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2010 National Monitoring Programs Annual Report (UATMP, NATTS, CSATAM)
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2010 National Monitoring Programs Annual Report (UATMP, NATTS, and CSATAM)

DISCLAIMER

Through its Office of Air Quality Planning and Standards, the U.S. Environmental Protection Agency funded and managed the research described in this report under EPA Contract No. EP-D-09-048 to Eastern Research Group, Inc. This report has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products in this report does not constitute endorsement or recommendation for their use.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

List of Appendices

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

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LIST OF TABLES (Continued)

LIST OF ACRONYMS

AADT	Average annual daily traffic
AGL	Above ground level
AIRS	Aerometric Information and Retrieval System
AQS	Air Quality System (of the Aerometric Information and Retrieval 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
NATA	National Air Toxics Assessment

LIST OF ACRONYMS (Continued)

NATTS	National Air Toxics Trends Site
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 Hydrocarbons
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 2010 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 2010 NMP includes data from samples collected at 52 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); 30 sites sampled for 14 carbonyl compounds; nine sites sampled for 80 speciated nonmethane organic compounds (SNMOC); 26 sites sampled for 22 polycyclic aromatic hydrocarbons (PAH); 14 sites sampled for 11 metals; and 23 sites sampled for hexavalent chromium. Over 214,900 ambient air concentrations were measured during the 2010 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 2010 NMP serve a wide range of purposes. Not only do these data characterize the nature and extent of air pollution close to the 52 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 (NMOC). This report focuses on monitoring sites participating in the UATMP, NATTS, and CSATAM programs. These programs have the following program-specific objectives:

- The primary purpose of the UATMP is to characterize the composition and magnitude of air toxics pollution through ambient air monitoring.
- The primary purpose of the CSATAM program is to conduct local-scale investigative air toxics monitoring projects.
- The primary goal 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.

1.1   Background

EPA began the NMOC program in 1984. Monitoring for selected NMOC 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 NATTS Pilot program 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, 2010a).

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 NATTS, UATMP, 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. As such, 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 2010 NATTS, UATMP, and CSATAM monitoring efforts of the NMP. Data collected at 52 sites around the country are included in this

report. The operating agencies of these 52 sites have opted to have their samples analyzed by EPA's contract laboratory, Eastern Research Group, Inc. 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 52 sites included in this report are located in or near 34 urban or rural locations in 23 states and the District of Columbia, including 33 metropolitan or micropolitan statistical areas (MSA). Much of the data analysis and interpretation contained in this report focuses on pollutant-specific risk potential.

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 52 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.

This report offers participating agencies useful 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 might 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?

- 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 every participating NATTS, UATMP, 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 2010 NATTS, UATMP, 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 the Air Quality System (AQS) of EPA's Aerometric Information Retrieval System (AIRS) at http://www.epa.gov/ttn/airs/airsaqs/.

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 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 Summary of Results 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 2010 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 National Monitoring Programs (specifically, the NATTS, UATMP, and CSATAM).
2	The 2010 National Monitoring Programs Network	This section provides information on the 2010 National Monitoring Programs and network: • Monitoring locations • Pollutants selected for monitoring • Sampling and analytical methods • Sampling schedules • Completeness of the air monitoring programs.

Table 1-1. Organization of the 2010 National Monitoring Programs Report (Continued)

Report Section	Section Title	Overview of Contents
3	Summary of the 2010 National Monitoring Programs Data Treatments and Methods	This section presents and discusses the data treatments used on the 2010 National Monitoring Programs 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.
4	Summary of the 2010 National Monitoring Programs Results	This section presents and discusses the results of the data treatments from the 2010 National Monitoring Programs 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), Riverside-San Bernardino-Ontario, CA MSA (RUCA), and 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, RICO, and RUCO)
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 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 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	Site in Michigan	Monitoring results for the site in the Detroit-Warren-Livonia, MI MSA (DEMI)
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)

Table 1-1. Organization of the 2010 National Monitoring Programs Report (Continued)

Report Section	Section Title	Overview of Contents
18	Sites in New York	Monitoring results for the sites in the New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (BXNY and MONY), Rochester, NY MSA (ROCH), and Buffalo-Niagara Falls, NY MSA (TONY)
19	Sites in Oklahoma	Monitoring results for the sites in the Tulsa, OK MSA (TOOK and TMOK), Oklahoma City, OK MSA (MWOK and OCOK), and Pryor Creek, OK (PROK)
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 2010 National Monitoring Programs ambient air monitoring data.
30	Summary of Results 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 2010 National Monitoring Programs Network

Agencies operating NATTS, UATMP, or CSATAM sites may choose to have their samples analyzed by EPA's contract laboratory, Eastern Research Group, Inc. (ERG) in Morrisville, NC. Data from 52 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 (SNMOC) and/or Method TO-15), carbonyl compounds from sorbent cartridge samples (Method TO-11A), polycyclic aromatic hydrocarbons (PAH) from polyurethane foam (PUF) and XAD-2® resin samples (Method TO-13A), hexavalent chromium from sodium bicarbonate-coated filters (EPA-approved method), and trace metals from filters (Method IO-3.5). 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, collection schedules, sampling and analytical methods, and completeness of the 2010 NMP dataset.

2.1   Monitoring Locations

For the NATTS Program, 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 52 monitoring sites participating in the 2010 programs, which encompass 34 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, 2009). A CBSA refers to either a metropolitan or micropolitan statistical area (Census Bureau, 2012).

Table 2-1 lists the respective monitoring program and the years of program participation for the 52 monitoring sites. Forty-eight monitoring sites have been included in previous annual reports, while four new sites began sampling in 2010.

As Figure 2-1 and Table 2-1 show, the 2010 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 location types of the monitoring sites vary significantly, based on 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 2010 National Monitoring Programs Monitoring Sites
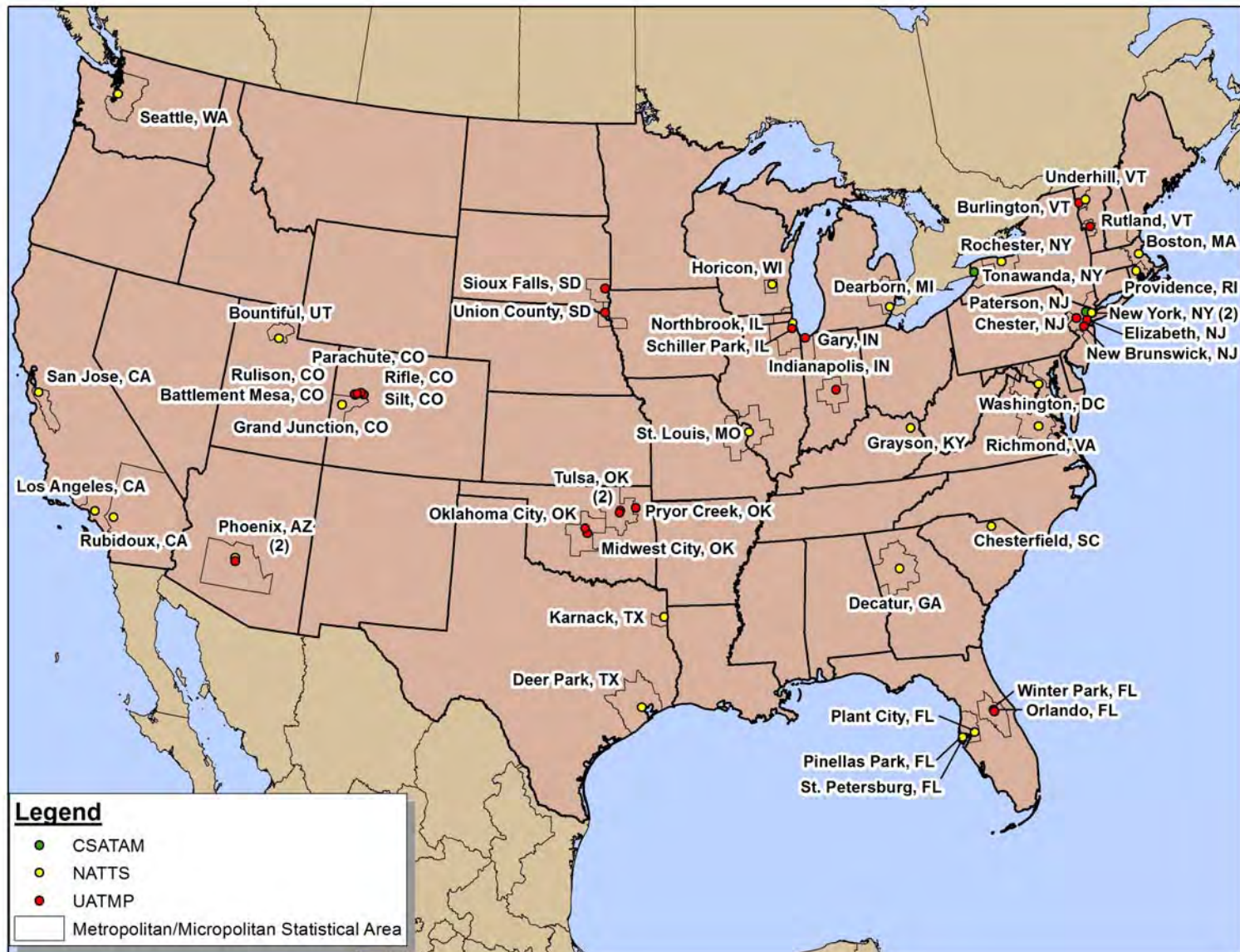
Table 2-1. 2010 National Monitoring Programs Sites and Past Program Participation

Monitoring Location and Site	Program	2000 and Earlier	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Battlement Mesa, CO (BMCO)	UATMP											✓
Boston, MA (*BOMA*)	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Bountiful, UT (*BTUT*)	NATTS				✓	✓	✓	✓	✓	✓	✓	✓
Burlington, VT (BURVT)	UATMP										✓	✓
Chester, NJ (CHNJ)	UATMP		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chesterfield, SC (*CHSC*)	NATTS						✓	✓	✓	✓	✓	✓
Dearborn, MI (*DEMI*)	NATTS		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Decatur, GA (*SDGA*)	NATTS						✓	✓	✓	✓	✓	✓
Deer Park, TX (*CAMS 35*)	NATTS								✓	✓	✓	✓
Elizabeth, NJ (ELNJ)	UATMP	1999-2000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
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								✓			✓
Los Angeles, CA (*CELA*)	NATTS								✓	✓	✓	✓
Midwest City, OK (MWOK)	UATMP										✓	✓

Yellow shading indicates a new site for year 2010; green shading indicates past participation with a gap in sampling under the NMP.
BOLD ITALICS = EPA-designated NATTS site.

Table 2-1. 2010 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2000 and Earlier	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
New Brunswick, NJ (NBNJ)	UATMP		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
New York, NY *(BXNY)*	NATTS							✓	✓	✓	✓	✓
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		✓	✓	✓	✓		✓	✓	✓	✓	✓
Phoenix, AZ (SPAZ)	UATMP		✓						✓	✓	✓	✓
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									✓	✓	✓
Rochester, NY *(ROCH)*	NATTS							✓	✓	✓	✓	✓
Rubidoux, CA *(RUCA)*	NATTS									✓	✓	✓	✓

Yellow shading indicates a new site for year 2010; green shading indicates past participation with a gap in sampling under the NMP.
BOLD ITALICS = EPA-designated NATTS site.

Table 2-1. 2010 National Monitoring Programs Sites and Past Program Participation (Continued)

Monitoring Location and Site	Program	2000 and Earlier	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Rulison, CO (RUCO)	UATMP										✓	✓
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	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tonawanda, NY (TONY)	CSATAM									✓	✓	✓
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			✓	✓	✓	✓	✓	✓	✓	✓

Yellow shading indicates a new site for year 2010; green shading indicates past participation with a gap in sampling under the NMP.
BOLD ITALICS = EPA-designated NATTS site.

Table 2-2. Site Characterizing Information for 2010 National Monitoring Programs Sites

Site Code	AQS Code	Location	Land Use	Location Setting	Estimated Daily Traffic, AADT[a] (Year)	Population Residing Within 10 Miles of the Monitoring Site[b]	County-level Vehicle Registration, # of Vehicles (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	41,500 (2010)	554,850	879,317 (2010)	1,381.26	3,808.72
BMCO	NA	Battlement Mesa, CO	Residential	Rural	2,527 (2002)	5,941	74,847 (2009)	1,364.26	353.08
BOMA	25-025-0042	Boston, MA	Commercial	Urban/City Center	31,400 (2007)	1,670,959	501,587 (2010)	572.38	1,156.01
BRCO	08-045-0009	Silt, CO	Agricultural	Rural	150 (2002)	24,174	74,847 (2009)	1,364.26	353.08
BTUT	49-011-0004	Bountiful, UT	Residential	Suburban	113,955 (2010)	259,066	239,754 (2010)	391.90	1,198.09
BURVT	50-007-0014	Burlington, VT	Commercial	Urban/City Center	4,000 (2010)	116,261	223,316 (2010)	347.53	623.35
BXNY	36-005-0110	New York, NY	Residential	Urban/City Center	100,230 (2008)	6,590,357	248,600 (2010)	2,171.17	1,217.06
CAMS 35	48-201-1039	Deer Park, TX	Residential	Suburban	31,043 (2004)	715,640	3,115,974 (2010)	9,322.29	11,313.66
CAMS 85	48-203-0002	Karnack, TX	Agricultural	Rural	1,400 (2010)	3,034	69,883 (2010)	593.11	413.72
CELA	06-037-1103	Los Angeles, CA	Residential	Urban/City Center	235,000 (2010)	3,679,965	7,410,625 (2010)	14,794.19	14,628.66
CHNJ	34-027-3001	Chester, NJ	Agricultural	Rural	12,917 (2010)	244,577	389,359 (2010)[d]	198.46	1,907.47

BOLD ITALICS = EPA-designated NATTS site.

[a] AADT is average annual daily traffic.

[b] Reference: Xionetic, 2011.

[c] Reference: EPA, 2012b.

[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; as such, this site has two AQS codes.

[f] The 10-mile population estimate for BXNY was used as a surrogate for MONY.

NA = Data not loaded into AQS per agency request.

Table 2-2. Site Characterizing Information for 2010 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	Estimated Daily Traffic, AADT[a] (Year)	Population Residing Within 10 Miles of the Monitoring Site[b]	County-level Vehicle Registration, # of Vehicles (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)
CHSC	45-025-0001	Chesterfield, SC	Forest	Rural	550 (2010)	5,605	40,431 (2009)	97.19	209.23
DEMI	26-163-0033	Dearborn, MI	Industrial	Suburban	106,900 (2010)	1,082,362	1,336,940 (2010)	7,384.27	7,014.06
ELNJ	34-039-0004	Elizabeth, NJ	Industrial	Suburban	250,000 (2006)	2,180,662	424,894 (2010)[d]	360.61	1,342.05
GLKY	21-043-0500	Grayson, KY	Residential	Rural	428 (2009)	16,880	36,031 (2010)	55.08	179.45
GPCO[e]	08-077-0017 08-077-0018	Grand Junction, CO	Commercial	Urban/City Center	12,000 (2010)	117,098	180,119 (2009)	532.80	573.11
HOWI	55-027-0001	Horicon, WI	Agricultural	Rural	5,000 (2008)	21,539	98,211 (2010)	531.88	467.91
INDEM	18-089-0022	Gary, IN	Industrial	Urban/City Center	52,440 (2009)	406,979	182,989 (2010)	1,486.55	1,857.03
MONY	36-005-0080	New York, NY	Residential	Urban/City Center	134,421 (2008)	6,590,357[f]	248,600 (2010)	2,171.17	1,217.06
MWOK	40-109-0041	Midwest City, OK	Commercial	Urban/City Center	41,200 (2010)	361,698	809,783 (2010)	1,242.77	3,717.21
NBIL	17-031-4201	Northbrook, IL	Residential	Suburban	34,100 (2009)	859,738	2,083,141 (2010)	15,376.26	11,796.13
NBNJ	34-023-0006	New Brunswick, NJ	Agricultural	Rural	114,322 (2010)	783,724	640,893 (2010)[d]	475.76	2,290.35

BOLD ITALICS = EPA-designated NATTS site.

[a] AADT is average annual daily traffic.

[b] Reference: Xionetic, 2011.

[c] Reference: EPA, 2012b.

[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; as such, this site has two AQS codes.

[f] The 10-mile population estimate for BXNY was used as a surrogate for MONY.

NA = Data not loaded into AQS per agency request.

Table 2-2. Site Characterizing Information for 2010 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	Estimated Daily Traffic, AADT[a] (Year)	Population Residing Within 10 Miles of the Monitoring Site[b]	County-level Vehicle Registration, # of Vehicles (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)
OCOK	40-109-1037	Oklahoma City, OK	Residential	Suburban	41,600 (2010)	380,090	809,783 (2010)	1,242.77	3,717.21
ORFL	12-095-2002	Winter Park, FL	Commercial	Urban/City Center	31,500 (2010)	1,003,746	1,037,369 (2010)	1,791.25	4,785.53
PACO	08-045-0005	Parachute, CO	Residential	Urban/City Center	2,600 (2010)	7,898	74,847 (2009)	1,364.26	353.08
PAFL	12-095-1004	Orlando, FL	Commercial	Suburban	43,500 (2010)	872,658	1,037,369 (2010)	1,791.25	4,785.53
PANJ	34-031-0005	Paterson, NJ	Commercial	Urban/City Center	22,272 (2010)	1,332,800	396,602 (2010)[d]	162.17	1,064.24
PROK	40-097-0187	Pryor Creek, OK	Industrial	Suburban	15,900 (2010)	26,739	40,832 (2010)	329.16	256.05
PRRI	44-007-0022	Providence, RI	Residential	Urban/City Center	136,800 (2009)	660,225	485,837 (2010)[d]	906.46	1,485.96
PXSS	04-013-9997	Phoenix, AZ	Residential	Urban/City Center	193,000 (2009)	1,473,228	3,739,918 (2010)	1,618.22	11,681.75
RICO	08-045-0007	Rifle, CO	Commercial	Urban/City Center	17,000 (2010)	17,641	74,847 (2009)	1,364.26	353.08
RIVA	51-087-0014	Richmond, VA	Residential	Suburban	74,000 (2009)	460,195	347,790 (2010)	740.28	1,020.76
ROCH	36-055-1007	Rochester, NY	Residential	Urban/City Center	116,725 (2008)	639,090	552,184 (2010)	1,809.55	2,250.12

BOLD ITALICS = EPA-designated NATTS site.

[a] AADT is average annual daily traffic.

[b] Reference: Xionetic, 2011.

[c] Reference: EPA, 2012b.

[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; as such, this site has two AQS codes.

[f] The 10-mile population estimate for BXNY was used as a surrogate for MONY.

NA = Data not loaded into AQS per agency request.

Table 2-2. Site Characterizing Information for 2010 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	Estimated Daily Traffic, AADT[a] (Year)	Population Residing Within 10 Miles of the Monitoring Site[b]	County-level Vehicle Registration, # of Vehicles (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)
RUCA	06-065-8001	Rubidoux, CA	Residential	Suburban	145,000 (2010)	990,029	1,707,950 (2010)	2,552.70	3,490.17
RUCO	NA	Rulison, CO	Agricultural	Rural	699 (2002)	17,641	74,847 (2009)	1,364.26	353.08
RUVT	50-021-0002	Rutland,VT	Commercial	Urban/City Center	7,200 (2010)	34,336	118,002 (2010)	135.82	308.74
S4MO	29-510-0085	St. Louis, MO	Residential	Urban/City Center	81,174 (2009)	811,927	1,121,528 (2010)	1,054.65	1,157.32
SDGA	13-089-0002	Decatur, GA	Residential	Suburban	145,890 (2010)	793,817	472,535 (2011)	779.22	3,044.68
SEWA	53-033-0080	Seattle, WA	Industrial	Suburban	234,000 (2010)	952,319	1,763,504 (2010)	3,191.49	9,694.40
SJJCA	06-085-0005	San Jose, CA	Commercial	Urban/City Center	103,000 (2010)	1,486,476	1,517,995 (2010)	3,325.51	2,772.68
SKFL	12-103-0026	Pinellas Park, FL	Residential	Suburban	49,500 (2010)	672,114	879,317 (2010)	1,381.26	3,808.72
SPAZ	04-013-4003	Phoenix, AZ	Residential	Urban/City Center	130,000 (2009)	898,861	3,739,918 (2010)	1,618.22	11,681.75
SPIL	17-031-3103	Schiller Park, IL	Mobile	Suburban	170,700 (2009)	2,046,549	2,083,141 (2010)	15,376.26	11,796.13
SSSD	46-099-0008	Sioux Falls, SD	Commercial	Urban/City Center	21,340 (2010)	190,685	208,911 (2010)	382.22	600.33

BOLD ITALICS = EPA-designated NATTS site.
[a]AADT is average annual daily traffic.
[b]Reference: Xionetic, 2011.
[c]Reference: EPA, 2012b.
[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; as such, this site has two AQS codes.
[f]The 10-mile population estimate for BXNY was used as a surrogate for MONY.
NA = Data not loaded into AQS per agency request.

Table 2-2. Site Characterizing Information for 2010 National Monitoring Programs Sites (Continued)

Site Code	AQS Code	Location	Land Use	Location Setting	Estimated Daily Traffic, AADT[a] (Year)	Population Residing Within 10 Miles of the Monitoring Site[b]	County-level Vehicle Registration, # of Vehicles (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)
SYFL	12-057-3002	Plant City, FL	Residential	Rural	10,700 (2010)	323,844	1,125,844 (2010)	2,633.02	4,579.82
TMOK	40-143-1127	Tulsa, OK	Residential	Urban/City Center	12,700 (2010)	320,319	604,284 (2010)	1,219.02	3,065.07
TONY	36-029-1013	Tonawanda, NY	Industrial	Urban/City Center	74,406 (2008)	598,180	669,746 (2010)	2,387.82	2,632.06
TOOK	40-143-0235	Tulsa, OK	Industrial	Urban/City Center	62,566 (2010)	456,229	604,284 (2010)	1,219.02	3,065.07
UCSD	46-127-0001	Union County, SD	Agricultural	Rural	156 (2007)	6,153	25,051 (2010)	62.28	122.79
UNVT	50-007-0007	Underhill, VT	Forest	Rural	1,200 (2005)	35,228	223,316 (2010)	347.53	623.35
WADC	11-001-0043	Washington, D.C.	Commercial	Urban/City Center	7,700 (2009)	1,911,152	219,173 (2009)	632.23	1,257.69
WPIN	18-097-0078	Indianapolis, IN	Residential	Suburban	143,410 (2009)	787,003	204,908 (2010)	2,965.43	3,380.45

BOLD ITALICS = EPA-designated NATTS site.
[a]AADT is average annual daily traffic.
[b]Reference: Xionetic, 2011.
[c]Reference: EPA, 2012b.
[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; as such, this site has two AQS codes.
[f]The 10-mile population estimate for BXNY was used as a surrogate for MONY.
NA = Data not loaded into AQS per agency request.

The proximity of the monitoring locations 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:

- Stationary and mobile source HAP emissions in the monitoring site's residing county, according to the 2008 National Emissions Inventory (NEI).

- The number of people living within 10 miles of each monitoring site.

- 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).

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 (VOC), metals, and particulate matter. 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 VOC.

- *EPA-approved SNMOC Method* was used to measure 80 ozone precursors. This method was often used 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 PAH.

- *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 five 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 chemical concentration in ambient air is below the method sensitivity (as gauged by the method detection limit), the analytical method might not differentiate the pollutant from other pollutants in the sample or from the random "noise" inherent in laboratory analyses. While quantification below the MDL is possible, the measurement reliability is lower. Therefore, when samples contain concentrations at levels 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, 2012c) 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

2-13

the 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 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 2010 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 of each MDL is presented for each pollutant in Tables 2-5 through 2-8. 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, 2006a).

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 concurrent 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 naturally 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 VOC and/or 80 SNMOC, 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 of the concentrations 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. These raw data 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 0.04 parts per billion by volume (ppbv). SNMOC detection limits are expressed in parts per billion Carbon (ppbC). All of the SNMOC MDLs are less than 0.40 ppbC.

Table 2-3. 2010 VOC Method Detection Limits

Pollutant	2010 MDL (ppbv)	Pollutant	2010 MDL (ppbv)	Pollutant	2010 MDL (ppbv)
Acetonitrile	0.016	1,2-Dibromoethane	0.012	Methyl Isobutyl Ketone	0.010
Acetylene	0.025	*m*-Dichlorobenzene	0.010	Methyl Methacrylate	0.021
Acrolein	0.036	*o*-Dichlorobenzene	0.012	Methyl *tert*-Butyl Ether	0.009
Acrylonitrile	0.027	*p*-Dichlorobenzene	0.010	*n*-Octane	0.011
tert-Amyl Methyl Ether	0.013	Dichlorodifluoromethane	0.012	Propylene	0.028
Benzene	0.019	1,1-Dichloroethane	0.017	Styrene	0.010
Bromochloromethane	0.018	1,2-Dichloroethane	0.015	1,1,2,2-Tetrachloroethane	0.011
Bromodichloromethane	0.021	1,1-Dichloroethene	0.013	Tetrachloroethylene	0.011
Bromoform	0.011	*cis*-1,2-Dichloroethylene	0.036	Toluene	0.013
Bromomethane	0.013	*trans*-1,2-Dichloroethylene	0.014	1,2,4-Trichlorobenzene	0.018
1,3-Butadiene	0.010	Dichloromethane	0.023	1,1,1-Trichloroethane	0.020
Carbon Disulfide	0.011	1,2-Dichloropropane	0.025	1,1,2-Trichloroethane	0.018
Carbon Tetrachloride	0.024	*cis*-1,3-Dichloropropene	0.015	Trichloroethylene	0.017
Chlorobenzene	0.014	*trans*-1,3-Dichloropropene	0.016	Trichlorofluoromethane	0.012
Chloroethane	0.012	Dichlorotetrafluoroethane	0.012	Trichlorotrifluoroethane	0.014
Chloroform	0.017	Ethyl Acrylate	0.011	1,2,4-Trimethylbenzene	0.011
Chloromethane	0.016	Ethyl *tert*-Butyl Ether	0.009	1,3,5-Trimethylbenzene	0.010
Chloromethylbenzene	0.017	Ethylbenzene	0.012	Vinyl Chloride	0.013
Chloroprene	0.014	Hexachloro-1,3-butadiene	0.012	*m,p*-Xylene[1]	0.014
Dibromochloromethane	0.011	Methyl Ethyl Ketone	0.026	*o*-Xylene	0.010

[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. 2010 SNMOC Method Detection Limits[1]

Pollutant	2010 MDL (ppbC)	Pollutant	2010 MDL (ppbC)	Pollutant	2010 MDL (ppbC)
Acetylene	0.195	*n*-Heptane	0.178	*n*-Octane	0.166
Benzene	0.178	1-Heptene	0.370	1-Octene	0.280
1,3-Butadiene	0.180	*n*-Hexane	0.236	*n*-Pentane	0.094
n-Butane	0.169	1-Hexene	0.357	1-Pentene	0.121
cis-2-Butene	0.177	*cis*-2-Hexene	0.360	*cis*-2-Pentene	0.189
trans-2-Butene	0.141	*trans*-2-Hexene	0.360	*trans*-2-Pentene	0.140
Cyclohexane	0.189	Isobutane	0.128	*a*-Pinene	0.240
Cyclopentane	0.124	Isobutene/1-Butene[2]	0.153	*b*-Pinene	0.240
Cyclopentene	0.240	Isopentane	0.185	Propane	0.202
n-Decane	0.230	Isoprene	0.237	*n*-Propylbenzene	0.205
1-Decene	0.240	Isopropylbenzene	0.205	Propylene	0.160
m-Diethylbenzene	0.241	2-Methyl-1-Butene	0.240	Propyne	0.200
p-Diethylbenzene	0.141	3-Methyl-1-Butene	0.240	Styrene	0.275
2,2-Dimethylbutane	0.195	2-Methyl-1-Pentene	0.360	Toluene	0.237
2,3-Dimethylbutane	0.201	4-Methyl-1-Pentene	0.360	*n*-Tridecane	0.290
2,3-Dimethylpentane	0.374	2-Methyl-2-Butene	0.240	1-Tridecene	0.290
2,4-Dimethylpentane	0.234	Methylcyclohexane	0.193	1,2,3-Trimethylbenzene	0.169
n-Dodecane	0.286	Methylcyclopentane	0.140	1,2,4-Trimethylbenzene	0.242
1-Dodecene	0.290	2-Methylheptane	0.169	1,3,5-Trimethylbenzene	0.170
Ethane	0.121	3-Methylheptane	0.115	2,2,3-Trimethylpentane	0.280
2-Ethyl-1-butene	0.360	2-Methylhexane	0.112	2,2,4-Trimethylpentane	0.171
Ethylbenzene	0.181	3-Methylhexane	0.151	2,3,4-Trimethylpentane	0.140
Ethylene	0.377	2-Methylpentane	0.135	*n*-Undecane	0.216
m-Ethyltoluene	0.146	3-Methylpentane	0.196	1-Undecene	0.220
o-Ethyltoluene	0.178	*n*-Nonane	0.185	*m*-Xylene/*p*-Xylene[2]	0.280
p-Ethyltoluene	0.236	1-Nonene	0.240	*o*-Xylene	0.188

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

[2] Because isobutene and 1-butene elute from the GC column at the same time, the SNMOC analytical method reports the sum of concentrations 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.

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 of the concentrations for these isomers, and not the separate concentrations for each isomer. These raw data 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 reported by the ERG laboratory for every pollutant is less than 0.008 ppbv.

Table 2-5. 2010 Carbonyl Compound Method Detection Limits

Pollutant	Minimum MDL (ppbv)	Maximum MDL (ppbv)	Average MDL (ppbv)
Acetaldehyde	0.0020	0.0230	0.0060
Acetone	0.0030	0.0300	0.0078
Benzaldehyde	0.0007	0.0070	0.0019
Butyraldehyde	0.0009	0.0090	0.0023
Crotonaldehyde	0.0010	0.0100	0.0026
2,5-Dimethylbenzaldehyde	0.0004	0.0050	0.0012
Formaldehyde	0.0020	0.0400	0.0044
Hexaldehyde	0.0006	0.0060	0.0013
Isovaleraldehyde	0.0007	0.0090	0.0025
Propionaldehyde	0.0010	0.0130	0.0026
Tolualdehydes[1]	0.0010	0.0170	0.0031
Valeraldehyde	0.0009	0.0110	0.0027

[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 D6209-98 (ASTM, 2004). 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 quartz 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 PAH. PAH raw data are presented in Appendix F.

Table 2-6 lists the MDLs for the 22 PAH target pollutants. Although the sensitivity varies from pollutant-to-pollutant and from site-to-site due to the different volumes pulled through the samples, the average MDLs for PAH ranged from 0.029 (coronene) to 1.44 (naphthalene) nanograms per cubic meter (ng/m^3).

Table 2-6. 2010 PAH Method Detection Limits

Pollutant	Minimum MDL (ng/m^3)	Maximum MDL (ng/m^3)	Average MDL (ng/m^3)
Acenaphthene	0.036	0.367	0.072
Acenaphthylene	0.024	0.243	0.048
Anthracene	0.027	0.269	0.053
Benzo(a)anthracene	0.027	0.270	0.054
Benzo(a)pyrene	0.025	0.250	0.050
Benzo(b)fluoranthene	0.036	0.362	0.071
Benzo(e)pyrene	0.028	0.279	0.055
Benzo(g,h,i)perylene	0.018	0.180	0.035
Benzo(k)fluoranthene	0.024	0.245	0.049
Chrysene	0.021	0.213	0.042
Coronene	0.015	0.147	0.029
Cyclopenta[cd]pyrene	0.029	0.294	0.058
Dibenz(a,h)anthracene	0.021	0.210	0.042
Fluoranthene	0.022	0.222	0.044
Fluorene	0.026	0.268	0.053
9-Fluorenone	0.030	0.306	0.060
Indeno(1,2,3-cd)pyrene	0.017	0.170	0.034
Naphthalene	0.215	7.400	1.437
Perylene	0.021	0.209	0.041
Phenanthrene	0.052	0.694	0.135
Pyrene	0.021	0.217	0.043
Retene	0.050	0.661	0.129

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 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. These raw data 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 MDLs ranged from 0.001 ng/m^3 (beryllium) to 2.92 ng/m^3 (chromium) for the quartz filters and from 0.007 ng/m^3 (nickel) to 4.64 ng/m^3 (chromium) for the Teflon$^®$ filters.

Table 2-7. 2010 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	0.003	0.041	0.031	Antimony	0.006	0.010	0.009
Arsenic	0.007	1.330	0.052	Arsenic	0.003	0.070	0.062
Beryllium	0.001	0.008	0.001	Beryllium	0.006	0.030	0.028
Cadmium	0.047	0.085	0.068	Cadmium	0.009	0.050	0.011
Chromium	1.710	28.700	2.916	Chromium	0.320	5.510	4.644
Cobalt	0.011	0.185	0.019	Cobalt	0.003	0.010	0.010
Lead	0.497	82.800	1.019	Lead	0.009	0.020	0.011
Manganese	0.205	3.450	0.351	Manganese	0.030	0.050	0.044
Mercury	0.002	1.100	0.013	Mercury	0.040	0.230	0.053
Nickel	1.020	42.000	1.736	Nickel	0.004	0.200	0.007
Selenium	0.010	2.180	0.085	Selenium	0.080	0.140	0.120

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, 2006a). 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 MDL for the program, which is presented in Table 2-8, was 0.0028 ng/m^3. Raw data are presented in Appendix H.

Table 2-8. 2010 Hexavalent Chromium Method Detection Limits

Pollutant	Minimum MDL (ng/m^3)	Maximum MDL (ng/m^3)	Average MDL (ng/m^3)
Hexavalent Chromium	0.0008	0.0665	0.0028

2.3   Sample Collection Schedules

Table 2-9 presents the first and last date on which sample collection occurred for each monitoring site sampling in 2010. The first sample date for each site is generally in January 2010 and continued through December 2010, although there were a few exceptions. The following sites began sampling after January 2010 or ended sampling before December 2010:

- The Karnack, TX site (CAMS 85) started sampling hexavalent chromium in February.

- The Paterson, NJ site (PANJ) began sampling VOC in April.

- The Tonawanda, NY site (TONY) stopped sampling in July.

In some instances, an existing site began sampling additional methods under the NMP in 2010:

- In February, the Deer Park, TX site (CAMS 35) began sampling hexavalent chromium under the NMP, in addition to PAH.

- In June, the Grayson, KY site (GLKY) began sampling VOC under the NMP, in addition to hexavalent chromium and PAH.

In other instances, an existing site stopped sampling certain methods under the NMP in 2010:

- The Horicon, WI site (HOWI) stopped sampling PAH under the NMP because the Wisconsin Department of National Resources laboratory began performing the analysis.

- The Underhill, VT site (UNVT) stopped sampling carbonyl compounds under the NMP because the Vermont Department of Environmental Conservation laboratory began performing this analysis.

Additionally, the instruments at several monitoring sites moved to alternative locations mid-year:

- The Mayville, WI NATTS site (MVWI) stopped sampling in December 2009 and the instrumentation was moved to the Horicon, WI site (HOWI). Sampling began at HOWI in late December 2009. Because only two samples were collected at HOWI in 2009, that site was not included in the 2008-2009 NMP annual report; thus, the two 2009 samples have been included with HOWI's 2010 samples.

- The New York, NY site (BXNY) stopped sampling in June 2010 and the instrumentation was moved another New York site (MONY). Sampling at MONY began in July 2010.

- The Rulison, CO site (RUCO) stopped sampling in mid-September 2010 and the instrumentation was moved to the Battlement Mesa, CO site (BMCO). Sampling at BMCO began later in September 2010.

Table 2-9. 2010 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	1/2/10	12/28/10	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BMCO	9/17/10	12/29/10	7	9[2]	78	--		--	--	--	--	--	--	--	18	18	100	--	--	--
BOMA	1/2/10	12/28/10	--	--	--	--	--	--	61	61	100	61	61	100	--	--	--	60	61	98
BRCO	1/2/10	12/29/10	17	24[2]	71	--	--	--	--	--	--	--	--	--	61	61	100	--	--	--
BTUT	1/2/10	12/28/10	53	61	87	57	61	93	59	61	97	59	61	97	57	61	93	57	61	93
BURVT[2]	1/2/10	12/28/10	--	--	--	31	31	100	--	--	--	--	--	--	--	--	--	--	--	--
BXNY	1/2/10	6/13/10	--	--	--	--	--	--	28	28	100	--	--	--	--	--	--	28	28	100
CAMS 35	1/2/10	12/28/10	--	--	--	--	--	--	52	55	95	--	--	--	--	--	--	57	61	93
CAMS 85	2/7/10	12/28/10	--	--	--	--	--	--	51	55	93	--	--	--	--	--	--	--	--	--
CELA	1/2/10	12/28/10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	59	61	97
CHNJ	1/2/10	12/28/10	59	61	97	57	61	93	--	--	--	--	--	--	--	--	--	--	--	--
CHSC	1/2/10	12/28/10	--	--	--	--	--	--	62	61	>100	--	--	--	--	--	--	58	61	95
DEMI	1/2/10	12/28/10	60	61	98	61	61	100	59	61	97	--	--	--	--	--	--	59	61	97
ELNJ	1/2/10	12/28/10	59	61	97	59	61	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 not a 1-in-6 schedule.
[3] Includes two samples from December 2009.
BOLD ITALICS = EPA-designated NATTS site.
Shading indicates that completeness is below the DQO of 85%.

Table 2-9. 2010 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
GLKY	1/2/10	12/28/10	--	--	--	35	35	100	61	61	100	--	--	--	--	--	--	60	61	98
GPCO	1/2/10	12/28/10	61	61	100	59	61	97	58	61	95	--	-	--	--	--	--	57	61	93
HOWI[3]	12/21/09	12/28/10	--	--	--	--	--	--	63	63	100	--	--	--	--	--	--	31	32	97
INDEM	1/2/10	12/28/10	61	61	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MONY	7/13/10	12/28/10	--	--	--	--	--	--	27	29	93	--	--	--	--	--	--	29	29	100
MWOK	1/2/10	12/28/10	60	61	98	61	61	100	--	--	--	61	61	100	--	--	--	--	--	--
NBIL	1/2/10	12/28/10	55	61	90	55	61	90	61	61	100	61	61	100	55	61	90	59	61	97
NBNJ	1/2/10	12/28/10	58	61	95	55	61	90	--	--	--	--	--	--	--	--	--	--	--	--
OCOK	1/2/10	12/28/10	60	61	98	61	61	100	--	--	--	61	61	100	--	--	--	--	--	--
ORFL	1/2/10	12/28/10	60	61	98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PACO	1/2/10	12/29/10	28	30[2]	93	--	--	--	--	--	--	--	--	--	58	61	95	--	--	--
PAFL[2]	1/8/10	12/22/10	--	--	--	--	--	--	--	--	--	30	30	100	--	--	--	--	--	--
PANJ[2]	4/26/10	12/22/10	--	--	--	21	21	100	--	--	--	--	--	--	--	--	--	--	--	--
PROK	1/2/10	12/28/10	60	61	98	61	61	100	--	--	--	61	61	100	--	--	--	--	--	--
PRRI	1/2/10	12/28/10	--	--	--	--	--	--	60	61	98	--	--	--	--	--	--	58	61	95

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 and not a 1-in-6 schedule.

[3] Includes two samples from December 2009.

BOLD ITALICS = EPA-designated NATTS site.

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

Table 2-9. 2010 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
PXSS	1/2/10	12/28/10	20	61	33	61	61	100	57	61	93	59	61	97	--	--	--	59	61	97
RICO	1/2/10	12/29/10	24	30[2]	80	--	--	--	--	--	--	--	--	--	60	61	98	--	--	--
RIVA	1/2/10	12/28/10	--	--	--	--	--	--	61	61	100	--	--	--	--	--	--	60	61	98
ROCH	1/2/10	12/28/10	--	--	--	--	--	--	59	61	97	--	--	--	--	--	--	3	61	5
RUCA	1/2/10	12/28/10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	61	98
RUCO	1/2/10	9/11/10	18	21[2]	86	--	--	--	--	--	--	--	--	--	40	43	93	--	--	--
RUVT[2]	1/2/10	12/28/10	--	--	--	28	31	90	--	--	--	--	--	--	--	--	--	--	--	--
S4MO	1/2/10	12/28/10	54	61	89	53	61	87	57	61	93	60	61	98	--	--	--	58	61	95
SDGA	1/2/10	12/28/10	--	--	--	--	--	--	60	61	98	--	--	--	--	--	--	59	61	97
SEWA	1/2/10	12/28/10	59	61	97	59	61	97	59	61	97	58	61	95	--	--	--	58	61	95
SJJCA	1/2/10	12/28/10	--	--	--	--	--	--	--	--	--	58	58	100	--	--	--	59	61	97
SKFL	1/2/10	12/28/10	61	61	100	--	--	--	61	61	100	--	--	--	--	--	--	59	61	97
SPAZ[2]	1/11/10	12/22/10	--	--	--	29	30	97	--	--	--	--	--	--	--	--	--	--	--	--
SPIL	1/2/10	12/28/10	58	61	95	60	61	98	--	--	--	--	--	--	--	--	--	--	--	--
SSSD	1/2/10	12/28/10	61	61	100	60	61	98	--	--	--	--	--	--	60	61	98	--	--	--

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 and not a 1-in-6 schedule.

[3] Includes two samples from December 2009.

BOLD ITALICS = EPA-designated NATTS site.

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

Table 2-9. 2010 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
SYFL	1/2/10	12/28/10	61	61	100	--	--	--	57	61	93	--	--	--	--	--	--	60	61	98
TMOK	1/2/10	12/28/10	60	61	98	61	61	100				60	61	98						
TONY	1/2/10	7/1/10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	29	30	94
TOOK	1/2/10	12/28/10	60	61	98	61	61	100	--	--	--	61	61	100	--	--	--	--	--	--
UCSD	1/2/10	12/29/10	58	61	95	59	61	97	--	--	--	--	--	--	59	61	97	--	--	--
UNVT	1/2/10	12/28/10	30	30	100	60	61	98	58	61	95	61	61	100	--	--	--	60	61	98
WADC	1/2/10	12/28/10	--	--	--	--	--	--	60	61	98	--	--	--	--	--	--	58	61	95
WPIN	1/2/10	12/28/10	56	61	92	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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 and not a 1-in-6 schedule.
[3] Includes two samples from December 2009.
BOLD ITALICS = EPA-designated NATTS site.
Shading indicates that completeness is below the DQO of 85%.

According to the NMP schedule, 24-hour integrated samples were to be collected at each monitoring site every 1-in-6 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, and RUCO) 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 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 shows the following:

- 24 sites collected VOC samples and 30 sites collected carbonyl compound samples; VOC and carbonyl compound samples were collected concurrently at 19 sites.

- 9 sites collected SNMOC samples.

- 26 sites collected PAH samples.

- 14 sites collected metals samples.

- 23 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 PAH. 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 and a measure of the efficiency with which the program is managed. The completeness for each monitoring site is presented in Table 2-9. Table 2-10 presents method-specific completeness. Appendix I identifies samples that were invalidated and lists the reason for invalidation, based on the applied AQS null code.

Table 2-10. Method Completeness Rates for 2010

Method	# of Valid Samples	# of Samples Scheduled	Method Completeness (%)	Minimum Site-Specific Completeness (%)	Maximum Site-Specific Completeness (%)
VOC	1,264	1,307	96.71	86.89 (*S4MO*)	100.00 (10 Sites)
SNMOC	468	488	95.90	90.16 (*NBIL*)	100.00 (2 Sites)
Carbonyl Compounds	1,499	1,608	93.22	32.79 (*PXSS*)	100.00 (7 Sites)
PAH	1,354	1,462	92.61	4.92 (*ROCH*)	100.00 (2 Sites)
Metals Analysis	811	820	98.90	95.08 (*SEWA*)	100.00 (9 Sites)
Hexavalent Chromium	1,291	1,328	97.21	92.73 (*CAMS 85*)	>100 (*CHSC*)

The following observations summarize the completeness of the monitoring datasets for samples collected during the 2010 NMP sampling year, as shown in Tables 2-9 and 2-10.

- For VOC sampling, the site-specific completeness for 2010 ranged from 87 to 100 percent, with an overall completeness of 97 percent.

- For SNMOC sampling, the site-specific completeness for 2010 ranged from 90 to 100 percent, with an overall completeness of 96 percent.

- For carbonyl compound sampling, the site-specific completeness for 2010 ranged from 33 to 100 percent, with an overall completeness of 93 percent.

- For PAH sampling, the site-specific completeness for 2010 ranged from 5 to 100 percent, with an overall completeness of 93 percent.

- For metals sampling, the site-specific completeness for 2010 ranged from 95 to 100 percent, with an overall completeness of 99 percent.

- For hexavalent chromium sampling, the site-specific completeness for 2010 ranged from 93 to greater than 100 percent, with an overall completeness of 97 percent.

The data quality objective (DQO) 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, 2009). The data in Table 2-9 shows that five datasets from a total of 126 datasets from the 2010 NMP monitoring sites did not meet this data quality objective (cells shaded in Table 2-9).

- Three of the five site-method combinations for which completeness was less than 85 percent were for Garfield County carbonyl compound sites (BRCO, BMCO, and RICO). The instrumentation at RUCO was moved to the new BMCO location in September; as such, BMCO did not have time to make up invalid carbonyl compound samples. In addition, these sites tended to experience issues with their carbonyl compound samplers.

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

- Problems with the PAH sampler at ROCH led to the invalidation of nearly all of ROCH's PAH data for 2010. The sampler was re-certified at the end of 2010 and the final three samples from 2010 were kept.

3.0   Summary of the 2010 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 2010 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 214,954 valid air toxics concentrations (including non-detects, duplicate analyses, replicate analyses, and analyses for collocated samples) were produced from 8,529 valid samples collected at 52 sites during the 2010 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
VOC	24	C	J
SNMOC	9	D	K
Carbonyl Compounds	30	E	L
PAH	26	F	M
Metals	14	G	N
Hexavalent Chromium	23	H	O

3.1   Approach to Data Treatment

This section examines the various statistical tools employed to characterize the data collected during the 2010 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 data for data analysis.

Pairs of duplicate (or collocated) and replicate measurements were averaged together in order to calculate a single concentration for each pollutant for each method for each sample day at each monitoring site. 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 VOC and SNMOC, 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).

The treatment of non-detects in the 2010 NMP report differs from previous reports. For the 2010 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 to only risk-related analyses; however, in the 2010 NMP report, the substitution of zeros was applied to all analyses. This approach is consistent with how data are loaded into AQS per the NATTS TAD (EPA, 2009b) as well as other EPA air toxics monitoring programs such as the School Air Toxics Monitoring Program (SATMP) (EPA, 2011a). The substitution of zeros for non-detects would result 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 very 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 duration-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. The first quarter in a calendar year includes 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, 6 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 (2010). 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 µg/m^3, thus the interval over which the true average would be expected to fall would be between 1.00 to 1.50 µg/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 2010 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, 2010b). 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 and ecological effects" (EPA, 2011c).

Health risks are typically divided into cancer risk and noncancer health risks when referring to human health risk. Cancer risk is defined as the likelihood of developing cancer as a result of exposure 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 value below which no adverse health effects are expected (EPA, 2011b).

In order to assess health risk, EPA and other agencies develop screening values, 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 screening approach that utilizes a risk-based methodology for performing an initial screen of ambient air toxics monitoring datasets (EPA, 2010b). This *preliminary risk screening process* provides a risk-based

methodology for analysts and interested parties to identify which pollutants may pose a risk in their area. Not all pollutants analyzed under the NMP have screening values; of the 172 pollutants sampled under the NMP, 72 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 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 per day per site.

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

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

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

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

In regards to Step 5 above, the actual cumulative contribution may exceed 95 percent in order to include all pollutants contributing to the minimum 95 percent criteria (refer to acenaphthene in Table 4-7 for an example). In addition, if the 95 percent cumulative criterion is reached, but the next pollutant contributed equally to the number of failed screens, that pollutant was also designated as a pollutant of interest. Results for the program-wide risk 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 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 been updated (EPA, 2012d).

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.

For the 2010 NMP report, another step for identifying the pollutants of interest was added. In addition to the preliminary risk-screening approach described above, the pollutants of interest designation was further refined based on the NATTS TAD (EPA, 2009b). This document identifies 19 pollutants ("Method Quality Objective (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	VOC/TO-15
Benzene	
1,3-Butadiene	
Carbon Tetrachloride	
Chloroform	
Tetrachloroethylene	
Trichloroethylene	
Vinyl Chloride	
Acetaldehyde	Carbonyl Compounds/ TO-11A
Formaldehyde	
Naphthalene	PAH/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 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 screening process due to questions about the consistency and reliability of the measurements (EPA, 2010c). 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 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 screening process or any other data analysis contained in this report.

3.3 Noncancer Risk Screening Evaluation Using Minimum Risk Levels

In addition to the preliminary risk screening described above, a second risk screening was conducted using the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Level (MRL) health benchmarks (ATSDR, 2010). 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" (ATSDR, 2012). MRLs are intended to be used as screening tools, similar to the risk screening approach discussed above, and "exposure to a level above the MRL does not mean that adverse health effects will occur" (ATSDR, 2012). 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, 2012). 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 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 were 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 were greater than their respective MRLs is expanded upon in the individual state sections.

3.4 Additional Program-Level Analyses of the 2010 National Monitoring Programs Dataset

This section summarizes additional analyses performed on the 2010 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, 2012e). 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, 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 for each of the program-level pollutants of interest across the program sites. The coefficient of variation provides a relative measure of variability by expressing 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 coefficients of variation are shown in the form of scatter plots, where data points represent the coefficients of variation 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. The annual average concentration for each program-wide pollutant of interest for each site is plotted in the form of a bar graph. 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 VOC, SNMOC, 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.

Quarterly variability is the third type of variability assessed in this report. The concentration data for each site were divided into four quarters for each 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, 2012f).

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, 2012a). A few of VOC 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 (EPA, 2012g and NOAA, 2012b). 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 NMP for 2010, 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 2010 NMP report, point sources plotted near the monitoring sites were obtained from Version 2 of the 2008 NEI (EPA, 2012b). 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. As such, the total number of emission sources surrounding the monitoring sites is generally lower in the 2008 NEI vs. the 2005 NEI. Thus, when comparing facility maps and emission estimates presented in the 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 general climatology is provided, based on the area in which 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, one average for all days in 2010 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, 2009 and 2010). Although some monitoring sites have meteorological instruments on-site and report this 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 it to AQS; thus it is 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.

In addition to the climate summary and the statistical calculations performed on meteorological observations collected near each monitoring site, the following sections describe the 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

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. 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 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. 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 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 needed to run the cluster analysis. The cluster analysis is useful for scientifically and quantitatively determining where the 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 years prior to sampling; second, a wind rose presenting the wind data for the entire calendar year; and lastly, a wind rose presenting the 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.

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 maps show where a parcel of air 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 boxplots, to visually show this comparison. These boxplots were created in Microsoft Excel, using the Peltier Box and Whisker Plot Utility (Peltier, 2012). This analysis was conducted for the selected NATTS MQO Core Analytes shown in Table 3-3. Note that for sites that sampled SNMOC, benzene and 1,3-butadiene are showed only in comparison to those sites sampling SNMOC as opposed to sites sampling these pollutants with Method TO-15, to match Tables 4-1 through 4-6 in Section 4.1.

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

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

The boxplots 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 indicates 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 can be seen in Figure 5-10. Note that the program-level average concentrations shown for VOC,

SNMOC, and carbonyl compounds in Tables 4-1 through 4-3 are presented in method-specific units, but have been converted to a common unit of measurement ($\mu g/m^3$) for the purposes of this analysis. These graphs are presented in Section 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 within a given state.

3.5.4   Site Trends Analysis

Table 2-1 presents current monitoring sites that have participated in the NMP in previous years. Site-specific trends analyses were conducted for sites with at least 5 consecutive years of method-specific data analyzed under the NMP. The approach to this trends analysis is described below and the results are presented in the individual state sections (Sections 5 through 28).

In 2009, EPA expanded the list of Core Analytes for the NATTS program to 19 pollutants, as discussed in Section 3.2. For this report, a trends analysis was conducted for the selected NATTS MQO Core Analytes shown in Table 3-4. This table is very similar to Table 3-3; however, PAHs were not included in this analysis because they have not been analyzed for under the NMP for 5 consecutive years. Twenty-five of the 52 sites met the criteria for 3-year rolling statistical metrics to be calculated.

Table 3-4. NATTS MQO Core Analytes Selected for Trends Analysis

Pollutant	Class/Method
Benzene	VOC/TO-15
1,3-Butadiene	
Acetaldehyde	Carbonyl Compounds/ TO-11A
Formaldehyde	
Arsenic	Metals/IO-3.5
Manganese	
Hexavalent Chromium	Metals/EPA

The trends figures and analyses are presented as 3-year rolling statistical metrics. The following criteria were used to calculate valid rolling statistical metrics:

- Analysis performed under the NMP.

- A minimum of at least 5 years of consecutive data.

The five individual 3-year rolling statistical metrics are presented as box and whisker plots, or simply boxplots, an example of which can be seen in Figure 5-17. The statistical metrics shown include the minimum and maximum concentration measured during each 3-year period (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 3-year rolling average concentration (as denoted by the white diamond). Each of the five rolling metrics represents all measurements from that 3-year period. The use of rolling averages allows for a smoothing of raw data in order to identify long-term trends (NIST, 2012).

Data used in this analysis were downloaded from EPA's AQS database (EPA, 2012h). 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. Samples with precision data (duplicates, collocates, and/or replicates) were averaged together to allow for the determination of a single concentration per pollutant per site per date, reflecting the data treatment described in Section 3.1.

3.5.5 Risk Screening and Pollutants of Interest

The risk 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 these 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 and noncancer surrogate risk approximations.
- 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 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 had preprocessed daily measurements greater than their respective ATSDR acute MRL health benchmark. 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 and Noncancer Surrogate Risk Approximations

Risk was further examined by calculating cancer and noncancer surrogate risk 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). Noncancer risk is presented as the Noncancer Hazard Quotient (HQ). 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 risk factors applied to calculate cancer and noncancer surrogate risk approximations are typically UREs or RfCs (respectively), which are developed by EPA. However, UREs and RfCs are not available for all pollutants. In the absence of EPA values, risk factors developed by agencies with credible methods and that are similar in scope and definition were used (EPA, 2012d). Cancer URE and noncancer RfC risk factors can be applied to the annual averages to approximate surrogate chronic risk estimates based on ambient monitoring data. While these risk 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 surrogate chronic risk 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 risk 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 relevant 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 surrogate chronic cancer and noncancer risk approximations 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.

   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 PAH 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 PAH are grouped into POM Groups in order to assess risk attributable to these pollutants (EPA, 2011d). Thus, emissions data and toxicity-weighted emissions for PAH are presented by POM Groups for this analysis. Table 3-5 presents the 22 PAH measured by Method TO-13A and their associated POM Groups. The POM groups are sub-grouped in Table 3-5 because toxicity research has lead to the refining of UREs for certain PAH (EPA, 2012d). 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 additional pollutants analyzed by Method TO-13A and listed in Table 3-5 do not have assigned POM Groups.

Table 3-5. 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	

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

Table 3-5. POM Groups for PAHs (Continued)

Pollutant	POM Group	POM Subgroup
Perylene	Group 2	Group 2b
Phenanthrene	Group 2	Group 2d
Pyrene	Group 2	Group 2d
Retene	NA	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 2010 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 each analytical method: 1) detection rates of the target pollutants, 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

Every pollutant has an MDL, 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 55 percent of the reported measurements (based on the preprocessed daily measurements) were above the MDLs. The following list shows the percent of measurements that were above the MDLs:

- 42.8 percent of VOC

- 53.8 percent of SNMOC

- 80.9 percent of carbonyl compounds

- 64.7 percent of PAH

- 75.0 percent of metals

- 72.2 percent of 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 (1,499), using the preprocessed daily measurements. These pollutants were reported in every valid carbonyl compound sample collected (1,499). Benzene, chloromethane, dichlorodifluoromethane, propylene, toluene, trichlorofluoromethane, and trichlorotrifluoroethane were detected in every VOC sample collected (1,264). Twelve pollutants, including acetylene, benzene, ethylene, and toluene, were detected in every SNMOC sample collected (468). Naphthalene, phenanthrene, pyrene, and fluoranthene were detected in every valid PAH sample collected (1,354). Antimony, chromium, lead, manganese, and nickel were detected in every metal sample collected (811). Hexavalent chromium was detected in 933 (out of 1,291) samples.

Similar to previous years' reports, BTUT and NBIL had the greatest number of measured detections (7,174 for BTUT and 6,768 for NBIL). They were also the only two sites that collected samples for all six analytical methods/pollutant groups. Yet, the detection rates for these sites (69 and 66 percent, respectively) were not as high as other sites. Detection rates for sites that sampled suites of pollutants that are frequently detected tended to be higher (refer to the list of method-specific percentages of measurements above the MDL listed above). For example, metals were rarely reported as non-detects. As a result, sites that sampled only metals (such as PAFL) would be expected to have higher detection rates. PAFL's detection rate is 100 percent. Conversely, VOCs had the lowest percentage of concentrations greater than the MDLs (42.5 percent). A site measuring only VOC would be expected to have lower detection rates, such as SPAZ (50.5 percent).

Table 4-1. Statistical Summaries of the VOC Concentrations

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum[2] (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Median (ppbv)	Mode (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)	Coefficient of Variation
Acetonitrile	1,260	4	0.036	5,530	26.3	0.361	0.190	0.197	3.09	184	6.97
Acetylene	1,263	1	0.079	9.08	0.862	0.659	1.10	0.424	1.01	0.753	0.874
Acrolein	1,241	23	0.053	46.2	0.590	0.306	0	0.196	0.483	2.09	3.54
Acrylonitrile	151	1,113	0.010	1.36	0.017	0	0	0	0	0.084	5.11
tert-Amyl Methyl Ether	4	1,260	0.003	0.010	0.00002	0	0	0	0	0.0005	18.9
Benzene	1,264	0	0.041	2.17	0.311	0.245	0.260	0.173	0.373	0.223	0.716
Bromochloromethane	6	1,258	0.010	0.013	0.00005	0	0	0	0	0.001	14.6
Bromodichloromethane	71	1,193	0.003	1.31	0.004	0	0	0	0	0.047	10.7
Bromoform	13	1,251	0.001	0.014	0.00006	0	0	0	0	0.001	12.0
Bromomethane	1,040	224	0.008	0.884	0.013	0.011	0	0.009	0.014	0.028	2.23
1,3-Butadiene	1,033	231	0.004	0.409	0.038	0.026	0	0.012	0.048	0.044	1.17
Carbon Tetrachloride	1,219	45	0.004	10.9	0.567	0.037	0.010	0.013	0.272	1.38	2.43
Carbon Disulfide	1,258	6	0.005	0.193	0.099	0.102	0.110	0.086	0.116	0.025	0.254
Chlorobenzene	7	1,257	0.005	0.029	0.00008	0	0	0	0	0.001	15.2
Chloroethane	347	917	0.006	0.217	0.007	0	0	0	0.010	0.017	2.33
Chloroform	1,021	243	0.010	2.47	0.038	0.020	0	0.014	0.031	0.119	3.10
Chloromethane	1,264	0	0.031	3.18	0.631	0.613	0.560	0.567	0.680	0.122	0.193
Chloromethylbenzene	7	1,257	0.006	0.011	0.00005	0	0	0	0	0.001	13.6
Chloroprene	11	1,253	0.013	0.090	0.0004	0	0	0	0	0.005	12.7
Dibromochloromethane	110	1,154	0.001	0.200	0.001	0	0	0	0	0.009	7.17
1,2-Dibromoethane	21	1,243	0.002	0.011	0.0001	0	0	0	0	0.001	8.08
m-Dichlorobenzene	72	1,192	0.002	0.109	0.0008	0	0	0	0	0.005	5.68
o-Dichlorobenzene	31	1,233	0.002	0.018	0.0002	0	0	0	0	0.001	7.07
p-Dichlorobenzene	725	539	0.002	3.52	0.019	0.007	0	0	0.019	0.105	5.55
Dichlorodifluoromethane	1,264	0	0.022	1.30	0.578	0.579	0.530	0.534	0.619	0.070	0.122
1,1-Dichloroethane	13	1,251	0.002	0.013	0.00009	0	0	0	0	0.001	10.4
1,2-Dichloroethane	214	1,050	0.010	0.061	0.003	0	0	0	0	0.008	2.32
1,1-Dichloroethene	18	1,246	0.005	0.030	0.0002	0	0	0	0	0.001	9.69

[1] Out of 1,264 valid samples.
[2] Excludes zeros for non-detects.

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
cis-1,2-Dichloroethylene	14	1,250	0.035	0.150	0.001	0	0	0	0	0.013	9.97
trans-1,2-Dichloroethylene	21	1,243	0.007	0.207	0.0004	0	0	0	0	0.007	15.5
Dichloromethane	1,263	1	0.023	1,510	3.05	0.124	0.080	0.086	0.221	49.9	16.3
1,2-Dichloropropane	2	1,262	0.011	0.012	0.00002	0	0	0	0	0.0005	25.1
cis-1,3-Dichloropropene	3	1,261	0.004	0.009	0.00002	0	0	0	0	0.0004	21.5
trans-1,3-Dichloropropene	0	1,264	Not Detected								
Dichlorotetrafluoroethane	1,263	1	0.006	0.088	0.020	0.018	0.018	0.017	0.020	0.010	0.519
Ethyl Acrylate	7	1,257	0.020	0.050	0.0002	0	0	0	0	0.003	14.3
Ethyl *tert*-Butyl Ether	19	1,245	0.002	0.029	0.0002	0	0	0	0	0.002	9.59
Ethylbenzene	1,258	6	0.005	7.25	0.082	0.053	0.020	0.030	0.100	0.216	2.63
Hexachloro-1,3-butadiene	22	1,242	0.002	0.033	0.0001	0	0	0	0	0.001	10.5
Methyl Ethyl Ketone	1,263	1	0.030	9.03	0.502	0.397	0.190	0.256	0.616	0.443	0.883
Methyl Isobutyl Ketone	1,102	162	0.005	0.389	0.038	0.030	0	0.018	0.050	0.036	0.935
Methyl Methacrylate	54	1,210	0.009	0.390	0.003	0	0	0	0	0.021	7.77
Methyl *tert*-Butyl Ether	27	1,237	0.002	0.054	0.0003	0	0	0	0	0.003	8.82
n-Octane	1,098	166	0.006	1.80	0.046	0.031	0	0.018	0.053	0.084	1.84
Propylene	1,264	0	0.090	66.0	0.560	0.367	0.290	0.260	0.572	1.92	3.42
Styrene	1,106	158	0.005	15.9	0.072	0.022	0	0.014	0.039	0.573	7.99
1,1,2,2-Tetrachloroethane	12	1,252	0.005	0.012	0.00009	0	0	0	0	0.0009	10.6
Tetrachloroethylene	1,054	210	0.004	0.199	0.025	0.016	0	0.008	0.030	0.029	1.18
Toluene	1,264	0	0.033	22.7	0.585	0.350	0.240	0.183	0.707	1.06	1.81
1,2,4-Trichlorobenzene	44	1,220	0.001	0.067	0.0004	0	0	0	0	0.004	8.32
1,1,1-Trichloroethane	1,067	197	0.006	0.185	0.010	0.010	0.010	0.009	0.012	0.008	0.816
1,1,2-Trichloroethane	11	1,253	0.004	0.014	0.00009	0	0	0	0	0.001	11.1
Trichloroethylene	297	967	0.001	1.79	0.011	0	0	0	0	0.073	6.40
Trichlorofluoromethane	1,264	0	0.009	2.07	0.295	0.281	0.260	0.262	0.306	0.089	0.302
Trichlorotrifluoroethane	1,264	0	0.007	0.301	0.094	0.093	0.090	0.087	0.101	0.013	0.135
1,2,4-Trimethylbenzene	1,243	21	0.003	0.562	0.072	0.049	0.030	0.026	0.089	0.073	1.02

[1] Out of 1,264 valid samples.
[2] Excludes zeros for non-detects.

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
1,3,5-Trimethylbenzene	1,195	69	0.002	0.187	0.025	0.019	0.010	0.011	0.031	0.023	0.937
Vinyl chloride	53	1,211	0.002	0.046	0.0004	0	0	0	0	0.002	6.21
m,p-Xylene	1,256	8	0.009	2.70	0.198	0.126	0.020	0.061	0.260	0.220	1.11
o-Xylene	1,247	17	0.004	0.888	0.075	0.051	0.040	0.027	0.099	0.075	0.997

[1] Out of 1,264 valid samples.
[2] Excludes zeros for non-detects.

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	468	0	0.155	10.9	1.74	1.24	1.04	0.820	2.07	1.51	0.866
Benzene	468	0	0.180	7.89	1.97	1.54	1.54	0.926	2.63	1.39	0.705
1,3-Butadiene	164	304	0.061	4.91	0.114	0	0	0	0.121	0.329	2.89
n-Butane	425	43	0.599	162	17.2	10.3	0	3.38	24.6	19.9	1.15
cis-2-Butene	415	53	0.067	6.06	0.263	0.184	0	0.131	0.285	0.394	1.50
trans-2-Butene	396	72	0.056	6.69	0.280	0.143	0	0.095	0.278	0.526	1.87
Cyclohexane	463	5	0.069	19.2	2.50	1.35	0	0.257	3.94	2.96	1.18
Cyclopentane	463	5	0.094	26.4	0.734	0.499	0	0.270	0.885	1.32	1.80
Cyclopentene	135	333	0.057	2.43	0.111	0	0	0	0.112	0.302	2.72
n-Decane	446	22	0.072	5.84	0.641	0.442	0	0.212	0.853	0.652	1.02
1-Decene	4	464	0.234	1.49	0.008	0	0	0	0.000	0.097	12.6
m-Diethylbenzene	282	186	0.069	1.82	0.162	0.117	0	0	0.208	0.235	1.45
p-Diethylbenzene	184	284	0.061	3.18	0.186	0	0	0	0.137	0.486	2.61
2,2-Dimethylbutane	466	2	0.099	3.98	0.735	0.579	1.25	0.324	0.965	0.561	0.763
2,3-Dimethylbutane	442	26	0.088	7.67	1.07	0.808	0	0.277	1.52	1.03	0.961
2,3-Dimethylpentane	460	8	0.116	4.97	1.03	0.964	0	0.610	1.33	0.595	0.576
2,4-Dimethylpentane	453	15	0.069	2.12	0.496	0.428	0	0.229	0.637	0.359	0.724
n-Dodecane	457	11	0.057	12.2	0.413	0.249	0	0.149	0.458	0.719	1.74
1-Dodecene	377	91	0.065	2.10	0.296	0.214	0	0.106	0.390	0.320	1.08
Ethane	468	0	1.76	549	55.3	23.0	114	5.67	77.6	73.7	1.33
2-Ethyl-1-butene	7	461	0.182	8.70	0.035	0	0	0	0.000	0.466	13.3
Ethylbenzene	462	6	0.096	65.1	1.04	0.416	0	0.258	0.648	4.57	4.41
Ethylene	468	0	0.579	33.3	2.87	2.30	1.44	1.72	3.16	2.67	0.929
m-Ethyltoluene	432	36	0.057	2.89	0.355	0.298	0	0.163	0.469	0.295	0.832
o-Ethyltoluene	404	64	0.036	1.59	0.266	0.225	0	0.129	0.369	0.213	0.802
p-Ethyltoluene	442	26	0.051	1.31	0.267	0.235	0	0.157	0.333	0.181	0.678
n-Heptane	466	2	0.101	12.5	2.18	1.30	1.52	0.310	3.45	2.29	1.05

[1] Out of 468 valid samples.
[2] Excludes zeros for non-detects.

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	315	153	0.082	4.18	0.628	0.342	0	0	1.04	0.743	1.18
cis-2-Hexene	45	423	0.093	0.527	0.019	0	0	0	0	0.065	3.49
trans-2-Hexene	40	428	0.076	0.533	0.015	0	0	0	0	0.057	3.83
n-Hexane	468	0	0.159	40.4	4.17	2.56	1.16	0.695	6.23	4.83	1.16
1-Hexene	439	29	0.075	1.05	0.230	0.223	0	0.175	0.287	0.114	0.493
Isobutane	468	0	0.245	262	15.1	7.25	26.6	1.42	21.2	22.3	1.48
Isobutene/1-Butene	441	27	0.184	32.1	2.09	0.663	0	0.464	1.41	4.48	2.14
Isopentane	465	3	0.396	868	15.8	8.78	14.2	3.98	17.9	43.3	2.74
Isoprene	434	34	0.047	10.4	0.665	0.287	0	0.159	0.593	1.11	1.67
Isopropylbenzene	311	157	0.068	3.44	0.106	0.113	0	0	0.147	0.183	1.72
2-Methyl-1-butene	259	209	0.049	20.2	0.292	0.104	0	0	0.287	1.13	3.88
3-Methyl-1-butene	6	462	0.095	0.514	0.003	0	0	0	0	0.027	10.9
2-Methyl-1-pentene	19	449	0.055	0.402	0.008	0	0	0	0	0.040	5.34
4-Methyl-1-pentene	141	327	0.088	1.03	0.094	0	0	0	0.171	0.172	1.83
2-Methyl-2-butene	265	203	0.050	54.5	0.406	0.105	0	0	0.246	3.43	8.45
Methylcyclohexane	466	2	0.097	34.5	4.84	2.26	10.1	0.362	7.75	5.87	1.21
Methylcyclopentane	468	0	0.120	19.3	2.37	1.52	0.423	0.518	3.51	2.47	1.05
2-Methylheptane	437	31	0.077	3.54	0.698	0.499	0	0.171	1.04	0.658	0.943
3-Methylheptane	415	53	0.055	2.70	0.527	0.35	0	0.136	0.774	0.512	0.972
2-Methylhexane	426	42	0.190	10.2	1.58	1.22	0	0.574	2.27	1.37	0.864
3-Methylhexane	421	47	0.039	10.4	1.70	1.30	0	0.506	2.52	1.54	0.907
2-Methylpentane	452	16	0.140	35.4	4.73	3.51	0	1.41	6.73	4.42	0.936
3-Methylpentane	468	0	0.135	17.6	2.39	1.75	1.24	0.609	3.41	2.38	0.995
n-Nonane	456	12	0.064	4.02	0.764	0.465	0	0.184	1.04	0.780	1.02
1-Nonene	334	134	0.073	1.77	0.155	0.133	0	0	0.209	0.184	1.19
n-Octane	461	7	0.090	13.4	1.50	0.844	0	0.224	2.19	1.71	1.14
1-Octene	250	218	0.029	1.17	0.144	0.099	0	0	0.241	0.186	1.29
n-Pentane	468	0	0.173	6,315	23.0	6.11	10.1	1.99	13.2	291	12.6

[1] Out of 468 valid samples.
[2] Excludes zeros for non-detects.

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-Pentene	464	4	0.090	26.8	0.619	0.238	0.192	0.176	0.350	2.17	3.50
cis-2-Pentene	354	114	0.043	19.2	0.213	0.130	0	0.076	0.183	1.12	5.25
trans-2-Pentene	412	56	0.051	4.67	0.249	0.172	0	0.122	0.314	0.318	1.28
a-Pinene	347	121	0.052	18.9	0.310	0.198	0	0	0.334	0.945	3.05
b-Pinene	59	409	0.075	2.70	0.043	0	0	0	0	0.186	4.34
Propane	468	0	0.168	389	38.1	19.8	60.1	6.10	52.1	46.7	1.23
n-Propylbenzene	405	63	0.073	2.89	0.192	0.175	0	0.119	0.242	0.188	0.980
Propylene	468	0	0.376	7.13	1.22	0.958	1.03	0.761	1.36	0.858	0.701
Propyne	0	468	Not Detected								
Styrene	209	259	0.062	105	0.390	0	0	0	0.157	4.87	12.5
Toluene	468	0	0.196	63.1	4.20	3.31	1.33	1.47	5.59	4.40	1.05
n-Tridecane	50	418	0.051	3.58	0.033	0	0	0	0	0.192	5.88
1-Tridecene	23	445	0.065	3.58	0.016	0	0	0	0	0.170	10.8
1,2,3-Trimethylbenzene	292	176	0.043	20.6	0.196	0.115	0	0	0.191	0.978	5.00
1,2,4-Trimethylbenzene	465	3	0.067	2.85	0.565	0.464	0.563	0.279	0.740	0.424	0.751
1,3,5-Trimethylbenzene	416	52	0.054	1.71	0.353	0.274	0	0.149	0.484	0.298	0.845
2,2,3-Trimethylpentane	291	177	0.099	1.46	0.205	0.170	0	0	0.303	0.232	1.13
2,2,4-Trimethylpentane	356	112	0.083	7.41	0.548	0.312	0	0.101	0.734	0.756	1.38
2,3,4-Trimethylpentane	408	60	0.059	2.65	0.249	0.165	0	0.109	0.269	0.302	1.21
n-Undecane	458	10	0.035	15.6	0.598	0.388	0	0.203	0.697	0.926	1.55
1-Undecene	179	289	0.043	4.99	0.239	0	0	0	0.192	0.573	2.40
m-Xylene/*p*-Xylene	467	1	0.100	14.6	2.04	1.62	1.54	0.601	2.89	1.91	0.939
o-Xylene	455	13	0.086	4.32	0.560	0.448	0	0.240	0.741	0.464	0.829
SNMOC (Sum of Knowns)	468	0	17.4	7,053	228	136	263	51.6	293	386	1.69
Sum of Unknowns	468	0	11.9	849	82.7	51.9	69.1	34.2	91.7	102	1.23
TNMOC	468	0	34.1	7,535	311	231	103	102	397	423	1.36

[1] Out of 468 valid samples.
[2] Excludes zeros for non-detects.

4-8

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	1,499	0	0.089	5.99	1.06	0.893	1.03	0.597	1.29	0.718	0.677
Acetone	1,499	0	0.055	7.40	1.20	1.03	1.01	0.659	1.56	0.801	0.668
Benzaldehyde	1,481	18	0.006	0.244	0.029	0.023	0.017	0.016	0.034	0.024	0.806
Butyraldehyde	1,496	3	0.006	0.859	0.091	0.074	0.077	0.049	0.111	0.069	0.756
Crotonaldehyde	1,486	13	0.006	1.12	0.104	0.044	0.024	0.026	0.112	0.153	1.47
2,5-Dimethylbenzaldehyde	0	1,499	Not Detected								
Formaldehyde	1,499	0	0.136	43.5	2.01	1.66	1.67	1.09	2.47	1.80	0.894
Hexaldehyde	1,473	26	0.005	0.885	0.032	0.023	0.014	0.014	0.036	0.046	1.46
Isovaleraldehyde	32	1,467	0.008	0.108	0.001	0	0	0	0	0.006	8.77
Propionaldehyde	1,486	13	0.006	1.01	0.118	0.097	0.076	0.063	0.150	0.089	0.753
Tolualdehydes	1,164	335	0.006	0.224	0.023	0.020	0	0.009	0.034	0.021	0.911
Valeraldehyde	1,438	61	0.004	0.567	0.029	0.021	0	0.013	0.034	0.036	1.22

[1] Out of 1,499 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/m³)	Maximum (ng/m³)	Arithmetic Mean (ng/m³)	Median (ng/m³)	Mode (ng/m³)	First Quartile (ng/m³)	Third Quartile (ng/m³)	Standard Deviation (ng/m³)	Coefficient of Variation
Acenaphthene	1,332	22	0.090	175	3.98	2.04	0	0.983	4.30	7.69	1.93
Acenaphthylene	624	730	0.029	175	0.872	0	0	0	0.540	6.38	7.32
Anthracene	793	561	0.031	69.1	0.479	0.138	0	0	0.428	2.76	5.77
Benzo(a)anthracene	627	727	0.010	35.8	0.123	0	0	0	0.086	1.14	9.25
Benzo(a)pyrene	683	671	0.007	42.7	0.131	0.020	0	0	0.100	1.32	10.0
Benzo(b)fluoranthene	1,184	170	0.013	38.7	0.274	0.110	0	0.047	0.279	1.27	4.62
Benzo(e)pyrene	1,044	310	0.011	22.2	0.142	0.059	0	0.022	0.146	0.696	4.89
Benzo(g,h,i)perylene	1,198	156	0.009	29.2	0.169	0.071	0	0.036	0.161	0.947	5.61
Benzo(k)fluoranthene	721	633	0.007	13.5	0.072	0.022	0	0	0.071	0.440	6.11
Chrysene	1,288	66	0.013	28.8	0.266	0.128	0	0.074	0.271	0.955	3.59
Coronene	874	480	0.009	13.6	0.074	0.037	0	0	0.074	0.429	5.77
Cyclopenta[cd]pyrene	228	1,126	0.007	55.1	0.066	0	0	0	0	1.51	23.0
Dibenz(a,h)anthracene	196	1,158	0.012	3.52	0.012	0	0	0	0	0.106	8.89
Fluoranthene	1,354	0	0.030	111	2.40	1.29	1.05	0.694	2.57	4.78	1.99
Fluorene	1,353	1	0.078	152	4.82	2.91	2.26	1.75	5.39	8.09	1.68
9-Fluorenone	1,347	7	0.048	25	1.63	1.07	1.47	0.634	2	1.77	1.09
Indeno(1,2,3-cd)pyrene	933	421	0.014	30.7	0.145	0.055	0	0	0.140	0.966	6.68
Naphthalene	1,354	0	0.309	1,490	95.3	66.4	104	36.6	117	117	1.23
Perylene	517	837	0.015	6.88	0.055	0	0	0	0.047	0.227	4.10
Phenanthrene	1,354	0	0.057	239	9.63	5.51	5.40	2.98	11.2	14.4	1.49
Pyrene	1,354	0	0.022	154	1.51	0.813	1.33	0.440	1.56	5.44	3.61
Retene	1,304	50	0.023	61.1	0.360	0.169	0	0.098	0.307	1.72	4.77

[1] Out of 1,354 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 (ng/m³)[3]	Maximum (ng/m³)	Arithmetic Mean (ng/m³)	Median (ng/m³)	Mode (ng/m³)	First Quartile (ng/m³)	Third Quartile (ng/m³)	Standard Deviation (ng/m³)	Coefficient of Variation
Antimony (PM_{10})	507	0	0.030	9.60	1.07	0.757	0.200	0.460	1.28	1.08	1.01
Arsenic (PM_{10})	504	3	0.010	4.77	0.558	0.415	0.240	0.240	0.700	0.535	0.959
Beryllium (PM_{10})	393	114	0.00005	0.040	0.003	0.002	0	0.0003	0.004	0.005	1.42
Cadmium (PM_{10})	506	1	0.010	2.05	0.164	0.084	0.040	0.050	0.176	0.238	1.45
Chromium (PM_{10})	507	0	0.260	10.9	2.26	2.00	1.79	1.66	2.92	0.907	0.401
Cobalt (PM_{10})	504	3	0.000002	1.68	0.127	0.077	0.060	0.048	0.140	0.177	1.39
Lead (PM_{10})	507	0	0.080	47.8	3.67	2.32	1.56	1.45	3.74	4.95	1.35
Manganese (PM_{10})	507	0	0.280	200	6.82	4.03	11.0	2.15	7.97	11.6	1.71
Mercury (PM_{10})	421	86	0.00003	0.290	0.012	0.007	0	0.003	0.013	0.021	1.71
Nickel (PM_{10})	507	0	0.070	10.6	1.06	0.845	1.01	0.594	1.22	0.915	0.861
Selenium (PM_{10})	504	3	0.001	3.95	0.453	0.330	0.200	0.184	0.554	0.435	0.959
Antimony (TSP)	304	0	0.079	16.7	0.653	0.450	0.267	0.292	0.712	1.14	1.75
Arsenic (TSP)	304	0	0.113	2.24	0.544	0.457	0.339	0.341	0.667	0.311	0.572
Beryllium (TSP)	303	1	0.000055	0.081	0.016	0.012	0.011	0.008	0.020	0.013	0.828
Cadmium (TSP)	304	0	0.033	1.64	0.175	0.130	0.122	0.088	0.208	0.172	0.982
Chromium (TSP)	304	0	0.832	10.3	1.75	1.58	1.49	1.35	1.91	0.816	0.466
Cobalt (TSP)	304	0	0.055	8.02	0.532	0.323	0.254	0.212	0.552	0.722	1.36
Lead (TSP)	304	0	0.593	26.0	3.20	2.57	2.36	1.83	3.87	2.26	0.707
Manganese (TSP)	304	0	1.79	60.4	14.8	13.6	13.7	7.55	19.0	9.61	0.651
Mercury (TSP)	299	5	0.000875	0.064	0.010	0.009	0.007	0.006	0.013	0.007	0.678
Nickel (TSP)	304	0	0.211	7.82	0.877	0.732	0.299	0.514	1.03	0.647	0.738
Selenium (TSP)	304	0	0.076	2.21	0.588	0.536	1.03	0.347	0.789	0.331	0.563

[1] For PM_{10}, out of 507 valid samples.
[2] For TSP, out of 304 valid samples.
[3] Excludes zeros for non-detects.

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

Pollutant	# of Measured Detections[1]	# of Non-Detects[1]	Minimum (ng/m^3)[2]	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	933	358	0.0024	3.51	0.037	0.018	0	0	0.032	0.129	3.49

[1] Out of 1,291 valid samples.
[2] Excludes zeros for non-detects.

4.1.2 Concentration Range and Data Distribution

The concentrations measured during the 2010 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 carbon tetrachloride, 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 VOC, acetonitrile (0.036 to 5,530 ppbv)

- For SNMOC, *n*-pentane (0.173 to 6,315 ppbC)

- For carbonyl compounds, formaldehyde (0.136 to 43.5 ppbv)

- For PAH, naphthalene (0.309 to 1,490 ng/m^3)

- For metals, both size fractions, manganese (0.28 to 200 ng/m^3 for PM_{10} and 1.79 to 60.35 ng/m^3 for TSP)

- For hexavalent chromium, 0.0024 to 3.51 ng/m^3.

A large number of monitoring sites that sampled for hexavalent chromium measured elevated concentrations on July 4, 2006. Hexavalent chromium is a component in fireworks (NLM, 2012) and it is possible that Independence Day fireworks celebrations may have caused this increased concentration level. Based on the 1-in-6 sampling schedule for 2010, samples were collected on July 1 and July 7, thereby missing any potential holiday celebrations. For 2010, the maximum hexavalent chromium concentrations were measured on various days across the calendar year. Three sites measured their maximum hexavalent chromium in January, one in February, two in April, two in June, six in July, two in August, one in September, two in October, one in November, and three in December. One site (S4MO) took a measurement on July 4 because they were making up a missed sample; the maximum hexavalent chromium concentration for this site was from the July 4 sample. S4MO is one of the six sites that measured its highest hexavalent chromium concentration in July. Additional examples of this phenomenon can be seen in the site-specific trends analysis section of the individual state sections. Additional studies of this phenomenon were recommended in the 2006 UATMP

Report. The next year hexavalent chromium is scheduled to be sampled on Independence Day is July 4, 2014.

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, mode, median, first and third quartiles, standard deviation, and coefficient of variation) for each of the pollutants sampled during the 2010 NMP by 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 VOC by average mass concentration, as presented in Table 4-1, are:
- acetonitrile (26.3 ± 10.1 ppbv)

- dichloromethane (3.05 ± 2.75 ppbv)

- acetylene (0.862 ± 0.042 ppbv).

The top three SNMOC by average mass concentration, as presented in Table 4-2, are:
- ethane (55.3 ± 6.69 ppbC)

- propane (38.1 ± 4.24 ppbC)

- *n*-pentane (23.0 ± 26.46 ppbC).

The top three carbonyl compounds by average mass concentration, as presented in Table 4-3, are:
- formaldehyde (2.01 ± 0.09 ppbv)

- acetone (1.20 ± 0.04 ppbv)

- acetaldehyde (1.06 ± 0.04 ppbv).

The top three PAH by average mass concentration, as presented in Tables 4-4, are:
- naphthalene (95.3 ± 6.25 ng/m^3)

- phenanthrene (9.63 ± 0.77 ng/m^3)

- fluorene (4.82 ± 0.43 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$_{10}$ = 6.82 ± 1.01 ng/m^3, TSP = 14.8 ± 1.08 ng/m^3)

- lead (PM$_{10}$ = 3.67 ± 0.43 ng/m^3, TSP = 3.20 ± 0.26 ng/m^3)

- total chromium (PM$_{10}$ = 2.26 ± 0.08 ng/m^3, TSP = 1.75 ± 0.09 ng/m^3).

The average mass concentration of hexavalent chromium, as presented in Table 4-6, is 0.037 ± 0.007 ng/m^3.

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

4.2 Preliminary Risk Screening and Pollutants of Interest

Based on the preliminary risk screening approach 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 benzene failed the highest number of screens (1,500), although formaldehyde and acetaldehyde were not far behind (1,499 and 1,467, respectively). These three pollutants were also among those with the highest number of measured detections. Conversely, vinyl chloride and xylenes failed only one screen each. The number of measured detections for these three pollutants varied significantly. Xylenes were detected in 1,498 samples while vinyl chloride was detected in only 53 samples (both out of 1,501).

Table 4-7. Program–Level Risk Screening Summary

Pollutant	Screening Value (μg/m³)	# of Failed Screens	# of Measured Detections	% of Failed Screens	% of Total Failures	Cumulative % Contribution
Benzene	0.13	1,500	1,501	99.93	13.95	13.95
Formaldehyde	0.077	1,499	1,499	100.00	13.94	27.89
Acetaldehyde	0.45	1,467	1,499	97.87	13.64	41.53
Carbon Tetrachloride	0.17	1,244	1,258	98.89	11.57	53.10
Naphthalene	0.029	1,082	1,354	79.91	10.06	63.16
1,3-Butadiene	0.03	1,013	1,115	90.85	9.42	72.58
Arsenic	0.00023	672	808	83.17	6.25	78.83
Manganese	0.005	478	811	58.94	4.44	83.27
Ethylbenzene	0.4	391	1,494	26.17	3.64	86.91
p-Dichlorobenzene	0.091	367	725	50.62	3.41	90.32
1,2-Dichloroethane	0.038	214	214	100.00	1.99	92.31
Acrylonitrile	0.015	151	151	100.00	1.40	93.71
Fluorene	0.011	100	1,353	7.39	0.93	94.64
Acenaphthene	0.011	92	1,332	6.91	0.86	95.50
Hexavalent Chromium	0.000083	87	933	9.32	0.81	96.31
Trichloroethylene	0.2	55	297	18.52	0.51	96.82
Nickel	0.0021	52	811	6.41	0.48	97.30
Propionaldehyde	0.8	39	1,486	2.62	0.36	97.67
Cadmium	0.00056	37	810	4.57	0.34	98.01
Fluoranthene	0.011	35	1,354	2.58	0.33	98.34
Benzo(a)pyrene	0.00057	33	683	4.83	0.31	98.64
Dichloromethane	7.7	33	1,263	2.61	0.31	98.95
1,2-Dibromoethane	0.0017	21	21	100.00	0.20	99.14
Lead	0.015	15	811	1.85	0.14	99.28
Hexachloro-1,3-butadiene	0.045	13	22	59.09	0.12	99.40
1,1,2,2-Tetrachloroethane	0.017	12	12	100.00	0.11	99.52
Chloroprene	0.0021	11	11	100.00	0.10	99.62
Acenaphthylene	0.011	8	624	1.28	0.07	99.69
Chloromethylbenzene	0.02	7	7	100.00	0.07	99.76
Bromomethane	0.5	5	1,040	0.48	0.05	99.80
1,1,2-Trichloroethane	0.0625	3	11	27.27	0.03	99.83
Benzo(a)anthracene	0.0057	2	627	0.32	0.02	99.85
Benzo(b)fluoranthene	0.0057	2	1,184	0.17	0.02	99.87
Benzo(e)pyrene	0.011	2	1,044	0.19	0.02	99.89
Benzo(g,h,i)perylene	0.011	2	1,198	0.17	0.02	99.91
Benzo(k)fluoranthene	0.0057	2	721	0.28	0.02	99.93
Chloroform	9.8	2	1,021	0.20	0.02	99.94
Dibenz(a,h)anthracene	0.00052	2	196	1.02	0.02	99.96
Indeno(1,2,3-cd)pyrene	0.0057	2	933	0.21	0.02	99.98
Vinyl chloride	0.11	1	53	1.89	0.01	99.99
Xylenes	10	1	1,498	0.07	0.01	100.00
Total		10,754	33,785	31.83		

BOLD = EPA MQO NATTS Core Analyte.

