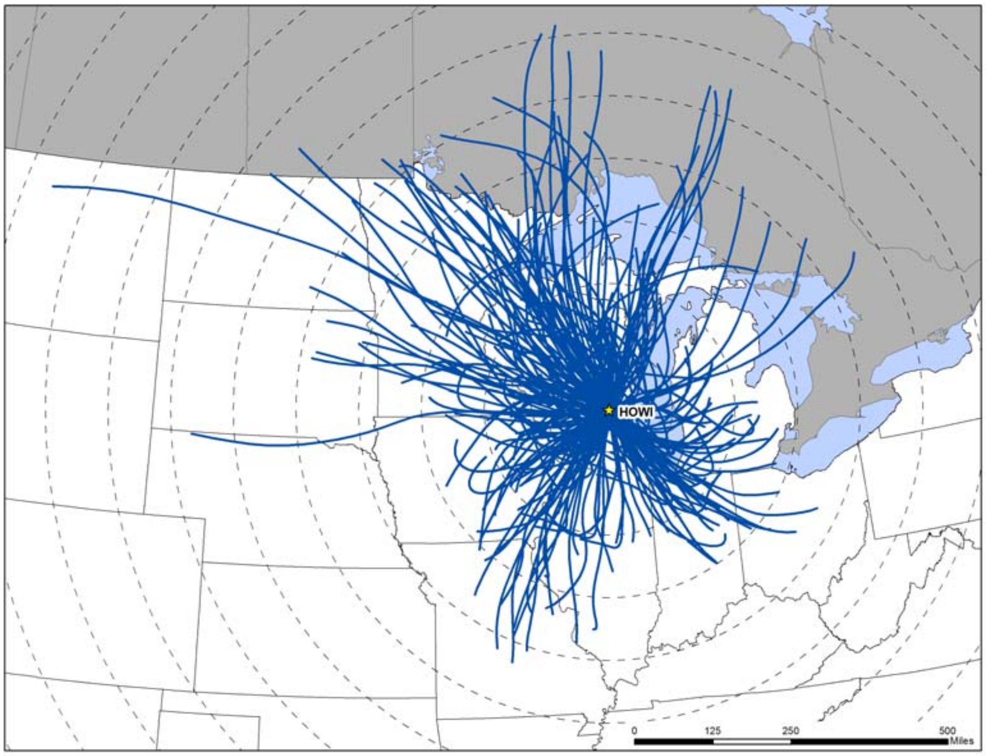
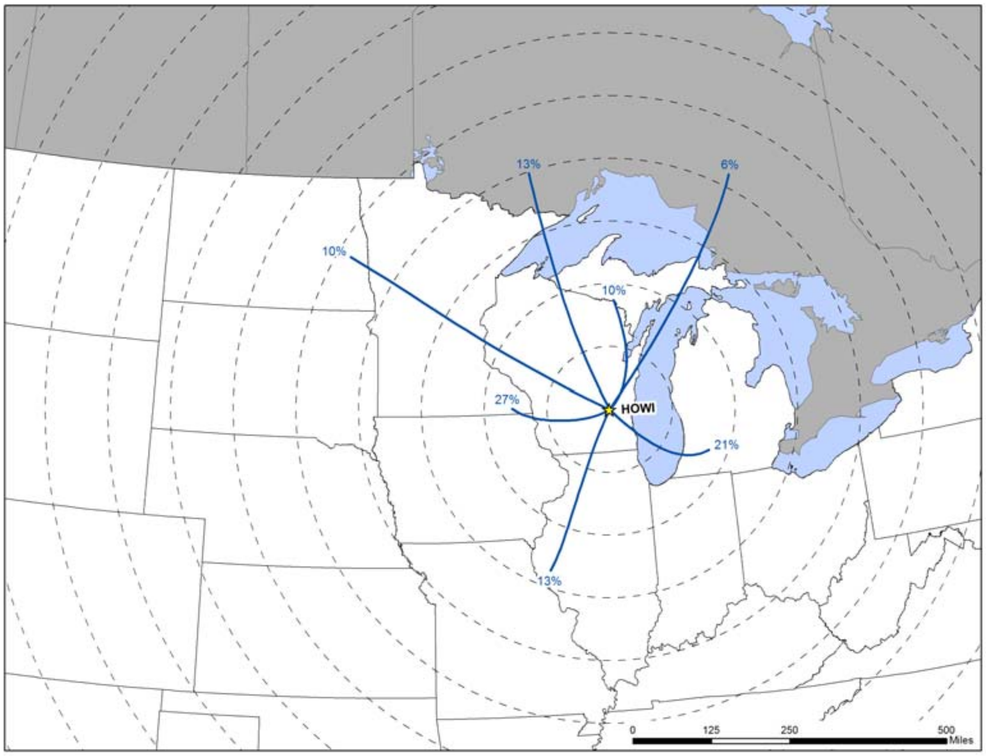


Figure 28-4. Back Trajectory Cluster Map for HOWI



Observations from Figures 28-3 and 28-4 for HOWI include the following:

- Back trajectories originated from a variety of directions at HOWI, although a majority of the back trajectories originate from a direction with a westerly component.

- The 24-hour air shed domain for HOWI is among the larger in size compared to other NMP monitoring sites. The farthest away a back trajectory originated was north-central Montana, or approximately 950 miles away. However, the average trajectory length was 274 miles and most trajectories (88 percent) originated within 450 miles of the site.

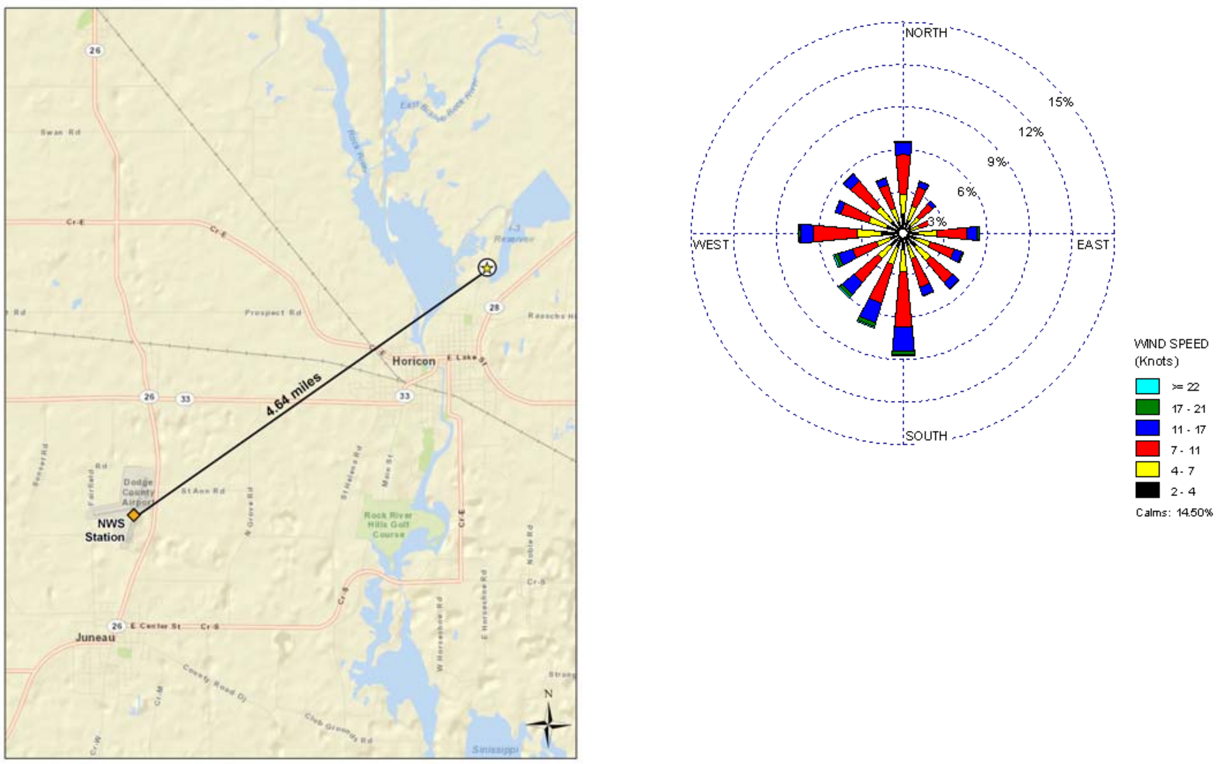
- The cluster analysis shows that about 16 percent of the back trajectories originated from the north and northeast of HOWI, although of varying distances (10 percent originated over Lakes Michigan and Superior while another 6 percent originated over Ontario, Canada). Another 13 percent of back trajectories originated to the north-northwest to north of HOWI. Ten percent of back trajectories originated to the northwest and greater than 400 miles away of HOWI. Twenty-seven percent of back trajectories are represented by the short trajectory originating to the west of the site. The individual back trajectories represented by this cluster trajectory originated from the northwest, west, and southwest and within 300 miles of the site. Thirteen percent of back trajectories originated from the southeast to southwest of the site over Illinois, Missouri, and Iowa while another 21 percent originated to the east to southeast over Michigan, Ohio, and Indiana.

28.2.4 Wind Rose Comparison

Hourly surface wind data from the NWS weather station at Dodge County Airport near HOWI 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.

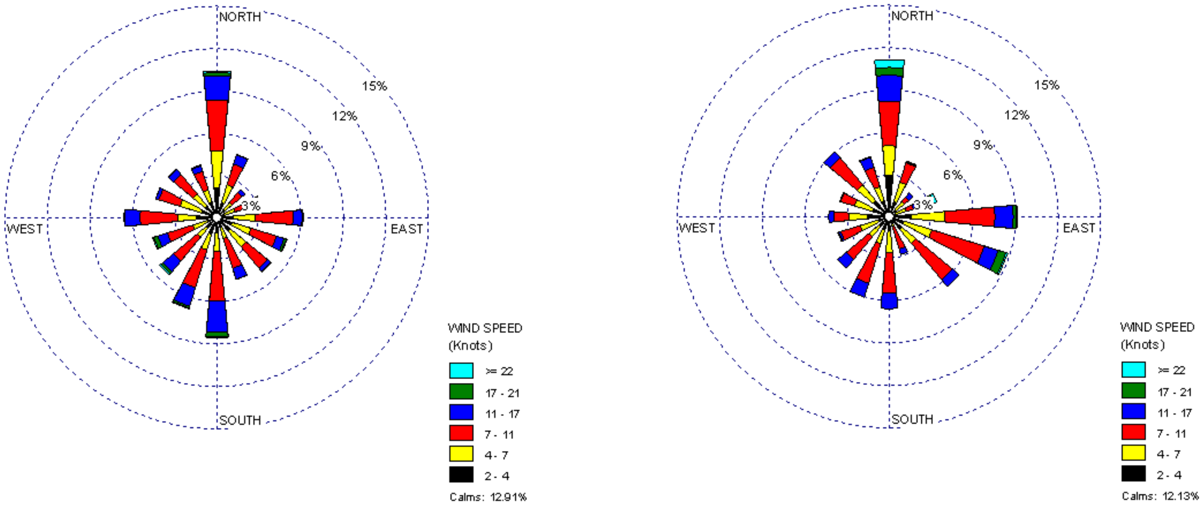
Figure 28-5 presents a map showing the distance between the NWS station and HOWI, which may be useful for identifying topographical influences that can affect the meteorological patterns experienced at this location. Figure 28-5 also presents three different wind roses for the HOWI monitoring site. First, a historical wind rose representing 2003 to 2010 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 2011 is presented. Next, a wind rose representing wind data for days on which samples were collected in 2011 is presented. These can be used to identify the predominant wind speed and direction for 2011 and determine if wind observations on sample days were representative of conditions experienced over the entire year and historically.

Figure 28-5. Wind Roses for the Dodge County Airport Weather Station near HOWI



Distance between HOWI and NWS Station

2003-2010 Historical Wind Rose



2011 Wind Rose

Sample Day Wind Rose

Observations from Figure 28-5 for HOWI include the following:

- The Dodge County Airport weather station is located approximately 4.6 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 nearly 15 percent of the hourly measurements.
- The wind patterns shown on the 2011 wind rose resemble the historical wind patterns, although winds from the north were observed more frequently.
- The sample day wind rose shows that winds from the north were observed even more frequently on sample days and that a higher percentage of strong (> 22 knots) winds were observed for these northerly winds. In addition, winds from the east to southeast were observed more frequently than winds from the southwest quadrant.

28.3 Pollutants of Interest

Site-specific “pollutants of interest” were determined for the Wisconsin monitoring site in order to allow 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.” 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. In addition, if any of the NATTS MQO Core Analytes measured by the monitoring site did not meet the pollutant of interest criteria based on the preliminary risk-based screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk-based screening process is presented in Section 3.2.

Table 28-4. Risk-Based Screening Results for the Wisconsin Monitoring Site

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	41	0.00	0.00	0.00
Total		0	41	0.00		

Table 28-4 presents the results of the preliminary risk-based screening process for HOWI. Observations from Table 28-4 include the following:

- Hexavalent chromium was detected in 41 of the 61 valid samples collected at HOWI.
- Hexavalent chromium did not fail any screens. However, hexavalent chromium is the pollutant of interest for HOWI because it is a NATTS MQO Core Analyte and because it is the only pollutant sampled for at HOWI.

28.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Wisconsin monitoring site. Where applicable, the following calculations and data analyses were performed: Time period-based concentration averages (quarterly and annual) are provided for the pollutant of interest for the Wisconsin monitoring site, where the data meet the applicable criteria. Concentration averages for the pollutants of interest are also presented graphically for the site to illustrate how the site's concentrations compare to the program-level averages, as presented in Section 4.1. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site. Additional site-specific statistical summaries for HOWI are provided in Appendix O.

28.4.1 2011 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Wisconsin 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 of 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 HOWI are presented in Table 28-5, 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 28-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Wisconsin 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)
Horicon, Wisconsin - HOWI						
Hexavalent Chromium	41/61	0.004 ± 0.004	0.023 ± 0.009	0.022 ± 0.006	0.010 ± 0.007	0.015 ± 0.004

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

Observations for HOWI from Table 28-5 include the following:

- Concentrations of hexavalent chromium spanned an order of magnitude, ranging from 0.0078 ng/m^3 to 0.072 ng/m^3. The maximum concentration was measured on May 9, 2011.

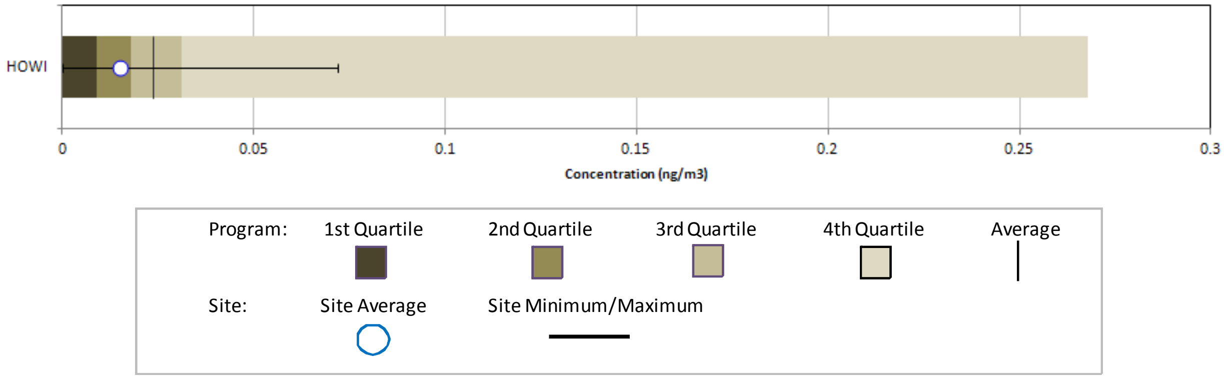
- Hexavalent chromium was most often detected in the warmer months of the year. Nine non-detects were measured during the first quarter of 2011, two each in the second and third quarters, and seven were measured in the fourth quarter of the year.

- The annual average concentration of hexavalent chromium for HOWI was on the low side compared to other NMP sites sampling this pollutant, ranking 15th out 22.

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 the selected NATTS MQO Core Analytes listed in Section 3.5.3, where applicable. Thus, a box plot for hexavalent chromium was created for HOWI. Figure 28-6 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.