While seven pollutants exhibited a failure rate of 100 percent, most of them were infrequently detected. Of these seven, formaldehyde was detected in all 1,499 samples, while other pollutants (chloroprene and chloromethylbenzene, for example) were detected relatively few times. 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 risk screening process. Other pollutants with relatively high failure rates include benzene, acrylonitrile, 1,2-dichloroethane, 1,2-dibromoethane, 1,1,2,2-tetrachloroethane, and carbon tetrachloride. While each of these pollutants failed more than 98 percent of screens, four of them (acrylonitrile, 1,2-dichloroethane, 1,2-dibromoethane, 1,1,2,2-tetrachloroethane) were detected in fewer than 15 percent of samples collected.

EPA periodically revises the risk screening values based on new studies or updated information. The screening values are often adjusted upward or downward, added, or removed altogether. Screening values that have increased since the last report include dichloromethane (from 2.1 $\mu g/m^3$ to 7.7 $\mu g/m^3$) and tetrachloroethylene (from 0.17 $\mu g/m^3$ to 3.8 $\mu g/m^3$). Screening values that have decreased since the last report include nickel (from 0.009 $\mu g/m^3$ to 0.0021 $\mu g/m^3$), chloroprene (from 0.7 $\mu g/m^3$ to 0.0021 $\mu g/m^3$), trichloroethylene (from 0.5 $\mu g/m^3$ to 0.2 $\mu g/m^3$), and many of the PAH (such as benzo(a)pyrene from 0.00091 to 0.00057 $\mu g/m^3$). Perylene now has a risk screening value (0.011 $\mu g/m^3$) while anthracene, phenanthrene, and pyrene no longer have screening values.

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 tetrachoroethylene, 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 six of the pollutants contributing to the top 95 percent of failed screens (ethylbenzene, *p*-dichlorobenzene, 1,2-dichloroethane, acrylonitrile, fluorene, and acenaphthene) 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
- Hexavalent Chromium
- Lead
- Manganese
- Naphthalene
- Nickel
- Tetrachloroethylene
- Trichloroethylene
- Vinyl Chloride

The 2010 list of pollutants of interest identified via the preliminary risk screening approach is similar to the 2008-2009 list of pollutants of interest. However, there are a few exceptions. For the 2008-2009 NMP report, 1,2-dichloroethane was just outside the 95 percent criteria cut-off for the pollutants of interest designation. Fluorene and acenaphthene are also new to the list but they have revised screening values, as discussed above. Tetrachloroethylene was not identified as a pollutant of interest for 2010 via the preliminary risk screening approach as its screening value increased significantly.

Of the 80 pollutants sampled for under the NMP that have corresponding screening values, concentrations of 41 pollutants failed at least one screen (or roughly 51 percent). Of these, a total of 10,754 of 33,785 concentrations (31.8 percent) failed screens. If the measured detections for tetrachloroethylene and beryllium (the two NATTS MQO Core Analytes that did not fail any screens) are included in the total number of concentrations (35,535), the percentage

of failed screens is approximately 30 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 much less (10,754 of 51,634, or 20.8 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 risk screening process across the sites. As shown, S4MO had the largest number of failed screens (574), followed by PXSS (526) and TMOK (503). 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 Screening Comparison

Site	# of Failed Screens	Total # of Measured Detections[1]	% of Failed Screens	# of Pollutant Groups Analyzed
S4MO	574	2,538	22.62	5
PXSS	526	2,389	22.02	5
TMOK	503	1,861	27.03	3
TOOK	499	1,855	26.90	3
BTUT	483	2,383	20.27	6
NBIL	468	2,572	18.20	6
OCOK	467	1,895	24.64	3
DEMI	466	2,085	22.35	4
MWOK	466	1,859	25.07	3
SEWA	444	2,348	18.91	5
PROK	434	1,845	23.52	3
GPCO	424	1,933	21.93	4
ELNJ	387	1,284	30.14	2
SPIL	373	1,271	29.35	2
NBNJ	320	1,202	26.62	2
SSSD	303	1,289	23.51	3
UCSD	283	1,256	22.53	3
CHNJ	276	1,070	25.79	2
UNVT	223	1,974	11.30	5
SKFL	177	888	19.93	3
RICO	176	487	36.14	2

[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 Screening Comparison (Continued)

Site	# of Failed Screens	Total # of Measured Detections[1]	% of Failed Screens	# of Pollutant Groups Analyzed
SYFL	158	775	20.39	3
SPAZ	152	551	27.59	1
PACO	146	454	32.16	2
INDEM	122	183	66.67	1
AZFL	122	183	66.67	1
ORFL	120	179	67.04	1
BOMA	114	1,392	8.19	3
WPIN	113	168	67.26	1
PANJ	105	394	26.65	1
BURVT	105	531	19.77	1
GLKY	103	1,163	8.86	3
BRCO	100	424	23.58	2
SJJCA	96	1,134	8.47	2
RUVT	95	461	20.61	1
RUCO	87	299	29.10	2
MONY	73	395	18.48	2
CELA	70	589	11.88	1
PRRI	65	757	8.59	2
RIVA	61	637	9.58	2
TONY	61	417	14.63	1
WADC	60	638	9.40	2
CAMS 35	59	580	10.17	2
SDGA	58	642	9.03	2
RUCA	57	600	9.50	1
BXNY	54	401	13.47	2
BMCO	39	138	28.26	2
PAFL	36	300	12.00	1
CAMS 85	33	51	64.71	1
HOWI	10	396	2.53	2
CHSC	6	449	1.34	2
ROCH	2	69	2.90	2

[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 AZFL had the highest failure rates (approximately 67 percent each), each of 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, to name a few. For this reason, the number of pollutant groups for which sampling was conducted is also presented in Table 4-8. Every site had at least one pollutant fail a screen.

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 VOC, carbonyl compounds, PAH, and metals respectively). As described in Section 3.1.1, 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 PAH 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 VOC 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 pollutant of interest shown.

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

Rank	Acrylonitrile (μg/m³)	Benzene (μg/m³)	1,3-Butadiene (μg/m³)	Carbon Tetrachloride (μg/m³)	Chloroform (μg/m³)	*p*-Dichlorobenzene (μg/m³)
1	SPAZ 0.39 ± 0.23	TOOK 2.34 ± 0.36	SPAZ 0.26 ± 0.08	*SEWA* 0.72 ± 0.04	*NBIL* 1.06 ± 0.53	*BTUT* 0.54 ± 0.74
2	*S4MO* 0.17 ± 0.14	PACO 1.72 ± 0.21	*PXSS* 0.21 ± 0.05	*NBIL* 0.72 ± 0.03	*DEMI* 0.63 ± 0.08	*S4MO* 0.35 ± 0.18
3	NBNJ 0.14 ± 0.11	SPAZ 1.69 ± 0.37	RICO 0.16 ± 0.06	SPIL 0.71 ± 0.03	*PXSS* 0.37 ± 0.05	SPAZ 0.28 ± 0.06
4	UCSD 0.05 ± 0.03	RUCO 1.62 ± 0.18	SPIL 0.14 ± 0.02	*DEMI* 0.69 ± 0.03	*BTUT* 0.28 ± 0.40	OCOK 0.24 ± 0.07
5	*PXSS* 0.05 ± 0.03	TMOK 1.57 ± 0.20	*GPCO* 0.14 ± 0.02	SPAZ 0.66 ± 0.04	SPAZ 0.24 ± 0.04	MWOK 0.18 ± 0.04
6	CHNJ 0.04 ± 0.02	RICO 1.46 ± 0.17	*S4MO* 0.12 ± 0.03	*PXSS* 0.66 ± 0.03	*S4MO* 0.19 ± 0.04	*PXSS* 0.16 ± 0.03
7	OCOK 0.03 ± 0.03	*GPCO* 1.40 ± 0.16	ELNJ 0.12 ± 0.01	PROK 0.65 ± 0.03	PROK 0.14 ± 0.11	TOOK 0.15 ± 0.03
8	SPIL 0.02 ± 0.02	*PXSS* 1.38 ± 0.20	RUVT 0.12 ± 0.05	MWOK 0.64 ± 0.04	*SEWA* 0.14 ± 0.01	TMOK 0.14 ± 0.03
9	TMOK 0.02 ± 0.02	*BTUT* 1.22 ± 0.16	*BTUT* 0.10 ± 0.02	CHNJ 0.64 ± 0.03	ELNJ 0.13 ± 0.02	PROK 0.10 ± 0.03
10	*GPCO* 0.02 ± 0.01	BRCO 1.10 ± 0.18	TMOK 0.10 ± 0.02	OCOK 0.64 ± 0.04	NBNJ 0.12 ± 0.02	ELNJ 0.09 ± 0.02

BOLD ITALICS = EPA-designated NATTS Site.

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

Rank	1,2-Dichloroethane (µg/m³)	Ethylbenzene (µg/m³)	Tetrachloroethylene (µg/m³)	Trichloroethylene (µg/m³)	Vinyl Chloride (µg/m³)
1	PROK 0.02 ± 0.01	PACO 0.98 ± 0.98	*PXSS* 0.40 ± 0.08	SPIL 0.79 ± 0.40	*DEMI* 0.003 ± 0.002
2	MWOK 0.02 ± 0.01	RICO 0.95 ± 0.86	*GPCO* 0.39 ± 0.07	*BTUT* 0.09 ± 0.11	MWOK 0.002 ± 0.004
3	CHNJ 0.02 ± 0.01	SPAZ 0.76 ± 0.18	SPAZ 0.33 ± 0.09	UCSD 0.08 ± 0.10	*BTUT* 0.002 ± 0.002
4	*BTUT* 0.02 ± 0.01	UCSD 0.75 ± 1.05	SPIL 0.32 ± 0.06	*NBIL* 0.07 ± 0.02	RUVT 0.002 ± 0.004
5	OCOK 0.02 ± 0.01	*PXSS* 0.60 ± 0.10	*S4MO* 0.23 ± 0.06	*S4MO* 0.05 ± 0.02	NBNJ 0.002 ± 0.001
6	SPIL 0.02 ± 0.01	TMOK 0.55 ± 0.13	MWOK 0.22 ± 0.06	SPAZ 0.05 ± 0.02	*S4MO* 0.001 ± 0.001
7	*SEWA* 0.02 ± 0.01	*DEMI* 0.50 ± 0.11	*DEMI* 0.21 ± 0.05	*PXSS* 0.03 ± 0.03	OCOK 0.001 ± 0.001
8	*S4MO* 0.02 ± 0.01	*GPCO* 0.50 ± 0.07	NBIL 0.21 ± 0.05	ELNJ 0.03 ± 0.01	*UNVT* 0.001 ± 0.001
9	NBNJ 0.02 ± 0.01	*BTUT* 0.48 ± 0.15	ELNJ 0.20 ± 0.03	*GPCO* 0.03 ± 0.01	TOOK 0.001 ± 0.001
10	*ELNJ* 0.02 ± 0.01	TOOK 0.47 ± 0.08	RUVT 0.18 ± 0.04	*DEMI* 0.02 ± 0.01	UCSD 0.001 ± 0.002

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	*S4MO* 4.10 ± 0.59	ELNJ 4.46 ± 0.64
2	*SKFL* 3.36 ± 0.48	*BTUT* 3.66 ± 0.63
3	AZFL 2.94 ± 0.40	*NBIL* 3.59 ± 2.18
4	NBNJ 2.92 ± 0.37	WPIN 3.58 ± 0.45
5	ELNJ 2.73 ± 0.39	TMOK 3.35 ± 0.40
6	WPIN 2.56 ± 0.33	TOOK 3.14 ± 0.45
7	*BTUT* 2.25 ± 0.27	*DEMI* 2.80 ± 0.31
8	TOOK 2.20 ± 0.29	*GPCO* 2.78 ± 0.23
9	*GPCO* 2.00 ± 0.20	*SYFL* 2.76 ± 0.49
10	TMOK 2.00 ± 0.20	*S4MO* 2.74 ± 0.33

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* 13.74 ± 7.06	*PRRI* 0.20 ± 0.07	*DEMI* 12.62 ± 6.23	*GPCO* 147.04 ± 22.61
2	*NBIL* 10.46 ± 3.16	*GPCO* 0.18 ± 0.08	*NBIL* 10.69 ± 2.98	*CELA* 143.33 ± 24.02
3	*GPCO* 7.30 ± 1.53	*DEMI* 0.17 ± 0.04	*CELA* 6.90 ± 1.11	*DEMI* 137.84 ± 20.80
4	*CELA* 6.15 ± 1.18	*S4MO* 0.16 ± 0.05	*S4MO* 6.57 ± 1.39	*S4MO* 135.13 ± 35.06
5	*S4MO* 5.76 ± 1.35	*NBIL* 0.11 ± 0.03	*GPCO* 6.44 ± 0.78	*SDGA* 127.84 ± 23.35
6	*CAMS 35* 4.07 ± 0.71	*BOMA* 0.10 ± 0.02	*CAMS 35* 4.57 ± 0.78	*WADC* 110.77 ± 18.56
7	*RIVA* 3.63 ± 0.65	*RIVA* 0.08 ± 0.04	*PRRI* 4.56 ± 0.70	*RIVA* 106.17 ± 16.89
8	*PRRI* 3.34 ± 0.57	*PXSS* 0.07 ± 0.03	*RIVA* 4.50 ± 0.60	*NBIL* 105.54 ± 31.79
9	*WADC* 2.98 ± 0.51	*CELA* 0.07 ± 0.05	*WADC* 4.41 ± 0.67	*CAMS 35* 92.93 ± 14.64
10	*SDGA* 2.86 ± 0.57	*SDGA* 0.06 ± 0.04	*RUCA* 3.75 ± 0.51	*SKFL* 90.08 ± 17.04

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* 1.02 ± 0.20	TOOK 0.66 ± 0.08	*S4MO* 0.007 ± 0.001	PROK 0.023 ± 0.005	*S4MO* 0.62 ± 0.11	TOOK 0.28 ± 0.06	*CAMS 85* 0.31 ± 0.16
2	*NBIL* 0.75 ± 0.17	TMOK 0.62 ± 0.09	*PXSS* 0.006 ± 0.002	TOOK 0.019 ± 0.003	*BOMA* 0.19 ± 0.02	TMOK 0.23 ± 0.04	*PXSS* 0.13 ± 0.03
3	*BTUT* 0.61 ± 0.15	PROK 0.55 ± 0.07	PAFL 0.004 ± 0.002	OCOK 0.014 ± 0.003	*NBIL* 0.13 ± 0.02	PROK 0.17 ± 0.04	*CAMS 35* 0.05 ± 0.01
4	*SEWA* 0.58 ± 0.09	OCOK 0.44 ± 0.08	*NBIL* 0.004 ± 0.001	TMOK 0.012 ± 0.002	*PXSS* 0.12 ± 0.03	OCOK 0.10 ± 0.01	*DEMI* 0.04 ± 0.01
5	PAFL 0.57 ± 0.10	MWOK 0.44 ± 0.06	*BTUT* 0.003 ± 0.001	MWOK 0.010 ± 0.002	*BTUT* 0.10 ± 0.03	MWOK 0.10 ± 0.01	*S4MO* 0.03 ± 0.01
6	*PXSS* 0.56 ± 0.14		*BOMA* 0.003 ± 0.001		*SEWA* 0.09 ± 0.02		*SEWA* 0.03 ± 0.01
7	*SJJCA* 0.37 ± 0.07		*SJJCA* 0.002 ± <0.001		PAFL 0.06 ± 0.01		*BTUT* 0.03 ± 0.01
8	*BOMA* 0.36 ± 0.05		*SEWA* 0.002 ± 0.001		*SJJCA* 0.06 ± 0.01		*SKFL* 0.02 ± <0.01
9	*UNVT* 0.21 ± 0.04		*UNVT* 0.001 ± <0.001		*UNVT* 0.06 ± 0.01		*NBIL* 0.02 ± <0.01
10							*BOMA* 0.02 ± 0.01

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* 11.66 ± 2.60	TOOK 4.46 ± 0.51	*S4MO* 17.15 ± 7.07	TOOK 23.61 ± 3.15	*SEWA* 1.91 ± 0.48	TOOK 1.10 ± 0.12
2	*PXSS* 3.42 ± 0.71	TMOK 3.72 ± 0.40	*PXSS* 12.38 ± 2.53	TMOK 15.88 ± 1.95	*BOMA* 1.25 ± 0.14	MWOK 0.98 ± 0.17
3	*NBIL* 3.11 ± 0.53	PROK 3.06 ± 0.58	*NBIL* 6.74 ± 1.57	PROK 12.84 ± 2.00	*PXSS* 1.23 ± 0.21	TMOK 0.89 ± 0.11
4	PAFL 3.08 ± 1.34	MWOK 2.69 ± 0.80	*SEWA* 5.75 ± 1.79	OCOK 11.98 ± 1.68	*NBIL* 1.06 ± 0.19	PROK 0.82 ± 0.26
5	*BTUT* 2.68 ± 0.57	OCOK 2.08 ± 0.22	*BTUT* 5.61 ± 0.79	MWOK 9.55 ± 1.41	PAFL 1.05 ± 0.24	OCOK 0.59 ± 0.06
6	*SEWA* 2.63 ± 0.32		*SJJCA* 3.76 ± 0.68		*S4MO* 1.04 ± 0.14	
7	*BOMA* 2.53 ± 0.35		*BOMA* 3.18 ± 0.48		*BTUT* 0.94 ± 0.12	
8	*SJJCA* 2.13 ± 0.44		PAFL 3.04 ± 0.97		*SJJCA* 0.84 ± 0.10	
9	*UNVT* 1.45 ± 0.32		*UNVT* 1.94 ± 0.38		*UNVT* 0.26 ± 0.04	
10						

BOLD ITALICS = EPA-designated NATTS Site.

Some observations from Tables 4-9 through 4-12 include the following:

- The highest annual average concentration among the program-wide pollutants of interest was calculated for formaldehyde for ELNJ (4.46 ± 0.64 µg/m^3). All 10 of the annual averages of formaldehyde and six of the 10 annual averages of acetaldehyde shown in Table 4-10 are higher than the next highest annual average concentration for another analytical method/pollutant.

- Behind ELNJ, BTUT and NBIL have the next highest annual average concentrations of formaldehyde (3.66 ± 0.63 µg/m^3 and 3.59 ± 2.18 µg/m^3, respectively). However, the confidence interval for NBIL's annual average is more than three times that of BTUT or ELNJ. This likely indicates that NBIL's annual average is influenced by outliers while ELNJ and BTUT's concentrations tend to be consistently higher. While less than 1 µg/m^3 separates these three sites' annual averages, their median concentrations range from 1.32 µg/m^3 for NBIL, to 2.94 µg/m^3 for BTUT, to 3.79 µg/m^3 for ELNJ.

- Among the VOC, the annual average concentrations of benzene are the only annual averages consistently greater than 1 ug/m^3. TOOK's annual average benzene concentration (2.34 ± 0.36 µg/m^3) is significantly higher than the next highest annual average (1.72 ± 0.21 µg/m^3 for PACO). TOOK has the four highest benzene measurements and 12 of the 20 highest benzene concentrations among all sites sampling this pollutant. Five of the six Colorado sites have one of the top 10 benzene concentrations; only BMCO does not appear in Table 4-9 for benzene. This site did not begin sampling until September 2010; thus, annual averages could not be calculated.

- The difference between the highest and tenth highest annual average concentration of carbon tetrachloride is only 0.08 µg/m^3. The difference between the highest and lowest annual average concentration of this pollutant among all NMP sites is 0.20 µg/m^3, indicating the relative uniformity in concentrations of this pollutant in ambient air.

- NBIL's annual average chloroform concentration (1.06 ± 0.53 µg/m^3) is nearly two times higher than the next highest annual average (DEMI, 0.63 ± 0.08 µg/m^3). Of the 24 concentrations of chloroform greater than 1 µg/m^3, 13 were measured at NBIL and eight were measured at DEMI.

- BTUT's annual average concentration of *p*-dichlorobenzene has a large confidence interval associated with it, indicating the likely influence of outliers. The highest concentration of *p*-dichlorobenzene measured at BTUT was 21.2 µg/m^3, nearly seven times higher than the next highest measurement of 3.11 µg/m^3 (also measured at BTUT). These were the two highest measurements of this pollutant among sites sampling VOC.

- The top 10 annual average concentrations of 1,2-dichloroethane range from 0.021 µg/m^3 (PROK) to 0.015 µg/m^3 (ELNJ). Although not shown in Table 4-9, the lowest annual average concentration of this pollutant is 0.007 µg/m^3 (TOOK), indicating the relatively small range of concentrations measured for this pollutant.

- Note the relatively large confidence intervals associated with three of the top four annual average concentrations of ethylbenzene. This likely indicates the presence of outliers. Of the seven measurements of ethylbenzene greater than 5 µg/m^3, one was measured at UCSD (31.5 µg/m^3,) two were measured at PACO (26.7 µg/m^3 and 11.9 µg/m^3), and two at RICO (25.7 µg/m^3 and 6.73 µg/m^3). Note that the second highest concentration of ethylbenzene measured at UCSD is 2.08 µg/m^3. Also, the median concentrations of ethylbenzene for each of these three sites is less than half the annual averages, while SPAZ's median concentration (0.62 µg/m^3) is much closer to the respective annual average (0.76 µg/m^3), indicating that SPAZ's concentrations tended to be consistently higher compared to the other three sites.

- SPIL's annual average concentration of trichloroethylene (0.79 ± 0.40 µg/m^3) is more than seven times higher than the next highest annual average (BTUT, 0.09 ± 0.11 µg/m^3). Of the 18 concentrations of trichloroethylene greater than 1 µg/m^3, 15 were measured at SPIL.

- Among the sites sampling PAHs, the annual averages for DEMI, GPCO, and S4MO are among the top five for each of the four PAH pollutants of interest.

- Although GPCO has the highest annual average concentration of naphthalene, the highest measurements of this pollutant were not measured at this site. Three of the New York sites measured some of the highest concentrations of naphthalene. In particular, the TONY site has the two highest measurements among all sites sampling naphthalene. TONY has 9 of 15 concentrations greater than 500 ng/m^3 and BXNY and MONY have one each. However, annual averages could not be calculated for these three sites due to abbreviated sampling durations.

- CAMS 85 has the highest annual average concentration of hexavalent chromium. CAMS 85 is the only site with hexavlanet chromium concentrations greater than 1 ng/m^3 (ranging from 1.17 ng/m^3 to 3.51 ng/m^3). The annual average concentration of hexavalent chromium for CAMS 85 is more than twice the next highest annual average (PXSS). Both of these annual averages are an order of magnitude higher than the other listed sites. Of the 25 measurements of hexavalent chromium greater than 0.25 ng/m^3, 17 were measured at CAMS 85 and eight at PXSS.

- S4MO has the highest annual average concentration of five of the six PM$_{10}$ metals: arsenic, beryllium, cadmium, lead, and manganese. In addition, S4MO's annual average nickel concentration ranks sixth. Moreover, S4MO's annual averages of cadmium, lead, and manganese are significantly higher than the other annual averages listed. S4MO is the only site sampling PM$_{10}$ metals with cadmium concentrations greater than 1 ng/m^3 (11 ranging from 1.01 to 2.05 ng/m^3). The 12 highest concentrations of lead were measured at S4MO (ranging from 18.0 ng/m^3 to 47.8 ng/m^3). The highest manganese concentration among all sites sampling PM$_{10}$

metals was measured at S4MO (200 ng/m^3) and was an order of magnitude higher than the next highest manganese concentration (84.5 ng/m^3), also measured at S4MO.

- 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.

- S4MO was on the top 10 list for 21 of the 24 program-level pollutants of interest; PXSS and BTUT were both on the top 10 list for 17 of the 24 program-level pollutants of interest. NBIL appears in Tables 4-9 through 4-12 a total of 16 times. Conversely, 13 sites do not appear in Table 4-9 through 4-12 at all. However, some sites did not meet the criteria for annual averages to be calculated.

4.2.2   Risk Screening Assessment Using MRLs

A summary of the program-level MRL risk assessment is presented in Table 4-13. Dichloromethane and formaldehyde are the only pollutants with at least one concentration or time-period average concentration greater than their respective ATSDR heath risk benchmarks. Out of 1,495 measured detections of formaldehyde, one concentration is higher than the ATSDR acute MRL (50 µg/m^3), which was measured at NBIL. Two measured detections of dichloromethane are greater than the ATSDR acute MRL for dichloromethane (2,000 µg/m^3), which were measured at BTUT and GPCO. Concentrations that are greater than their respective acute MRL are discussed on a site-specific basis in further detail in Sections 5 through 28.

Out of 103 quarterly averages of formaldehyde, none of the quarterly averages are greater than the ATSDR intermediate MRL (40 µg/m^3). None of the quarterly averages of dichloromethane are greater than the ATSDR intermediate MRL (1,000 µg/m^3). In addition, none of the annual averages of either formaldehyde or dichloromethane are greater than their respective ATSDR chronic MRLs (10 µg/m^3 and 1,000 µg/m^3, respectively). Graphical displays of the site-specific quarterly averages for the program-level pollutants of interest are presented and discussed in Section 4.4.2.

Table 4-13. Program-Level MRL Risk Screening Assessment

Sampling Method	Pollutant	Acute Risk		Intermediate Risk					Chronic Risk	
		ATSDR Acute MRL[1] ($\mu g/m^3$)	# of Concentrations > MRL/ # of Measured Detections	ATSDR Intermediate MRL[1] ($\mu g/m^3$)	# of 1st Quarter Avg Conc > MRL/ # of Quarterly Averages	# of 2nd Quarter Avg Conc > MRL/ # of Quarterly Averages	# of 3rd Quarter Avg Conc > MRL/ # of Quarterly Averages	# of 4th Quarter Avg Conc > MRL/ # of Quarterly Averages	ATSDR Chronic MRL[1] ($\mu g/m^3$)	# of Annual Avg Conc > MRL/ # of Annual Averages
TO-11A	Formaldehyde	50	1/1,495	40	0/23	0/28	0/27	0/25	10	0/24
TO-15	Dichloromethane	2,000	2/1,263	1,000	0/22	0/22	0/23	0/23	1,000	0/22

[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

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, 2012e). 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 Union County, SD, and Chesterfield County, SC (where UCSD and CHSC are located, respectively). Estimated non-road county emissions were also highest in Los Angeles County, CA, followed by Cook County, IL and Maricopa County, AZ. Estimated non-road county emissions were lowest in Carter County, KY (where GLKY is located), and Union County, SD.

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

Site	County-level Motor Vehicle Registration (# of Vehicles)	Estimated 10-Mile Vehicle Ownership (# of Vehicles)	Annual Average Daily Traffic (# of Vehicles)	County-level Daily VMT	County-Level On-road Emissions[1] (tpy)	County-Level Non-road Emissions[1] (tpy)	Hydrocarbon Average[2] (ppbv)
AZFL	879,317	532,212	41,500	23,138,726	2,650.97	1,157.75	NA
BMCO	74,847	7,921	2,527	1,942,038	260.03	93.05	NA
BOMA	501,587	1,158,723	31,400	NA	715.05	440.97	NA
BRCO	74,847	32,230	150	1,942,038	260.03	93.05	NA
BTUT	239,754	201,757	113,955	7,360,752	861.85	336.23	4.37
BURVT	223,316	165,680	4,000	4,027,945	371.91	251.44	2.76
BXNY	248,600	1,181,520	100,230	NA	825.34	391.72	NA
CAMS 35	3,115,974	542,457	31,043	NA	8,521.88	2,791.78	NA
CAMS 85	69,883	3,224	1,400	NA	284.17	129.54	NA
CELA	7,410,625	2,774,128	235,000	211,876,660	9,556.40	5,072.27	NA
CHNJ	389,359	193,281	12,917	14,256,044	1,202.20	705.27	1.13
CHSC	40,431	4,856	550	1,302,685	128.86	80.37	NA
DEMI	1,336,940	796,952	106,900	47,115,093	5,900.70	1,113.36	3.01
ELNJ	424,894	1,723,298	250,000	12,485,902	951.86	390.19	5.55
GLKY	36,031	21,977	428	1,164,000	163.87	15.58	1.24
GPCO	180,119	144,154	12,000	2,047,739	392.28	180.83	4.66
HOWI	98,211	23,836	5,000	2,659,643	247.41	220.50	NA
INDEM	182,989	150,152	52,440	11,801,000	1,222.76	634.27	NA
MONY	248,600	1,181,520	134,421	NA	825.34	391.72	NA
MWOK	809,783	406,137	41,200	NA	2,900.47	816.74	2.10
NBIL	2,083,141	344,352	34,100	89,621,776	7,721.47	4,074.66	2.27
NBNJ	640,893	619,349	114,322	20,415,685	1,617.22	673.13	1.98
OCOK	809,783	426,788	41,600	NA	2,900.47	816.74	2.13
ORFL	1,037,369	905,833	31,500	35,657,527	3,198.03	1,587.49	NA
PACO	74,847	10,530	2,600	1,942,038	260.03	93.05	NA
PAFL	1,037,369	787,532	43,500	35,657,527	3,198.03	1,587.49	NA

[1]Reference: EPA, 2012b
[2]This parameter is only available for monitoring sites sampling VOC.
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 (# of Vehicles)	Estimated 10-Mile Vehicle Ownership (# of Vehicles)	Annual Average Daily Traffic (# of Vehicles)	County-level Daily VMT	County-Level On-road Emissions[1] (tpy)	County-Level Non-road Emissions[1] (tpy)	Hydrocarbon Average[2] (ppbv)
PANJ	396,602	1,053,264	22,272	8,178,167	616.98	447.26	7.05
PROK	40,832	26,447	15,900	NA	172.07	83.98	1.96
PRRI	485,837	511,525	136,800	NA	1,104.51	381.46	NA
PXSS	3,739,918	1,439,566	193,000	89,448,000	7,862.48	3,819.27	4.59
RICO	74,847	23,520	17,000	1,942,038	260.03	93.05	NA
RIVA	347,790	520,602	74,000	8,260,273	831.85	188.91	NA
ROCH	552,184	474,074	116,725	NA	1,566.25	683.88	NA
RUCA	1,707,950	767,438	145,000	55,167,650	2,486.42	1,003.76	NA
RUCO	74,847	23,520	699	1,942,038	260.03	93.05	NA
RUVT	118,002	65,811	7,200	1,766,027	158.14	150.60	2.77
S4MO	1,121,528	690,875	81,174	23,385,327	974.72	182.60	3.28
SDGA	472,535	541,355	145,890	21,057,000	2,272.55	772.13	NA
SEWA	1,763,504	866,590	234,000	23,454,115	6,932.11	2,762.29	1.99
SJJCA	1,517,995	1,262,220	103,000	39,402,370	1,960.08	812.60	NA
SKFL	879,317	644,692	49,500	23,138,726	2,650.97	1,157.75	NA
SPAZ	3,739,918	878,323	130,000	89,448,000	7,862.48	3,819.27	5.85
SPIL	2,083,141	819,706	170,700	89,621,776	7,721.47	4,074.66	2.91
SSSD	208,911	234,348	21,340	3,716,475	467.40	132.93	1.74
SYFL	1,125,844	295,497	10,700	34,745,256	3,252.93	1,326.89	NA
TMOK	604,284	319,719	12,700	NA	2,197.21	867.85	3.57
TONY	669,746	436,105	74,406	NA	1,954.05	678.01	NA
TOOK	604,284	455,374	62,566	NA	2,197.21	867.85	4.15
UCSD	25,051	10,630	156	790,541	91.81	30.98	1.51
UNVT	223,316	50,202	1,200	4,027,945	371.91	251.44	0.85
WADC	211,653	669,201	7,700	NA	929.71	327.98	NA
WPIN	204,908	178,215	143,410	35,081,000	2,664.97	715.48	NA

[1]Reference: EPA, 2012b
[2]This parameter is only available for monitoring sites sampling VOC.
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. According to the EPA, approximately 47 percent of hydrocarbon emissions are from mobile sources (both on-road and non-road) (EPA, 2012i). 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 VOC. Note that only sites sampling VOC have data in this column. Table 4-14 shows that PANJ, SPAZ, and ELNJ had the highest hydrocarbon averages among the sites monitoring VOC. Each of these sites is located in a highly populated urban area and in close proximity to heavily traveled roadways. For example, ELNJ is located near Exit 13 on I-95 near New York City.

The sites with the lowest hydrocarbon averages are UNVT, CHNJ, and GLKY. All three sites are located in rural areas. However, CHNJ is still located within the New York City MSA, although on the periphery. The daily average hydrocarbon concentration 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 the 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 hydrocarbon concentration are presented in Table 4-14. As previously discussed, PANJ, SPAZ, and ELNJ had the highest average hydrocarbon concentrations, respectively, while UNVT, CHNJ, and GLKY had the lowest. Table 4-14 also shows that SPAZ, PXSS, NBIL, and SPIL had the highest county-level vehicle ownership of the sites sampling VOC, while UCSD, GLKY, and PROK have the lowest. CELA, which had the highest county-level vehicle ownership of all the sites, did not sample VOC. The Pearson correlation coefficient calculated between these two datasets is 0.32. While this correlation falls below the "strong" classification, it does indicate a positive correlation between hydrocarbon concentrations and vehicle registration.

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 (from Table 2-2) to estimate a 10-mile population, which is 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 VOC, while UCSD, GLKY, and PROK have the lowest. Again, CELA, which had the highest 10-mile estimated vehicle ownership of all the sites, did not sample VOC under the NMP. The Pearson correlation coefficient calculated between the average hydrocarbon calculations and the 10-mile vehicle registration estimates is 0.63. This represents a strong positive correlation, indicating that as vehicle registration inside the 10-mile radius increases, concentration of hydrocarbons tend to proportionally increase.

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 the ambient air.

4.3.4 Estimated Traffic Volume

In NMP reports prior to 2007, traffic data, which represents the average number of vehicles passing a monitoring site on a daily basis, were obtained from AQS. However, much of the populated traffic data reflected traffic conditions during site initiation, and were often 5 or more years old. Thus, beginning with the 2007 NMP report, updated traffic data 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 2010, primarily 2008-2010. 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 site.

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 PXSS have the highest daily traffic volume of the sites sampling VOC, while UCSD, GLKY, and UNVT, have the lowest. For all monitoring sites (not just those sampling VOC), 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 third highest hydrocarbon average (behind PANJ and SPAZ), but SEWA, PXSS, and SPIL, which have the second, third, and fourth highest traffic volumes, have the 17th, 5th, and 11th highest hydrocarbon averages, respectively. CELA did not measure VOC. A Pearson correlation coefficient calculated between the average hydrocarbon calculations and the traffic counts is 0.36. 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 from 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. 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), SPIL and NBIL (Cook County, IL), and PXSS and SPAZ (Maricopa County, AZ). The sites with the lowest county-level VMT, where available, are UCSD (Union County, SD), GLKY (Carter County, KY), and CHSC (Chesterfield County, SC). A Pearson correlation coefficient calculated between the average hydrocarbon concentrations and VMT, where available is relatively weak (0.23), although indicating a slight positive relationship between the two. However, this correlation is higher than correlations calculated for the 2007 and 2008-2009 NMP reports (-0.02 and 0.06, respectively). It is important to note that many of the sites with larger VMT did not measure VOC (such as CELA, RUCA, and SJJCA). In addition, county-level VMT were not readily available for Rhode Island, New York, Oklahoma, Massachusetts, Texas, and the District of Columbia.

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 coefficient of variations and the inter-site comparison analyses are discussed together in this section. Figures 4-1a through 4-24a are graphical displays of site-specific coefficient of variations (standard deviation vs. annual average concentration) for the program-level pollutants of interest. Figures 4-1b through 4-24b are graphs depicting the site-specific annual averages overlain on the program-level average, as discussed in Section 4.1. For each program-wide pollutants of interest, the coefficient of variation 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 average concentration and/or standard deviation in the coefficient of variation graph is easily identified 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).

A couple of 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 coefficient of variation graphs either. For the sites sampling metals, sites collecting PM_{10} samples are presented in green while sites collecting TSP samples are presented in pink.

The coefficient of variation 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 coefficients of variation shown in Figure 4-10 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 µg/m^3 (GPCO) to 0.72 µg/m^3 (SEWA and NBIL). Further, the confidence intervals for all sites are less than 0.1 µg/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 larger than the x-axis scale for the annual average concentration. This indicates that there is more variability in the annual average concentrations themselves, as indicated in Figure 4-13b by the relatively large confidence intervals. This pollutant was not detected frequently (17 percent of samples) and therefore has many zero substitutions included in each annual average, which contributes to both the low range of annual average concentrations and the large confidence intervals.

Several of the coefficients of variations for the program-wide pollutants of interest follow a linear trend line. Many of the annual averages of acetaldehyde, benzene, and tetrachloroethylene exhibit this trend, as shown in Figures 4-2a, 4-5a, and 4-22a, respectively. This means that as the annual averages increase, so do the standard deviations, indicating increasing variability. This increased variability is a result of an increased range of individual measurements that are used to calculate the annual average. This is supported by the inter-site variability shown in Figures 4-2b, 4-5b, and 4-22b. The annual averages that extend well above the program average for each pollutant tend to have a wider confidence interval associated with them, indicating the likely influence of outliers. The annual averages well below the program average tend to have much smaller confidence intervals.

Trichloroethylene appears to exhibit clustering in Figure 4-23a; however, trichloroethylene is detected infrequently and yields 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 SPIL's annual average and standard deviation was removed and the scales adjusted, the trichloroethylene concentrations would show more variability. The annual average trichloroethylene concentration for SPIL is nearly eight times the annual average

4-40

trichloroethylene concentration for any other site, as shown in both Figure 4-23a and 4-23b. If the four highest concentrations (those greater than 2 µg/m^3) were removed from the calculation, SPIL's annual average would still be 0.44 ± 0.14 µg/m^3, and more than four times the next highest annual average (BTUT). SPIL's annual average trichloroethylene concentration is discussed in Section 4.2.1.

Although many of the other pollutants do not exhibit easily classifiable clustering, or even 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 exhibited for *p*-dichlorobenzene in Figure 4-12a indicates that this particular average is likely influenced by outliers. Figure 4-12b shows that this is BTUT's annual average, which is discussed in more detail in Section 4.2.1. Excluding this data point would allow the rest to follow a more linear trend line. The same is true for formaldehyde. The larger standard deviation exhibited for NBIL in Figure 4-16a indicates that this particular annual average was likely influenced by outliers. Although NBIL's annual average concentration of formaldehyde is not the highest among sites sampling this pollutant, its confidence interval is the largest, as shown in Figure 4-16b. This annual average is discussed also discussed in Section 4.2.1 as well as Section 4.2.2. Excluding this data point would allow the rest to follow a more linear trend line.

Another example is shown in Figures 4-3a and 4-3b for acrylonitrile. The annual averages for NBNJ, S4MO, and SPAZ are shown by the data points with the high standard deviations in Figure 4-3a and by the large confidence intervals in Figure 4-3b. Without these three data points on the coefficient of variation graph, Figure 4-3a would exhibit clustering around the annual average concentration. However, the standard deviations are relatively large due predominantly to the large number of zeros substituted for non-detects (a 12 percent detection rate). Vinyl chloride is another infrequently detected pollutant (less than 5 percent detection rate) for which the annual averages have very large standard deviations in Figure 4-24a and large confidence intervals in Figure 4-24b. While Figure 4-24a appears to show that coefficient of variations for this pollutant follow a linear pattern, this figure also indicates a high variability in the concentrations, as shown by the standard deviations (note how many of the standard deviations are more than double the corresponding annual averages). Further, the confidence intervals for nearly all the sites shown in Figure 4-24b are large.

Figure 4-1a. Coefficient of Variation Analysis of Acenaphthene Across 26 Sites
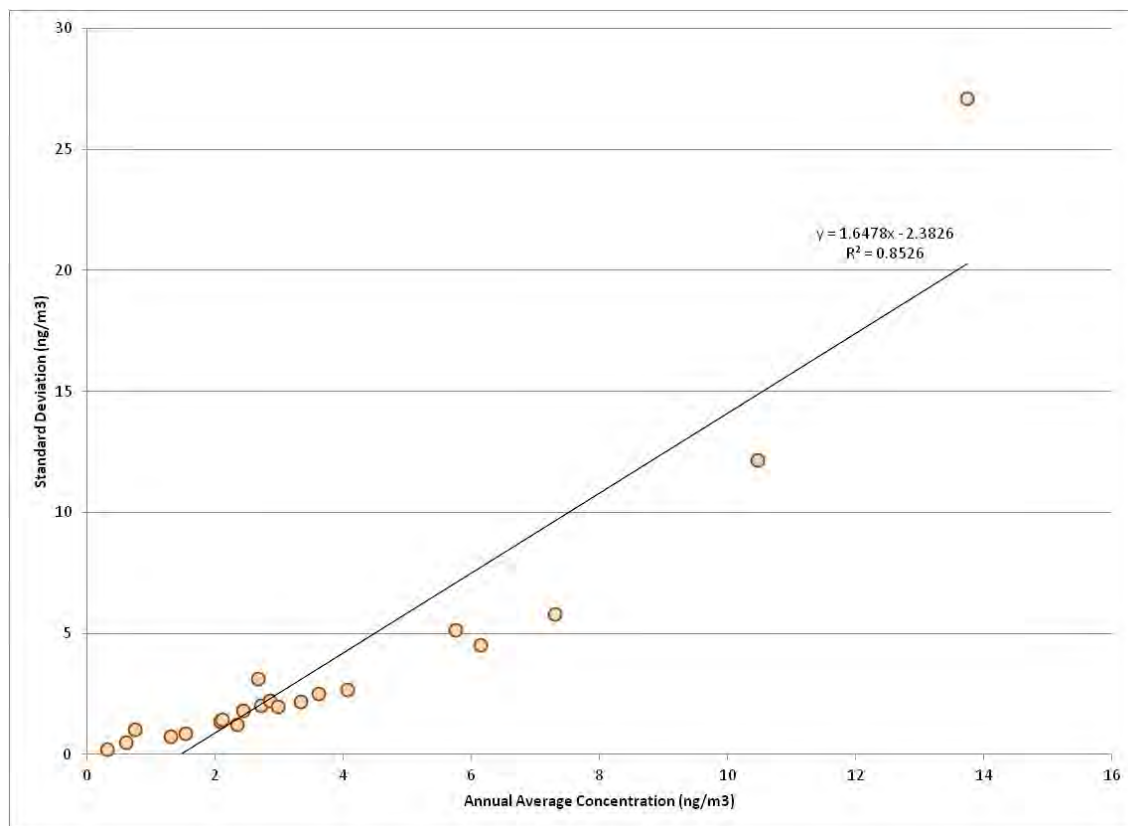
Figure 4-1b. Inter-Site Variability for Acenaphthene
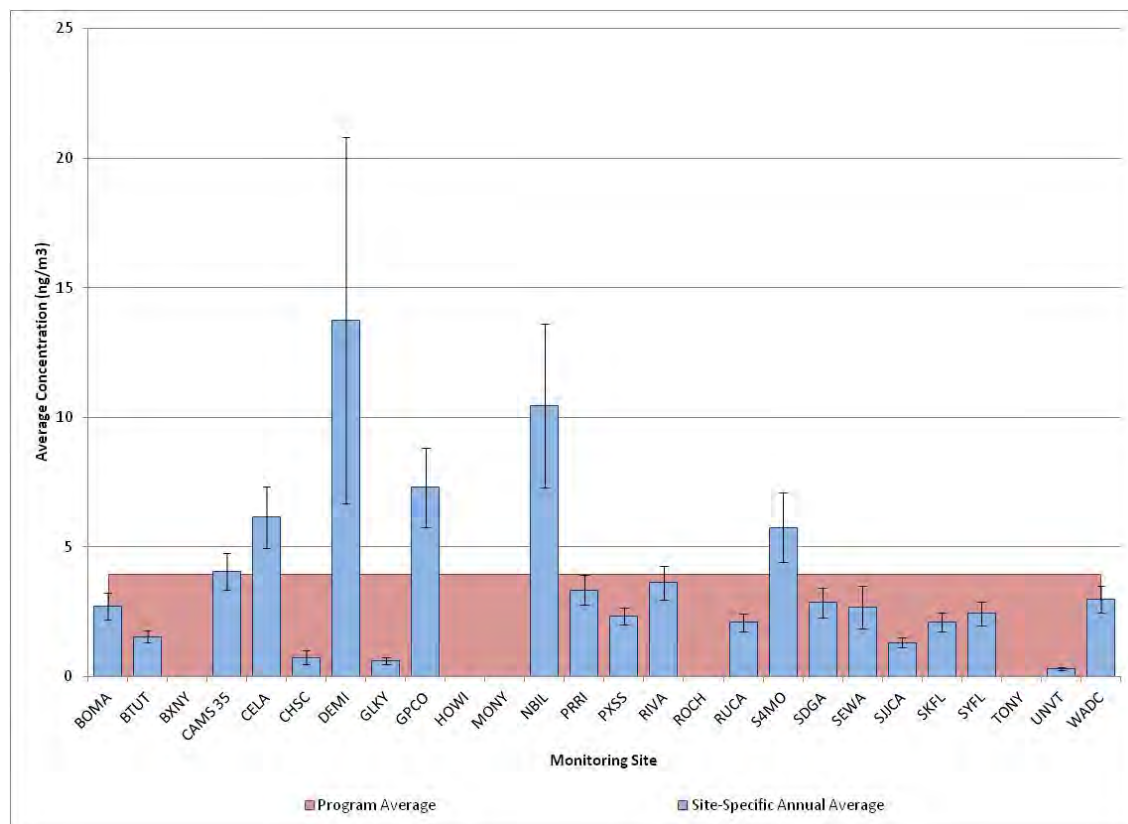
Figure 4-2a. Coefficient of Variation Analysis of Acetaldehyde Across 30 Sites
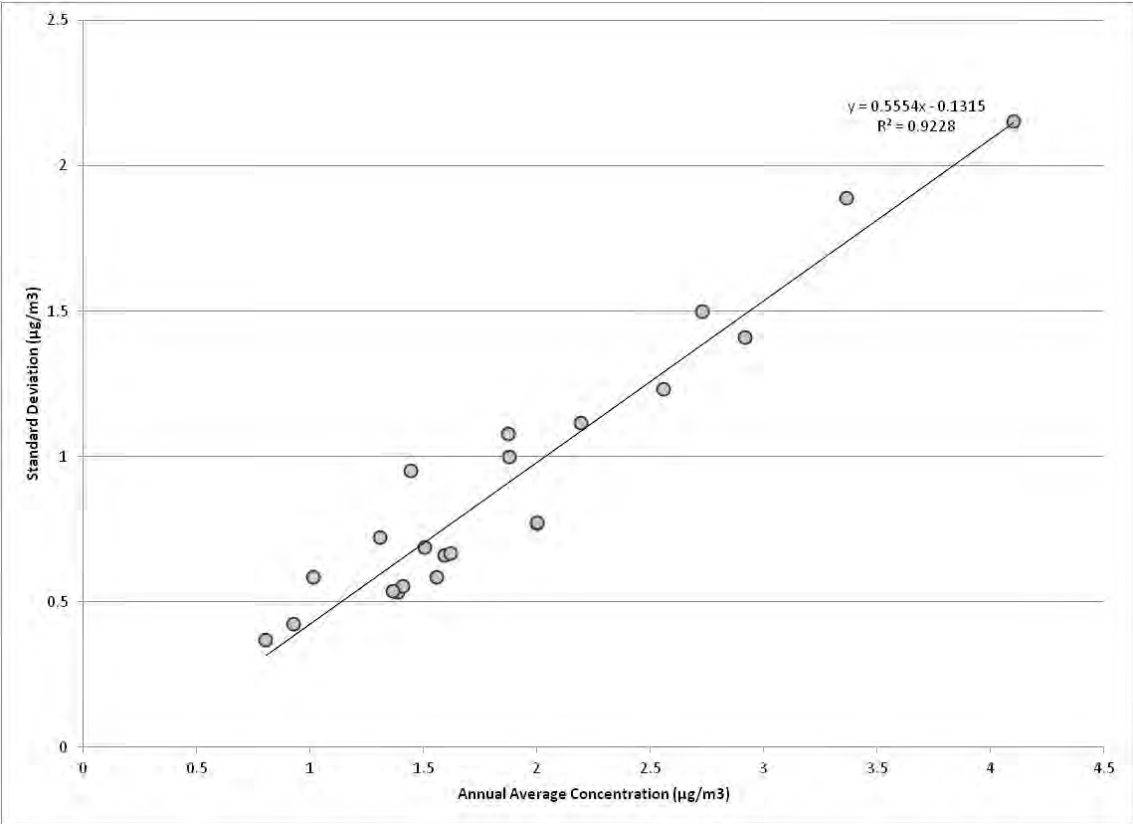
Figure 4-2b. Inter-Site Variability for Acetaldehyde
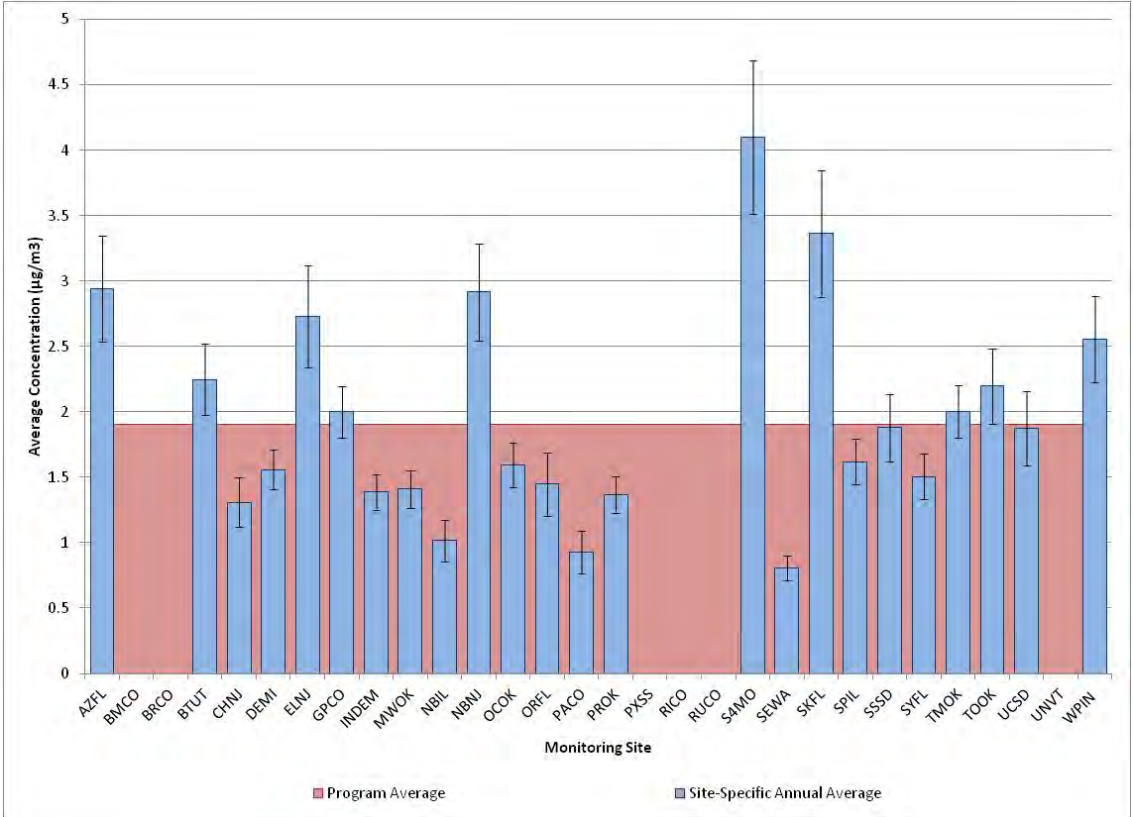
Figure 4-3a. Coefficient of Variation Analysis of Acrylonitrile Across 24 Sites
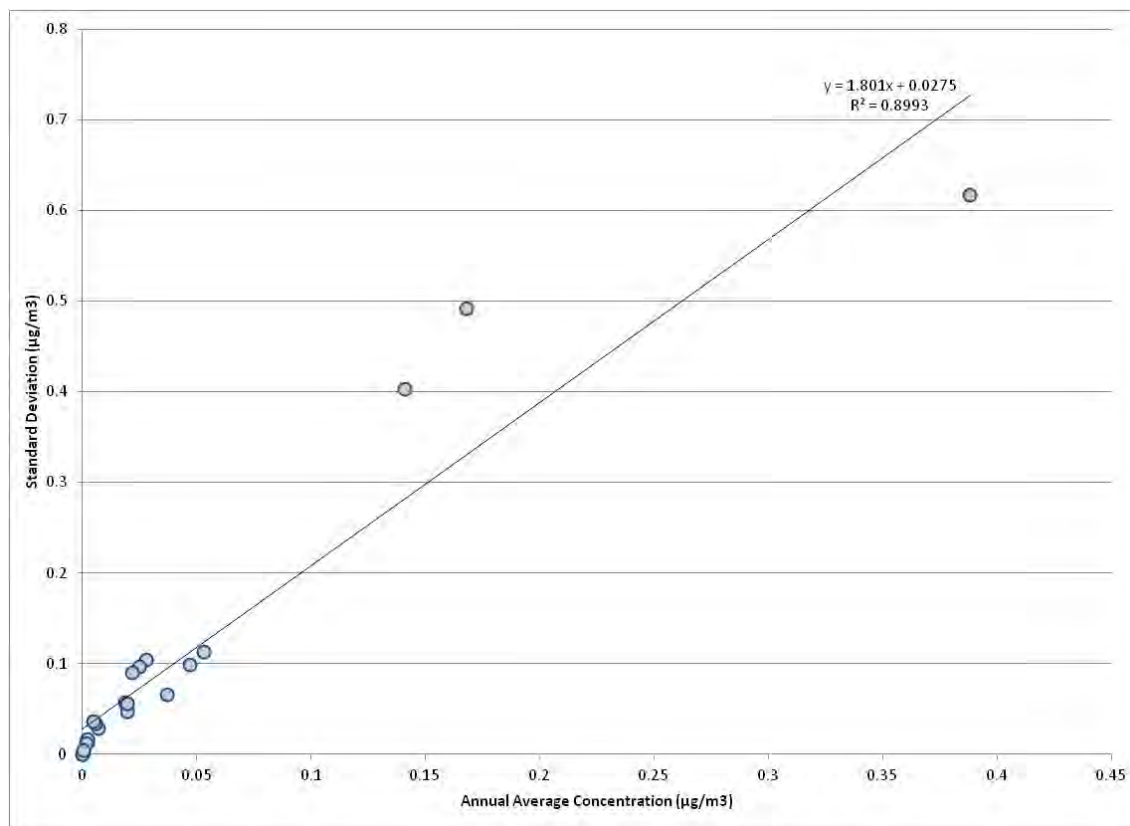
Figure 4-3b. Inter-Site Variability for Acrylonitrile
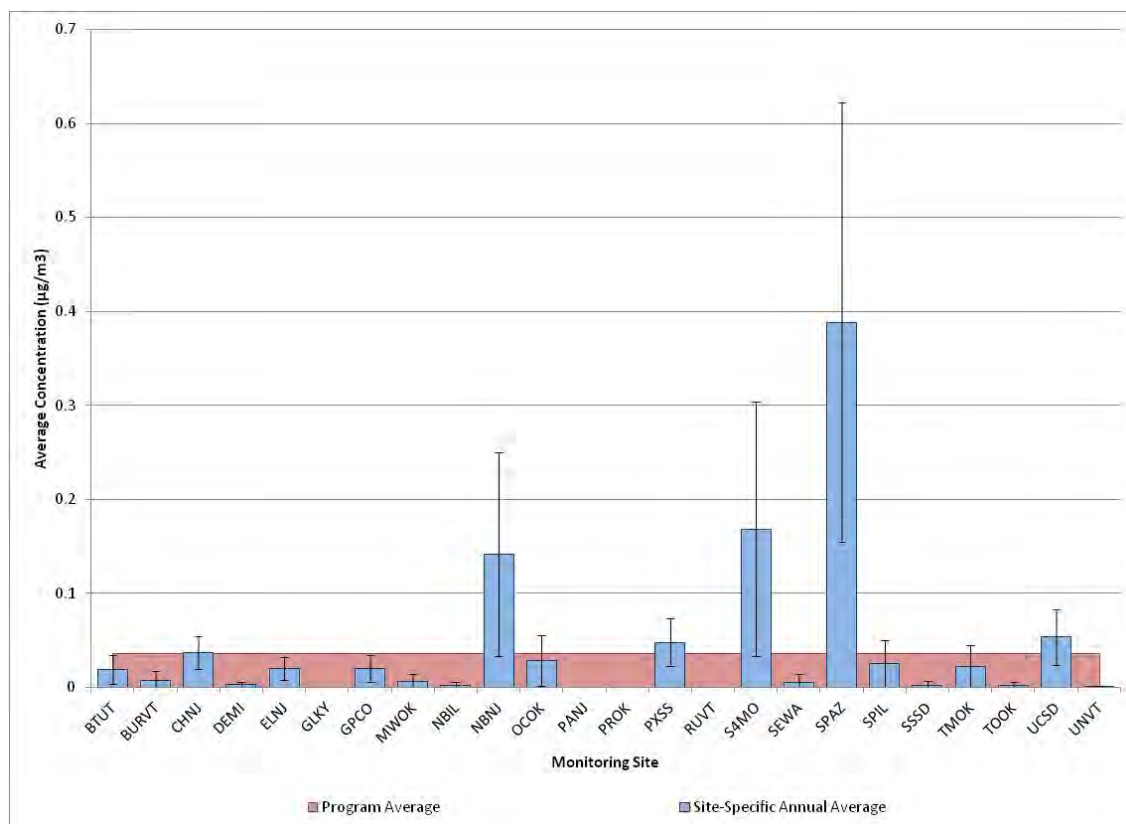
Figure 4-4a. Coefficient of Variation Analysis of Arsenic Across 14 Sites
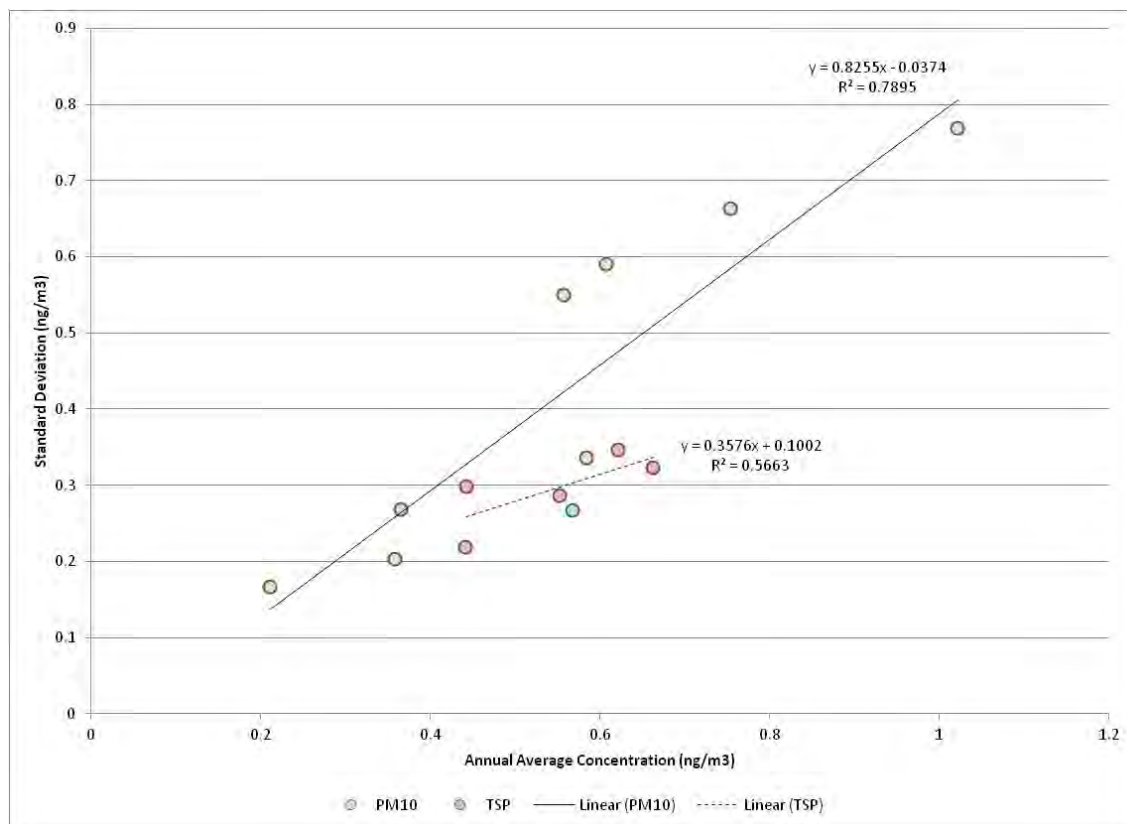
Figure 4-4b. Inter-Site Variability for Arsenic
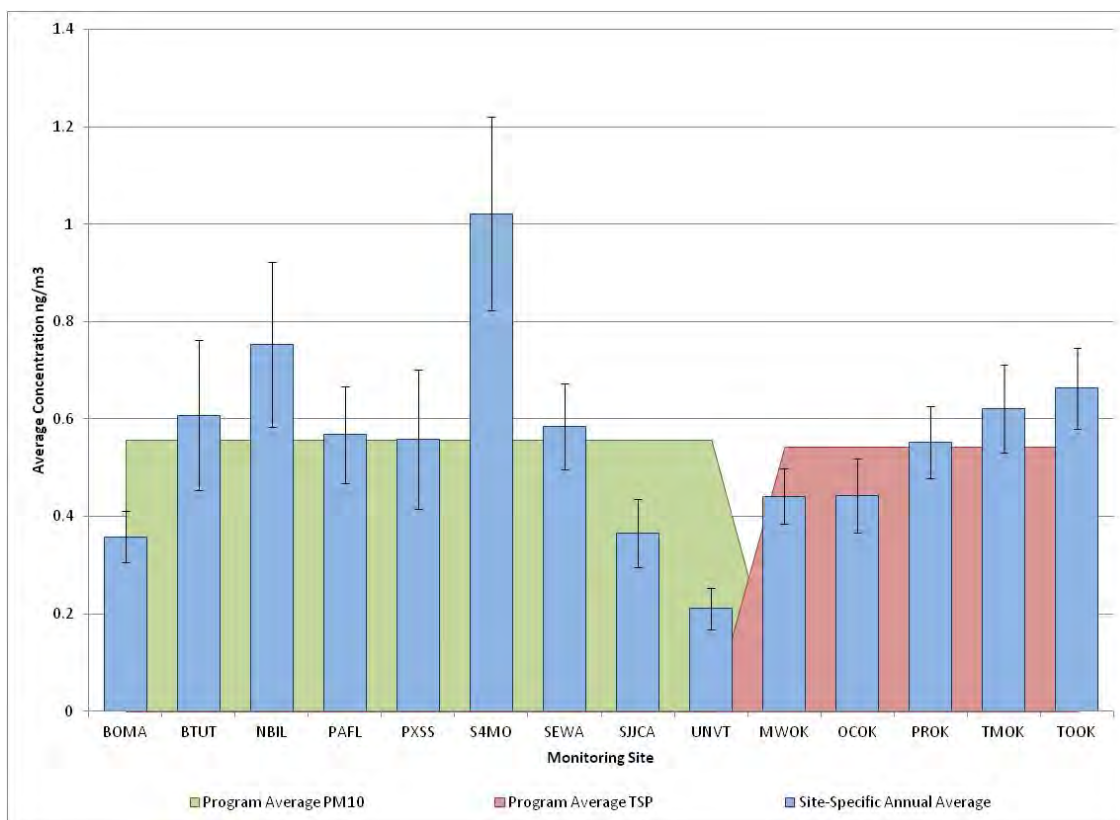
Figure 4-5a. Coefficient of Variation Analysis of Benzene Across 24 Sites
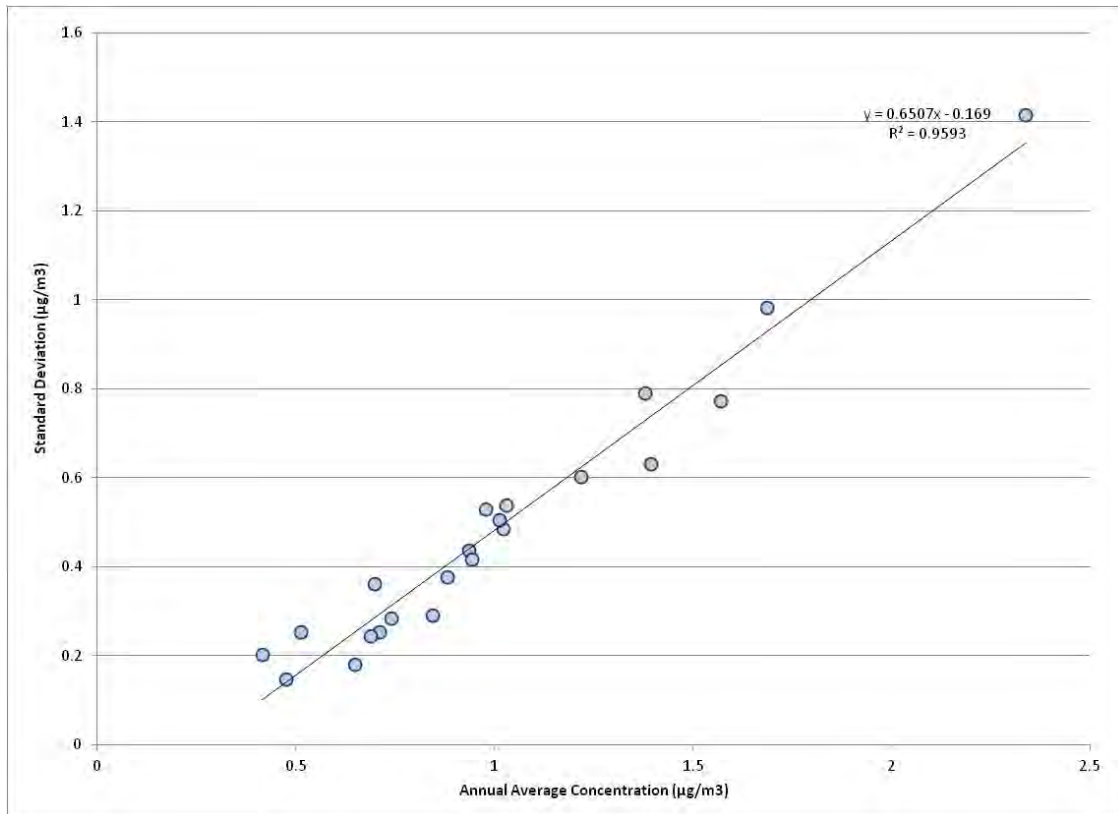
Figure 4-5b. Inter-Site Variability for Benzene
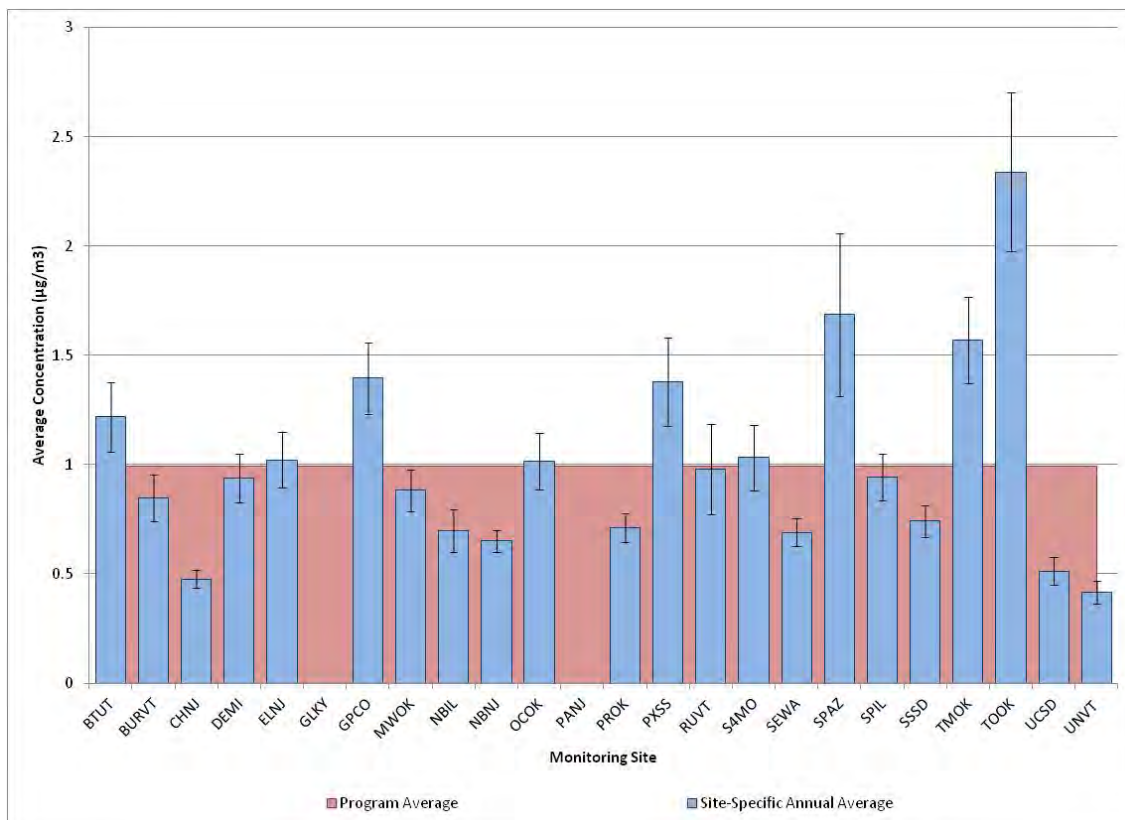
Figure 4-6a. Coefficient of Variation Analysis of Benzo(a)pyrene Across 26 Sites
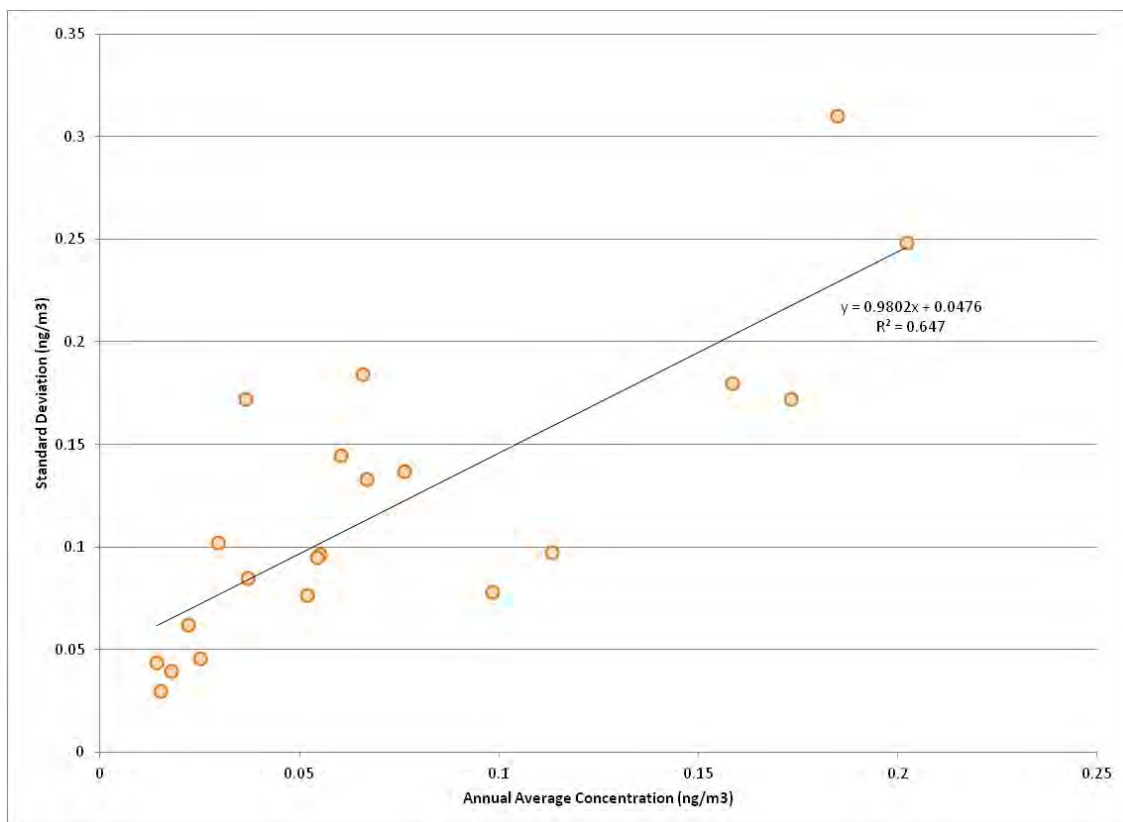
Figure 4-6b. Inter-Site Variability for Benzo(a)pyrene
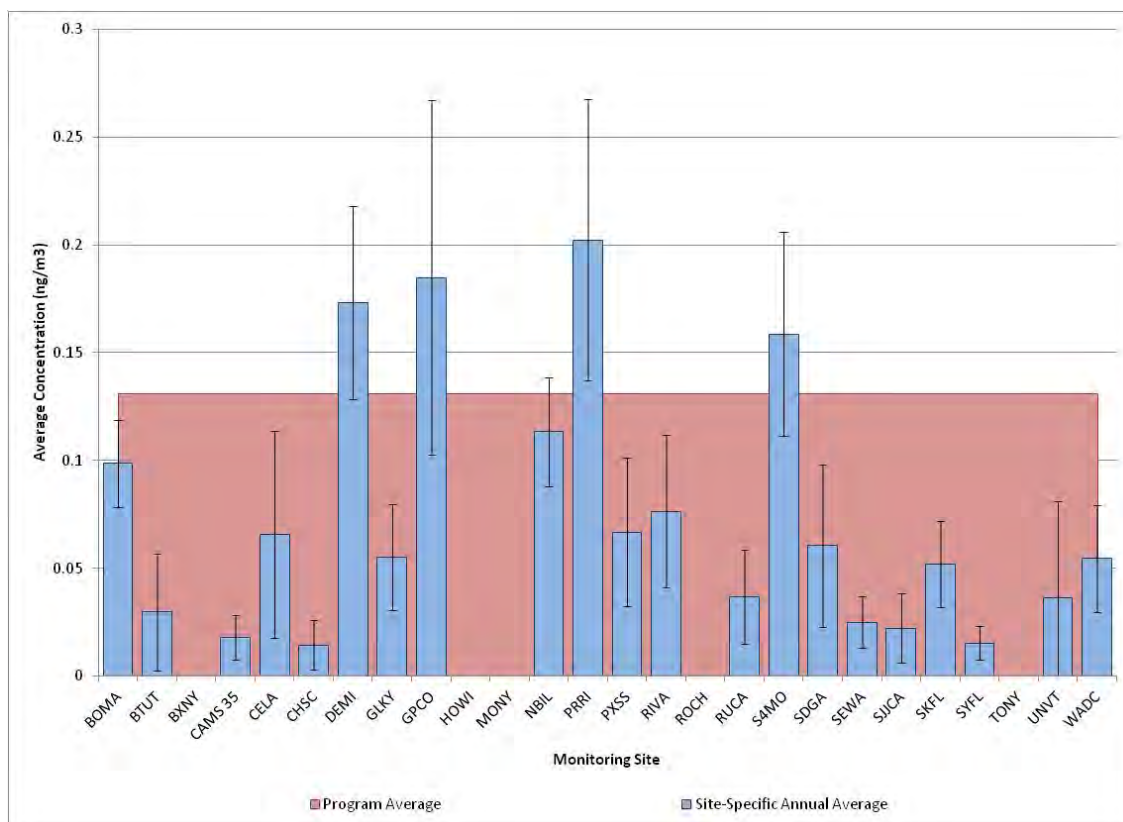
Figure 4-7a. Coefficient of Variation Analysis of Beryllium Across 14 Sites
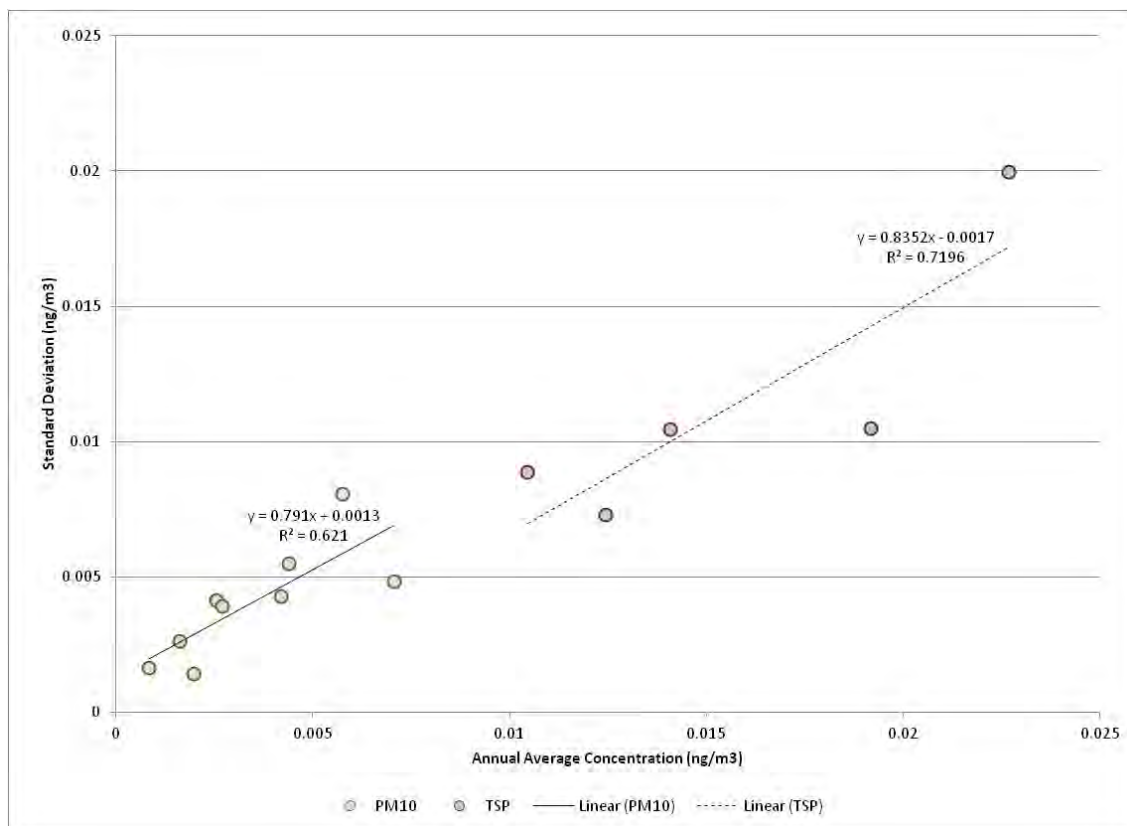
Figure 4-7b. Inter-Site Variability for Beryllium
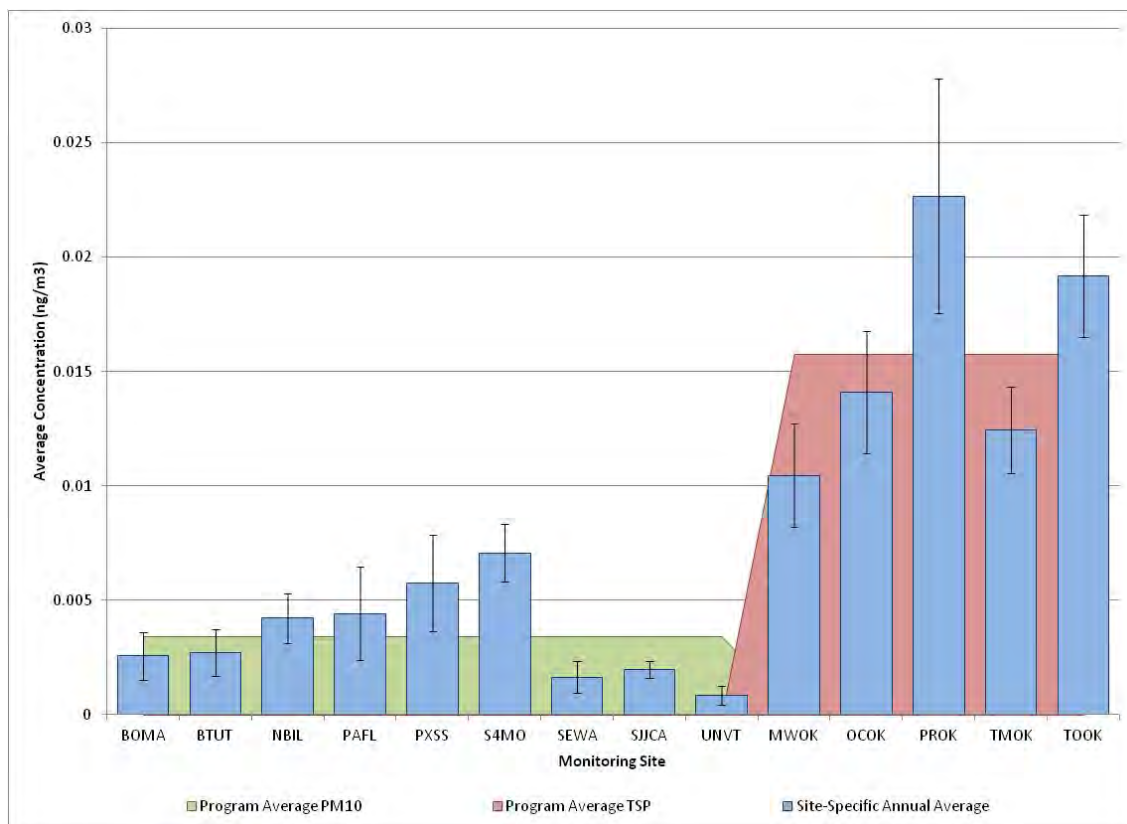
Figure 4-8a. Coefficient of Variation Analysis of 1,3-Butadiene Across 24 Sites
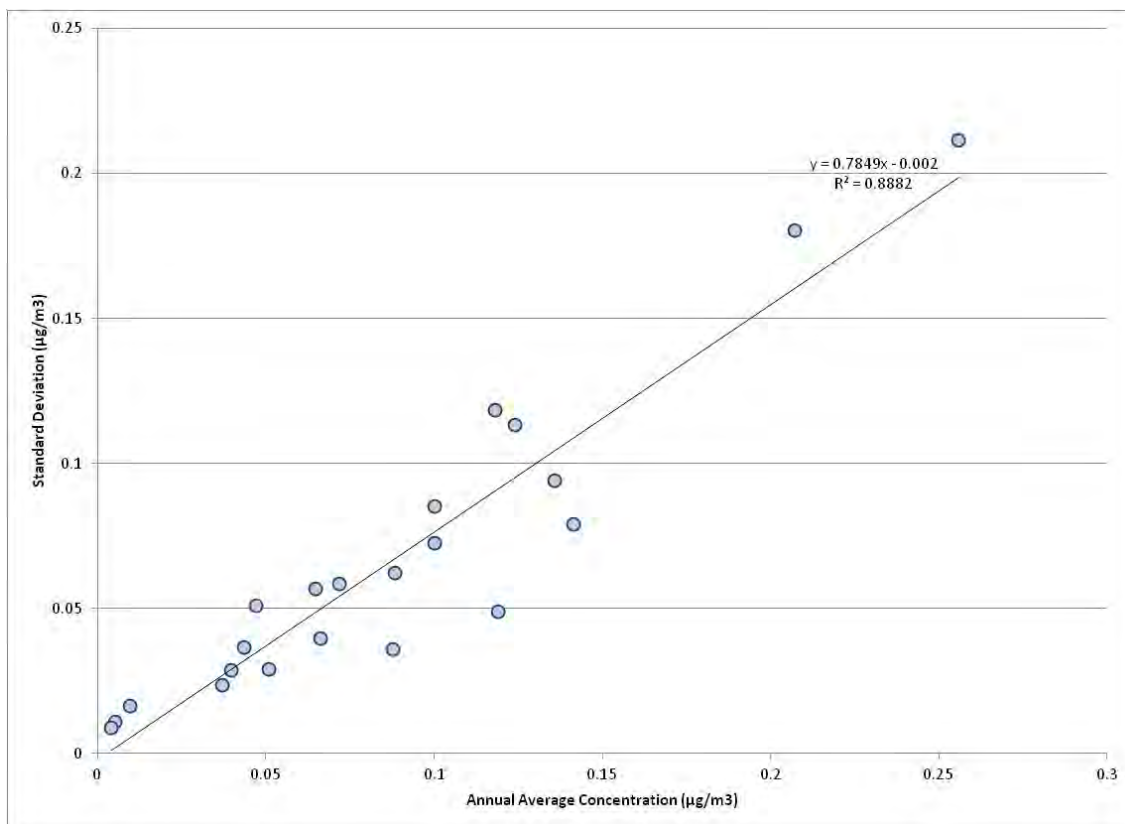
Figure 4-8b. Inter-Site Variability for 1,3-Butadiene
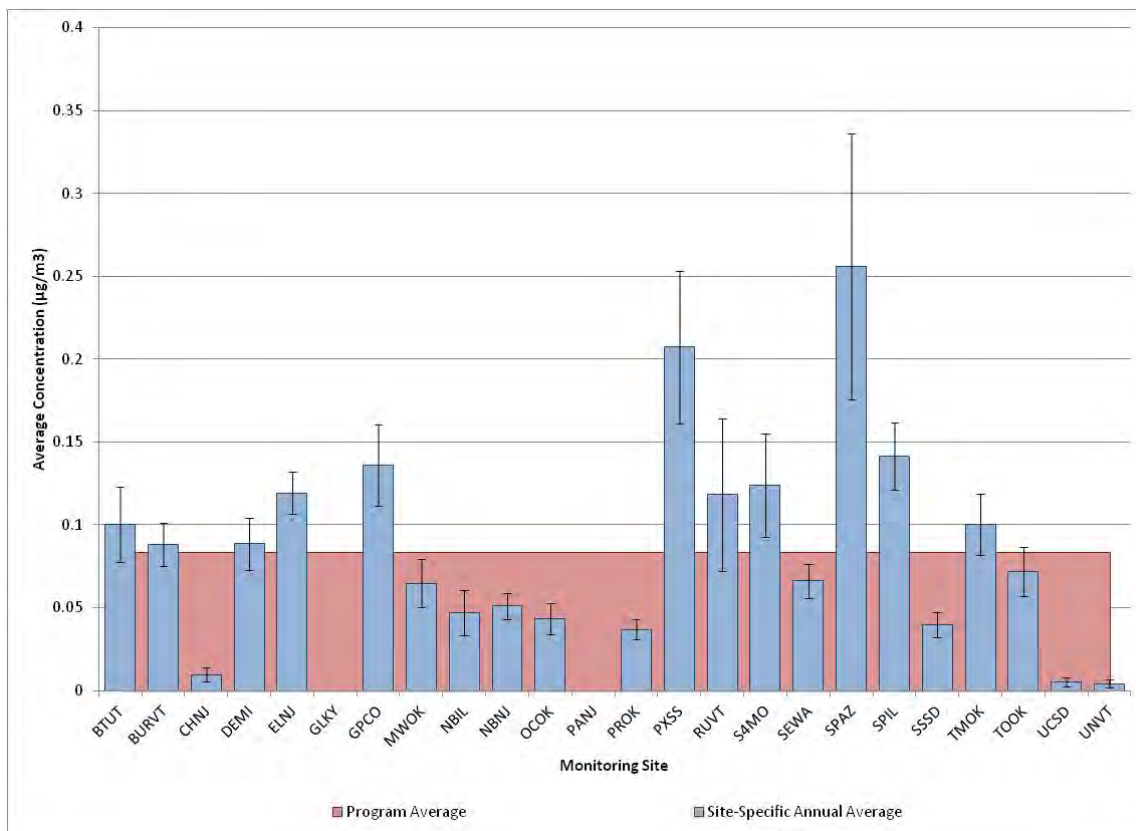
Figure 4-9a. Coefficient of Variation Analysis of Cadmium Across 14 Sites
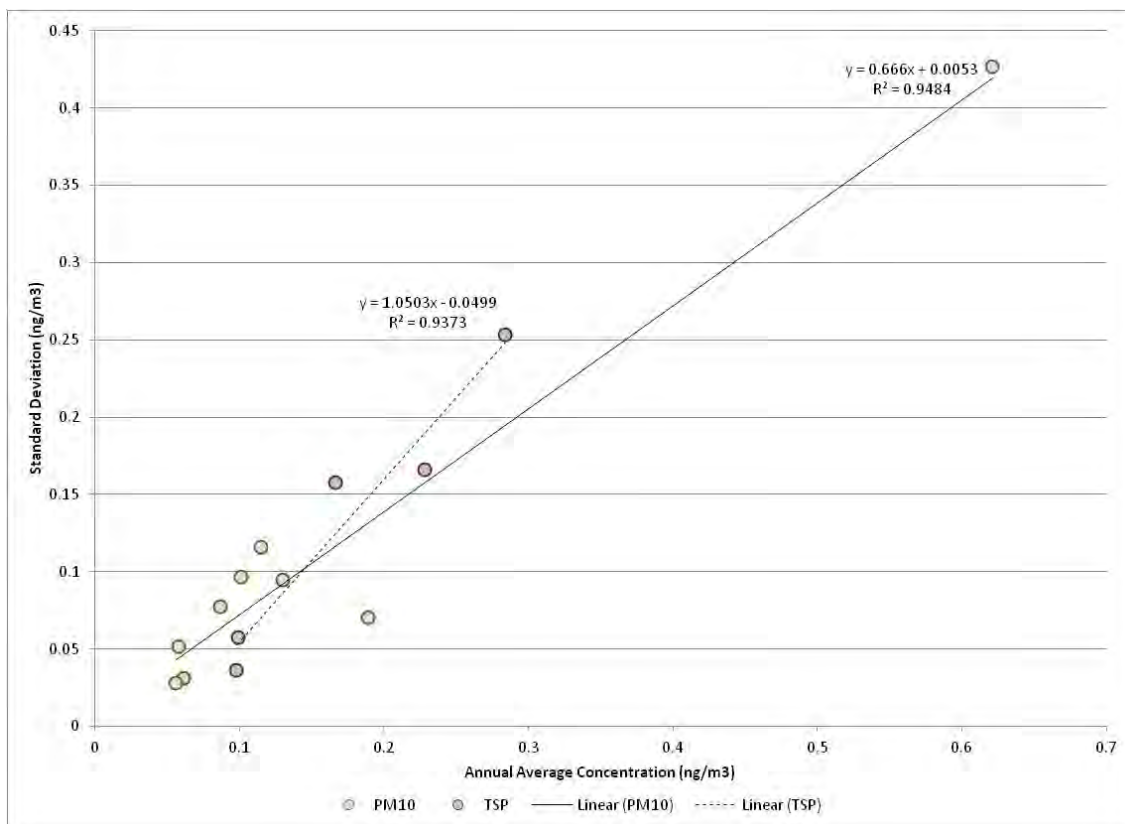
Figure 4-9b. Inter-Site Variability for Cadmium
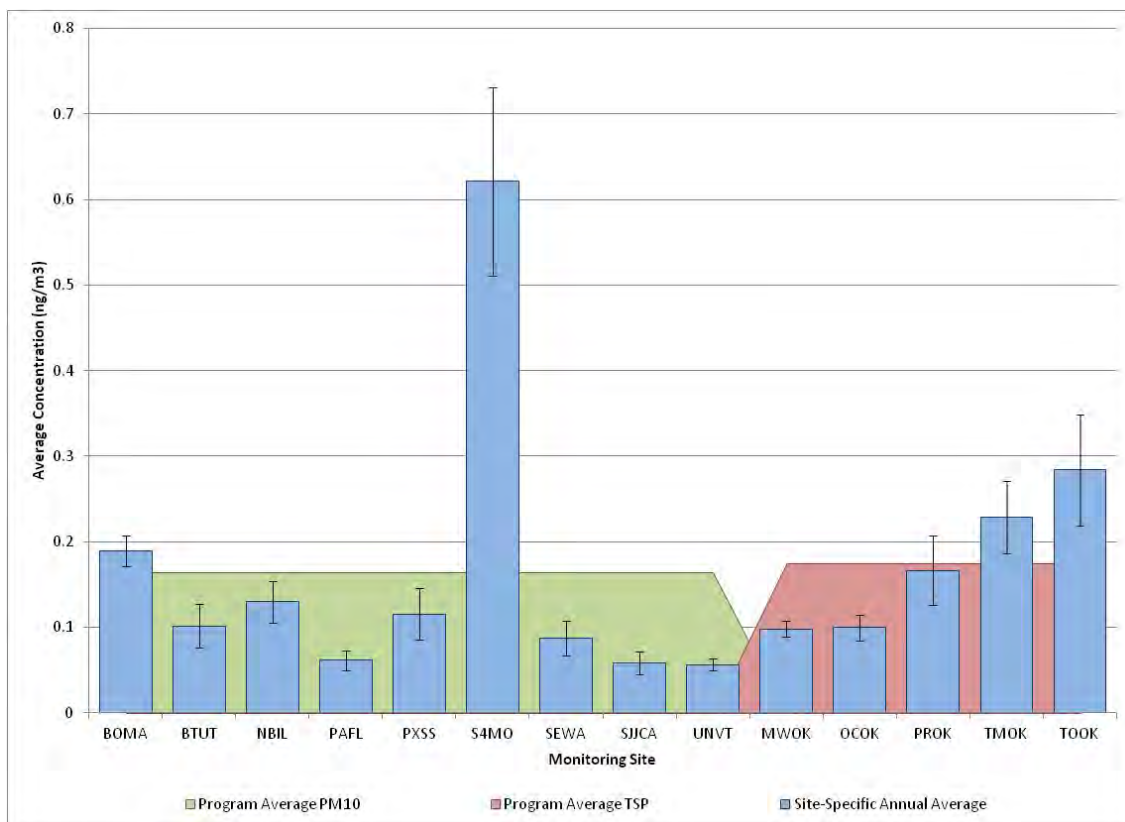
Figure 4-10a. Coefficient of Variation Analysis of Carbon Tetrachloride Across 24 Sites
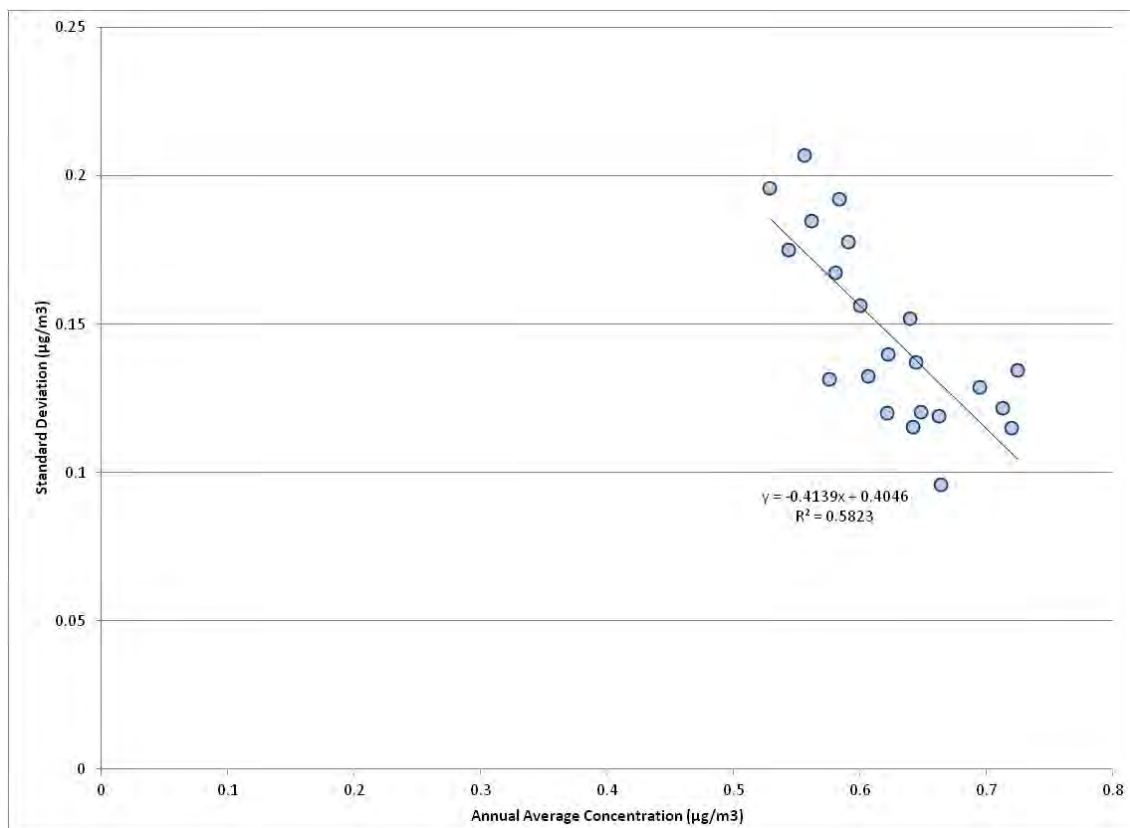
Figure 4-10b. Inter-Site Variability for Carbon Tetrachloride
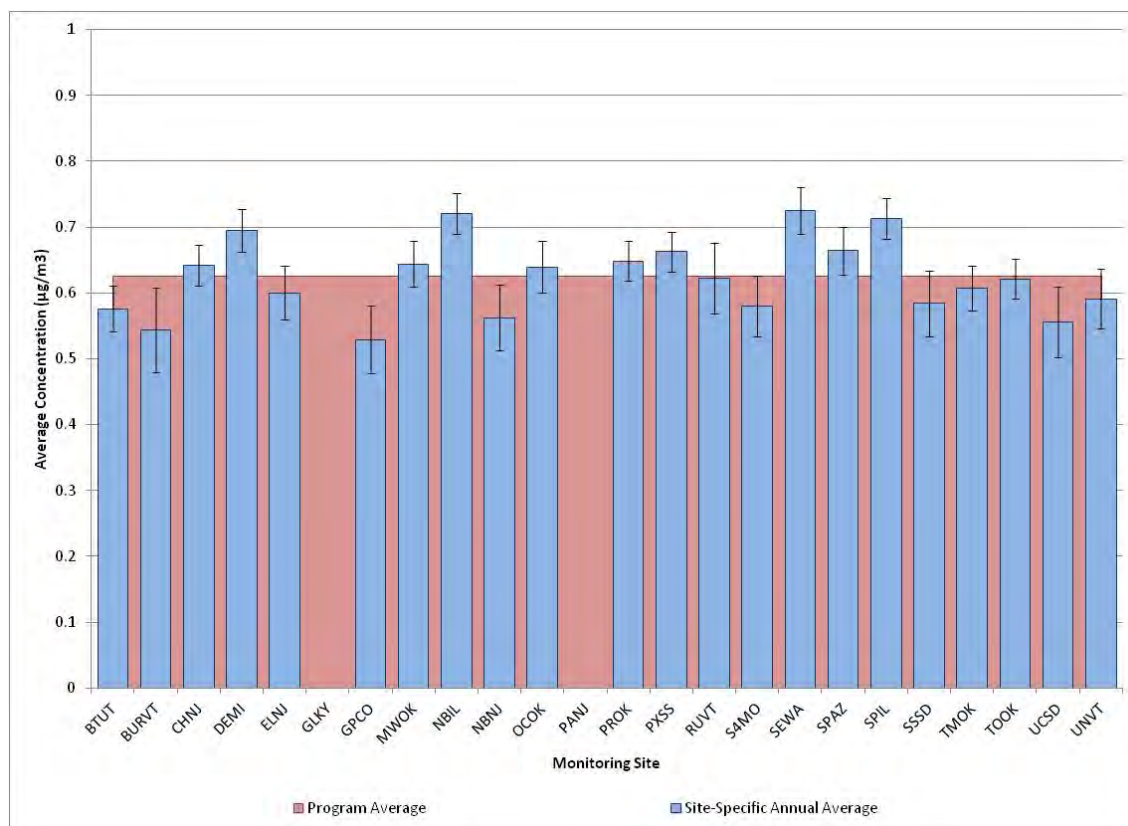
Figure 4-11a. Coefficient of Variation Analysis of Chloroform Across 24 Sites
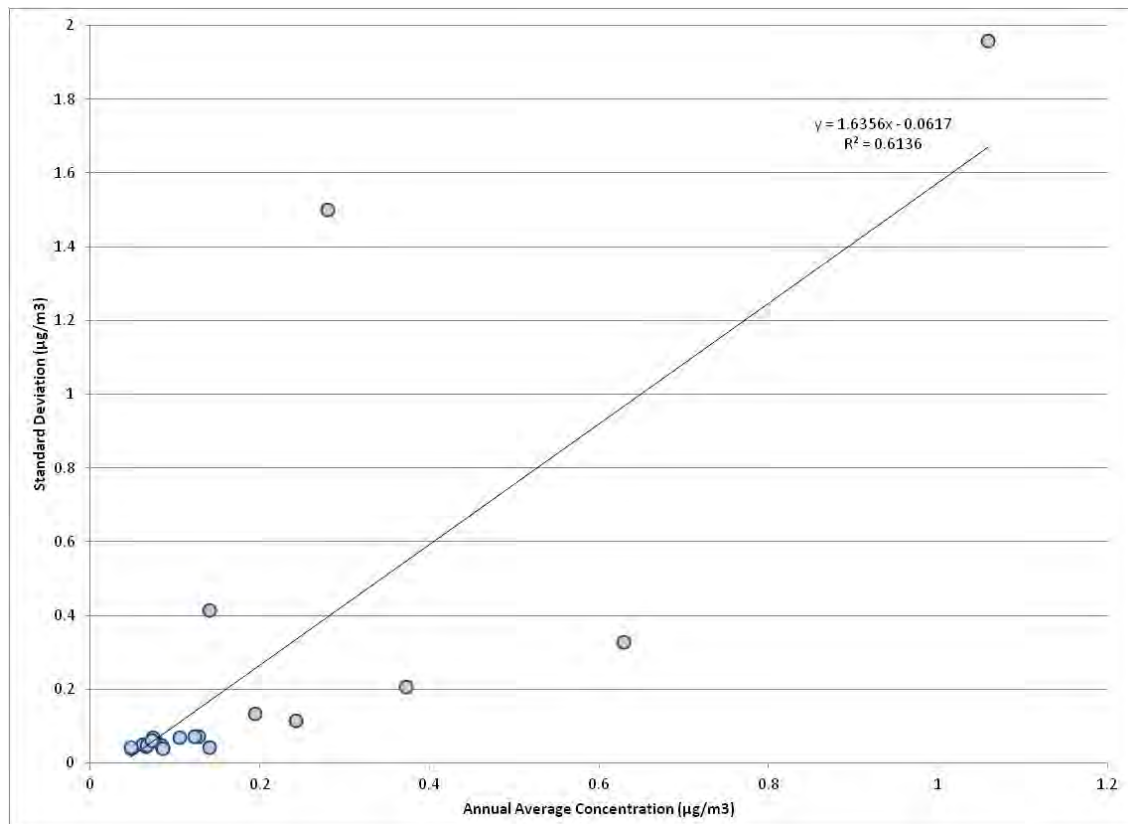
Figure 4-11b. Inter-Site Variability for Chloroform
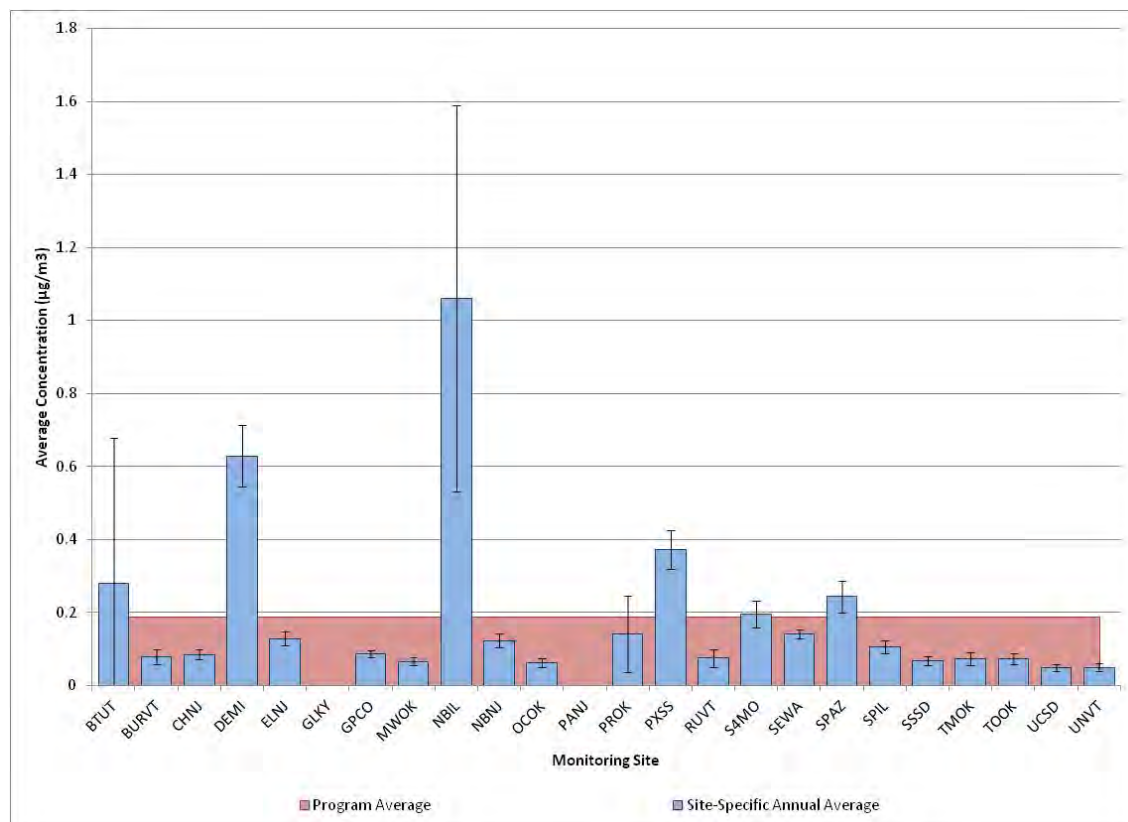
Figure 4-12a. Coefficient of Variation Analysis of *p*-Dichlorobenzene Across 24 Sites
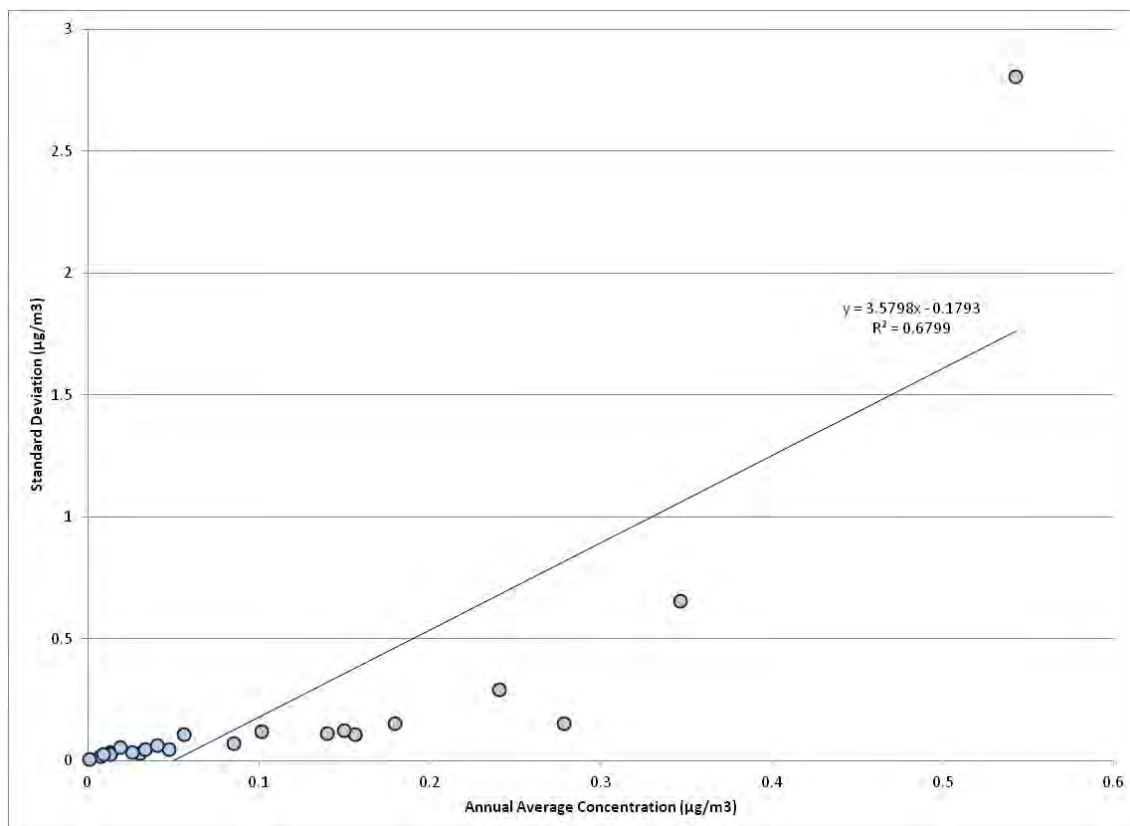
Figure 4-12b. Inter-Site Variability for *p*-Dichlorobenzene
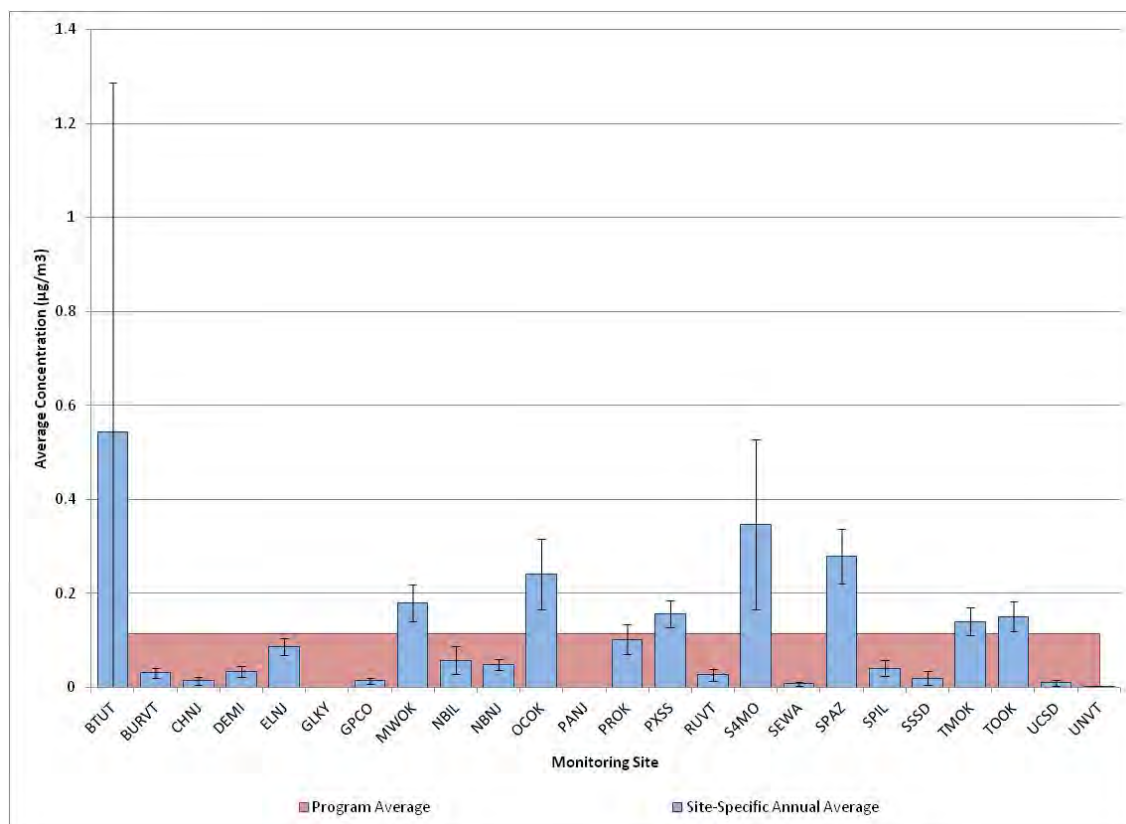
Figure 4-13a. Coefficient of Variation Analysis of 1,2-Dichloroethane Across 24 Sites
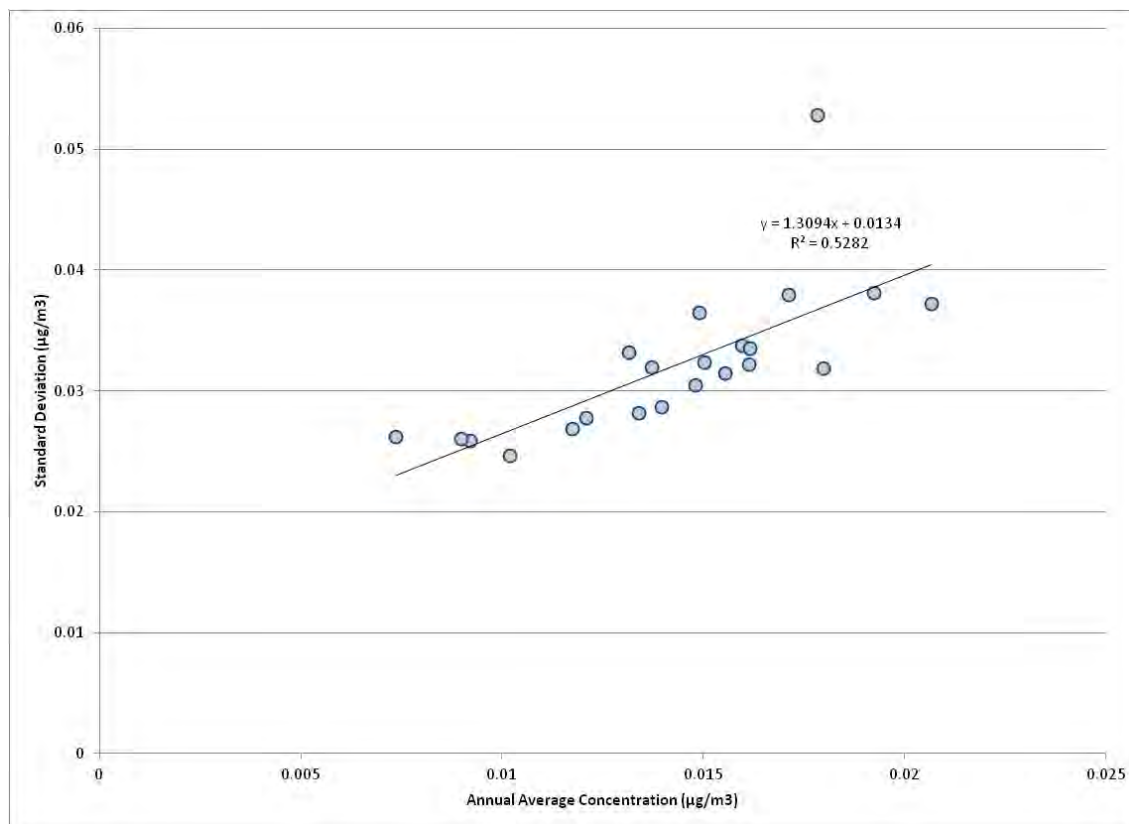
Figure 4-13b. Inter-Site Variability for 1,2-Dichloroethane
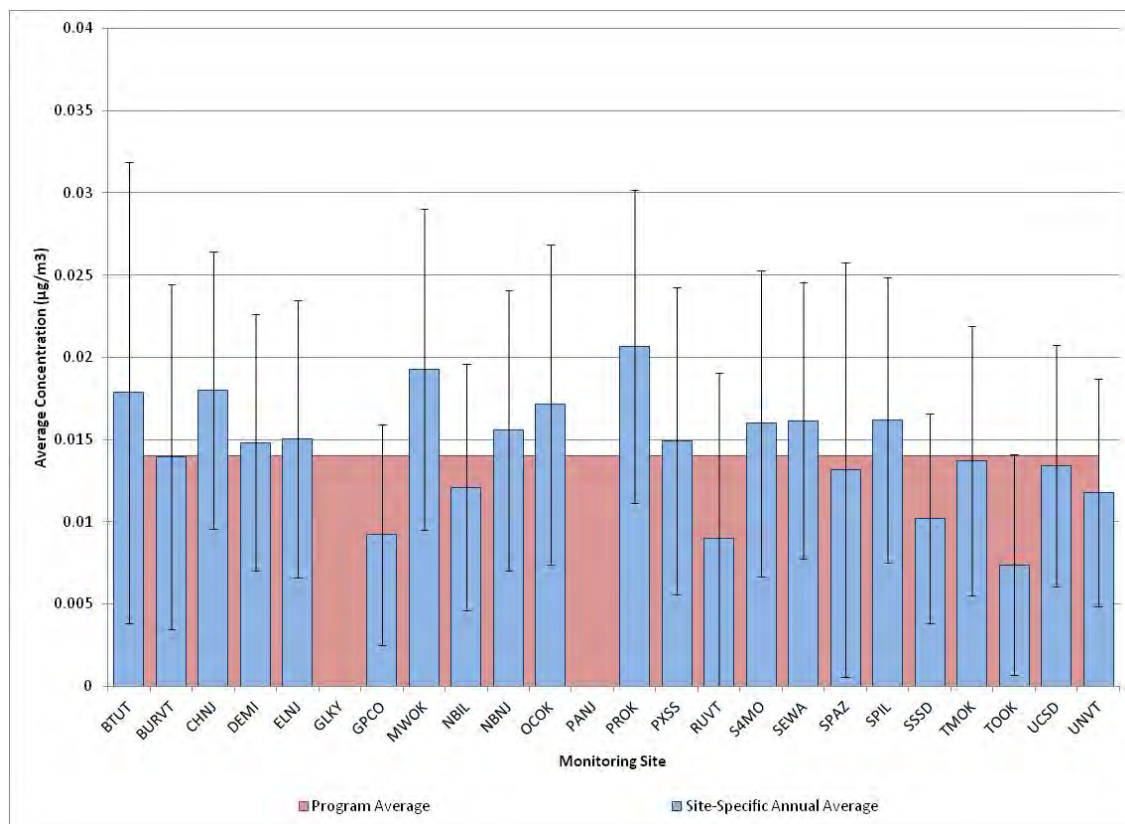
Figure 4-14a. Coefficient of Variation Analysis of Ethylbenzene Across 24 Sites
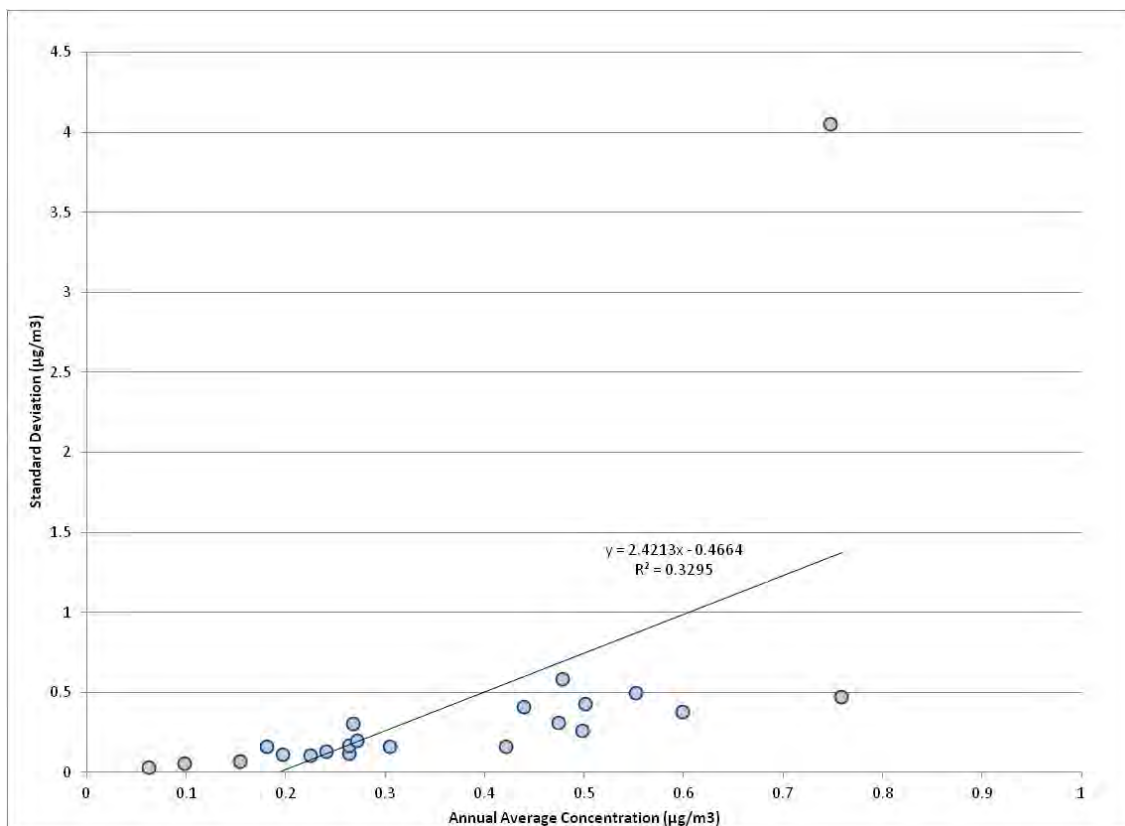
Figure 4-14b. Inter-Site Variability for Ethylbenzene
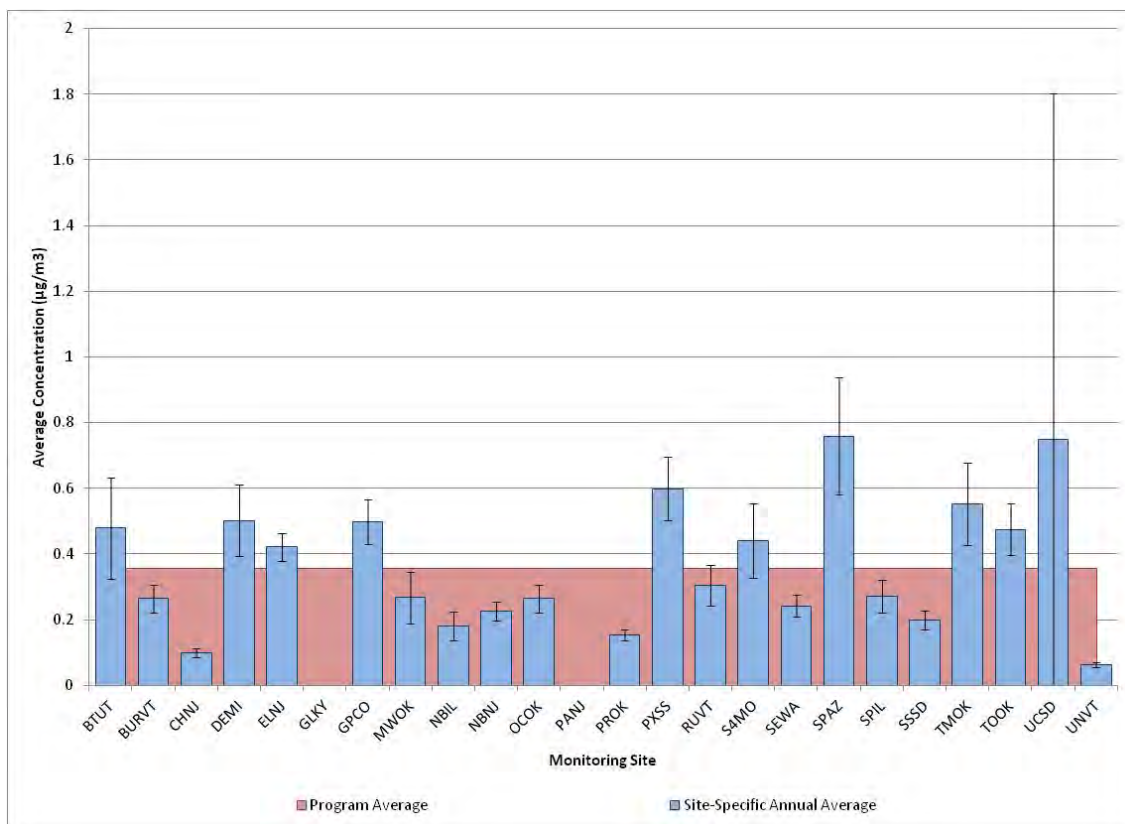
Figure 4-15a. Coefficient of Variation Analysis of Fluorene Across 26 Sites

$y = 1.5763x - 3.2564$
$R^2 = 0.7966$
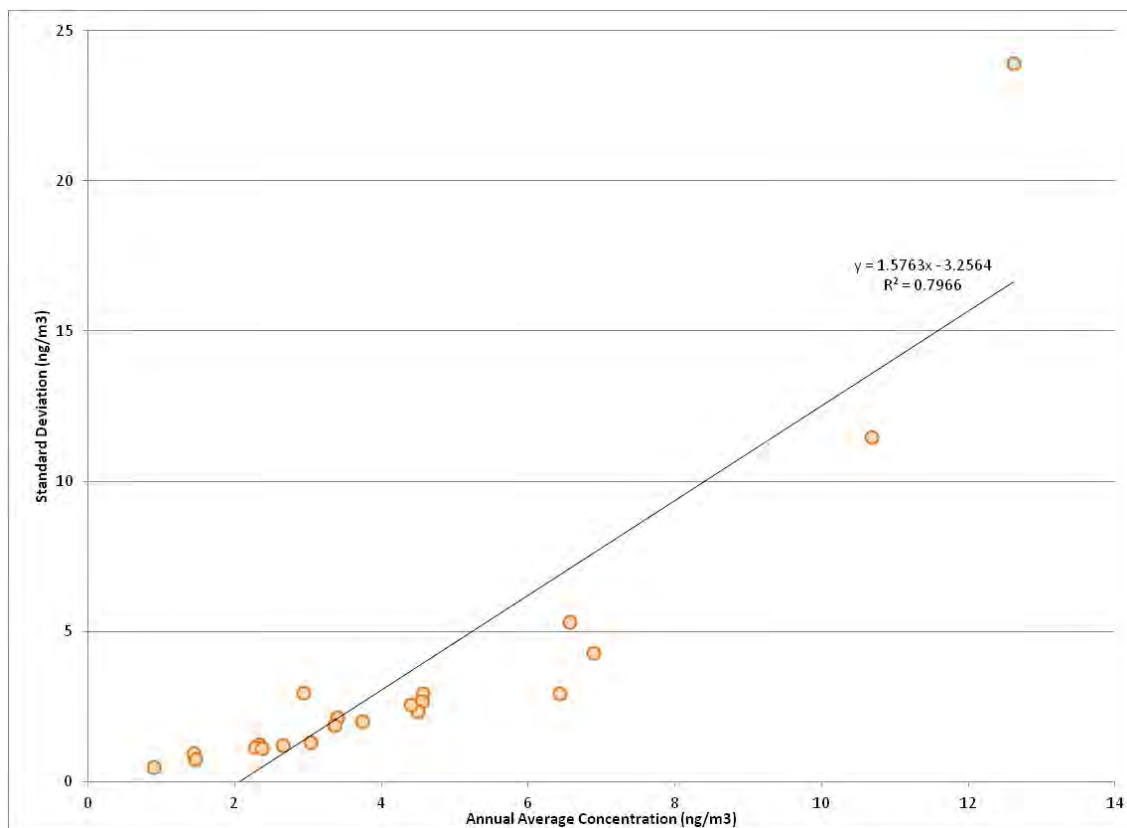
Figure 4-15b. Inter-Site Variability for Fluorene
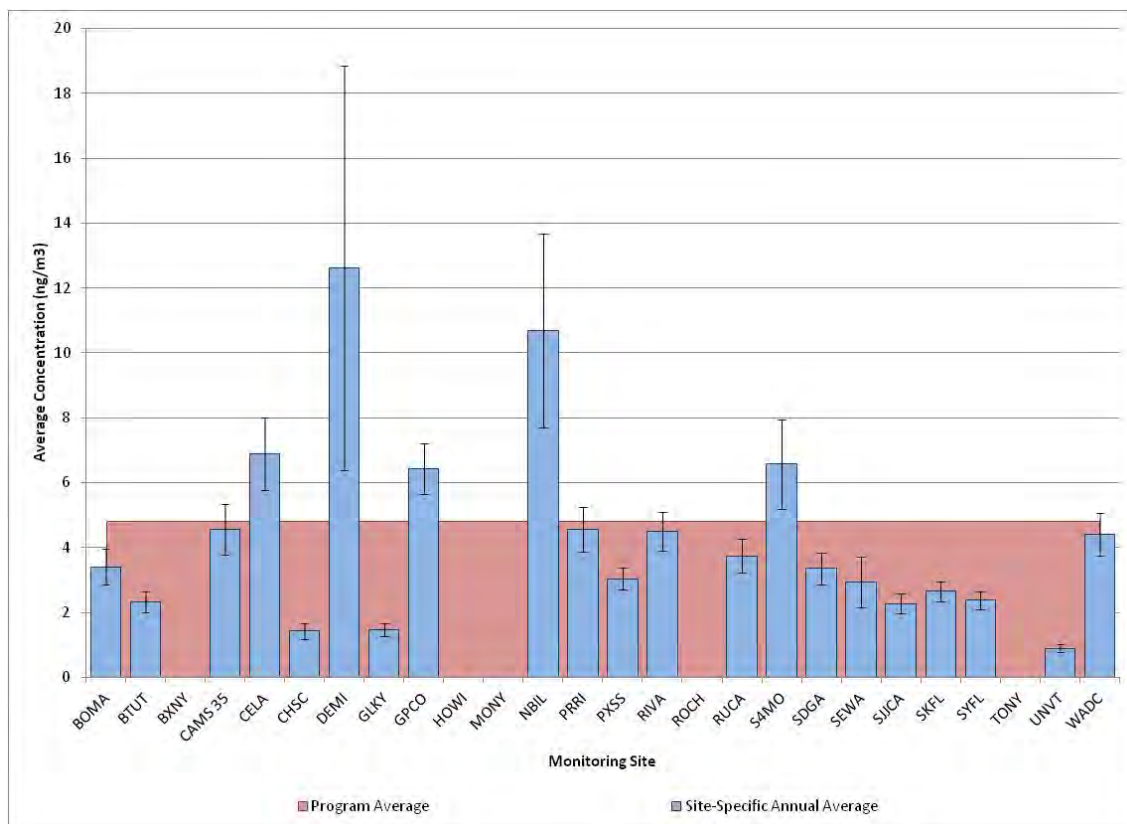
Figure 4-16a. Coefficient of Variation Analysis of Formaldehyde Across 30 Sites
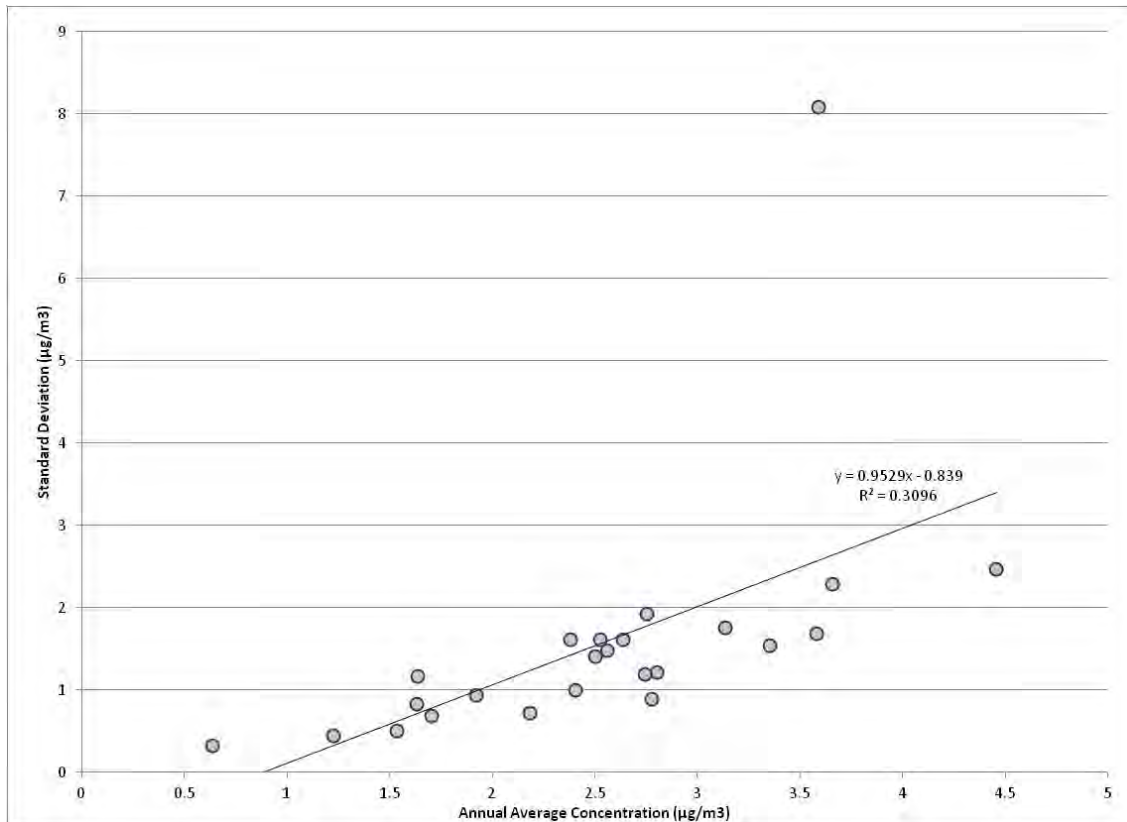
Figure 4-16b. Inter-Site Variability for Formaldehyde
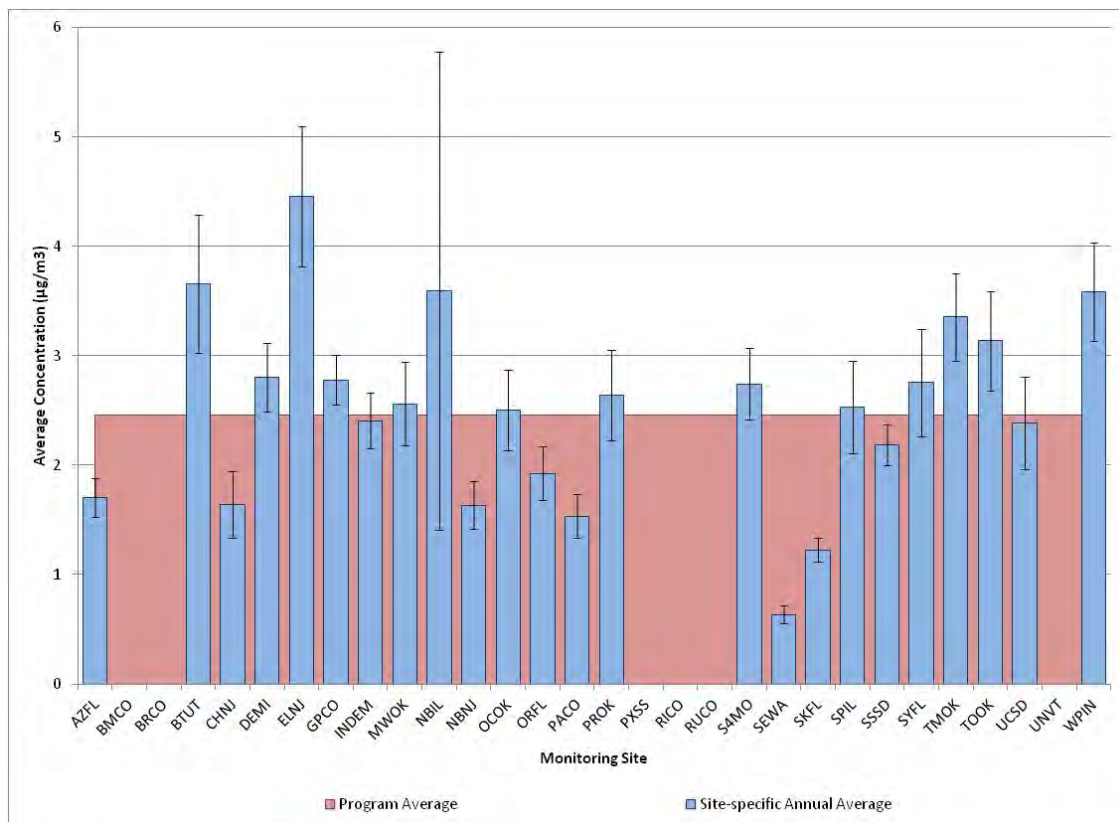
Figure 4-17a. Coefficient of Variation Analysis of Hexavalent Chromium Across 23 Sites
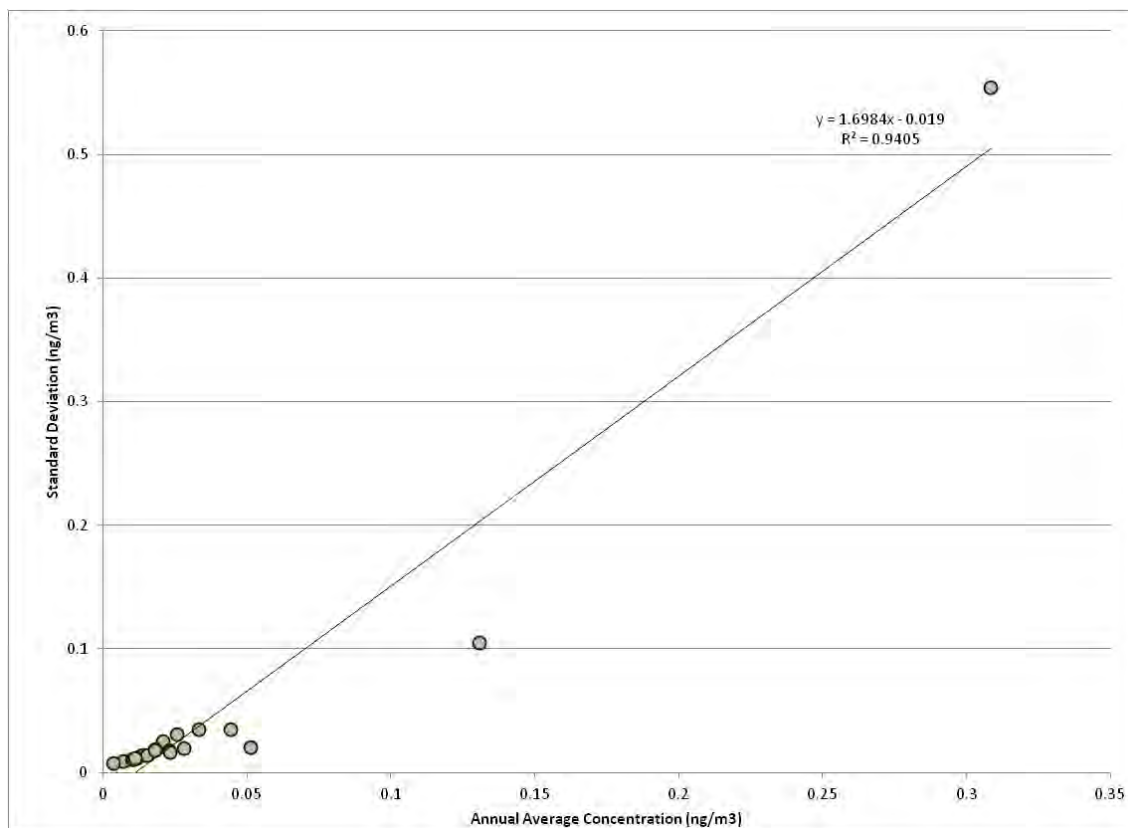
Figure 4-17b. Inter-Site Variability for Hexavalent Chromium
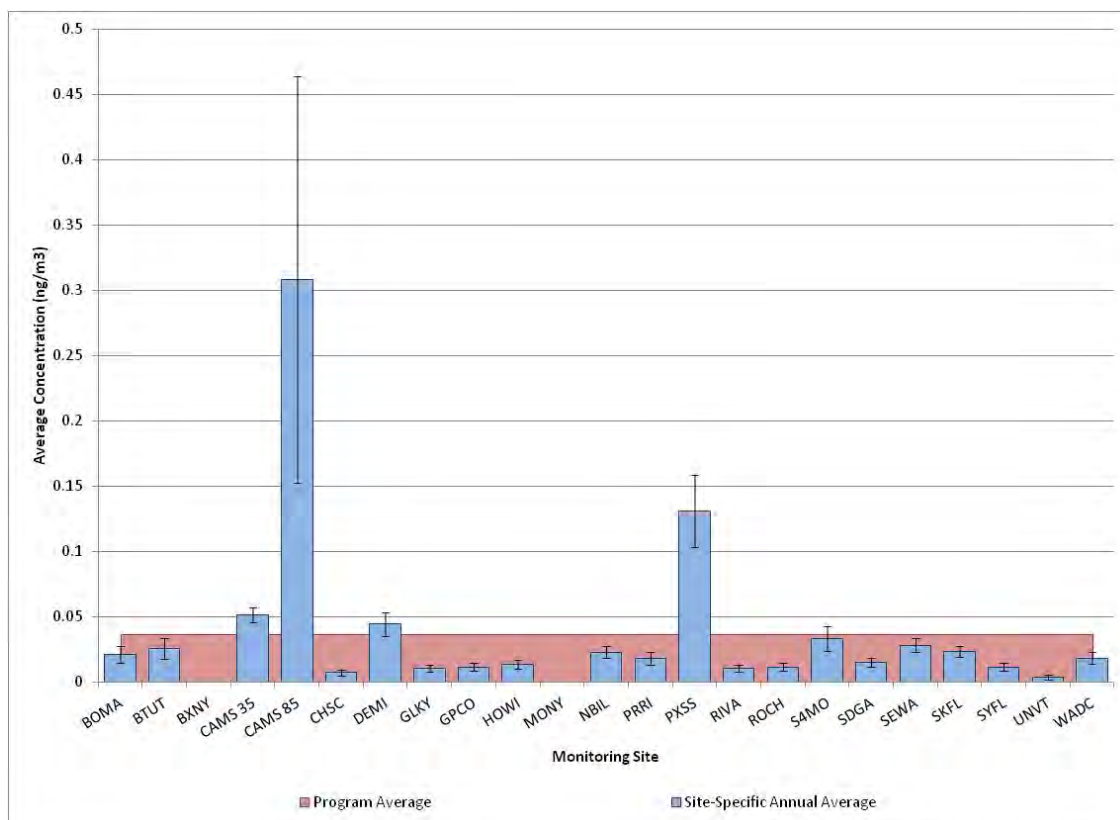
Figure 4-18a. Coefficient of Variation Analysis of Lead Across 14 Sites
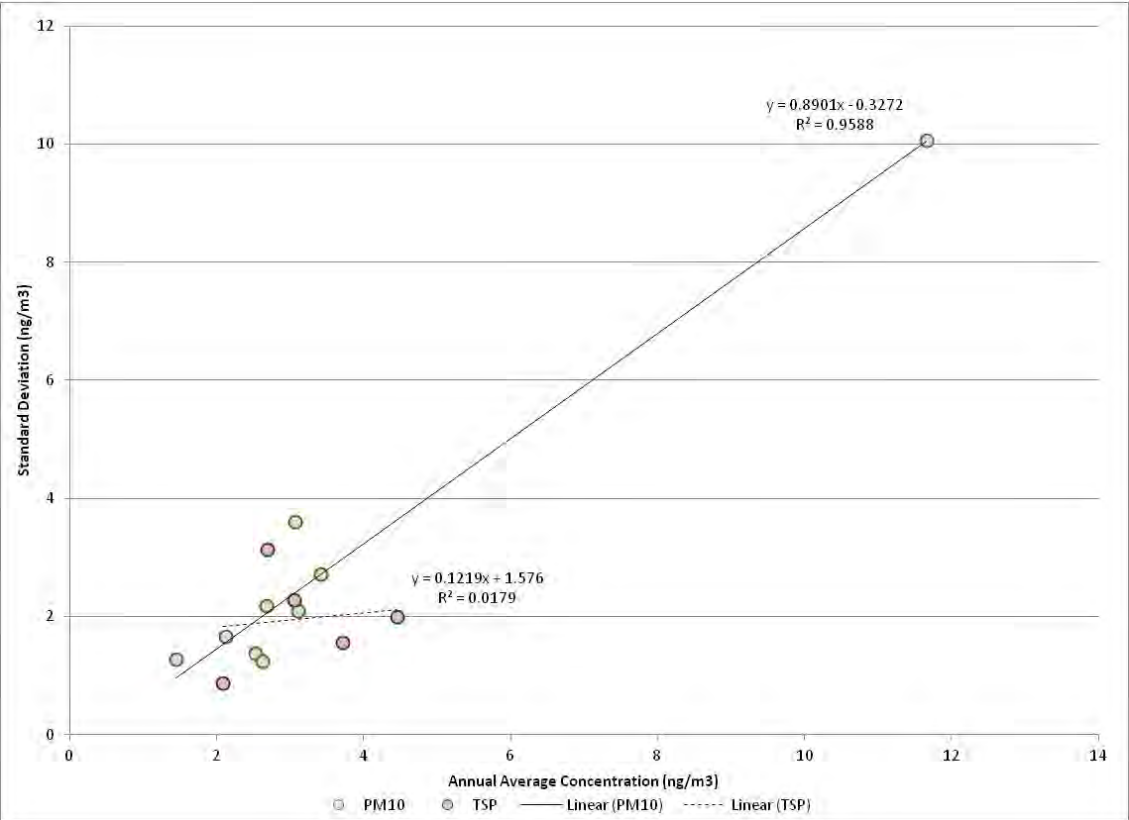
Figure 4-18b. Inter-Site Variability for Lead
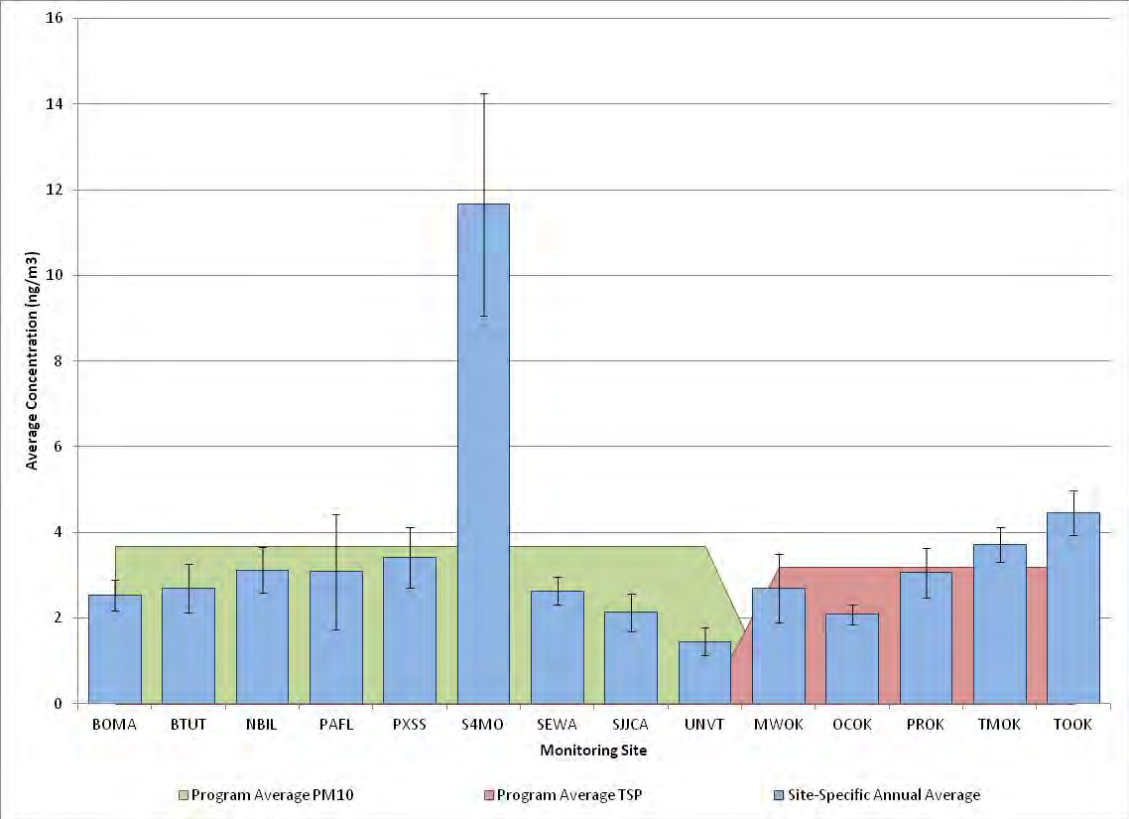
Figure 4-19a. Coefficient of Variation Analysis of Manganese Across 14 Sites
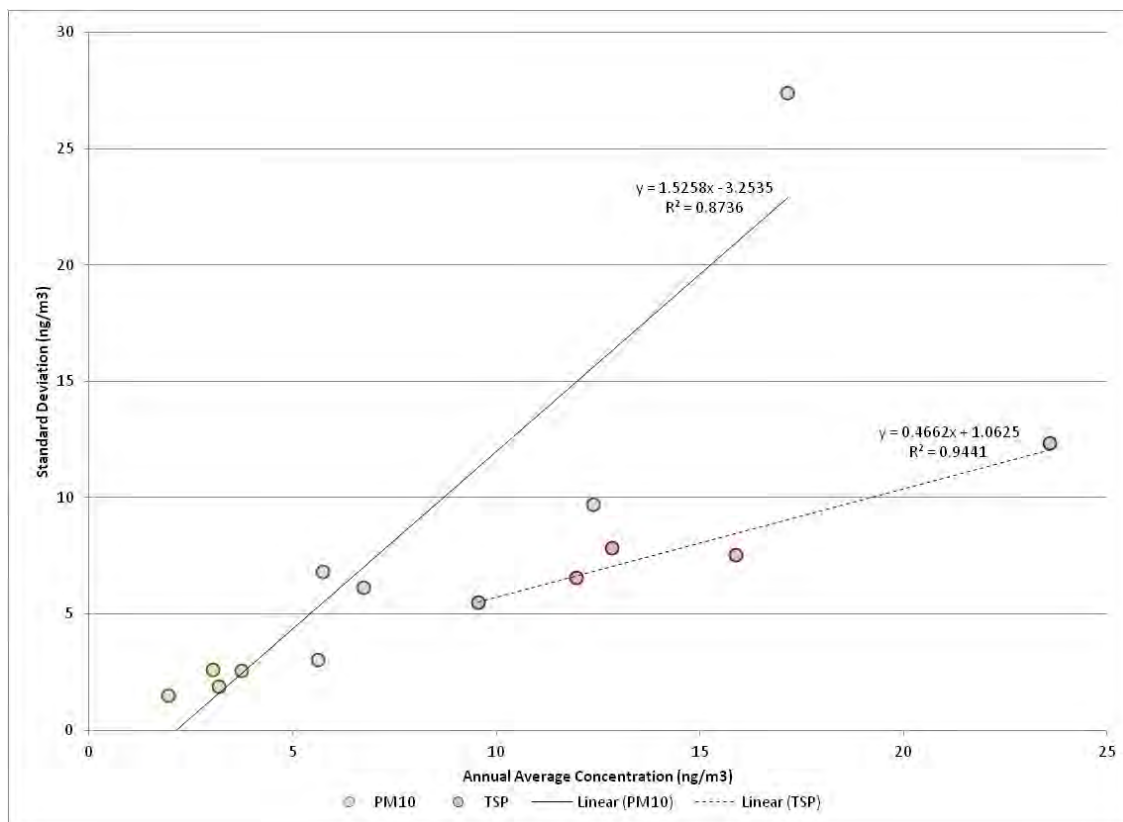
Figure 4-19b. Inter-Site Variability for Manganese
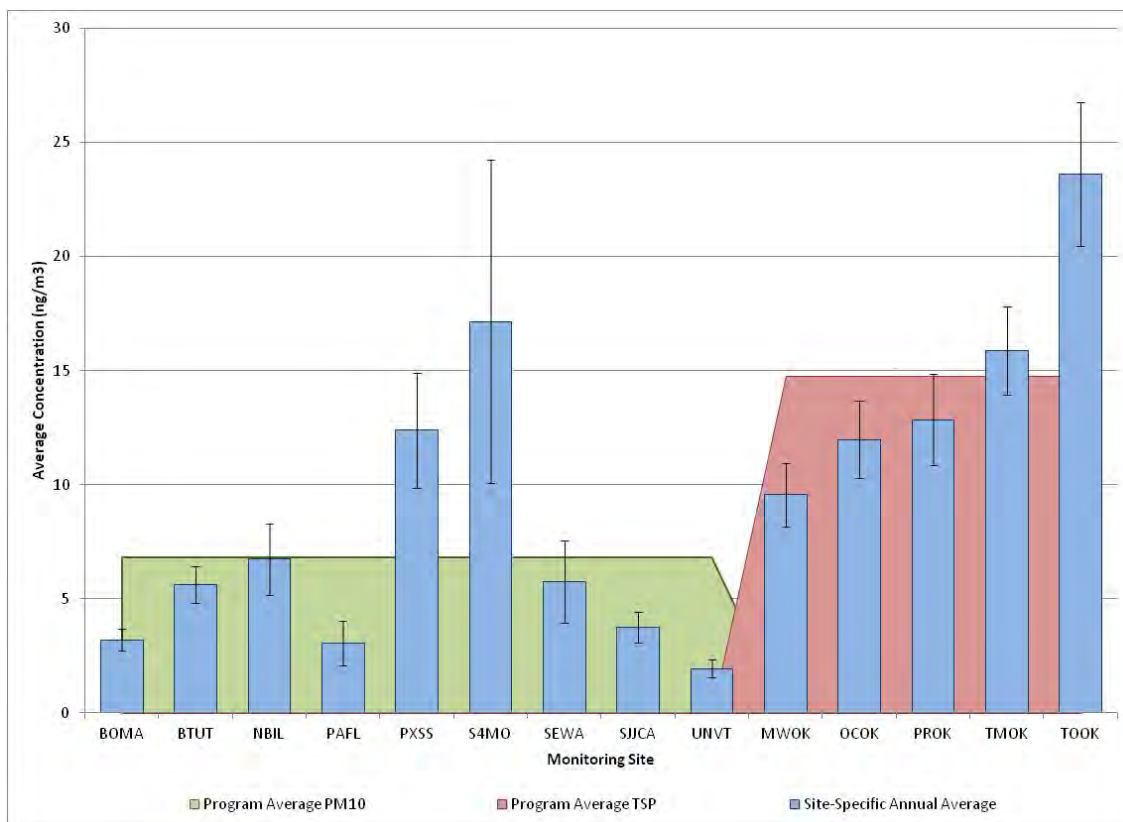
Figure 4-20a. Coefficient of Variation Analysis of Naphthalene Across 26 Sites
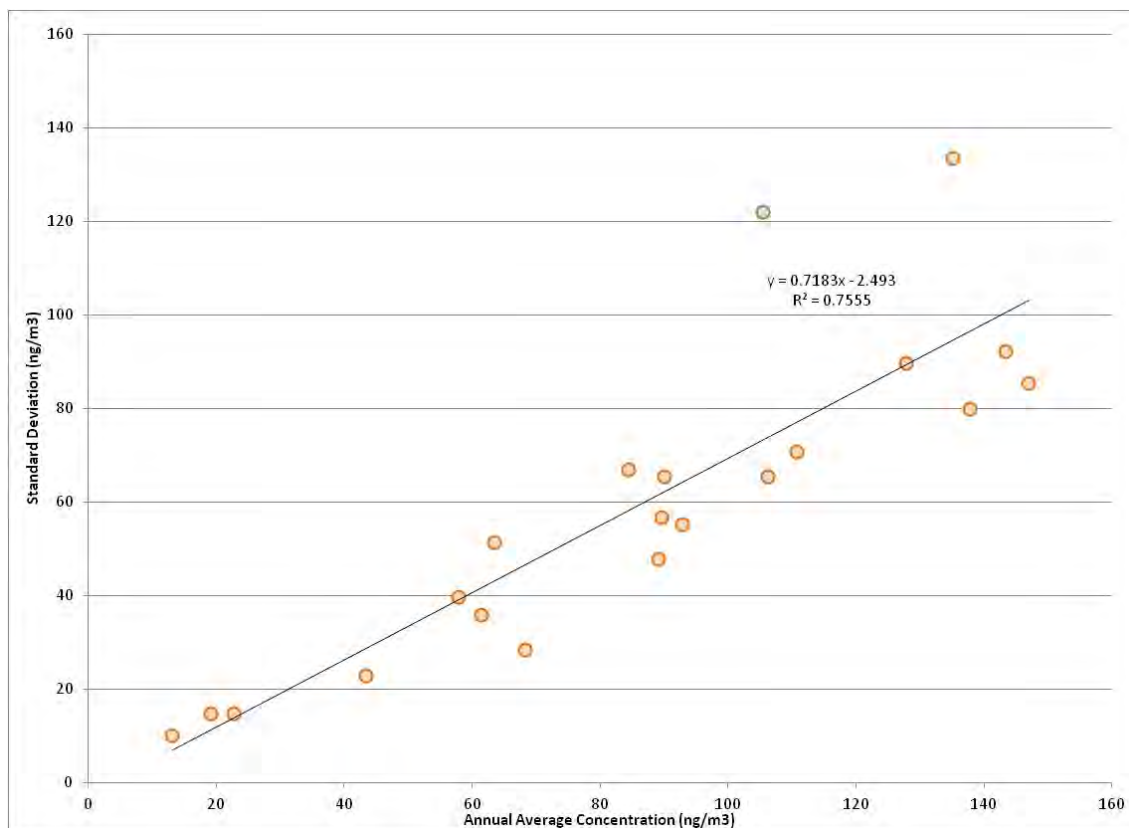
Figure 4-20b. Inter-Site Variability for Naphthalene
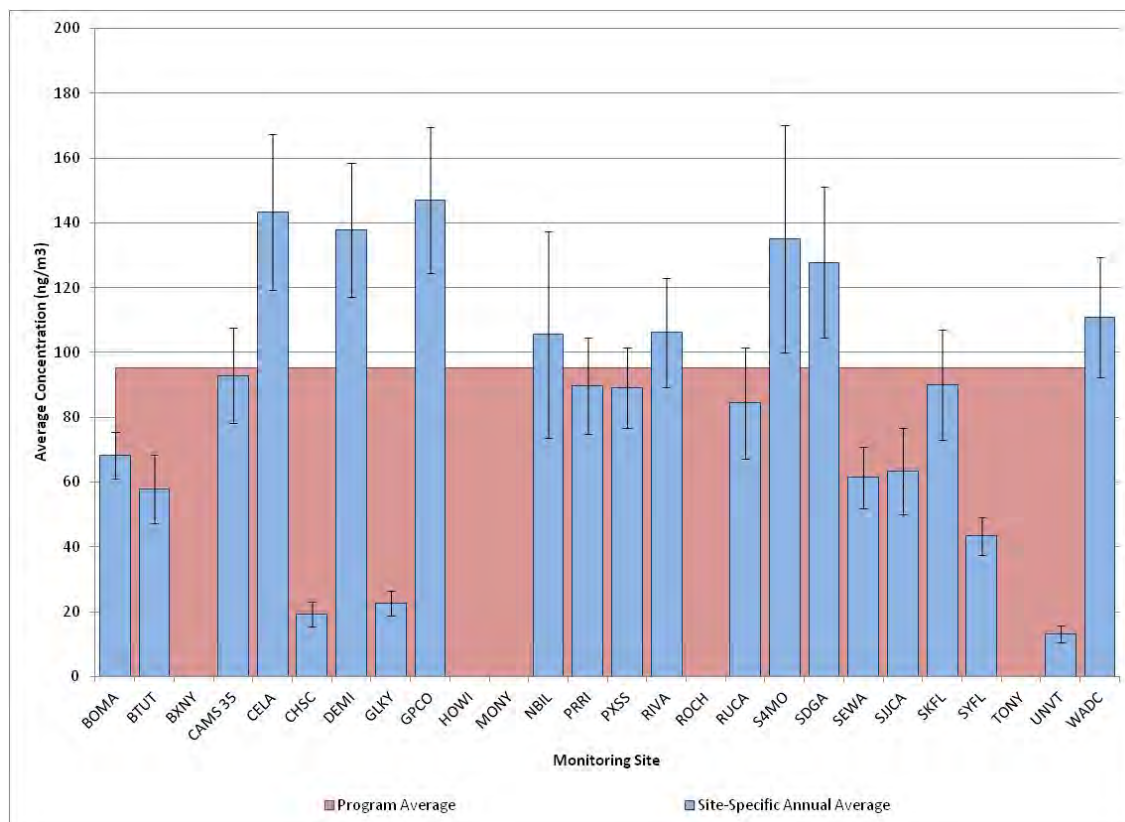
Figure 4-21a. Coefficient of Variation Analysis of Nickel Across 14 Sites
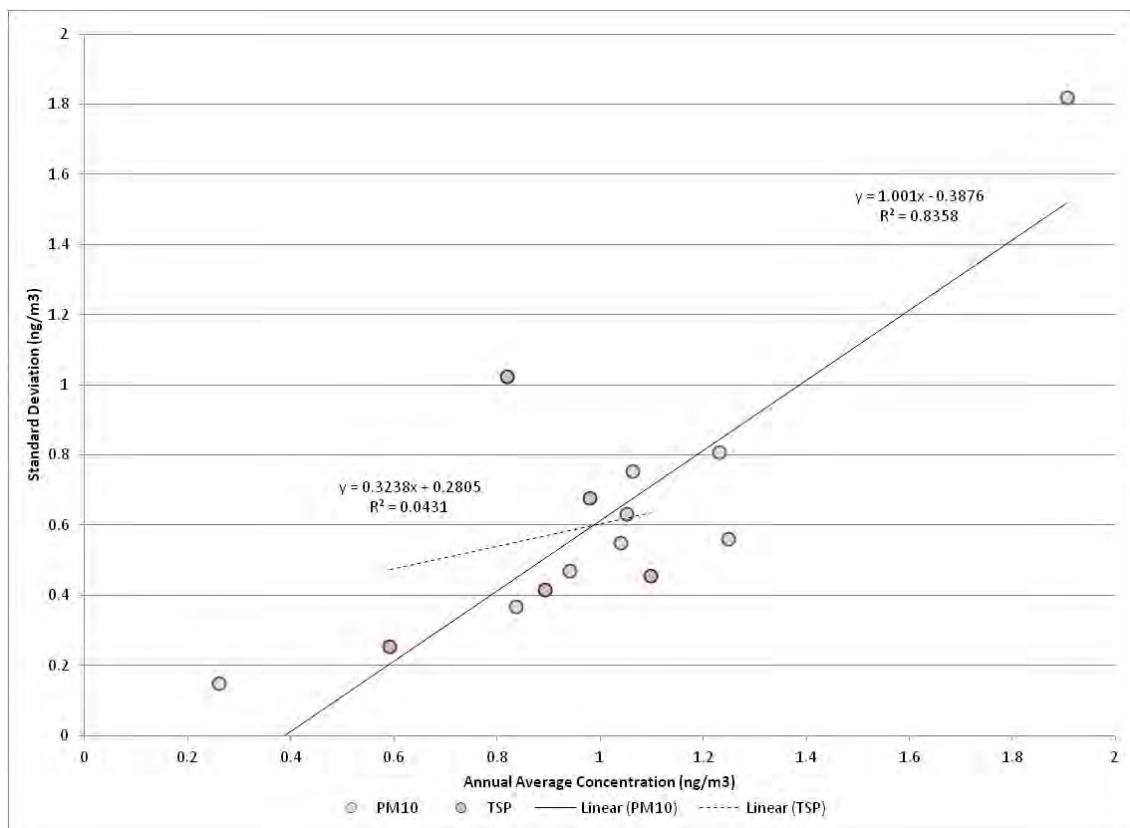
Figure 4-12b. Inter-Site Variability for Nickel
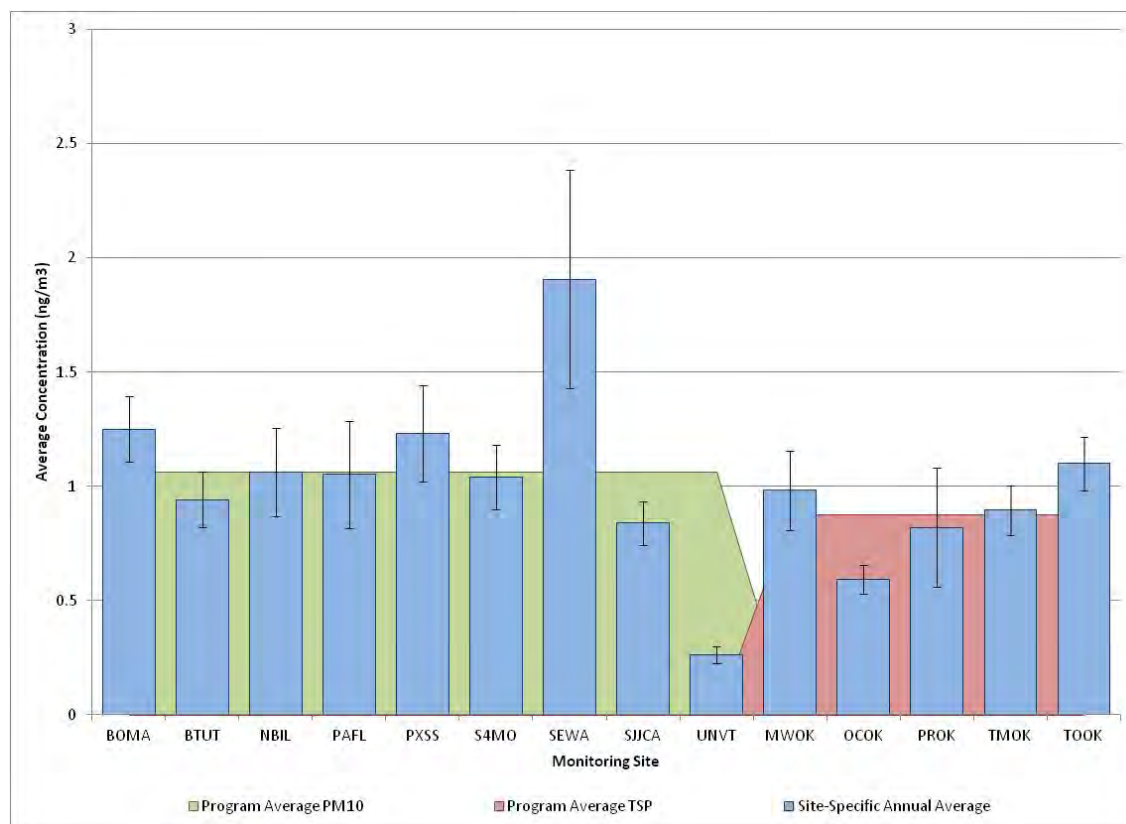
Figure 4-22a. Coefficient of Variation Analysis of Tetrachloroethylene Across 24 Sites
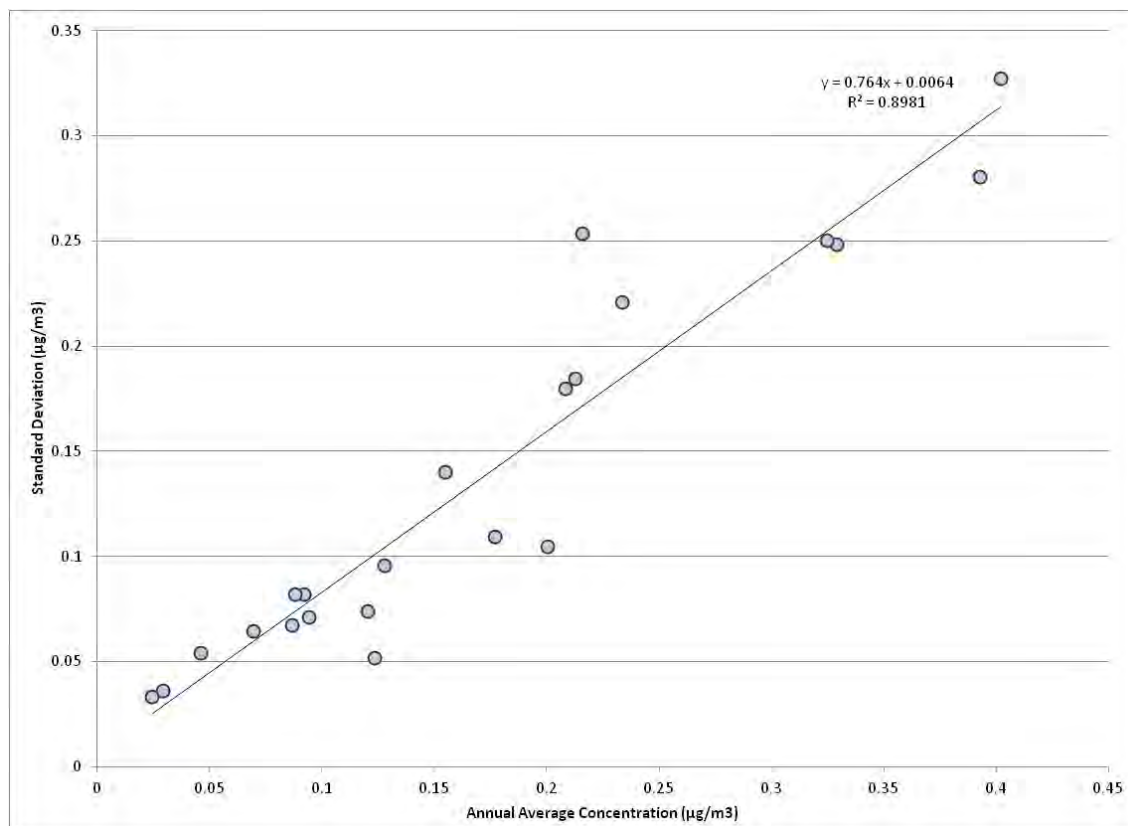
Figure 4-22b. Inter-Site Variability for Tetrachloroethylene
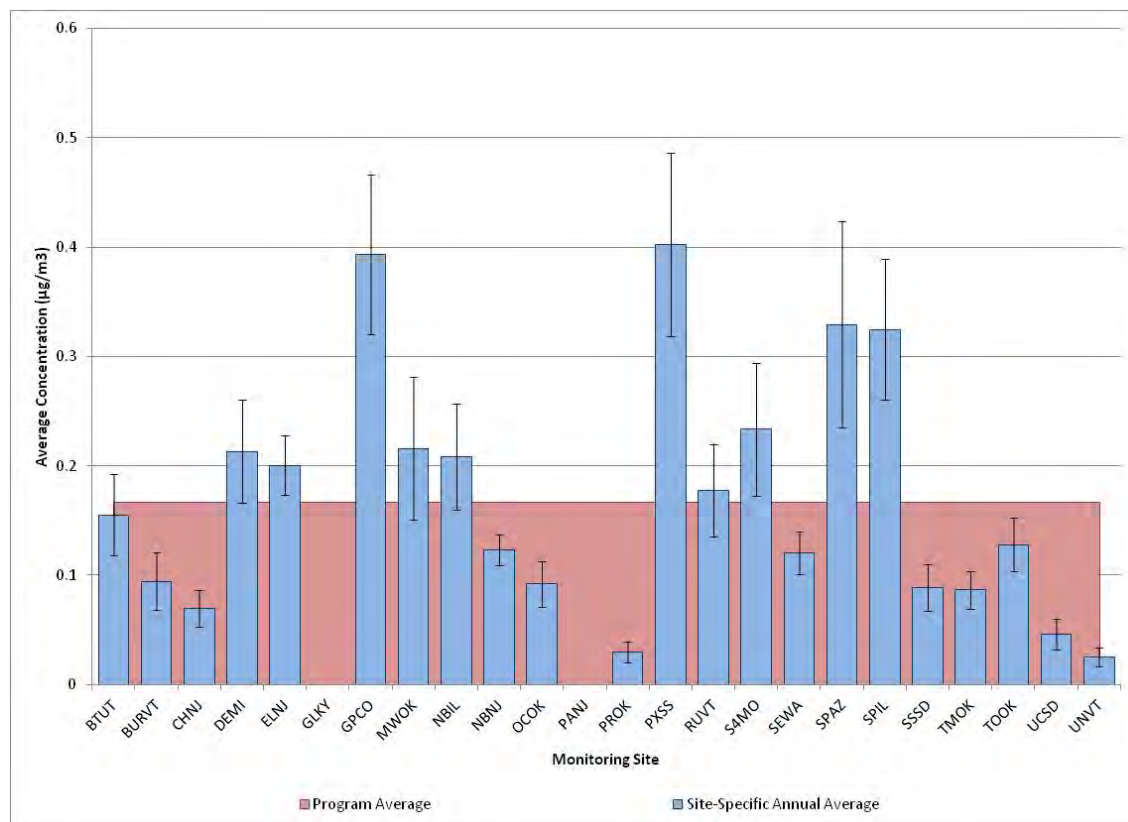
Figure 4-23a. Coefficient of Variation Analysis of Trichloroethylene Across 24 Sites
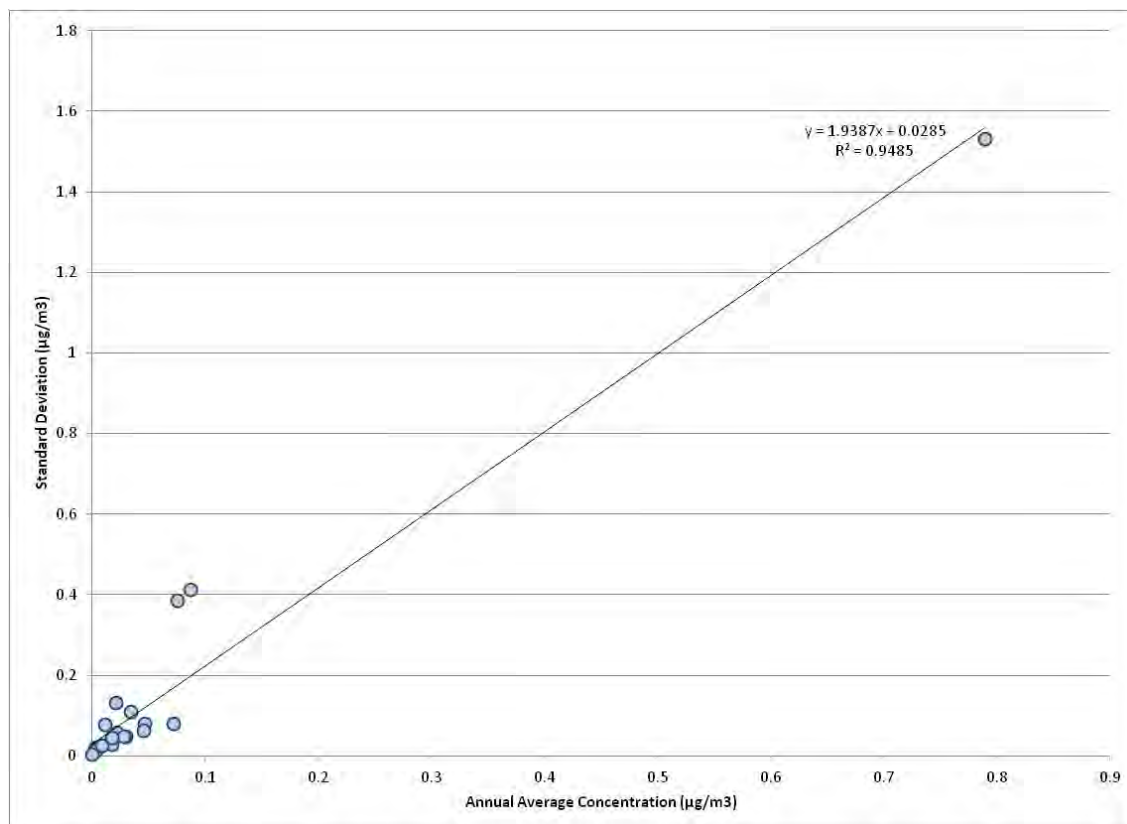
Figure 4-23b. Inter-Site Variability for Trichloroethylene
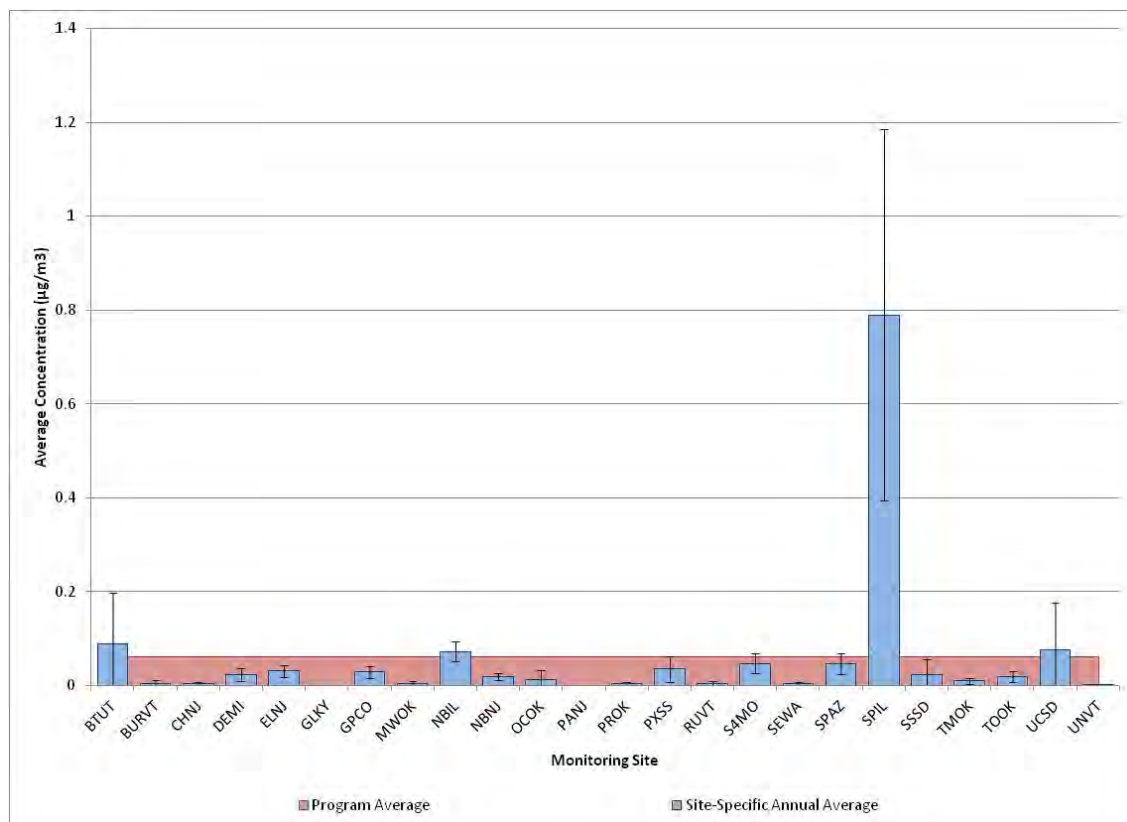
Figure 4-24a. Coefficient of Variation Analysis of Vinyl Chloride Across 24 Sites
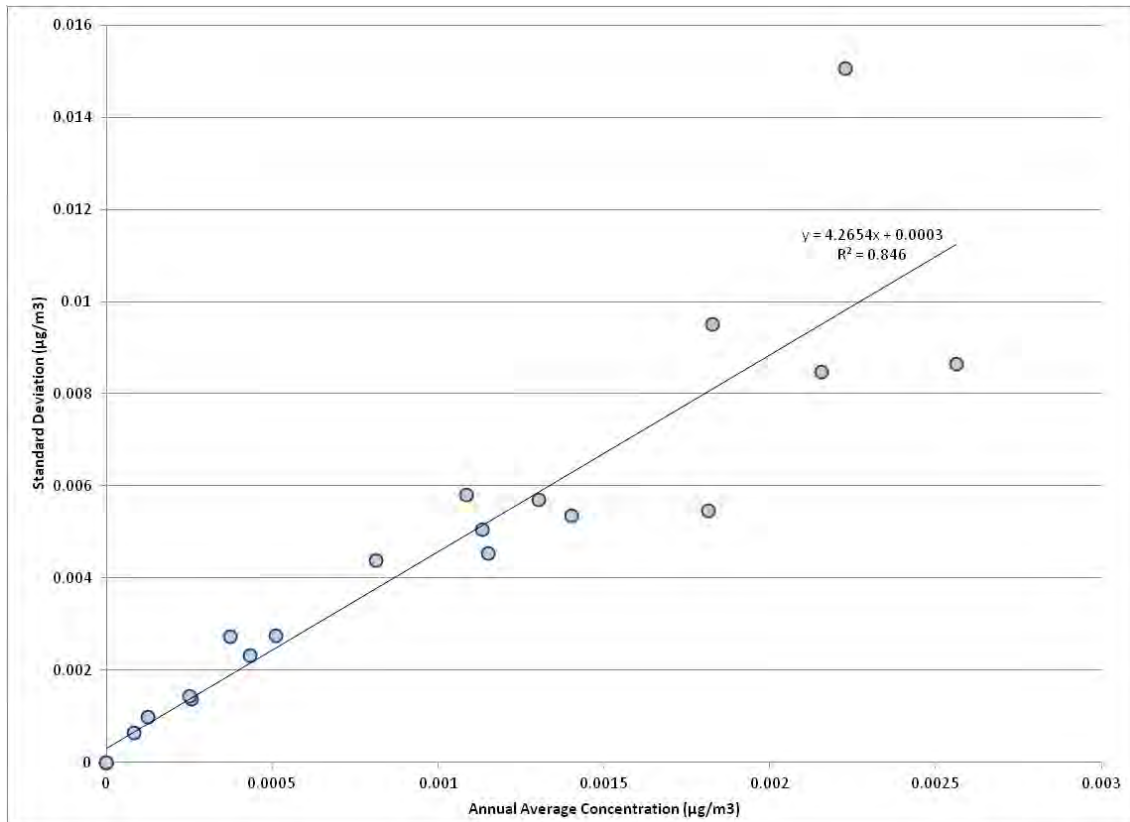
Figure 4-24b. Inter-Site Variability for Vinyl Chloride
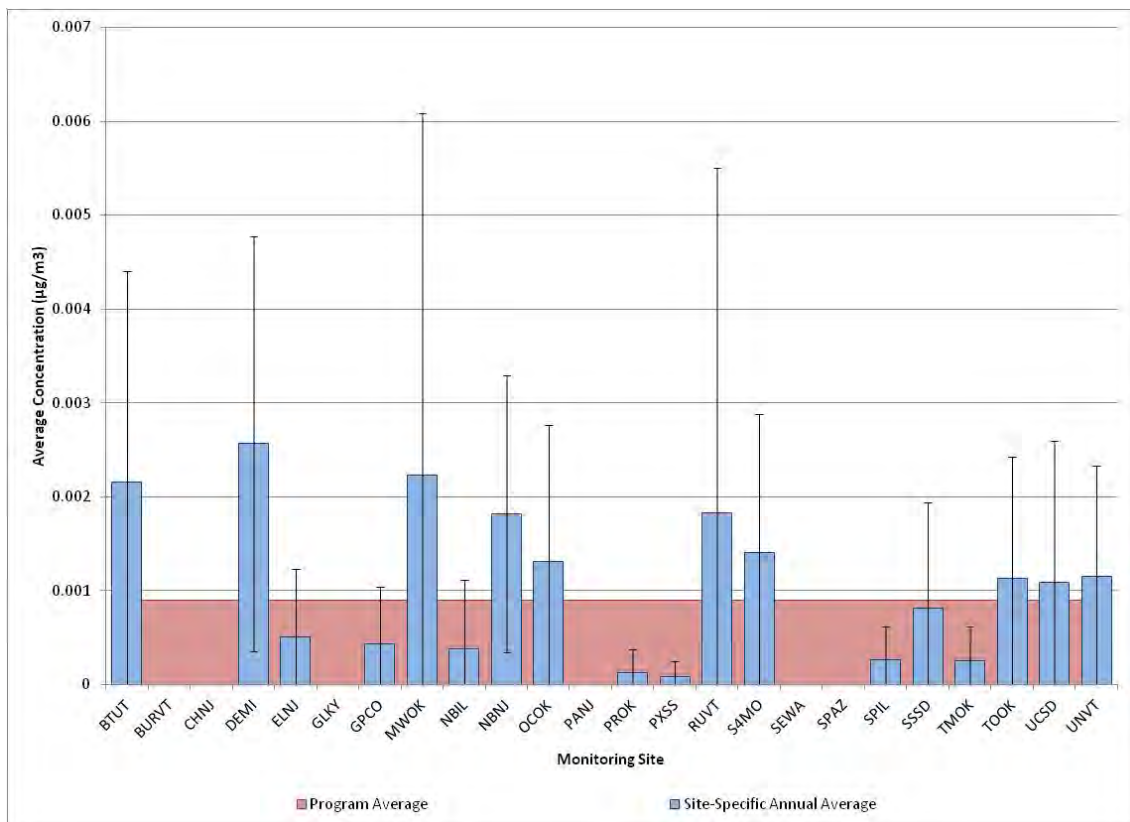
4.4.2 Quarterly Variability Analysis

Figures 4-25 through 4-48 provide a graphical display of the quarterly average concentrations for each of the program-level pollutants of interest. Quarterly averages are calculated based on the criteria specified in Section 3.1.1. 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 4-42b. Note that the scales on the PM_{10} and TSP graphs are the same for a given pollutant. The scales are also the same when a graph is split into two graphs for a given pollutant.