Figure 28-6. Program vs. Site-Specific Average Hexavalent Chromium Concentration



Observations from Figure 28-6 include the following:

- Figure 28-6 shows that the annual average concentration of hexavalent chromium for HOWI is less than the program-level average as well as the program-level median concentration. The maximum concentration measured at HOWI is considerably less than the program-level maximum concentration. There were 20 non-detects of hexavalent chromium measured at HOWI.

28.4.3 Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the selected NATTS MQO Core Analytes for 5 consecutive years or longer, as described in Section 3.5.4. Because sampling under the NMP did not begin until December 2009 at HOWI, a trends analysis was not conducted for this site.

28.5 Additional Risk-Based Screening Evaluations

The following risk-based screening evaluations were conducted to characterize risk at the Wisconsin monitoring site. Refer to Sections 3.3 and 3.5.5 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 Wisconsin 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 to 14 days); intermediate (exposures of 15 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 2011.

28.5.2 Cancer Risk and Noncancer Hazard Approximations

For the pollutants of interest for the Wisconsin 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 may want to shift or confirm their air-monitoring priorities. Refer to Section 3.5.5.2 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 Wisconsin Monitoring Site

Pollutant	Cancer URE (µg/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 Hazard Approximation (HQ)
Horicon, Wisconsin - HOWI						
Hexavalent Chromium	0.012	0.0001	41/61	0.015 ± 0.004	0.18	<0.01

Observations for HOWI from Table 28-6 include the following:

- The cancer risk approximation for hexavalent chromium is less than 1.0 in-a-million (0.18 in-a-million).
- The noncancer hazard approximation for hexavalent chromium is less than 1.0, indicating that no adverse health effects are expected from this pollutant.

28.5.3 Risk-Based Emissions Assessment

In addition to the risk-based screenings discussed above, Tables 28-7 and 28-8 present 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 2008 NEI, the 10 pollutants with the highest toxicity-weighted emissions, and the cancer risk approximation for hexavalent chromium, as calculated from the annual average provided in Table 28-6. Table 28-8 presents similar information, but identifies the noncancer hazard approximation for hexavalent chromium, also calculated from annual average provided in Table 28-6.

The pollutants listed in Tables 28-7 and 28-8 are limited to those that have cancer and noncancer toxicity factors, respectively. As a result, although the actual value of the emissions is the same, the highest emitted pollutants in the cancer table may be different from the noncancer table. 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 28.3, HOWI sampled for hexavalent chromium only. 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 3.5.5.3. Similar to the cancer risk and noncancer hazard approximations, this analysis may help policy-makers prioritize their air monitoring activities.

Observations from Table 28-7 include the following:

- Benzene, formaldehyde, and acetaldehyde are the highest emitted pollutants with cancer UREs in Dodge County.
- Benzene is the pollutant with the highest toxicity-weighted emissions (of the pollutants with cancer UREs), followed by formaldehyde and hexavalent chromium.
- Seven of the highest emitted pollutants in Dodge County also have the highest toxicity-weighted emissions.
- Hexavalent chromium, which is the only pollutant sampled for at HOWI, has the third highest toxicity-weighted emissions for Dodge County, but is not among the highest emitted. Hexavalent chromium emissions in Dodge County rank 17th.
- Several POM Groups rank among Dodge County's highest total emissions and toxicity-weighted emissions.

Table 28-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Wisconsin 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)**
Horicon, Wisconsin (Dodge County) - HOWI					
Benzene	90.74	Benzene	7.08E-04	Hexavalent Chromium	0.18
Formaldehyde	47.98	Formaldehyde	6.24E-04		
Acetaldehyde	31.44	Hexavalent Chromium, PM	3.70E-04		
Ethylbenzene	26.35	1,3-Butadiene	2.90E-04		
1,3-Butadiene	9.67	Naphthalene	2.08E-04		
Naphthalene	6.11	POM, Group 3	2.07E-04		
POM, Group 2b	1.31	POM, Group 2b	1.15E-04		
Tetrachloroethylene	1.00	POM, Group 5a	1.12E-04		
Trichloroethylene	0.85	Acetaldehyde	6.92E-05		
Dichloromethane	0.82	Ethylbenzene	6.59E-05		

Table 28-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Hazard Approximations for Pollutants with Noncancer RfCs for the Wisconsin 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)**
Horicon, Wisconsin (Dodge County) - HOWI					
Toluene	329.03	Acrolein	163,416.51	Hexavalent Chromium	<0.01
Xylenes	146.74	Manganese, PM	6,223.90		
Methanol	98.40	Cyanide Compounds, gas	5,737.27		
Benzene	90.74	Formaldehyde	4,895.94		
Formaldehyde	47.98	1,3-Butadiene	4,837.37		
Methyl isobutyl ketone	33.47	Acetaldehyde	3,493.32		
Acetaldehyde	31.44	Benzene	3,024.81		
Hexane	31.15	Chlorine	2,097.57		
Hydrochloric acid	26.97	Naphthalene	2,036.14		
Ethylbenzene	26.35	Xylenes	1,467.40		

Observations from Table 28-8 include the following:

- Toluene, xylenes, and methanol are the highest emitted pollutants with noncancer RfCs in Dodge County.
- The pollutants with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) are acrolein, manganese, and cyanide compounds (gaseous).
- Five of the highest emitted pollutants in Dodge County also have the highest toxicity-weighted emissions.
- Hexavalent chromium does not appear among the pollutants with the highest emissions or toxicity-weighted emissions. This pollutant's emissions rank 32nd and its toxicity-weighted emissions rank 19th (among the pollutants with noncancer RfCs).

28.6 Summary of the 2011 Monitoring Data for HOWI

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.*
- *Concentrations of hexavalent chromium measured at HOWI ranged from 0.0078 ng/m^3 to 0.072 ng/m^3. The annual average concentration of hexavalent chromium ranked 15th compared to other NMP sites sampling this pollutant.*
- *Hexavalent chromium has the third highest toxicity-weighted emissions for Dodge County, but is not among the highest emitted.*

29.0 Data Quality

This section discusses the data quality of the ambient air measurements that constitute the 2011 NMP dataset. Each monitoring program under the NMP has its own specific DQO(s) 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, 2011), the following MQOs were assessed: completeness, precision, and accuracy (also called bias).

The quality assessments presented in this section show that the 2011 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.

29.1 Completeness

Completeness refers to the number of valid samples actually 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, 2011). The MQO of 85 percent completeness was met by all but seven out of 123 site-method combinations. Completeness statistics are presented and discussed more thoroughly in Section 2.4.

29.2 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 2011 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 29.3.

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. A coefficient of variation of one 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 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 pollutant-specific CV was calculated for each monitoring site.
- A site-specific CV was calculated for each method.
- A method-specific CV was calculated and compared to the precision MQO.

Table 29-1 presents the 2011 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 method precision. This table also includes the number of pairs that were included in the calculation of the method precision. The number of pairs including those with concentrations less than the MDL is also included in Table 29-1 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 29-1. 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)	11.88	2,971	3,773
SNMOC	11.59	1,176	1,614
Carbonyl Compounds (TO-11A)	6.83	1,540	1,541
PAH (TO-13)	11.83	375	488
Metals Analysis (Method IO-3.5)	13.58	1,506	1,854
Hexavalent Chromium (EPA-approved method)	14.54	110	118
MQO	15.00 percent CV		

Tables 29-2 through 29-7 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. The shaded rows in each table identify the NATTS MQO Core Analytes for each method. 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 (i.e., the concentration difference between 0.01 ng/m^3 and 0.02 ng/m^3 is 100 percent).

29.2.1 VOC Method Precision

Table 29-2 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 for NMP sites sampling VOCs. The pollutant-specific CV ranged from 0 percent for a few pollutants for several sites to 134.72 percent (carbon disulfide for GLKY). The pollutant-specific average CV ranged from 0 percent (a few pollutants) to 42.77 percent (dibromochloromethane). Note that in these cases, the number of pairs included in the calculations are low. The site-specific average CV ranged from 7.26 percent for S4MO to 20.00 percent for GLKY. The overall average method precision for VOCs was 11.88 percent.

Table 29-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site

Pollutant	***BTUT***	**BURVT**	**CHNJ**	***DEMI***	**ELNJ**	***GLKY***
Acetylene	5.51	5.96	5.81	6.09	8.41	5.27
Acrylonitrile	NA	**25.98**	**21.63**	NA	**37.52**	**81.91**
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	**17.92**	8.61	6.36	4.24	9.93	6.14
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA
Bromomethane	**31.09**	11.96	**21.94**	3.37	14.70	8.69
1,3-Butadiene	10.60	6.58	**19.37**	6.71	9.09	**20.13**
Carbon Disulfide	**35.12**	NA	**18.31**	**18.74**	9.11	**134.72**
Carbon Tetrachloride	6.48	**22.80**	11.85	7.94	11.93	4.34
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	**39.12**	5.66	**18.86**	11.22	8.32	NA
Chloroform	3.57	14.59	13.41	**34.72**	9.56	4.76
Chloromethane	6.39	14.08	10.91	6.97	8.43	5.98
Chloromethylbenzene	NA	NA	NA	NA	NA	NA
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	NA	NA	3.82	NA
Dichlorodifluoromethane	4.70	7.36	7.01	6.54	8.32	4.69
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	10.28	12.46	0.00	3.63	0.00	4.04
1,1-Dichloroethene	0.00	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	0.00	NA	NA	NA	NA	NA
Dichloromethane	13.31	**38.38**	**22.91**	**16.61**	9.59	**43.48**
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	7.47	7.65	14.02	6.29	8.78	3.21
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	NA
Ethylbenzene	8.27	9.63	8.53	7.74	6.29	**15.26**
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	**15.67**	**25.98**	10.88	**18.05**	**30.11**	**32.47**
Methyl Methacrylate	NA	NA	NA	NA	3.93	NA
Methyl *tert*-Butyl Ether	NA	NA	NA	NA	7.14	NA

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	***BTUT***	**BURVT**	**CHNJ**	***DEMI***	**ELNJ**	***GLKY***
n-Octane	11.63	11.26	12.50	6.68	7.76	**15.70**
Propylene	11.23	13.72	7.21	6.37	10.05	11.64
Styrene	10.85	11.18	9.07	5.55	11.25	11.80
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	6.67	5.52	13.82	5.99	9.69	NA
Toluene	8.14	12.82	14.42	11.00	5.10	**15.50**
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	NA
Trichlorofluoromethane	5.18	4.99	7.12	4.15	8.44	3.11
Trichlorotrifluoroethane	4.78	4.98	8.40	3.51	8.08	2.91
1,2,4-Trimethylbenzene	8.97	11.08	6.34	12.03	8.92	9.09
1,3,5-Trimethylbenzene	**16.52**	6.86	7.71	7.10	10.93	NA
Vinyl chloride	NA	NA	NA	NA	NA	NA
m,p-Xylene	8.27	11.54	9.08	8.62	6.45	**20.64**
o-Xylene	9.58	9.80	8.22	8.96	6.98	14.41
Average by Site	11.33	12.36	11.69	9.19	9.95	**20.00**

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	***GPCO***	**MWOK**	***NBIL***	**NBNJ**	**OCOK**	**PANJ**
Acetylene	3.10	3.44	2.16	8.12	**36.98**	6.97
Acrylonitrile	1.91	NA	13.58	NA	NA	NA
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	5.76	3.94	**15.01**	**23.48**	**53.15**	13.66
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	**41.30**	NA	NA	NA
Bromoform	NA	NA	**34.49**	NA	NA	NA
Bromomethane	11.58	**57.64**	10.68	**18.21**	13.55	8.84
1,3-Butadiene	5.48	3.81	6.17	7.19	**70.59**	2.28
Carbon Disulfide	10.17	NA	7.78	**15.72**	NA	NA
Carbon Tetrachloride	**27.27**	8.39	**20.65**	11.88	**20.39**	10.88
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	2.24	NA	10.27	**40.41**	NA	**19.00**
Chloroform	7.07	4.04	**34.50**	11.61	0.00	1.75
Chloromethane	1.77	7.71	4.35	6.08	2.26	4.81
Chloromethylbenzene	NA	NA	NA	NA	NA	NA
Chloroprene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	**42.77**	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	NA	NA	NA	**72.04**
Dichlorodifluoromethane	1.92	3.13	2.77	6.38	2.32	8.69
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	0.00	0.00	5.00	3.29	NA	0.00
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	**21.33**	8.82	**30.01**	14.40	7.42	0.20
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	4.66	4.14	4.74	13.33	5.43	9.87
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	NA
Ethylbenzene	**29.96**	6.17	6.72	13.01	14.88	9.85
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	**15.80**	**17.78**	**24.84**	10.03	**25.67**	**39.31**
Methyl Methacrylate	NA	NA	NA	NA	NA	NA
Methyl *tert*-Butyl Ether	NA	NA	NA	6.15	NA	NA

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	***GPCO***	**MWOK**	***NBIL***	**NBNJ**	**OCOK**	**PANJ**
n-Octane	**19.10**	8.97	13.91	8.91	10.05	**19.96**
Propylene	2.94	5.89	4.53	14.87	**56.41**	0.37
Styrene	**19.64**	8.40	8.52	10.10	**26.16**	10.88
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	6.85	7.96	5.16	**16.00**	0.75	5.14
Toluene	**15.86**	5.71	6.38	9.35	**32.49**	**19.92**
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	1.17	NA	NA	NA	NA	NA
Trichlorofluoromethane	2.83	3.33	4.37	6.13	3.11	10.07
Trichlorotrifluoroethane	3.14	4.31	1.86	12.31	4.43	7.07
1,2,4-Trimethylbenzene	**54.82**	13.85	11.81	6.93	**17.64**	**32.12**
1,3,5-Trimethylbenzene	**53.68**	9.85	10.44	8.93	12.03	**25.63**
Vinyl chloride	NA	NA	NA	NA	NA	NA
m,p-Xylene	**39.37**	8.02	6.77	14.41	13.16	**17.95**
o-Xylene	**38.85**	12.84	6.76	13.57	**25.33**	**20.20**
Average by Site	14.58	9.09	13.28	12.25	**19.75**	14.52

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	**PROK**	***PXSS***	***S4MO***	***SEWA***	**SPIL**	**SSSD**
Acetylene	9.63	4.70	4.91	4.00	3.02	5.55
Acrylonitrile	**33.67**	NA	NA	NA	4.81	NA
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	11.22	6.96	5.83	4.62	8.71	9.01
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA
Bromomethane	8.99	3.41	8.50	11.65	4.35	9.35
1,3-Butadiene	10.24	4.11	5.26	5.02	**28.49**	7.39
Carbon Disulfide	NA	**51.10**	5.16	NA	3.80	NA
Carbon Tetrachloride	**25.33**	8.10	6.54	13.14	12.38	**43.22**
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	5.66	0.00	3.45	NA	5.24	4.88
Chloroform	NA	5.14	3.74	**16.59**	14.29	0.00
Chloromethane	8.53	3.47	7.17	4.35	3.91	6.19
Chloromethylbenzene	NA	NA	NA	NA	NA	NA
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	**44.84**	2.44	5.74	NA	NA	NA
Dichlorodifluoromethane	7.73	3.50	3.66	4.01	5.65	4.80
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	14.43	6.73	8.87	11.47	9.67	3.86
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	8.60	**58.38**	10.94	**68.48**	9.73	11.40
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	8.70	5.61	4.55	**30.09**	3.42	6.00
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	NA
Ethylbenzene	12.88	4.06	4.82	5.87	**32.32**	3.77
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	**21.81**	**17.20**	7.58	**20.19**	7.33	**23.38**
Methyl Methacrylate	NA	NA	NA	NA	NA	NA
Methyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	**26.93**