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 frequently not detected in some quarters but were in others and have a quarterly average concentration of zero as a result of the substitution of zeros for non-detects. One of the most apparent examples of this is Figure 4-27 for acrylonitrile. This pollutant was frequently not detected (151 measured detections out of 1,264 valid samples); of the 94 possible quarterly averages of this pollutant, 42 of them are zero. Thus, few quarterly averages appear in Figure 4-27. Further, most of the remaining quarterly averages have relatively few measurements and many zero substitutions for non-detects, resulting in relatively low quarterly averages. (Although this pollutant was detected in only 12 percent of VOC samples collected, its risk screening value is relatively low; thus, all 151 measured detections of this pollutant failed screens.)

Another reason for 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 4-29 are primarily due to sampling duration. BMCO did not begin sampling VOC until the third quarter of 2012, in September. Thus, the first and second quarterly averages are blank. Because the criteria in Section 3.1.1 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), BMCO could not get a quarterly average for the third

quarter because it did not sample long enough within that quarter. Therefore, the first quarterly average that could be calculated for BMCO was the fourth quarter.

Both examples can be shown in Figure 4-36 for *p*-dichlorobenzene. For example, PANJ started sampling at the end of April 2010; thus, quarterly averages could not be calculated for the first quarter. There were not enough valid samples in the second quarter to meet the 75 percent criteria for PANJ for a quarterly average to be calculated, thus no second quarter average is shown either. A similar situation is shown for GLKY, where sampling began in June 2010. Conversely, CHNJ, RUVT, and UCSD sampled continuously in 2010 but did not detect this pollutant in a single sample in the first quarter. As such, both the start and stop dates of each site and the quarterly average criteria must be considered when interpreting the quarterly average concentration graphs.

Some pollutants of interest, such as acetaldehyde, benzene, carbon tetrachloride, ethylbenzene, formaldehyde, and naphthalene, were detected year-round. Comparing the quarterly averages for the 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 4-40, with 18 of the 29 sites sampling formaldehyde exhibiting the highest quarterly average during July through September, followed by second quarter (with seven), both of which include warmer months of the year. Conversely, benzene averages tended to be higher during the fourth quarter followed by the first quarter, or the colder months, as shown in Figure 4-29. 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 with higher concentrations in the first quarter; acenaphthene and ethylbenzene with higher concentrations in the third quarter; and 1,3-butadiene with higher concentrations in the fourth quarter.

Other notable trends may also be revealed in these graphs. Figure 4-37 for 1,2-dichlorethane shows that nearly all (over 95 percent) of the measured detections of this pollutant were measured during the first and second quarter of 2010. Figure 4-48 for vinyl chloride shows that this pollutant was infrequently detected, but like 1,2-dichloroethane, was most frequently detected in the first two quarters of the year.

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 4-33a, 4-35, 4-41, 4-42a, 4-44, and 4-47 for cadmium, chloroform, hexavalent chromium, lead, naphthalene, and trichloroethylene, respectively. For example, Figure 4-47 shows that the quarterly averages of trichloroethylene for SPIL are significantly higher than for other sites sampling VOC. Figures 4-33a and 4-42a show that S4MO's quarterly averages of cadmium and lead are significantly higher than the quarterly averages for the other sites sampling metals. Conversely, these graphs may also reveal when there is very little variability in the quarterly averages across other sites. Figure 4-34 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 24 program-level pollutants of interest have ATSDR Intermediate MRLs. For the 10 that do, the quarterly average concentrations were significantly below 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 4-25. Comparison of Average Quarterly Acenaphthene Concentrations
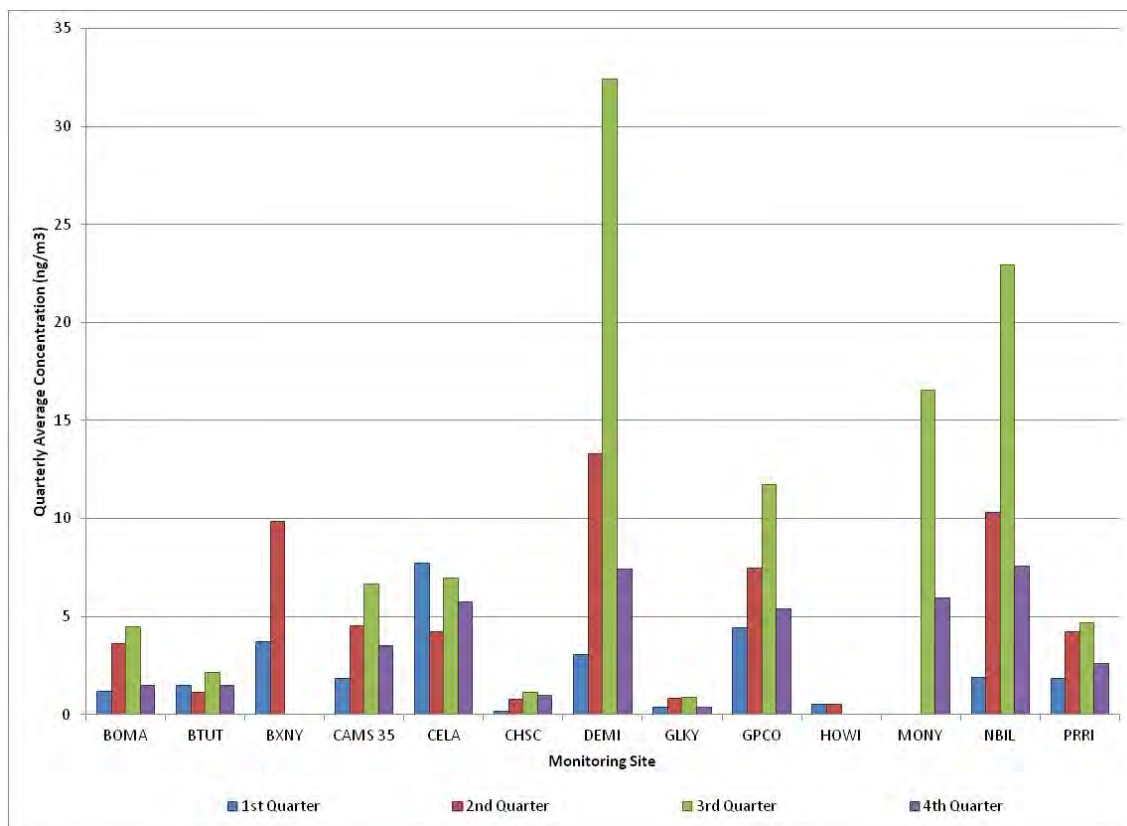
Figure 4-25. Comparison of Average Quarterly Acenaphthene Concentrations (Continued)
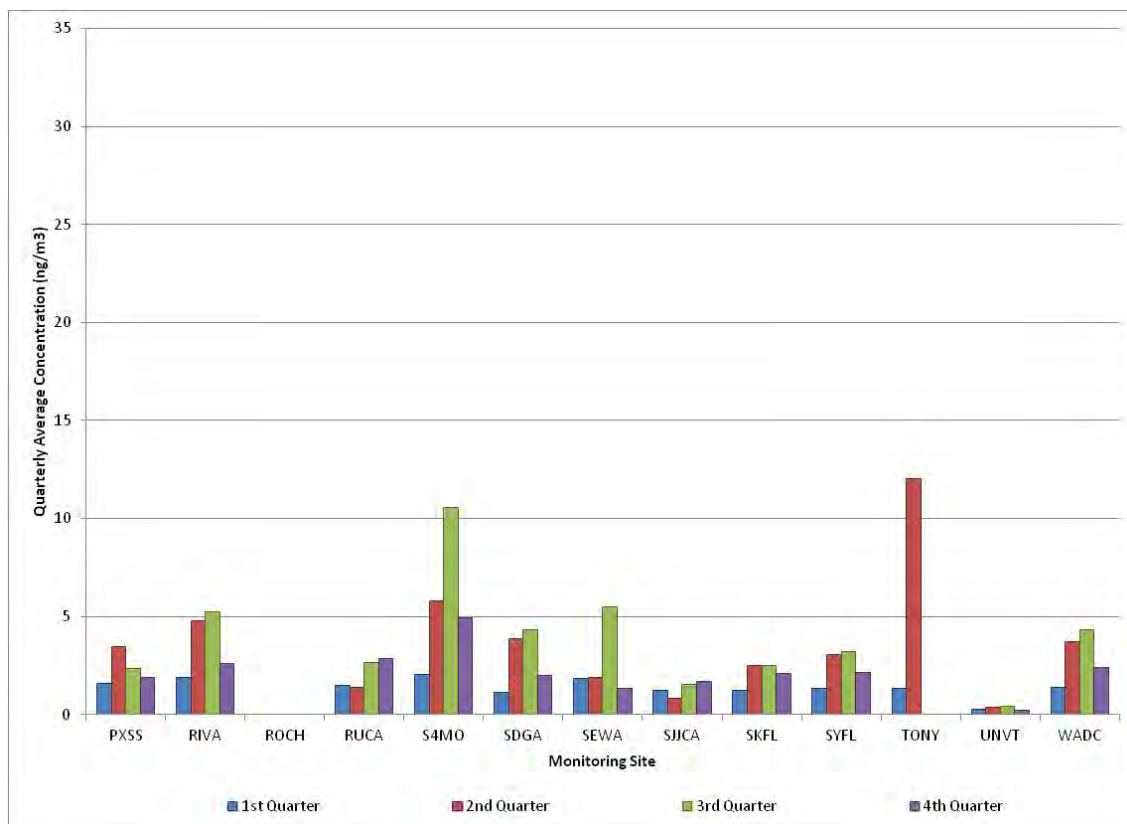
Figure 4-26. Comparison of Average Quarterly Acetaldehyde Concentrations
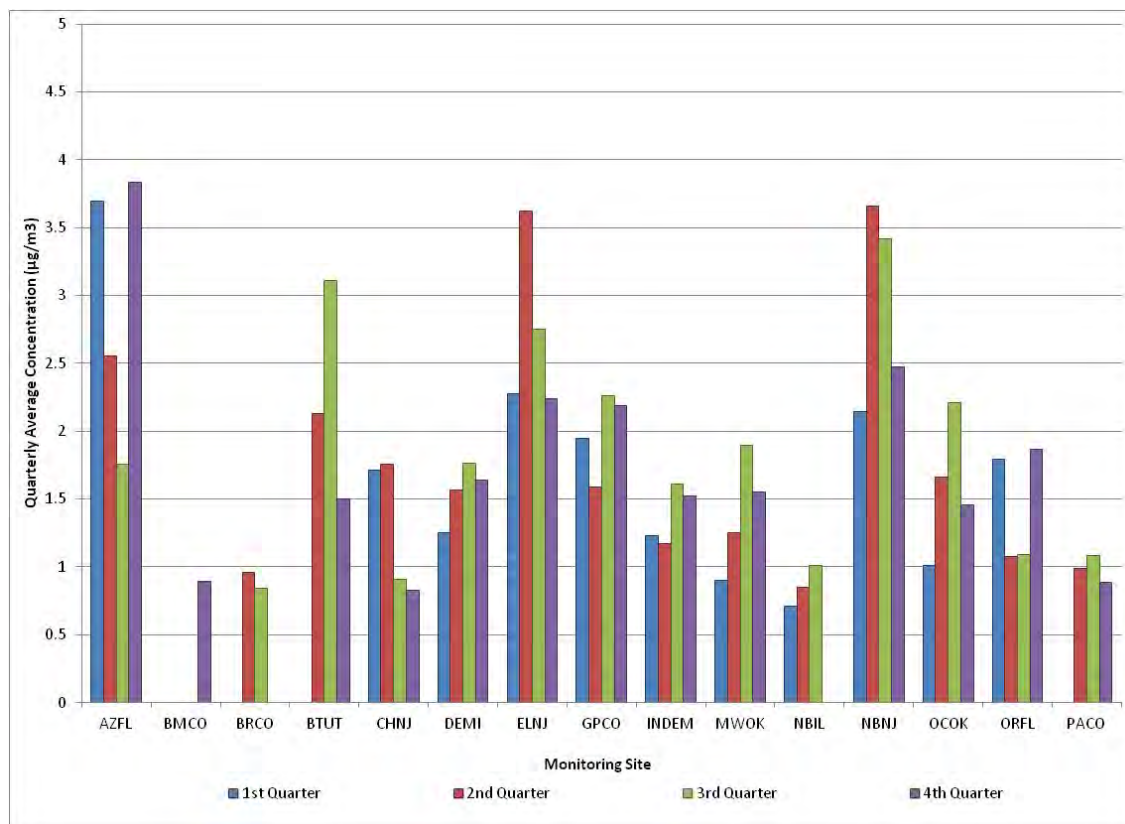
Figure 4-26. Comparison of Average Quarterly Acetaldehyde Concentrations (Continued)
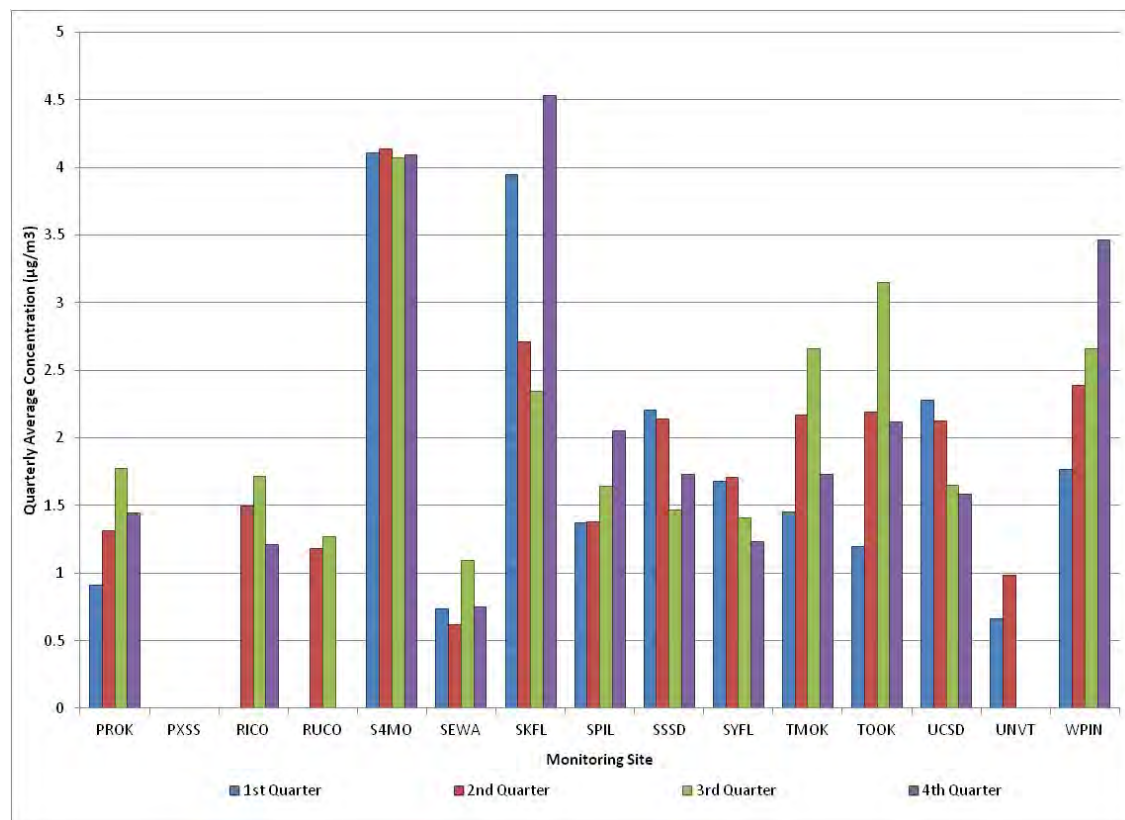
Figure 4-27. Comparison of Average Quarterly Acrylonitrile Concentrations
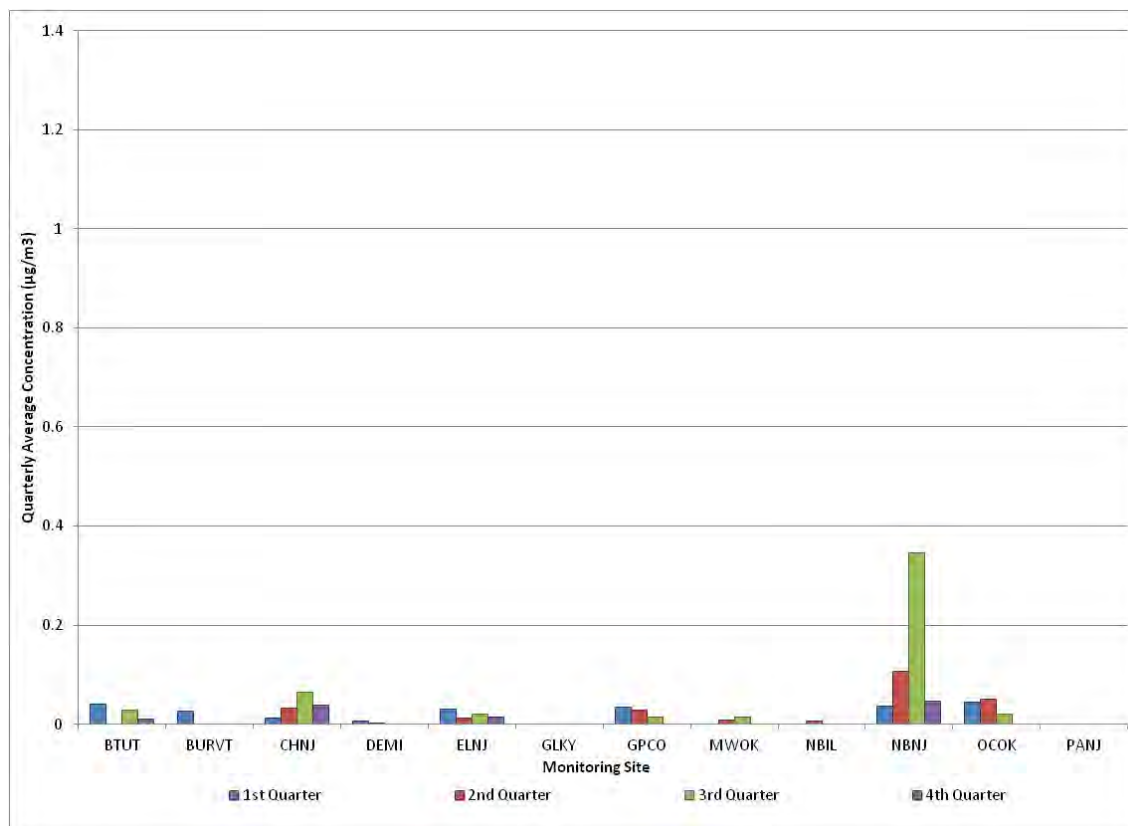
Figure 4-27. Comparison of Average Quarterly Acrylonitrile Concentrations (Continued)
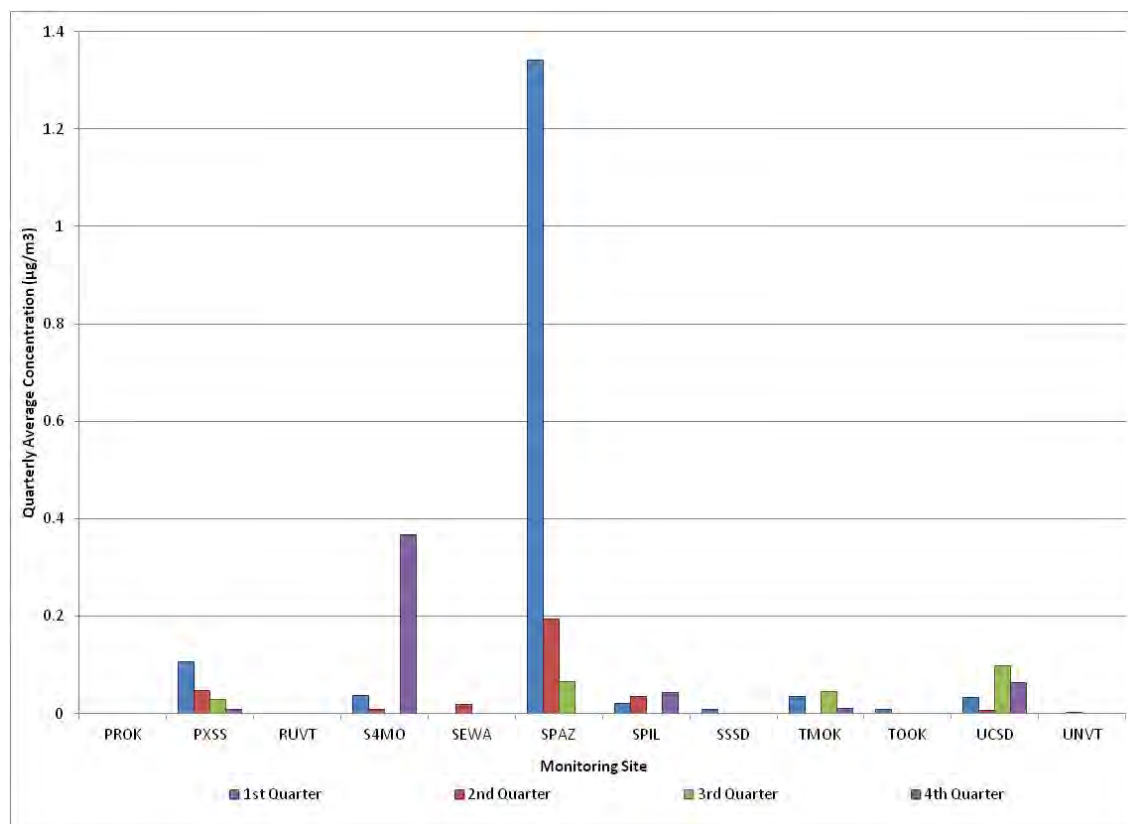
Figure 4-28a. Comparison of Average Quarterly Arsenic (PM$_{10}$) Concentrations
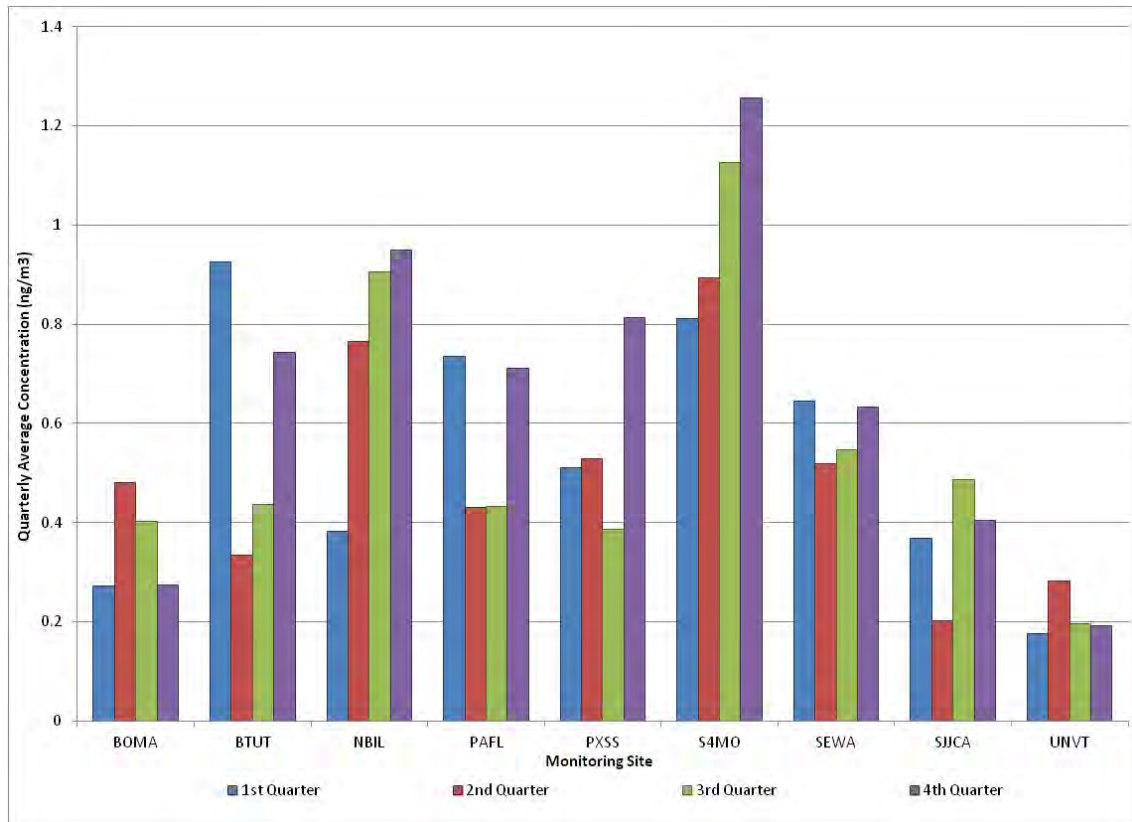
Figure 4-28b. Comparison of Average Quarterly Arsenic (TSP) Concentrations
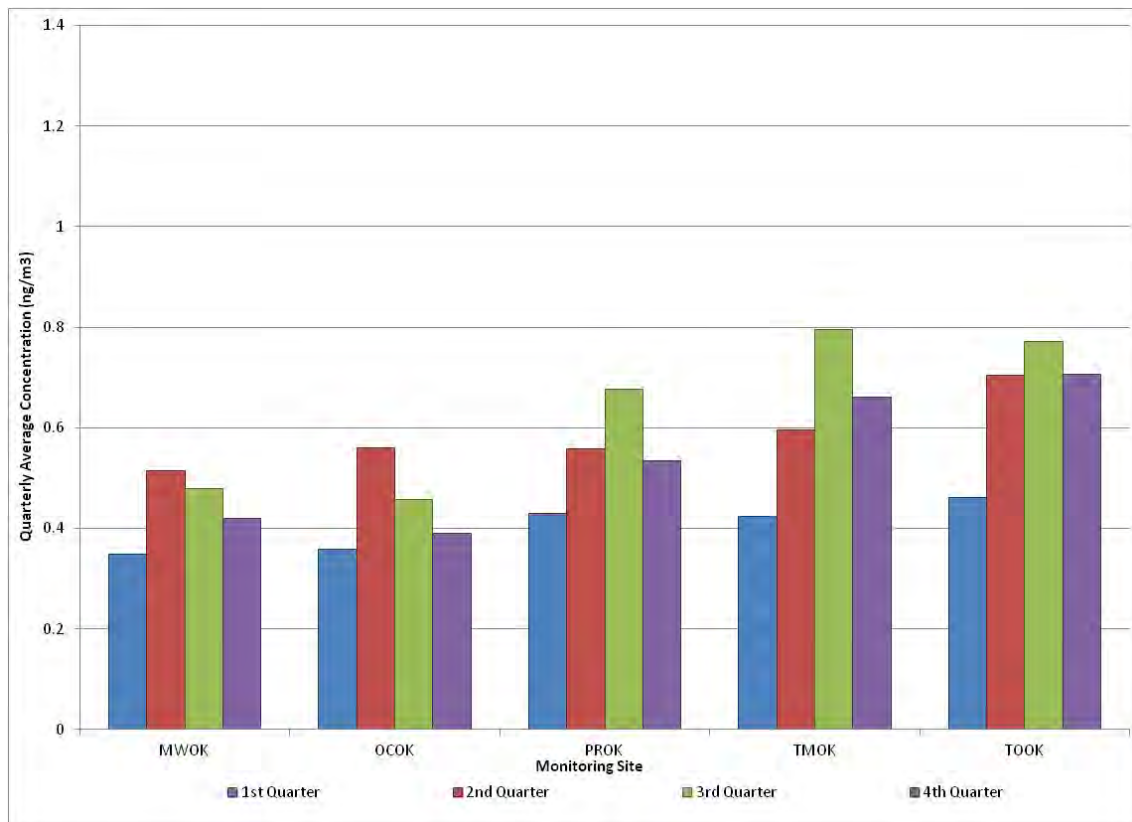
Figure 4-29. Comparison of Average Quarterly Benzene Concentrations
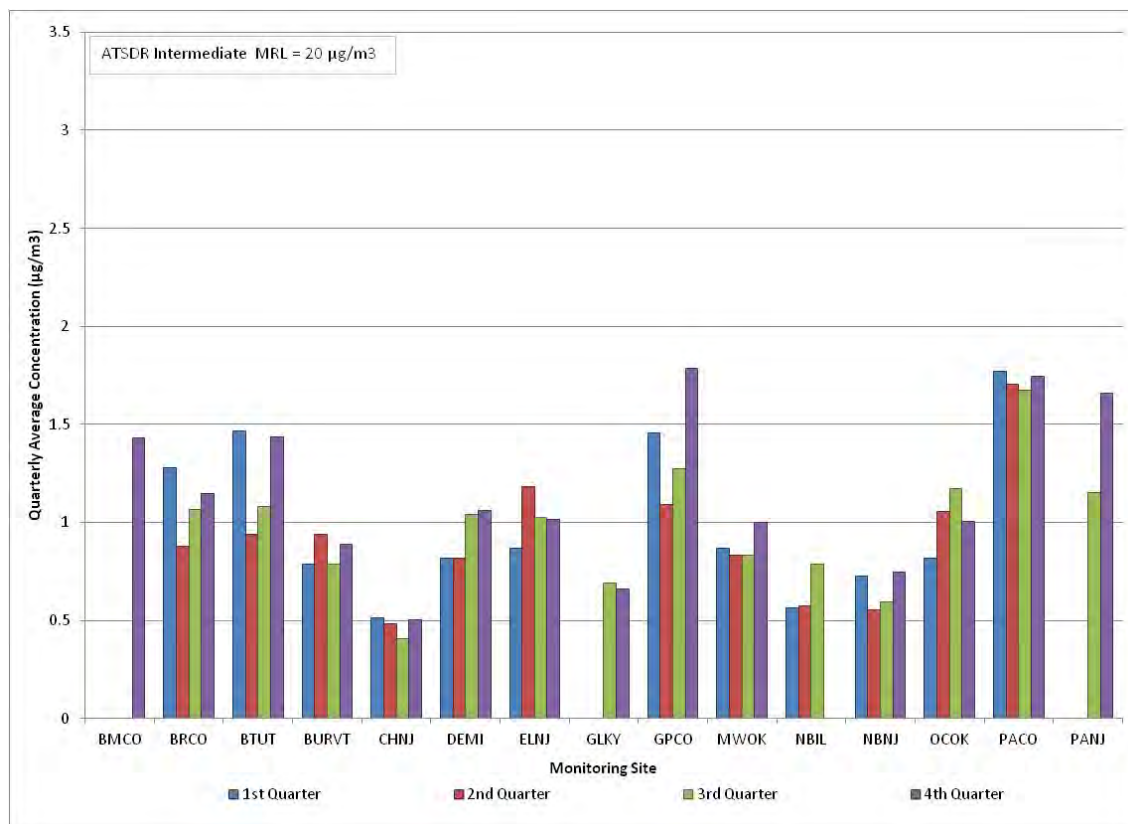
Figure 4-29. Comparison of Average Quarterly Benzene Concentrations (Continued)
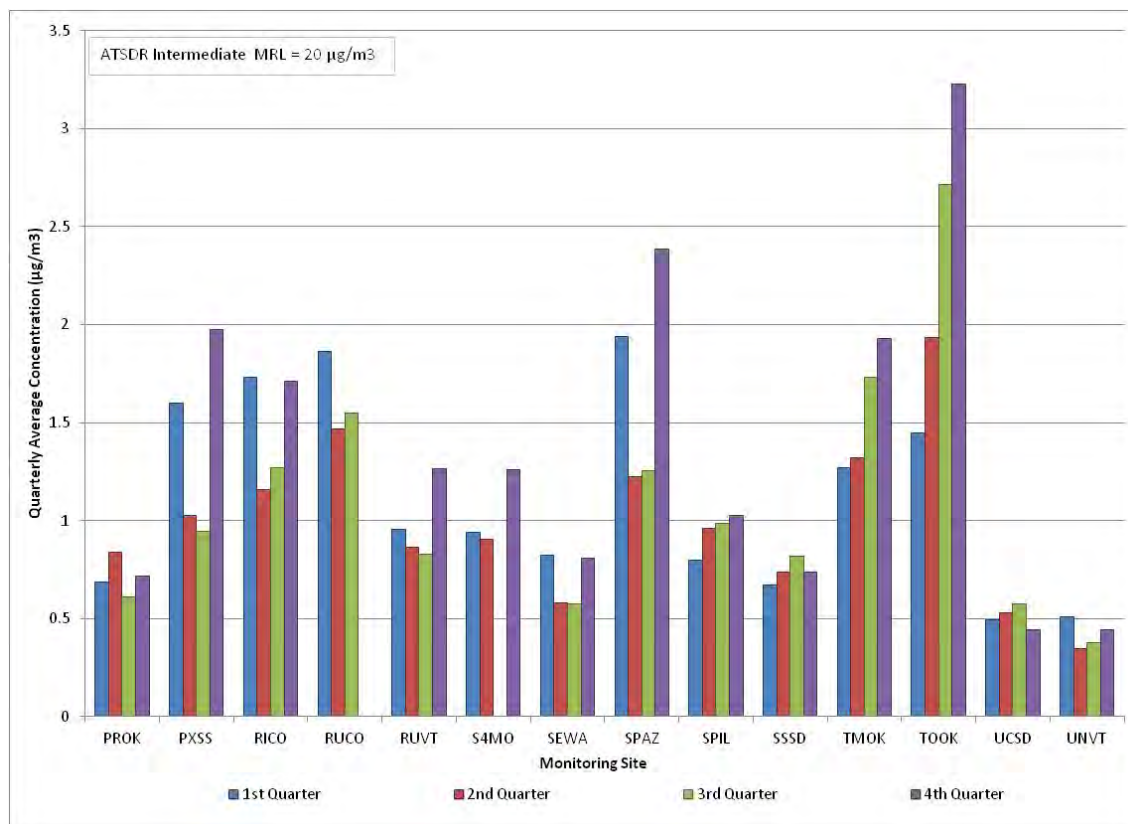
Figure 4-30. Comparison of Average Quarterly Benzo(a)pyrene Concentrations
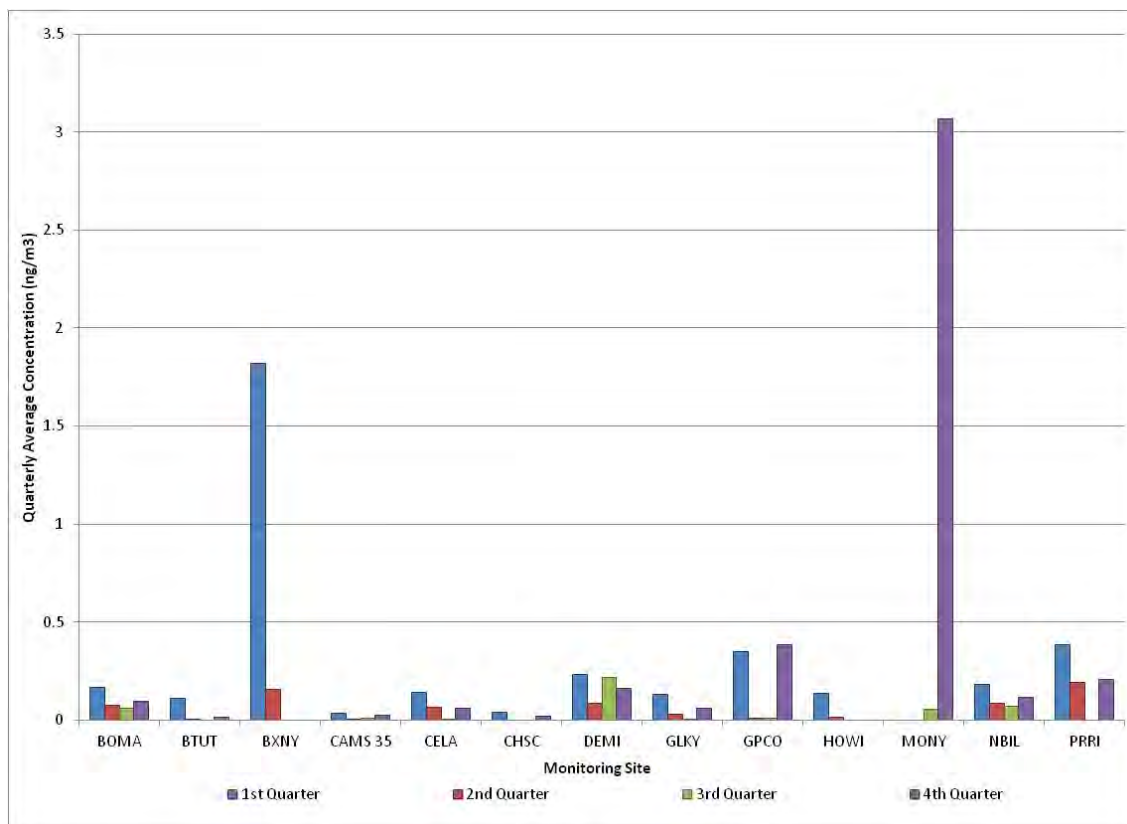
Figure 4-30. Comparison of Average Quarterly Benzo(a)pyrene Concentrations Continued)
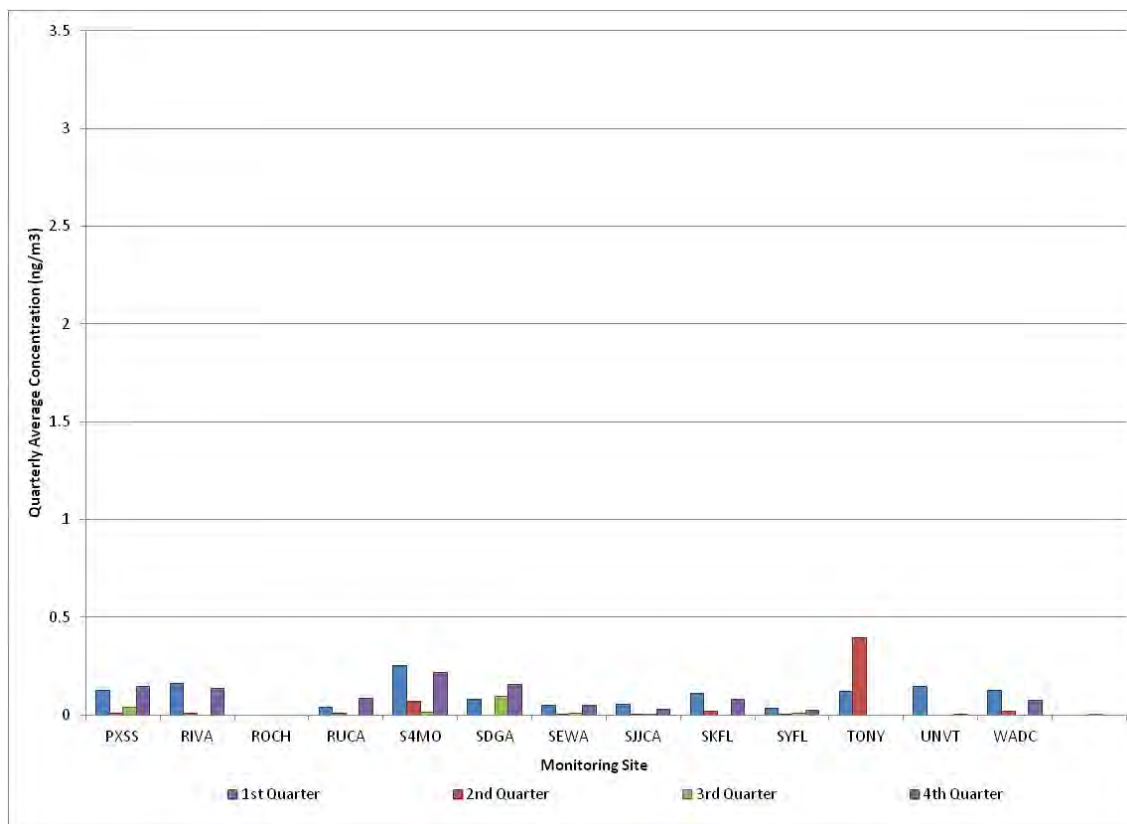
Figure 4-31a. Comparison of Average Quarterly Beryllium (PM$_{10}$) Concentrations
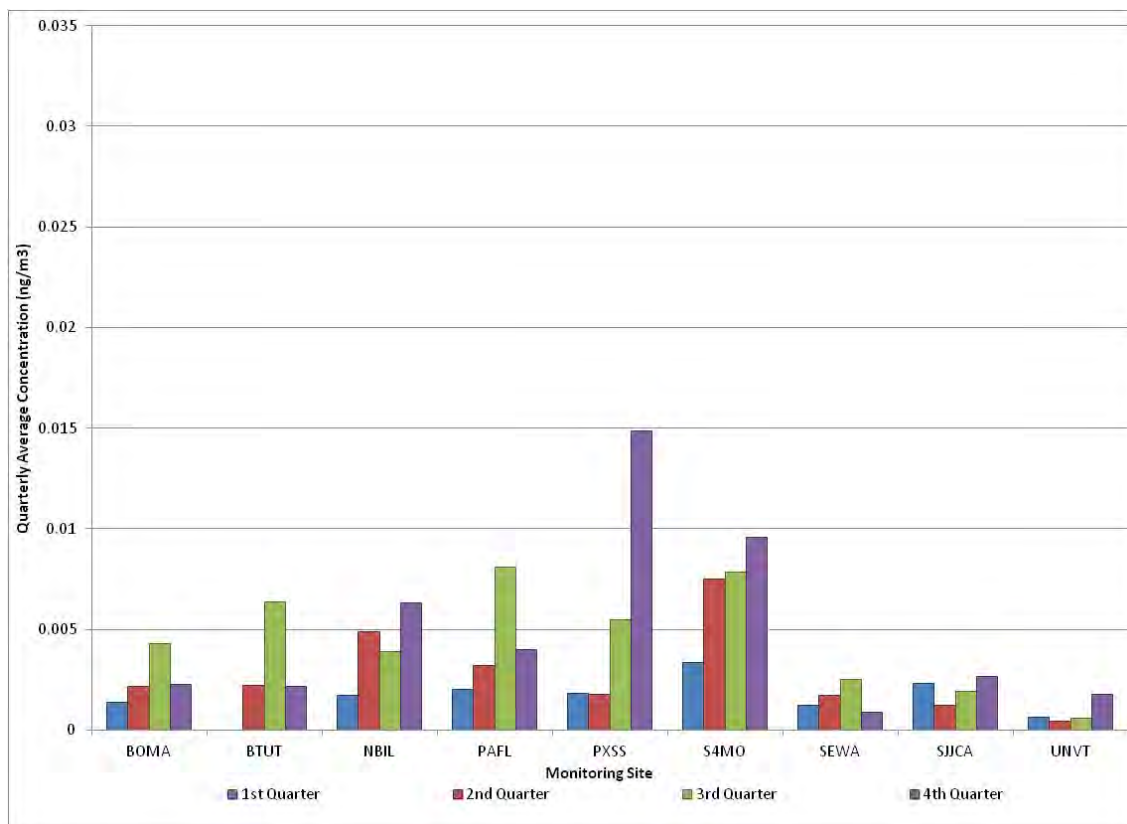
Figure 4-31b. Comparison of Average Quarterly Beryllium (TSP) Concentrations
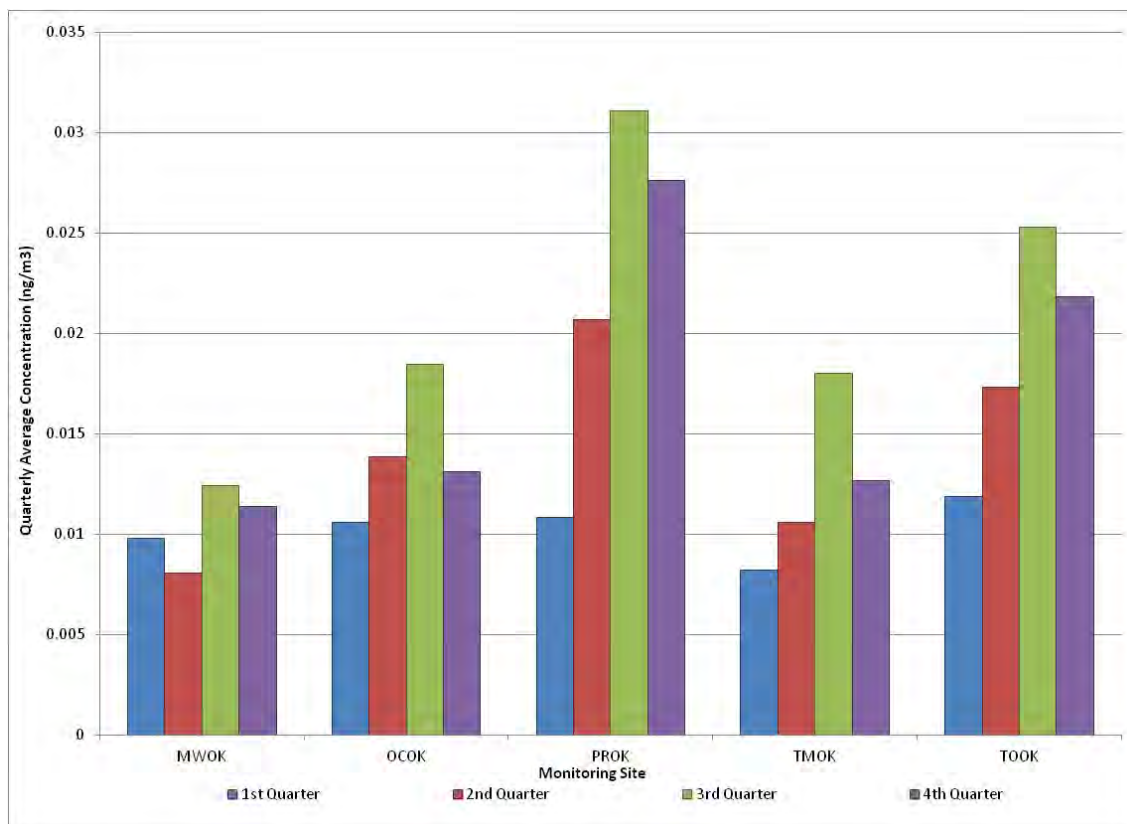
Figure 4-32. Comparison of Average Quarterly 1,3-Butadiene Concentrations
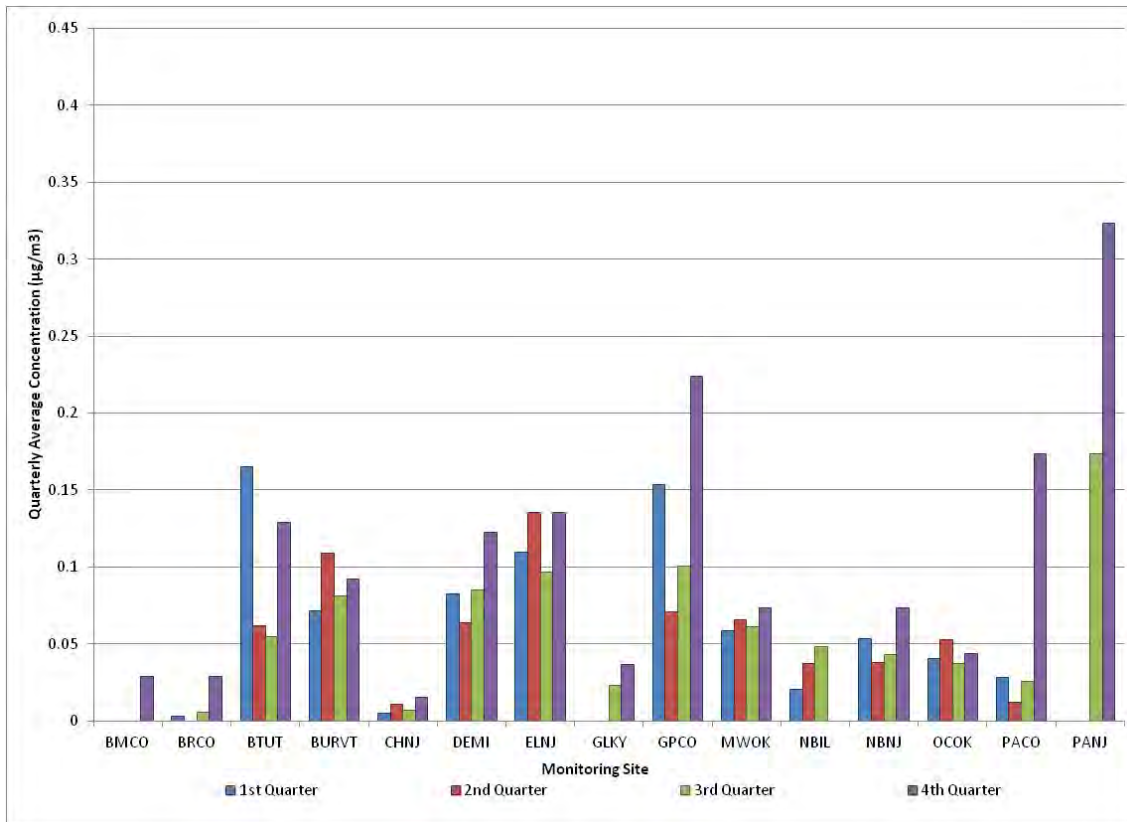
Figure 4-32. Comparison of Average Quarterly 1,3-Butadiene Concentrations (Continued)
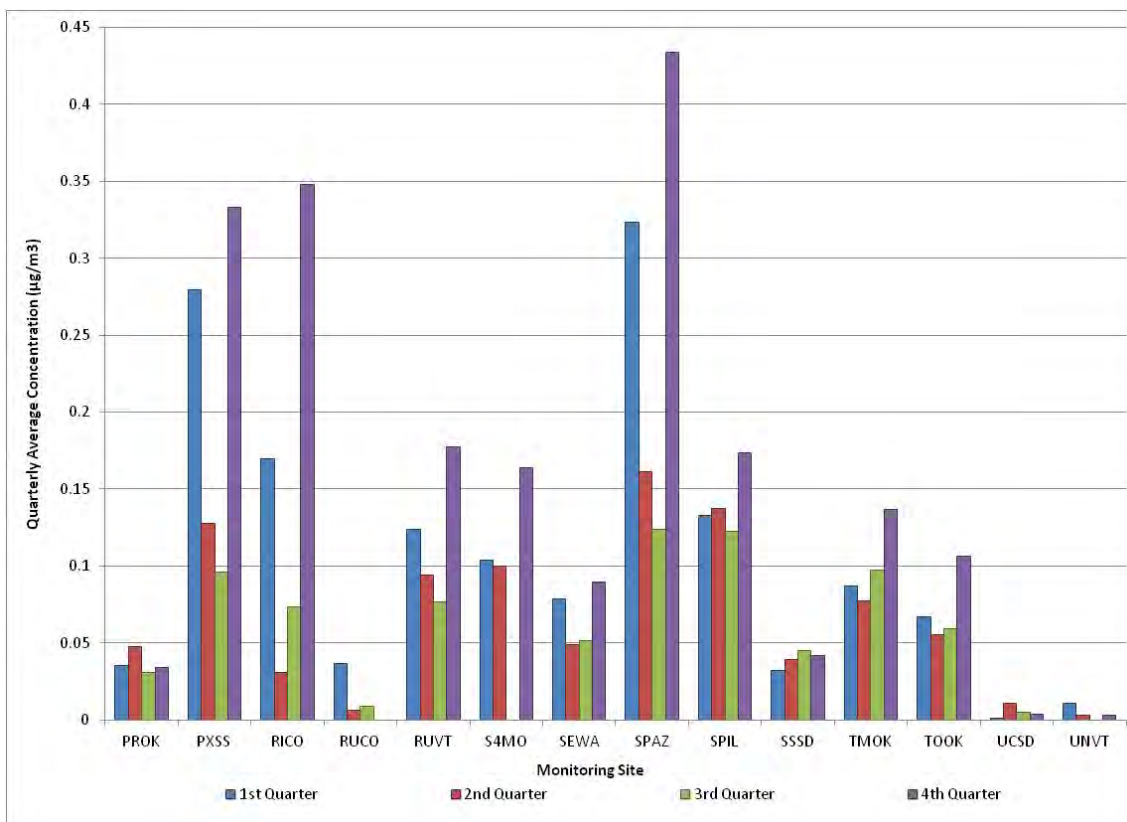
Figure 4-33a. Comparison of Average Quarterly Cadmium (PM$_{10}$) Concentrations
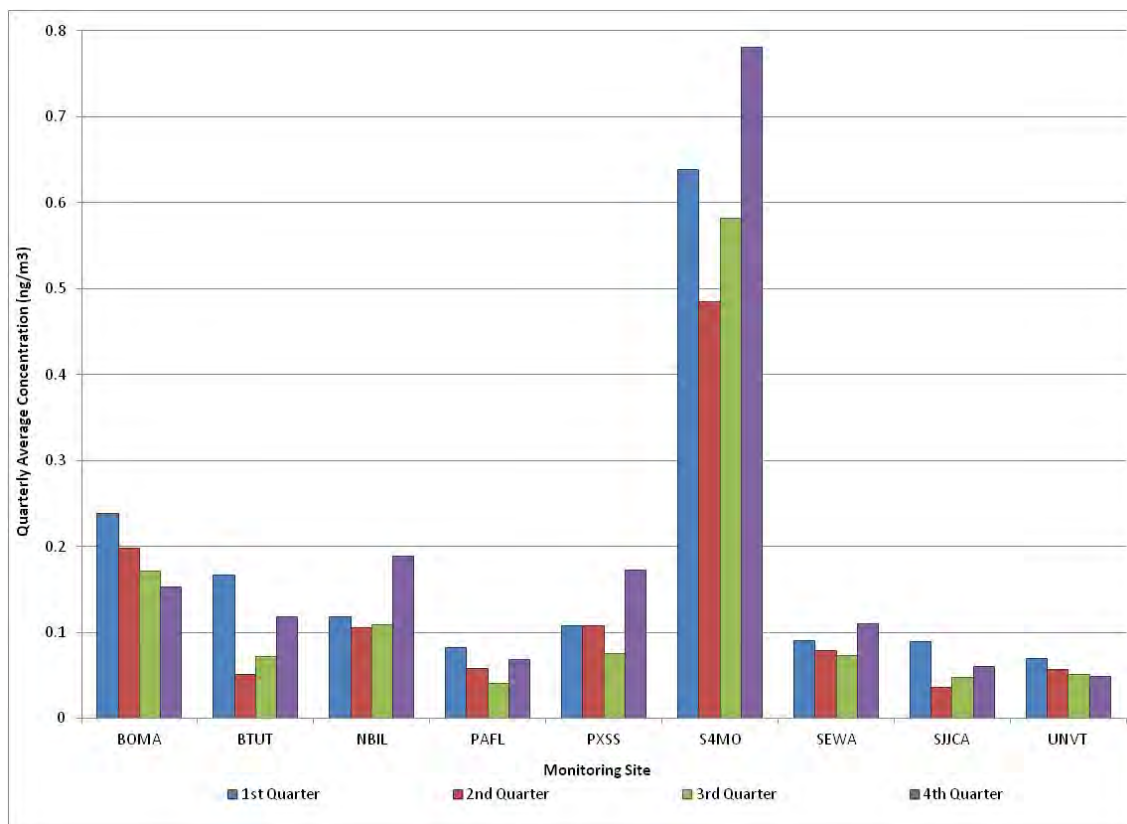
Figure 4-33b. Comparison of Average Quarterly Cadmium (TSP) Concentrations
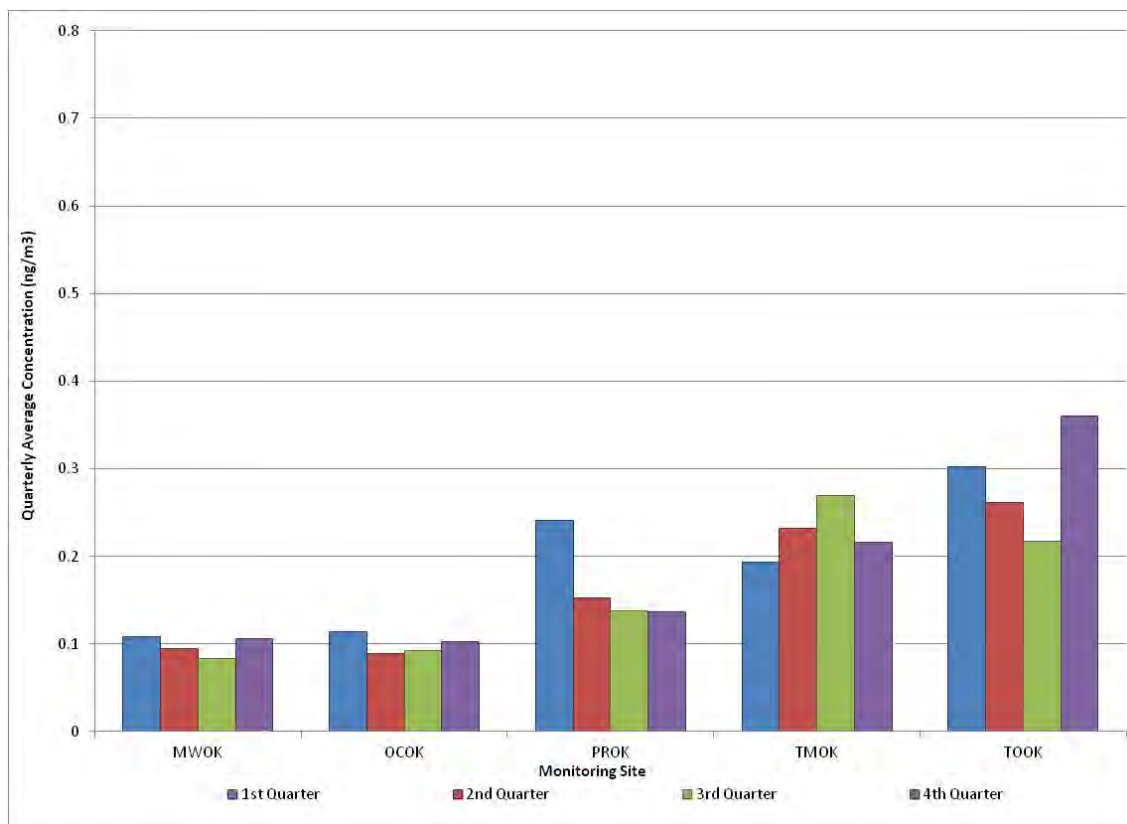
Figure 4-34. Comparison of Average Quarterly Carbon Tetrachloride Concentrations
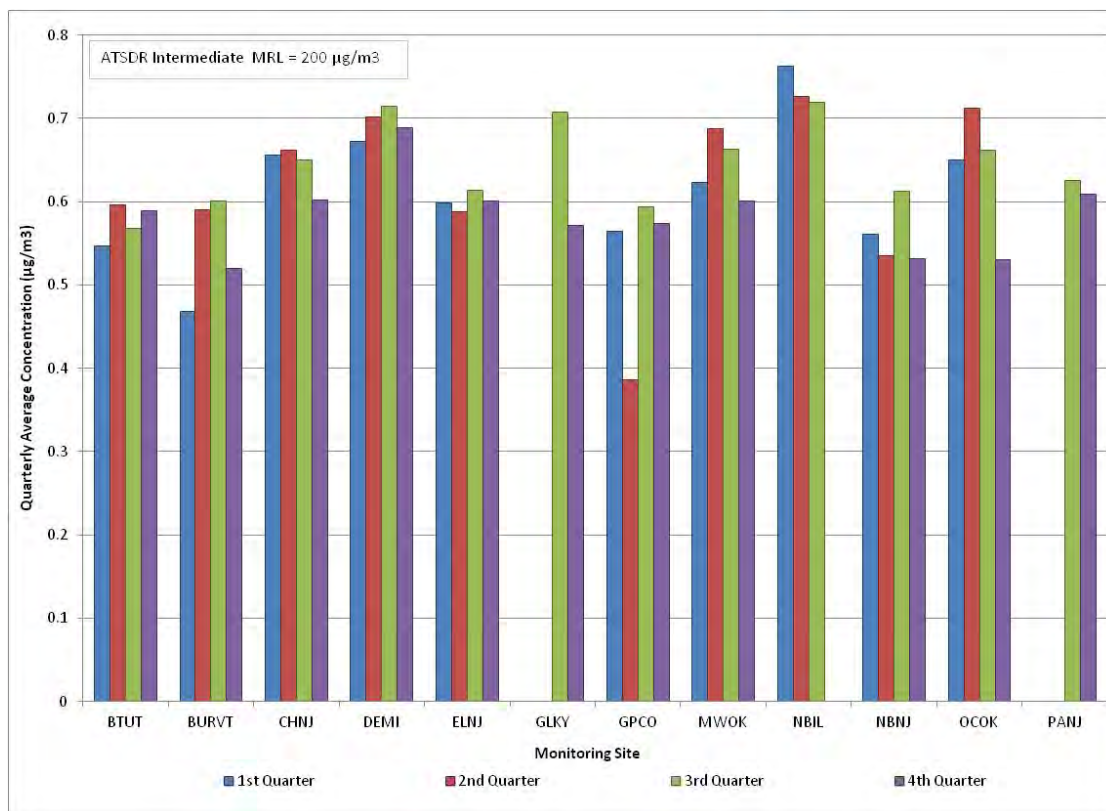
Figure 4-34. Comparison of Average Quarterly Carbon Tetrachloride Concentrations (Continued)
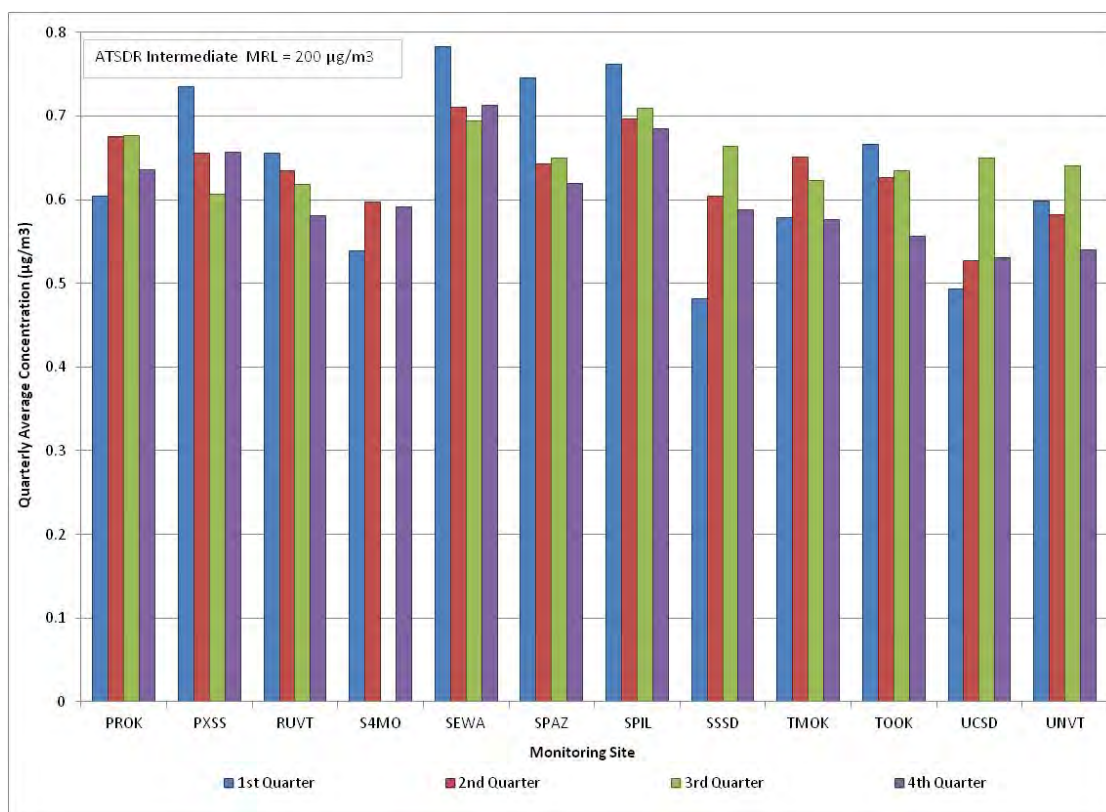
Figure 4-35. Comparison of Average Quarterly Chloroform Concentrations
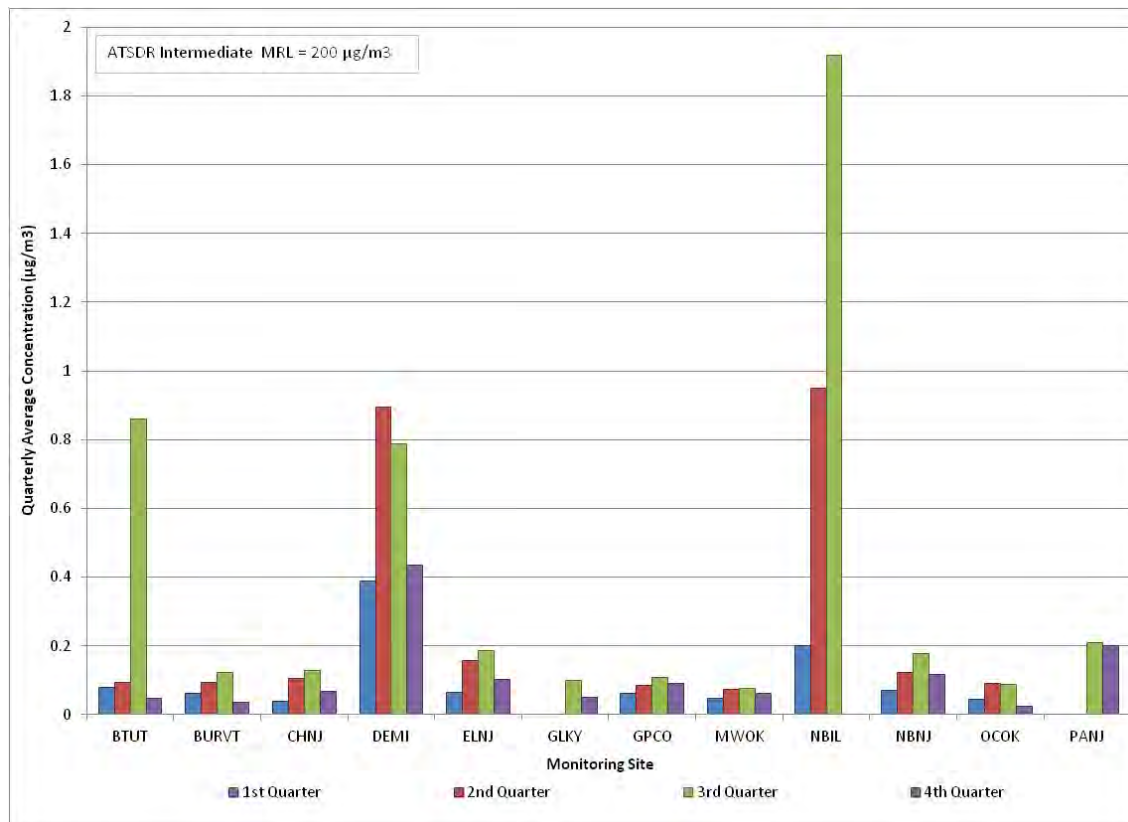
Figure 4-35. Comparison of Average Quarterly Chloroform Concentrations (Continued)
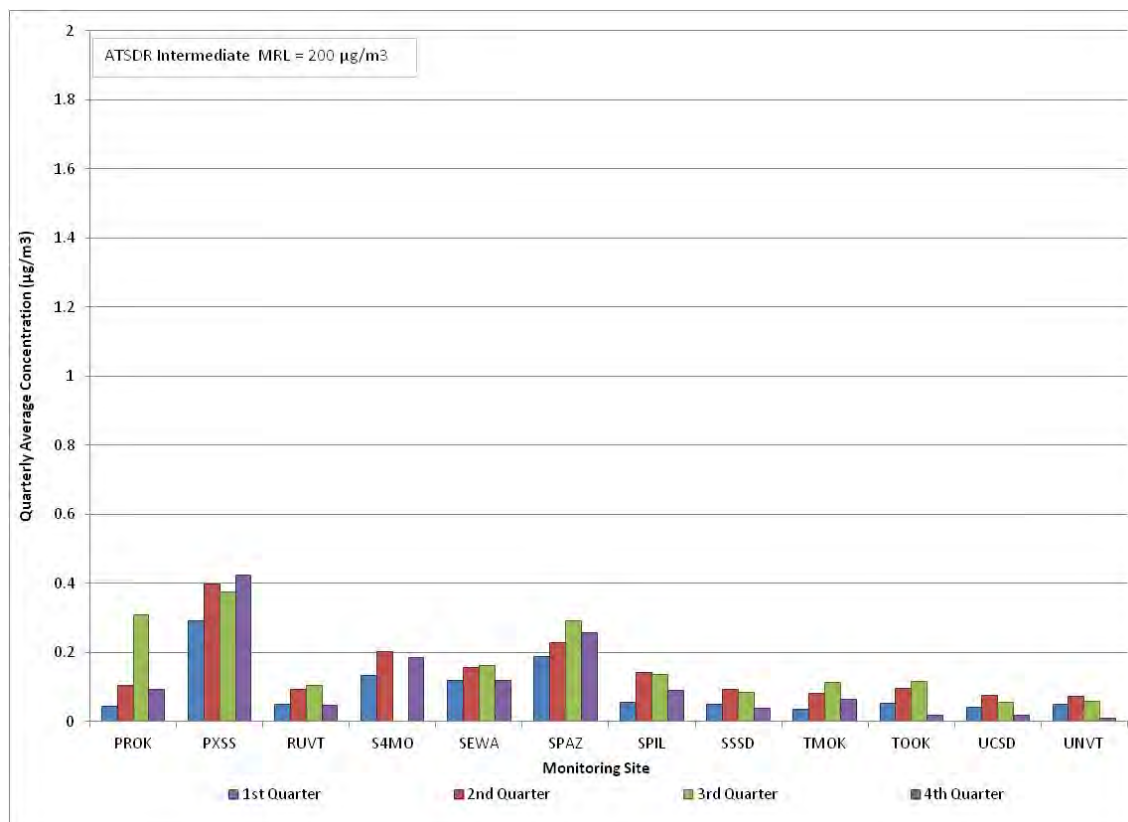
Figure 4-36. Comparison of Average Quarterly *p*-Dichlorobenzene Concentrations
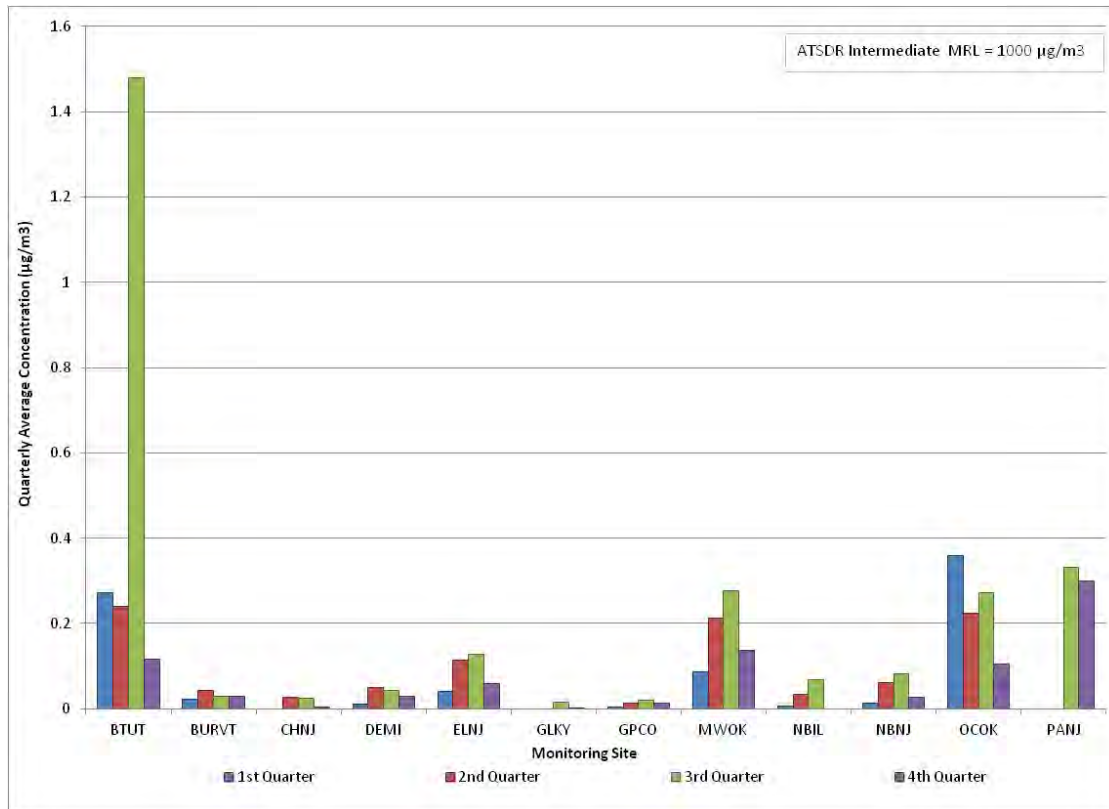
Figure 4-36. Comparison of Average Quarterly *p*-Dichlorobenzene Concentrations (Continued)
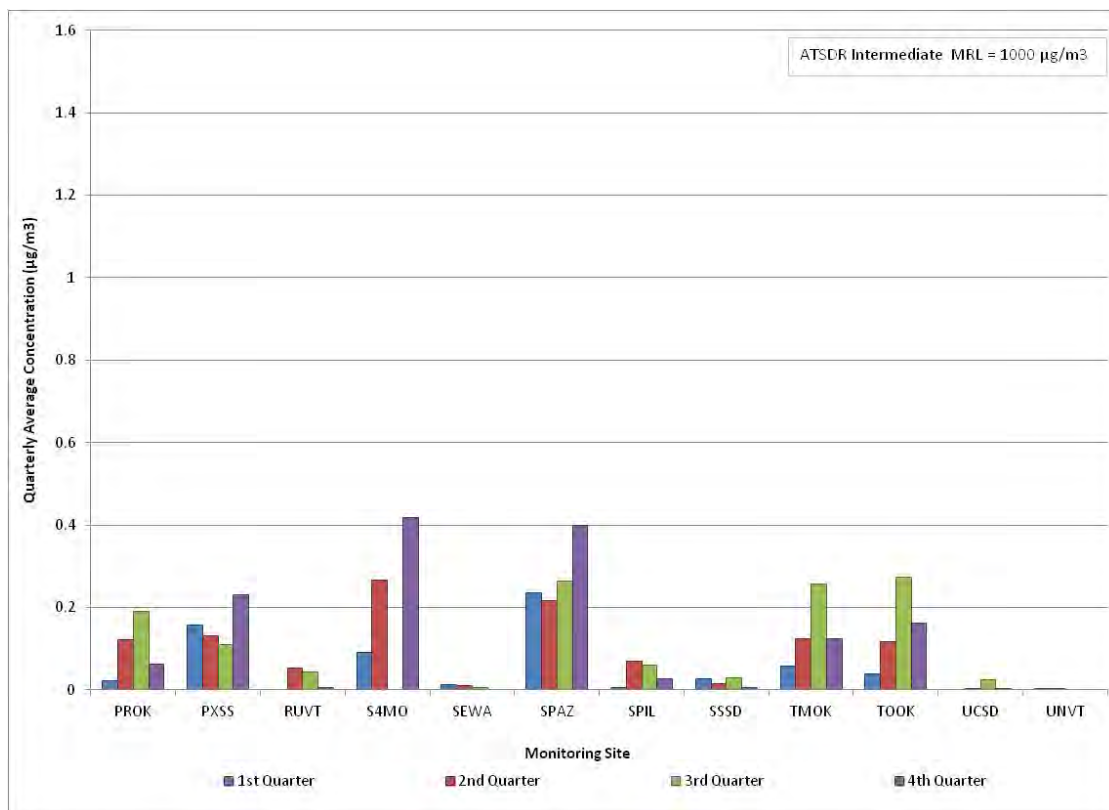
Figure 4-37. Comparison of Average Quarterly 1,2-Dichloroethane Concentrations
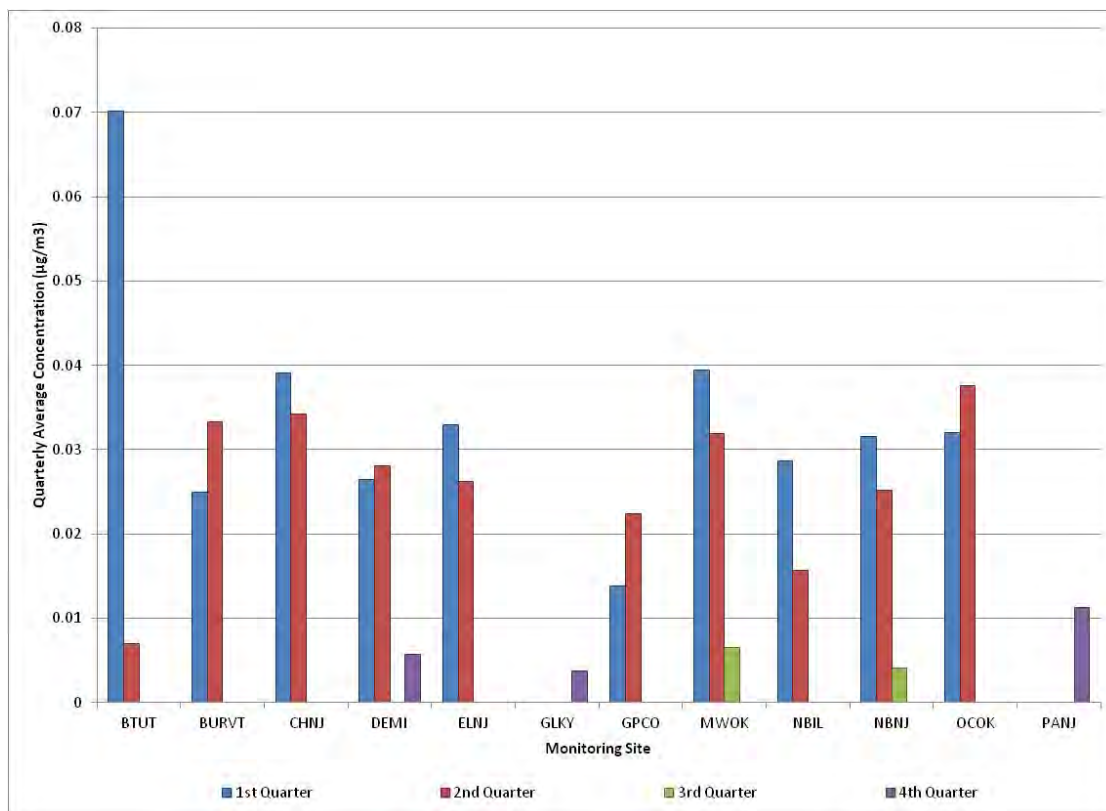
Figure 4-37. Comparison of Average Quarterly 1,2-Dichloroethane Concentrations (Continued)
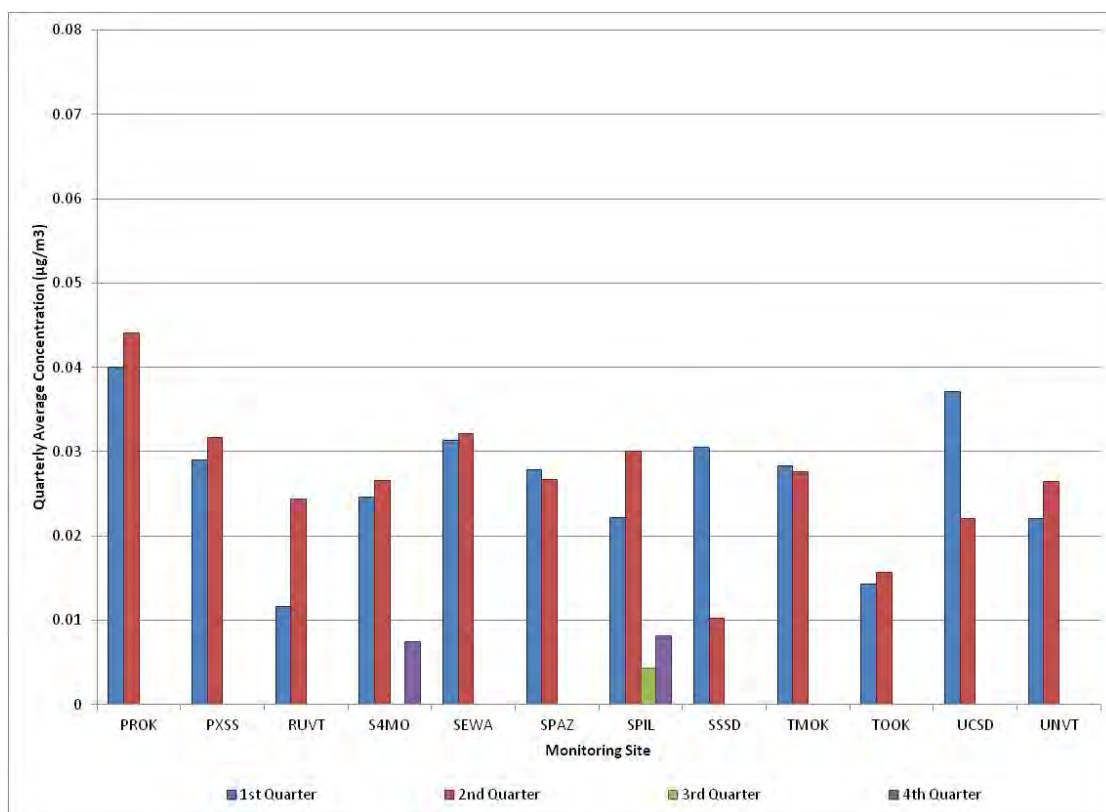
Figure 4-38. Comparison of Average Quarterly Ethylbenzene Concentrations
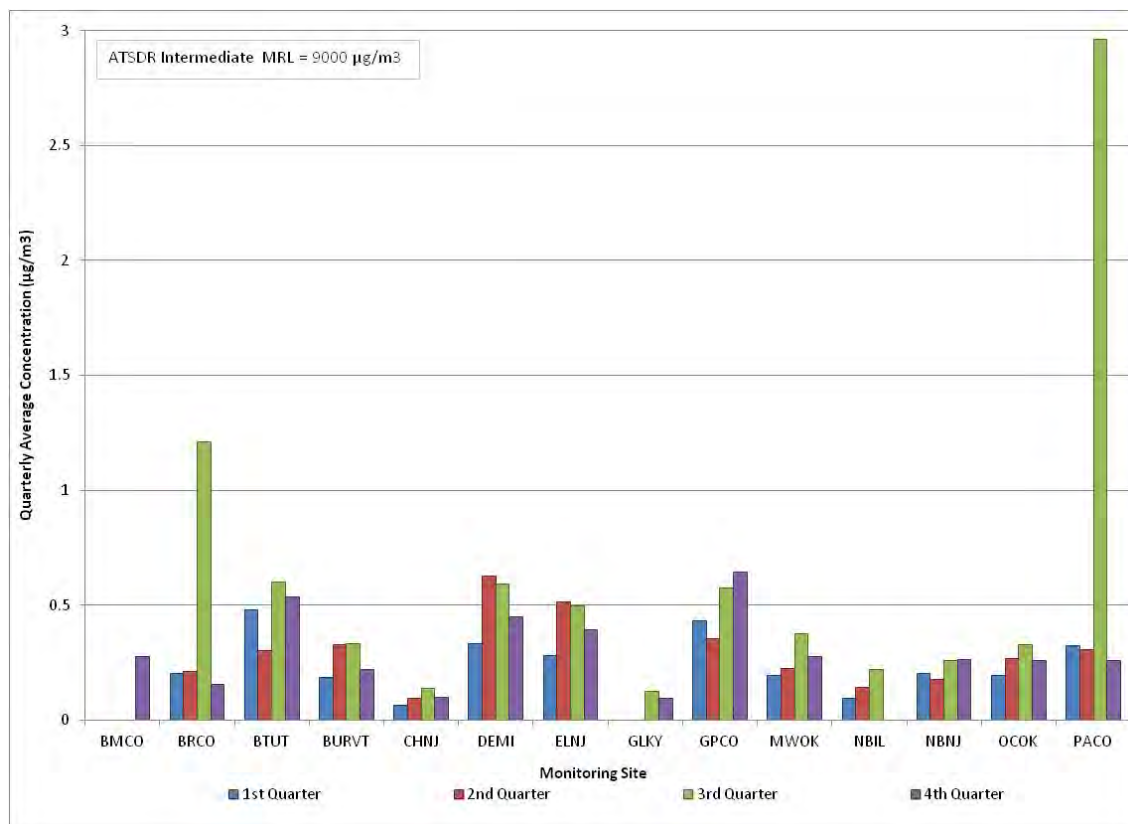
Figure 4-38. Comparison of Average Quarterly Ethylbenzene Concentrations (Continued)
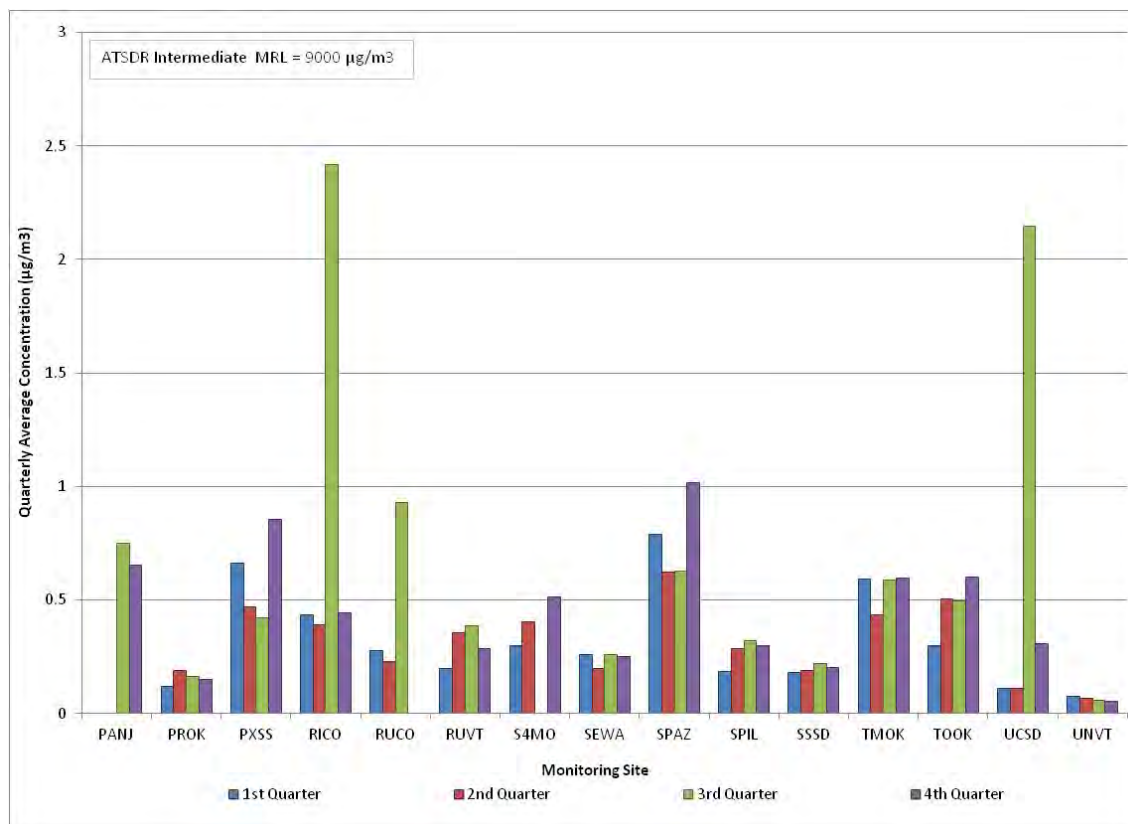
Figure 4-39. Comparison of Average Quarterly Fluorene Concentrations
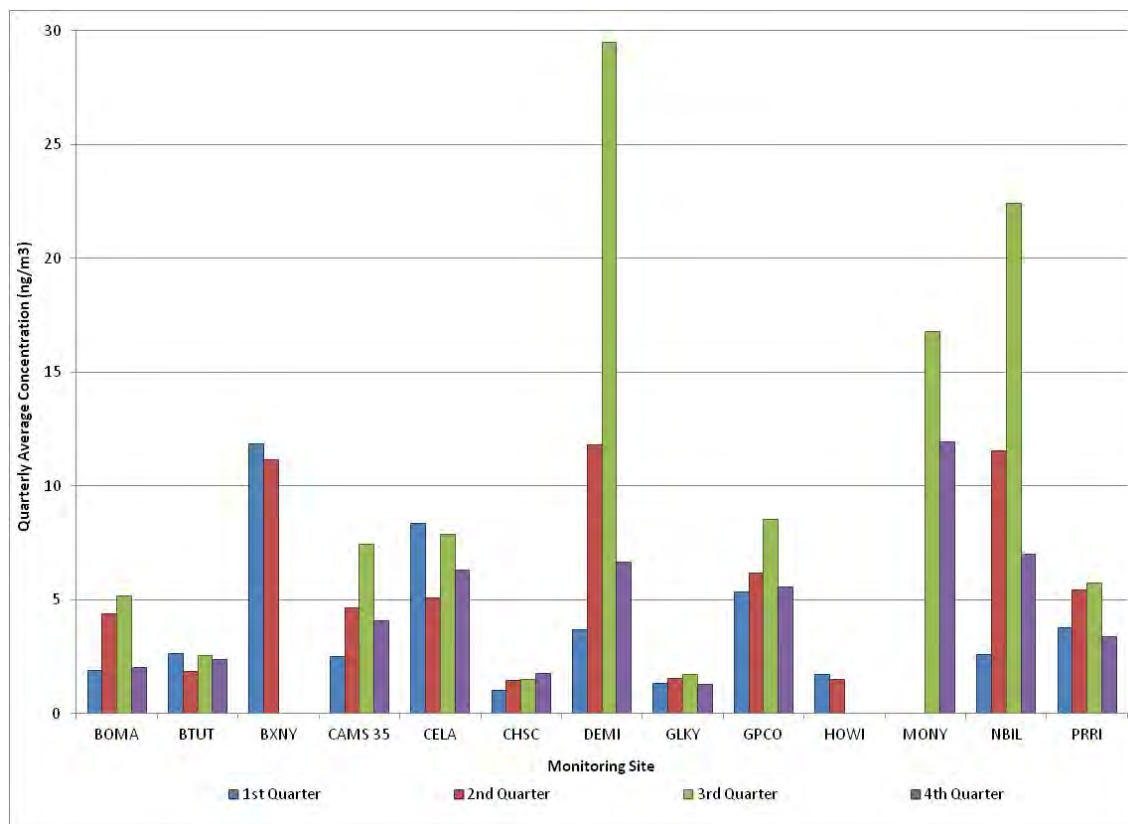
Figure 4-39. Comparison of Average Quarterly Fluorene Concentrations (Continued)
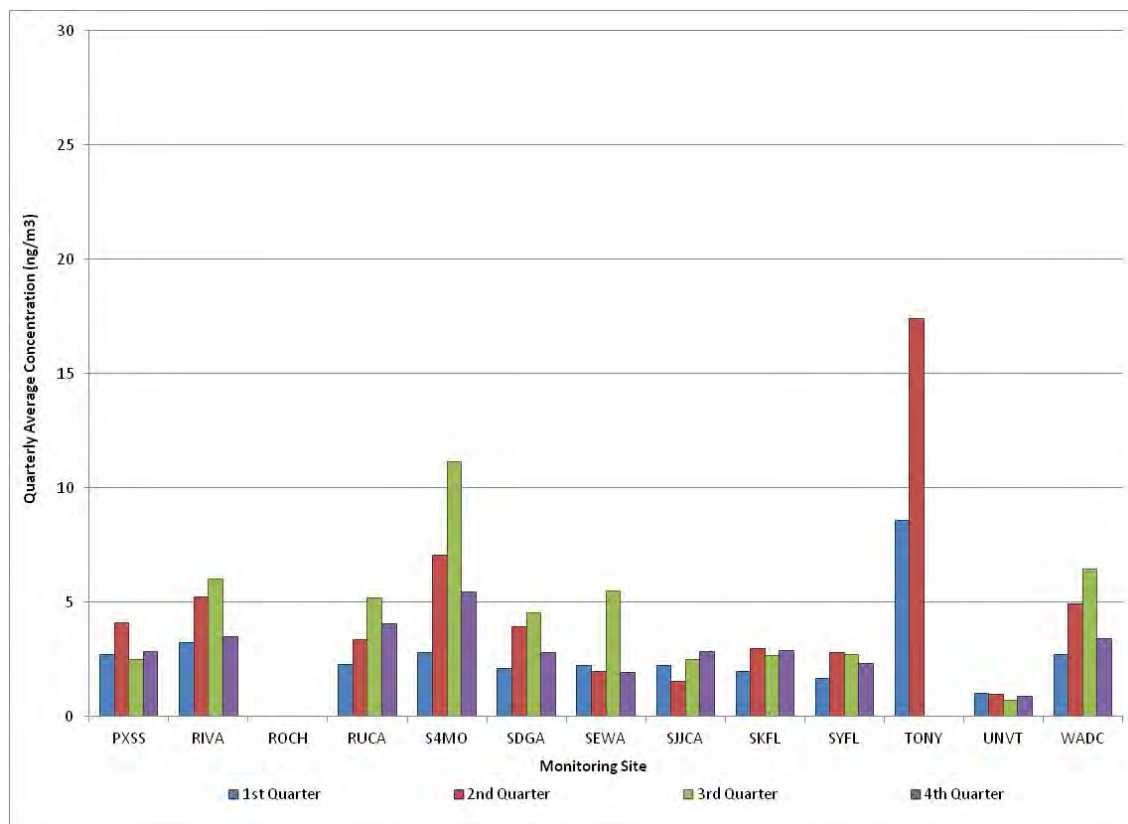
Figure 4-40. Comparison of Average Quarterly Formaldehyde Concentrations
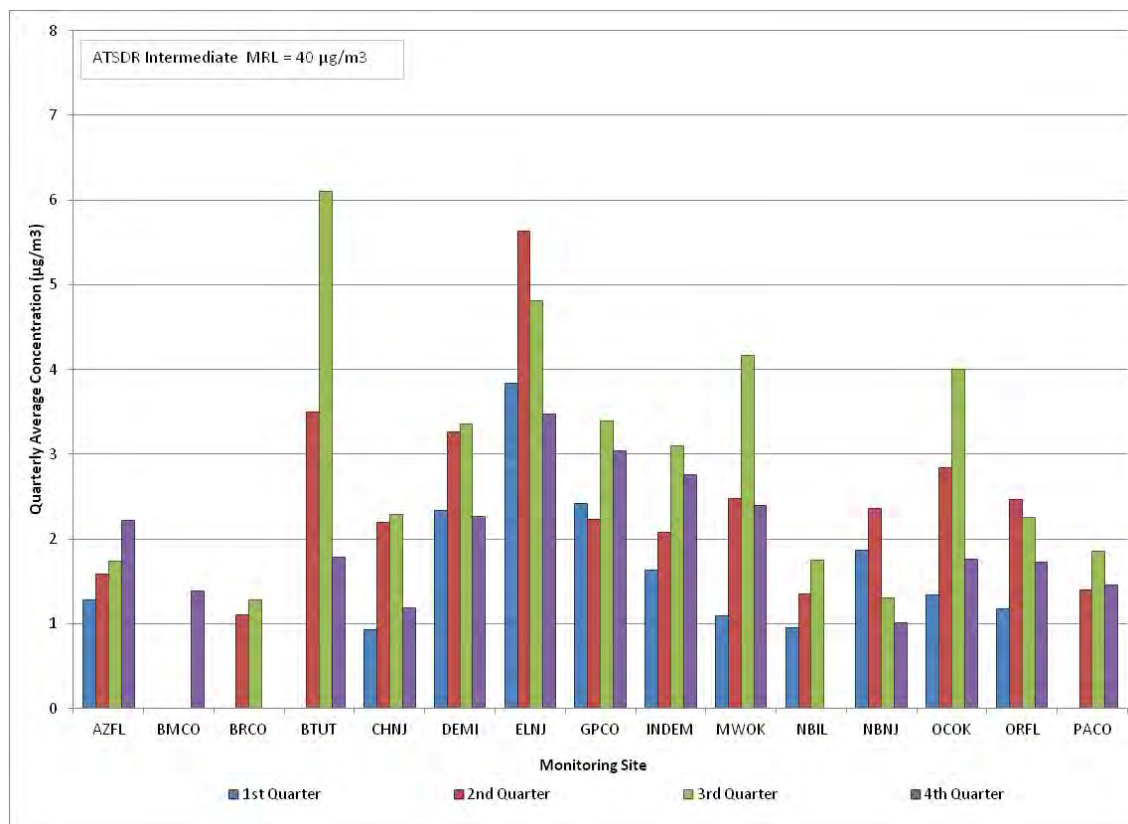
Figure 4-40. Comparison of Average Quarterly Formaldehyde Concentrations (Continued)
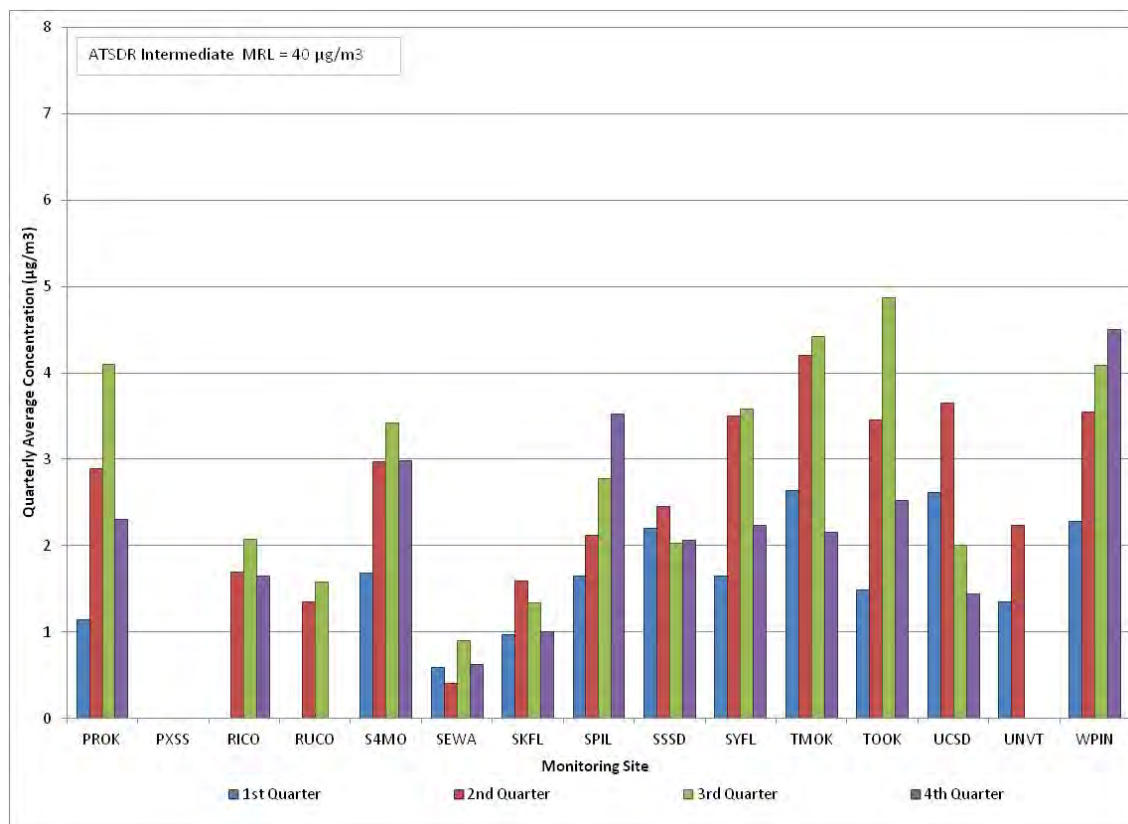
Figure 4-41. Comparison of Average Quarterly Hexavalent Chromium Concentrations
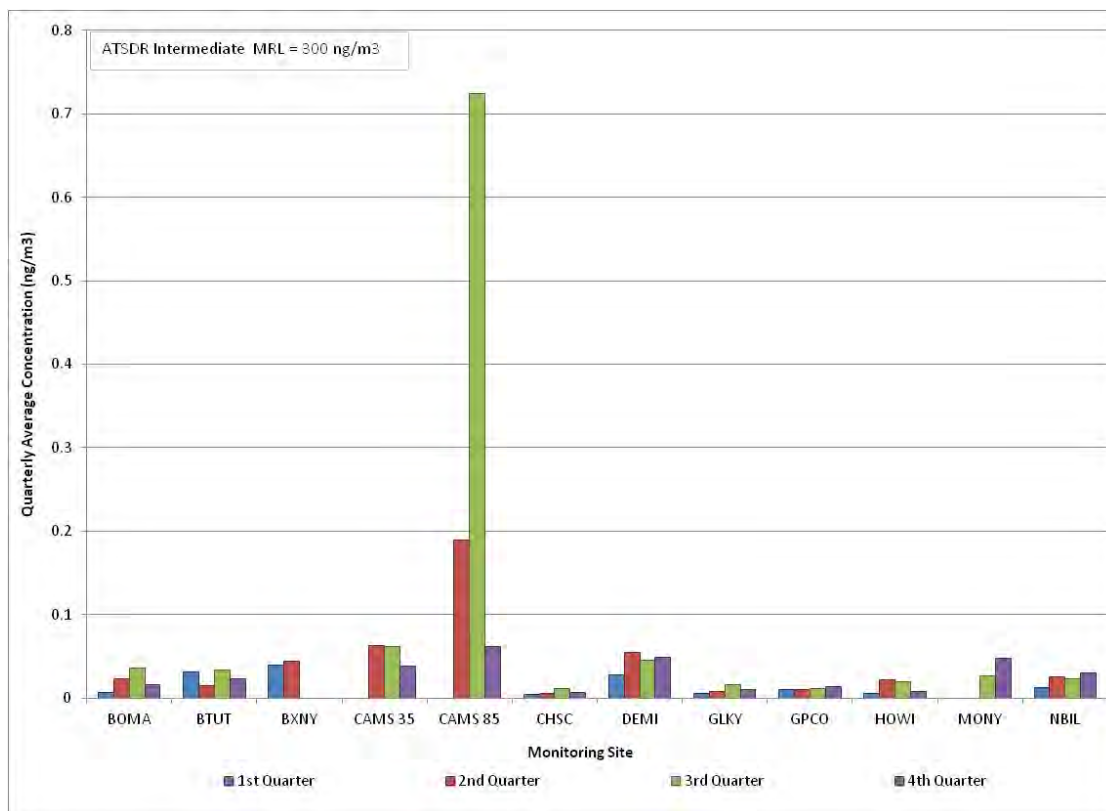
Figure 4-41. Comparison of Average Quarterly Hexavalent Chromium Concentrations (Continued)
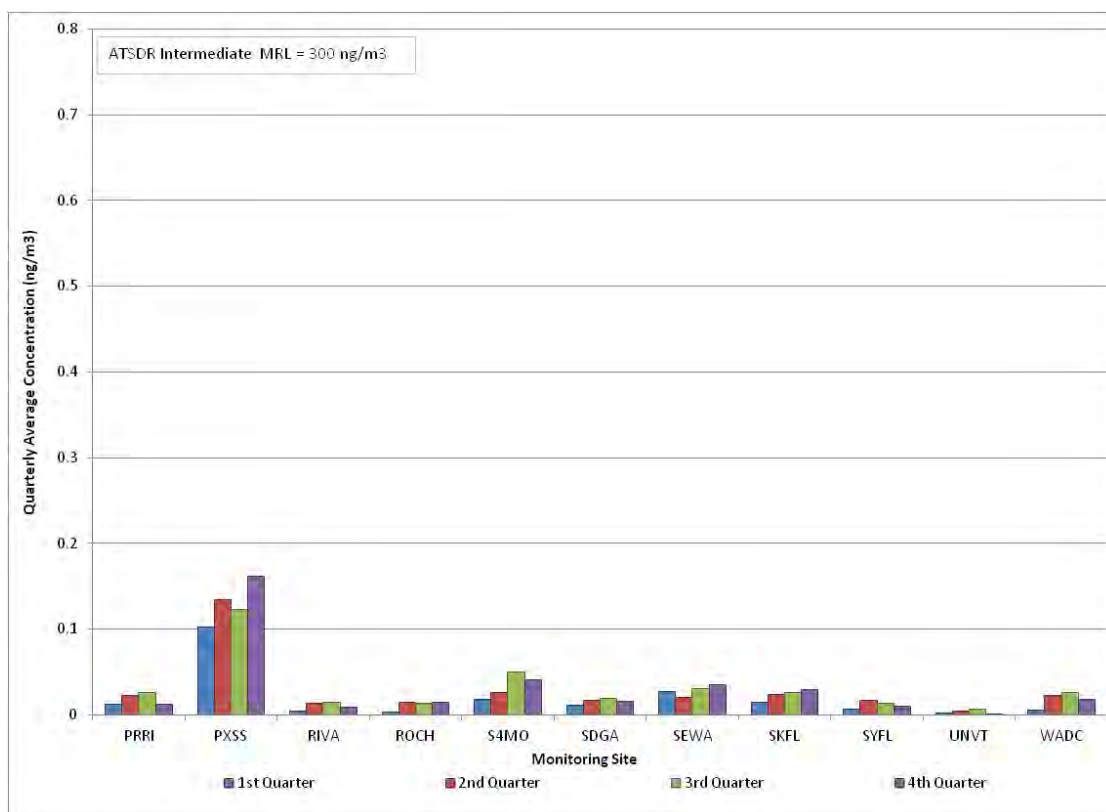
Figure 4-42a. Comparison of Average Quarterly Lead (PM$_{10}$) Concentrations
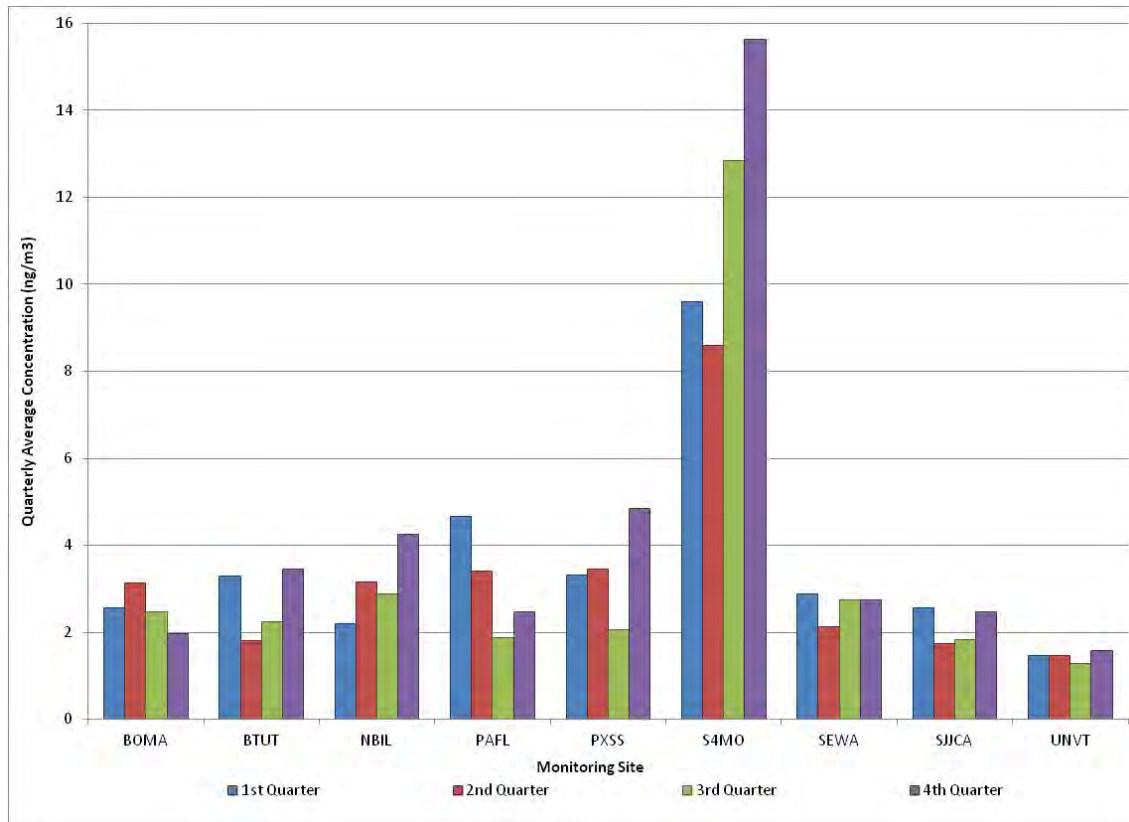
Figure 4-42b. Comparison of Average Quarterly Lead (TSP) Concentrations
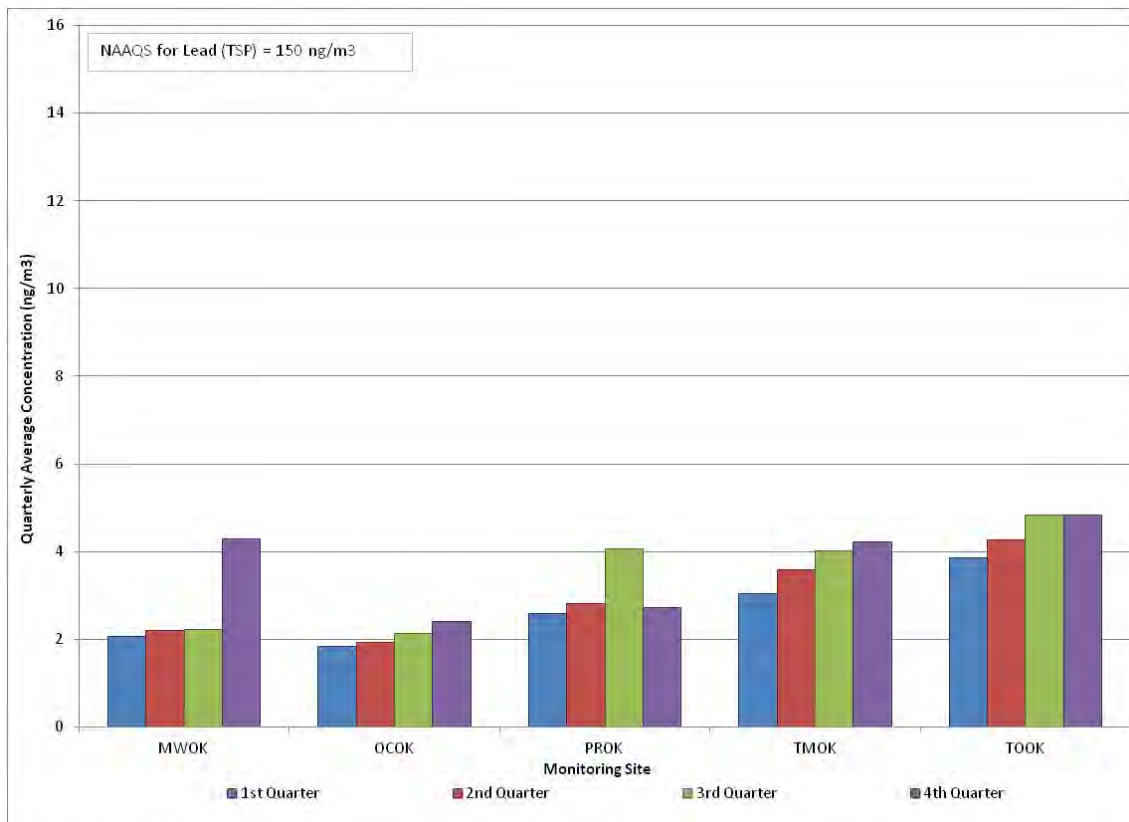
Figure 4-43a. Comparison of Average Quarterly Manganese (PM$_{10}$) Concentrations
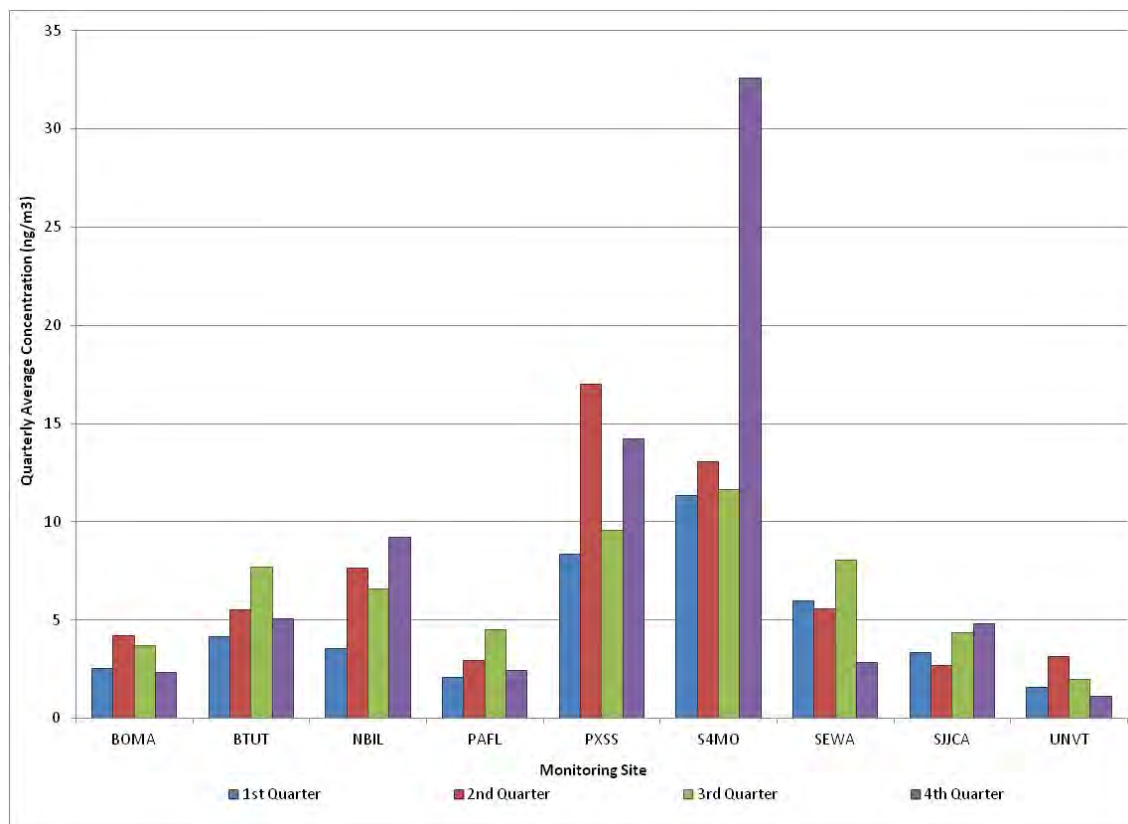
Figure 4-43b. Comparison of Average Quarterly Manganese (TSP) Concentrations
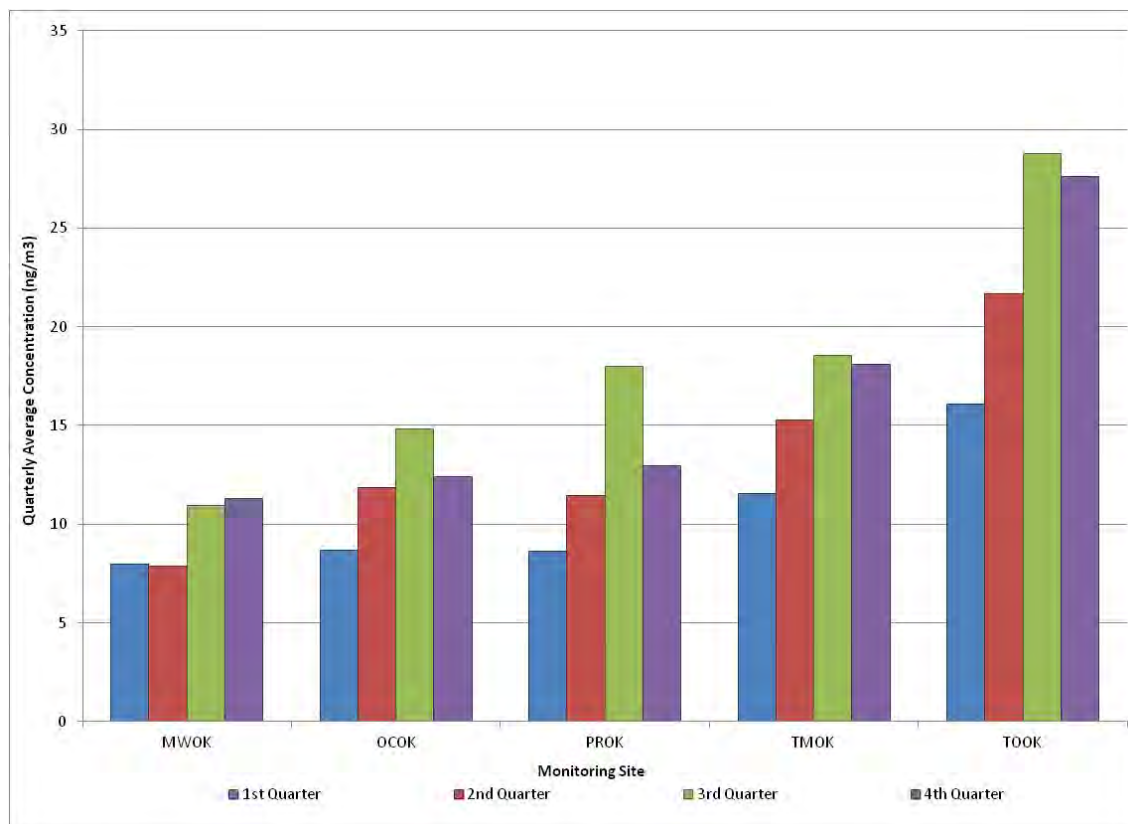
Figure 4-44. Comparison of Average Quarterly Naphthalene Concentrations
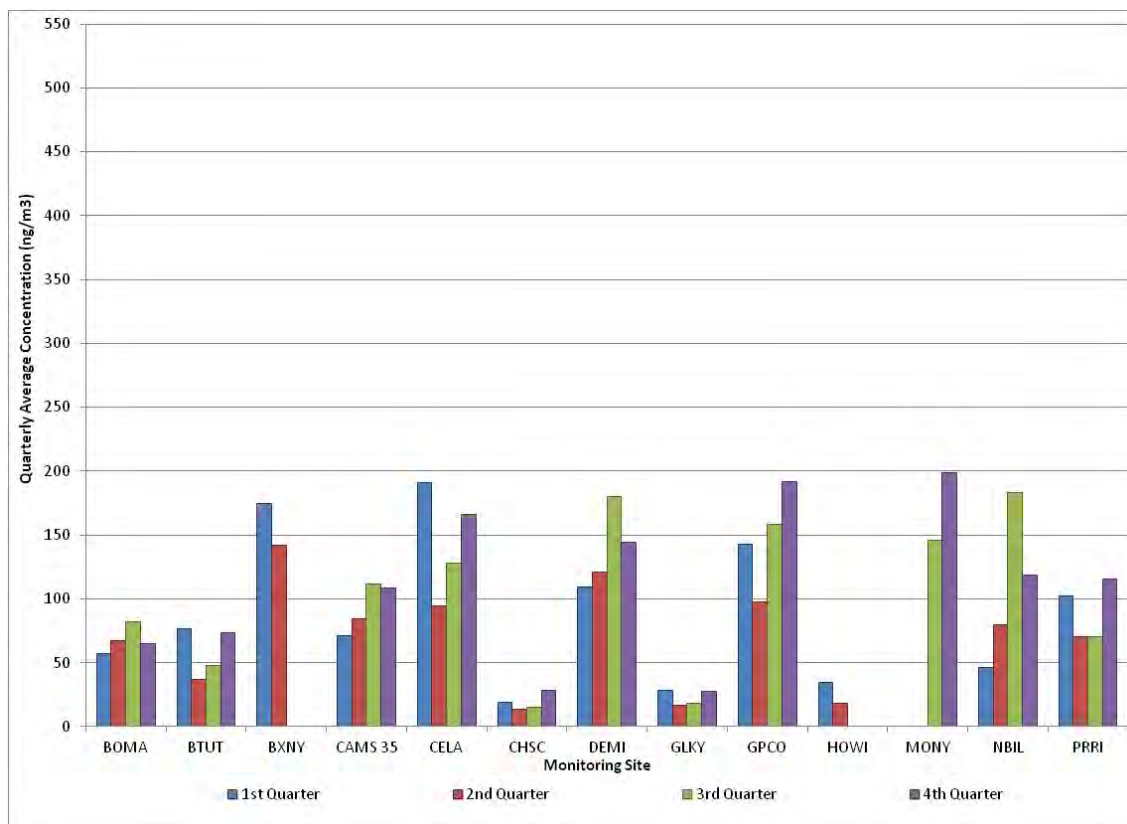
Figure 4-44. Comparison of Average Quarterly Naphthalene Concentrations (Continued)
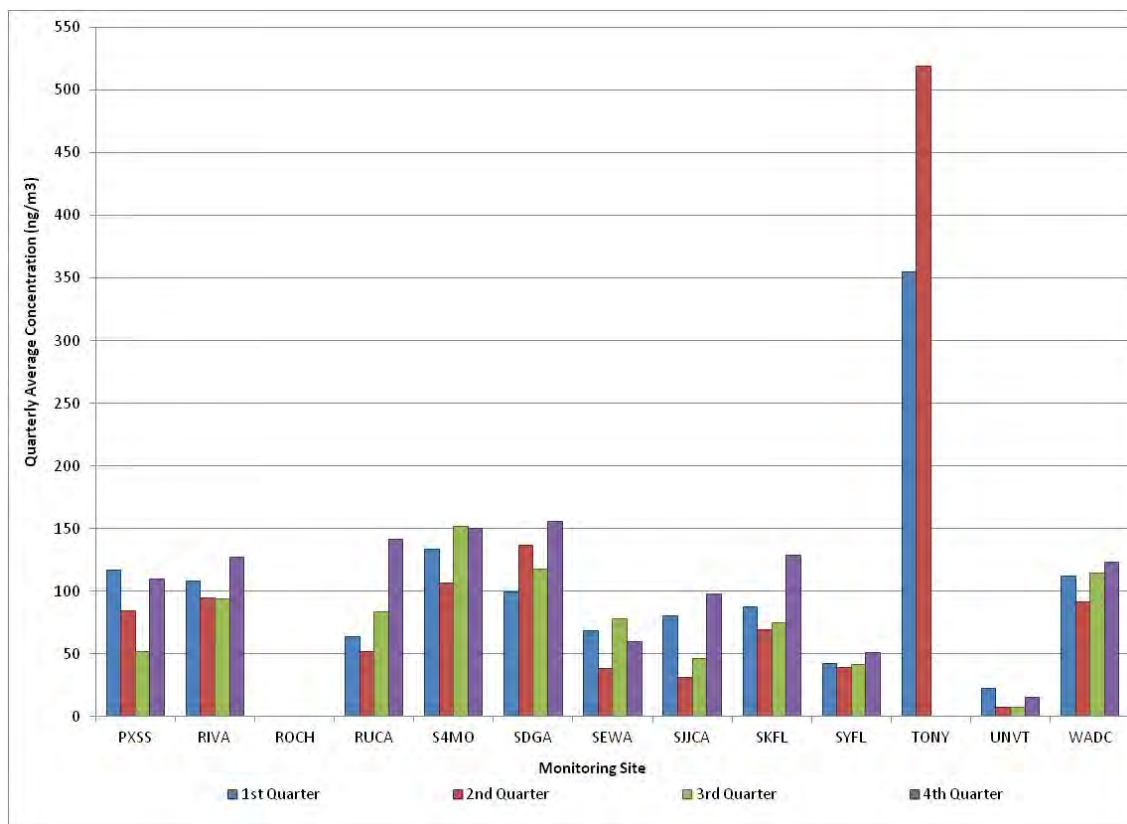
Figure 4-45a. Comparison of Average Quarterly Nickel (PM$_{10}$) Concentrations
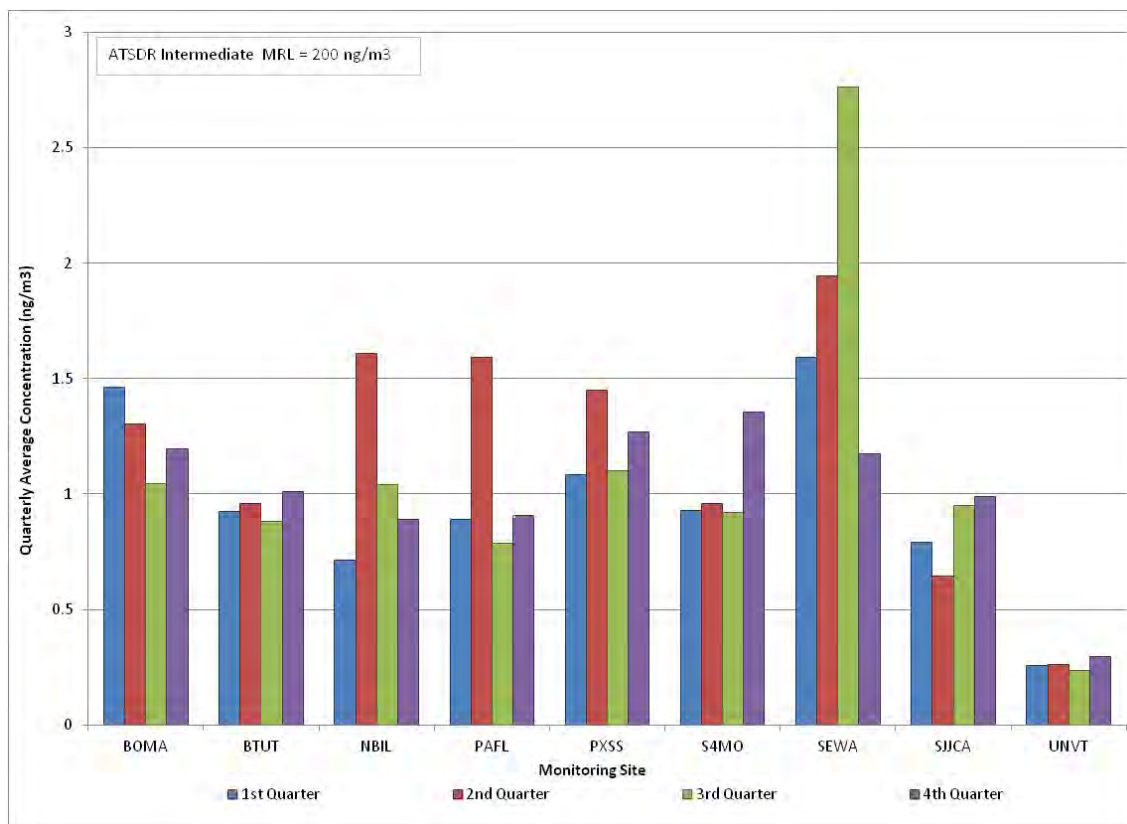
Figure 4-45b. Comparison of Average Quarterly Nickel (TSP) Concentrations
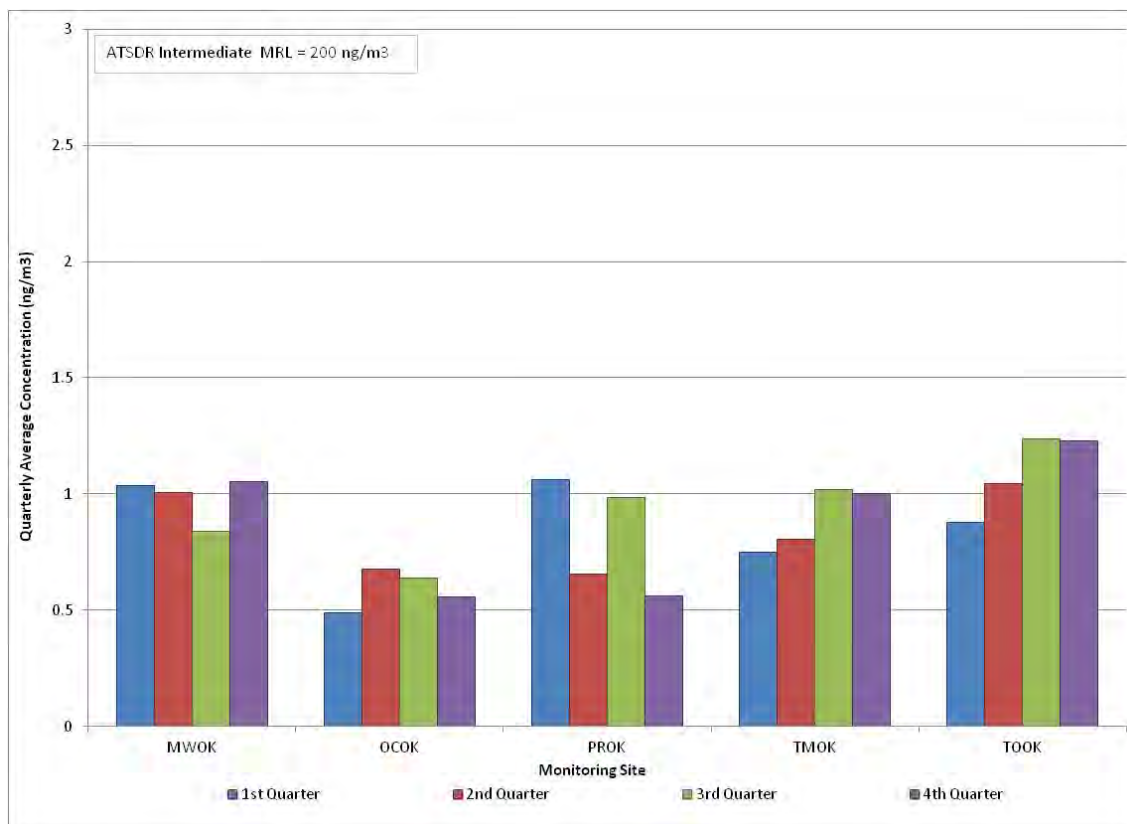
Figure 4-46. Comparison of Average Quarterly Tetrachloroethylene Concentrations
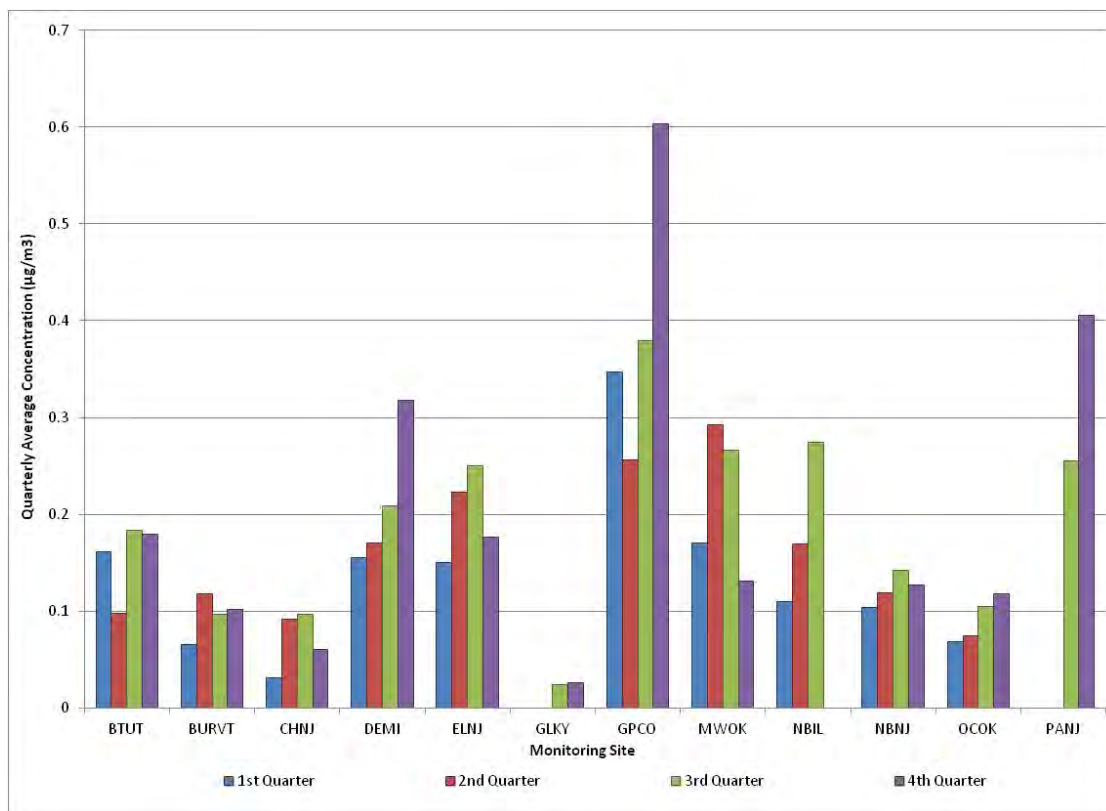
Figure 4-46. Comparison of Average Quarterly Tetrachloroethylene Concentrations (Continued)
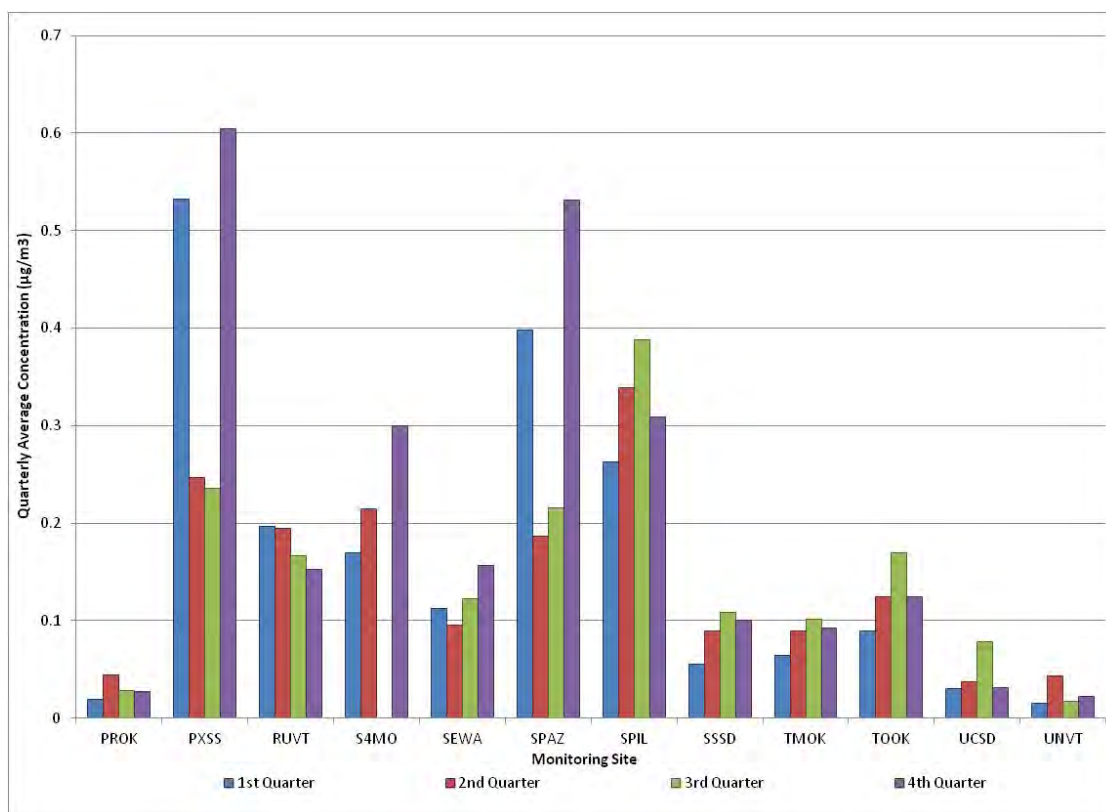
Figure 4-47. Comparison of Average Quarterly Trichloroethylene Concentrations
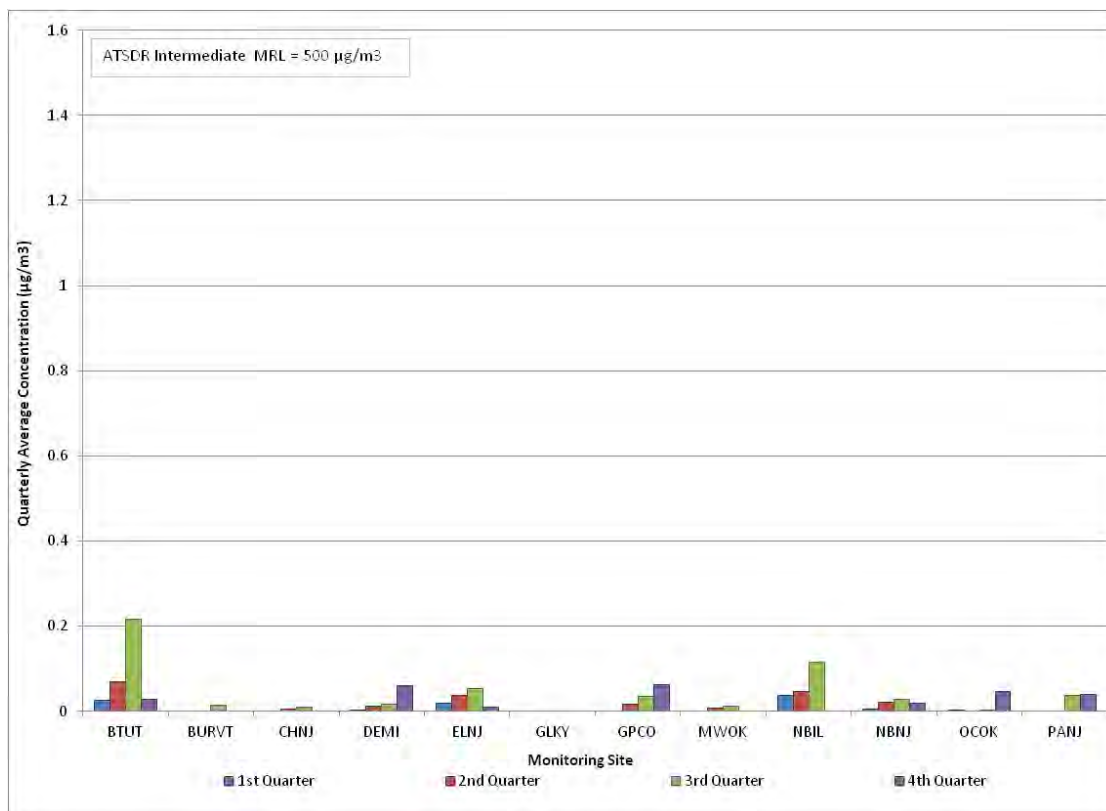
Figure 4-47. Comparison of Average Quarterly Trichloroethylene Concentrations (Continued)
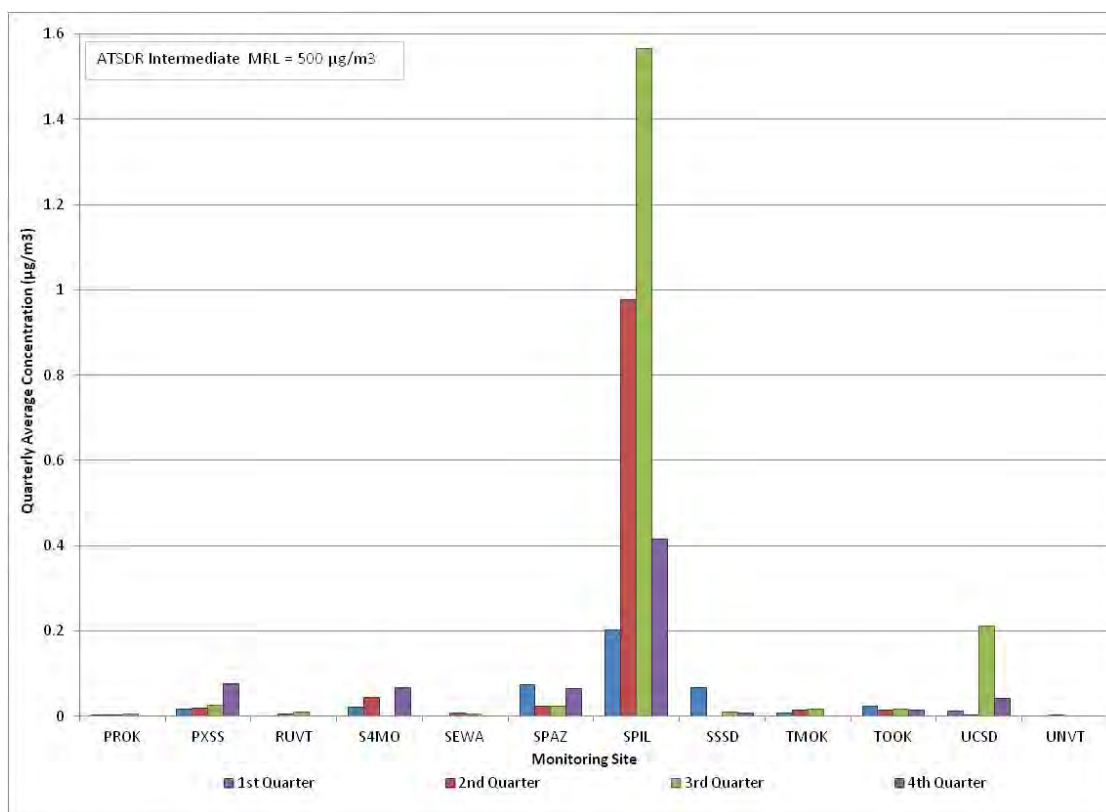
Figure 4-48. Comparison of Average Quarterly Vinyl Chloride Concentrations
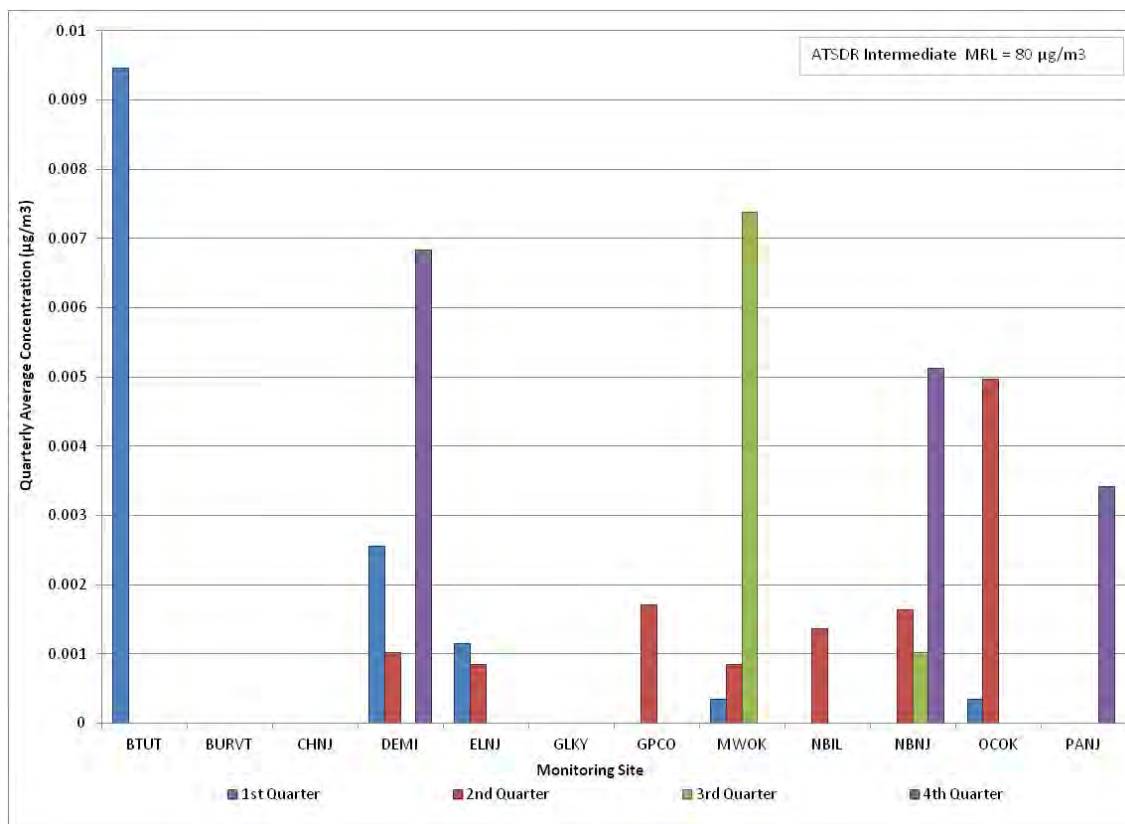
Figure 4-48. Comparison of Average Quarterly Vinyl Chloride Concentrations (Continued)
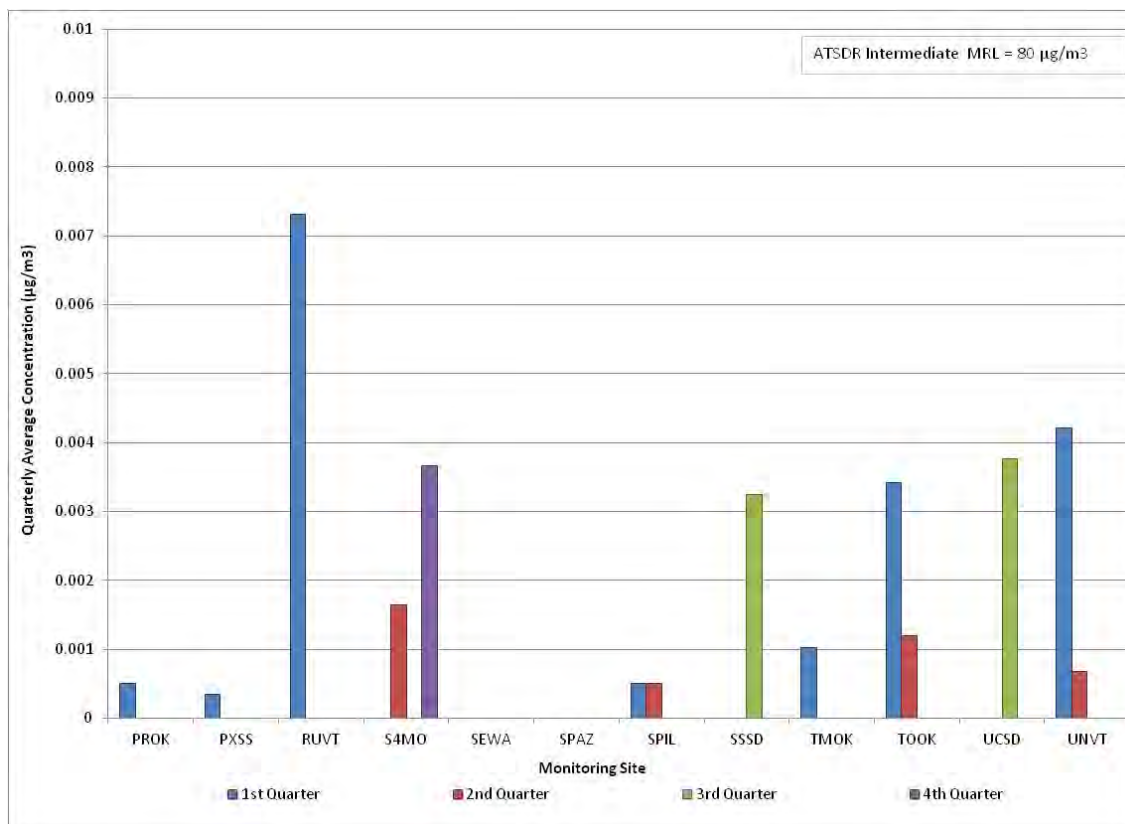
4.5   Greenhouse Gases