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	PROK	***PXSS***	***S4MO***	***SEWA***	SPIL	SSSD
n-Octane	**27.83**	6.15	7.13	11.41	7.17	10.20
Propylene	7.35	3.78	6.76	4.11	**16.63**	8.77
Styrene	11.33	5.21	**19.41**	10.68	4.05	5.83
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	NA	5.47	11.67	0.88	3.76	NA
Toluene	10.40	4.83	3.79	7.13	6.68	7.52
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	5.44	7.67	NA
Trichlorofluoromethane	8.00	3.32	4.05	4.20	5.14	4.25
Trichlorotrifluoroethane	8.60	4.03	5.02	5.46	5.57	4.86
1,2,4-Trimethylbenzene	12.69	4.27	13.22	6.61	12.85	6.57
1,3,5-Trimethylbenzene	NA	3.08	**24.70**	1.71	3.54	5.26
Vinyl chloride	NA	NA	0.00	NA	NA	NA
m,p-Xylene	12.37	4.88	4.31	5.01	**32.71**	5.59
o-Xylene	**16.50**	4.14	6.60	5.74	8.60	4.98
Average by Site	14.47	8.67	7.26	10.71	9.70	9.18

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	TMOK	TOOK	UCSD	# of Pairs	Average by Pollutant
Acetylene	3.85	5.84	6.32	139	6.94
Acrylonitrile	**17.16**	NA	**22.48**	17	**26.07**
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA
Benzene	6.50	12.52	9.13	139	11.56
Bromochloromethane	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	6	**41.30**
Bromoform	NA	NA	NA	1	**34.49**
Bromomethane	9.01	8.74	7.41	89	13.51
1,3-Butadiene	6.15	13.05	0.00	123	11.80
Carbon Disulfide	**31.95**	NA	8.17	56	**26.91**
Carbon Tetrachloride	**27.46**	8.21	10.85	138	**15.24**
Chlorobenzene	NA	NA	NA	NA	NA
Chloroethane	5.24	**22.52**	**18.27**	22	12.96
Chloroform	6.43	3.14	NA	62	9.94
Chloromethane	3.92	6.98	6.67	139	6.24
Chloromethylbenzene	NA	NA	NA	NA	NA
Chloroprene	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	5	**42.77**
1,2-Dibromoethane	NA	NA	NA	NA	NA
m-Dichlorobenzene	NA	NA	NA	NA	NA
o-Dichlorobenzene	NA	NA	NA	NA	NA
p-Dichlorobenzene	NA	**26.05**	NA	11	**25.82**
Dichlorodifluoromethane	4.15	4.30	5.51	139	5.10
1,1-Dichloroethane	NA	NA	NA	NA	NA
1,2-Dichloroethane	2.57	0.00	5.39	35	5.08
1,1-Dichloroethene	NA	NA	NA	1	0.00
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	NA	NA	NA	1	0.00
Dichloromethane	4.95	13.52	**17.19**	136	**20.46**
1,2-Dichloropropane	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	3.60	7.90	5.04	138	7.83
Ethyl Acrylate	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	NA	NA
Ethylbenzene	**15.25**	9.11	8.83	138	11.10
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	**51.20**	10.53	6.95	101	**20.61**
Methyl Methacrylate	NA	NA	NA	1	3.93
Methyl *tert*-Butyl Ether	NA	NA	NA	5	13.41

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-2. VOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	TMOK	TOOK	UCSD	# of Pairs	Average by Pollutant
n-Octane	8.51	10.31	8.53	134	11.60
Propylene	5.59	**38.67**	**15.05**	139	12.00
Styrene	**21.97**	3.79	**19.03**	112	11.65
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA
Tetrachloroethylene	8.00	8.32	3.82	61	6.97
Toluene	**15.13**	**16.00**	6.54	139	11.18
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA
Trichloroethylene	NA	NA	NA	5	4.76
Trichlorofluoromethane	3.54	6.21	5.64	139	5.10
Trichlorotrifluoroethane	6.34	4.89	5.14	139	5.51
1,2,4-Trimethylbenzene	**30.10**	5.09	0.00	126	13.57
1,3,5-Trimethylbenzene	8.50	5.56	NA	65	12.34
Vinyl chloride	NA	NA	0.00	2	0.00
m,p-Xylene	**20.61**	6.83	5.08	135	12.46
o-Xylene	**26.26**	7.68	4.52	133	12.41
Average by Site	13.11	10.22	8.14	--	11.88

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.2.2 SNMOC Method Precision

The SNMOC method precision for duplicate and collocated samples is presented in Table 29-3 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV for NMP sites sampling SNMOCs. The results from duplicate and collocated samples show low- to high-level variability among pollutants and sites, ranging from a CV of 0 percent (1,3-butadiene for RICO) to 111.81 percent (cyclopentene for RICO). The pollutant-specific average CV ranged from 0.76 percent (*n*-tridecane) to 36.81 percent (cyclopentene). Note that in these cases, the number of pairs included in the calculations is low. The site-specific average CV ranged from 6.69 percent for RICO to 16.27 percent for PACO, with an overall method average of 11.59 percent.

Table 29-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site

Pollutant	BMCO	***BTUT***	***NBIL***	PACO	RICO
Acetylene	4.20	8.69	5.66	**18.44**	1.66
Benzene	**22.62**	5.52	14.77	6.46	10.17
1,3-Butadiene	NA	10.57	NA	NA	0.00
n-Butane	NA	1.68	8.94	3.24	5.83
cis-2-Butene	4.36	4.23	NA	5.37	7.22
trans-2-Butene	14.36	**50.21**	**18.46**	**34.08**	6.57
Cyclohexane	8.57	6.25	9.98	**36.80**	0.39
Cyclopentane	6.45	9.97	13.04	**18.69**	1.32
Cyclopentene	9.75	**39.65**	**15.48**	7.37	**111.81**
n-Decane	7.24	9.69	**24.07**	6.79	4.14
1-Decene	NA	NA	**29.73**	NA	NA
m-Diethylbenzene	3.45	**22.32**	14.44	9.29	5.10
p-Diethylbenzene	**38.12**	**16.52**	**20.92**	12.67	**17.46**
2,2-Dimethylbutane	7.55	6.08	9.21	**22.02**	4.82
2,3-Dimethylbutane	NA	11.78	7.34	2.83	5.36
2,3-Dimethylpentane	NA	8.88	11.15	4.48	4.27
2,4-Dimethylpentane	9.00	11.83	7.69	5.91	9.64
n-Dodecane	1.89	8.36	**33.55**	9.73	2.81
1-Dodecene	0.96	**18.21**	NA	NA	8.34
Ethane	1.93	1.04	**22.69**	**35.08**	0.36
2-Ethyl-1-butene	NA	NA	NA	NA	NA
Ethylbenzene	**18.13**	6.34	10.36	9.79	3.99
Ethylene	1.15	4.40	5.26	2.57	2.81
m-Ethyltoluene	12.65	8.11	**18.53**	8.25	1.47
o-Ethyltoluene	9.30	6.02	11.82	4.99	**20.72**
p-Ethyltoluene	NA	11.13	13.54	4.00	8.00
n-Heptane	**20.04**	4.56	11.93	**32.07**	1.99
1-Heptene	NA	NA	NA	3.88	0.45
n-Hexane	**20.87**	3.46	11.54	**34.26**	4.05
1-Hexene	NA	NA	NA	NA	NA
cis-2-Hexene	NA	NA	NA	NA	NA
trans-2-Hexene	NA	NA	NA	NA	NA
Isobutane	2.14	1.47	10.74	**39.12**	2.17
Isobutene/1-Butene	NA	12.05	11.60	6.21	NA
Isopentane	7.14	9.62	11.44	**28.73**	8.26
Isoprene	NA	9.43	12.08	6.70	2.89
Isopropylbenzene	NA	NA	NA	3.43	NA
2-Methyl-1-butene	4.03	7.31	NA	NA	1.76
3-Methyl-1-butene	NA	NA	NA	NA	NA
2-Methyl-1-pentene	NA	NA	NA	NA	NA

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	**BMCO**	***BTUT***	***NBIL***	**PACO**	**RICO**
4-Methyl-1-pentene	NA	NA	NA	NA	NA
2-Methyl-2-butene	7.74	9.85	7.59	11.80	1.78
Methylcyclohexane	**15.38**	4.52	**16.85**	**30.65**	1.52
Methylcyclopentane	14.63	3.98	10.24	**31.27**	0.70
2-Methylheptane	13.95	7.13	**40.13**	**26.98**	1.28
3-Methylheptane	**31.78**	5.22	**29.85**	**26.69**	6.31
2-Methylhexane	13.08	5.92	**23.77**	2.21	2.51
3-Methylhexane	10.64	5.25	14.86	**25.51**	5.01
2-Methylpentane	**15.53**	5.00	11.62	**20.66**	2.57
3-Methylpentane	12.16	6.22	9.11	**28.04**	0.84
n-Nonane	**20.71**	7.72	**19.61**	**15.72**	2.35
1-Nonene	NA	NA	**33.64**	10.90	NA
n-Octane	9.62	11.73	**15.90**	**30.03**	2.22
1-Octene	NA	NA	NA	8.64	NA
n-Pentane	12.74	11.42	5.64	**57.12**	3.63
1-Pentene	2.90	14.86	**17.33**	**24.34**	5.26
cis-2-Pentene	NA	NA	NA	NA	9.30
trans-2-Pentene	NA	6.08	2.02	5.81	3.59
a-Pinene	NA	**32.81**	5.58	NA	7.64
b-Pinene	NA	2.42	NA	NA	NA
Propane	7.05	1.56	**19.53**	**39.92**	2.07
n-Propylbenzene	5.71	3.81	**15.61**	7.14	4.88
Propylene	10.71	6.44	5.11	7.95	13.60
Propyne	NA	NA	**29.19**	NA	NA
Styrene	NA	4.06	NA	NA	NA
Toluene	**37.22**	6.11	8.03	**27.29**	1.83
n-Tridecane	NA	0.76	NA	NA	NA
1-Tridecene	NA	NA	NA	NA	NA
1,2,3-Trimethylbenzene	**22.81**	8.99	**17.02**	2.13	4.25
1,2,4-Trimethylbenzene	**16.26**	6.66	13.79	6.45	2.76
1,3,5-Trimethylbenzene	**26.94**	1.77	**26.54**	2.64	2.57
2,2,3-Trimethylpentane	NA	2.37	0.14	1.65	NA
2,2,4-Trimethylpentane	NA	8.49	9.18	1.75	**17.52**
2,3,4-Trimethylpentane	**19.21**	6.78	5.17	11.39	1.68
n-Undecane	4.53	10.48	**24.29**	3.54	13.74
1-Undecene	NA	3.39	**41.10**	**67.91**	NA
m-Xylene/*p*-Xylene	NA	9.26	8.98	0.67	4.48
o-Xylene	**25.65**	5.68	11.73	**15.98**	3.25
Average by Site	12.61	8.92	**15.17**	**16.27**	6.69

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	SSSD	UCSD	# of Pairs	Average by Pollutant
Acetylene	2.28	3.38	30	6.33
Benzene	8.23	8.39	29	10.88
1,3-Butadiene	NA	NA	3	5.28
n-Butane	2.98	2.73	20	4.23
cis-2-Butene	4.19	NA	10	5.07
trans-2-Butene	5.83	**15.99**	16	**20.79**
Cyclohexane	11.88	3.04	22	10.99
Cyclopentane	**21.14**	**17.78**	24	12.62
Cyclopentene	NA	NA	6	**36.81**
n-Decane	2.54	NA	19	9.08
1-Decene	NA	NA	1	**29.73**
m-Diethylbenzene	13.14	**15.39**	25	11.87
p-Diethylbenzene	13.70	4.43	21	**17.69**
2,2-Dimethylbutane	9.18	3.53	26	8.91
2,3-Dimethylbutane	5.36	4.30	16	6.16
2,3-Dimethylpentane	1.36	NA	15	6.03
2,4-Dimethylpentane	3.57	NA	16	7.94
n-Dodecane	8.46	10.69	19	10.78
1-Dodecene	**52.37**	**90.37**	8	**34.05**
Ethane	1.40	1.52	30	9.15
2-Ethyl-1-butene	NA	NA	0	NA
Ethylbenzene	12.75	13.86	26	10.74
Ethylene	3.21	4.70	30	3.44
m-Ethyltoluene	5.85	NA	19	9.14
o-Ethyltoluene	2.50	NA	15	9.23
p-Ethyltoluene	3.36	NA	8	8.00
n-Heptane	3.04	3.26	22	10.98
1-Heptene	NA	NA	3	2.17
n-Hexane	7.44	5.59	29	12.46
1-Hexene	NA	NA	0	NA
cis-2-Hexene	NA	NA	0	NA
trans-2-Hexene	NA	NA	0	NA
Isobutane	**19.56**	5.13	30	11.48
Isobutene/1-Butene	**23.99**	5.38	11	11.85
Isopentane	**25.45**	**15.82**	28	**15.21**
Isoprene	2.58	3.19	16	6.15
Isopropylbenzene	NA	NA	1	3.43
2-Methyl-1-butene	14.61	NA	10	6.93
3-Methyl-1-butene	NA	NA	0	NA
2-Methyl-1-pentene	NA	NA	0	NA

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-3. SNMOC Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	SSSD	UCSD	# of Pairs	Average by Pollutant
4-Methyl-1-pentene	NA	NA	0	NA
2-Methyl-2-butene	NA	NA	13	7.75
Methylcyclohexane	3.24	0.68	22	10.41
Methylcyclopentane	7.61	13.90	27	11.76
2-Methylheptane	NA	NA	12	**17.89**
3-Methylheptane	NA	NA	12	**19.97**
2-Methylhexane	**18.37**	10.78	26	10.95
3-Methylhexane	11.79	**18.73**	26	13.11
2-Methylpentane	**23.06**	5.68	30	12.02
3-Methylpentane	10.01	5.24	28	10.23
n-Nonane	1.25	NA	18	11.23
1-Nonene	NA	NA	3	**22.27**
n-Octane	3.00	NA	18	12.09
1-Octene	NA	NA	1	8.64
n-Pentane	**47.27**	**19.65**	30	**22.49**
1-Pentene	**18.88**	**30.02**	22	**16.23**
cis-2-Pentene	NA	NA	1	9.30
trans-2-Pentene	7.37	NA	17	4.97
a-Pinene	3.89	NA	5	12.48
b-Pinene	NA	NA	1	2.42
Propane	1.40	2.25	30	10.54
n-Propylbenzene	NA	NA	7	7.43
Propylene	5.38	11.97	30	8.74
Propyne	NA	NA	1	**29.19**
Styrene	1.72	**17.40**	3	7.73
Toluene	13.23	7.22	29	14.42
n-Tridecane	NA	NA	2	0.76
1-Tridecene	NA	NA	0	NA
1,2,3-Trimethylbenzene	6.83	NA	14	10.34
1,2,4-Trimethylbenzene	12.98	9.76	27	9.81
1,3,5-Trimethylbenzene	6.76	NA	12	11.20
2,2,3-Trimethylpentane	NA	NA	4	1.39
2,2,4-Trimethylpentane	10.00	3.58	24	8.42
2,3,4-Trimethylpentane	**17.81**	NA	18	10.34
n-Undecane	**20.84**	NA	16	12.90
1-Undecene	NA	14.34	4	**31.68**
m-Xylene/*p*-Xylene	1.04	3.91	15	4.72
o-Xylene	7.20	4.30	24	10.54
Average by Site	10.43	11.00	--	11.59

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.2.3 Carbonyl Compound Method Precision

Table 29-4 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 for NMP sites sampling carbonyl compounds. The duplicate and collocated sample results show low- to mid-level variability among the sites, ranging from a CV of 0.86 percent (formaldehyde for MWOK) to 49.32 percent (tolualdehydes for UCSD). The pollutant-specific average CV ranged from 3.32 percent (acetaldehyde) to 17.74 percent (tolualdehydes). The site-specific average CV ranged from 3.92 percent for OCOK to 11.59 percent for UCSD. The average CV for every site is less than the program MQO of 15 percent. The overall average method precision was 6.83 percent for carbonyl compounds.