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 1,264 valid VOC samples). Chloroform, bromomethane, and 1,1,1-trichloroethane were the only pollutants detected in less than 85 percent of VOC samples collected, although all 10 were still detected in greater than 80 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 GWP (5 and 8.7, respectively). Dichloromethane has the highest program 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 two sites contributed to this high average concentration. Four concentrations of this pollutant greater than 1000 $\mu g/m^3$ were measured at BTUT and GPCO (one at GPCO and three at BTUT). An additional six concentrations greater than 100 $\mu g/m^3$ were measured at BTUT. Besides dichloromethane, only three additional GHGs shown in Table 4-15 have program averages greater than 1 $\mu g/m^3$: 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	2010 Program Average ($\mu g/m^3$)
Dichlorodifluoromethane	10,900	1,264	2.86 ± 0.02
Dichlorotetrafluoroethane	10,000	1,263	0.14 ± <0.01
Trichlorotrifluoroethane	6,130	1,264	0.73 ± 0.01
Trichlorofluoromethane	4,750	1,264	1.66 ± 0.03
Carbon Tetrachloride	1,400	1,258	0.63 ± 0.01
1,1,1-Trichloroethane	146	1,067	0.06 ± <0.01
Chloroform	31	1,021	0.19 ± 0.03

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

Table 4-15. Greenhouse Gases Measured by Method TO-15 (Continued)

Pollutant	Global Warming Potential[1] (100 yrs)	Total # of Measured Detections	2010 Program Average (µg/m³)
Chloromethane	13	1,264	1.31 ± 0.01
Dichloromethane	8.7	1,263	10.63 ± 9.59
Bromomethane	5	1,040	0.05 ± 0.01

[1]GWP presented here are taken 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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 5-1 describes the area surrounding each monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

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

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

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

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

Legend

⬟	PXSS NATTS site	◯	10 mile radius
⬟	SPAZ UATMP site	▢	County boundary

Source Category Group (No. of Facilities)

✠	Aerospace/Aircraft Manufacturing (1)
✦	Aircraft Operations (39)
C	Chemical Manufacturing (1)
✦	Electricity Generation via Combustion (4)
≈	Flexible Polyurethane Foam Production (1)
▣	Furniture Plant (3)
?	Miscellaneous Commercial/Industrial (4)
M	Miscellaneous Manufacturing (1)
R	Rubber and Miscellaneous Plastics Products (1)

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] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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 while SPAZ is located farther south. Figure 5-1 shows that PXSS is located in a highly residential area on North 17th Avenue in central Phoenix. The Grand Canal is shown at 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 in South Phoenix, near the intersection of W. Tamarisk Avenue and S. Central Avenue. 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.

As Figure 5-3 shows, SPAZ and PXSS are located within 7 miles of each other. The majority of emissions sources are located between the sites, to the south of PXSS and north of SPAZ. The source category with the highest number of 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the Arizona monitoring sites. Table 5-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 5-2 also contains annual average daily traffic information. For both sites, traffic data for locations along I-17 were selected. Finally, Table 5-2 presents the 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	3,827,371	3,739,918	0.98	1,473,228	1,439,566	193,000	89,448,000
SPAZ				898,861	878,323	130,000	

[1] County-level population estimates reflect 2010 data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Arizona DOT (AZ DOT, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2009 data from the Arizona DOT (AZ DOT, 2009)
[5] County-level VMT reflects 2010 data for all public roads from the Arizona DOT (AZ DOT, 2011)
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 5-2 include the following:

- Maricopa County has the fourth highest county 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 in the middle of the range compared to other NMP sites.

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

- PXSS experiences a higher annual average traffic volume compared to SPAZ, based on locations along I-17. The traffic volume near PXSS is the fourth highest compared to traffic volumes near other NMP sites.

- The Maricopa County daily VMT is the third 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, 2012).

5.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather station nearest these sites were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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 2010. 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. 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	Sample Day	86.3 ± 3.7	75.5 ± 3.6	38.3 ± 2.8	56.0 ± 2.1	32.0 ± 3.9	1010.8 ± 1.1	5.1 ± 0.5
	136° (SE)	2010	85.6 ± 1.7	75.2 ± 1.6	38.8 ± 1.3	56.0 ± 1.0	32.8 ± 1.7	1010.7 ± 0.5	5.2 ± 0.2
South Phoenix, Arizona - SPAZ									
Phoenix Sky Harbor Intl Airport 23183 (33.44, -111.99)	5.46 miles	Sample Day	84.8 ± 5.9	74.1 ± 5.8	38.6 ± 4.4	55.5 ± 3.5	34.0 ± 6.1	1010.6 ± 1.6	5.2 ± 0.8
	70° (ENE)	2010	85.6 ± 1.7	75.2 ± 1.6	38.8 ± 1.3	56.0 ± 1.0	32.8 ± 1.7	1010.7 ± 0.5	5.2 ± 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 2010. Included in Figure 5-4 are four back trajectories per sample day. Figure 5-5 is the corresponding cluster analysis for 2010. Similarly, Figure 5-6 is the composite back trajectory map for days on which samples were collected at SPAZ and Figure 5-7 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, 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 was smaller for PXSS than for many other NMP monitoring sites. The farthest away a trajectory originated from PXSS was off Baja California, or less than 450 miles away. However, most trajectories (86 percent) originated less than 250 miles from PXSS.

- 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 southeast. Trajectories also originated from the northwest, north, and northeast.

- The cluster analysis map supports the observations above regarding the direction of trajectory origin as well as the observations about trajectory distances. Nearly all of the cluster trajectories originated within 300 miles of PXSS, and four of the six are less than 200 miles long.

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.

- The composite trajectory map for SPAZ has a trajectory distribution pattern similar to PXSS. The cluster analysis maps are also similar to each other. This is expected given their close proximity to each other.

- Similar to PXSS, most trajectories (90 percent) originated within 250 miles of SPAZ.

Figure 5-4. 2010 Composite Back Trajectory Map for PXSS
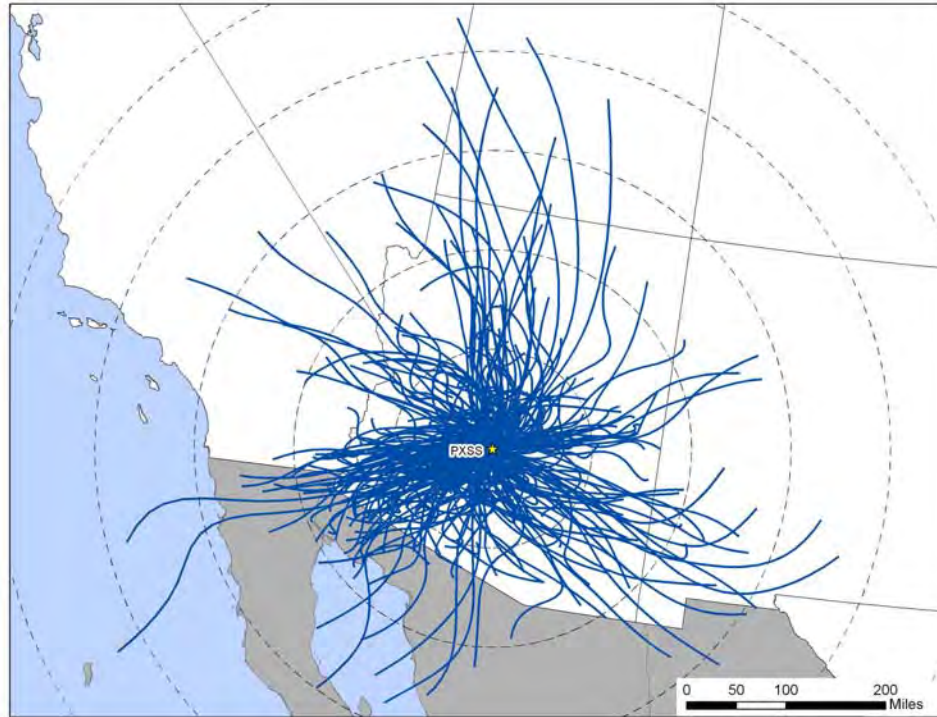
Figure 5-5. Back Trajectory Cluster Map for PXSS
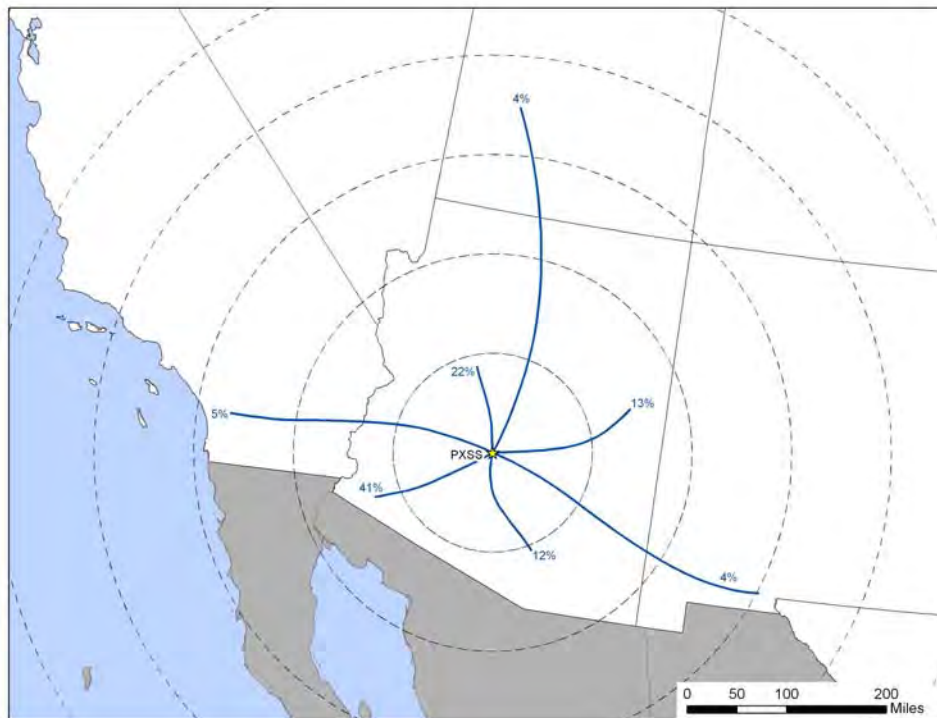
Figure 5-6. 2010 Composite Back Trajectory Map for SPAZ
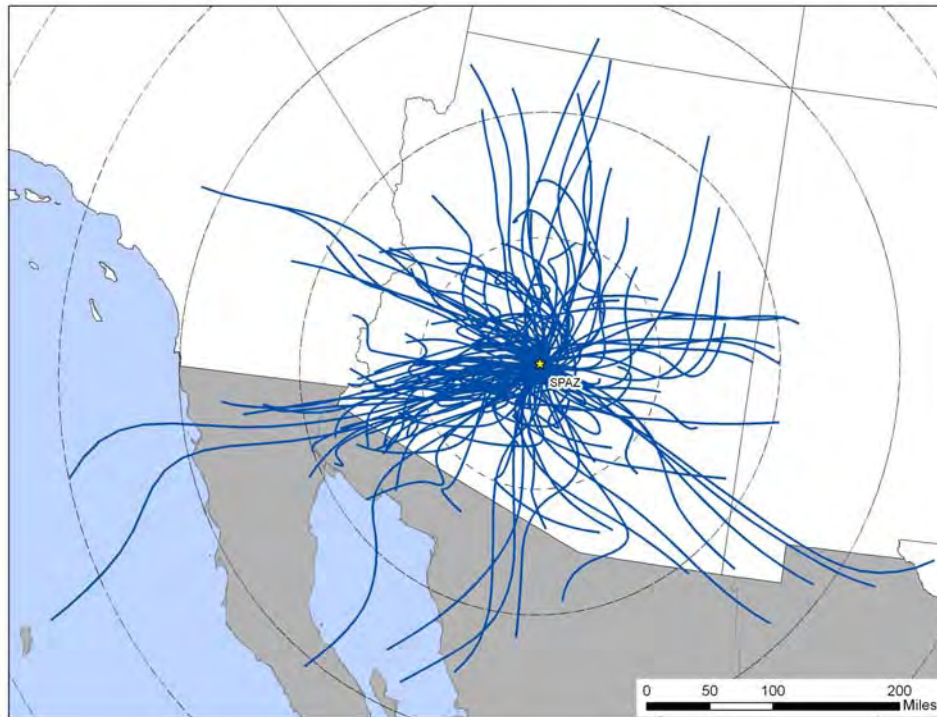
Figure 5-7. Back Trajectory Cluster Map for SPAZ
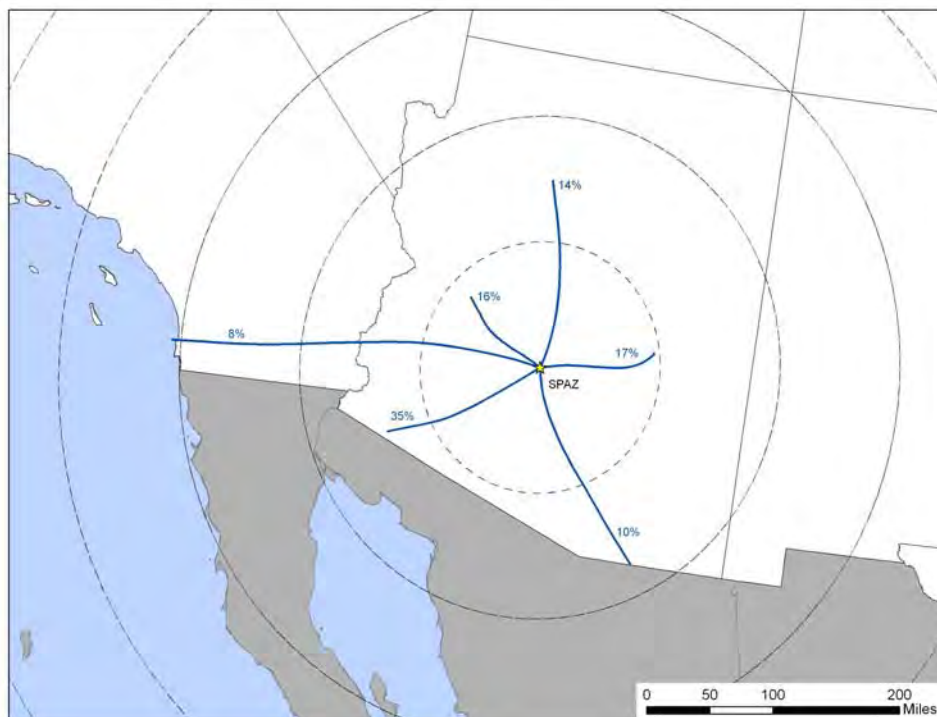
5.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the PXSS monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figure 5-9 presents the three wind roses and distance map for SPAZ.

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 2010 wind roses for PXSS are the same as those for SPAZ.

- The historical wind rose shows that easterly, westerly, and east-southeasterly winds were the most commonly observed wind directions near PXSS and SPAZ. Winds from the northwest, north, and northeast were infrequently observed, as were winds from the south. Calm winds ($\leq$ 2 knots) account for more than 15 percent of the hourly wind measurements from 1999 to 2009.

- The 2010 wind patterns are similar to the historical wind patterns. Further, the sample day wind patterns also resemble the historical and 2010 wind patterns, indicating that conditions on sample days were representative of those experienced over the entire year and historically.