Table 29-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site

Pollutant	**AZFL**	***BTUT***	**CHNJ**	***DEMI***	**ELNJ**	***GLKY***	***GPCO***
Acetaldehyde	3.62	2.30	2.41	10.13	1.80	3.13	2.08
Acetone	7.03	3.53	6.37	4.57	10.82	5.96	6.34
Benzaldehyde	7.14	4.88	7.46	9.12	3.76	7.66	5.34
Butyraldehyde	5.31	4.24	3.91	12.76	5.64	4.23	4.50
Crotonaldehyde	2.61	1.66	3.53	**16.58**	5.88	5.94	3.90
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	6.28	5.64	3.58	11.67	2.37	2.51	2.21
Hexaldehyde	7.19	8.15	4.18	11.00	10.39	2.86	7.69
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	2.80	2.60	4.88	8.35	2.12	3.31	3.17
Tolualdehydes	**18.13**	**26.30**	9.49	9.93	**22.21**	8.90	**36.57**
Valeraldehyde	8.91	4.69	1.35	9.91	4.24	8.93	6.23
Average by Site	6.90	6.40	4.71	10.40	6.92	5.34	7.81

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	**INDEM**	**MWOK**	***NBIL***	**NBNJ**	**OCOK**	**ORFL**	**PROK**
Acetaldehyde	7.65	1.82	2.25	8.57	1.57	7.19	1.17
Acetone	9.23	10.78	7.49	4.76	4.83	**16.62**	2.80
Benzaldehyde	9.96	6.04	5.91	6.51	4.81	7.14	9.12
Butyraldehyde	5.81	6.34	6.91	7.64	1.62	7.98	4.79
Crotonaldehyde	7.15	2.69	4.20	5.94	3.64	7.71	2.66
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	9.55	0.86	2.89	6.50	1.90	3.79	2.16
Hexaldehyde	8.68	9.20	7.62	10.72	5.70	10.05	4.90
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	6.45	4.35	2.01	7.01	1.45	4.57	3.16
Tolualdehydes	8.34	7.02	10.32	**37.94**	9.41	**36.96**	6.87
Valeraldehyde	7.96	8.58	5.03	8.47	4.24	6.31	6.60
Average by Site	8.08	5.77	5.46	10.41	3.92	10.83	4.42

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	***PXSS***	***S4MO***	***SEWA***	***SKFL***	**SPIL**	**SSSD**	***SYFL***
Acetaldehyde	2.64	1.39	1.84	2.58	1.74	4.41	2.07
Acetone	4.43	3.46	1.89	8.69	8.10	**18.22**	7.56
Benzaldehyde	3.61	4.98	12.41	8.15	4.10	7.03	9.07
Butyraldehyde	3.21	3.92	3.58	8.18	4.16	6.01	4.13
Crotonaldehyde	3.08	3.70	7.54	6.83	8.10	3.97	4.81
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	5.82	3.19	3.96	2.64	3.21	8.29	2.81
Hexaldehyde	5.77	7.36	6.38	8.05	5.65	9.06	7.37
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	3.36	4.18	4.66	2.83	1.89	5.37	3.07
Tolualdehydes	9.46	**24.50**	8.85	**37.07**	9.41	11.33	13.73
Valeraldehyde	8.30	6.71	3.75	5.44	4.43	7.00	6.94
Average by Site	4.97	6.34	5.49	9.05	5.08	8.07	6.16

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-4. Carbonyl Compound Method Precision: Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	TMOK	TOOK	UCSD	WPIN	# of Pairs	Average by Pollutant
Acetaldehyde	2.02	1.89	2.25	4.61	158	3.32
Acetone	4.21	1.60	12.68	8.63	158	7.22
Benzaldehyde	3.10	7.85	6.53	5.24	157	6.68
Butyraldehyde	3.64	3.42	7.15	6.79	157	5.43
Crotonaldehyde	2.51	3.08	7.50	10.05	153	5.41
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	0	NA
Formaldehyde	1.79	1.02	6.62	4.93	158	4.25
Hexaldehyde	6.17	7.03	12.55	11.31	157	7.80
Isovaleraldehyde	NA	NA	NA	NA	0	NA
Propionaldehyde	4.23	2.33	5.03	5.89	158	3.96
Tolualdehydes	9.70	7.05	**49.32**	14.72	131	**17.74**
Valeraldehyde	3.17	6.77	6.23	11.20	153	6.46
Average by Site	4.05	4.20	11.59	8.34	--	6.83

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.2.4 PAH Method Precision

The method precision results for collocated PAH samples are shown in Table 29-5 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV for NMP sites sampling PAHs. 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 data for PAHs is based on only five sites for 2011.

The results from collocated samples show low- to mid-level variability among sites, ranging from a CV of 0.38 percent (benzo(a)anthracene for SDGA) to 58.36 percent (anthracene for DEMI). The pollutant-specific average CV ranged from 1.65 percent (cyclopenta[cd]pyrene) to 21.17 percent (anthracene). The site-specific average CV ranged from 5.98 percent for SEWA to 19.42 percent for RUCA. The overall average method precision was 11.83 percent.

Table 29-5. PAH Method Precision: Coefficient of Variation Based on Collocated Samples by Site

Pollutant	***DEMI***	***RUCA***	***SDGA***	***SEWA***	***SYFL***	# of Pairs	Average by Pollutant
Acenaphthene	7.47	**26.38**	10.45	7.16	11.42	29	12.58
Acenaphthylene	10.29	**33.31**	11.41	8.82	13.02	11	**15.37**
Anthracene	**58.36**	6.32	7.12	12.89	NA	13	**21.17**
Benzo(a)anthracene	**49.45**	NA	0.38	3.70	9.82	8	**15.84**
Benzo(a)pyrene	4.36	NA	5.22	12.66	13.78	7	9.00
Benzo(b)fluoranthene	6.24	13.93	5.09	6.38	**15.29**	23	9.38
Benzo(e)pyrene	6.42	6.74	9.00	1.12	**19.75**	16	8.61
Benzo(g,h,i)perylene	7.69	10.06	11.21	0.41	**15.67**	14	9.01
Benzo(k)fluoranthene	7.00	NA	1.75	5.32	9.63	8	5.92
Chrysene	7.29	8.38	**15.48**	7.25	10.43	27	9.77
Coronene	2.51	NA	NA	1.92	1.00	3	1.81
Cyclopenta[cd]pyrene	NA	NA	1.09	2.20	NA	2	1.65
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	0	NA
Fluoranthene	4.61	**24.59**	5.91	5.33	12.67	29	10.62
Fluorene	5.13	**24.32**	7.88	6.69	11.82	29	11.17
9-Fluorenone	4.84	**26.96**	6.12	6.81	13.26	29	11.60
Indeno(1,2,3-cd)pyrene	7.02	NA	**17.93**	2.23	13.14	12	10.08
Naphthalene	8.59	**15.49**	6.41	5.98	**15.27**	29	10.34
Perylene	NA	NA	NA	NA	NA	0	NA
Phenanthrene	5.77	**28.02**	8.33	5.47	11.79	29	11.88
Pyrene	5.60	**27.07**	**19.90**	7.44	13.39	29	14.68
Retene	**20.10**	**20.28**	**16.60**	9.75	**21.07**	28	**17.56**
Average by Site	12.04	19.42	8.80	5.98	12.90	--	11.83

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.2.5 Metals Method Precision

The method precision for all collocated metals samples are presented in Table 29-6 as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV for NMP sites sampling metals. All samples evaluated in this section are collocated samples. The results from collocated samples show low- to mid-level variability among sites, ranging from a CV of 0 percent (nickel for UNVT and beryllium for GLKY) to 45.18 percent (mercury for UNVT). The pollutant-specific average CV ranged from 5.16 percent (chromium) to 26.44 percent (mercury). The site-specific average CV ranged from 8.70 percent for BOMA to 20.84 percent for GLKY. The overall average method precision for metals was 13.58 percent.

Table 29-6. Metals Method Precision: Coefficient of Variation Based on Collocated Samples by Site

Pollutant	***BOMA***	***BTUT***	**GLKY**	***S4MO***	**TOOK**	***UNVT***	**# of Pairs**	**Average by Pollutant**
Antimony	3.26	6.79	**19.08**	5.48	8.86	9.05	169	8.75
Arsenic	4.06	11.01	**21.90**	11.80	5.95	**23.20**	158	12.99
Beryllium	**18.02**	11.11	0.00	**22.00**	7.47	NA	74	11.72
Cadmium	**18.07**	**15.67**	**20.56**	8.64	**17.90**	**16.15**	168	**16.17**
Chromium	5.43	NA	NA	2.13	7.93	NA	66	5.16
Cobalt	12.25	**15.02**	**31.64**	**18.74**	14.56	NA	156	**18.44**
Lead	6.43	13.09	14.99	5.13	7.85	4.55	169	8.67
Manganese	3.69	10.38	**16.15**	5.46	8.28	4.16	169	8.02
Mercury	**15.22**	**20.20**	**27.65**	**36.97**	13.45	**45.18**	115	**26.44**
Nickel	4.89	3.13	**43.46**	**43.24**	9.07	0.00	99	**17.30**
Selenium	4.37	**18.57**	12.99	10.10	5.23	12.34	163	10.60
Average by Site	8.70	12.50	**20.84**	**15.43**	9.69	14.33	--	13.58

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.2.6 Hexavalent Chromium Method Precision

Table 29-7 presents the method precision results from collocated hexavalent chromium samples as the CV per site and the overall average CV for NMP sites sampling hexavalent chromium. All samples evaluated in this section are collocated samples. Hexavalent chromium is a NATTS MQO Core Analyte and the sites shown in Table 29-6 are collocated NATTS sites. The site-specific CV ranged from 6.04 percent for SYFL to 31.21 percent for PXSS, with an overall average method precision of 14.54 percent.

Table 29-7. Hexavalent Chromium Method Precision: Coefficient of Variation Based on Collocated Samples by Site

Site	Average CV
BOMA	**27.62**
BTUT	**22.35**
CAMS 35	10.97
CHSC	8.86
DEMI	10.93
GLKY	**20.41**
GPCO	10.91
HOWI	9.10
MONY	8.25
NBIL	**18.21**
PRRI	**17.14**
PXSS	**31.21**
RIVA	11.46
ROCH	**19.56**
S4MO	7.86
SDGA	**16.80**
SEWA	11.03
SKFL	10.80
SYFL	6.04
UNVT	**15.45**
WADC	10.31
# of Pairs	110
Average by Site	14.54

BOLD ITALICS = EPA-designated NATTS Site

Orange shading indicates the average CV for this method

29.3 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). CVs were calculated for every replicate analysis run on duplicate or collocated samples collected during the program year. However, only results at or above the MDL were used in these calculations, similar to the calculation of method precision discussed in Section 29.2.

Table 29-8 presents the 2011 NMP analytical precision for VOCs, SNMOCs, carbonyl compounds, PAHs, metals, and hexavalent chromium, presented as average CV (expressed as a percentage). The analytical precision averaged across all sites collecting duplicate or collocated samples met the program MQO, which is 15 percent CV. The analytical precision for all six methods was less than 8 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 29-8 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 29-8. 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)	6.60	6,174	7,397
SNMOC	7.39	2,437	3,059
Carbonyl Compounds (TO-11A)	2.43	3,178	3,178
PAH (TO-13)	4.61	761	941
Metals Analysis (Method IO-3.5)	7.91	3,074	3,721
Hexavalent Chromium (EPA-approved method)	6.69	223	225
MQO	15.00 percent CV		

Tables 29-9 through 29-14 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 29-9 through 29-14, the number of pairs in comparison to the respective tables listed for duplicate or collocated analyses in Tables 29-2 through 29-7, is approximately twice as high because each sample produces a replicate for each duplicate (or collocated) sample. The replicate analyses of both duplicate and collocated samples indicate that the analytical precision level is within the program MQOs. The shaded rows in each table identify the NATTS MQO Core Analytes for each method.

29.3.1 VOC Analytical Precision

Table 29-9 presents analytical precision results from replicate analyses of 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 for NMP sites sampling VOCs. The analytical precision results from replicate analyses of all duplicate and collocated samples 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 26.61 percent (methyl isobutyl ketone for TMOK). The pollutant-specific average CV ranged from 3.01 percent (1,1,1-trichloroethane) to 20.47 percent (*trans*-1,2-dichloroethylene). Note that in these cases, the number of pairs included in the calculations are low. The site-specific average CV ranged from 4.31 percent for GPCO to 9.18 percent for PROK. The overall average analytical precision was 6.60 percent.

Table 29-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	***BTUT***	BURVT	CHNJ	***DEMI***	ELNJ	***GLKY***
Acetylene	7.75	3.60	6.21	4.03	5.26	5.35
Acrylonitrile	NA	5.41	4.62	NA	8.88	4.42
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	5.24	5.04	6.01	6.45	5.27	6.69
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA
Bromomethane	7.47	10.34	**15.71**	10.83	11.50	12.27
1,3-Butadiene	9.42	5.44	**18.58**	7.56	6.20	6.44
Carbon Disulfide	5.85	NA	6.62	4.03	4.58	6.04
Carbon Tetrachloride	5.84	4.78	6.43	6.31	6.70	6.56
Chlorobenzene	NA	NA	NA	NA	NA	9.43
Chloroethane	6.07	14.36	10.45	3.02	0.00	NA
Chloroform	12.57	11.04	12.04	6.04	5.43	6.81
Chloromethane	5.49	3.48	6.39	5.81	4.78	4.47
Chloromethylbenzene	NA	NA	NA	NA	NA	NA
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	NA	NA	2.70	NA
Dichlorodifluoromethane	5.35	3.48	6.19	5.79	4.73	4.85
1,1-Dichloroethane	NA	NA	NA	NA	NA	13.69
1,2-Dichloroethane	10.09	9.97	8.45	5.56	1.89	6.18
1,1-Dichloroethene	0.00	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	**20.47**	NA	NA	NA	NA	NA
Dichloromethane	6.59	4.56	7.18	4.78	5.13	4.70
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	11.21	8.12	12.42	12.67	6.96	8.94
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	NA
Ethylbenzene	6.00	7.07	8.17	7.53	5.72	6.74
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	6.75	7.36	11.54	10.41	**16.20**	9.94
Methyl Methacrylate	NA	NA	8.95	NA	**4.47**	NA

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	***BTUT***	**BURVT**	**CHNJ**	***DEMI***	**ELNJ**	***GLKY***
Methyl *tert*-Butyl Ether	NA	NA	NA	NA	5.61	9.12
n-Octane	5.42	11.93	7.34	**16.65**	7.36	6.98
Propylene	5.60	4.30	5.25	5.55	4.96	5.82
Styrene	8.43	13.45	7.49	9.26	12.02	6.66
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	4.70	7.19	**16.63**	5.16	7.91	NA
Toluene	4.71	4.27	6.30	4.98	4.38	5.16
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	NA
Trichlorofluoromethane	5.94	3.66	6.29	5.39	4.19	4.60
Trichlorotrifluoroethane	8.30	6.33	7.00	6.49	5.37	5.45
1,2,4-Trimethylbenzene	6.47	8.55	8.45	6.54	8.01	7.78
1,3,5-Trimethylbenzene	8.20	6.14	8.93	5.27	11.14	13.26
Vinyl chloride	NA	NA	NA	NA	NA	**20.20**
m,p-Xylene	5.06	6.13	8.68	6.60	5.46	7.21
o-Xylene	6.16	7.53	**16.21**	9.83	8.99	7.46
Average by Site	7.18	7.06	9.09	7.02	6.39	7.70

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	***GPCO***	MWOK	***NBIL***	NBNJ	OCOK	PANJ
Acetylene	3.50	5.05	5.67	5.23	3.30	4.45
Acrylonitrile	4.22	9.75	4.78	3.71	NA	NA
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	4.55	4.71	5.78	4.62	5.58	5.93
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	6.52	NA	NA	NA
Bromoform	NA	NA	7.71	NA	NA	NA
Bromomethane	6.93	6.30	10.23	7.47	11.91	3.23
1,3-Butadiene	3.22	6.56	4.60	3.89	8.45	5.28
Carbon Disulfide	3.54	1.95	3.92	4.58	NA	NA
Carbon Tetrachloride	4.86	5.29	9.48	5.01	7.01	6.55
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	3.62	5.24	8.77	1.37	NA	5.30
Chloroform	4.88	7.36	4.02	7.06	3.23	3.54
Chloromethane	3.58	2.50	3.89	4.30	2.58	4.94
Chloromethylbenzene	NA	NA	NA	NA	NA	NA
Chloroprene	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	3.98	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	3.82	NA	NA	NA	5.77
Dichlorodifluoromethane	3.31	2.50	3.94	4.28	2.56	4.91
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	1.96	6.46	9.66	5.74	NA	5.92
1,1-Dichloroethene	NA	NA	NA	6.15	NA	NA
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA
Dichloromethane	6.72	4.13	6.39	3.71	6.31	4.72
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	3.24	5.41	4.65	6.51	7.82	6.98
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	7.44	NA	NA
Ethylbenzene	3.27	4.39	3.75	4.70	7.13	4.67
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	5.31	3.82	10.20	6.23	8.32	3.69
Methyl Methacrylate	9.03	NA	NA	NA	NA	NA

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	***GPCO***	MWOK	***NBIL***	NBNJ	OCOK	PANJ
Methyl *tert*-Butyl Ether	NA	NA	NA	3.92	NA	NA
n-Octane	5.08	4.29	6.63	6.98	8.75	5.07
Propylene	4.41	2.48	3.98	4.16	3.25	4.82
Styrene	3.42	7.82	6.94	7.33	13.70	3.61
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	4.66	5.64	6.11	6.71	8.78	6.47
Toluene	3.30	3.32	3.92	4.47	4.51	5.92
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	3.01
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA
Trichloroethylene	4.98	NA	NA	NA	NA	NA
Trichlorofluoromethane	3.70	2.88	3.51	4.37	3.13	5.41
Trichlorotrifluoroethane	5.33	4.40	3.55	4.18	7.29	4.75
1,2,4-Trimethylbenzene	3.55	7.72	4.43	6.45	10.05	5.61
1,3,5-Trimethylbenzene	4.19	6.25	6.43	8.77	9.84	4.58
Vinyl chloride	NA	NA	NA	11.79	NA	8.32
m,p-Xylene	3.62	4.29	4.13	5.02	7.51	5.16
o-Xylene	3.11	7.58	4.34	6.16	13.46	5.30
Average by Site	4.31	5.07	5.73	5.56	7.15	5.14

NA = No pairs with concentrations greater than or equal to the MDL

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Table 29-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	**PROK**	***PXSS***	***S4MO***	***SEWA***	**SPIL**	**SSSD**
Acetylene	8.28	4.96	4.71	3.16	4.92	4.88
Acrylonitrile	4.91	2.76	NA	7.97	5.79	13.24
tert-Amyl Methyl Ether	NA	NA	NA	NA	NA	NA
Benzene	7.12	6.60	5.10	3.10	7.08	4.24
Bromochloromethane	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA
Bromomethane	8.25	8.87	**16.11**	12.78	7.88	7.20
1,3-Butadiene	7.03	5.24	7.20	7.36	5.53	8.44
Carbon Disulfide	NA	6.52	4.14	NA	4.68	1.79
Carbon Tetrachloride	7.32	6.66	4.87	4.56	6.55	3.86
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroethane	9.41	7.44	3.70	0.00	14.17	9.75
Chloroform	NA	4.86	8.05	8.37	6.73	8.03
Chloromethane	6.35	4.63	4.72	3.36	5.16	4.05
Chloromethylbenzene	NA	NA	NA	NA	NA	NA
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	9.09	6.24	4.24	NA	NA	NA
Dichlorodifluoromethane	6.28	4.58	4.59	3.16	5.28	3.83
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	10.23	5.25	9.95	2.86	12.20	8.52
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	6.97	6.98	4.37	3.15	5.04	5.06
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	9.05	7.44	9.52	5.29	8.21	7.43
Ethyl Acrylate	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	NA
Ethylbenzene	11.11	4.67	5.44	4.09	8.88	5.00
Hexachloro-1,3-butadiene	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	NA	NA	NA	NA	NA	NA
Methyl Isobutyl Ketone	7.70	9.51	6.43	9.22	6.39	7.74
Methyl Methacrylate	NA	NA	NA	NA	NA	NA

NA = No pairs with concentrations greater than or equal to the MDL

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Table 29-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	PROK	***PXSS***	***S4MO***	***SEWA***	SPIL	SSSD
Methyl *tert*-Butyl Ether	NA	NA	NA	NA	NA	7.58
n-Octane	**17.76**	6.26	6.00	11.33	10.49	6.46
Propylene	7.19	4.51	5.14	5.69	5.86	4.37
Styrene	**15.25**	9.23	**15.26**	8.36	10.66	5.93
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	NA	4.84	8.96	8.75	6.86	8.52
Toluene	6.72	4.29	4.11	1.98	5.94	3.77
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	0.00	6.52	NA
Trichlorofluoromethane	6.26	4.08	3.89	2.51	4.58	3.14
Trichlorotrifluoroethane	7.05	6.55	7.03	4.90	5.23	5.78
1,2,4-Trimethylbenzene	**15.67**	5.45	11.27	6.59	11.48	5.76
1,3,5-Trimethylbenzene	NA	6.17	**19.15**	7.44	10.28	5.33
Vinyl chloride	NA	NA	6.79	NA	NA	NA
m,p-Xylene	10.68	4.70	5.00	3.45	8.08	5.26
o-Xylene	14.60	5.35	7.03	9.82	10.72	5.30
Average by Site	9.18	5.88	7.24	5.53	7.54	6.08

NA = No pairs with concentrations greater than or equal to the MDL

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Table 29-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	TMOK	TOOK	UCSD	# of Pairs	Average by Pollutant
Acetylene	2.97	5.88	6.80	283	5.05
Acrylonitrile	14.40	NA	4.34	45	6.61
tert-Amyl Methyl Ether	NA	NA	NA	0	NA
Benzene	5.05	7.32	6.81	283	5.63
Bromochloromethane	NA	NA	NA	0	NA
Bromodichloromethane	NA	NA	NA	12	6.52
Bromoform	NA	NA	NA	2	7.71
Bromomethane	8.19	8.92	5.79	191	9.44
1,3-Butadiene	5.37	6.59	9.60	249	7.05
Carbon Disulfide	2.90	0.44	3.14	129	4.05
Carbon Tetrachloride	5.55	6.82	6.49	282	6.07
Chlorobenzene	NA	NA	NA	1	9.43
Chloroethane	5.06	7.19	6.30	50	6.38
Chloroform	2.33	2.27	12.24	144	6.84
Chloromethane	3.32	5.72	5.78	283	4.54
Chloromethylbenzene	NA	NA	NA	0	NA
Chloroprene	NA	NA	NA	0	NA
Dibromochloromethane	NA	NA	NA	11	3.98
1,2-Dibromoethane	NA	NA	NA	0	NA
m-Dichlorobenzene	NA	NA	NA	0	NA
o-Dichlorobenzene	NA	NA	NA	0	NA
p-Dichlorobenzene	6.12	4.23	NA	29	5.28
Dichlorodifluoromethane	3.17	5.93	5.90	283	4.51
1,1-Dichloroethane	NA	NA	NA	1	13.69
1,2-Dichloroethane	1.82	3.62	8.58	69	6.75
1,1-Dichloroethene	NA	NA	NA	3	3.07
cis-1,2-Dichloroethylene	NA	NA	NA	0	NA
trans-1,2-Dichloroethylene	NA	NA	NA	2	**20.47**
Dichloromethane	5.18	5.18	5.17	277	5.33
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	5.92	6.54	6.45	280	7.66
Ethyl Acrylate	NA	NA	NA	0	NA
Ethyl *tert*-Butyl Ether	NA	NA	NA	1	7.44
Ethylbenzene	4.24	6.68	5.08	281	5.92
Hexachloro-1,3-butadiene	NA	NA	NA	0	NA
Methyl Ethyl Ketone	NA	NA	NA	0	NA
Methyl Isobutyl Ketone	**26.61**	7.80	6.99	216	8.96
Methyl Methacrylate	NA	NA	NA	4	7.48

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Table 29-9. VOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	TMOK	TOOK	UCSD	# of Pairs	Average by Pollutant
Methyl *tert*-Butyl Ether	NA	NA	NA	12	6.56
n-Octane	6.16	6.91	10.60	278	8.31
Propylene	3.70	5.41	5.37	283	4.85
Styrene	12.46	9.43	5.25	241	9.14
1,1,2,2-Tetrachloroethane	NA	NA	NA	0	NA
Tetrachloroethylene	9.05	9.64	9.01	129	7.66
Toluene	4.24	6.33	4.62	283	4.63
1,2,4-Trichlorobenzene	NA	NA	NA	0	NA
1,1,1-Trichloroethane	NA	NA	NA	1	3.01
1,1,2-Trichloroethane	NA	NA	NA	0	NA
Trichloroethylene	NA	NA	5.44	10	4.24
Trichlorofluoromethane	3.00	6.76	5.20	282	4.40
Trichlorotrifluoroethane	7.23	5.40	4.83	283	5.83
1,2,4-Trimethylbenzene	5.15	5.60	8.74	262	7.59
1,3,5-Trimethylbenzene	7.96	6.42	NA	141	8.20
Vinyl chloride	NA	NA	**16.85**	8	12.79
m,p-Xylene	4.07	6.69	5.59	277	5.83
o-Xylene	14.70	6.83	7.50	273	8.48
Average by Site	6.64	6.17	6.95	--	6.60

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BOLD ITALICS = EPA-designated NATTS Site
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29.3.2 SNMOC Analytical Precision

Table 29-10 presents analytical precision results from replicate analyses of all duplicate and collocated SNMOC samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV for NMP sites sampling SNMOCs. The CV ranged from 0 percent (2-methyl-2-butene for BMCO) to 43.71 percent (1-dodecene for NBIL). The pollutant-specific average CV ranged from 0.37 percent (1-hexene) to 18.93 percent (1-dodecene). The site-specific average CV ranged from 4.47 percent for PACO to 16.14 percent for BMCO. The overall program average CV was 7.39 percent.

Table 29-10. SNMOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	BMCO	***BTUT***	***NBIL***	PACO	RICO
Acetylene	**15.60**	**23.90**	2.64	3.66	2.07
Benzene	**19.92**	3.83	3.97	2.16	2.44
1,3-Butadiene	NA	8.51	NA	NA	4.22
n-Butane	NA	1.10	1.53	1.13	0.35
cis-2-Butene	1.14	7.38	NA	3.44	12.46
trans-2-Butene	6.91	4.51	5.97	3.86	2.55
Cyclohexane	**19.11**	5.12	12.13	3.90	1.37
Cyclopentane	11.11	5.20	11.78	6.87	3.29
Cyclopentene	2.99	12.75	2.46	10.74	11.70
n-Decane	**18.02**	4.52	6.37	2.50	5.77
1-Decene	NA	NA	2.40	NA	NA
m-Diethylbenzene	5.85	9.43	6.63	4.76	9.48
p-Diethylbenzene	**20.70**	**15.21**	**16.02**	7.87	4.52
2,2-Dimethylbutane	**16.09**	7.80	7.09	7.83	8.00
2,3-Dimethylbutane	NA	8.96	2.82	1.56	6.24
2,3-Dimethylpentane	NA	5.99	6.57	2.84	7.78
2,4-Dimethylpentane	**15.39**	8.63	4.85	3.84	9.49
n-Dodecane	14.08	3.23	9.99	6.74	8.71
1-Dodecene	**36.60**	5.82	**43.71**	0.62	7.18
Ethane	**19.42**	**25.25**	0.46	0.86	0.45
2-Ethyl-1-butene	NA	NA	NA	NA	NA
Ethylbenzene	**17.66**	7.32	5.22	4.61	7.79
Ethylene	10.91	**28.33**	1.98	1.50	1.24
m-Ethyltoluene	4.25	3.63	6.33	2.19	7.03
o-Ethyltoluene	NA	8.83	**15.29**	6.87	11.81
p-Ethyltoluene	8.91	8.57	10.04	5.63	7.41
n-Heptane	**18.74**	2.59	6.14	1.78	2.63
1-Heptene	**23.95**	NA	NA	1.75	3.13
n-Hexane	**20.94**	2.99	3.42	2.80	0.77
1-Hexene	NA	0.56	NA	0.19	NA
cis-2-Hexene	NA	NA	NA	NA	NA
trans-2-Hexene	NA	NA	NA	NA	NA
Isobutane	**20.27**	1.37	1.89	1.09	1.06
Isobutene/1-Butene	NA	14.23	4.74	6.61	NA
Isopentane	**19.00**	1.90	1.78	5.68	1.63
Isoprene	NA	2.61	1.88	**16.23**	5.50
Isopropylbenzene	NA	NA	2.22	4.84	NA
2-Methyl-1-butene	**20.20**	8.43	NA	NA	3.43
3-Methyl-1-butene	NA	NA	NA	NA	NA

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Table 29-10. SNMOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	BMCO	***BTUT***	***NBIL***	PACO	RICO
2-Methyl-1-pentene	NA	NA	NA	NA	NA
4-Methyl-1-pentene	NA	NA	NA	NA	NA
2-Methyl-2-butene	0.00	4.56	9.79	7.82	4.62
Methylcyclohexane	**21.56**	4.73	13.26	1.79	0.99
Methylcyclopentane	**21.32**	4.08	3.35	1.70	0.56
2-Methylheptane	**19.29**	11.13	**17.65**	1.86	4.64
3-Methylheptane	**25.42**	6.69	7.49	3.84	4.92
2-Methylhexane	**22.60**	3.54	14.42	1.84	5.47
3-Methylhexane	**23.73**	7.75	9.87	7.34	2.39
2-Methylpentane	**18.00**	4.42	3.88	5.51	0.38
3-Methylpentane	**19.62**	4.68	6.74	1.53	1.60
n-Nonane	**21.86**	6.37	5.84	1.76	7.08
1-Nonene	NA	NA	13.51	5.72	NA
n-Octane	**24.58**	5.45	6.69	5.15	3.74
1-Octene	NA	2.75	NA	4.61	NA
n-Pentane	**20.42**	3.06	2.49	2.18	0.70
1-Pentene	**23.91**	5.25	7.64	**15.59**	6.40
cis-2-Pentene	NA	NA	NA	NA	5.92
trans-2-Pentene	2.56	6.90	11.96	**21.16**	4.63
a-Pinene	NA	13.09	3.39	NA	4.86
b-Pinene	NA	2.36	NA	NA	NA
Propane	**19.12**	0.30	0.36	0.78	0.25
n-Propylbenzene	NA	5.50	**20.84**	5.38	11.34
Propylene	**15.48**	6.48	4.19	2.15	1.24
Propyne	NA	NA	8.74	NA	NA
Styrene	NA	10.46	8.20	NA	NA
Toluene	**19.07**	1.91	3.26	1.64	4.14
n-Tridecane	NA	7.54	NA	NA	NA
1-Tridecene	NA	NA	NA	NA	NA
1,2,3-Trimethylbenzene	8.06	12.73	**16.22**	7.09	10.18
1,2,4-Trimethylbenzene	14.19	5.51	8.35	1.97	4.87
1,3,5-Trimethylbenzene	0.43	6.43	7.87	7.66	5.39
2,2,3-Trimethylpentane	NA	6.02	4.72	4.94	NA
2,2,4-Trimethylpentane	NA	10.51	13.08	1.20	**15.81**
2,3,4-Trimethylpentane	**18.58**	5.16	10.66	6.24	5.16
n-Undecane	**16.17**	9.98	6.72	3.44	11.98
1-Undecene	NA	2.93	1.32	2.60	NA
m-Xylene/*p*-Xylene	NA	4.47	3.71	2.57	1.64
o-Xylene	11.14	7.09	4.92	3.07	6.11
Average by Site	**16.14**	7.05	7.57	4.47	5.06