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

1999-2009 Historical Wind Rose
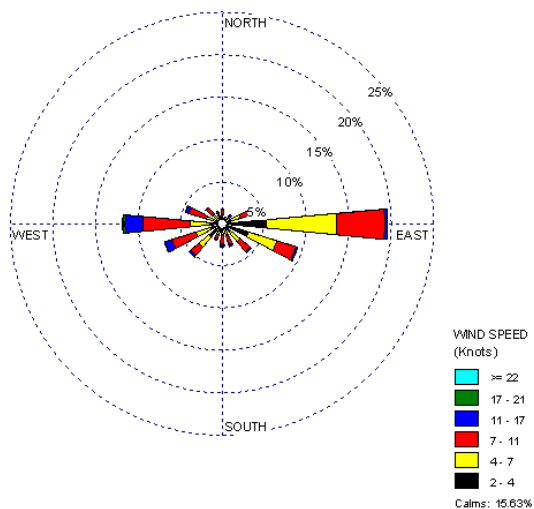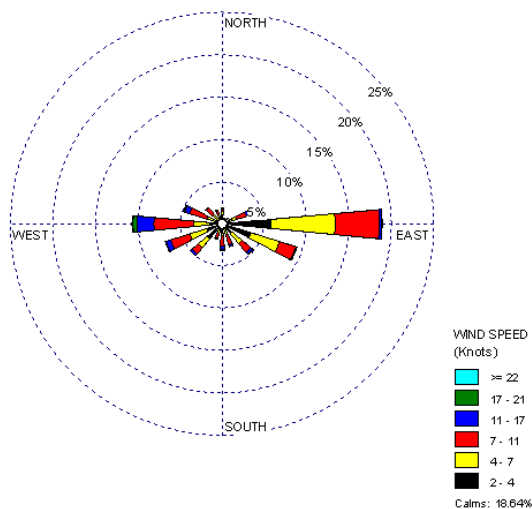
2010 Wind Rose

2010 Sample Day Wind Rose
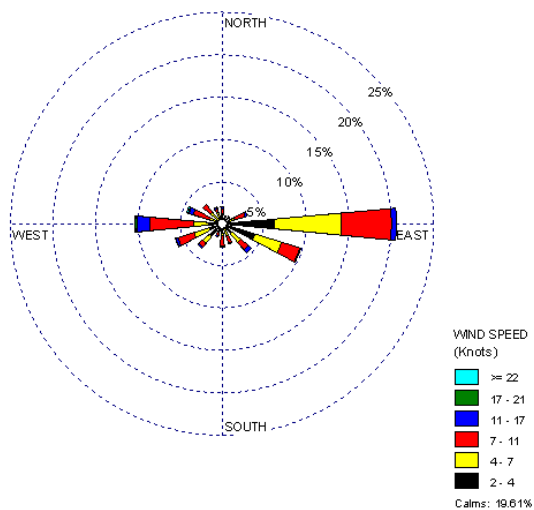
Distance between PXSS and NWS Station
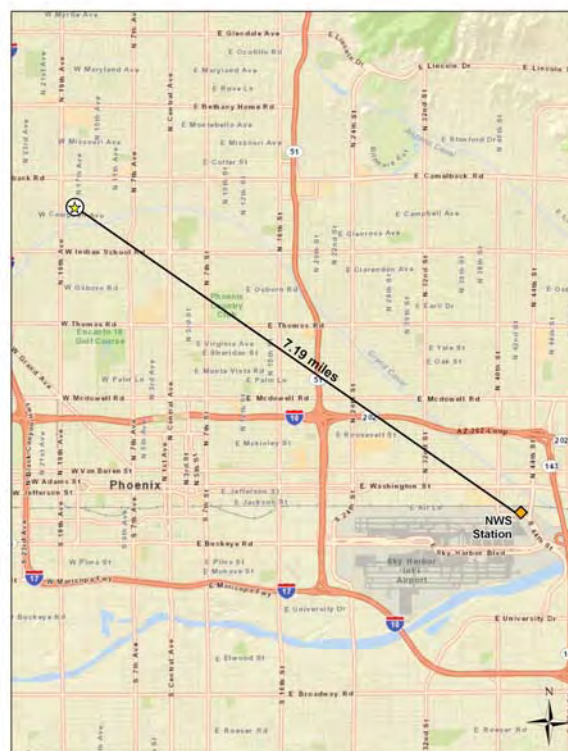
Figure 5-9. Wind Roses for the Phoenix Sky Harbor International Airport Weather Station near SPAZ

1999-2009 Historical Wind Rose
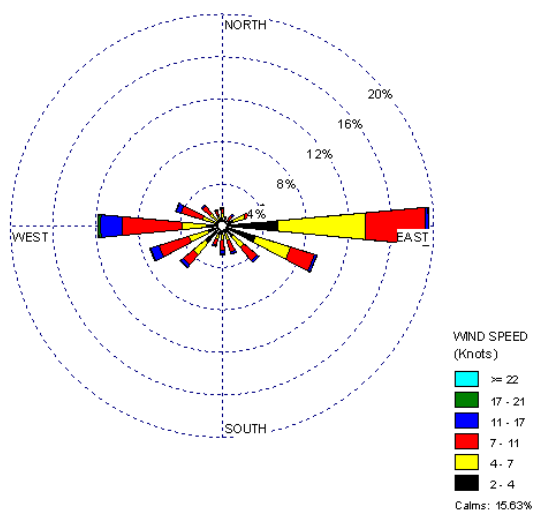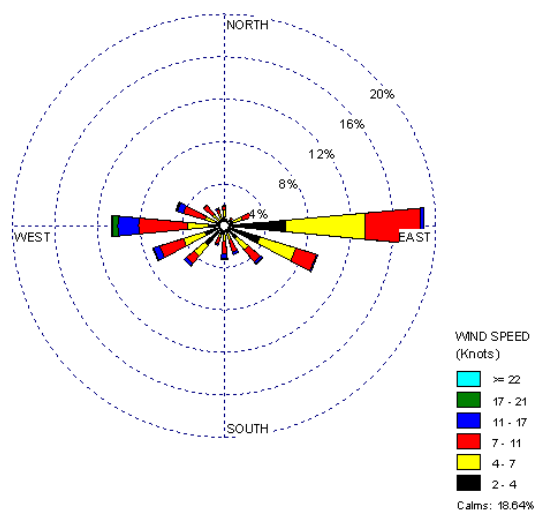
2010 Wind Rose

2010 Sample Day Wind Rose
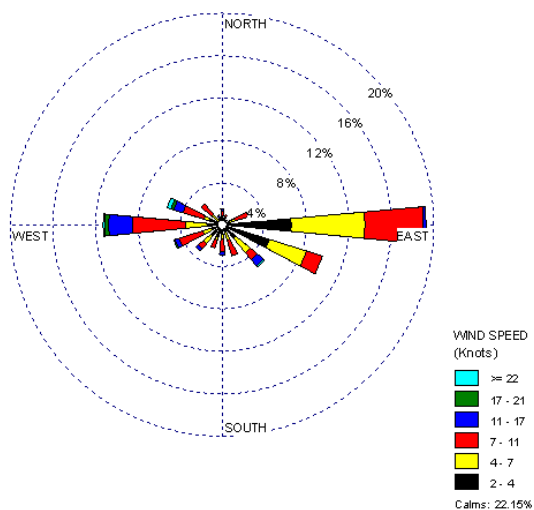
Distance between SPAZ and NWS Station
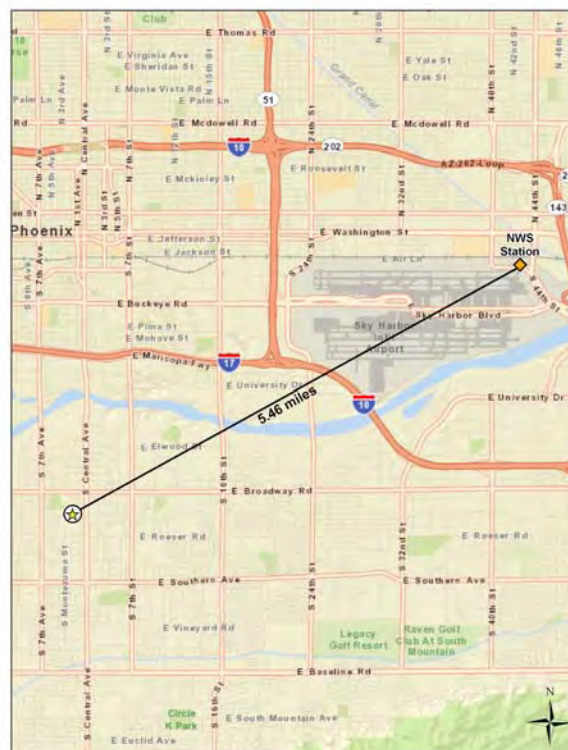
5.3   Pollutants of Interest

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 5-4 presents the pollutants of interest 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 VOC, carbonyl compounds, PAH, metals (PM_{10}), and hexavalent chromium; SPAZ sampled for VOC only.

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-two pollutants failed at least one screen for PXSS, of which 14 are NATTS MQO Core Analytes.

- Twelve pollutants, of which nine are NATTS MQO Core Analytes, were initially identified as pollutants of interest for PXSS. Benzo(a)pyrene, cadmium, lead, nickel, and trichloroethylene were added to PXSS's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not contribute to 95 percent of PXSS's total failed screens. Four additional NATTS MQO Core Analytes were added to PXSS's pollutants of interest, even though their concentrations did not fail any screens: beryllium, chloroform, tetrachloroethylene, and vinyl chloride. These four pollutants are not shown in Table 5-4.

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

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

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Phoenix, Arizona - PXSS						
Benzene	0.13	61	61	100.00	11.60	11.60
Carbon Tetrachloride	0.17	61	61	100.00	11.60	23.19
1,3-Butadiene	0.03	57	59	96.61	10.84	34.03
Naphthalene	0.029	57	59	96.61	10.84	44.87
Manganese (PM$_{10}$)	0.005	54	59	91.53	10.27	55.13
Arsenic (PM$_{10}$)	0.00023	44	59	74.58	8.37	63.50
p-Dichlorobenzene	0.091	42	52	80.77	7.98	71.48
Ethylbenzene	0.4	40	61	65.57	7.60	79.09
Hexavalent Chromium	0.000083	31	57	54.39	5.89	84.98
Acetaldehyde	0.45	20	20	100.00	3.80	88.78
Formaldehyde	0.077	20	20	100.00	3.80	92.59
Acrylonitrile	0.015	13	13	100.00	2.47	95.06
1,2-Dichloroethane	0.038	9	9	100.00	1.71	96.77
Nickel (PM$_{10}$)	0.0021	7	59	11.86	1.33	98.10
Chloroprene	0.0021	3	3	100.00	0.57	98.67
Benzo(a)pyrene	0.00057	1	21	4.76	0.19	98.86
Cadmium (PM$_{10}$)	0.00056	1	59	1.69	0.19	99.05
1,2-Dibromoethane	0.0017	1	1	100.00	0.19	99.24
Dichloromethane	7.7	1	61	1.64	0.19	99.43
Lead (PM$_{10}$)	0.015	1	59	1.69	0.19	99.62
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.19	99.81
Trichloroethylene	0.2	1	21	4.76	0.19	100.00
Total		526	875	60.11		
South Phoenix, Arizona - SPAZ						
Benzene	0.13	29	29	100.00	19.08	19.08
1,3-Butadiene	0.03	29	29	100.00	19.08	38.16
Carbon Tetrachloride	0.17	29	29	100.00	19.08	57.24
p-Dichlorobenzene	0.091	26	29	89.66	17.11	74.34
Ethylbenzene	0.4	23	29	79.31	15.13	89.47
Acrylonitrile	0.015	9	9	100.00	5.92	95.39
1,2-Dichloroethane	0.038	4	4	100.00	2.63	98.03
Chloroprene	0.0021	2	2	100.00	1.32	99.34
Trichloroethylene	0.2	1	13	7.69	0.66	100.00
Total		152	173	87.86		

- PXSS failed the second highest number of screens (526) among all NMP sites, behind only S4MO with 574 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 much lower, at 22 percent. This is due primarily to the relatively high number of pollutants sampled at this site, as discussed in Section 4.2.

- Nine pollutants failed screens for SPAZ, of which four are NATTS MQO Core Analytes. Six pollutants were initially identified as pollutants of interest for SPAZ. Trichoroethylene was added to SPAZ's pollutants of interest because it is a NATTS

MQO Core Analyte, even though this pollutant did not contribute to 95 percent of SPAZ's total failed screens. Two additional NATTS MQO Core Analytes were added to SPAZ's pollutants of interest, even though their concentrations did not fail any screens: chloroform and tetrachloroethylene. These two pollutants are not shown in Table 5-4. 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 88 percent of the measured detections failed screens (of the pollutants failing at least one screen).

- The following pollutants of interest failed 100 percent of screens for both sites: acrylonitrile, benzene, carbon tetrachloride, chloroprene, and 1,2-dichloroethane. 1,3-Butadiene also failed 100 percent of screens for SPAZ. Acetaldehyde, 1,2-dibromoethane, 1,1,2,2-tetrachloroethane, and formaldehyde failed 100 percent of screens at PXSS. However, 1,2-dibromoethane and 1,1,2,2-tetrachloroethane were each detected only once at PXSS.

5.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Arizona monitoring sites. Concentration averages are provided for the pollutants of interest for each Arizona site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site, where applicable. Additional site-specific statistical summaries are provided in Appendices J, L, M, N, and O.

5.4.1   2010 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 PAH, 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.

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/m^3 (1.38 ± 0.20 µg/m^3). Benzene appears to exhibit a seasonal trend, with higher quarterly averages for the colder months of the year. However, the confidence intervals indicate that this difference is not statistically significant.

- Similar to benzene, concentrations of benzo(a)pyrene, 1,3-butadiene, ethylbenzene, *p*-dichlorobenzene, naphthalene, and tetrachloroethylene also appear to be higher during the colder months of the year. Again, the difference in quarterly average concentrations is not statistically significant for these pollutants.

- Acrylonitrile concentrations appear much higher during the first quarter of 2010 and then decrease across the remaining quarters. However, the confidence intervals for each are relatively high compared to the averages themselves. This pollutant was detected in only 13 of 61 samples, resulting in many zero substitutions into the averages. This pollutant was detected more frequently in the first half of the year than the second (seven times in the first quarter, three times in the second, twice in the third, and once in the fourth).

- The fourth quarter average concentration of trichloroethylene has a confidence interval higher than the concentration itself. The highest concentration of trichloroethylene (0.829 µg/m^3) was measured on November 22, 2010 and is nearly six times higher than the next highest concentration (0.144 µg/m^3), measured on January 26, 2010.

- Note that neither acetaldehyde nor formaldehyde have quarterly 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 from mid-February 2010 through the end of the year.

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 ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Phoenix, Arizona - PXSS						
Acetaldehyde	16/20	NA	NA	NA	NA	NA
Acrylonitrile	13/61	0.11 ± 0.07	0.05 ± 0.06	0.03 ± 0.04	0.01 ± 0.02	0.05 ± 0.03
Benzene	61/61	1.60 ± 0.47	1.03 ± 0.22	0.95 ± 0.30	1.97 ± 0.42	1.38 ± 0.20
1,3-Butadiene	59/61	0.28 ± 0.12	0.13 ± 0.04	0.10 ± 0.05	0.33 ± 0.10	0.21 ± 0.05
Carbon Tetrachloride	61/61	0.73 ± 0.03	0.66 ± 0.07	0.61 ± 0.08	0.66 ± 0.04	0.66 ± 0.03
Chloroform	61/61	0.29 ± 0.07	0.40 ± 0.11	0.37 ± 0.13	0.42 ± 0.11	0.37 ± 0.05
p-Dichlorobenzene	52/61	0.16 ± 0.06	0.13 ± 0.04	0.11 ± 0.06	0.23 ± 0.06	0.16 ± 0.03
Ethylbenzene	61/61	0.66 ± 0.22	0.47 ± 0.11	0.42 ± 0.15	0.85 ± 0.22	0.60 ± 0.10
Formaldehyde	16/20	NA	NA	NA	NA	NA
Tetrachloroethylene	57/61	0.53 ± 0.21	0.25 ± 0.06	0.24 ± 0.11	0.60 ± 0.18	0.40 ± 0.08
Trichloroethylene	21/61	0.02 ± 0.02	0.02 ± 0.01	0.03 ± 0.02	0.08 ± 0.11	0.03 ± 0.03
Vinyl Chloride	1/61	<0.01 ± <0.01	0	0	0	<0.01 ± <0.01
Arsenic (PM$_{10}$)[a]	59/59	0.51 ± 0.21	0.53 ± 0.40	0.39 ± 0.16	0.81 ± 0.30	0.56 ± 0.14
Benzo(a)pyrene [a]	21/59	0.13 ± 0.10	0.01 ± 0.01	0	0.14 ± 0.09	0.07 ± 0.03
Beryllium (PM$_{10}$) [a]	42/59	<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	0.11 ± 0.04	0.11 ± 0.09	0.08 ± 0.03	0.17 ± 0.06	0.12 ± 0.03
Hexavalent Chromium [a]	57/57	0.10 ± 0.05	0.13 ± 0.06	0.12 ± 0.05	0.16 ± 0.07	0.13 ± 0.03
Lead (PM$_{10}$) [a]	59/59	3.33 ± 1.03	3.46 ± 1.76	2.06 ± 0.49	4.85 ± 1.82	3.42 ± 0.71
Manganese (PM$_{10}$) [a]	59/59	8.35 ± 2.33	17.02 ± 8.10	9.58 ± 2.20	14.20 ± 3.73	12.38 ± 2.53
Naphthalene [a]	59/59	116.50 ± 27.38	84.39 ± 17.84	51.97 ± 11.84	109.87 ± 29.97	89.15 ± 12.41
Nickel (PM$_{10}$) [a]	59/59	1.08 ± 0.42	1.45 ± 0.57	1.10 ± 0.37	1.27 ± 0.31	1.23 ± 0.21

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
[a] Average concentrations provided for the pollutants below the black 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 ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
South Phoenix, Arizona - SPAZ						
Acrylonitrile	9/29	1.34 ± 0.28	0.19 ± 0.42	0.07 ± 0.14	0	0.39 ± 0.23
Benzene	29/29	1.94 ± 0.66	1.22 ± 0.49	1.26 ± 0.68	2.39 ± 1.05	1.69 ± 0.37
1,3-Butadiene	29/29	0.32 ± 0.15	0.16 ± 0.09	0.12 ± 0.08	0.43 ± 0.24	0.26 ± 0.08
Carbon Tetrachloride	29/29	0.75 ± 0.03	0.64 ± 0.09	0.65 ± 0.06	0.62 ± 0.10	0.66 ± 0.04
Chloroform	28/29	0.19 ± 0.08	0.23 ± 0.09	0.29 ± 0.12	0.26 ± 0.07	0.24 ± 0.04
p-Dichlorobenzene	29/29	0.23 ± 0.08	0.22 ± 0.08	0.27 ± 0.15	0.40 ± 0.12	0.28 ± 0.06
Ethylbenzene	29/29	0.79 ± 0.34	0.62 ± 0.34	0.63 ± 0.38	1.02 ± 0.45	0.76 ± 0.18
Tetrachloroethylene	29/29	0.40 ± 0.22	0.19 ± 0.07	0.22 ± 0.09	0.53 ± 0.27	0.33 ± 0.09
Trichloroethylene	13/29	0.07 ± 0.07	0.02 ± 0.03	0.02 ± 0.04	0.06 ± 0.06	0.05 ± 0.02

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
[a] Average concentrations provided for the pollutants below the black line are presented in ng/m^3 for ease of viewing.

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

- Similar to PXSS, the pollutant with the highest annual average concentration by mass is benzene. This is also the only pollutant with an annual average concentration greater than 1 µg/m^3 (1.69 ± 0.37 µg/m^3). The fourth quarter average concentration of benzene has a relatively high confidence interval compared to the other quarterly averages. The two highest concentrations of benzene were measured on December 10, 2010 (4.64 µg/m^3) and December 1, 2010 (3.65 µg/m^3). The December 10, 2010 concentration was the fifth highest benzene measurement among all NMP sites sampling benzene.

- Concentrations of benzene, 1,3-butadiene, ethylbenzene, and tetrachloroethylene appear to be higher during the colder months of the year. Similar to concentrations of these pollutants for PXSS, the difference in quarterly average concentrations is not statistically significant.

- The first quarter average acrylonitrile concentration is significantly higher than the other quarterly averages. Of the nine measured detections of this pollutant (out of 29 valid samples), seven were measured during the first quarter of 2010 (with one in the second quarter and one in the third quarter). This explains the large confidence intervals associated with these quarterly averages as well as the zero for the fourth quarter average.

- Each of the quarterly average concentrations of trichloroethylene has a confidence interval equal to or greater than the concentration itself. This pollutant was detected in fewer than half of the valid samples collected and analyzed. The average concentrations of both acrylonitrile and trichloroethylene demonstrate the variability introduced by substituting zeros for non-detects where a pollutant is detected infrequently.

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 26 times.

- SPAZ has the highest annual average concentration of acrylonitrile and 1,3-butadiene among all NMP sites sampling these pollutants. PXSS ranks fifth and second for these pollutants, respectively.

- PXSS has the highest annual average concentration of tetrachloroethylene among all NMP sites sampling this pollutant. SPAZ ranks third for this pollutant.

- SPAZ also has the third highest annual average concentrations of ethylbenzene and *p*-dichlorobenzene, while PXSS has the third highest annual average concentration of chloroform.

- PXSS has the second highest annual average concentration of hexavalent chromium, behind only CAMS 85. The annual averages of hexavalent chromium for these two sites are an order of magnitude higher than the annual averages for the remaining eight sites shown in Table 4-12.

- For the PM_{10} metals, PXSS has the second highest annual average concentration of beryllium, lead, and manganese and the third highest annual average concentration of nickel.

5.4.2 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 benzene and 1,3-butadiene were created for both PXSS and SPAZ. Box plots were also created for arsenic, benzo(a)pyrene, hexavalent chromium, manganese, and naphthalene for PXSS. Figures 5-10 through 5-16 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 5-10. Program vs. Site-Specific Average Arsenic (PM₁₀) Concentration

Figure 5-10. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration
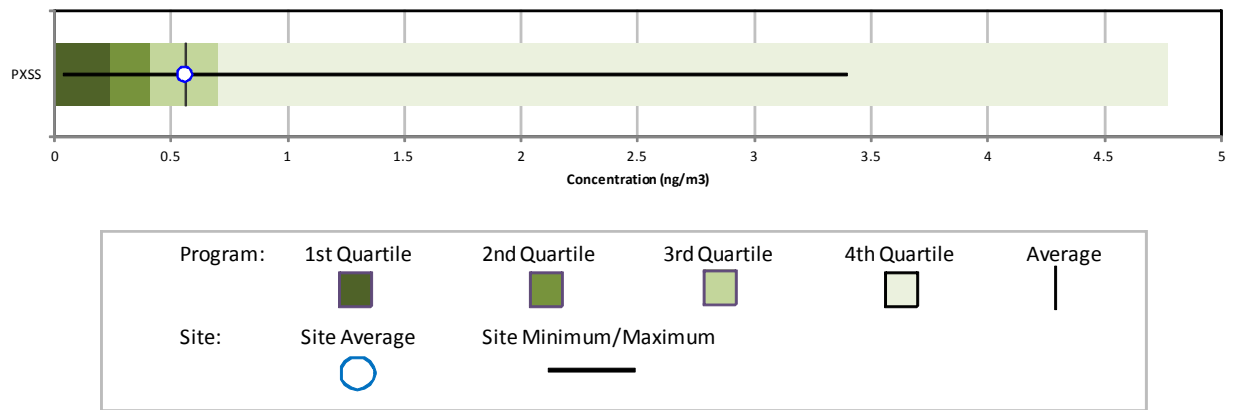
Figure 5-11. Program vs. Site-Specific Average Benzene Concentration
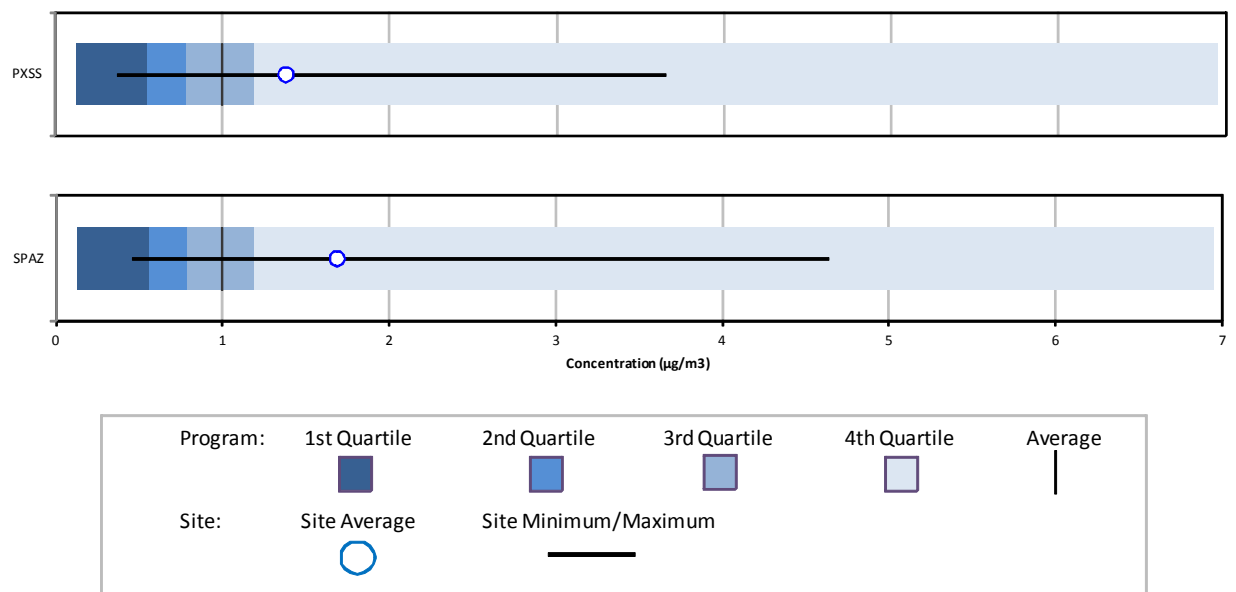
Figure 5-12. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Program Max Concentration = 42.7 ng/m3
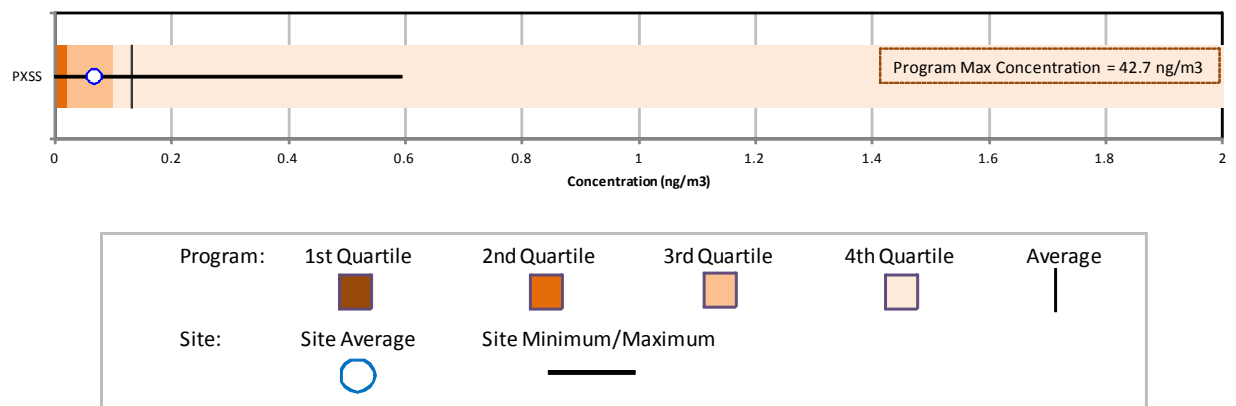
Figure 5-13. Program vs. Site-Specific Average 1,3-Butadiene Concentration
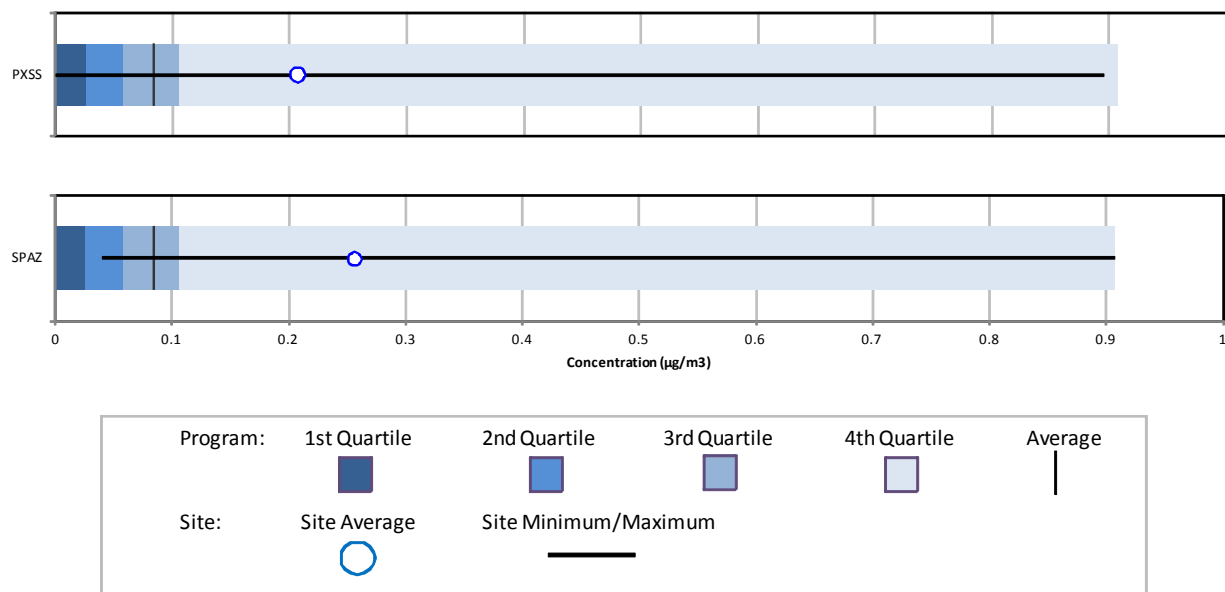
Figure 5-14. Program vs. Site-Specific Average Hexavalent Chromium Concentration
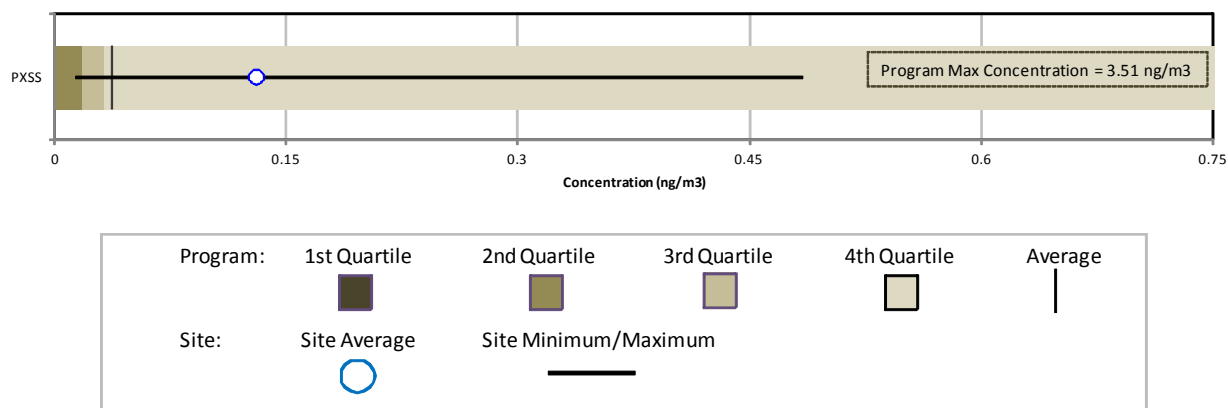
Figure 5-15. Program vs. Site-Specific Average Manganese (PM$_{10}$) Concentration
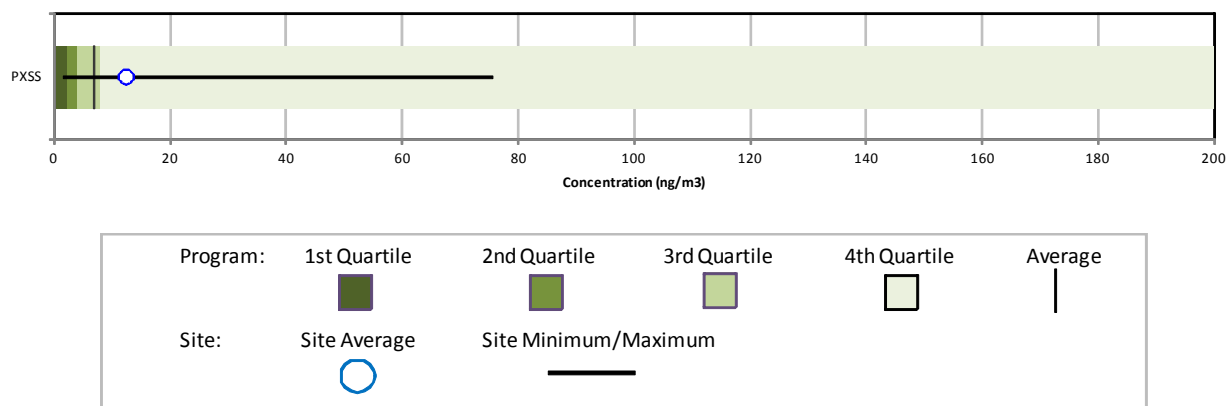
Figure 5-16. Program vs. Site-Specific Average Naphthalene Concentration
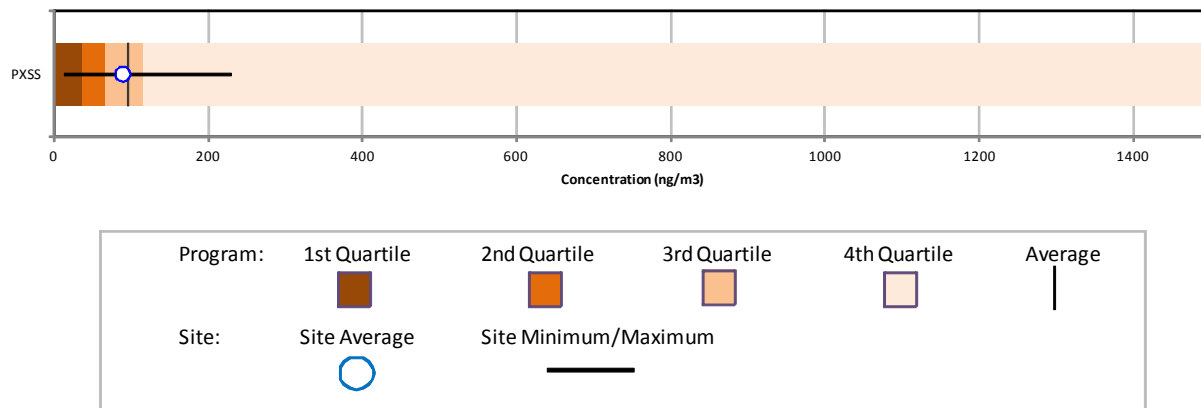
Observations from Figures 5-10 through 5-16 include the following:

- Figure 5-10 shows that PXSS's annual average arsenic (PM$_{10}$) concentration is nearly identical to the program-level average for arsenic (PM$_{10}$). There were no non-detects of arsenic measured at PXSS.

- Figure 5-11 for benzene shows both sites, as both SPAZ and PXSS sampled VOC. While neither Arizona site measured the maximum benzene concentration across the program, both annual averages are greater than the program-level average concentration. In addition, SPAZ's benzene concentrations are slightly higher than PXSS's concentrations, as illustrated by the annual average and the maximum concentrations measured. There were no non-detects of benzene measured at either site (or among sites sampling VOC).

- Figure 5-12 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 concentration for PXSS is below the program-level average concentration. Figure 5-12 also shows that the maximum concentration measured at PXSS is well below 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. 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 in Section 5.4.1 and shown in Table 4-9. SPAZ's 1,3-butadiene annual average concentration is slightly higher than PXSS's annual average concentration. Note that the maximum concentration measured across the program was measured at SPAZ (0.907 µg/m^3), although PXSS's maximum concentration was not much lower (0.896 µg/m^3) and was the second highest 1,3-butadiene concentration (for

Method TO-15) across the program. There were no non-detects of 1,3-butadiene measured at SPAZ, but there were two measured at PXSS.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 5-14 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 5-14 shows the annual average concentration of hexavalent chromium for PXSS is greater than the program-level average (more than three times higher). While the maximum concentration measured at PXSS is well below the program maximum concentration, PXSS has the second highest annual average concentration among NMP sites sampling hexavalent chromium (behind only CAMS 85), as discussed in Section 5.4.1 and shown in Table 4-12. There were no non-detects of hexavalent chromium measured at PXSS.

- Figure 5-15 shows the annual average concentration of manganese (PM$_{10}$) for PXSS is greater than the program-level average (nearly twice as high). While the maximum concentration measured at PXSS is well below the program maximum concentration, PXSS has the second highest annual average concentration among the NMP sites sampling manganese (PM$_{10}$), behind only S4MO, as shown in Table 4-12. There were no non-detects of manganese measured at PXSS.

- Figure 5-16 shows that the annual naphthalene average for PXSS is very similar to the program-level average concentration. The maximum naphthalene concentration measured at PXSS is well below the program-level maximum concentration. There were no non-detects of naphthalene measured at PXSS.

- 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 for 5 years as part of the NMP; thus, Figures 5-17 through 5-19 present the 3-year rolling statistical metrics for arsenic, hexavalent chromium, and manganese, respectively. SPAZ has not sampled continuously for 5 years as part of the NMP; therefore, the trends analysis was not conducted for this site. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 5-17. Three-Year Rolling Statistical Metrics for Arsenic (PM$_{10}$) Concentrations Measured at PXSS
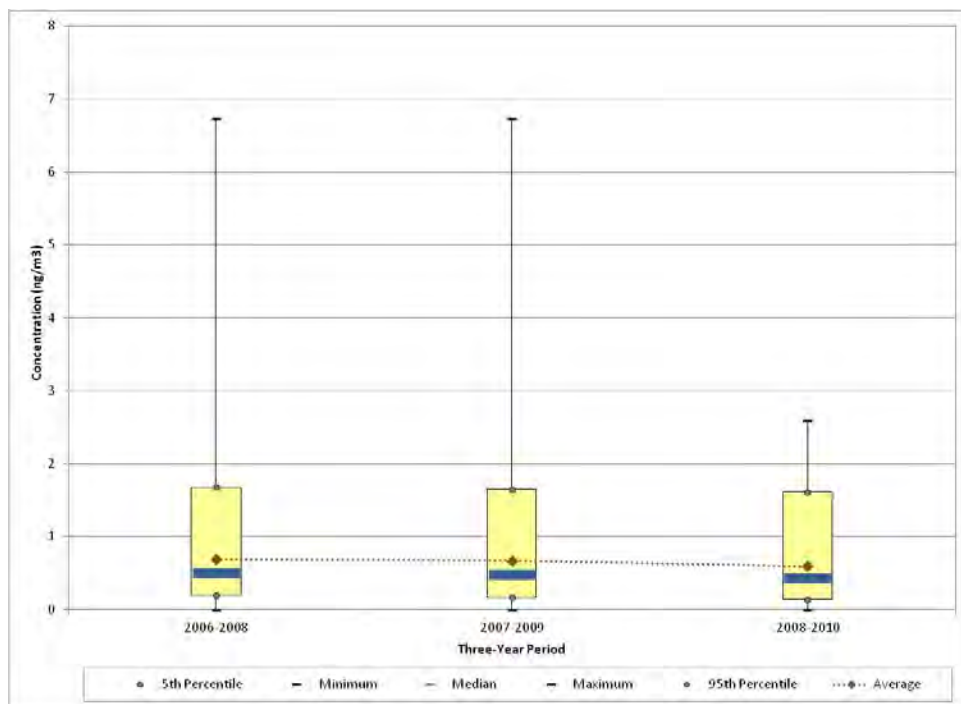
Figure 5-18. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at PXSS
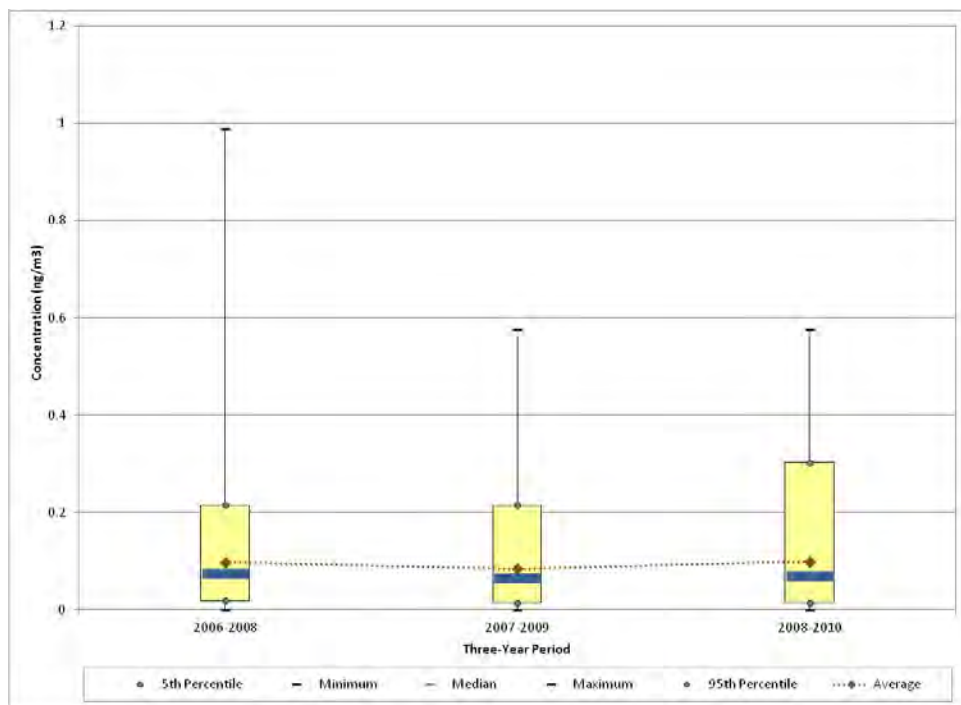
Figure 5-19. Three-Year Rolling Statistical Metrics for Manganese (PM$_{10}$) Concentrations Measured at PXSS
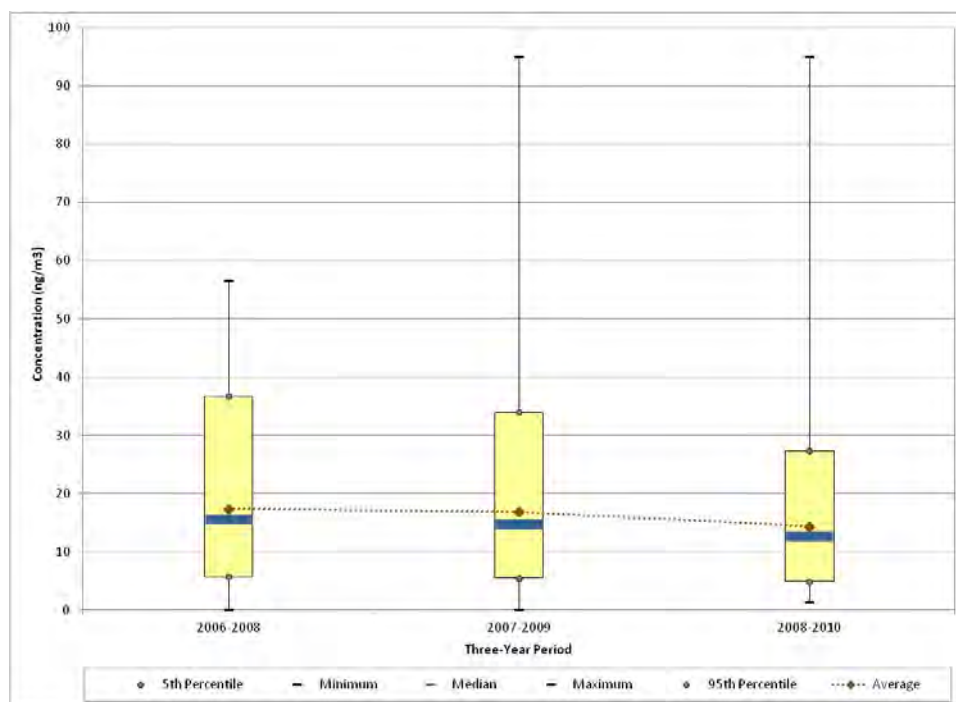
Observations from Figure 5-17 for arsenic measurements at PXSS include the following:

- PXSS began sampling arsenic under the NMP in January 2006.

- The maximum arsenic concentration was measured on December 26, 2007 and is more than twice the next highest concentration, measured in December 2006. The maximum concentration for each year was measured in December or January, with the exception of 2008, which was measured in September.

- The average rolling concentrations show little change over the years of sampling, which is also true of most for the other statistical parameters, with the exception of the maximum concentration. The maximum concentration for all years of sampling ranged from 2 to 3 ng/m^3, with the exception of 2007.

Observations from Figure 5-18 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. The maximum concentrations for subsequent years were nearly half that measurement or less.

- The average rolling concentrations exhibit a slight decrease from 2006-2008 to 2007-2009 and then return to initial levels for 2008-2010.

5-28

- The 95th percentile increased for the third 3-year period, indicating an increase in the range of concentrations measured.

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

- The two highest manganese concentrations were measured in July and August of 2009.

- The rolling average, median, and 95th percentile decreased slightly for the second and third 3-year periods shown, even with the highest manganese concentrations measured in 2009.

5.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

5.5.1   Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Arizona monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for each site were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Arizona monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Arizona monitoring sites.

5.5.2   Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Arizona monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and

noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 5-6, where applicable.

Table 5-6. Cancer and Noncancer Surrogate Risk Approximations for the Arizona Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Phoenix, Arizona - PXSS						
Acetaldehyde	0.0000022	0.009	16/20	NA	NA	NA
Acrylonitrile	0.000068	0.002	13/61	0.05 ± 0.03	3.22	0.02
Arsenic (PM$_{10}$)[a]	0.0043	0.000015	59/59	<0.01 ± <0.01	2.40	0.04
Benzene	0.0000078	0.03	61/61	1.38 ± 0.20	10.76	0.05
Benzo(a)pyrene [a]	0.00176	--	21/59	<0.01 ± <0.01	0.12	--
Beryllium (PM$_{10}$) [a]	0.0024	0.00002	42/59	<0.01 ± <0.01	0.01	<0.01
1,3-Butadiene	0.00003	0.002	59/61	0.21 ± 0.05	6.22	0.10
Cadmium (PM$_{10}$) [a]	0.0018	0.00001	59/59	<0.01 ± <0.01	0.21	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.66 ± 0.03	3.97	<0.01
Chloroform	--	0.098	61/61	0.37 ± 0.05	--	<0.01
p-Dichlorobenzene	0.000011	0.8	52/61	0.16 ± 0.03	1.72	<0.01
Ethylbenzene	0.0000025	1	61/61	0.60 ± 0.10	1.50	<0.01
Formaldehyde	0.000013	0.0098	16/20	NA	NA	NA
Hexavalent Chromium [a]	0.012	0.0001	57/57	<0.01 ± <0.01	1.57	<0.01
Lead (PM$_{10}$) [a]	--	0.00015	59/59	<0.01 ± <0.01	--	0.02
Manganese (PM$_{10}$) [a]	--	0.00005	59/59	0.01 ± <0.01	--	0.25
Naphthalene [a]	0.000034	0.003	59/59	0.09 ± 0.01	3.03	0.03
Nickel (PM10) a	0.00048	0.00009	59/59	<0.01 ± <0.01	0.59	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. Cancer and Noncancer Surrogate 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 Risk Approximation (HQ)
Tetrachloroethylene	0.00000026	0.04	57/61	0.40 ± 0.08	0.10	0.01
Trichloroethylene	0.0000048	0.002	21/61	0.03 ± 0.03	0.16	0.02
Vinyl Chloride	0.0000088	0.1	1/61	<0.01 ± <0.01	<0.01	<0.01
South Phoenix, Arizona - SPAZ						
Acrylonitrile	0.000068	0.002	9/29	0.39 ± 0.23	26.40	0.19
Benzene	0.0000078	0.03	29/29	1.69 ± 0.37	13.15	0.06
1,3-Butadiene	0.00003	0.002	29/29	0.26 ± 0.08	7.67	0.13
Carbon Tetrachloride	0.000006	0.1	29/29	0.66 ± 0.04	3.98	0.01
Chloroform	--	0.098	28/29	0.24 ± 0.04	--	<0.01
p-Dichlorobenzene	0.000011	0.8	29/29	0.28 ± 0.06	3.07	<0.01
Ethylbenzene	0.0000025	1	29/29	0.76 ± 0.18	1.90	<0.01
Tetrachloroethylene	0.00000026	0.04	29/29	0.33 ± 0.09	0.09	0.01
Trichloroethylene	0.0000048	0.002	13/29	0.05 ± 0.02	0.22	0.02

-- = 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/m³, refer to Table 5-5.

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

- The pollutants with the highest annual average concentrations by mass are benzene, carbon tetrachloride, and ethylbenzene.

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

- None of PXSS's pollutants of interest have noncancer risk approximations greater than 1.0. The pollutant with the highest noncancer risk approximation is manganese (0.25).

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

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

- The pollutants with the highest annual average concentrations by mass are benzene, ethylbenzene, and carbon tetrachloride.

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

- SPAZ's annual acrylonitrile average concentration is two orders of magnitude higher than PXSS's annual average for this pollutant. Thus, SPAZ's cancer risk approximation for acrylonitrile is more than eight times higher than PXSS's cancer risk approximation.

- None of SPAZ's pollutants of interest have noncancer risk approximations greater than 1.0. The pollutant with the highest noncancer risk approximation is acrylonitrile (0.19).

5.5.3   Risk-Based Emissions Assessment

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

The pollutants listed in Table 5-7 and 5-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 VOC, carbonyl compounds, PAH, metals (PM_{10}), and hexavalent chromium; SPAZ sampled for VOC only. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	10.76
Formaldehyde	969.28	Benzene	9.80E-03	1,3-Butadiene	6.22
Ethylbenzene	766.10	1,3-Butadiene	5.38E-03	Carbon Tetrachloride	3.97
Acetaldehyde	487.50	Naphthalene	3.08E-03	Acrylonitrile	3.22
1,3-Butadiene	179.20	Ethylbenzene	1.92E-03	Naphthalene	3.03
Naphthalene	90.54	Hexavalent Chromium, PM	1.70E-03	Arsenic	2.40
Dichloromethane	28.45	POM, Group 2b	1.29E-03	p-Dichlorobenzene	1.72
POM, Group 2b	14.68	Acetaldehyde	1.07E-03	Hexavalent Chromium	1.57
POM, Group 1a	2.61	Arsenic, PM	7.14E-04	Ethylbenzene	1.50
Propylene oxide	1.66	POM, Group 5a	3.83E-04	Nickel	0.59
South Phoenix, Arizona (Maricopa County) – SPAZ					
Benzene	1,256.37	Formaldehyde	1.26E-02	Acrylonitrile	26.40
Formaldehyde	969.28	Benzene	9.80E-03	Benzene	13.15
Ethylbenzene	766.10	1,3-Butadiene	5.38E-03	1,3-Butadiene	7.67
Acetaldehyde	487.50	Naphthalene	3.08E-03	Carbon Tetrachloride	3.98
1,3-Butadiene	179.20	Ethylbenzene	1.92E-03	p-Dichlorobenzene	3.07
Naphthalene	90.54	Hexavalent Chromium, PM	1.70E-03	Ethylbenzene	1.90
Dichloromethane	28.45	POM, Group 2b	1.29E-03	Trichloroethylene	0.22
POM, Group 2b	14.68	Acetaldehyde	1.07E-03	Tetrachloroethylene	0.09
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 Risk Approximations for Pollutants with Noncancer RfCs for the Arizona Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Phoenix, Arizona (Maricopa County) – PXSS					
Toluene	3,931.16	Acrolein	2,430,403.47	Manganese	0.25
Xylenes	2,893.73	Formaldehyde	98,905.78	1,3-Butadiene	0.10
Benzene	1,256.37	1,3-Butadiene	89,599.85	Benzene	0.05
Formaldehyde	969.28	Acetaldehyde	54,166.44	Arsenic	0.04
Hexane	963.82	Lead, PM	42,964.38	Naphthalene	0.03
Ethylbenzene	766.10	Benzene	41,879.01	Acrylonitrile	0.02
Acetaldehyde	487.50	Naphthalene	30,178.52	Lead	0.02
Ethylene glycol	240.60	Xylenes	28,937.26	Trichloroethylene	0.02
1,3-Butadiene	179.20	Arsenic, PM	11,077.09	Nickel	0.01
Glycol ethers, gas	98.40	Propionaldehyde	8,611.73	Cadmium	0.01
South Phoenix, Arizona (Maricopa County) – SPAZ					
Toluene	3,931.16	Acrolein	2,430,403.47	Acrylonitrile	0.19
Xylenes	2,893.73	Formaldehyde	98,905.78	1,3-Butadiene	0.13
Benzene	1,256.37	1,3-Butadiene	89,599.85	Benzene	0.06
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		

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 surrogate risk approximations for PXSS. While benzene and 1,3-butadiene both appear on the list of 10 highest emissions and 10 highest toxicity-weighted emissions for Maricopa County, carbon tetrachloride does not appear on either list.

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

- While acrylonitrile's cancer risk approximation is the highest cancer risk approximation for SPAZ, this pollutant appears on neither emissions-based list.

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 screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- Manganese, 1,3-butadiene, and benzene have the highest noncancer risk approximations for PXSS, although all of them are well below an HQ of 1.0. Only benzene and 1,3-butadiene appear on all three lists. In addition to benzene and 1,3-butadiene, arsenic, lead, and naphthalene appear on both toxicity-based lists.

- Acrylonitrile, 1,3-butadiene, and benzene have the highest noncancer risk approximations for SPAZ, although all of them are well below an HQ of 1.0. Benzene and 1,3-butadiene appear on all three lists while acrylonitrile appears on neither emissions-based list.

5.6   Summary of the 2010 Monitoring Data for PXSS and SPAZ

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

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

❖ *Of the site-specific pollutants of interest for the Arizona sites, benzene had the highest annual average concentration for both sites. This was the only pollutant with an annual average greater than 1 µg/m^3 for either site.*

❖ *Concentrations of several VOC, including benzene and 1,3-butadiene, tended to be slightly higher during the colder months of the year.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest, where they could be calculated, were greater than their associated MRL noncancer health risk benchmarks.*

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 through 6-3 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban locations. Figures 6-4 through 6-6 identify 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 6-4 through 6-6. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 6-1 describes the area surrounding each monitoring site by providing supplemental geographical information such as land, location setting, and locational coordinates.

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

Figure 6-2. Rubidoux, California (RUCA) Monitoring Site
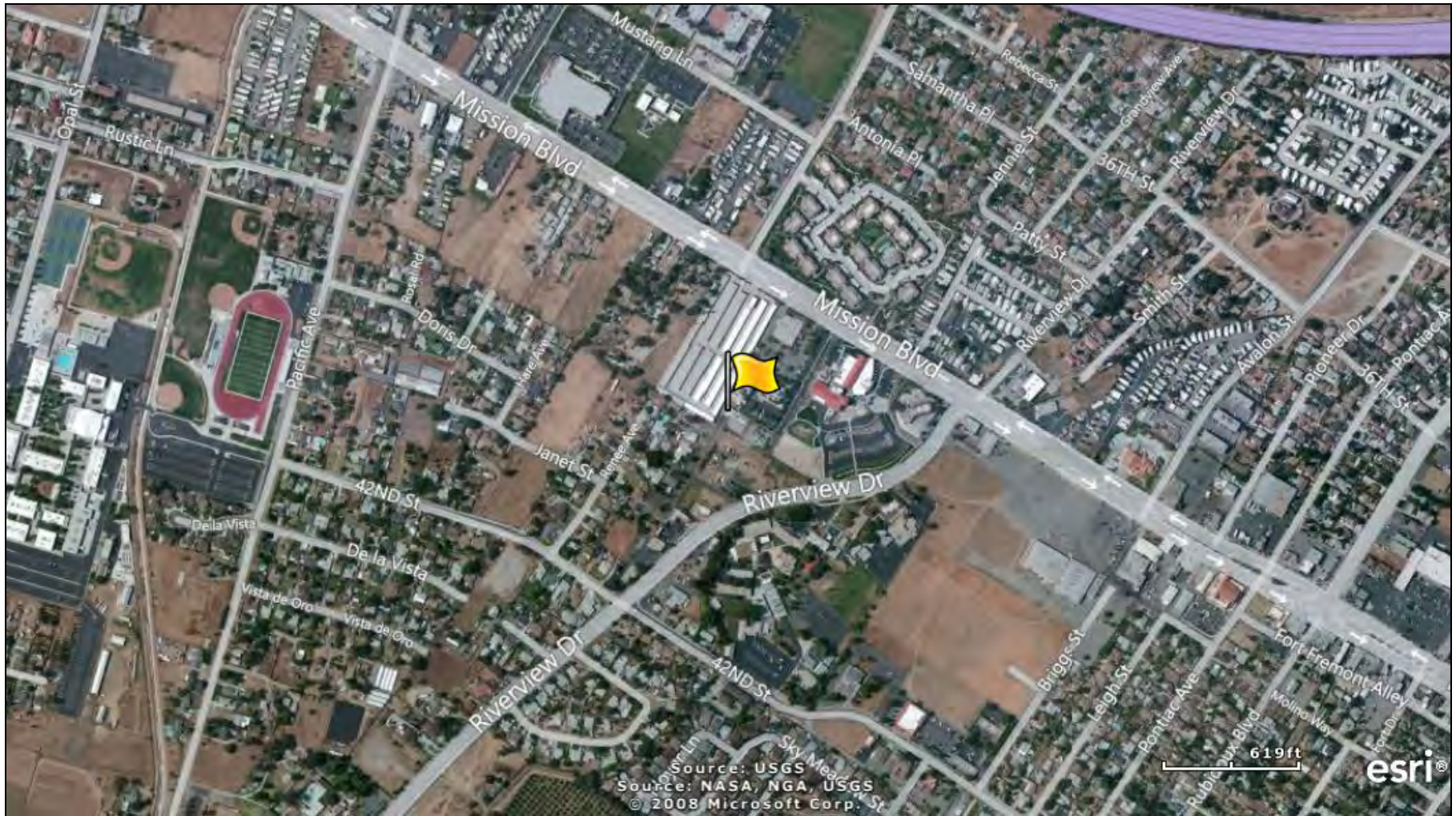
Figure 6-3. San Jose, California (SJJCA) Monitoring Site

Figure 6-4. 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.

Legend

⭐ CELA NATTS site   ◯ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

- Aerospace/Aircraft Manufacturing (2)
- Air-conditioning/Refrigeration (1)
- Aircraft Operations (62)
- Asphalt Processing/Roofing Manufacturing (2)
- Auto Body Shop/Painters (12)
- Automobile/Truck Manufacturing (4)
- Bakery (4)
- Battery Manufacturing (2)
- Building Construction (4)
- Bulk Terminals/Bulk Plants (2)
- Chemical Manufacturing (8)
- Concrete Batch Plant (1)
- Crematory - Animal/Human (2)
- Electrical Equipment (2)
- Electricity Generation via Combustion (5)
- Electroplating, Plating, Polishing, Anodizing, & Coloring (17)
- Fabricated Metal Products (11)

- Flexible Polyurethane Foam Production (2)
- F Food Processing/Agriculture (13)
- Furniture Plant (20)
- Glass Manufacturing (2)
- Λ Grain Handling (2)
- Heating Equipment Manufacturing (1)
- H Hospital (4)
- Hot Mix Asphalt Plant (1)
- Industrial Machinery and Equipment (5)
- Institutional - prison (1)
- Institutional - school (1)
- I Iron and Steel Foundry (7)
- Landfill (1)
- Leather and Leather Products (1)
- Mineral Products (1)
- ? Miscellaneous Commercial/Industrial (31)

- M Miscellaneous Manufacturing (6)
- M Municipal Waste Combustor (1)
- Oil and/or Gas Production (11)
- Petroleum Refinery (1)
- Pharmaceutical Manufacturing (1)
- 1 Primary Metal Production (8)
- P Printing/Publishing (26)
- Pulp and Paper Plant/Wood Products (9)
- R Rubber and Miscellaneous Plastics Products (6)
- 2 Secondary Metal Processing (4)
- < Site Remediation Activity (1)
- Steel Mill (2)
- S Surface Coating (10)
- π Telecommunications (2)
- T Textile Mill (8)
- Transportation Equipment (2)
- Wastewater Treatment (6)
- W Woodwork, Furniture, Millwork & Wood Preserving (2)

6-5

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

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

Legend

⭐ RUCA NATTS site   ◯ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

- ✖ Aerospace/Aircraft Manufacturing (1)
- ✛ Aircraft Operations (12)
- ▮ Asphalt Processing/Roofing Manufacturing (3)
- ◊ Auto Body Shop/Painters (6)
- 🚚 Automobile/Truck Manufacturing (7)
- Ᏸ Bakery (3)
- ⚓ Boat Manufacturing (1)
- ▱ Brick Manufacturing & Structural Clay (2)
- ▮ Building Construction (3)
- B Bulk Terminals/Bulk Plants (2)
- C Chemical Manufacturing (1)
- ▪ Concrete Batch Plant (5)
- e Electrical Equipment (5)
- ⚡ Electricity Generation via Combustion (4)
- ◉ Fabricated Metal Products (10)

- ⬯ Flexible Polyurethane Foam Production (1)
- F Food Processing/Agriculture (18)
- ▢ Furniture Plant (1)
- ▮ Gasoline/Diesel Service Station (1)
- Ⓗ Hospital (1)
- ☀ Hot Mix Asphalt Plant (1)
- ✳ Industrial Machinery and Equipment (2)
- Ⓤ Institutional - prison (1)
- Ⓢ Institutional - school (5)
- ▲ Landfill (4)
- ∱ Lumber/sawmill (1)
- ✕ Mine/Quarry (3)
- ▽ Mineral Products (2)
- ? Miscellaneous Commercial/Industrial (10)
- M Miscellaneous Manufacturing (2)

- ● Oil and/or Gas Production (3)
- ◈ Other Solid Waste Incineration (1)
- 7 Portland Cement Manufacturing (2)
- 1 Primary Metal Production (4)
- P Printing/Publishing (10)
- ⊞ Pulp and Paper Plant/Wood Products (4)
- R Rubber and Miscellaneous Plastics Products (6)
- 2 Secondary Metal Processing (2)
- < Site Remediation Activity (1)
- > Solid Waste Disposal - Commercial/Institutional (1)
- ▼ Steel Mill (4)
- S Surface Coating (4)
- ⇌ Transportation Equipment (3)
- ❊ Transportation and Marketing of Petroleum Products (1)
- ⚒ Wastewater Treatment (9)
- W Woodwork, Furniture, Millwork & Wood Preserving (2)

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

Legend

⭐ SJJCA NATTS site   ◯ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

- ⬯ Air-conditioning/Refrigeration (2)
- ✈ Aircraft Operations (19)
- ▮ Asphalt Processing/Roofing Manufacturing (4)
- ◊ Auto Body Shop/Painters (235)
- 🚗 Automobile/Truck Manufacturing (17)
- Ƀ Bakery (2)
- ✕ Battery Manufacturing (1)
- ▭ Brick Manufacturing & Structural Clay (3)
- ▮ Building Construction (15)
- B Bulk Terminals/Bulk Plants (5)
- C Chemical Manufacturing (5)
- O Clay Ceramics Manufacturing (1)
- ■ Concrete Batch Plant (10)
- ⋈ Crematory - Animal/Human (3)
- ⊕ Dry Cleaning Facility (161)
- e Electrical Equipment (250)
- ⚡ Electricity Generation via Combustion (2)
- E Electroplating, Plating, Polishing, Anodizing, & Coloring (14)
- 4 Engine Testing (1)

- ⊙ Fabricated Metal Products (35)
- ⟰ Flexible Polyurethane Foam Production (2)
- F Food Processing/Agriculture (43)
- ▱ Furniture Plant (37)
- ▮ Gasoline/Diesel Service Station (9)
- ▧ Glass Manufacturing (1)
- ∧ Grain Handling (2)
- ⁓ Heating Equipment Manufacturing (7)
- H Hospital (16)
- ⚘ Hot Mix Asphalt Plant (1)
- ⚙ Industrial Machinery and Equipment (19)
- ⚙ Institutional - school (27)
- I Iron and Steel Foundry (1)
- ◓ Laboratory (7)
- ◖ Leather and Leather Products (1)
- ƒ Lumber/sawmill (1)
- Ⱥ Military Base/National Security Facility (7)
- ✕ Mine/Quarry (5)

- ▮ Mineral Wool Manufacturing (1)
- ? Miscellaneous Commercial/Industrial (212)
- M Miscellaneous Manufacturing (69)
- ● Oil and/or Gas Production (3)
- �
 Pharmaceutical Manufacturing (9)
- 1 Primary Metal Production (2)
- P Printing/Publishing (30)
- ⊞ Pulp and Paper Plant/Wood Products (14)
- R Rubber and Miscellaneous Plastics Products (3)
- 2 Secondary Metal Processing (3)
- ‹ Site Remediation Activity (13)
- › Solid Waste Disposal - Commercial/Institutional (26)
- ▼ Steel Mill (1)
- S Surface Coating (32)
- π Telecommunications (102)
- T Textile Mill (5)
- ⤙ Transportation Equipment (5)
- ⚙ Transportation and Marketing of Petroleum Products (3)
- ▮ Wastewater Treatment (18)
- W Woodwork, Furniture, Millwork & Wood Preserving (2)

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, VOC, 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, VOC, 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, VOC, Carbonyl compounds, O_3, NMOC, Meteorological parameters, PM_{10}, PM_{10} Speciation, Black carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation.

[1] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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 just northeast of downtown Los Angeles, near 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 6-4 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 about three-quarters of a mile to the southeast of the site. Figure 6-2 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 6-5 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 6-3 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 6-3. Guadalupe Parkway, which can be seen on the bottom left of Figure 6-3, 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. 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; and telecommunications.

Table 6-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the California monitoring sites. Table 6-2 also includes a vehicle registration-to-county population

ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 6-2 also contains annual average daily traffic information. Finally, Table 6-2 presents the daily VMT for each county.

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	9,830,420	7,410,625	0.75	3,679,965	2,774,128	235,000	211,876,660
RUCA	2,203,332	1,707,950	0.78	990,029	767,438	145,000	55,167,650
SJJCA	1,787,694	1,517,995	0.85	1,486,476	1,262,220	103,000	39,402,370

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the California DMV (CA DMV, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data from the California DOT (CA DOT, 2010)
[5] County-level VMT reflects 2010 data for all public roads from the California DOT (CA DOT, 2011)
BOLD ITALICS = EPA-designated NATTS Site.

Observations from Table 6-2 include the following:

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

- Riverside and Santa Clara Counties are also in the top 10 for county population and county-level 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 (RUCA), based on county population. 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. The traffic count for CELA is based on data from Exit 136 off I-5 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.

- The Los Angeles County's daily VMT was the highest among all counties with NMP sites, where VMT was available. This VMT was an order of magnitude higher than the next highest county-level VMT (Cook County, IL). Riverside and Santa Clara Counties were 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 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, 2012).

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 2010

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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 2010. 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. Table 6-3 also shows a marked wind speed difference between CELA and RUCA (which are located less than 50 miles apart), as alluded to in Section 6.2.1, although wind speeds for both sites are very light. A statistically significant difference is also shown for the average maximum temperature. As expected, conditions near SJJCA tended to be cooler.

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	Sample Day	73.6 ± 2.3	64.3 ± 1.8	49.5 ± 1.9	56.3 ± 1.4	62.2 ± 3.2	1014.3 ± 0.9	1.3 ± 0.2
	248° (WSW)	2010	73.5 ± 0.9	64.4 ± 0.7	49.1 ± 0.9	56.2 ± 0.6	61.4 ± 1.4	1014.3 ± 0.4	1.3 ± 0.1
Rubidoux, California - RUCA									
Riverside Municipal Airport 03171 (33.95, -117.44)	3.49 miles	Sample Day	77.7 ± 3.2	64.6 ± 2.3	46.2 ± 2.3	54.7 ± 1.7	57.3 ± 3.9	1013.2 ± 0.9	3.7 ± 0.4
	214° (SW)	2010	77.5 ± 1.3	64.4 ± 1.0	45.9 ± 1.0	54.6 ± 0.7	57.5 ± 1.8	1013.2 ± 0.4	3.8 ± 0.1
San Jose, California - SJJCA									
San Jose Intl. Airport 23293 (37.36, -121.93)	1.90 miles	Sample Day	69.2 ± 2.6	59.4 ± 1.9	47.4 ± 1.2	53.0 ± 1.3	67.6 ± 2.8	1015.8 ± 1.3	5.1 ± 0.5
	316° (NW)	2010	69.2 ± 1.1	59.1 ± 0.8	47.1 ± 0.6	52.8 ± 0.6	67.6 ± 1.1	1015.7 ± 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 2010. Included in Figure 6-7 are four back trajectories per sample day. Figure 6-8 is the corresponding cluster analysis for 2010. Similarly, Figure 6-9 is the composite back trajectory map for days on which samples were collected at RUCA and Figure 6-10 is the corresponding cluster analysis; Figure 6-11 is the composite back trajectory map for days on which samples were collected at SJJCA and Figure 6-12 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, 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 was somewhat smaller for CELA than for many other NMP monitoring sites, based on the average distance of the trajectories. The farthest away a trajectory originated was off the northwest coast of California, or less than 650 miles away. However, most trajectories (88 percent) originated within 300 miles of CELA.

- Back trajectories originated from a variety of directions at CELA. However, a large cluster of trajectories originated from the northwest. Another cluster originated from the east-northeast. Very few trajectories originated from the east, southeast, south, or southwest.

- The cluster analysis shows that over 50 percent of trajectories originated from the northwest, although of varying distances. The cluster analysis also shows that approximately 25 percent of trajectories originated from a direction within the northeast quadrant. Another 22 percent originated off the coast and within about 300 miles of CELA. The cluster marked with 2 percent represents the five back trajectories originating well to the south and off Baja California.

Figure 6-7. 2010 Composite Back Trajectory Map for CELA
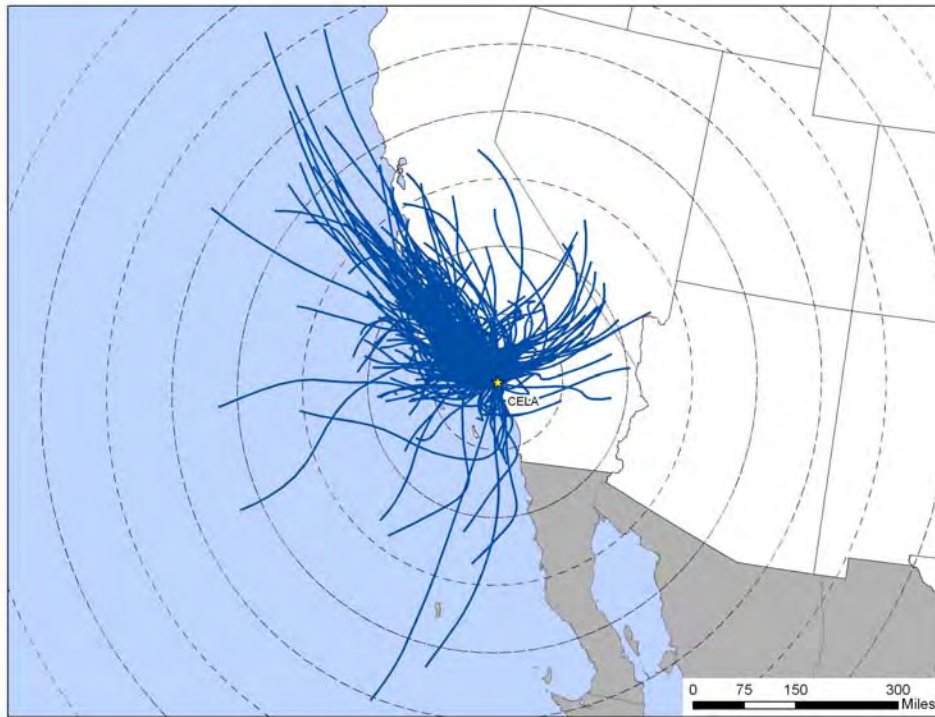
Figure 6-8. Back Trajectory Cluster Map for CELA

Figure 6-9. 2010 Composite Back Trajectory Map for RUCA
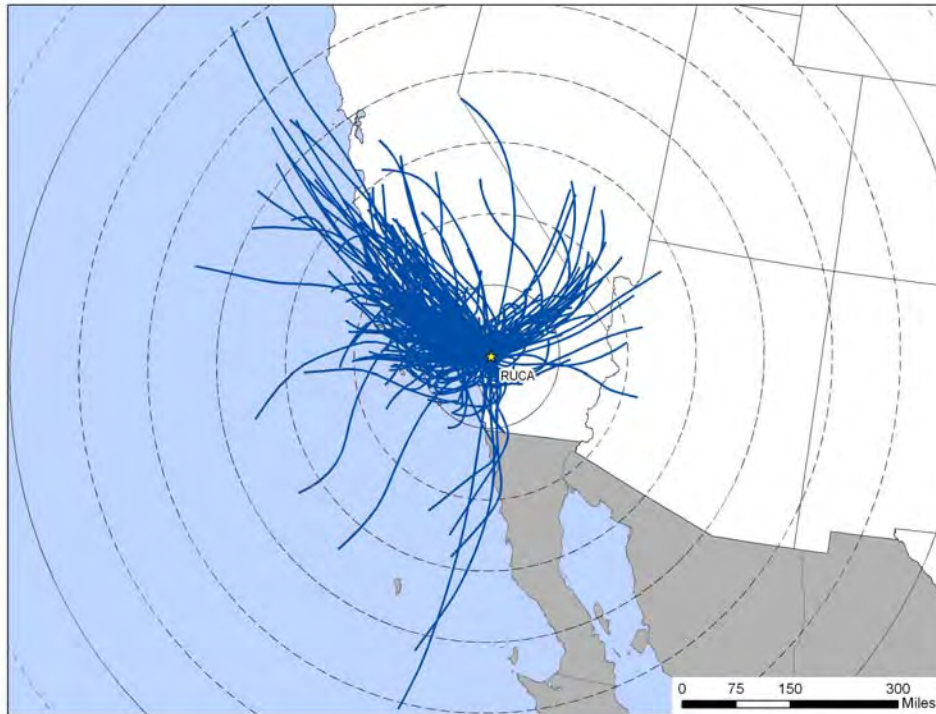
Figure 6-10. Back Trajectory Cluster Map for RUCA

Figure 6-11. 2010 Composite Back Trajectory Map for SJJCA
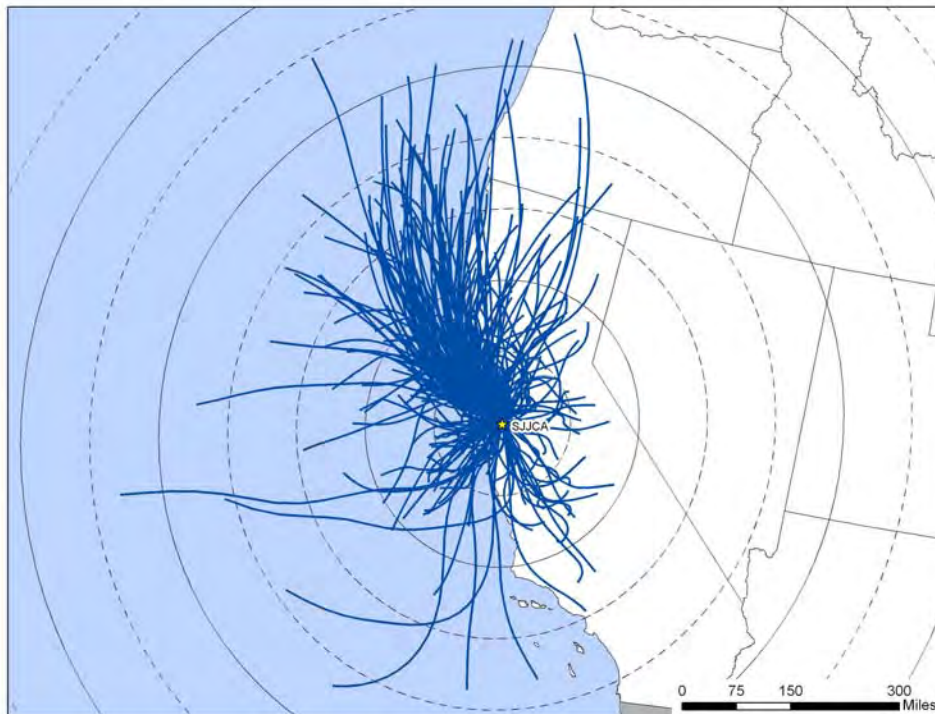
Figure 6-12. Back Trajectory Cluster Map for SJJCA
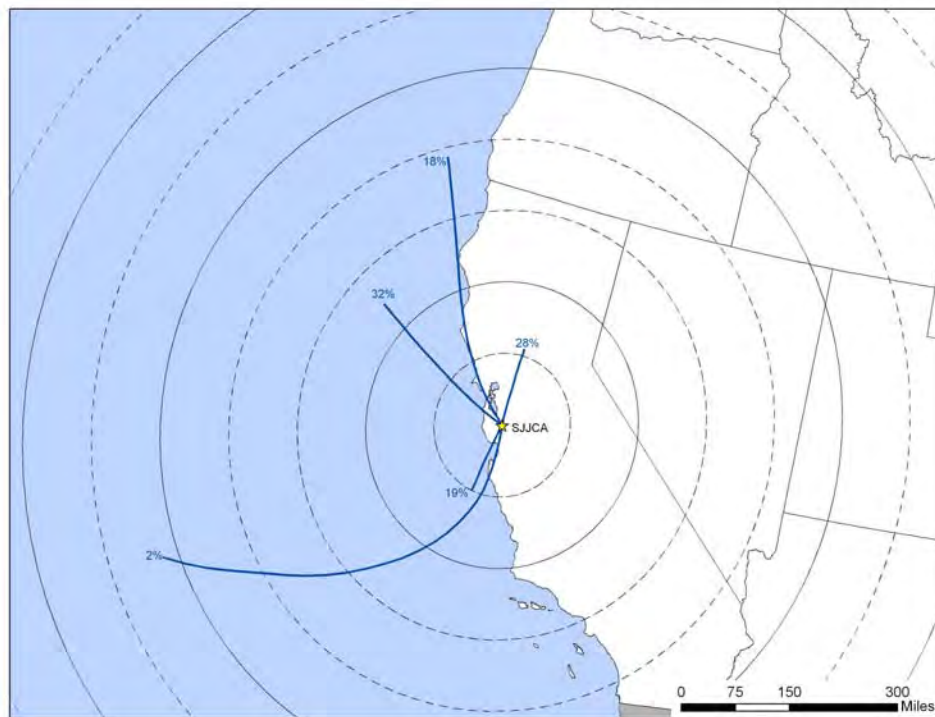
Observations from Figures 6-9 and 6-10 for RUCA include the following:

- Not surprisingly, the back trajectories for RUCA resemble the ones for CELA. The 24-hour air shed domain for RUCA is similar in size to CELA, as the farthest away a trajectory originated was also off the northwest coast of California, or nearly 600 miles away. Like CELA, most trajectories (90 percent) originated within 300 miles of RUCA.

- 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 cluster analysis for RUCA is similar to CELA in direction, but not necessarily the percentage of said directions. Figure 6-10 shows that 35 percent of trajectories originated primarily from the northwest. However, some trajectories originating to the northwest but of shorter distances were grouped with the trajectories originating offshore (as represented by the cluster shown with 46 percent). The clustering program uses both direction and distance to determine clusters, which is why there are two clusters originating to the northwest, one offshore and one inland. The cluster analysis also shows that approximately 18 percent of trajectories originated from the northeast. The cluster marked with 2 percent represents the five back trajectories originating well to the south and off Baja California.

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 larger than the other two California sites but still smaller compared to other NMP sites. The farthest away a trajectory originated was less than 600 miles away, well off shore the Oregon coast. However, 72 percent of trajectories originated within 300 miles of SJJCA and 90 percent originated within 400 miles of the site.

- Back trajectories originated from a variety of directions at SJJCA. The map shows a larger number of trajectories originating from the northwest to north to northeast of the site. Fewer trajectories originated from the east, southeast, south, and southwest.

- The cluster analysis shows that 78 percent of trajectories originated from the northwest and northeast quadrants. Most of the trajectories originating from the southeast and southwest quadrants were shorter in length and are represented by the 19 percent cluster. Only four back trajectories, representing approximately two percent of trajectories, originated to the southwest and well offshore.

6.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the CELA monitoring site. First, a historical wind rose representing 2000 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days that samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figures 6-14 and 6-15 present the three wind roses and distance maps for RUCA and SJJCA, respectively.

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 ($\leq$ 2 knots) observed for 57 percent of the wind observations. For wind speeds greater than 2 knots, westerly and west-southwesterly winds were most common. Wind speeds greater than 11 knots were not measured at this weather station.

- The 2010 wind rose is similar to the historical wind rose in wind patterns, although calms winds were observed more often (67 percent) in 2010. Further, the wind patterns shown on the sample day wind rose also resemble the historical and full-year wind patterns, indicating that conditions on sample days were representative of those experienced over the entire year and historically.

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

2000-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between CELA and NWS Station
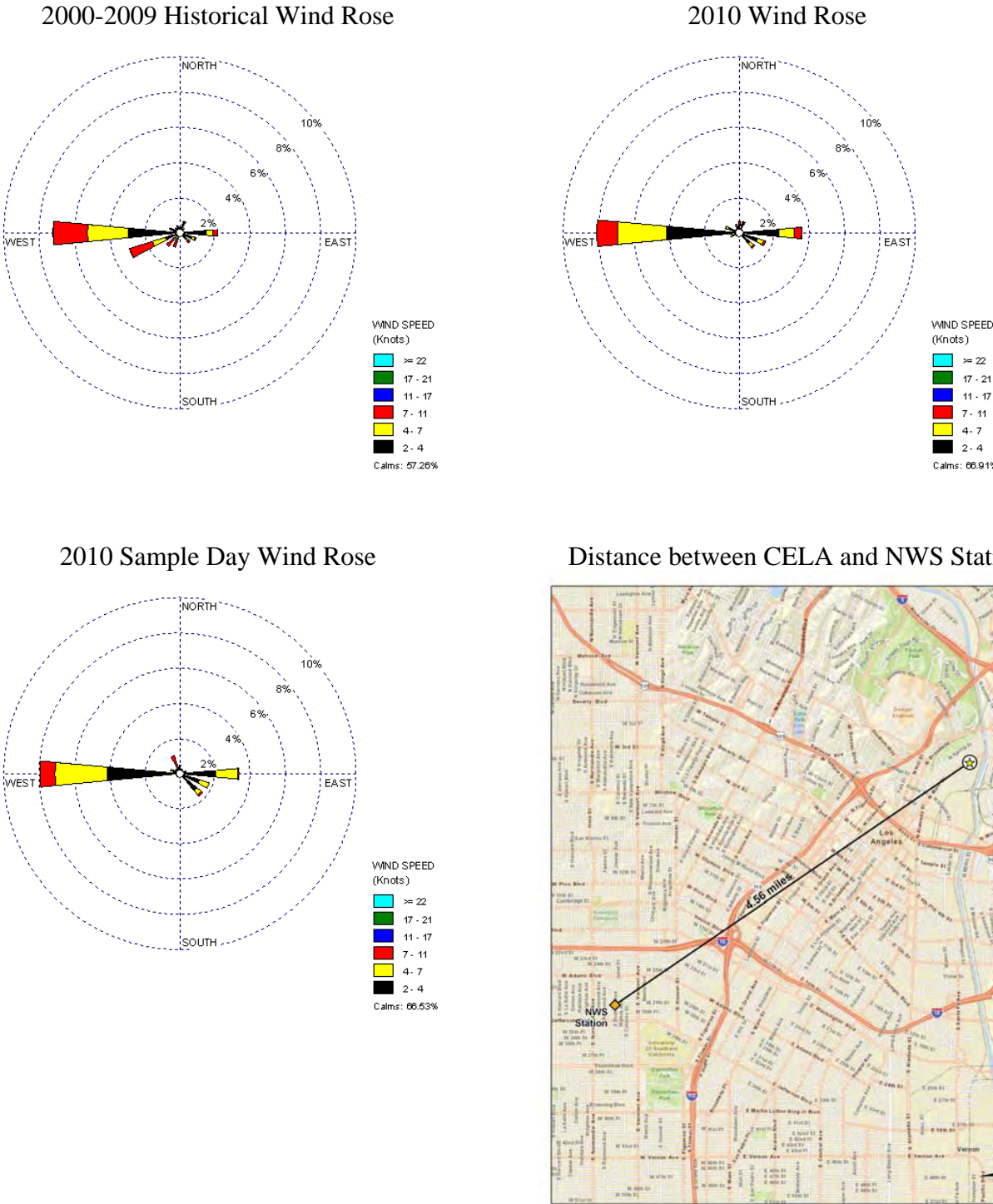
Figure 6-14. Wind Roses for the Riverside Municipal Airport Weather Station near RUCA

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between RUCA and NWS Station
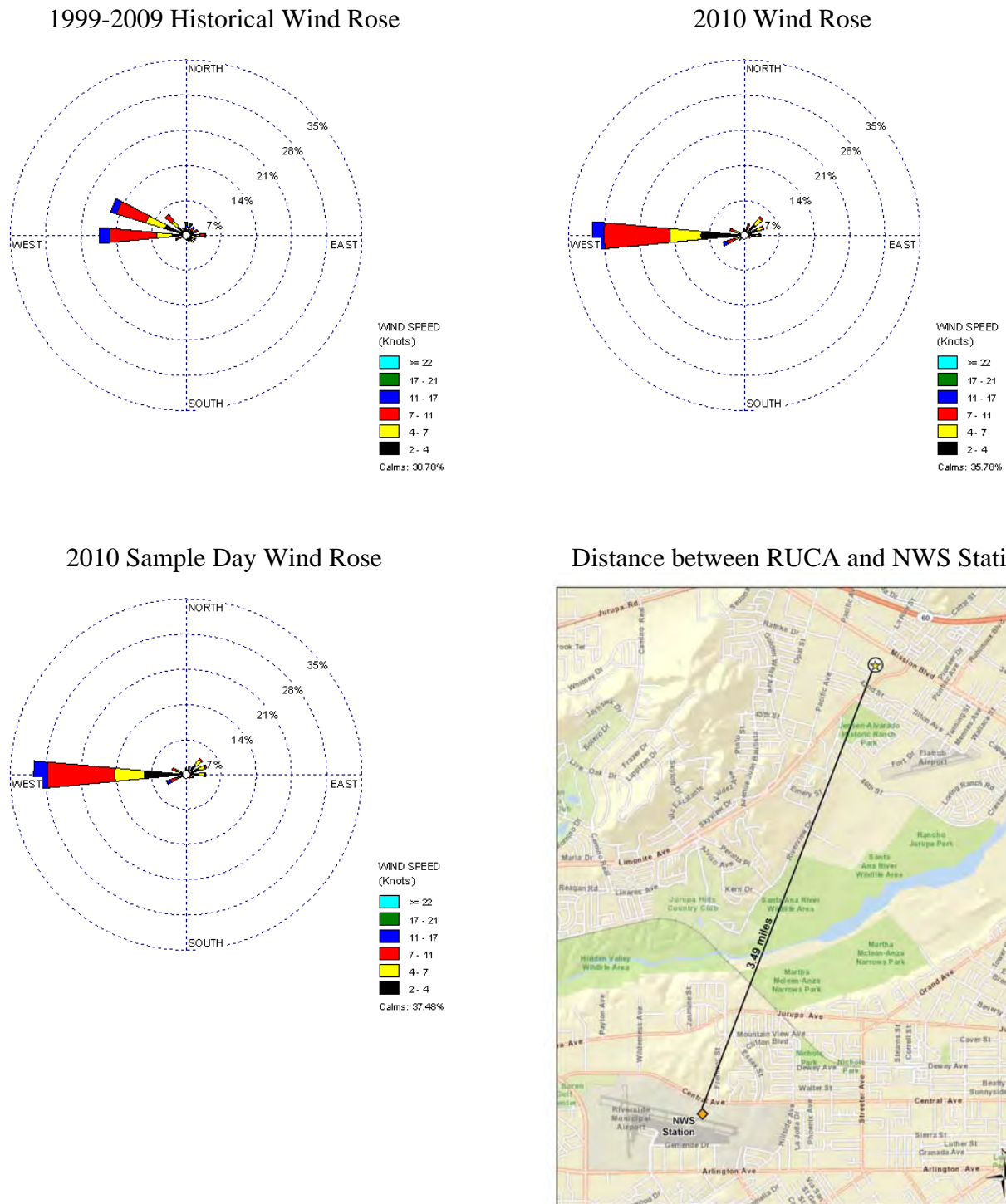
Figure 6-15. Wind Roses for the San Jose International Airport Weather Station near SJJCA

1999-2009 Historical Wind Rose
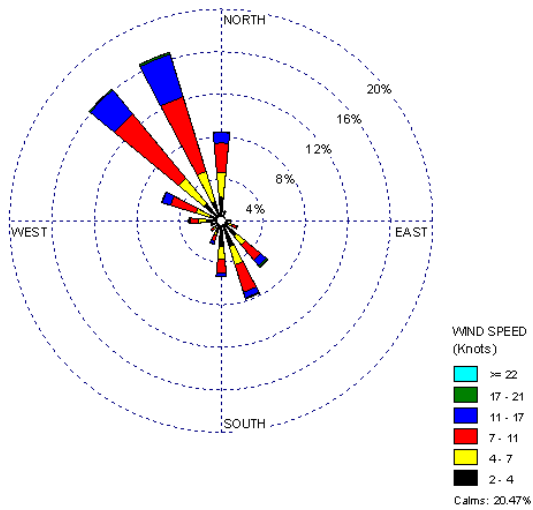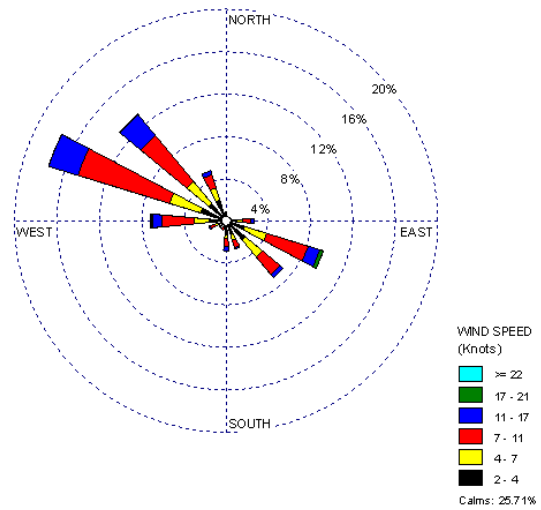
2010 Wind Rose

2010 Sample Day Wind Rose
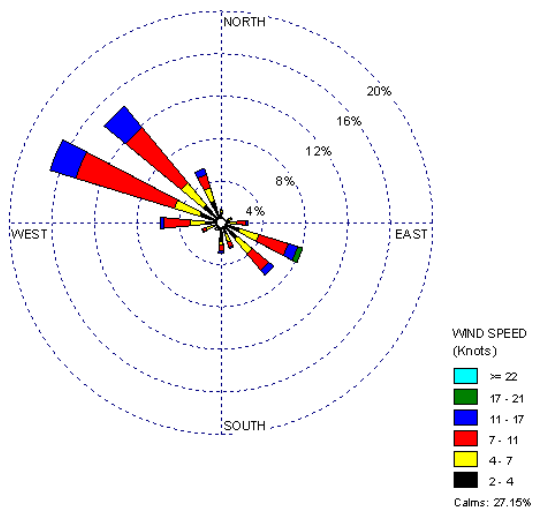
Distance between SJJCA and NWS Station

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 approximately 31 percent of the time near RUCA, westerly and west-northwesterly winds were also frequently observed, based on the historical wind rose.