NA = No pairs with concentrations greater than or equal to the MDL

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Table 29-10. SNMOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	SSSD	UCSD	# of Pairs	Average by Pollutant
Acetylene	3.86	5.21	61	8.13
Benzene	3.30	4.23	60	5.69
1,3-Butadiene	NA	NA	7	6.36
n-Butane	2.55	2.52	40	1.53
cis-2-Butene	3.90	NA	19	5.66
trans-2-Butene	8.64	6.56	31	5.57
Cyclohexane	3.71	3.23	45	6.94
Cyclopentane	7.13	5.55	49	7.28
Cyclopentene	NA	NA	9	8.13
n-Decane	2.78	NA	38	6.66
1-Decene	NA	NA	2	2.40
m-Diethylbenzene	6.21	5.22	52	6.80
p-Diethylbenzene	10.71	**16.08**	45	13.01
2,2-Dimethylbutane	11.47	8.22	52	9.50
2,3-Dimethylbutane	7.92	4.50	32	5.33
2,3-Dimethylpentane	1.79	NA	32	4.99
2,4-Dimethylpentane	6.67	NA	34	8.14
n-Dodecane	4.32	1.77	38	6.98
1-Dodecene	**21.25**	**17.31**	18	**18.93**
Ethane	1.24	0.85	61	6.93
2-Ethyl-1-butene	NA	NA	0	NA
Ethylbenzene	10.83	7.70	53	8.73
Ethylene	1.24	2.39	61	6.80
m-Ethyltoluene	5.43	NA	38	4.81
o-Ethyltoluene	1.35	NA	29	8.83
p-Ethyltoluene	4.70	NA	22	7.54
n-Heptane	4.35	3.35	44	5.65
1-Heptene	NA	NA	8	9.61
n-Hexane	5.63	4.83	60	5.91
1-Hexene	NA	NA	2	0.37
cis-2-Hexene	4.76	NA	1	4.76
trans-2-Hexene	NA	NA	0	NA
Isobutane	1.98	2.67	61	4.33
Isobutene/1-Butene	5.06	1.56	26	6.44
Isopentane	5.76	2.46	58	5.46
Isoprene	3.72	6.70	31	6.11
Isopropylbenzene	NA	NA	2	3.53
2-Methyl-1-butene	7.81	3.16	22	8.61
3-Methyl-1-butene	NA	NA	0	NA

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-10. SNMOC Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	SSSD	UCSD	# of Pairs	Average by Pollutant
2-Methyl-1-pentene	NA	NA	0	NA
4-Methyl-1-pentene	NA	AN	0	NA
2-Methyl-2-butene	3.73	2.49	27	4.72
Methylcyclohexane	5.95	1.55	45	7.12
Methylcyclopentane	4.26	4.71	57	5.71
2-Methylheptane	7.00	NA	26	10.26
3-Methylheptane	5.76	NA	27	9.02
2-Methylhexane	3.40	4.25	54	7.93
3-Methylhexane	8.78	**16.23**	54	10.87
2-Methylpentane	5.64	4.59	61	6.06
3-Methylpentane	4.20	5.77	58	6.31
n-Nonane	2.75	NA	37	7.61
1-Nonene	NA	NA	7	9.62
n-Octane	3.15	2.38	40	7.31
1-Octene	NA	NA	3	3.68
n-Pentane	2.67	6.47	61	5.43
1-Pentene	13.10	**18.65**	46	12.94
cis-2-Pentene	NA	NA	3	5.92
trans-2-Pentene	7.35	NA	34	9.09
a-Pinene	4.82	NA	12	6.54
b-Pinene	NA	NA	3	2.36
Propane	0.87	0.82	61	3.22
n-Propylbenzene	1.01	NA	15	8.81
Propylene	2.89	3.53	61	5.14
Propyne	NA	NA	2	8.74
Styrene	2.35	0.36	6	5.34
Toluene	5.11	2.61	59	5.39
n-Tridecane	NA	NA	4	7.54
1-Tridecene	NA	NA	0	NA
1,2,3-Trimethylbenzene	5.71	**22.52**	32	11.79
1,2,4-Trimethylbenzene	5.62	7.86	55	6.91
1,3,5-Trimethylbenzene	5.56	NA	25	5.56
2,2,3-Trimethylpentane	NA	NA	9	5.23
2,2,4-Trimethylpentane	5.34	4.62	49	8.43
2,3,4-Trimethylpentane	7.42	NA	36	8.87
n-Undecane	6.89	6.70	38	8.84
1-Undecene	NA	6.73	8	3.40
m-Xylene/*p*-Xylene	2.48	10.57	30	4.24
o-Xylene	5.26	11.62	49	7.03
Average by Site	5.33	6.07	--	7.39

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.3.3 Carbonyl Compound Analytical Precision

Table 29-11 presents the analytical precision results from replicate analyses of 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 for NMP sites sampling carbonyl compounds. The overall average variability was 2.43 percent, which is well within the program MQO of 15 percent CV. The analytical precision results from replicate analyses of duplicate and collocated samples range from 0.25 percent (acetaldehyde for CHNJ) to 7.48 percent (benzaldehyde for GLKY). The pollutant-specific average CV ranged from 0.73 percent (acetone) to 4.08 percent (tolualdehydes). The site-specific average CV ranged from 1.91 percent for PXSS to 2.97 percent for INDEM.

Table 29-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	**AZFL**	***BTUT***	**CHNJ**	***DEMI***	**ELNJ**	***GLKY***	***GPCO***
Acetaldehyde	1.03	0.44	0.25	0.29	0.76	0.93	0.59
Acetone	1.53	0.38	0.35	0.49	0.67	0.60	0.67
Benzaldehyde	4.35	3.77	2.72	3.42	2.40	7.48	1.35
Butyraldehyde	3.40	1.53	1.95	2.83	0.92	2.69	2.72
Crotonaldehyde	2.69	2.11	1.97	3.07	2.42	2.87	2.53
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	1.61	0.84	0.50	1.30	1.22	0.71	0.92
Hexaldehyde	4.08	2.98	3.45	4.21	3.98	3.33	3.36
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	2.21	1.39	2.33	1.81	1.42	1.90	1.40
Tolualdehydes	4.79	4.17	4.55	4.33	4.89	3.60	3.80
Valeraldehyde	3.96	2.83	3.39	4.45	3.38	4.92	3.08
Average by Site	2.96	2.04	2.15	2.62	2.21	2.90	2.04

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	INDEM	MWOK	***NBIL***	NBNJ	OCOK	ORFL	PROK
Acetaldehyde	1.47	0.59	0.95	0.84	0.58	0.52	0.41
Acetone	0.69	0.38	1.19	0.42	0.38	1.02	0.55
Benzaldehyde	4.60	3.30	3.82	3.62	2.79	3.62	3.44
Butyraldehyde	2.46	2.24	2.59	2.55	1.82	3.11	1.76
Crotonaldehyde	3.05	0.99	4.86	2.61	2.48	1.56	1.74
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	1.29	0.49	0.35	0.48	0.61	0.79	1.29
Hexaldehyde	4.31	3.22	3.48	4.09	3.04	3.96	2.98
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	2.59	2.10	2.60	1.99	1.08	2.23	2.08
Tolualdehydes	4.73	4.09	2.94	2.91	4.99	5.06	3.25
Valeraldehyde	4.52	4.13	4.34	1.60	2.76	4.51	2.72
Average by Site	2.97	2.15	2.71	2.11	2.05	2.64	2.02

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	***PXSS***	***S4MO***	***SEWA***	***SKFL***	SPIL	SSSD	***SYFL***
Acetaldehyde	1.23	0.47	1.26	0.62	0.27	2.14	0.56
Acetone	0.89	0.79	1.59	0.79	0.56	0.54	0.56
Benzaldehyde	1.82	3.65	3.86	3.70	3.13	4.21	3.32
Butyraldehyde	1.22	1.43	1.90	3.90	1.90	3.22	2.91
Crotonaldehyde	1.93	1.99	3.83	2.43	2.90	3.77	3.51
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	0.92	0.43	0.78	0.64	0.56	0.81	0.49
Hexaldehyde	3.64	3.87	4.00	3.85	2.21	3.49	2.62
Isovaleraldehyde	NA	NA	NA	NA	NA	NA	NA
Propionaldehyde	1.64	2.02	2.69	2.94	1.82	1.54	2.02
Tolualdehydes	3.81	4.70	2.42	4.50	4.20	4.96	4.53
Valeraldehyde	2.03	2.82	3.01	3.38	3.17	3.26	4.28
Average by Site	1.91	2.22	2.53	2.68	2.07	2.80	2.48

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

Table 29-11. Carbonyl Compound Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	TMOK	TOOK	UCSD	WPIN	# of Pairs	Average by Pollutant
Acetaldehyde	0.47	1.44	0.59	1.06	326	0.79
Acetone	0.55	0.77	1.01	0.89	326	0.73
Benzaldehyde	2.89	3.49	4.34	4.01	324	3.56
Butyraldehyde	2.73	2.80	2.91	2.27	324	2.39
Crotonaldehyde	1.79	2.63	4.25	3.34	316	2.69
2,5-Dimethylbenzaldehyde	NA	NA	NA	NA	0	NA
Formaldehyde	0.77	1.25	0.98	1.10	326	0.84
Hexaldehyde	3.89	4.71	3.12	3.49	324	3.57
Isovaleraldehyde	NA	NA	NA	NA	0	NA
Propionaldehyde	2.30	2.79	3.12	2.61	326	2.10
Tolualdehydes	3.25	3.89	3.11	4.56	269	4.08
Valeraldehyde	2.60	4.75	4.69	3.86	317	3.54
Average by Site	2.12	2.85	2.81	2.72	--	2.43

NA = No pairs with concentrations greater than or equal to the MDL

BOLD ITALICS = EPA-designated NATTS Site

Gray shading indicates NATTS MQO Core Analyte

Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.3.4 PAH Analytical Precision

Table 29-12 presents analytical precision results from replicate analyses of all collocated PAH samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV for NMP sites sampling PAHs. The analytical precision results from replicate analysis of collocated samples show low- to mid-level variability among sites, ranging from a CV of 0.82 percent (benzo(a)anthracene for SYFL) to 41.40 percent (anthracene for DEMI). The pollutant-specific average CV ranged from 1.21 percent (dibenz(a,h)anthracene) to 15.30 percent (anthracene). The site-specific average CV ranged from 3.15 percent for SEWA to 7.41 percent for DEMI. The overall average CV for all sites was 4.61 percent.

Table 29-12. PAH Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	***DEMI***	*RUCA*	***SDGA***	*SEWA*	***SYFL***	# of Pairs	Average by Pollutant
Acenaphthene	8.73	2.73	5.13	4.81	2.57	58	4.80
Acenaphthylene	3.26	2.09	1.89	7.90	13.34	22	5.70
Anthracene	**41.40**	4.19	**20.80**	2.89	7.21	28	**15.30**
Benzo(a)anthracene	**36.75**	2.43	1.39	2.35	0.82	17	8.75
Benzo(a)pyrene	4.41	NA	3.83	6.27	7.42	15	5.48
Benzo(b)fluoranthene	2.75	2.63	4.16	4.86	3.68	47	3.62
Benzo(e)pyrene	2.51	2.81	4.61	1.74	5.91	35	3.52
Benzo(g,h,i)perylene	2.79	1.33	1.30	2.12	3.35	27	2.18
Benzo(k)fluoranthene	2.61	NA	4.42	4.20	7.24	16	4.62
Chrysene	1.71	3.65	2.90	2.28	3.24	55	2.76
Coronene	3.96	NA	NA	2.97	10.94	6	5.96
Cyclopenta[cd]pyrene	NA	NA	2.21	1.56	NA	4	1.89
Dibenz(a,h)anthracene	NA	NA	NA	NA	1.21	1	1.21
Fluoranthene	3.43	3.16	3.94	2.61	2.89	58	3.21
Fluorene	3.38	3.90	3.69	3.38	2.80	58	3.43
9-Fluorenone	3.34	2.58	4.05	2.96	2.92	58	3.17
Indeno(1,2,3-cd)pyrene	4.55	9.17	9.13	0.91	4.94	25	5.74
Naphthalene	2.85	2.56	4.11	2.51	3.30	58	3.06
Perylene	NA	NA	NA	NA	NA	0	NA
Phenanthrene	1.61	1.11	1.74	1.35	2.22	58	1.61
Pyrene	3.80	3.79	4.06	2.60	2.78	58	3.40
Retene	6.86	3.50	4.46	2.79	4.31	57	4.39
Average by Site	7.41	3.23	4.62	3.15	4.66	--	4.61

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.3.5 Metals Analytical Precision

Table 29-13 presents analytical precision results from replicate analyses of all collocated metals samples as the CV per pollutant per site, the average CV per site, the average CV per pollutant, and the overall average CV for NMP sites sampling metals. The results from replicate analyses of collocated samples show low- to mid-level variability among sites, ranging from a CV of 0.30 percent (chromium for S4MO) to 34.02 percent (mercury for UNVT). The pollutant-specific average CV ranged from 1.29 percent (lead) to 16.52 percent (mercury). The site-specific average CV ranged from 3.01 percent for TOOK to 12.56 percent for GLKY. The overall average analytical precision was 7.91 percent.

Table 29-13. Metals Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	***BOMA***	***BTUT***	**GLKY**	***S4MO***	**TOOK**	***UNVT***	**# of Pairs**	**Average by Pollutant**
Antimony	1.40	1.17	2.85	0.96	2.16	2.24	342	1.80
Arsenic	2.09	11.01	11.23	7.21	1.98	**16.36**	323	8.32
Beryllium	14.31	**24.85**	**17.82**	13.30	4.58	NA	160	14.97
Cadmium	6.81	7.53	4.95	2.79	2.27	5.77	340	5.02
Chromium	2.83	NA	NA	0.30	3.03	NA	133	2.05
Cobalt	6.43	10.19	**29.23**	**19.55**	2.22	**15.71**	317	13.89
Lead	1.50	0.72	1.03	0.61	2.38	1.52	342	1.29
Manganese	1.13	1.08	0.81	1.15	2.22	3.44	342	1.64
Mercury	9.27	**20.20**	**17.53**	11.51	6.59	**34.02**	245	**16.52**
Nickel	1.80	3.24	**33.36**	9.58	3.74	2.86	201	9.10
Selenium	2.68	**17.70**	6.77	8.85	1.97	13.83	329	8.63
Average by Site	4.57	9.77	12.56	6.89	3.01	10.64	--	7.91

NA = No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Gray shading indicates NATTS MQO Core Analyte
Orange shading indicates the site-specific average CV for this method; the overall average CV for this method is calculated from the site-specific averages and provided in the final column of the table.

29.3.6 Hexavalent Chromium Analytical Precision

Table 29-14 presents analytical precision results from replicate analyses of all collocated hexavalent chromium samples as the CV per site and the overall average CV for NMP sites sampling hexavalent chromium. Hexavalent chromium is a NATTS MQO Core Analyte and the sites shown are NATTS sites. The range of variability for hexavalent chromium was 3.56 percent for HOWI to 13.83 percent for BTUT, with an overall average analytical precision of 6.69 percent.

Table 29-14. Hexavalent Chromium Analytical Precision: Coefficient of Variation Based on Replicate Analyses by Site

Site	Average CV
BOMA	8.29
BTUT	13.83
CAMS 35	5.22
CHSC	7.32
DEMI	4.56
GLKY	5.30
GPCO	8.03
HOWI	3.56
MONY	5.54
NBIL	6.44
PRRI	7.19
PXSS	4.92
RIVA	6.26
ROCH	9.40
S4MO	6.57
SDGA	5.44
SEWA	5.64
SKFL	5.71
SYFL	5.27
UNVT	7.74
WADC	8.34
# of Pairs	223
Average by Site	6.69

BOLD ITALICS = EPA-designated NATTS Site
Orange shading indicates the average CV for this method

29.4 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. Tables 29-15 through 29-19 present ERG's results from the 2011 NATTS PT audit samples for VOCs, carbonyl compounds, PAHs, metals, hexavalent chromium, respectively. 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. Shaded rows present results for NATTS MQO Core Analytes. 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

Table 29-15. VOC NATTS PT Audit Samples-Percent Difference from True Value

Pollutant	November 2011
Acrolein	-20.3
Benzene	10.2
1,3-Butadiene	10.9
Carbon Tetrachloride	**25.4**
Chloroform	-9.7
1,2-Dibromoethane	5.7
1,2-Dichloroethane	-11.8
Dichloromethane	6.4
1,2-Dichloropropane	2.8
cis-1,3-Dichloropropene	21.5
trans-1,3-Dichloropropene	**41.3**
1,1,2,2-Tetrachloroethane	1.1
Tetrachloroethylene	0.8
Trichloroethylene	-8.3
Vinyl Chloride	0.3

Gray shading indicates NATTS MQO Core Analyte

Table 29-16. Carbonyl Compound NATTS PT Audit Samples-Percent Difference from True Value

Pollutant	November 2011
Acetaldehyde	3.0
Benzaldehyde	8.0
Formaldehyde	-3.4
Propionaldehyde	-14.6

Gray shading indicates NATTS MQO Core Analyte

Table 29-17. PAH NATTS PT Audit Samples-Percent Difference from True Value

Pollutant	July 2011
Acenaphthene	-11.9
Anthracene	-13.6
Benzo(a)pyrene	-2.1
Fluoranthene	-9.4
Fluorene	-6.9
Naphthalene	-13.9
Phenanthrene	-7.9
Pyrene	-6.9

Gray shading indicates NATTS MQO Core Analyte

Table 29-18. Metals NATTS PT Audit Samples-Percent Difference from True Value

Pollutant	July 2011
Arsenic	1.1
Beryllium	-8.2
Cadmium	-6.0
Cobalt	-4.3
Lead	-6.3
Manganese	-4.0
Nickel	-6.8
Selenium	-15.6

Gray shading indicates NATTS MQO Core Analyte

Table 29-19. Hexavalent Chromium PT Audit Samples-Percent Difference from True Value Across Multiple Samples

Pollutant	July 2011			
	Concentration #1	Concentration #2	Concentration #3	Concentration #4
Hexavalent Chromium	-2.6	-6.0	-1.7	-0.8

Gray shading indicates NATTS MQO Core Analyte

The accuracy of the 2011 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 2011 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 2011 monitoring data accurately represent ambient air quality.