- The 2010 wind rose exhibits a similar percentage of calm winds as the historical wind rose. However, west-northwesterly winds were rarely observed in 2010. Westerly winds make up almost the same percentage of wind observations in 2010 as both westerly and west-northwesterly winds on the historical wind rose.

- 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.

- Historically, 40 percent of winds were from the northwest to north. Another 20 percent of winds were from the southeast to south. Northeasterly, easterly, and southwesterly winds were rarely observed. Approximately one-fifth of the winds were calm.

- The wind patterns on the 2010 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 2010 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 2010 wind roses. This shift was also shown on the 2009 sample day wind rose in the 2008-2009 NMP report.

- The wind patterns shown on the sample day wind rose resemble the wind patterns shown on the full-year wind rose, indicating that conditions on sample days 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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 6-4 presents the pollutants of interest 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 PAH only, while SJJCA sampled for metals (PM_{10}) and PAH.

Table 6-4. Risk 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	82.86	82.86
Acenaphthene	0.011	5	59	8.47	7.14	90.00
Fluorene	0.011	5	59	8.47	7.14	97.14
Benzo(a)pyrene	0.00057	2	18	11.11	2.86	100.00
Total		70	195	35.90		
Rubidoux, California - RUCA						
Naphthalene	0.029	56	60	93.33	98.25	98.25
Benzo(a)pyrene	0.00057	1	22	4.55	1.75	100.00
Total		57	82	69.51		
San Jose, California - SJJCA						
Naphthalene	0.029	45	59	76.27	46.88	46.88
Arsenic (PM_{10})	0.00023	37	58	63.79	38.54	85.42
Manganese (PM_{10})	0.005	13	58	22.41	13.54	98.96
Nickel (PM_{10})	0.0021	1	58	1.72	1.04	100.00
Total		96	233	41.20		

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 76 percent (SJJCA) to 98 percent (CELA).

- Four pollutants failed screens for CELA, including the two PAH NATTS MQO Core Analytes. In addition to naphthalene, acenaphthene and fluorene were also identified as pollutants of interest. Benzo(a)pyrene was added to CELA's pollutants of interest

6-24

because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of CELA's total failed screens.

- Benzo(a)pyrene was the only other pollutant besides naphthalene to fail screens for RUCA. Although this pollutant only failed one screen, it was added as a pollutant of interest because it is a NATTS MQO Core Analyte.

- Four pollutants failed screens for SJJCA, all of which are NATTS MQO Core Analytes. Three of these were initially identified as SJJCA's pollutants of interest. Nickel 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. Four additional NATTS MQO Core Analytes were added to SJJCA's pollutants of interest, even though their concentrations did not fail any screens: benzo(a)pyrene, beryllium, cadmium, and lead. These four pollutants are not shown in Table 6-4.

6.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the California monitoring sites. Concentration averages are provided for the pollutants of interest for each site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site, where applicable. Additional site-specific statistical summaries are provided in Appendices M and N.

6.4.1   2010 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

6-25

monitoring sites are presented in Table 6-5, where applicable. Note that if a pollutant was not detected in a given calendar quarter, the quarterly average simply reflects "0" because only zeros substituted for non-detects were factored into the quarterly average concentration.

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

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m^3)	2nd Quarter Average (ng/m^3)	3rd Quarter Average (ng/m^3)	4th Quarter Average (ng/m^3)	Annual Average (ng/m^3)
Los Angeles, California - CELA						
Acenaphthene	59/59	7.74 ± 3.10	4.21 ± 1.12	6.94 ± 2.96	5.74 ± 1.76	6.15 ± 1.18
Benzo(a)pyrene	18/59	0.14 ± 0.14	0.07 ± 0.13	<0.01 ± <0.01	0.06 ± 0.06	0.07 ± 0.05
Fluorene	59/59	8.34 ± 2.92	5.06 ± 0.90	7.87 ± 2.81	6.31 ± 1.66	6.90 ± 1.11
Naphthalene	59/59	190.70 ± 76.18	94.79 ± 15.28	127.69 ± 23.04	165.84 ± 56.21	143.33 ± 24.02
Rubidoux, California - RUCA						
Benzo(a)pyrene	22/60	0.04 ± 0.03	0.01 ± 0.01	0.01 ± 0.02	0.09 ± 0.09	0.04 ± 0.02
Naphthalene	60/60	64.08 ± 24.16	52.21 ± 11.24	83.38 ± 15.81	141.82 ± 59.37	84.40 ± 17.24
San Jose, California - SJJCA						
Arsenic (PM$_{10}$)	58/58	0.37 ± 0.15	0.20 ± 0.05	0.49 ± 0.18	0.40 ± 0.12	0.37 ± 0.07
Benzo(a)pyrene	10/59	0.06 ± 0.05	<0.01 ± <0.01	0	0.03 ± 0.04	0.02 ± 0.02
Beryllium (PM$_{10}$)	57/58	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Cadmium (PM$_{10}$)	58/58	0.09 ± 0.04	0.04 ± 0.01	0.05 ± 0.02	0.06 ± 0.02	0.06 ± 0.01
Lead (PM$_{10}$)	58/58	2.57 ± 1.03	1.74 ± 1.04	1.84 ± 0.61	2.48 ± 0.90	2.13 ± 0.44
Manganese (PM$_{10}$)	58/58	3.37 ± 1.13	2.66 ± 0.61	4.35 ± 1.64	4.81 ± 1.91	3.76 ± 0.68
Naphthalene	59/59	80.47 ± 25.88	31.46 ± 8.30	45.94 ± 17.52	98.20 ± 38.38	63.44 ± 13.38
Nickel (PM$_{10}$)	58/58	0.79 ± 0.21	0.64 ± 0.07	0.95 ± 0.22	0.99 ± 0.22	0.84 ± 0.10

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 annual average concentration of naphthalene for CELA is higher than RUCA and more than twice that of SJJCA. A similar pattern in the annual average concentrations of benzo(a)pyrene is also shown in Table 6-5. Benzo(a)pyrene was detected in less than half of the samples collected at each site while the other pollutants of interest were detected in nearly all of the samples collected at each site.

- Naphthalene and benzo(a)pyrene were generally highest during the first and fourth quarters of 2010 for each California site and have relatively large confidence intervals associated with them compared to the other quarters, particularly benzo(a)pyrene. These large confidence intervals make it difficult to definitively indentify a quarterly trend in the concentrations, especially for benzo(a)pyrene, which was detected in less than half of samples collected at these sites and therefore has many substituted zeros within the calculations, leading to a higher level of variability within the average concentrations, which is reflected in those confidence intervals.

- The first quarter average concentrations of all four pollutants of interest for CELA are higher than the other quarterly averages and have relatively high confidence intervals associated with them, indicating the possibility of outliers. With the exception of benzo(a)pyrene, the highest concentration of each of the pollutants of interest was measured on March 21, 2010. For naphthalene, the measurement on March 21, 2010 was 619 ng/m^3, while the next two highest concentrations, which were measured during the fourth quarter of 2010, were considerably lower (359 ng/m^3 and 358 ng/m^3). For acenaphthene and fluorene, the only concentrations greater than 20 ng/m^3 were measured on March 21, 2010 (24.6 ng/m^3 and 23.8 ng/m^3, respectively) and August 18, 2010 (22.6 ng/m^3 and 21.5 ng/m^3, respectively). The two highest benzo(a)pyrene concentrations were measured on February 1, 2010 (0.987 ng/m^3) and June 7, 2010 (0.981 ng/m^3); these two concentrations were more than three times higher than the third highest concentration.

- At RUCA, only four measurements of benzo(a)pyrene were greater than 0.1 ng/m^3, with three of the four being measured during the fourth quarter of 2010. The highest concentration of this pollutant was measured on December 4, 2010 (0.599 ng/m^3). Of the seven measurements of naphthalene greater than 150 ng/m^3, six were measured during the fourth quarter of 2010. The highest concentration of this pollutant was measured on December 10, 2010 (336 ng/m^3), which is almost half the highest concentration of naphthalene measured at CELA.

- Benzo(a)pyrene was detected the least at SJJCA (10 out of 59 samples). Five of these 10 were measured during the first quarter of 2010, one was measured during the second quarter, and four were measured during the fourth quarter of 2010. Of the three measurements of naphthalene greater than 150 ng/m^3, two were measured during the fourth quarter of 2010 and one in the first quarter of 2010. The highest concentration of this pollutant was measured at SJJCA on November 4, 2010 (289 ng/m^3).

- Of the PM$_{10}$ metals measured at SJJCA, manganese and lead are the only two pollutants with annual average concentrations greater than 1 ng/m^3. Based on the quarterly averages, the metals do not exhibit a quarterly trend like naphthalene and benzo(a)pyrene.

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 a total of four times. CELA has the second highest annual average concentration naphthalene among NMP sites sampling PAHs, behind only GPCO. This site also has the third highest annual average of fluorene, fourth highest concentration of acenaphthene, and ninth highest annual average of benzo(a)pyrene. RUCA has the 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 these pollutants.

6.4.2 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 benzo(a)pyrene and naphthalene were created for all three California sites. Box plots were also created for arsenic and manganese for SJJCA. Figures 6-16 through 6-19 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Observations from Figures 6-16 through 6-19 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}). There were no non-detects of arsenic measured at SJJCA.

- Figure 6-17 for benzo(a)pyrene shows the annual average concentrations of all three California sites. The program-level maximum concentration (42.7 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 2 ng/m^3. Note that the first quartile for this pollutant is zero and is not visible on this box plot. Each of the annual average concentrations of benzo(a)pyrene for the California sites is below the program-level average concentration. Figure 6-17 allows the reader to easily visualize how the California sites' annual average and maximum concentrations compare to each other.

- Figure 6-18 shows the annual average concentration of manganese (PM_{10}) for SJJCA is less than the program-level average and just below the program median. The maximum concentration measured at SJJCA is well below the program maximum concentration. There were no non-detects of manganese measured at SJJCA.

- Figure 6-19 for naphthalene shows the annual average concentrations of all three California sites. CELA's annual average concentration is greater than the program-level average and median concentrations, although its maximum concentration is well below the maximum measured across the program. RUCA's annual average is just below the program-level average and SJJCA's annual average is below both the program-level average and median concentrations. There were no non-detects of naphthalene measured at CELA, RUCA, or SJJCA.

Figure 6-16. Program vs. Site-Specific Average Arsenic (PM$_{10}$) Concentration
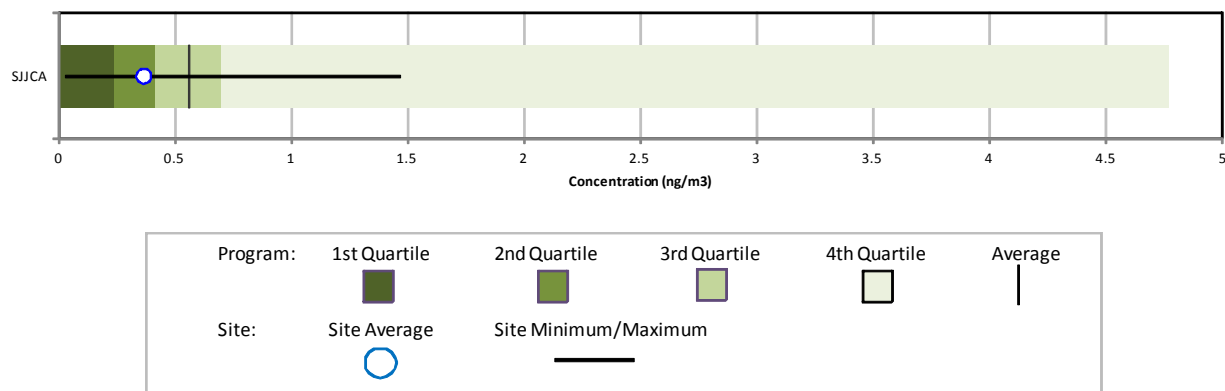
Figure 6-17. Program vs. Site-Specific Average Benzo(a)pyrene Concentration
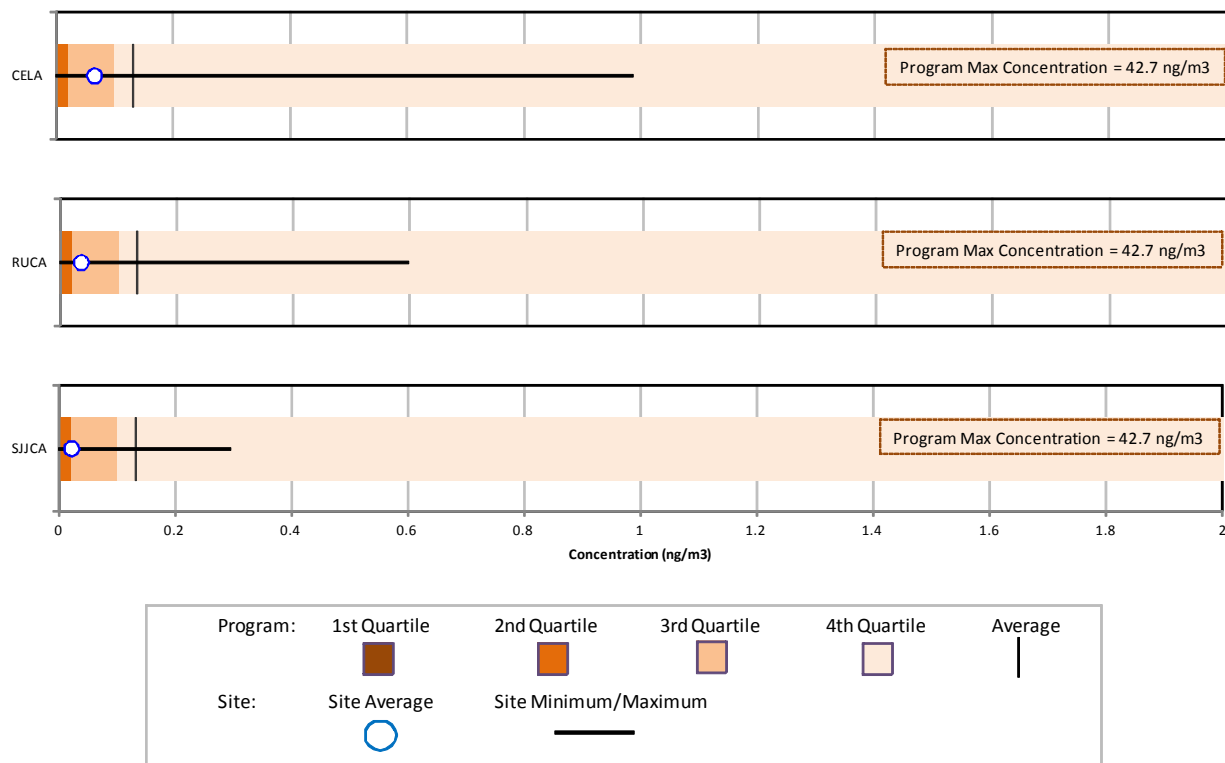
Figure 6-18. Program vs. Site-Specific Average Manganese (PM$_{10}$) Concentration
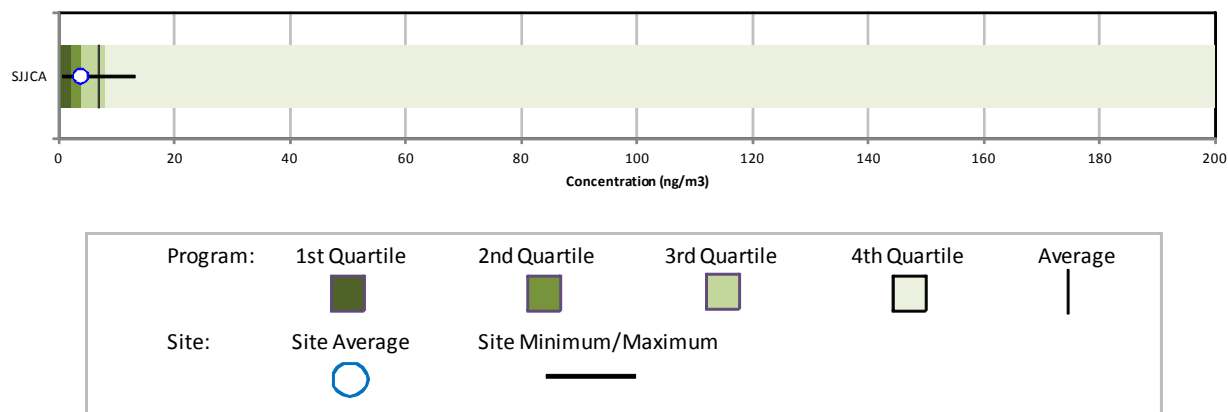
Figure 6-19. Program vs. Site-Specific Average Naphthalene Concentration
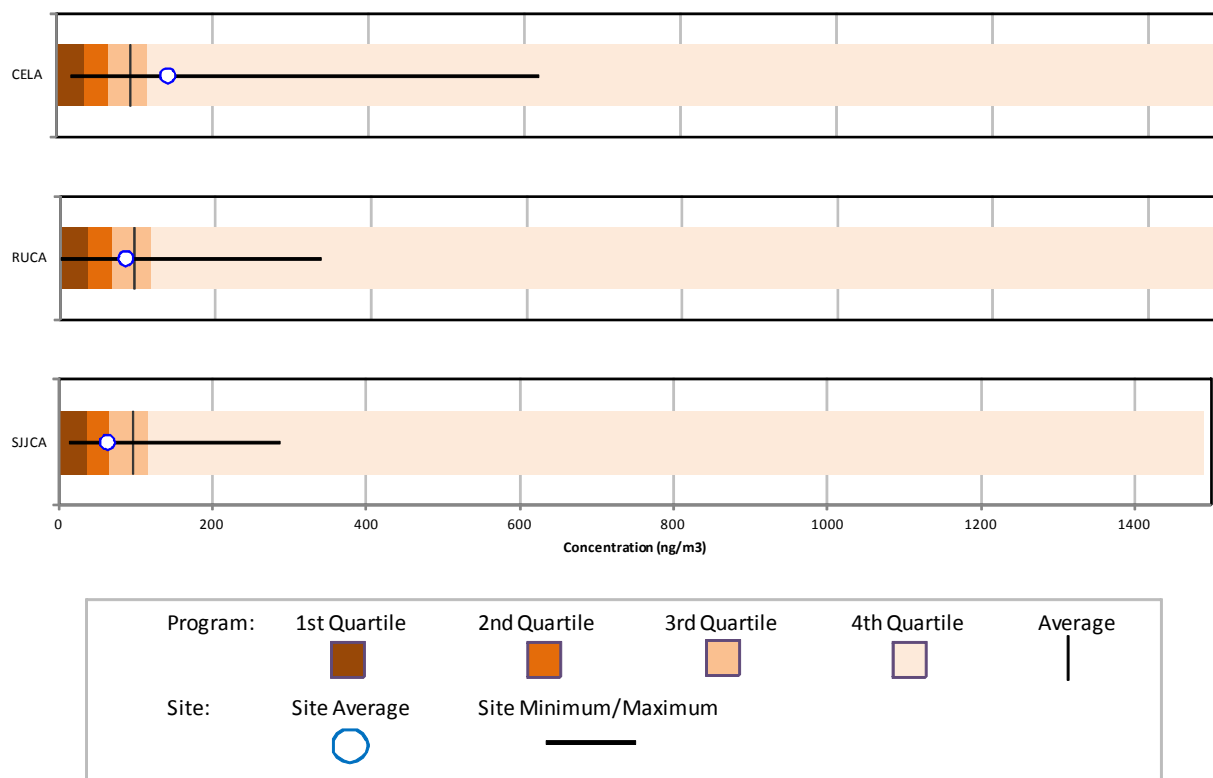
6.4.3 Concentration Trends

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. None of the California monitoring sites have sampled continuously for 5 years as part of the NMP; therefore, the trends analysis was not conducted.

6.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

6.5.1   Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the California monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for each site were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the California monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as a pollutant of interest for the California monitoring sites.

6.5.2   Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the California monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 6-6, where applicable.

Table 6-6. Cancer and Noncancer Surrogate 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 Risk Approximation (HQ)
Los Angeles, California - CELA						
Acenaphthene	0.000088	--	59/59	6.15 ± 1.18	0.54	--
Benzo(a)pyrene	0.00176	--	18/59	0.07 ± 0.05	0.12	--
Fluorene	0.000088	--	59/59	6.90 ± 1.11	0.61	--
Naphthalene	0.000034	0.003	59/59	143.33 ± 24.02	4.87	0.05
Rubidoux, California - RUCA						
Benzo(a)pyrene	0.00176	--	22/60	0.04 ± 0.02	0.07	--
Naphthalene	0.000034	0.003	60/60	84.40 ± 17.24	2.87	0.03
San Jose, California - SJJCA						
Arsenic (PM$_{10}$)	0.0043	0.000015	58/58	0.37 ± 0.07	1.57	0.02
Benzo(a)pyrene	0.00176	--	10/59	0.02 ± 0.02	0.04	--
Beryllium (PM$_{10}$)	0.0024	0.00002	57/58	<0.01 ± <0.01	<0.01	<0.01
Cadmium (PM$_{10}$)	0.0018	0.00001	58/58	0.06 ± 0.01	0.10	0.01
Lead (PM$_{10}$)	--	0.00015	58/58	2.13 ± 0.44	--	0.01
Manganese (PM$_{10}$)	--	0.00005	58/58	3.76 ± 0.68	--	0.08
Naphthalene	0.000034	0.003	59/59	63.44 ± 13.38	2.16	0.02
Nickel (PM$_{10}$)	0.00048	0.00009	58/58	0.84 ± 0.10	0.40	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 has the highest cancer risk approximation among the pollutants of interest for all three California monitoring sites. The cancer risk approximations range from 2.16 in-a-million for SJJCA to 4.87 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 was greater than 1.0 in-a-million (1.57 in-a-million).

- All of the noncancer risk approximations for the pollutants of interest for the California monitoring sites are less than 1.0, indicating no risk of noncancer health effects.

6.5.3 Risk-Based Emissions Assessment

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

The pollutants listed in Tables 6-7 and 6-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 PAH and SJJCA also sampled PM_{10} metals. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	4.87
Benzene	1,847.23	Hexavalent Chromium, PM	2.57E-02	Fluorene	0.61
Dichloromethane	1,347.58	Benzene	1.44E-02	Acenaphthene	0.54
Acetaldehyde	1,236.99	1,3-Butadiene	1.07E-02	Benzo(a)pyrene	0.12
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	2.87
Benzene	409.04	Formaldehyde	1.03E-02	Benzo(a)pyrene	0.07
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 Risk Factors (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	2.16
Benzene	353.73	Hexavalent Chromium, PM	7.13E-03	Arsenic	1.57
Acetaldehyde	254.78	Benzene	2.76E-03	Nickel	0.40
Ethylbenzene	201.33	1,3-Butadiene	2.24E-03	Cadmium	0.10
Dichloromethane	102.75	POM, Group 1a	1.70E-03	Benzo(a)pyrene	0.04
Tetrachloroethylene	97.93	Naphthalene	1.34E-03	Beryllium	<0.01
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 Risk Approximations for Pollutants with Noncancer RfCs for the California Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Los Angeles, California (Los Angeles County) - CELA					
1,1,1-Trichloroethane	7,345.47	Acrolein	8,698,970.49	Naphthalene	0.05
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 Risk Approximations for Pollutants with Noncancer RfCs for the California Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
San Jose, California (Santa Clara County) - SJJCA					
Toluene	1,394.35	Acrolein	1,999,590.36	Manganese	0.08
1,1,1-Trichloroethane	1,290.78	Chlorine	109,927.46	Arsenic	0.02
Formaldehyde	577.88	Formaldehyde	58,967.45	Naphthalene	0.02
Benzene	353.73	1,3-Butadiene	37,354.73	Lead	0.01
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 much higher 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. Hexavalent chromium emissions rank between 13th highest for RUCA to 18th highest for SJJCA.

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

- 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 one of the 10 highest emitted pollutants for the 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 higher 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 for any of the sites. 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 Clara Counties, while four of the highest emitted pollutants also have the highest toxicity-weighted emissions for Santa Clare County.

- Naphthalene, the only pollutant for which a noncancer risk approximation could be calculated for CELA and RUCA, has one of the 10 highest toxicity-weighted emissions for each county, but does not appear on the list of the 10 highest total emissions for either county. This is also true for Santa Clara County.

6-38

- Arsenic and lead are the only two pollutants for which noncancer risk approximations could be calculated for SJJCA and that also appear on the list of 10 highest toxicity-weighted emissions totals. None of the metals appear on the list of the 10 highest total emissions.

6.6   Summary of the 2010 Monitoring Data for CELA, RUCA, and SJJCA

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

❖ *Four PAH, including naphthalene and benzo(a)pyrene, failed screens for CELA, while only naphthalene and benzo(a)pyrene failed screens for RUCA. Naphthalene and three metals failed screens for SJJCA.*

❖ *Naphthalene had the highest annual average concentration among all the pollutants of interest for the California sites. The annual average concentrations of naphthalene were higher in magnitude for CELA than for RUCA and SJJCA. CELA's annual average naphthalene concentration was the second highest annual average among NMP sites sampling this pollutant.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

**7.0	Sites in Colorado**

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP and NATTS 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), while the other five 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), Rifle (RICO), and Rulison (RUCO). Figures 7-1 through 7-6 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 7-7 and 7-8 identify 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 7-7 and 7-8. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 7-1 describes the areas surrounding the monitoring sites by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 7-1. Grand Junction, Colorado (GPCO) Monitoring Site
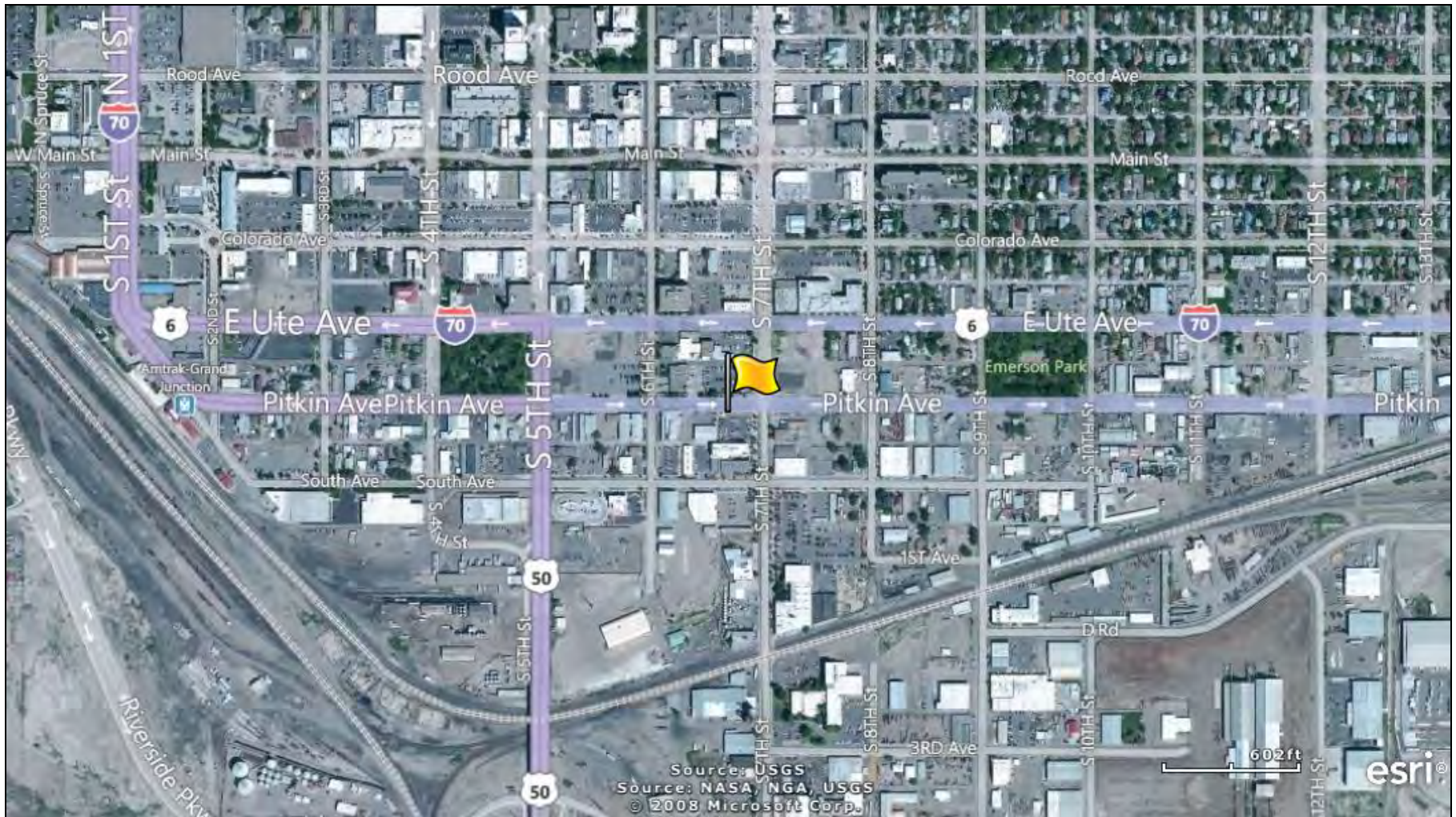
Figure 7-2. Battlement Mesa, Colorado (BMCO) Monitoring Site
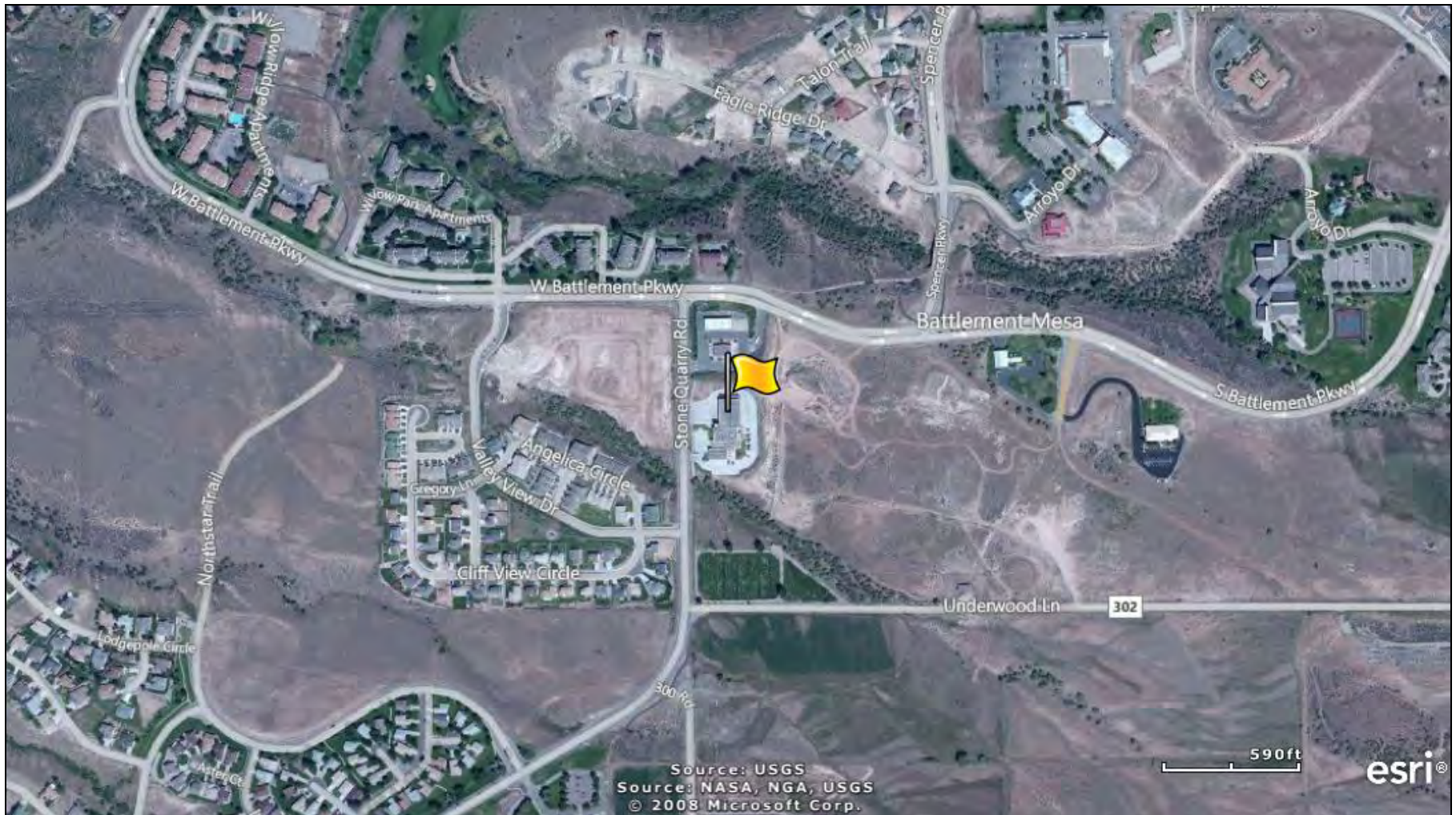
Figure 7-3. Silt, Colorado (BRCO) Monitoring Site

Figure 7-4. Parachute, Colorado (PACO) Monitoring Site
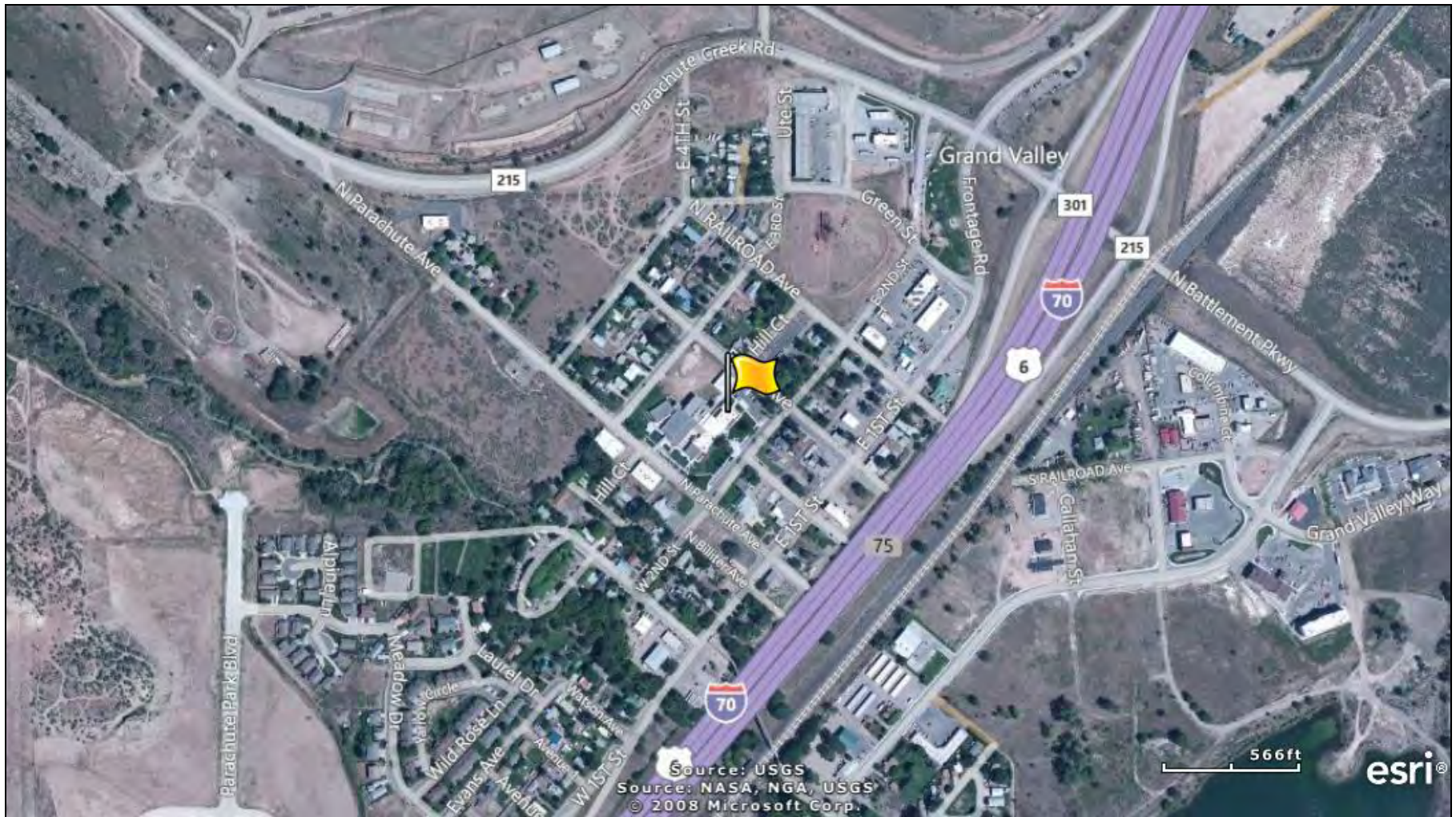
Figure 7-5. Rifle, Colorado (RICO) Monitoring Site
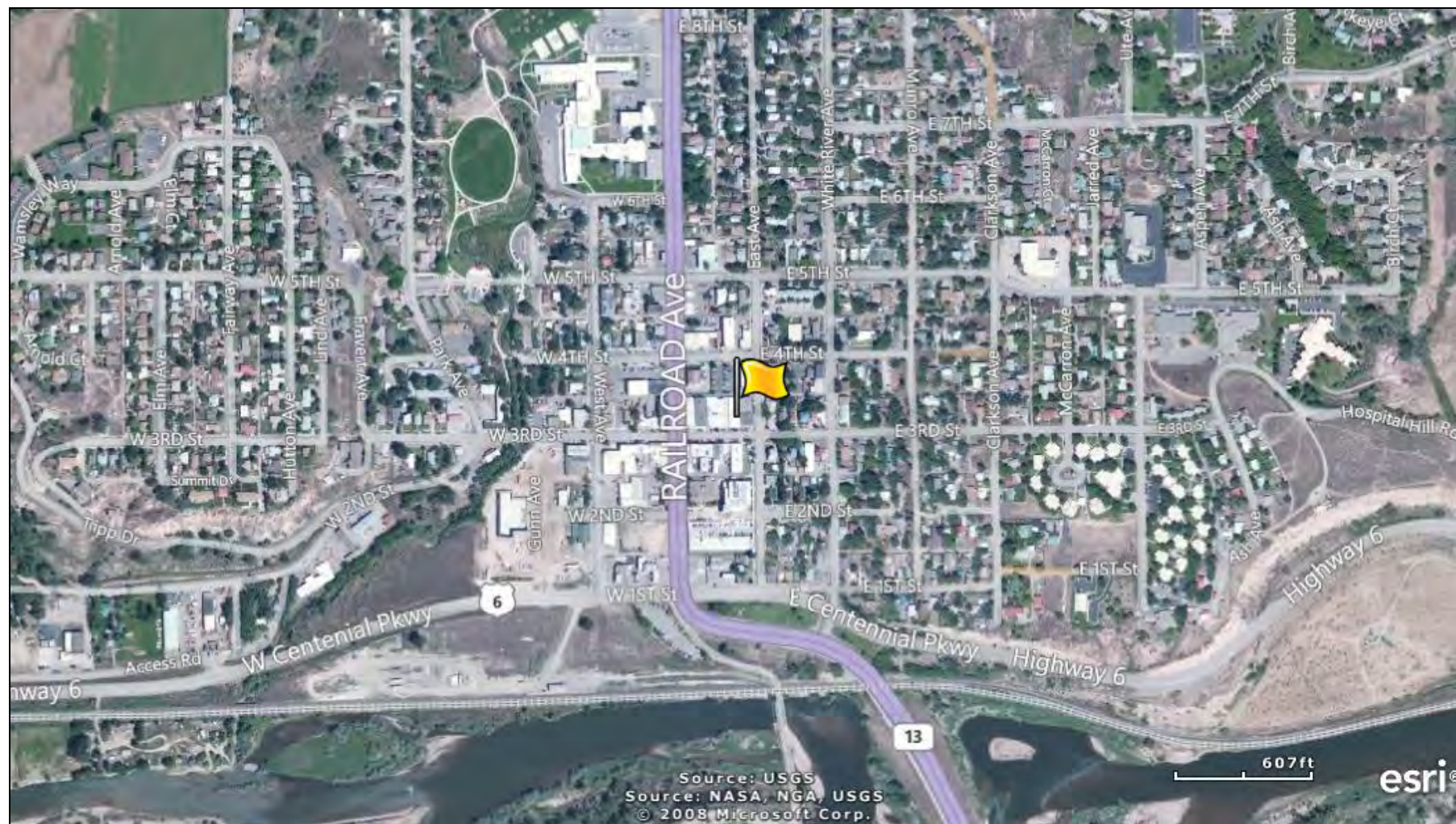
Figure 7-6. Rulison, Colorado (RUCO) Monitoring Site

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

Legend

⊕ GPCO NATTS site   ◯ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

+	Aircraft Operations (9)	▪	Gasoline/Diesel Service Station (47)
◊	Auto Body Shop/Painters (4)	⚒	Hot Mix Asphalt Plant (2)
🚗	Automobile/Truck Manufacturing (2)	✻	Industrial Machinery and Equipment (1)
▭	Brick Manufacturing & Structural Clay (1)	ⓢ	Institutional - school (4)
B	Bulk Terminals/Bulk Plants (4)	▲	Landfill (1)
C	Chemical Manufacturing (1)	✕	Mine/Quarry (23)
▪	Concrete Batch Plant (6)	?	Miscellaneous Commercial/Industrial (3)
⋈	Crematory - Animal/Human (4)	●	Oil and/or Gas Production (4)
⊕	Dry Cleaning (4)	R	Rubber and Miscellaneous Plastics Products (3)
e	Electrical Equipment (2)	2	Secondary Metal Processing (1)
E	Electroplating, Plating, Polishing, Anodizing, and Coloring (2)	<	Site Remediation Activity (2)
⊙	Fabricated Metal Products (1)	S	Surface Coating (2)
▤	Furniture Plant (1)	T	Textile Mill (1)
		▪	Wastewater Treatment (1)

Figure 7-8. NEI Point Sources Located Within 10 Miles of BMCO, BRCO, PACO, RICO, and RUCO

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	NA	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.
RUCO	NA	Rulison	Garfield	Not in an MSA	39.488744, -107.936989	Agricultural	Rural	No AQS entry.

[1] These monitoring sites report additional pollutants to AQS (EPA, 2012h); however, these data are not generated by ERG and are therefore not included in this report.
BOLD ITALICS = EPA-designated NATTS Site.
NA = No AQS entry

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 is on an adjacent 2-story building that has the hexavalent chromium samplers on the roof. 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. The 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 7-7 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. As shown in Figure 7-2, the monitoring site is located on the roof of the Grand Valley Fire Protection District facility, near the intersection of Stone Quarry Road and W. Battlement Parkway. The site is surrounded primarily by residential subdivisions. A cemetery is located to the south of the site and a church 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 7-3, 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 7-4. 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 7-5. Highway 13 and US-6 intersect just south of the site and across the Colorado River, I-70 is just over a half-mile south of the monitoring site. The surrounding area is considered commercial.

RUCO is located on the Potter Ranch, in Rulison, Colorado, about halfway between the towns of Parachute and Rifle. This location is less than 1 mile south of the I-70, as shown in Figure 7-6. The surrounding area is considered rural and agricultural.

The five Garfield County sites are located along a line running roughly east-west and spanning approximately 20 miles; hence they are shown together in Figure 7-8. 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the Colorado monitoring sites. Table 7-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 7-2 also contains annual average daily traffic information. Finally, Table 7-2 presents the 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.

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	146,313	180,119	1.23	117,098	144,154	12,000	2,047,739
BMCO				5,941	7,921	2,527	
BRCO				24,174	32,230	150	
PACO	56,139	74,847	1.33	7,898	10,530	2,600	1,942,038
RICO				17,641	23,520	17,000	
RUCO				17,641	23,520	699	

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2009 data from the Colorado Dept of Revenue (CO DOR, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2002 data for BMCO, BRCO, and RUCO from Garfield County (GCRBD, 2002) and 2010 data for GPCO, PACO, and RICO from the Colorado DOT (CO DOT, 2011)
[5] County-level VMT reflects 2010 data for state highways only from the Colorado DOT (CO DOT, 2010)

BOLD ITALICS = EPA-designated NATTS Site.

Observations from Table 7-2 include the following:

- Mesa County's population and vehicle ownership are considerably higher than those for Garfield County. This is also true for its 10-mile population and vehicle ownership. However, both counties rank in the bottom-third compared to all counties with NMP sites.

- The vehicle-per-person ratios for all six sites are among the highest for all NMP sites.

- The traffic volumes near GPCO and RICO are considerably higher than the traffic volumes near the other Garfield County sites. With the exception of RICO, the traffic volumes near the Colorado sites are in the bottom-third compared to other NMP sites. The lowest traffic volume among all NMP sites is for BRCO. The traffic estimate for GPCO came from Business-70 near 5th Avenue; from S. Battlement Parkway for BMCO; from the junction of County Roads 331 and 326 for BRCO; from Route 6 at Parachute Avenue for PACO; from the junction of Highway 13 and I-70 for RICO; and from County Road 323 for RUCO.

- 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.

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, Rulison, 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, 2011).

7.2.2   Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). The weather station nearest GPCO is located at Walker Field Airport (WBAN 23066); the closest weather station to the five 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 normal conditions throughout the year.

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	Sample Day	64.4 ± 5.8	52.8 ± 5.2	31.0 ± 2.7	41.8 ± 3.3	52.6 ± 6.0	1014.0 ± 1.9	5.8 ± 0.6
	22° (NNE)	2010	64.5 ± 2.3	52.8 ± 2.1	30.4 ± 1.2	41.6 ± 1.4	51.3 ± 2.4	1014.0 ± 0.9	6.2 ± 0.3
Battlement Mesa, Colorado - BMCO									
Garfield Co. Regional Airport 03016 (39.53, -107.73)	16.41 miles	Sample Day	55.5 ± 9.1	44.7 ± 7.0	29.2 ± 4.7	37.5 ± 5.0	60.9 ± 8.5	1017.4 ± 3.1	4.0 ± 1.2
	76° (ENE)	2010	62.6 ± 2.3	48.9 ± 2.0	28.4 ± 1.2	39.0 ± 1.4	53.9 ± 2.1	1015.3 ± 0.8	4.4 ± 0.3
Silt, Colorado - BRCO									
Garfield Co. Regional Airport 03016 (39.53, -107.73)	4.23 miles	Sample Day	62.8 ± 5.9	49.4 ± 4.9	28.7 ± 2.7	39.3 ± 3.3	53.6 ± 5.2	1015.1 ± 1.8	4.3 ± 0.6
	316° (NW)	2010	62.6 ± 2.3	48.9 ± 2.0	28.4 ± 1.2	39.0 ± 1.4	53.9 ± 2.1	1015.3 ± 0.8	4.4 ± 0.3
Parachute, Colorado - PACO									
Garfield Co. Regional Airport 03016 (39.53, -107.73)	17.22 miles	Sample Day	62.1 ± 5.7	48.6 ± 4.8	28.3 ± 2.8	38.7 ± 3.3	54.0 ± 4.9	1015.9 ± 1.8	4.2 ± 0.6
	81° (E)	2010	62.6 ± 2.3	48.9 ± 2.0	28.4 ± 1.2	39.0 ± 1.4	53.9 ± 2.1	1015.3 ± 0.8	4.4 ± 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	Sample Day	62.5 ± 5.9	49.2 ± 4.9	28.8 ± 2.8	39.2 ± 3.3	54.1 ± 5.1	1015.4 ± 1.8	4.2 ± 0.6
	105° (ESE)	2010	62.6 ± 2.3	48.9 ± 2.0	28.4 ± 1.2	39.0 ± 1.4	53.9 ± 2.1	1015.3 ± 0.8	4.4 ± 0.3
Rulison, Colorado - RUCO									
Garfield Co. Regional Airport 03016 (39.53, -107.73)	10.94 miles	Sample Day	66.2 ± 7.3	51.6 ± 6.4	28.9 ± 3.5	40.3 ± 4.3	50.5 ± 6.2	1014.9 ± 2.3	4.4 ± 0.7
	84° (E)	2010	62.6 ± 2.3	48.9 ± 2.0	28.4 ± 1.2	39.0 ± 1.4	53.9 ± 2.1	1015.3 ± 0.8	4.4 ± 0.3

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

Table 7-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for the entire year for 2010. 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 each site were representative of average weather conditions throughout the year, with one exception. The instruments at RUCO were moved in September 2010 to BMCO, where sampling took place from mid-September through the end of year; thus only sample days in the cooler months of autumn and the beginning of winter are included in the 2010 sample day average for BMCO. This explains the difference in several of the meteorological parameters, such as maximum and average temperatures and relative humidity, for BMCO. The sample day averages for RUCO were also affected by the exclusion of the latter portion of the year, but to a lesser extent.

7.2.3   Back Trajectory Analysis

Figure 7-9 is the composite back trajectory map for days on which samples were collected at the GPCO monitoring site in 2010. Included in Figure 7-9 are four back trajectories per sample day. Figure 7-10 is the corresponding cluster analysis for 2010. Similarly, Figures 7-11 through 7-19 are the composite back trajectory maps and corresponding cluster analyses for the Garfield County monitoring sites. A cluster analysis was not performed for BMCO because this site has less 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the sites in Figures 7-9 through 7-21 represents 100 miles.

Figure 7-9. 2010 Composite Back Trajectory Map for GPCO
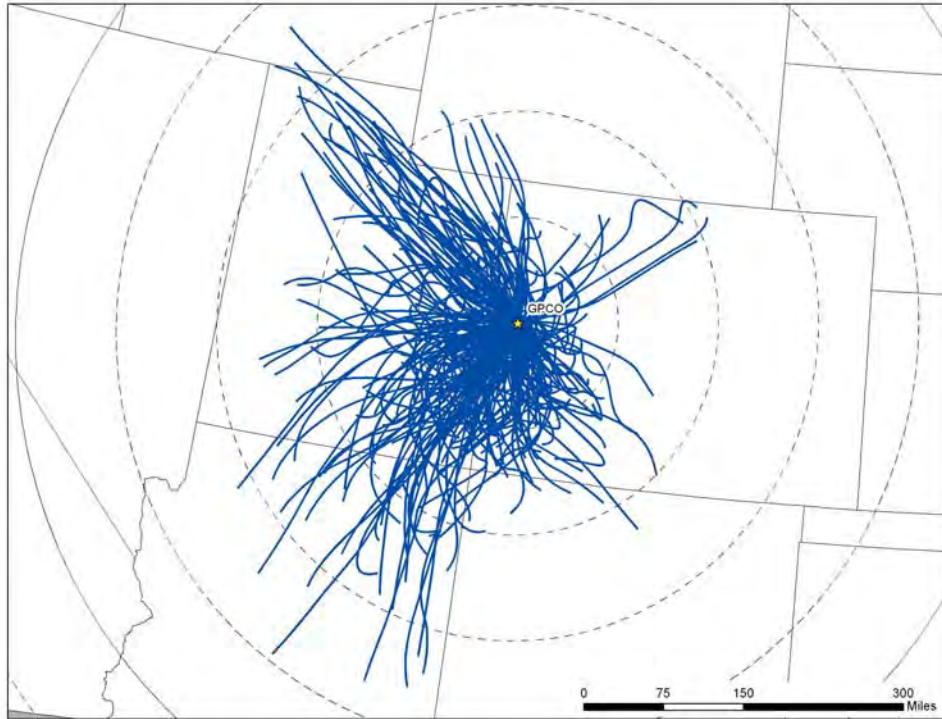
Figure 7-10. Back Trajectory Cluster Map for GPCO
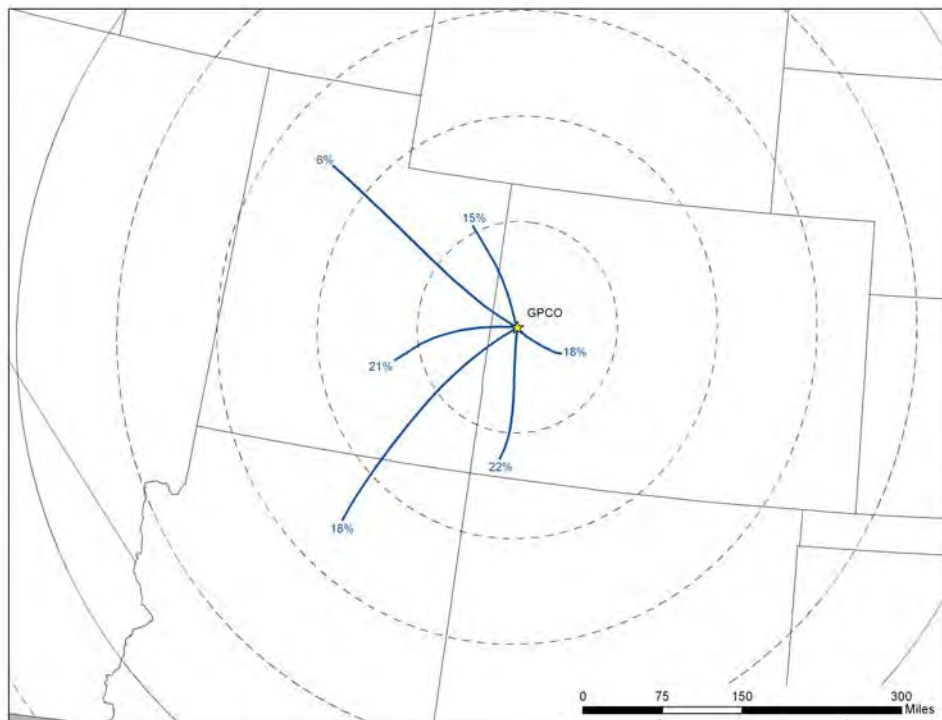
Figure 7-11. 2010 Composite Back Trajectory Map for BMCO
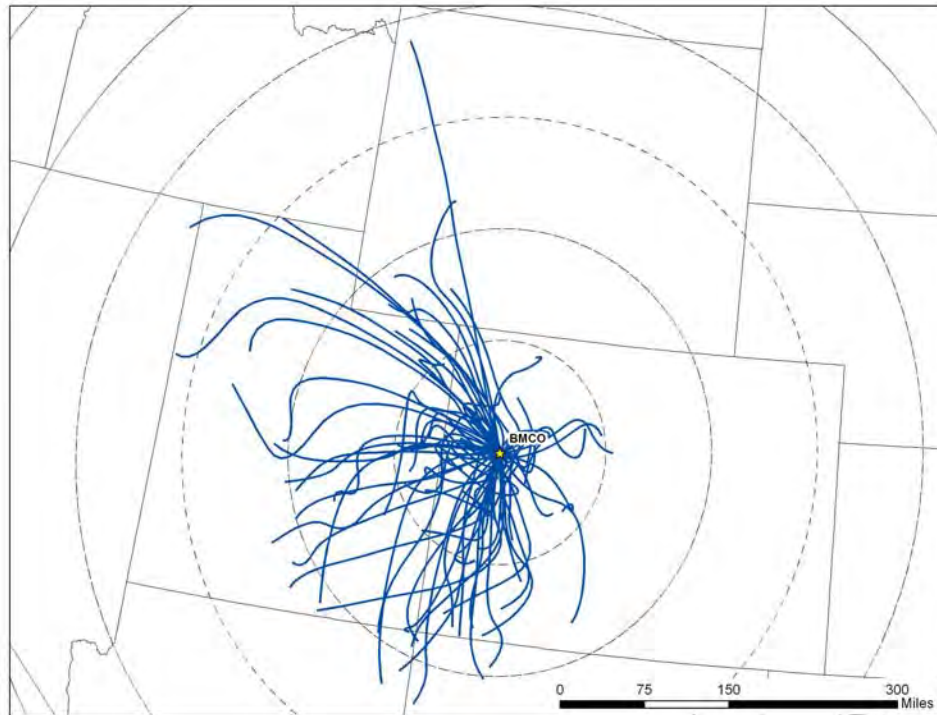
Figure 7-12. 2010 Composite Back Trajectory Map for BRCO
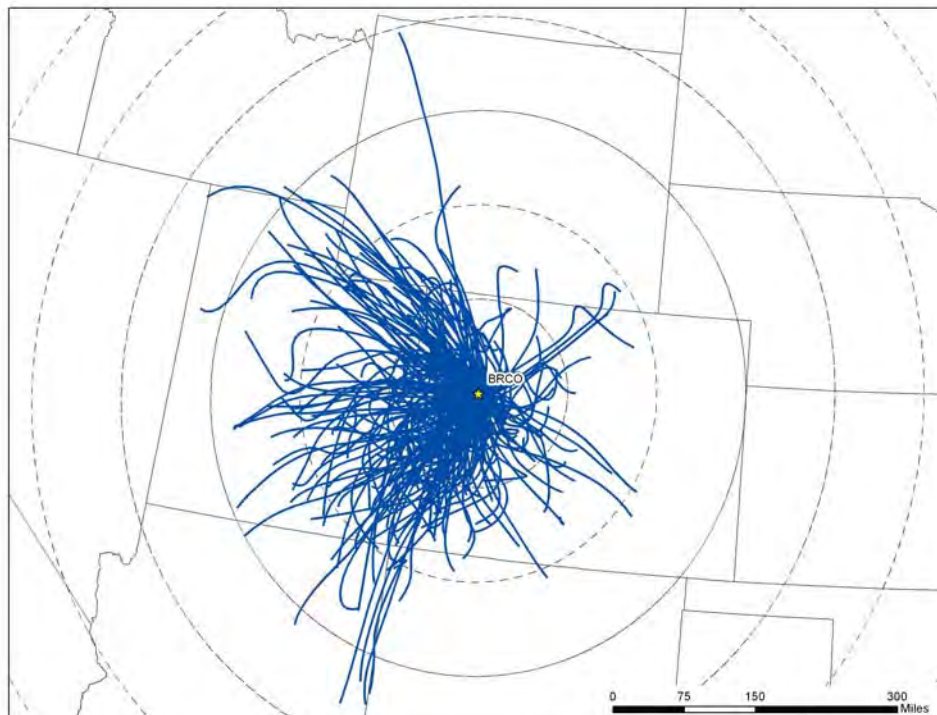
Figure 7-13. Back Trajectory Cluster Map for BRCO
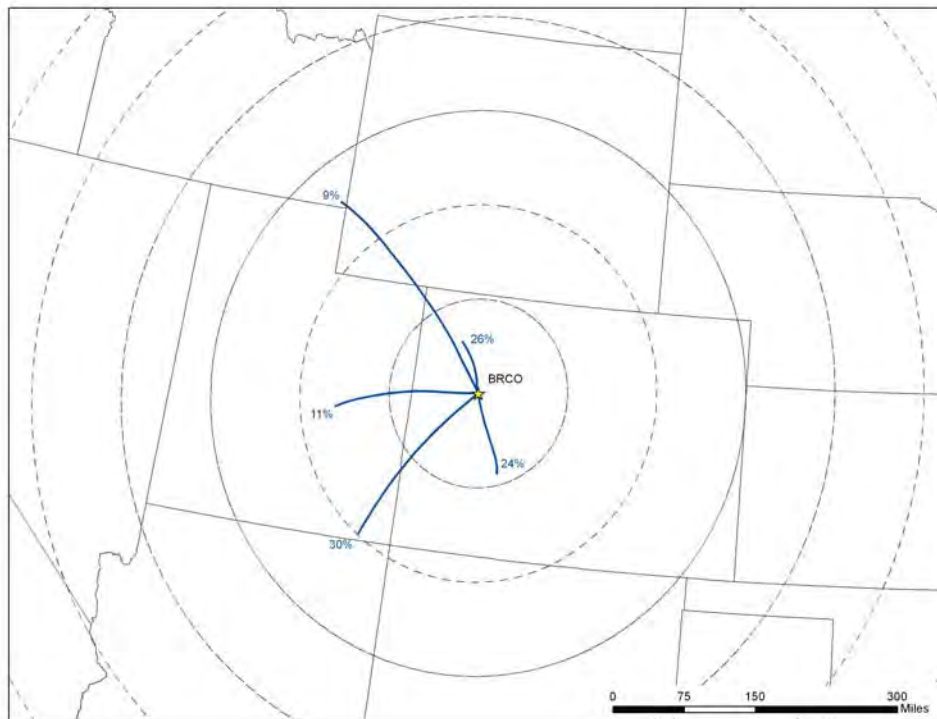
Figure 7-14. 2010 Composite Back Trajectory Map for PACO
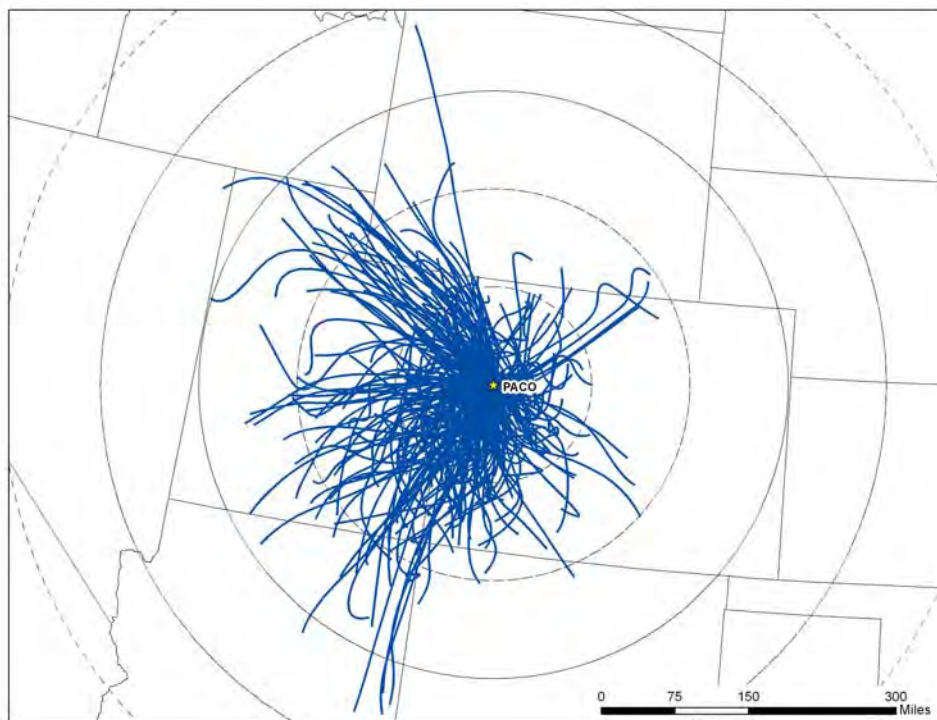
Figure 7-15. Back Trajectory Cluster Map for PACO
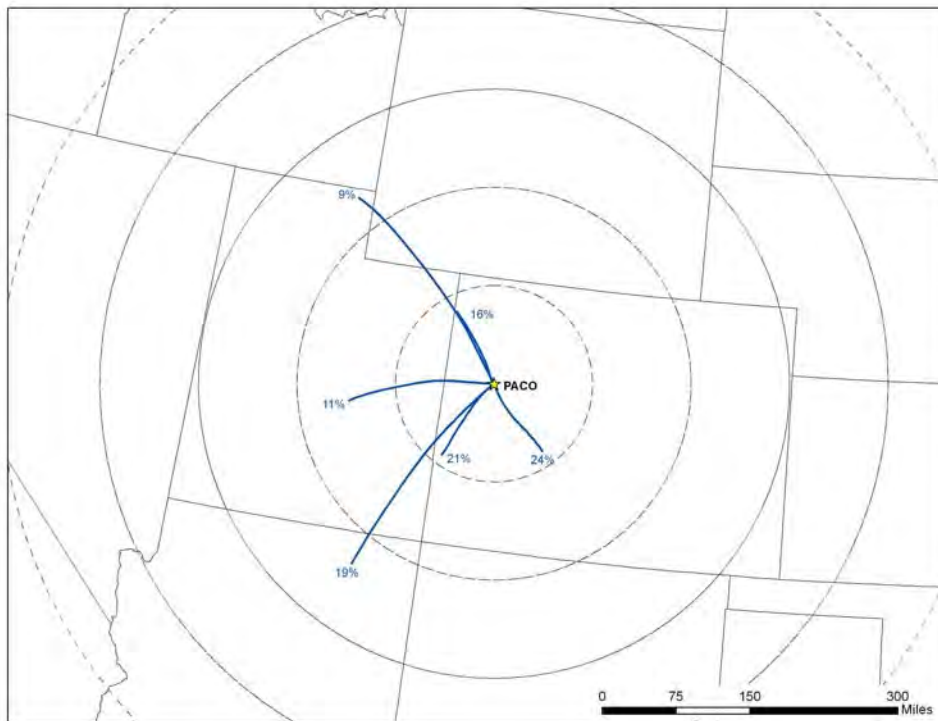
Figure 7-16. 2010 Composite Back Trajectory Map for RICO
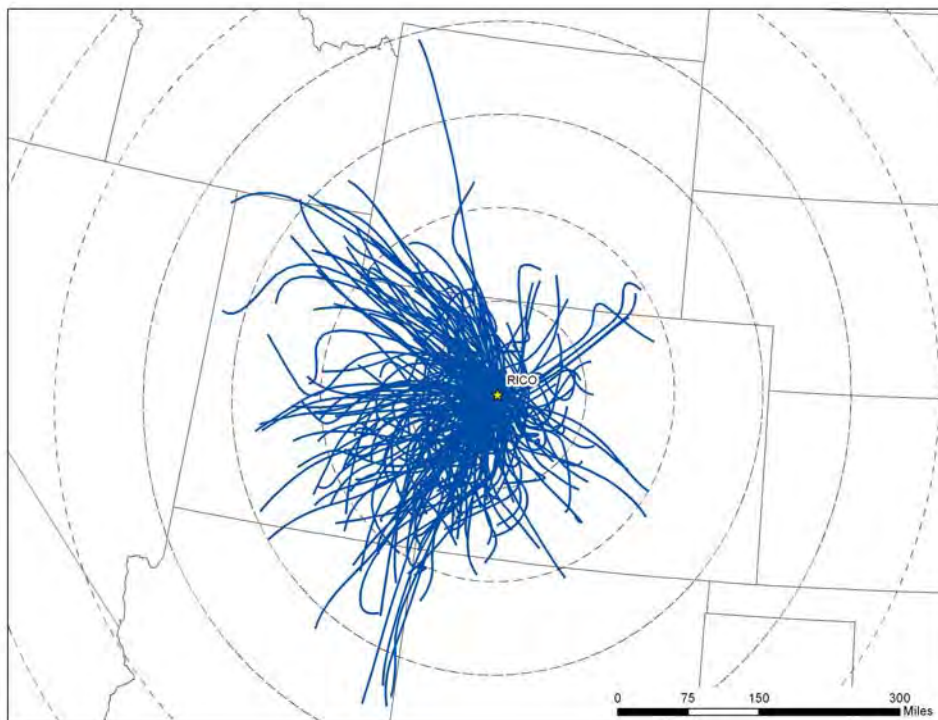
Figure 7-17. Back Trajectory Cluster Map for RICO
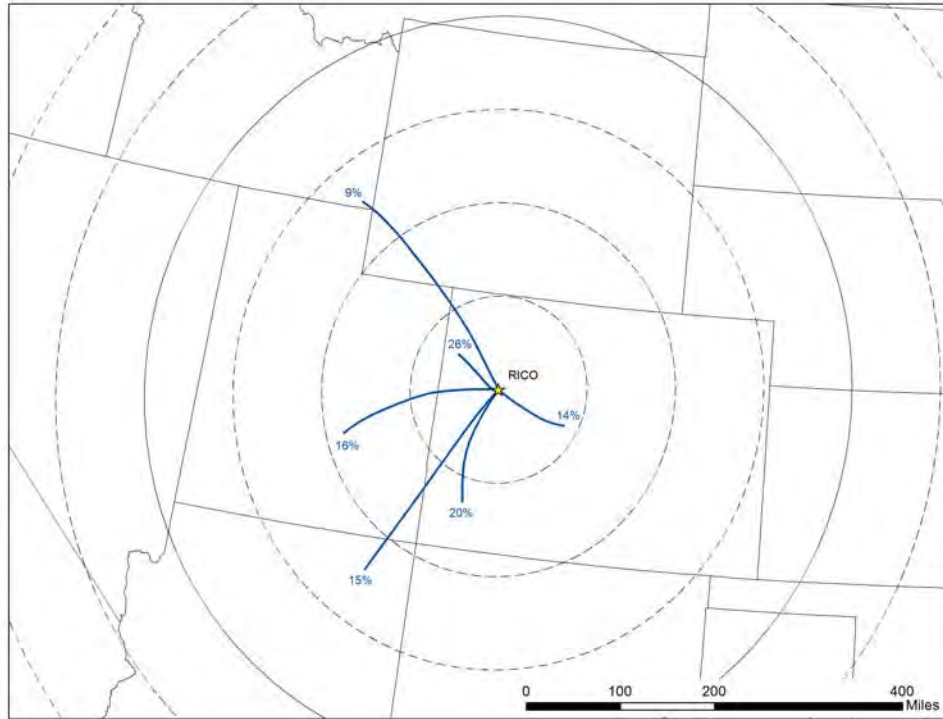
Figure 7-18. 2010 Composite Back Trajectory Map for RUCO
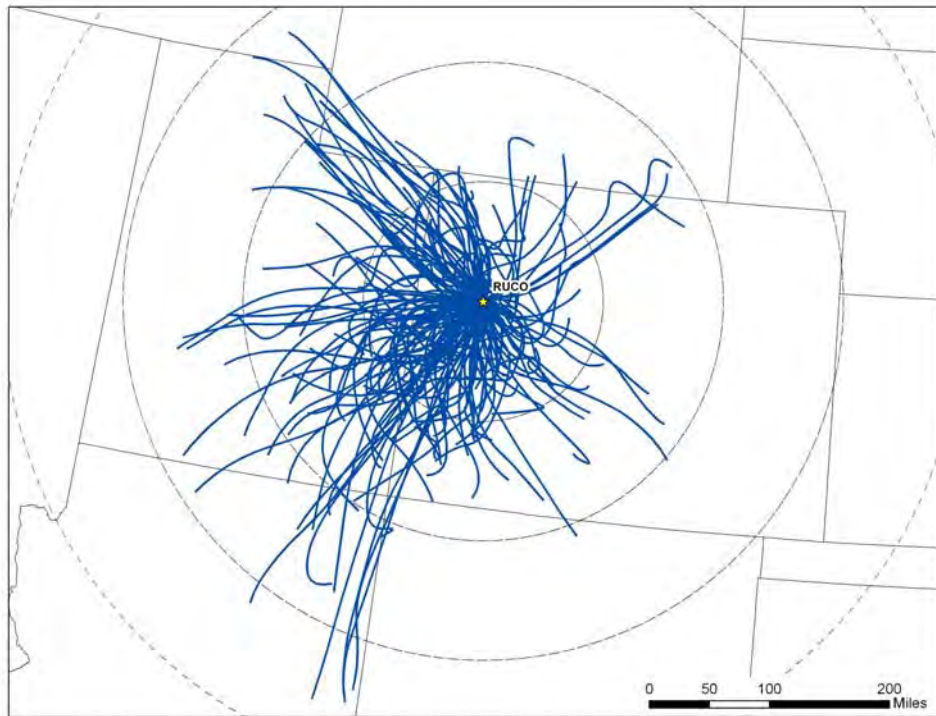
Figure 7-19. Back Trajectory Cluster Map for RUCO
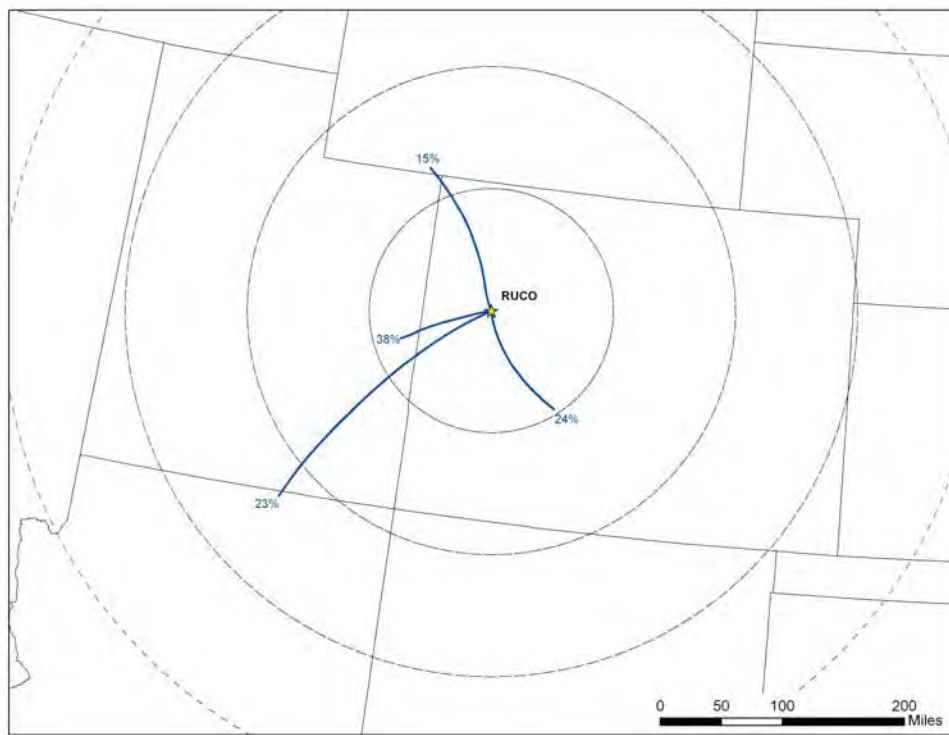
Observations for GPCO from Figures 7-9 and 7-10 include the following:

- The 24-hour air shed domain for GPCO was smaller than most other NMP monitoring sites. The farthest away a trajectory originated was central Arizona, or just less than 400 miles away. However, most trajectories (89 percent) originated within 300 miles of GPCO and the average trajectory length was approximately 150 miles.

- Back trajectories originated from a variety of directions at GPCO, although the majority of them had a westerly component.

- The cluster analysis shows that back trajectories frequently originated from the northwest, west, and southwest. Shorter back trajectories (200 miles or less) originating from the south (labeled 22 percent) were also common. The short cluster originating to the southeast represented several relatively short back trajectories originating from the northeast, east, southeast, and south. Thus, air moving towards GPCO is generally originating in Colorado, Utah, and Arizona.

Observations from Figures 7-11 through 7-19 for the Garfield County sites include the following:

- The composite back trajectory maps for the Garfield County sites resemble the ones for GPCO. This is expected, given the sites' close proximity to GPCO.

- The 24-hour air shed domains were among the smallest in size compared to other NMP sites, with the longest trajectories originating over northwest Wyoming, or just

less than 400 miles away. Note that this trajectory (November 29, 2010) is absent in Figure 7-18 for RUCO because the instrumentation had been moved to BMCO and thus this sample day is not included on this map. The average back trajectory length ranged from 145 to 148 miles for the Garfield County sites.

- Most of the back trajectories for the Garfield County sites had a westerly component, as confirmed by the cluster analysis maps. Those with a northeasterly to southeasterly component were generally represented by the short cluster originating to the southeast and represented up to a quarter of the trajectories.

- The composite back trajectory map for BMCO has fewer trajectories shown in Figure 7-11 because this site did not begin sampling until September 2010. A cluster analysis was not performed for BMCO because this site has less than 30 sample days.

7.2.4   Wind Rose Comparison

Hourly wind data from the NWS weather stations at the Walker Field Airport (for GPCO) and Garfield County Regional Airport (for BMCO, BRCO, PACO, RICO, and RUCO) 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 7-20 presents three different wind roses for the GPCO monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days that samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figures 7-21 through 7-25 present the wind roses and distance maps for the Garfield County monitoring sites.

Figure 7-20. Wind Roses for the Walker Field Airport Weather Station near GPCO

1999-2009 Historical Wind Rose
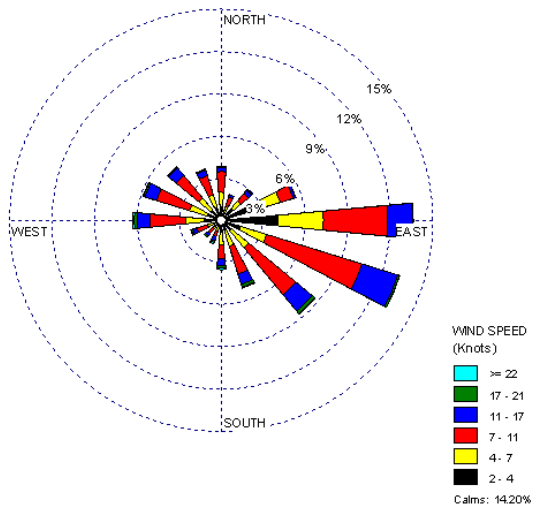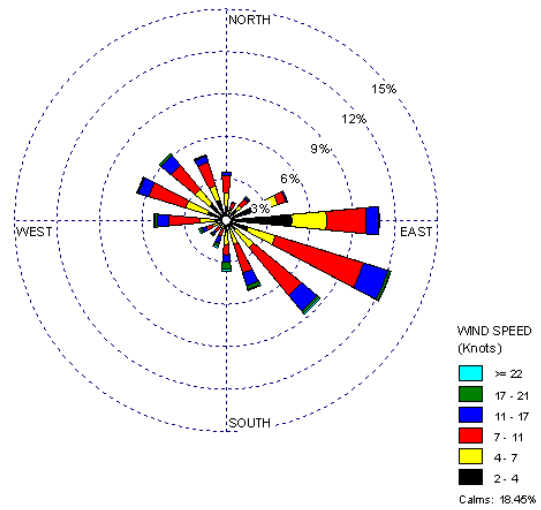
2010 Wind Rose

2010 Sample Day Wind Rose
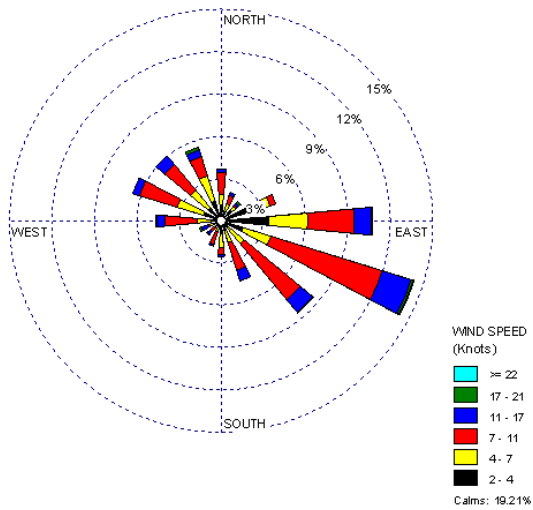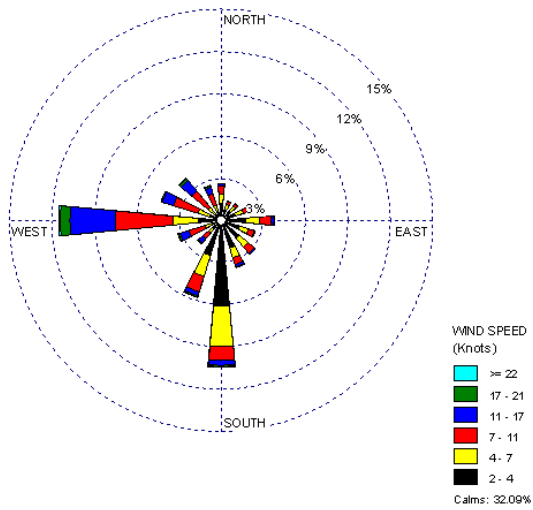
Distance between GPCO and NWS Station
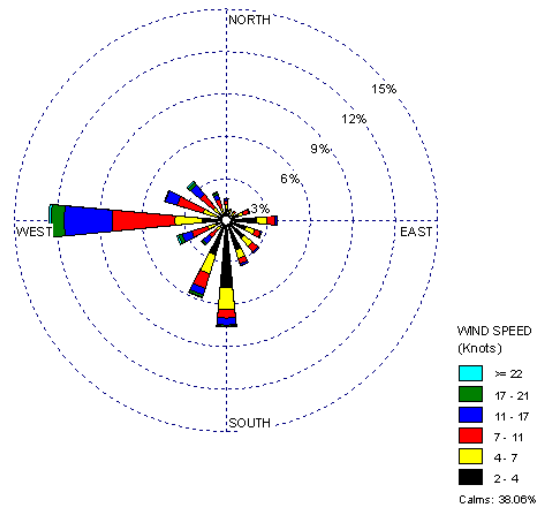
Figure 7-21. Wind Roses for the Garfield County Regional Airport near BMCO

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose
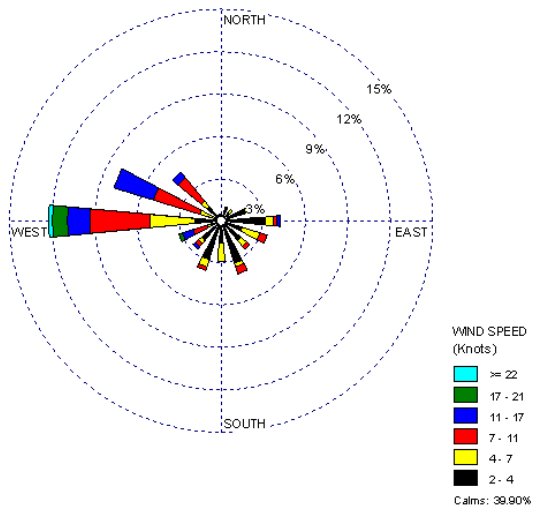
Distance between BMCO and NWS Station

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

1999-2009 Historical Wind Rose
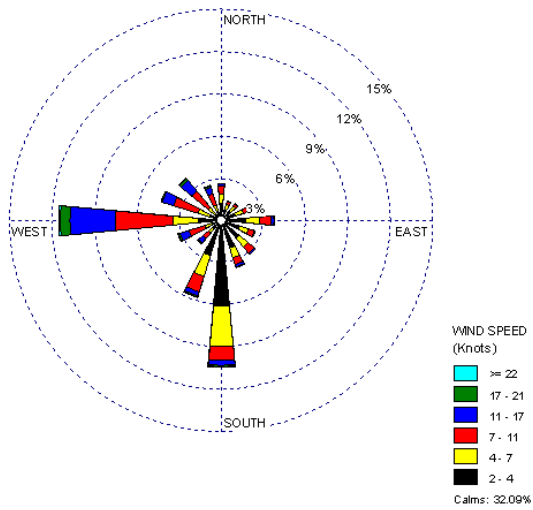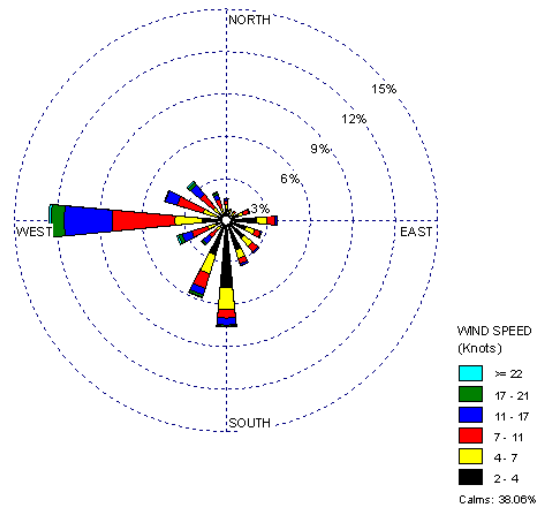
2010 Wind Rose

2010 Sample Day Wind Rose
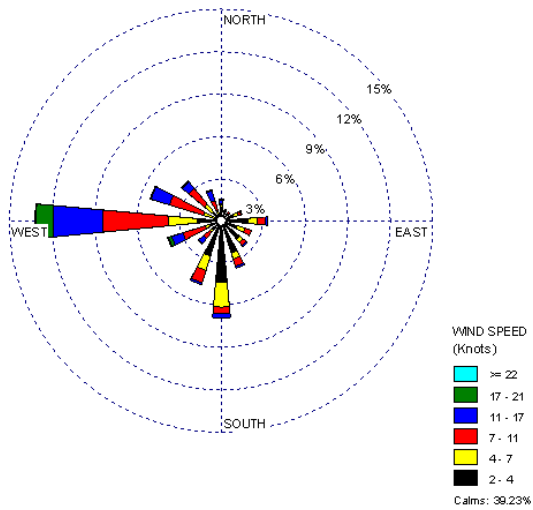
Distance between BRCO and NWS Station
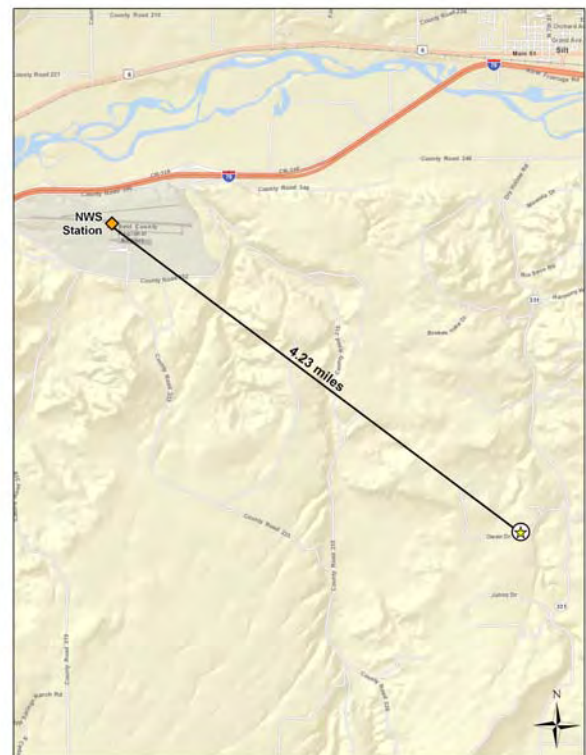
Figure 7-23. Wind Roses for the Garfield County Regional Airport near PACO

1999-2009 Historical Wind Rose
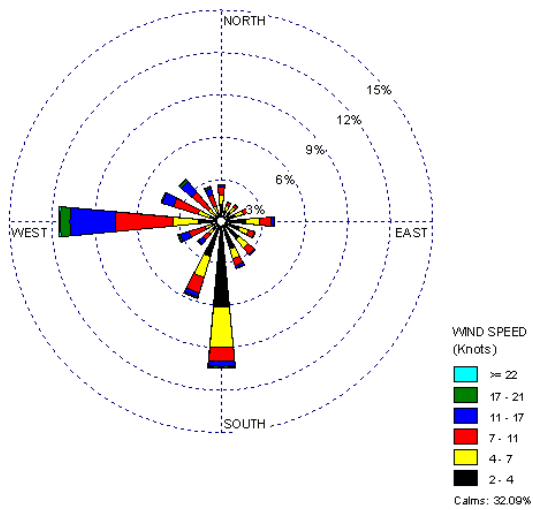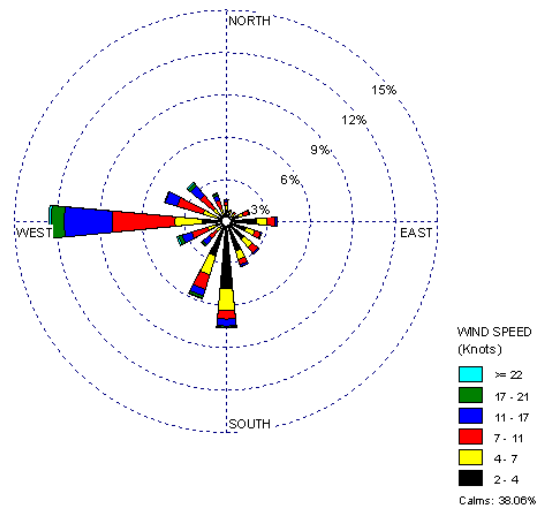
2010 Wind Rose

2010 Sample Day Wind Rose
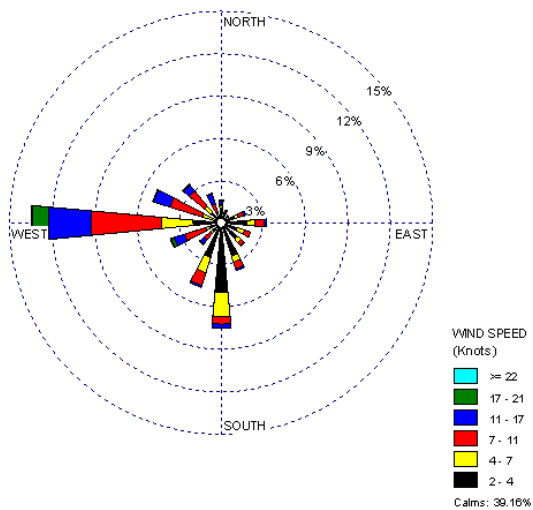
Distance between PACO and NWS Station

Figure 7-24. Wind Roses for the Garfield County Regional Airport near RICO

1999-2009 Historical Wind Rose
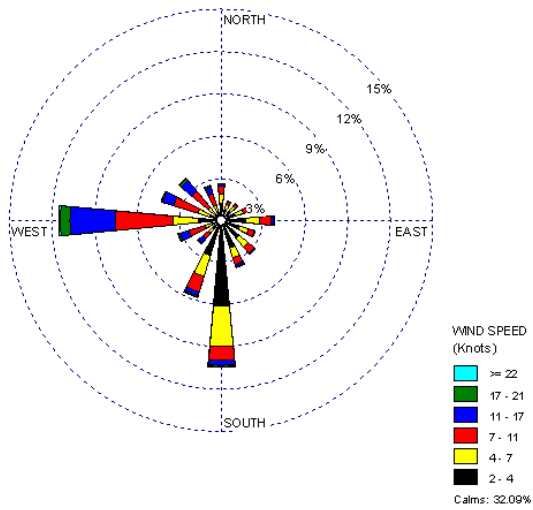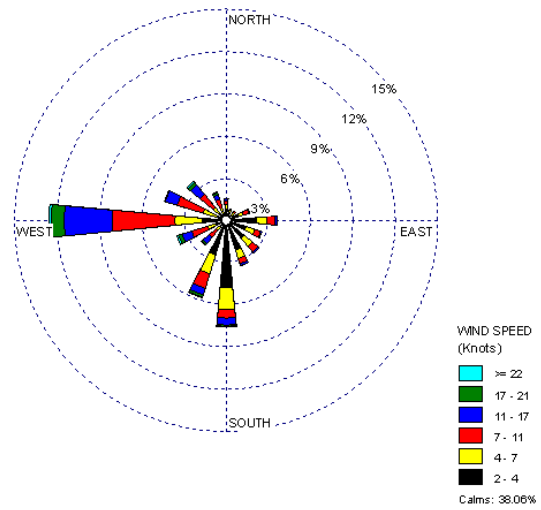
2010 Wind Rose

2010 Sample Day Wind Rose
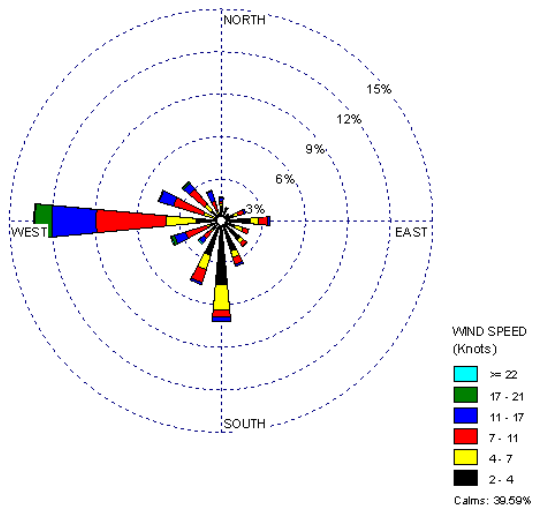
Distance between RICO and NWS Station
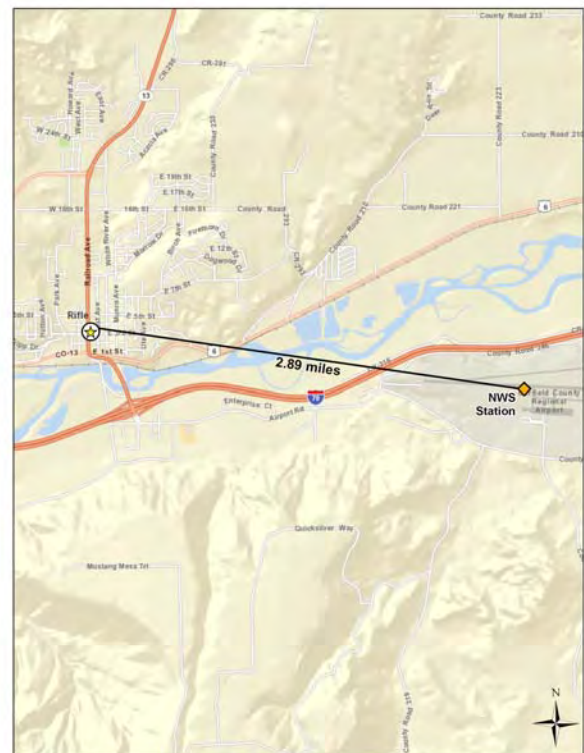
Figure 7-25. Wind Roses for the Garfield County Regional Airport near RUCO

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose
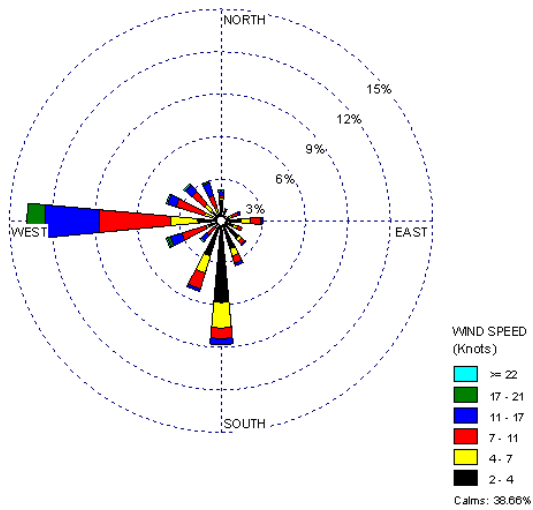
Distance between RUCO and NWS Station
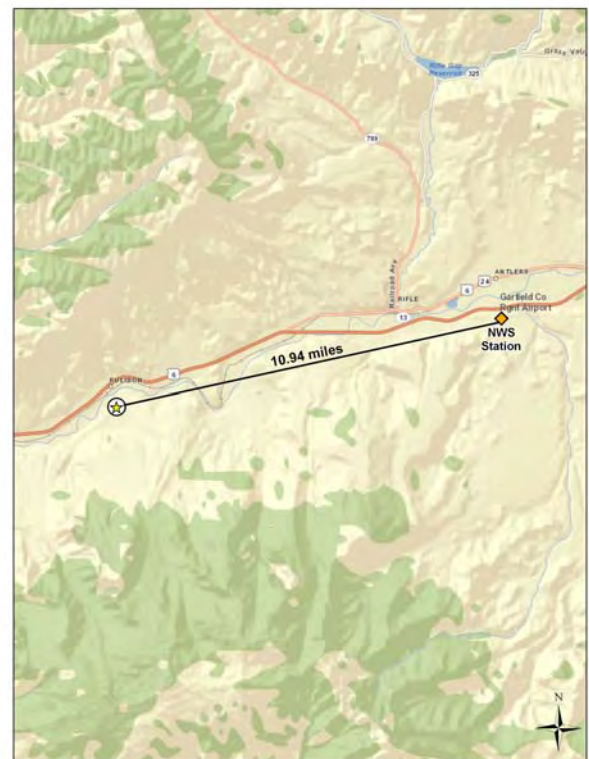
Observations from Figure 7-20 for GPCO include the following:

- The Walker Field Airport weather station is located approximately 5 miles north-northeast of GPCO.