30.0 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 monitoring 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.

30.1 Summary of Results

Analyses of the 2011 monitoring data identified the following notable results, observations, trends, and patterns in the program-level and state- and site-specific air monitoring data.

30.1.1 National-level Results Summary

- *Number of participating NATTS sites.* Twenty-five of the 51 sites are EPA-designated NATTS sites (BOMA, BTUT, 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).

- *Total number of samples collected and analyzed.* Over 8,800 samples were collected yielding over 218,900 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, a method detection limit 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 54 percent of the reported measurements were above the associated MDLs. Of the 177 pollutants monitored, only two pollutants were not detected over the course of the 2011 monitoring effort: *cis*-1,2-dichloroethylene and 2,5-dimethylbenzaldehyde.

- *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. In addition, the 18 NATTS MQO Core Analytes (excluding acrolein) are inherently classified as pollutants of interest. Only two NATTS MQO Core Analytes (beryllium and vinyl chloride) did not fail any screens. Hexachloro-1,3-butadiene is new to the program-level pollutants of interest for 2011.

- *Noncancer Risk-Based Screening using ATSDR MRLs*. Where an MRL was available, all of the preprocessed daily measurements were less than the associated ATSDR acute MRLs. Additionally, all of the quarterly or annual average concentrations of the pollutants with MRLs were less than the associated ATSDR intermediate or chronic MRLs.

- *Mobile Sources.* Site-specific hydrocarbon concentrations had positive correlations with county-level and 10-mile 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.

- *Carbon Tetrachloride.* 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 in at similar levels at any given location. NMP sites are located in a variety of locations across the county with difference purposes behind the monitoring at each site. The relative uniformity in the concentrations of carbon tetrachloride across the program confirms the ubiquitous nature of this pollutant and is an indication of the representativeness of the data generated under the program.

- *Seasonal Trends.* Formaldehyde concentrations tended to be highest during the third quarter of 2011, or during the period from July to September. Acenaphthene 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. Benzo(a)pyrene and 1,3-butadiene concentrations exhibit a similar trend. Arsenic concentrations tended to be highest between October and December.

30.1.2 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-three pollutants, of which 13 are NATTS MQO Core Analytes, failed screens for PXSS. PXSS failed the second highest number of screens among all NMP sites.

- Ten pollutants failed screens for SPAZ, of which four are NATTS MQO Core Analytes.

- Of the pollutants of interest for PXSS, benzene had the highest annual average concentration and was the only pollutant with an annual average concentration greater than 1 µg/m^3 for this site.

- Xylenes had the highest annual average concentration for SPAZ. Benzene and ethylbenzene also had annual average concentrations greater than 1 µg/m^3.

- PXSS had the highest annual average concentration of tetrachloroethylene, hexavalent chromium, beryllium, and manganese among NMP sites sampling these pollutants.

- SPAZ had the highest annual average concentrations of 1,3-butadiene, *p*-dichlorobenzene, and ethylbenzene among NMP sites sampling these pollutants.

- Annual average concentrations could not be calculated for the carbonyl compounds for PXSS due to a sampler problem that led to the invalidation of carbonyl compounds samples through the end of March 2011.

- Sampling for metals (PM_{10}) and hexavalent chromium has occurred at PXSS for at least 5 consecutive years; thus, a trends analysis was conducted for select pollutants. The concentrations of arsenic, lead, and manganese increased for 2011 from 2010 levels.

- Benzene and 1,3-butadiene had the highest cancer risk approximations for PXSS and SPAZ. 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 three California monitoring sites are located in Los Angeles (CELA), Rubidoux (RUCA), and San Jose (SJJCA). All three are NATTS sites.

- CELA and RUCA sampled for PAHs only. SJJCA sampled for PAHs and metals (PM_{10}).

- Three pollutants failed screens for CELA, of which one (naphthalene) is a NATTS MQO Core Analyte. Naphthalene was the only pollutant to fail screens for RUCA. Six pollutants failed screens for SJJCA, of which five are NATTS MQO Core Analytes.

- Naphthalene had the highest annual average concentration for each site. The annual average concentration of naphthalene for CELA was higher than the annual average concentrations for RUCA and SJJCA, and fourth highest compared to all NMP sites sampling naphthalene.

- 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 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 Santa Clara Counties while hexavalent chromium had the highest cancer toxicity-weighted emissions for Riverside County.

- 1,1,1-Trichloroethane was the highest emitted pollutant with a noncancer toxicity factor in Los Angeles County, while toluene was the highest emitted pollutant with a noncancer toxicity factor in Riverside and Santa Clara Counties. 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 four 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), and Rifle (RICO).

- GPCO sampled for VOCs, carbonyl compounds, PAHs, and hexavalent chromium. The Garfield County sites sampled for SNMOCs and carbonyl compounds.

- Twenty-three pollutants failed at least one screen for GPCO, of which eight are NATTS MQO Core Analytes. The number of pollutants that failed screens for the Garfield County sites ranged from four (BRCO) to five (BMCO, PACO, and RICO).

- Of the pollutants of interest for GPCO, formaldehyde had the highest annual average concentration, followed by acetaldehyde and benzene.

- Annual average concentrations for the carbonyl compounds for the Garfield County sites could not be calculated because these sites did not meet the necessary completeness criteria. The same is true for SNMOCs for BMCO. Benzene had the highest annual average concentration for the three remaining Garfield County sites; PACO had the highest annual average benzene concentration of all three sites.

- GPCO had the highest annual average concentrations of naphthalene and benzo(a)pyrene among sites sampling PAHs. GPCO also had the fourth highest annual average ethylbenzene concentration among all NMP sites sampling this pollutant. PACO, GPCO, and RICO are listed among the NMP sites with the highest annual average concentrations for sites that sampled benzene.

- VOC, carbonyl compound, and hexavalent chromium sampling has occurred at GPCO for at least 5 consecutive years; thus, a trends analysis was conducted for select pollutants. After several years without significant change, formaldehyde concentrations decreased significantly from 2009 to 2010, then held steady in 2011. Benzene concentrations exhibit an overall decreasing trend over recent years. Concentrations of hexavalent chromium have increased at GPCO since 2009.

- Formaldehyde had the highest cancer risk approximation for GPCO. Benzene had the highest cancer risk approximation for each of the three Garfield County sites where an annual average could be calculated (BRCO, PACO, and RICO). All noncancer hazard approximations were less than 1.0 for all five Colorado sites.

- 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. The only pollutant to fail screens for WADC was naphthalene.

- The pollutant with the highest annual average concentration for WADC was naphthalene, which was significantly higher than the annual average concentrations for benzo(a)pyrene and hexavalent chromium.

- Hexavalent chromium sampling has occurred at WADC for at least 5 consecutive years; thus, a trends analysis was conducted. The average concentration of hexavalent chromium increased significantly from 2009 to 2010 then held steady for 2011.

- Naphthalene had the only cancer risk approximation for WADC greater than 1.0 in-a-million. None of the pollutants of interest had a noncancer hazard approximation greater 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 MSA (ORFL and PAFL). SKFL and SYFL are NATTS 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 only metals (PM_{10}).

- Acetaldehyde and formaldehyde were the only pollutants to fail screens for AZFL and ORFL, where only carbonyl compounds were sampled. Five pollutants failed screens for SKFL and four pollutants failed screens for SYFL. Arsenic was the only pollutant to fail screens for PAFL, where only metals were sampled.

- Acetaldehyde had the highest annual average concentration for AZFL, while formaldehyde had the highest annual average concentration for SKFL, SYFL, and ORFL. SYFL had the highest annual average concentration of formaldehyde among the Florida sites. Manganese and lead had the highest annual average concentrations for PAFL.

- Carbonyl compound sampling has been conducted at AZFL, ORFL, SKFL, and SYFL for at least 5 consecutive years; thus a trends analysis was conducted for acetaldehyde and formaldehyde. Hexavalent chromium sampling has also been conducted at SYFL for at least 5 consecutive years. From 2010 to 2011, acetaldehyde concentrations have decreased at AZFL, SKFL, and SYFL while acetaldehyde concentrations have increased at ORFL. Concentrations of formaldehyde increased from 2010 to 2011 at SKFL, but have been steadily decreasing at ORFL since the onset of sampling. Hexavalent chromium concentrations have been increasing since 2009 at SYFL.

- 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 and Orange Counties.

- 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, south of Atlanta, is a NATTS site.

- SDGA sampled for PAHs and hexavalent chromium. Naphthalene, acenaphthene, and fluorene failed screens for SDGA, with naphthalene accounting for the majority of the total failed screens.

- Of the pollutants of interest for SDGA, naphthalene had the highest annual average concentration, ranking tenth among NMP sites sampling PAHs.

- Hexavalent chromium sampling has occurred at SDGA for at least 5 consecutive years; thus, a trends analysis was conducted. The range of hexavalent chromium measurements has decreased since the onset of sampling in 2006.

- Naphthalene was the only pollutant of interest with a cancer risk approximation greater than 1.0 in-a-million. None of the pollutants of interest for SDGA had a noncancer hazard approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in DeKalb County, while toluene was the highest emitted pollutant with a noncancer toxicity factor. Benzene also had the highest cancer toxicity-weighted emissions, while acrolein had the highest noncancer toxicity-weighted emissions for DeKalb County.

***Illinois*.**

- The 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.

- Both Illinois sites sampled for VOCs and carbonyl compounds. NBIL also sampled for SNMOCs, PAHs, hexavalent chromium, and metals (PM_{10}).

- Twenty-four pollutants failed screens for NBIL, of which 13 are NATTS MQO Core Analytes. Sixteen pollutants failed screens for SPIL, of which six are NATTS MQO Core Analytes.

- Of the pollutants of interest for NBIL, chloroform had the highest annual average concentration. This is also the highest annual average concentration of chloroform among NMP sites sampling this pollutant. NBIL also had the highest annual average concentration of fluorene among all NMP sites sampling PAHs.

- Formaldehyde had the highest annual average concentration for SPIL. SPIL had the highest annual average concentrations of trichloroethylene and acrylonitrile among NMP sites sampling these pollutants.

- VOC and carbonyl compound sampling have been conducted at NBIL and SPIL for at least 5 consecutive years. In addition, metals (PM_{10}) and hexavalent chromium sampling have been conducted at NBIL for at least 5 consecutive years. Thus, a trends analysis was conducted for these methods for both sites. Concentrations of acetaldehyde and 1,3-butadiene have an increasing trend at both sites in recent years. The concentrations for several of the pollutants for which a trends analysis was performed were at a minimum in 2009, particularly for SPIL.

- Formaldehyde had the highest cancer risk approximation for NBIL, while acrylonitrile had the highest cancer risk approximation for SPIL. All noncancer hazard approximations for the pollutants of interest for the Illinois sites were less than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Cook 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 Cook County.

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 INDEM.

- Of the pollutants of interest, formaldehyde had the highest annual average concentration for INDEM. Annual average concentrations for WPIN could not be calculated due to intermittent sampler issues.

- Carbonyl compound sampling has been conducted at INDEM for at least 5 consecutive years; thus, a trends analysis was conducted for acetaldehyde and formaldehyde. The concentration of both acetaldehyde and formaldehyde decreased dramatically at INDEM between 2008 and 2009, with little change since.

- Formaldehyde had the highest cancer risk approximation for INDEM. Neither of the pollutants of interest for INDEM had a noncancer hazard approximation greater than 1.0. Annual average concentrations could not be calculated for WPIN, therefore, cancer risk and noncancer hazard approximations could not be calculated.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in 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. Acrolein had the highest noncancer toxicity-weighted emissions for both counties.

***Kentucky*.**

- The Kentucky monitoring site is located near Grayson Lake, south of Grayson, Kentucky (GLKY). GLKY is a NATTS site.

- GLKY sampled for hexavalent chromium, metals (PM_{10}), carbonyl compounds, PAHs, and VOCs. Fifteen pollutants failed screens for GLKY, of which nine are NATTS MQO Core Analytes.

- Annual averages could not be calculated for metals (PM_{10}) and carbonyl compounds because sampling did not begin until May and August, respectively. Of the pollutants of interest for which annual averages could be calculated, carbon tetrachloride and benzene had the highest annual average concentrations for GLKY, though none of the calculated annual average concentrations were greater than 1 $\mu g/m^3$.

- Acrylonitrile had the highest cancer risk approximation for GLKY, followed by benzene and carbon tetrachloride. None of the pollutants of interest for GLKY had noncancer hazard approximations greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Carter County 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 Carter County.

***Massachusetts*.**

- The Massachusetts monitoring site (BOMA) is a NATTS site located in Boston.

- BOMA sampled for metals (PM_{10}), PAHs, and hexavalent chromium.

- Seven pollutants failed screens for BOMA, of which five are NATTS MQO Core Analytes. Naphthalene accounted for nearly half of the site's failed screens.

- Of the pollutants of interest, naphthalene had the highest annual average concentration. The annual average beryllium concentration for BOMA ranked third highest among sites sampling metals (PM_{10}).

- Metals and hexavalent chromium sampling have been conducted at BOMA for at least 5 consecutive years; thus, a trends analysis was conducted for arsenic, hexavalent chromium, and manganese. The concentrations of these pollutants have changed little in recent years.

- 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.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Suffolk County, while formaldehyde 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.

- Nineteen pollutants failed screens for DEMI, of which eight are NATTS MQO Core Analytes. Acetaldehyde and formaldehyde both failed screens for RRMI and SWMI; propionaldehyde also failed one screen for SWMI.

- Formaldehyde had the highest annual average concentration for all three Michigan sites. Compared to other NMP sites, DEMI had the second highest annual average concentration of chloroform among sites sampling VOCs. DEMI also had the highest annual average concentration of acenaphthene and the second highest annual average concentrations of fluorene and naphthalene among sites sampling PAHs. DEMI also has the fourth highest annual average concentration of hexavalent chromium.

- Hexavalent chromium, carbonyl compound, and VOC sampling has been conducted at DEMI for at least 5 consecutive years; thus, a trends analysis was conducted for select pollutants. The most notable trend is for benzene. Benzene concentrations exhibit a steady decreasing trend although concentrations have leveled out in recent years.

- Formaldehyde had the highest cancer risk approximation for all three sites. 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. Hydrochloric acid was the highest emitted pollutant with a noncancer toxicity factor in Wayne 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-five pollutants failed at least one screen for S4MO, of which 13 are NATTS MQO Core Analytes. S4MO failed the greatest number of screens among NMP sites.

- Of the pollutants of interest, formaldehyde and acetaldehyde had the highest annual average concentrations for S4MO. S4MO had the highest annual average concentrations of hexachloro-1,3-butadiene, arsenic, cadmium, and lead among all NMP sites sampling these pollutants.

- Carbonyl compound, VOC, metals (PM_{10}), and hexavalent chromium sampling have been conducted at S4MO for at least 5 consecutive years; thus, a trends analysis was conducted for select pollutants. Concentrations of acetaldehyde and benzene decreased from 2010 to 2011. Concentrations of formaldehyde increased significantly from 2010 to 2011.

- 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.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in St. Louis (city), while toluene was the highest emitted pollutant with a noncancer toxicity factor. Hexavalent chromium had the highest cancer toxicity-weighted emissions, while acrolein had the highest noncancer toxicity-weighted emissions in St. Louis (city).

***New Jersey*.**

- The four UATMP sites in New Jersey are located in Chester (CHNJ), Elizabeth (ELNJ), New Brunswick (NBNJ), and Paterson (PANJ).

- CHNJ, ELNJ, and NBNJ sampled for VOCs and carbonyl compounds, while PANJ sampled for VOCs only.

- Seventeen pollutants failed at least one screen for CHNJ; 16 pollutants failed at least one screen for ELNJ; 18 pollutants failed screens for NBNJ; and 10 failed screens for PANJ.

- Of the pollutants of interest, formaldehyde had the highest annual average concentration for CHNJ, ELNJ, and NBNJ. Annual average concentrations could not be calculated for PANJ due to a combination of a shortened sampling duration (sampling ended in the middle of May) and a 1-in-12 day sampling schedule.

- Compared to other NMP sites, CHNJ had the highest annual average concentration of 1,2-dichloroethane among sites sampling VOCs and ELNJ had the highest annual average concentration of formaldehyde among sites sampling carbonyl compounds.

- Carbonyl compound and VOC sampling has been conducted at CHNJ, ELNJ, and NBNJ for at least 5 consecutive years; thus, a trends analysis was conducted for select pollutants. Several of the pollutants for which a trends analysis was conducted exhibit slight increasing trends from 2010 to 2011, most notably 1,3-butadiene concentrations at CHNJ and acetaldehyde concentrations for ELNJ.

- Formaldehyde had the highest cancer risk approximations 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. Cancer risk and noncancer hazard approximations were not available for PANJ because annual average concentrations could not be calculated.

- Benzene was the highest emitted pollutant with a cancer URE in Union, Middlesex, Morris, and Passaic Counties. Benzene also had the highest toxicity-weighted emissions for Morris and Passaic Counties, while formaldehyde had the highest toxicity-weighted emissions for Union and Middlesex Counties.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in all four counties, while acrolein had the highest noncancer toxicity-weighted emissions for each county.

New York.

- The two New York monitoring sites are located in New York City (MONY) and Rochester (ROCH). Both are NATTS monitoring sites.

- Both New York sites sampled PAHs and hexavalent chromium.

- Seven pollutants failed screens for MONY and four pollutants failed screens for ROCH. Naphthalene failed the majority of screens for both sites.

- Naphthalene had the highest annual average concentration for both MONY and ROCH.

- Naphthalene had the highest cancer risk approximation for both sites. None of the pollutants of interest for either New York site had noncancer hazard approximations greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor for Bronx and Monroe Counties and had the highest cancer toxicity-weighted emissions for both counties.

- Methanol was the highest emitted pollutant with a noncancer toxicity factor in Bronx County, while toluene was the highest emitted pollutant with a noncancer toxicity factor in Monroe County. 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), one in Oklahoma City (OCOK), and one in the Oklahoma City suburb of Midwest City (MWOK).

- Each of the Oklahoma sites sampled for VOCs, carbonyls compounds, and metals (TSP).

- Twenty pollutants failed screens for TOOK; 19 failed screens for TMOK; 15 failed screens for PROK; 17 failed screens for MWOK; and 16 failed screens for OCOK.

- Of the pollutants of interest, formaldehyde had the highest annual average concentration for each Oklahoma site.

- TOOK had the highest annual average concentration of benzene among NMP sites sampling this pollutant. The five Oklahoma sites account for the third through seventh highest annual average concentrations of formaldehyde among NMP sites sampling carbonyl compounds.

- TOOK has sampled carbonyl compounds, VOCs, and TSP metals for at least 5 consecutive years, therefore a trends analysis was conducted for select pollutants. Concentrations of acetaldehyde, benzene, 1,3-butadiene, and manganese (TSP) exhibit an increasing trend since 2009.

- 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. Arsenic had the highest cancer toxicity-weighted emissions for Mayes County while benzene had the highest cancer toxicity-weighted emissions for Oklahoma and Tulsa Counties.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in Tulsa and Oklahoma Counties, while hydrochloric acid was the highest emitted pollutant with a noncancer toxicity factor in Mayes County. 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.

- Five pollutants failed screens for PRRI; 86 percent of failed screens are attributable to naphthalene.

- The annual average concentration of naphthalene was significantly higher than the annual averages for the other pollutants of interest.

- Hexavalent chromium sampling has been conducted at PRRI for at least 5 consecutive years; thus, a trends analysis was conducted. Concentrations of hexavalent chromium exhibit an increasing trend for the last 2 years of sampling.

- Naphthalene had the highest cancer risk approximation for PRRI and is the only one greater than 1.0 in-a-million; all 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 three screens out of 60 measured detections.

- The annual average concentration of naphthalene was significantly higher than the annual average concentrations of the other two NATTS MQO Core Analytes. Compared to other NMP sites sampling PAHs and hexavalent chromium, CHSC had some of the lowest annual average concentrations.

- Hexavalent chromium sampling has been conducted at CHSC for at least 5 consecutive years; thus, a trends analysis was conducted. Hexavalent chromium concentrations increased significantly from 2009 to 2010 then held steady for 2011.

- The cancer risk approximations for the pollutants of interest for CHSC were less than 1 in-a-million; all noncancer hazard approximations for CHSC were less than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Chesterfield County 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.

South Dakota.

- The UATMP sites in South Dakota are located in Sioux Falls (SSSD) and Union County (UCSD).

- Both South Dakota sites sampled for VOCs, SNMOCs, and carbonyl compounds.

- Fourteen pollutants failed screens for SSSD, of which five are NATTS MQO Core Analytes. Thirteen pollutants failed screens for UCSD, of which six are NATTS MQO Core Analytes.

- Formaldehyde and acetaldehyde had the highest annual average concentrations for both SSSD and UCSD and are the only two pollutants with annual averages greater than 1.0 $\mu g/m^3$ for these sites. UCSD had the second highest concentration of acrylonitrile among NMP sites sampling VOCs.

- Formaldehyde had the highest cancer risk approximations for both sites. None of the pollutants of interest for either South Dakota site had a noncancer hazard approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Minnehaha and Union Counties, while formaldehyde had the highest toxicity-weighted emissions for both counties.

- Toluene was the highest emitted pollutant with a noncancer toxicity factor in Minnehaha and Union Counties, while acrolein had the highest noncancer toxicity-weighted emissions for both counties.

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, while CAMS 85 sampled for hexavalent chromium only.

- Five pollutants failed screens for CAMS 35, with naphthalene contributing to nearly 71 percent of the total failed screens. Hexavalent chromium did not fail any screens for CAMS 85.

- Of the pollutants of interest for CAMS 35, naphthalene had the highest annual average concentration and is significantly higher than the annual averages for the other pollutants of interest. The annual average concentration of hexavalent chromium for CAMS 85 is less than half the annual average concentration for CAMS 35. The annual average concentration of hexavalent chromium for CAMS 85 is an order of magnitude lower than its annual average for 2010. This may be attributable to the use of stainless steel filter holders used in the sampler which may have contaminated the samples. Changing to a Teflon® filter holder has resulted in a decrease in hexavalent chromium concentrations at CAMS 85.

- Naphthalene had the highest cancer risk approximation among the pollutants of interest for CAMS 35 and was the only pollutant with a cancer risk approximation greater than 1 in-a-million for both sites. None of the pollutants of interest for either Texas site had a noncancer hazard approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Harris County, while formaldehyde had the highest cancer toxicity-weighted emissions. Formaldehyde was the highest emitted pollutant with a cancer toxicity factor in Harrison County, while hexavalent chromium 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 is located in Bountiful, north of Salt Lake City (BTUT).

- BTUT sampled for VOCs, carbonyl compounds, SNMOCs, PAHs, metals (PM_{10}), and hexavalent chromium.

- Twenty-one pollutants failed screens for BTUT, of which 12 are NATTS MQO Core Analytes.

- Of the pollutants of interest, dichloromethane had the highest annual average concentration for BTUT, followed by formaldehyde, acetaldehyde, and benzene. BTUT had the highest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds.

- Sampling for carbonyl compounds, VOCs, SNMOCs, metals (PM_{10}), and hexavalent chromium have been conducted at BTUT for at least 5 consecutive years; thus, a trends analysis was conducted for select pollutants. Concentrations of formaldehyde have been increasing in recent years, while concentrations of benzene have decreased. Concentrations of lead have an overall decreasing trend since the onset of sampling.

- The pollutant with the highest cancer risk approximation for BTUT is formaldehyde. 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 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 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.

- UNVT sampled for VOCs, hexavalent chromium, PAHs, and metals (PM_{10}). BURVT and RUVT sampled for VOCs only.

- Eleven pollutants failed screens for BURVT and seven failed screens for RUVT. Thirteen pollutants failed screens for UNVT.

- Benzene had the highest annual average concentration for BURVT and RUVT, while carbon tetrachloride had the highest annual average concentration for UNVT. Annual average concentrations of the pollutants of interest for UNVT were among the lowest compared to NMP sites sampling the same pollutants.

- UNVT has sampled hexavalent chromium for at least 5 consecutive years; thus, a trends analysis was conducted. The number of non-detects has decreased in recent years, resulting in an increase in the average concentration of hexavalent chromium for UNVT.

- Benzene and carbon tetrachloride have the highest cancer risk approximations for the Vermont monitoring sites. None of the noncancer hazard approximations were greater than an HQ of 1.0.

- Benzene was the highest emitted pollutant with a cancer toxicity factor in Chittenden and Rutland Counties and also had the highest cancer toxicity-weighted emissions for both counties. 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 pollutants of interest, naphthalene had the highest annual average concentration.
- Naphthalene had the highest cancer risk approximation for RIVA and is the only one with a cancer risk approximation greater than 1 in-a-million. 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.
- Eighteen pollutants failed screens for SEWA, of which 12 are NATTS MQO Core Analytes.
- Of the pollutants of interest for SEWA, acetaldehyde and formaldehyde had the highest annual average concentrations, although they are the lowest annual averages among NMP sites sampling carbonyl compounds. SEWA had the highest annual average concentration of nickel among NMP sites sampling metals (PM_{10}).
- Carbonyl compound, VOC, metals (PM_{10}), and hexavalent chromium sampling has been conducted at BTUT for at least 5 consecutive years; thus, a trends analysis was conducted for select pollutants. Although most of the selected pollutants exhibit increases from 2010 to 2011, the increase for formaldehyde is the only one that is statistically significant.
- Formaldehyde had the highest cancer risk approximation for SEWA. 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 and 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.

- The Wisconsin monitoring site is located in Horicon (HOWI) and is a NATTS site.

- HOWI sampled for hexavalent chromium only.

- Hexavalent chromium was detected in greater than 65 percent of samples collected but did not fail any screens.

- The annual average concentration of hexavalent chromium was on the low side compared to other NMP sites sampling hexavalent chromium, ranking 15th of out 22 sites.

- The cancer risk approximation for hexavalent chromium is less than 1 in-a-million and the noncancer hazard approximation for hexavalent chromium is 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. Toluene was the highest emitted pollutant with a noncancer toxicity factor in Dodge County, while acrolein had the highest noncancer toxicity-weighted emissions.

30.1.3 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. All 31 sites that sampled carbonyl compounds had acetaldehyde and formaldehyde as pollutants of interest. Benzene, 1,3-butadiene, and carbon tetrachloride were the most common VOC pollutants of interest. Every site that sampled benzene (28) had it as a pollutant of interest. All but one site that sampled PAHs (22) had naphthalene as a pollutant of interest (based on the risk-based screening process).

- Concentrations from two sites, CAMS 85 and HOWI, did not fail any screens. However, only hexavalent chromium was sampled at these two sites. Hexavalent chromium failed 65 percent of screens for CAMS 85 in 2010 but did not fail any for 2011. This difference is a result of replacing the stainless steel filter holder in the sampler with a Teflon® filter holder. A similar exchange was made at the PXSS site, where the number of failed screens was halved from 2010 to 2011.

- 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 19 sites. Naphthalene had the next highest at 12.

- The toxicity factor for formaldehyde used in the preliminary risk-based screening process, the cancer risk approximation calculations, and the toxicity-weighting of emissions decreased substantially since the 2007 report. This translated to a much higher toxicity potential for formaldehyde, leading to more failed screens, higher cancer risk approximations, and relatively higher toxicity-weighted emissions values for the 2008-2009 through 2011 reports than in previous reports.

- Formaldehyde, naphthalene, and benzene tended to have the highest cancer risk approximations on a site-specific basis. The cancer risk approximation calculated for BTUT from the annual average concentration of formaldehyde (58.42 in-a-million) is the highest of all annual average-based cancer risk approximations. Four other sites exhibited cancer risk approximations greater than 50 in-a-million for formaldehyde (S4MO, OCOK, MWOK, and TMOK). One additional cancer risk approximation was greater than 50 in-a-million, which was calculated from SPIL's annual average concentration of acrylonitrile.

- Carbon tetrachloride often had relatively high cancer risk approximations based on annual average concentrations among the monitoring sites, ranging between 3 and 4 in-a-million across the sites sampling VOCs, 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 (CAMS 85).

- 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 0.60) 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.

- Benzene, formaldehyde, and ethylbenzene often had the highest county-level emissions for participating counties (of those with a cancer URE). Both benzene and formaldehyde typically had the highest toxicity-weighted emissions, along with 1,3-butadiene (of those with a cancer URE).

- Toluene, xylenes, and methanol were often the highest emitted pollutants (of those with a noncancer RfC), although they rarely had top 10 toxicity-weighted emissions. Acrolein tended to have the highest toxicity-weighted emissions of pollutants with noncancer RfCs, although acrolein emissions were relatively low when compared to other pollutants. 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.

30.1.4 Data Quality Results Summary

Completeness, precision, and accuracy were assessed for the 2011 monitoring effort. The quality assessments presented in this report show that the 2011 monitoring data are of a known and high quality, consistent with the intended data use.

To the largest extent, ambient air concentration data sets met MQO for completeness. Only seven out of 123 site- and method-specific data sets failed to comply with the MQO of 85 percent completeness while 58 data sets achieved 100 percent completeness.

Method precision and analytical precision were determined for the 2011 NMP monitoring efforts using CV calculations based on duplicate, collocated, and replicate samples. The precision for each analytical method utilized during the 2011 NMP was within the MQO of 85 percent. 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.

30.2 Conclusions

Conclusions resulting from the data analyses of the data generated from the 2011 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.

- Where annual averages could be calculated and for those pollutants with available cancer UREs, none of the cancer risk approximations were greater than 100 in-a-million; 33 were greater than 10 in-a-million (24 for formaldehyde, six for benzene, and three for acrylonitrile); and less than half were greater than 1.0 in-a-million.

- Where annual averages could be calculated and for those pollutants with 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 was 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 every NMP county, 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. Yet, many of the data analyses utilized in this report require data from year-round (or nearly year-round) sampling. Of the 51 sites whose data are included in the 2011 report, only two sites sampled for an abbreviated duration (due to site initialization and/or site closure/relocation). Of the 123 site-method combinations, only six 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 decreased significantly for 2011 compared to 2010 (and 2010 was improved from the 2008-2009 monitoring effort). Fewer data gaps allow for more complete results and inter-site comparisons.

- Of the 51 monitoring sites participating in the 2011 NMP, only two sampled for all six available pollutant groups under the national program (BTUT and NBIL). Another four sites sampled all five pollutant groups required for NATTS sites. 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 2011 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. There are two major differences between reports prior to 2010 and the 2011 report. First, all statistical calculations include zero substitution for non-detect results (rather than just those calculations related to risk). Second, the detect criteria applied to quarterly averages was removed and replaced with a completeness criteria, allowing for the calculation of quarterly average concentrations for those pollutants detected less frequently than others. The only significant differences between the 2010 and 2011 reports are in regards to the trend analysis. For the 2011 report, this analysis utilized yearly average concentrations rather than 3-year rolling average concentrations. In addition, the list of pollutants for which this analysis was performed was extended to include lead.

30.3 Recommendations

Based on the conclusions from the 2011 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 2011 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. As discussed above, there was marked improvement in this area for 2011.

- *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.* The improvements made to the analytical methods prior to the 1999-2000 UATMP allowed for the measurement of ambient air concentrations of 11 pollutants that were not measured during previous programs. This improvement provides sponsoring agencies and a variety of interested parties with important information about air quality within their area. 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).

- *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, chloroform concentrations have been highest at NBIL for multiple report 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 2011 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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