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

- The 2010 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 conditions on sample days were representative of those experienced over the entire year and historically.

Observations from Figures 7-21 through 7-25 for the Garfield County sites include the following:

- The NWS weather station at Garfield County Regional Airport is the closest weather station to all five 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 2010 wind roses for the Garfield County sites are identical to each other. This is because the wind observations came from the same NWS weather station for all five sites.

- The historical wind roses show that calm winds were prevalent (representing just less than one-third of observations) near these five monitoring sites. Westerly and southerly winds were also common.

- The 2010 wind roses exhibit similar wind patterns as the historical wind rose, although there was a slightly higher percentage of calm wind observations and slightly fewer southerly wind observations.

- With the exception of BMCO, the sample day wind patterns for each site also resemble the historical and full-year wind patterns, indicating that conditions on sample days were representative of those experienced over the entire year and historically.

- BMCO's sample day wind rose is the only one that differs from the full-year and historical wind roses. Calm winds were still prevalent but represented 40 percent of the wind observations. Westerly winds were still frequently observed, but the southerly to south-southwesterly wind observations were greatly reduced. Instead, there was a higher number of west-northwesterly to northwesterly winds. Because this wind rose includes only sample days from mid-September through the end of the year, this wind rose is likely exhibiting a seasonal wind pattern variation.

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 7-4 presents the pollutants of interest 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 VOC, carbonyl compounds, PAH, and hexavalent chromium; the Garfield County sites sampled for SNMOC and carbonyl compounds only.

Table 7-4. Risk Screening Results for the Colorado Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Grand Junction, Colorado - GPCO						
Acetaldehyde	0.45	61	61	100.00	14.39	14.39
Formaldehyde	0.077	61	61	100.00	14.39	28.77
Benzene	0.13	59	59	100.00	13.92	42.69
1,3-Butadiene	0.03	57	58	98.28	13.44	56.13
Naphthalene	0.029	56	57	98.25	13.21	69.34
Carbon Tetrachloride	0.17	54	59	91.53	12.74	82.08
Ethylbenzene	0.4	33	59	55.93	7.78	89.86
Acenaphthene	0.011	8	57	14.04	1.89	91.75
Acrylonitrile	0.015	8	8	100.00	1.89	93.63
1,2-Dichloroethane	0.038	7	7	100.00	1.65	95.28
Benzo(a)pyrene	0.00057	5	32	15.63	1.18	96.46
Dichloromethane	7.7	4	59	6.78	0.94	97.41
Acenaphthylene	0.011	2	41	4.88	0.47	97.88
Bromomethane	0.5	2	52	3.85	0.47	98.35
p-Dichlorobenzene	0.091	2	14	14.29	0.47	98.82

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

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Fluorene	0.011	2	57	3.51	0.47	99.29
1,2-Dibromoethane	0.0017	1	1	100.00	0.24	99.53
Hexachloro-1,3-butadiene	0.045	1	2	50.00	0.24	99.76
Propionaldehyde	0.8	1	61	1.64	0.24	100.00
Total		424	805	52.67		
Rifle, Colorado - BMCO						
Benzene	0.13	18	18	100.00	46.15	46.15
1,3-Butadiene	0.03	8	8	100.00	20.51	66.67
Formaldehyde	0.077	7	7	100.00	17.95	84.62
Acetaldehyde	0.45	6	7	85.71	15.38	100.00
Total		39	40	97.50		
Silt, Colorado - BRCO						
Benzene	0.13	60	61	98.36	60.00	60.00
Formaldehyde	0.077	17	17	100.00	17.00	77.00
Acetaldehyde	0.45	12	17	70.59	12.00	89.00
1,3-Butadiene	0.03	6	6	100.00	6.00	95.00
Ethylbenzene	0.4	5	61	8.20	5.00	100.00
Total		100	162	61.73		
Parachute, Colorado - PACO						
Benzene	0.13	58	58	100.00	39.73	39.73
Formaldehyde	0.077	28	28	100.00	19.18	58.90
Acetaldehyde	0.45	25	28	89.29	17.12	76.03
1,3-Butadiene	0.03	22	22	100.00	15.07	91.10
Ethylbenzene	0.4	13	58	22.41	8.90	100.00
Total		146	194	75.26		
Rifle, Colorado - RICO						
Benzene	0.13	60	60	100.00	34.09	34.09
1,3-Butadiene	0.03	38	38	100.00	21.59	55.68
Ethylbenzene	0.4	30	60	50.00	17.05	72.73
Acetaldehyde	0.45	24	24	100.00	13.64	86.36
Formaldehyde	0.077	24	24	100.00	13.64	100.00
Total		176	206	85.44		
Rulison, Colorado - RUCO						
Benzene	0.13	40	40	100.00	45.98	45.98
Formaldehyde	0.077	18	18	100.00	20.69	66.67
Acetaldehyde	0.45	17	18	94.44	19.54	86.21
1,3-Butadiene	0.03	8	8	100.00	9.20	95.40
Ethylbenzene	0.4	4	39	10.26	4.60	100.00
Total		87	123	70.73		

Observations from Table 7-4 include the following:

- Nineteen pollutants failed at least one screen for GPCO, of which seven are NATTS MQO Core Analytes.

- Ten pollutants were initially identified as pollutants of interest for GPCO based on the risk screening process, of which six are NATTS MQO Core Analytes. Benzo(a)pyrene was added to GPCO's pollutants of interest because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of GPCO's total failed screens. Five additional NATTS MQO Core Analytes were also added to GPCO's pollutants of interest even though their concentrations did not fail any screens: chloroform, hexavalent chromium, tetrachloroethylene, trichloroethylene, and vinyl chloride. These five pollutants are not shown in Table 7-4.

- The number of pollutants failing screens for the Garfield County sites ranged from four to five. Four pollutants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) failed screens for each Garfield County site. These four pollutants were identified as pollutants of interest for all five sites. Ethylbenzene also failed screens for four of the five Garfield County sites (BMCO being the exception). Ethylbenzene was identified as a pollutant of interest for PACO and RICO.

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

- Formaldehyde failed 100 percent of screens for all six Colorado sites. Benzene and 1,3-butadiene failed 100 percent of screens at most of the sites.

7.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Colorado monitoring sites. Concentration averages are provided for the pollutants of interest for each Colorado monitoring site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites, where applicable. Additional site-specific statistical summaries are provided in Appendices J through M and Appendix O.

7.4.1   2010 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 PAH and hexavalent chromium for GPCO are presented in ng/m³ 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Grand Junction, Colorado - GPCO						
Acetaldehyde	61/61	1.95 ± 0.42	1.59 ± 0.34	2.26 ± 0.40	2.19 ± 0.40	2.00 ± 0.20
Acrylonitrile	8/59	0.03 ± 0.03	0.03 ± 0.04	0.01 ± 0.03	0	0.02 ± 0.01
Benzene	59/59	1.46 ± 0.26	1.09 ± 0.28	1.27 ± 0.36	1.79 ± 0.38	1.40 ± 0.16
1,3-Butadiene	58/59	0.15 ± 0.04	0.07 ± 0.01	0.10 ± 0.03	0.22 ± 0.06	0.14 ± 0.02
Carbon Tetrachloride	59/59	0.56 ± 0.11	0.39 ± 0.10	0.59 ± 0.08	0.57 ± 0.10	0.53 ± 0.05
Chloroform	54/59	0.06 ± 0.02	0.08 ± 0.01	0.11 ± 0.02	0.09 ± 0.02	0.09 ± 0.01
1,2-Dichloroethane	7/59	0.01 ± 0.02	0.02 ± 0.02	0	0	0.01 ± 0.01
Ethylbenzene	59/59	0.43 ± 0.10	0.35 ± 0.07	0.58 ± 0.18	0.64 ± 0.15	0.50 ± 0.07
Formaldehyde	61/61	2.41 ± 0.38	2.23 ± 0.43	3.39 ± 0.44	3.04 ± 0.40	2.78 ± 0.23
Tetrachloroethylene	59/59	0.35 ± 0.14	0.26 ± 0.11	0.38 ± 0.13	0.60 ± 0.18	0.39 ± 0.07
Trichloroethylene	19/59	0	0.02 ± 0.02	0.04 ± 0.02	0.06 ± 0.04	0.03 ± 0.01
Vinyl Chloride	2/59	0	<0.01 ± <0.01	0	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 black line for GPCO are presented in ng/m³ 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Acenaphthene[a]	57/57	4.41 ± 1.59	7.44 ± 2.08	11.75 ± 4.50	5.37 ± 1.76	7.30 ± 1.53
Benzo(a)pyrene[a]	32/57	0.35 ± 0.18	0.01 ± 0.01	0.01 ± 0.02	0.38 ± 0.23	0.18 ± 0.08
Hexavalent Chromium[a]	35/58	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± <0.01
Naphthalene[a]	57/57	143.02 ± 36.11	97.64 ± 21.69	158.19 ± 52.99	192.03 ± 59.44	147.04 ± 22.61
Battlement Mesa, Colorado - BMCO						
Acetaldehyde	7/7	NA	NA	NA	0.90 ± 0.34	NA
Benzene	18/18	NA	NA	NA	1.43 ± 0.34	NA
1,3-Butadiene	8/18	NA	NA	NA	0.03 ± 0.02	NA
Formaldehyde	7/7	NA	NA	NA	1.39 ± 0.46	NA
Silt, Colorado - BRCO						
Acetaldehyde	17/17	NA	0.96 ± 0.34	0.84 ± 0.42	NA	NA
Benzene	61/61	1.28 ± 0.35	0.88 ± 0.19	1.07 ± 0.45	1.15 ± 0.38	1.10 ± 0.18
1,3-Butadiene	6/61	<0.01 ± 0.01	0	0.01 ± 0.01	0.03 ± 0.04	0.01 ± 0.01
Formaldehyde	17/17	NA	1.10 ± 0.26	1.27 ± 0.51	NA	NA
Parachute, Colorado - PACO						
Acetaldehyde	28/28	NA	0.99 ± 0.25	1.08 ± 0.37	0.89 ± 0.29	0.93 ± 0.16
Benzene	58/58	1.77 ± 0.38	1.71 ± 0.42	1.67 ± 0.35	1.74 ± 0.55	1.72 ± 0.21
1,3-Butadiene	22/58	0.03 ± 0.03	0.01 ± 0.02	0.03 ± 0.02	0.17 ± 0.12	0.06 ± 0.04
Ethylbenzene	58/58	0.32 ± 0.07	0.31 ± 0.05	2.96 ± 3.84	0.26 ± 0.07	0.98 ± 0.98
Formaldehyde	28/28	NA	1.39 ± 0.29	1.86 ± 0.42	1.46 ± 0.30	1.53 ± 0.20
Rifle, Colorado - RICO						
Acetaldehyde	24/24	NA	1.50 ± 0.23	1.72 ± 0.36	1.21 ± 0.33	NA
Benzene	60/60	1.73 ± 0.41	1.16 ± 0.21	1.27 ± 0.20	1.71 ± 0.47	1.46 ± 0.17
1,3-Butadiene	38/60	0.17 ± 0.08	0.03 ± 0.03	0.07 ± 0.03	0.35 ± 0.17	0.16 ± 0.06

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
[a] Average concentrations provided for the pollutants below the black line for GPCO are presented in ng/m³ 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 ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Ethylbenzene	60/60	0.44 ± 0.10	0.39 ± 0.08	2.42 ± 3.29	0.44 ± 0.16	0.95 ± 0.86
Formaldehyde	24/24	NA	1.69 ± 0.23	2.07 ± 0.39	1.65 ± 0.37	NA
Rulison, Colorado - RUCO						
Acetaldehyde	18/18	NA	1.18 ± 0.24	1.27 ± 0.61	NA	NA
Benzene	40/40	1.86 ± 0.33	1.47 ± 0.30	1.55 ± 0.32	NA	1.62 ± 0.18
1,3-Butadiene	8/40	0.04 ± 0.03	0.01 ± 0.01	0.01 ± 0.01	NA	0.02 ± 0.01
Formaldehyde	18/18	NA	1.35 ± 0.19	1.57 ± 0.54	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 black 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 ($2.78 \pm 0.23 \, \mu g/m^3$), acetaldehyde ($2.00 \pm 0.20 \, \mu g/m^3$), and benzene ($1.40 \pm 0.16 \, \mu g/m^3$). These are also the only pollutants with annual average concentrations greater than 1 $\mu g/m^3$.

- The confidence intervals associated with the quarterly average concentrations of acrylonitrile are equal to or greater than the quarterly averages themselves (except for the fourth quarter, where it was not detected). This pollutant was detected only eight times in 2010 and its measurements ranged from 0.087 to 0.300 $\mu g/m^3$. Thus, a large number of zeros were substituted within the calculations, leading to a higher level of variability within the average concentrations, which is reflected in the confidence intervals.

- Formaldehyde concentrations were highest during third quarter of the year.

- Tetrachloroethylene's fourth quarter average concentration is the highest of the four quarterly averages. A review of the data shows that three concentrations greater than 1 $\mu g/m^3$ were measured at GPCO, two in December and one in January. Only 13 concentrations of tetrachloroethylene above 1 $\mu g/m^3$ were measured among all NMP sites sampling this pollutant. Further, the highest tetrachloroethylene concentration among all sites was measured at GPCO (1.35 $\mu g/m^3$).

- Concentrations of naphthalene appear highest during the fourth quarter of the year. A review of the data shows that of the 10 measurements of naphthalene greater than

200 ng/m^3, six were measured during the fourth quarter (three were measured in the third quarter and one in the first quarter.

- Average benzo(a)pyrene concentrations for the first and fourth quarters of 2010 are significantly higher than the average concentrations for the other two quarters and have large confidence intervals associated with them. A review of the data shows that the 23 concentration of this pollutant greater than 0.01 ng/m^3 were all measured during the first and fourth quarters of 2010. The remaining nine measured detections were spread across the quarters. The three measurements of benzo(a)pyrene greater than 1 ng/m^3 were among the 10 highest concentrations measured by all NMP sites sampling this pollutant.

- The third quarter average concentration of acenaphthene is higher than the other quarterly averages and has a relatively large confidence interval associated with it. The two highest concentrations of this pollutant were measured on September 17, 2010 (38.7 ng/m^3) and September 29, 2010 (22.4 ng/m^3). The September 17, 2010 measurement is the fifth highest concentration of this pollutant among all NMP sites sampling acenaphthene.

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

- Annual average concentrations for BMCO could not be calculated due to the abbreviated sampling duration; however, fourth quarter averages are presented. Annual average concentrations for the carbonyl compound pollutants of interest could not be calculated for BRCO and RICO because these sites did not meet the quarterly completeness criteria. In addition, annual average concentrations for the carbonyl compound pollutants of interest could not be calculated for RUCO due to a combination of an abbreviated sampling period and not meeting the quarterly completeness criteria. However, Appendices K and L provide the pollutant-specific average concentration for all valid samples collected over the entire sample period for each site.

- Of the SNMOC, benzene has the highest annual average concentrations by mass for each of the Garfield County sites. Annual average concentrations of benzene ranged from 1.10 ± 0.18 µg/m^3 for BRCO to 1.72 ± 0.21 µg/m^3 for PACO. While PACO's benzene concentrations were steady across 2010, the quarterly benzene concentrations for the other sites show more variability.

- The fourth quarter average concentrations of 1,3-butadiene for PACO and RICO are much higher than the other quarterly averages of this pollutant and have relatively large confidence intervals associated with them, indicating the likely influence of outliers. The highest 1,3-butadiene concentrations measured among five of the six Colorado monitoring sites were all measured in December (the exception being RUCO, but this site was not sampling in December). Each site's maximum 1,3-butadiene concentration was measured in the same two week stretch between December 11, 2010 and December 23, 2010. Among other NMP sites sampling this pollutant, three of RICO's 1,3-butadiene concentrations and one of PACO's rank among the 10 highest 1,3-butadiene concentrations program-wide.

- The third quarter average concentration of ethylbenzene for PACO and RICO are significantly higher than the other quarterly averages of this pollutant and have large confidence intervals associated with them, indicating the likely influence of outliers. Both sites measured this pollutant above 25 µg/m^3 within one sample day of each other (26.7 µg/m^3 on August 12, 2010 for PACO and 25.7 µg/m^3 on August 18, 2010 for RICO). These two concentrations represent the second and third highest measurements of ethylbenzene among all sites sampling this pollutant, behind only UCSD. BRCO and RUCO, for which ethylbenzene was not a pollutant of interest, measured their maximum ethylbenzene concentrations on August 18, 2010 and August 6, 2010, respectively. Program-wide, the 10 highest concentrations of this pollutant were measured during the third quarter 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 the Colorado sites from those tables include the following:

- As shown in Tables 4-9 through 4-12, the annual average concentrations for GPCO for 12 pollutants are among the 10 highest average concentrations for all NMP sites.

- GPCO appears frequently in Table 4-11 for the PAHs. GPCO has the highest annual concentration of naphthalene, the second highest concentration of benzo(a)pyrene, the third highest annual average of acenaphthene, and the fourth highest annual average of fluorene.

- As shown in Table 4-9, the five of the six Colorado sites account for five of the 10 highest daily average concentrations of benzene. PACO and RICO rank first and second among the highest annual average concentrations of ethylbenzene while RICO and GPCO rank third and fifth among the highest annual average concentrations of 1,3-butaidene. GPCO also has the second highest annual concentration of tetrachloroethylene, behind only PXSS.

7.4.2 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 benzene and 1,3-butadiene were created for each of the Colorado sites. Box plots for acetaldehyde and formaldehyde were created for the Colorado sites where annual averages could be calculated (GPCO and PACO). Box plots were also created for benzo(a)pyrene, hexavalent chromium, and naphthalene for GPCO. Figures 7-26 through 7-32 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 7-26. Program vs. Site-Specific Average Acetaldehyde Concentration
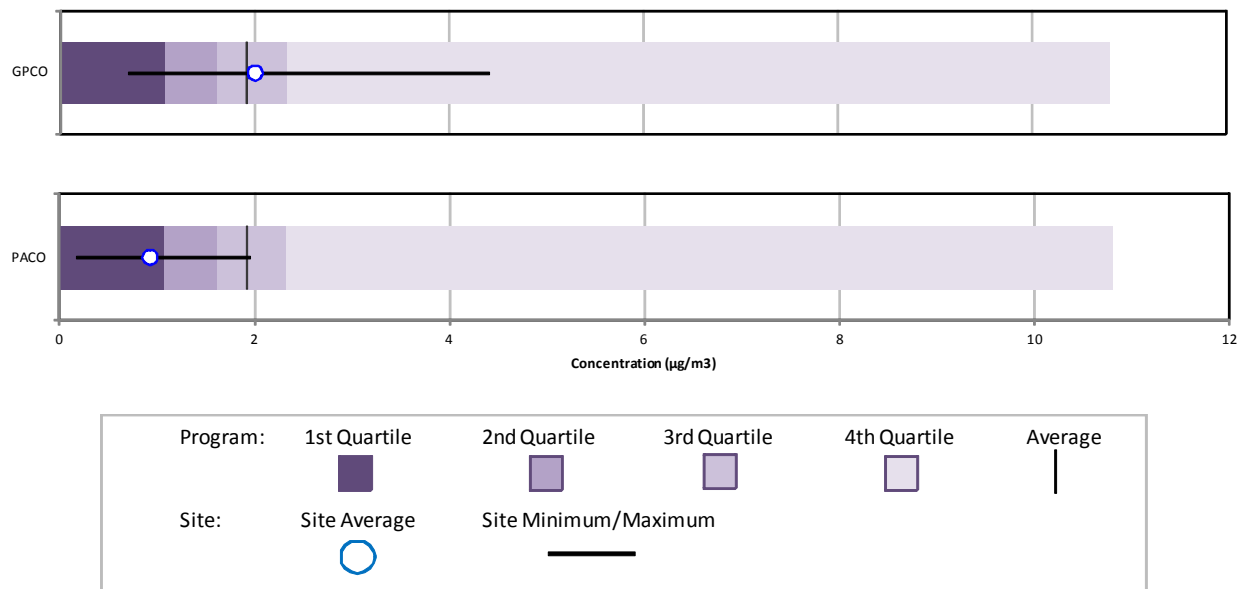
Figure 7-27a. Program vs. Site-Specific Average Benzene (Method TO-15) Concentration
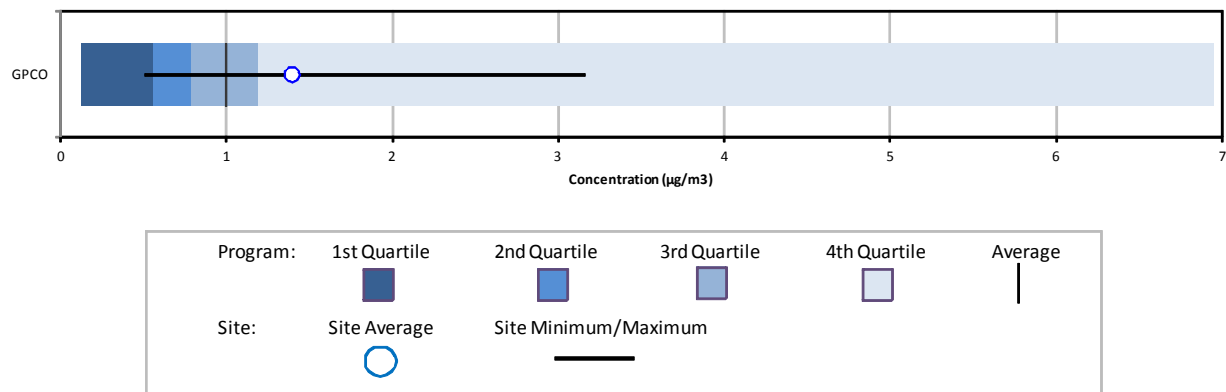
Figure 7-27b. Program vs. Site-Specific Average Benzene (SNMOC) Concentration
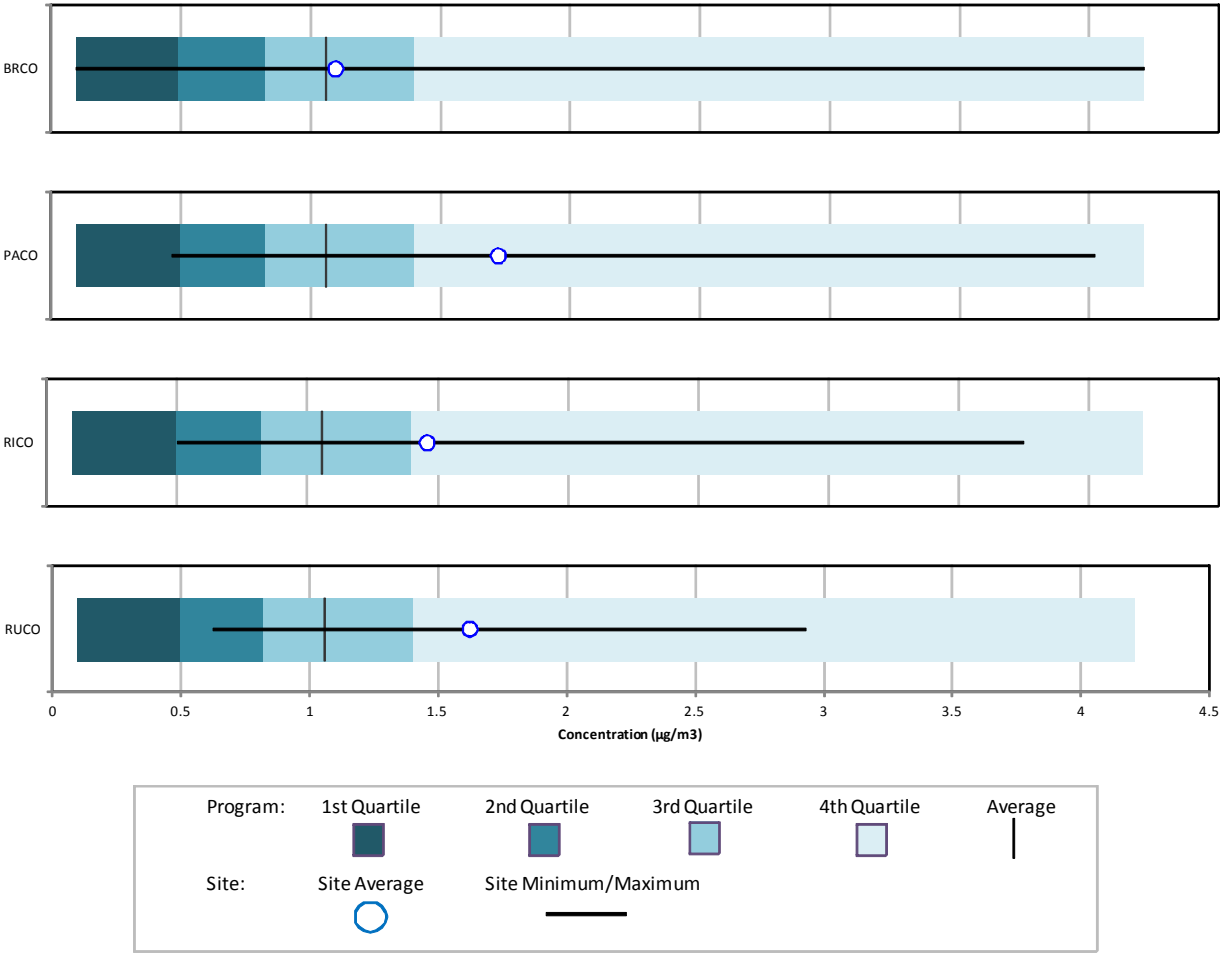
Figure 7-28. Program vs. Site-Specific Average Benzo(a)pyrene Concentration
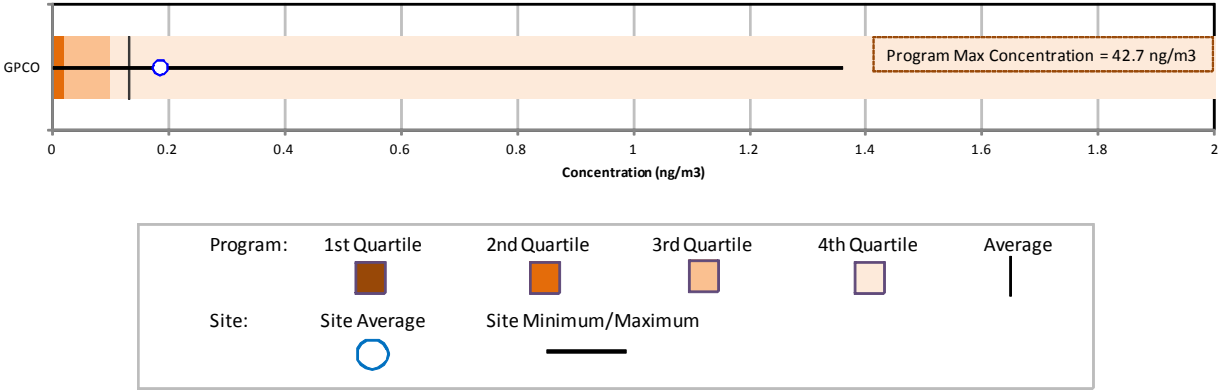
Figure 7-29a. Program vs. Site-Specific Average 1,3-Butadiene (Method TO-15) Concentration
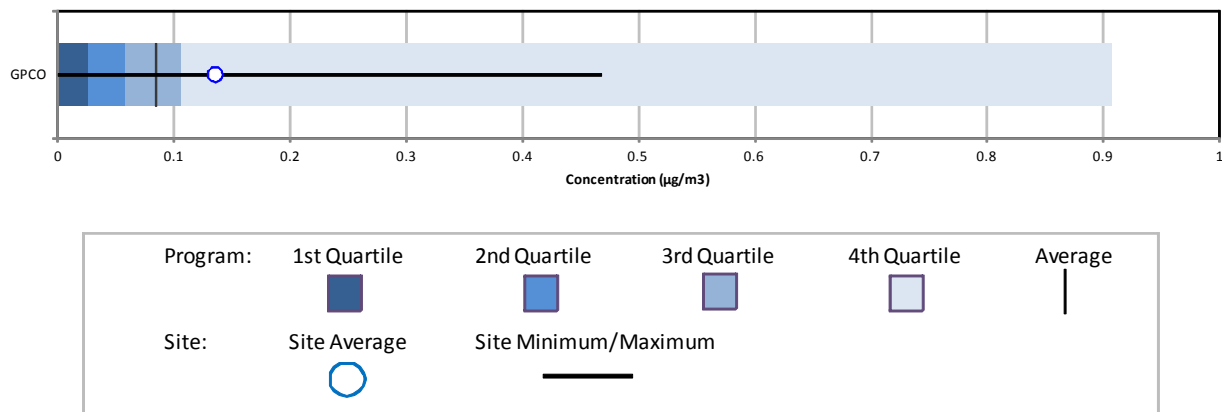
Figure 7-29b. Program vs. Site-Specific Average 1,3-Butadiene (SNMOC) Concentration
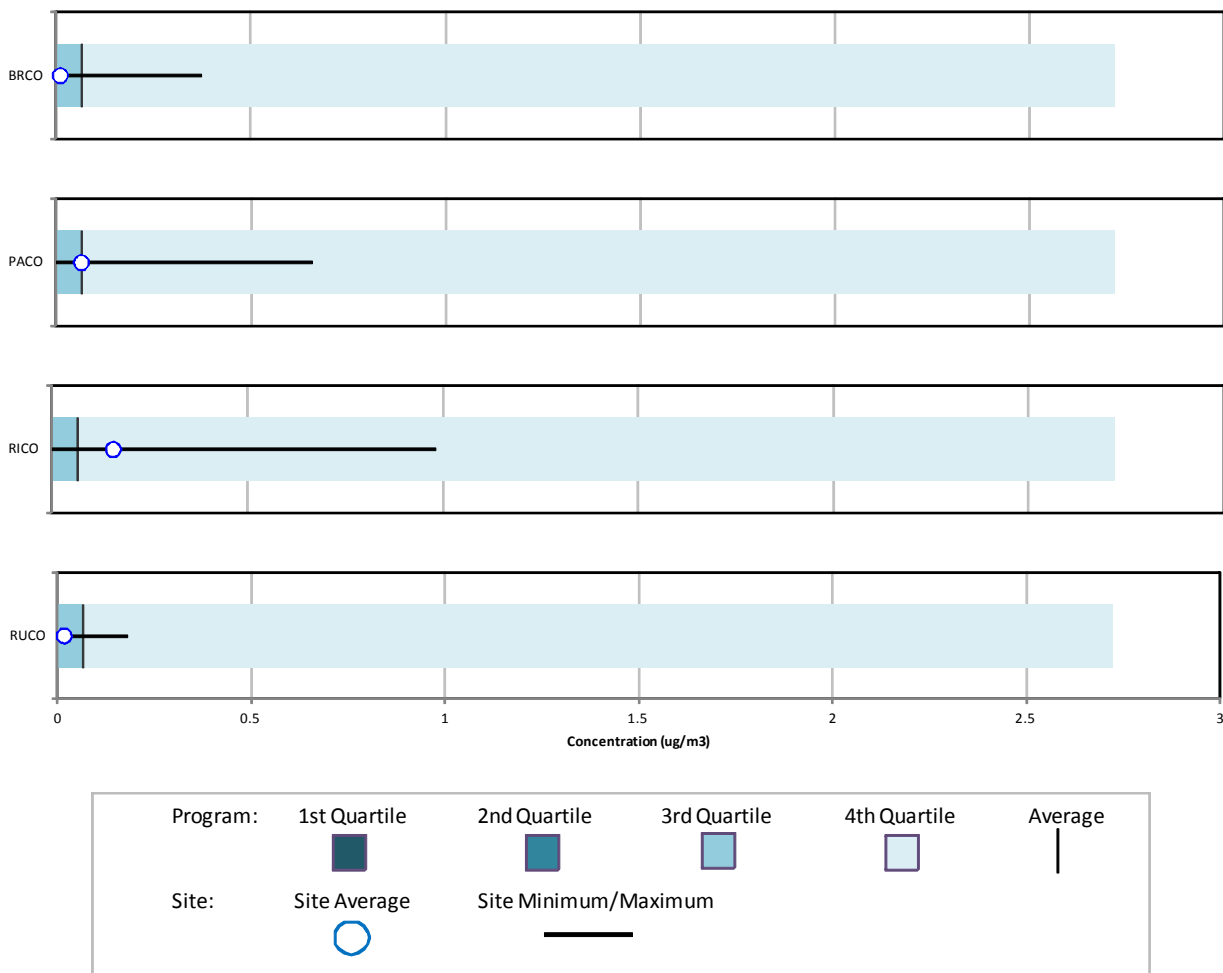
Figure 7-30. Program vs. Site-Specific Average Formaldehyde Concentration
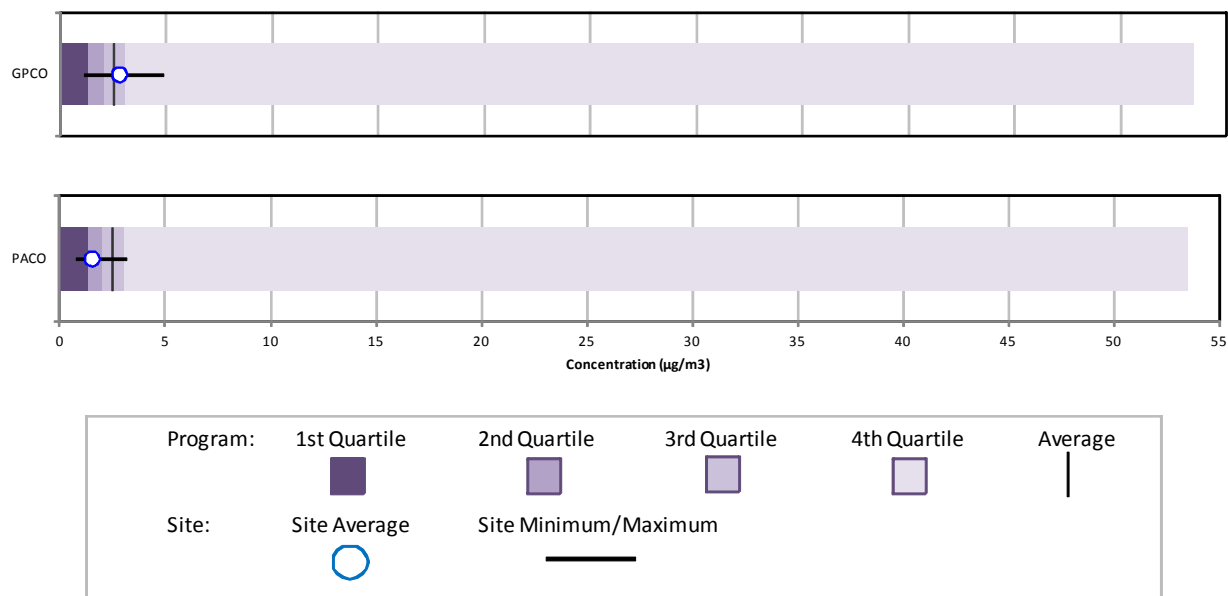
Figure 7-31. Program vs. Site-Specific Average Hexavalent Chromium Concentration
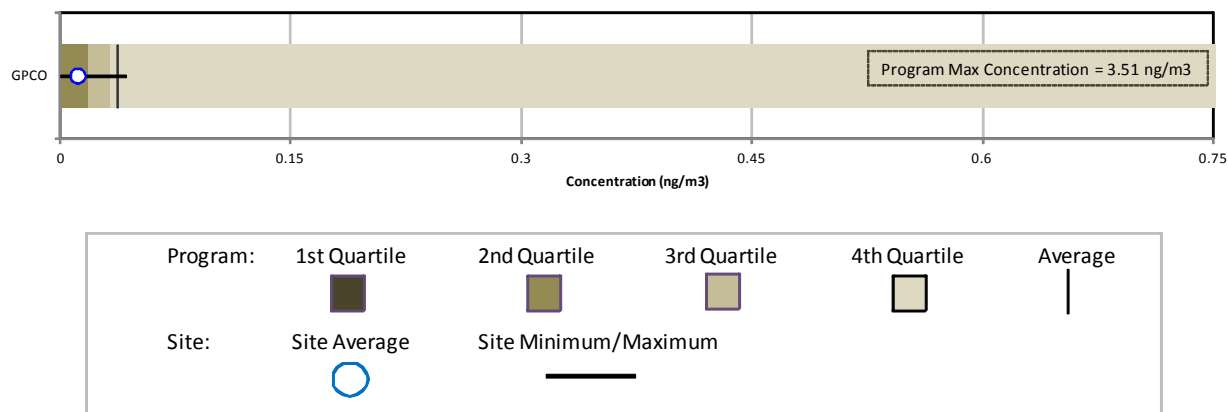
Figure 7-32. Program vs. Site-Specific Average Naphthalene Concentration
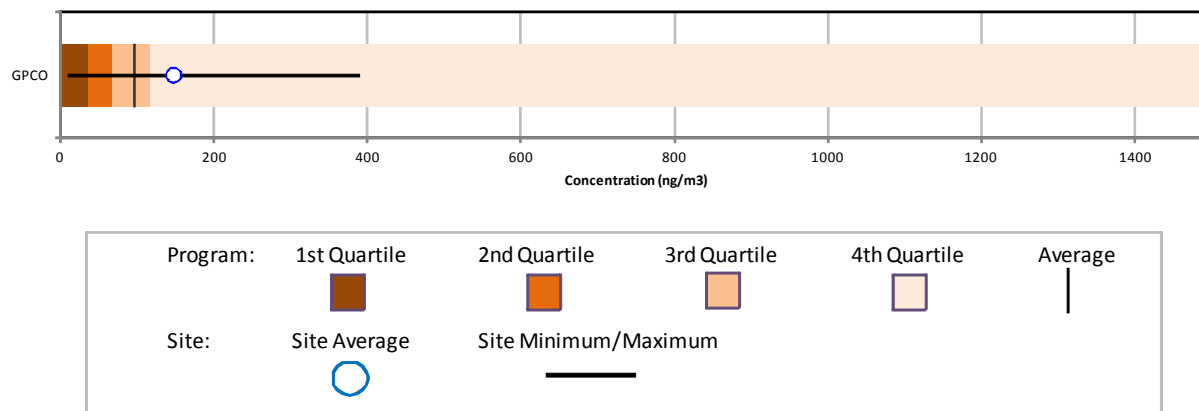
Observations from Figures 7-26 through 7-32 include the following:

- Figure 7-26 shows that GPCO's annual average acetaldehyde concentration is just greater than the program-level average while PACO's annual average concentration is well below the program-level average. The maximum acetaldehyde concentration for GPCO is more than twice the maximum concentration measured at PACO, although both were well below the maximum concentration measured across the program.

- Figure 7-27a presents the benzene concentration for GPCO compared to the benzene concentrations measured across the program for NMP sites sampling VOC with Method TO-15; Figure 7-27b presents the annual average benzene concentrations for the Garfield County sites compared to the benzene concentrations measured across the program for NMP sites sampling SNMOC. The box plots are presented this way to correspond with Tables 4-1 through 4-6 in Section 4.1, as discussed in Section 3.5.3.

- Figure 7-27a shows that the annual average benzene concentration for GPCO is greater than the program-level average, and is greater than the 75th percentile (or third quartile) for the program. For the Garfield County sites sampling SNMOC, the annual average for benzene is greater than the program-level average for all four sites for which annual average benzene concentrations could be calculated, as shown in Figure 7-27b. Note that the maximum benzene concentration measured by sites sampling SNMOC was measured at BRCO. A similar concentration was also measured at PACO. Among the Garfield County sites, the highest annual average concentration of benzene was calculated for PACO, followed by RUCO, RICO, and BRCO. An annual average concentration could not be calculated for BMCO.

- Figure 7-28 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 GPCO is greater than the program-level average concentration and is greater than the 75th percentile (or third quartile) for the program. Figure 7-28 also shows that the maximum concentration measured at GPCO is well below the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at GPCO.

- Similar to the box plots for benzene, Figure 7-29a 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 VOC with Method TO-15; Figure 7-29b 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 SNMOC.

- Figure 7-29a shows that GPCO's annual 1,3-butadiene concentration is greater than the program average and similar to other pollutants, this annual average is greater than the 75th percentile (or third quartile) for the program. For the Garfield County sites sampling SNMOC, RICO's annual average 1,3-butadiene concentration is greater than the program-level average, as shown in Figure 7-29b, while PACO's annual average is equal to the program-level average, and RUCO and BRCO's are below the program-level average. Note that the first and second quartiles for the program-level are both zero, and thus not shown in Figure 7-29b, indicating that at least half of the 1,3-butadiene concentrations measured by sites sampling SNMOC were non-detects. An annual average concentration could not be calculated for BMCO.

- Figure 7-30 shows that GPCO's annual average formaldehyde concentration is just greater than the program-level average while PACO's annual average concentration is less than the program-level average, similar to acetaldehyde concentrations for these sites. While it appears that the range of concentrations measured at these sites is relatively small, the range of measurements at the program-level is quite large.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 7-31 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 7-31 shows the annual average concentration of hexavalent chromium for GPCO is less than half the program-level average. GPCO's annual average concentration is also less than the program-level median (or 50th percentile).

- Figure 7-32 shows that the annual naphthalene average for GPCO is greater than the program-level average concentration. As discussed in the previous section, the annual average naphthalene concentration for GPCO is the highest among all NMP sites sampling this pollutant. However, the maximum naphthalene concentration measured at GPCO was well below the program-level maximum concentration.

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. While the Garfield County sites have not sampled continuously for 5 years as part of the NMP, GPCO has sampled carbonyl compounds and VOC since 2004 and hexavalent chromium since 2005. Thus, Figures 7-33 through 7-37 present the 3-year rolling 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.

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

- The maximum acetaldehyde concentration was measured during the 2004-2006 time frame, specifically 2004. The maximum concentrations measured in subsequent time periods were significantly lower. The two highest acetaldehyde concentrations (93 and 55 µg/m^3) were measured in 2004 and the six highest acetaldehyde concentrations (ranging from 93 µg/m^3 to 6.35 µg/m^3) were all measured in 2004 and 2005.

- The 5th and 95th percentiles, the median, and the average concentrations exhibit relatively little variation over time if the 2004-2006 time frame is excluded.

- The average concentrations show little variability after the 2004-2006 time frame and ranged from 2.47 µg/m^3 (2008-2010) to 2.73 µg/m^3 (2007-2009).

- Although difficult to discern in Figure 7-33, the rolling average and median values became more similar to each other over the periods shown. This indicates decreasing variability in the central tendency of acetaldehyde concentrations measured over the periods shown.

Figure 7-33. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at GPCO
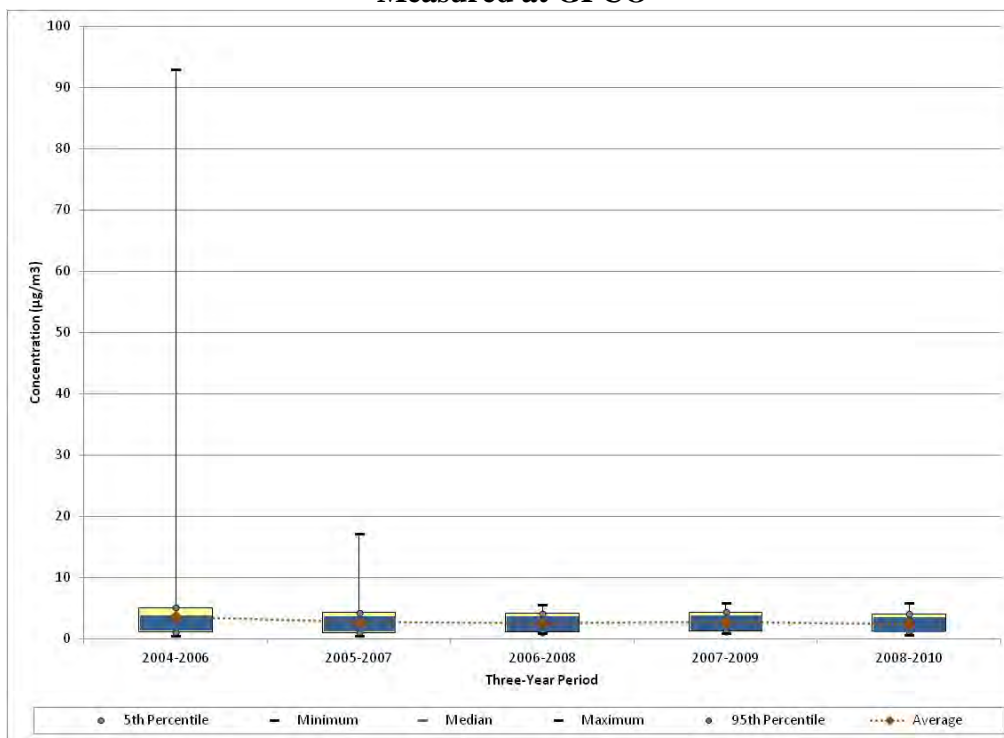
Figure 7-34. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at GPCO
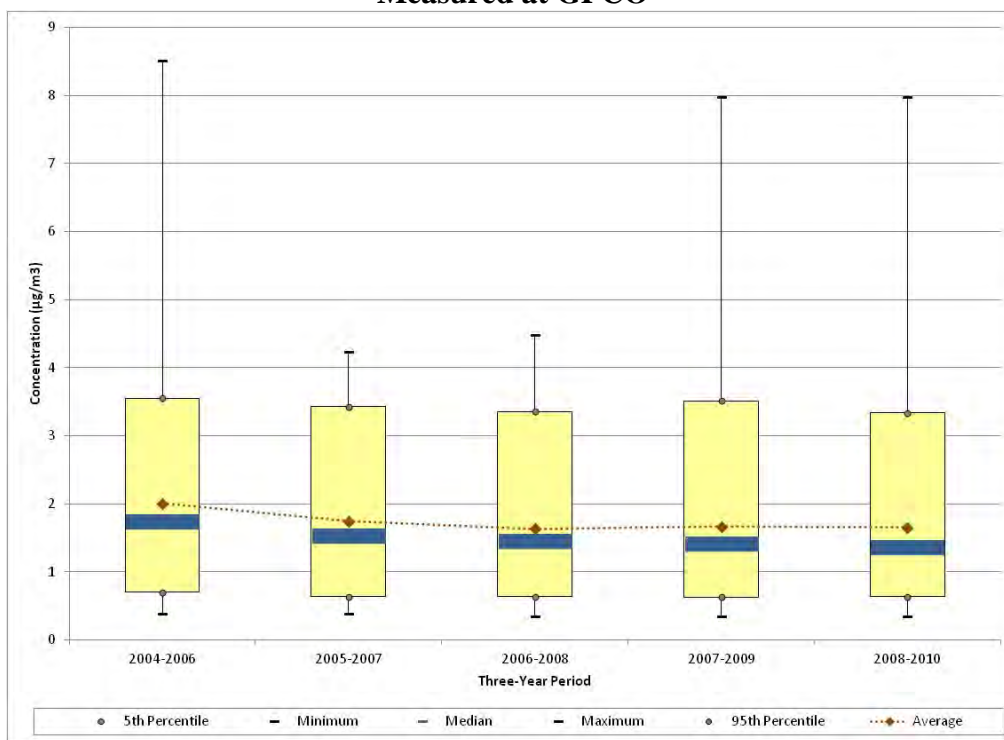
Figure 7-35. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at GPCO
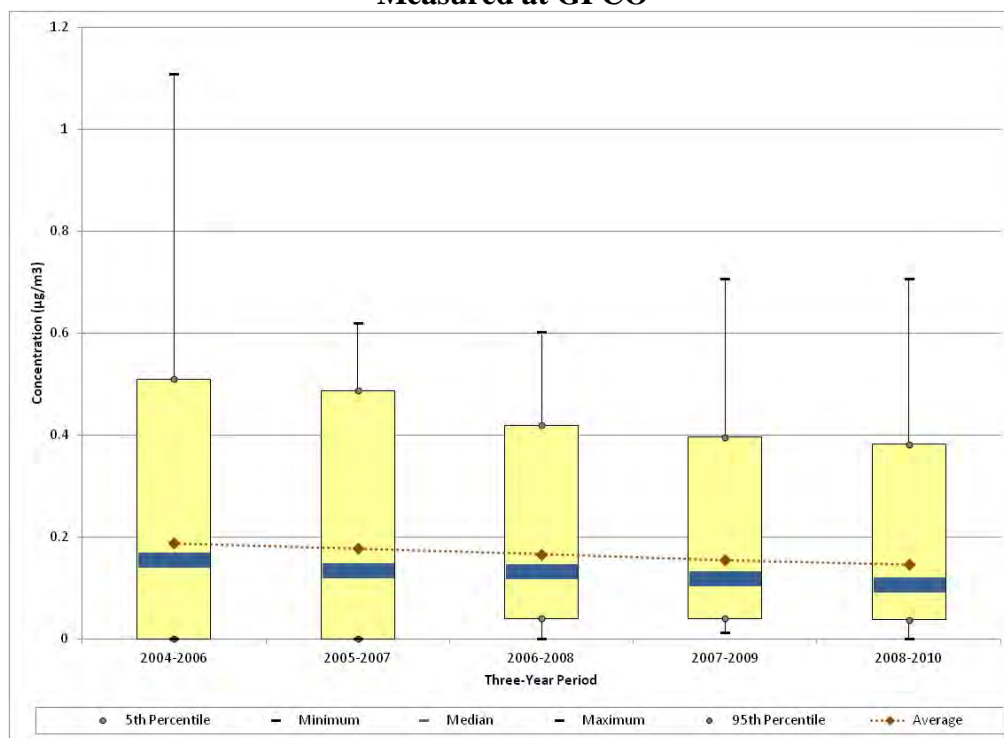
Figure 7-36. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at GPCO
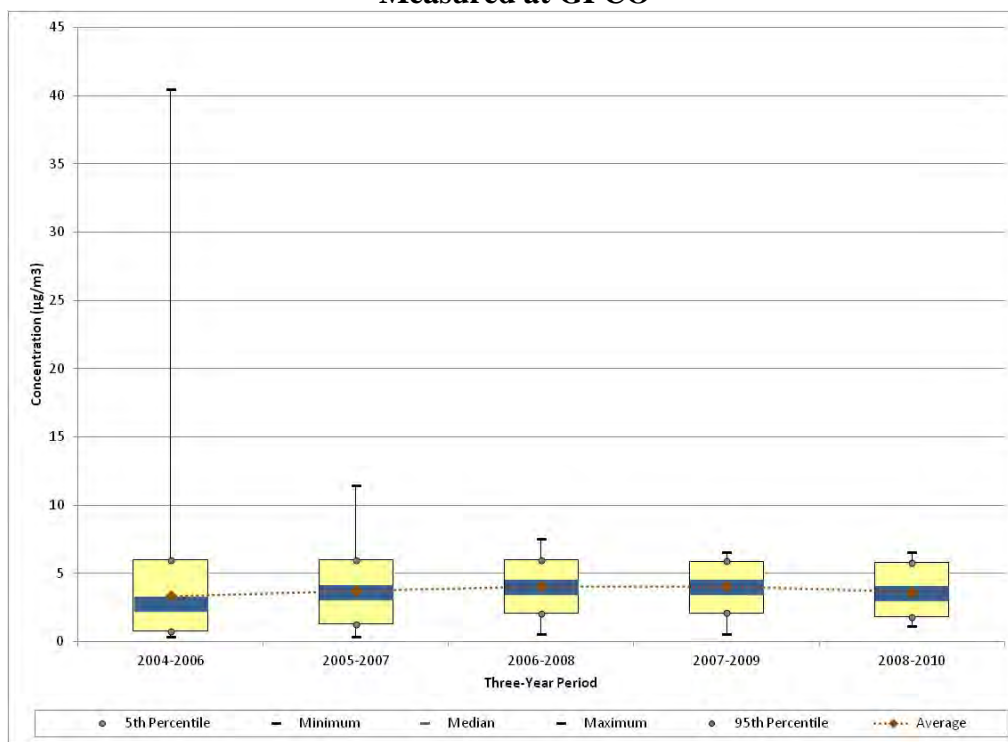
Figure 7-37. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at GPCO
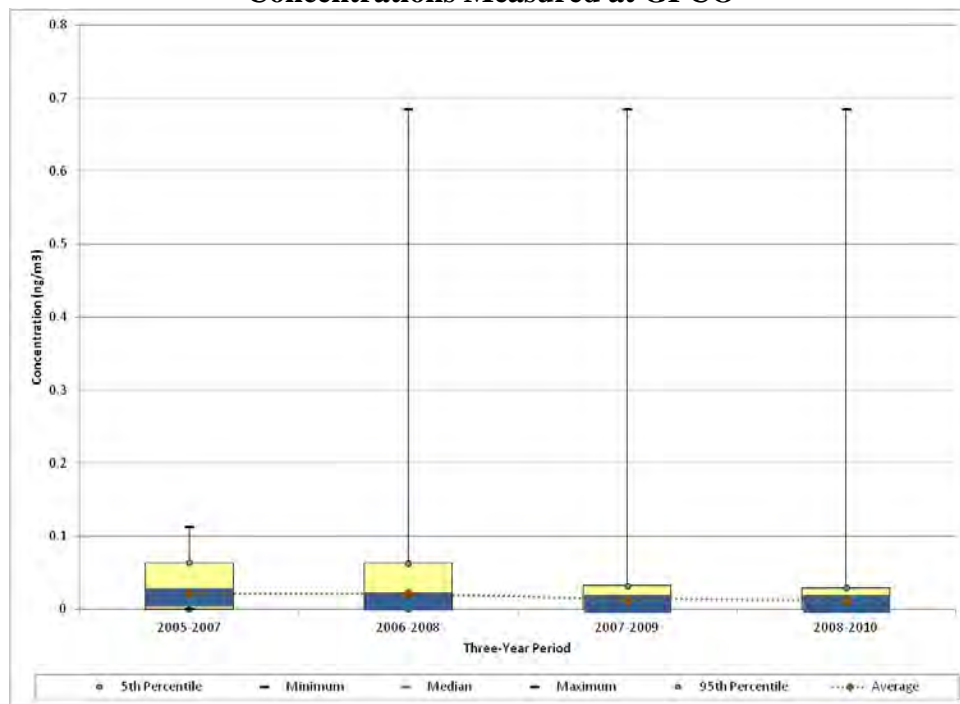
Observations from Figure 7-34 for benzene measurements at GPCO include the following:

- The maximum benzene concentration was measured on December 11, 2004. The maximum concentrations measured in subsequent years were much lower until July 9, 2009, when a similar concentration was measured.

- The 5th and 95th percentiles and the median have decreased slightly over time. The rolling average decreased as well, but increased slightly for 2007-2009 and 2008-2010, primarily as a result of the high concentration measured in 2009 (if this concentration were removed from consideration, the average concentrations would continue the slight, although not statistically significant, decreasing trend).

- The minimum concentration was greater than zero for all 3-year time periods, indicating that there were no non-detects reported for benzene over the period of sampling.

Observations from Figure 7-35 for 1,3-butadiene measurements at GPCO include the following:

- Similar to benzene, the maximum 1,3-butadiene concentration was measured on December 11, 2004. The maximum concentrations measured in subsequent time periods were lower.

- The rolling 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.

- In addition to the rolling average, the median and 95th percentile also exhibit a slight decreasing trend in concentrations.

- Conversely, the 5th percentile increased from zero for 2006-2008 and beyond. 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, and three percent in 2010.

Observations from Figure 7-36 for formaldehyde measurements at GPCO include the following:

- The trends graph for formaldehyde resembles the graph for acetaldehyde in that the maximum formaldehyde concentration was measured in 2004. The three highest concentrations of formaldehyde were measured on the same days as the three highest acetaldehyde concentrations. The maximum concentrations in subsequent time periods were significantly lower.

- Even with decreasing maximum concentrations, the rolling average formaldehyde concentrations (as well as several other statistical parameters) have a slight increasing trend through the 2007-2009 time frame, then decrease slightly for 2008-2010.

- Although difficult to discern in Figure 7-36, the minimum concentration measured increased for each time frame, doubling from 2007-2009 to 2008-2010.

Observations from Figure 7-37 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 concentrations measured at GPCO are greater than 0.1 ng/m^3, with the other being measured on August 9, 2006 (0.113 ng/m^3), which is the maximum concentration shown for the 2005-2007 time period.

- The rolling average concentrations of hexavalent chromium exhibit a slight decreasing trend, although the confidence intervals calculated on the dataset are relatively wide due, at least in part, to the maximum concentration. However, the median concentrations also show a decreasing trend, and this parameter is influenced less by outliers.

- Both the minimum concentration and 5th percentile for all 3-year periods shown are zero, indicating the presence of non-detects. The percentage of non-detects increased from 2006 through 2009, then decreased for 2010.

7.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

7.5.1   Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Colorado monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for each site were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL. The results of

this risk screening are summarized in Table 7-6. Where a quarterly or annual average exceeds the applicable MRL, the concentration is bolded.

Observations about dichloromethane in Table 7-6 include the following:

- Dichloromethane was the only pollutant where a preprocessed daily measurement and/or time-period average is greater than one or more of the MRL noncancer health risk benchmarks. Although this pollutant is not a pollutant of interest for any of the Colorado sites, its highest concentration is among the highest concentrations measured for any of the pollutants sampled under the NMP.

- One out of 59 measured detections of dichloromethane for GPCO is greater than the ATSDR acute MRL for this pollutant (2,000 $\mu g/m^3$). This concentration was measured on October 17, 2010. While this measurement (5,256 $\mu g/m^3$) was the highest concentration of this pollutant measured among all NMP sites sampling VOC, it was not the only concentration of dichloromethane to exceed the acute MRL, as discussed in Section 3.3.

- While none of the quarterly average concentrations of dichloromethane were greater than the ATSDR intermediate MRL of 1,000 $\mu g/m^3$, it is easy to see from Table 7-6 during which quarter the maximum measurement of dichloromethane was measured. The fourth quarter average dichloromethane concentration is two orders of magnitude higher than the other quarterly averages and its confidence interval is twice as high as the average itself. The second highest concentration of dichloromethane measured at GPCO was 67.9 $\mu g/m^3$ and was measured during the first quarter of 2010. However, the median dichloromethane concentration for this site is less than 1 $\mu g/m^3$.

- The annual average concentration of dichloromethane for GPCO (91.68 ± 176.67 $\mu g/m^3$) was well below the ATSDR chronic MRL for this pollutant (1,000 $\mu g/m^3$). Note that if the maximum concentration of dichloromethane were removed from the calculation, the annual average concentration would be 2.64 $\mu g/m^3$.

Table 7-6. Noncancer Risk Screening Summary for the Colorado Monitoring Sites

Pollutant	Acute ATSDR Acute MRL[1] (µg/m³)	# of Concentrations > MRL	# of Measured Detections	Intermediate ATSDR Intermediate MRL[1] (µg/m³)	1st Quarter Average (µg/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Chronic ATSDR Chronic MRL[1] (µg/m³)	Annual Average (µg/m³)
Grand Junction, Colorado - GPCO										
Dichloromethane	2,000	1	59	1,000	5.07 ± 9.24	1.74 ± 2.20	1.23 ± 0.87	377.75 ± 775.46	1,000	91.68 ± 176.67

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

For the pollutants whose concentrations are greater than their respective ATSDR acute MRL noncancer health risk benchmark(s), the concentrations were further examined by developing pollution roses for these pollutants. A pollution rose is a plot of concentration vs. wind speed and wind direction, as described in Section 3.5.5.1. Figure 7-38 is the dichloromethane pollution rose for GPCO.

Observations from the Figure 7-38 include the following:

- There was only one measured detection that was greater than the ATSDR acute MRL (2,000 µg/m^3) for dichloromethane (shown in orange).

- The concentration greater than the ATSDR acute MRL was measured on a day with light winds blowing from the southeast. However, there were many measurements of dichloromethane that were much lower and measured on days with average winds from the southeast.

- The three next highest concentrations, ranging from 16.6 µg/m^3 to 67.9 µg/m^3, were measured on days with winds from the north, as shown in Figure 7-38.

Figure 7-38. Dichloromethane Pollution Rose for GPCO
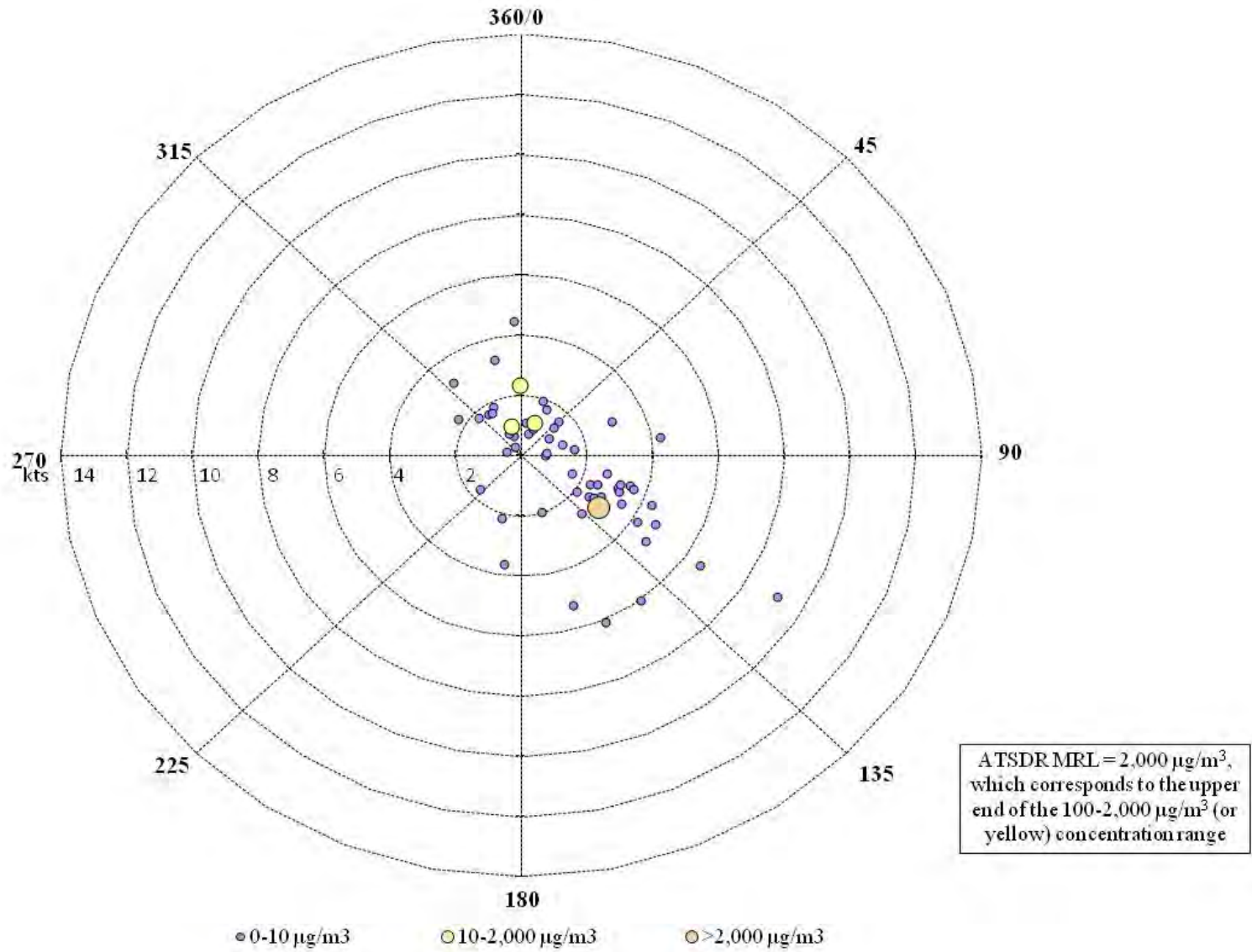
ATSDR MRL = 2,000 μg/m³, which corresponds to the upper end of the 100-2,000 μg/m³ (or yellow) concentration range

● 0-10 μg/m3   ○ 10-2,000 μg/m3   ○ >2,000 μg/m3

7.5.2   Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Colorado monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 7-7, where applicable.

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

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

- Formaldehyde also has the highest cancer risk approximation (36.12 in-a-million) for this site. Benzene has the second highest cancer risk approximation (10.88 in-a-million), while naphthalene has the third highest cancer risk approximation (5.00 in-a-million).

- None of the pollutants of interest for GPCO have noncancer risk approximations greater than 1.0. Formaldehyde has the highest noncancer risk approximation (0.28).

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

- Annual averages, and thus cancer and noncancer surrogate risk approximations, could not be calculated for BMCO due to the short sampling duration.

- Annual averages, and thus cancer and noncancer surrogate risk approximations, could not be calculated for acetaldehyde and formaldehyde for BRCO, RICO, and RUCO. This is due to the completeness criteria combined with the 1-in-12 day sampling schedule for these pollutants. Formaldehyde has the highest cancer risk approximation for PACO among its pollutants of interest.

- For all sites except PACO, benzene's cancer risk approximation is the highest among each site's pollutants of interest. Benzene's cancer risk approximations range from 8.55 in-a-million (BRCO) to 13.43 in-a-million (PACO). PACO's benzene cancer risk approximation is the second highest benzene cancer risk approximation compared to other NMP sites.

- None of the noncancer risk approximations calculated for the Garfield County sites were greater than 1.0. The highest noncancer risk approximation was calculated for PACO (for formaldehyde, 0.16).

Table 7-7. Cancer and Noncancer Surrogate Risk Approximations for the Colorado Monitoring Sites

Pollutant	Cancer URE ($\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu g/m^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Grand Junction, Colorado - GPCO						
Acenaphthene[a]	0.000088	--	57/57	0.01 ± <0.01	0.64	--
Acetaldehyde	0.0000022	0.009	61/61	2.00 ± 0.20	4.40	0.22
Acrylonitrile	0.000068	0.002	8/59	0.02 ± 0.01	1.35	0.01
Benzene	0.0000078	0.03	59/59	1.40 ± 0.16	10.88	0.05
Benzo(a)pyrene[a]	0.00176	--	32/57	<0.01 ± <0.01	0.33	--
1,3-Butadiene	0.00003	0.002	58/59	0.14 ± 0.02	4.07	0.07
Carbon Tetrachloride	0.000006	0.1	59/59	0.53 ± 0.05	3.17	0.01
Chloroform	--	0.098	54/59	0.09 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	7/59	0.01 ± 0.01	0.24	<0.01
Ethylbenzene	0.0000025	1	59/59	0.50 ± 0.07	1.25	<0.01
Formaldehyde	0.000013	0.0098	61/61	2.78 ± 0.23	36.12	0.28
Hexavalent Chromium[a]	0.012	0.0001	35/58	<0.01 ± <0.01	0.14	<0.01
Naphthalene[a]	0.000034	0.003	57/57	0.15 ± 0.02	5.00	0.05
Tetrachloroethylene	0.00000026	0.04	59/59	0.39 ± 0.07	0.10	0.01
Trichloroethylene	0.0000048	0.002	19/59	0.03 ± 0.01	0.13	0.01
Vinyl Chloride	0.0000088	0.1	2/59	<0.01 ± <0.01	<0.01	<0.01
Battlement Mesa, Colorado - BMCO						
Acetaldehyde	0.0000022	0.009	7/7	NA	NA	NA
Benzene	0.0000078	0.03	18/18	NA	NA	NA
1,3-Butadiene	0.00003	0.002	8/18	NA	NA	NA
Formaldehyde	0.000013	0.0098	7/7	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 7-7. Cancer and Noncancer Surrogate 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 Risk Approximation (HQ)
Silt, Colorado - BRCO						
Acetaldehyde	0.0000022	0.009	17/17	NA	NA	NA
Benzene	0.0000078	0.03	61/61	1.10 ± 0.18	8.55	0.04
1,3-Butadiene	0.00003	0.002	6/61	0.01 ± 0.01	0.31	0.01
Formaldehyde	0.000013	0.0098	17/17	NA	NA	NA
Parachute, Colorado - PACO						
Acetaldehyde	0.0000022	0.009	28/28	0.93 ± 0.16	2.04	0.10
Benzene	0.0000078	0.03	58/58	1.72 ± 0.21	13.43	0.06
1,3-Butadiene	0.00003	0.002	22/58	0.06 ± 0.04	1.91	0.03
Ethylbenzene	0.0000025	1	58/58	0.98 ± 0.98	2.46	<0.01
Formaldehyde	0.000013	0.0098	28/28	1.53 ± 0.20	19.95	0.16
Rifle, Colorado - RICO						
Acetaldehyde	0.0000022	0.009	24/24	NA	NA	NA
Benzene	0.0000078	0.03	60/60	1.46 ± 0.17	11.38	0.05
1,3-Butadiene	0.00003	0.002	38/60	0.16 ± 0.06	4.71	0.08
Ethylbenzene	0.0000025	1	60/60	0.95 ± 0.86	2.38	<0.01
Formaldehyde	0.000013	0.0098	24/24	NA	NA	NA
Rulison, Colorado - RUCO						
Acetaldehyde	0.0000022	0.009	18/18	NA	NA	NA
Benzene	0.0000078	0.03	40/40	1.62 ± 0.18	12.65	0.05
1,3-Butadiene	0.00003	0.002	8/40	0.02 ± 0.01	0.51	0.01
Formaldehyde	0.000013	0.0098	18/18	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.

7.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 7-8 and 7-9 present a risk-based evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 7-8 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 7-9 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 7-8 and 7-9 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 VOC, carbonyl compounds, PAH, and hexavalent chromium; the Garfield County sites sampled for SNMOC and carbonyl compounds only. In addition, the cancer and noncancer surrogate risk 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.

Table 7-8. 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 Risk Factors (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	36.12
Formaldehyde	112.12	Benzene	1.10E-03	Benzene	10.88
Acetaldehyde	45.52	1,3-Butadiene	4.25E-04	Naphthalene	5.00
Ethylbenzene	41.56	POM, Group 3	3.93E-04	Acetaldehyde	4.40
1,3-Butadiene	14.18	Naphthalene	2.59E-04	1,3-Butadiene	4.07
Naphthalene	7.63	POM, Group 2b	1.78E-04	Carbon Tetrachloride	3.17
Dichloromethane	6.38	Arsenic, PM	1.58E-04	Acrylonitrile	1.35
POM, Group 2b	2.02	Hexavalent Chromium, PM	1.37E-04	Ethylbenzene	1.25
Tetrachloroethylene	1.20	Ethylbenzene	1.04E-04	Acenaphthene	0.64
POM, Group 6	0.20	Acetaldehyde	1.00E-04	Benzo(a)pyrene	0.33
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 7-8. 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 Risk Factors (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	8.55
Benzene	269.17	Benzene	2.10E-03	1,3-Butadiene	0.31
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	Formaldehyde	19.95
Benzene	269.17	Benzene	2.10E-03	Benzene	13.43
Acetaldehyde	79.93	POM, Group 3	8.97E-04	Ethylbenzene	2.46
Ethylbenzene	27.66	1,3-Butadiene	4.81E-04	Acetaldehyde	2.04
1,3-Butadiene	16.04	POM, Group 2b	2.37E-04	1,3-Butadiene	1.91
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 Cancer Risk Approximations for Pollutants with Cancer UREs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer Risk Factors (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	11.38
Benzene	269.17	Benzene	2.10E-03	1,3-Butadiene	4.71
Acetaldehyde	79.93	POM, Group 3	8.97E-04	Ethylbenzene	2.38
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		
Rulison, Colorado (Garfield County) - RUCO					
Formaldehyde	324.22	Formaldehyde	4.21E-03	Benzene	12.65
Benzene	269.17	Benzene	2.10E-03	1,3-Butadiene	0.51
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 7-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk 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	0.22
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	0.05
Hexane	50.96	Naphthalene	2,543.73	Trichloroethylene	0.01
Acetaldehyde	45.52	Arsenic, PM	2,443.88	Acrylonitrile	0.01
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 7-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Silt, Colorado (Garfield County) - BRCO					
Toluene	419.91	Acrolein	2,021,060.94	Benzene	0.04
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	Formaldehyde	0.16
Formaldehyde	324.22	Formaldehyde	33,083.40	Acetaldehyde	0.10
Xylenes	321.33	Benzene	8,972.23	Benzene	0.06
Benzene	269.17	Acetaldehyde	8,880.90	1,3-Butadiene	0.03
Hexane	82.14	1,3-Butadiene	8,021.37	Ethylbenzene	<0.01
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 7-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Colorado Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Rifle, Colorado (Garfield County) - RICO					
Toluene	419.91	Acrolein	2,021,060.94	1,3-Butadiene	0.08
Formaldehyde	324.22	Formaldehyde	33,083.40	Benzene	0.05
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		
Rulison, Colorado (Garfield County) - RUCO					
Toluene	419.91	Acrolein	2,021,060.94	Benzene	0.05
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		

Observations from Table 7-8 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.

- In Mesa County, the two pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde and benzene, while 1,3-butadiene and POM, Group 3 rank third and fourth. In Garfield County, the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) are formaldehyde, benzene, POM, Group 3, and 1,3-butadiene.

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

- POM, Group 2b is the eighth highest emitted "pollutant" in Mesa County and ranks sixth for toxicity-weighted emissions. POM, Group 2b includes several PAH sampled for at GPCO including acenaphthene, fluoranthene, fluorene, and perylene. Acenaphthene has the ninth highest cancer risk approximation for GPCO.

- Benzo(a)pyrene is included in POM, Group 5a. The cancer risk approximation for this pollutant ranks 10th for GPCO, but POM, Group 5a does not appear on either emissions-based list (although its emissions rank 15th and its toxicity-weighted emissions rank 11th in Mesa County).

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

Observations from Table 7-9 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 share an additional eight pollutants 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 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.

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

- With the exception of ethylbenzene, all of the pollutants of interest listed on the noncancer risk approximations lists for the Garfield County sites also appear on both emissions-based lists for Mesa County. Although ethylbenzene is one of the highest emitted pollutants in Garfield County, it is not among the most toxic.

7.6   Summary of the 2010 Monitoring Data for the Sites in Colorado

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

- ❖ *Nineteen pollutants failed at least one screen for GPCO, while 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/m³. Benzene had the highest annual average concentrations for each of the Garfield County sites.*

- ❖ *One preprocessed daily measurement of dichloromethane from GPCO was greater than its associated acute MRL noncancer health risk benchmark. None of the quarterly or annual average concentrations of the pollutants of interest, where they could be calculated, were greater than their associated intermediate or chronic MRL noncancer health risk benchmarks.*

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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 8-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 8-1. Washington, D.C. (WADC) Monitoring Site
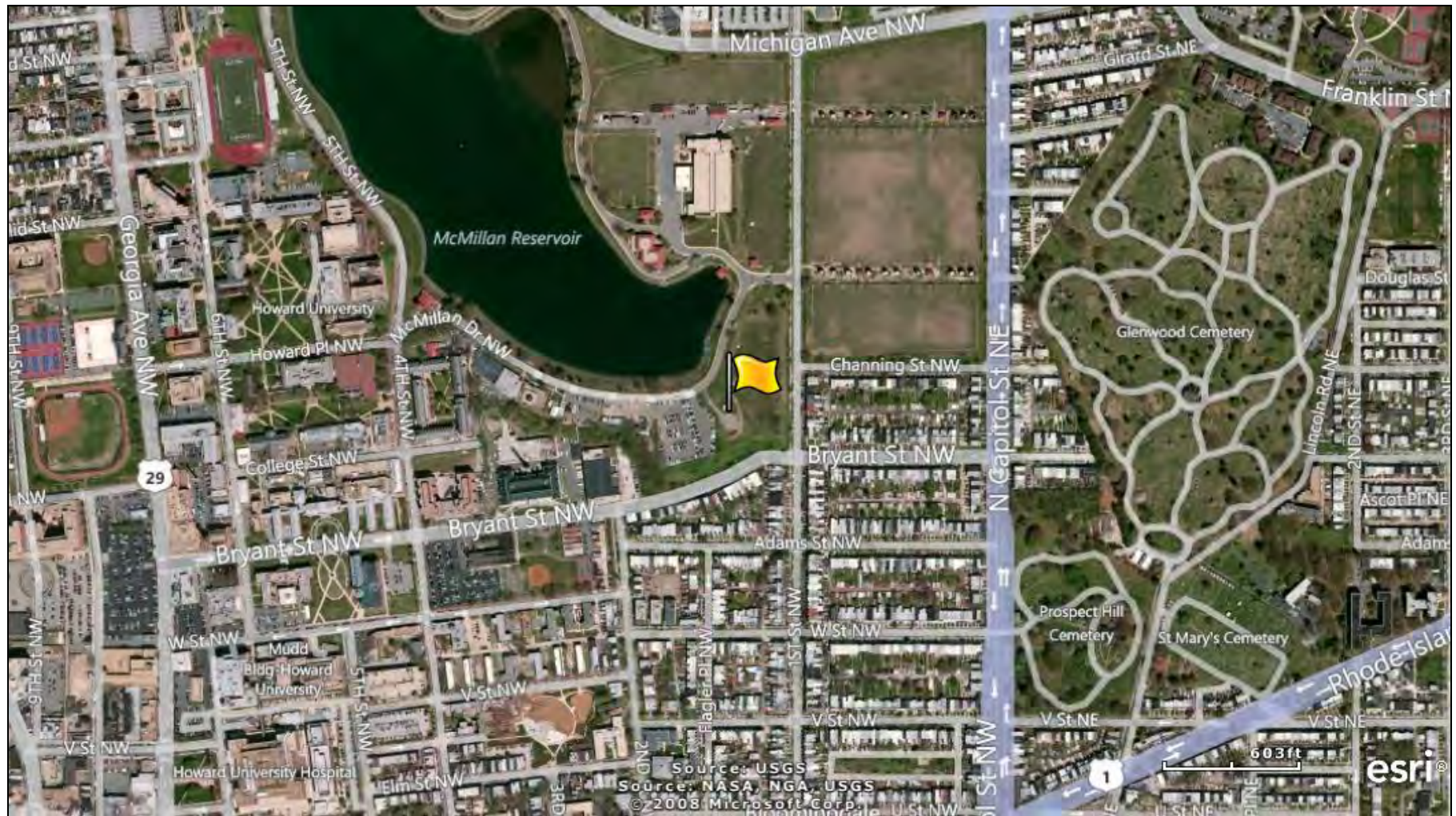
Figure 8-2. NEI Point Sources Located Within 10 Miles of WADC

Legend

⭐ WADC NATTS site ◯ 10 mile radius ▭ County boundary

Source Category Group (No. of Facilities)

- ☼ Air-conditioning/Refrigeration (2)
- ✛ Aircraft Operations (27)
- ▮ Asphalt Processing/Roofing Manufacturing (3)
- ⚡ Electricity Generation via Combustion (3)
- F Food Processing/Agriculture (1)
- Ⓗ Hospital (5)
- Ⓢ Institutional - school (10)
- Λ Military Base/National Security (5)
- ? Miscellaneous Commercial/Industrial (18)
- P Printing/Publishing (5)
- ❋ Transportation and Marketing of Petroleum Products (1)

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, VOC, 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] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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, schools is the next most numerous source category within 10 miles of the WADC monitoring site. The closest sources to WADC are hospitals and heliports at hospitals.

Table 8-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Washington, D.C. monitoring site. Table 8-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle registration was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 8-2 also contains annual average daily traffic information. District-level VMT was not readily available; thus, daily VMT for Washington, D.C. is not provided in Table 8-2.

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	604,453	219,173	0.36	1,911,152	692,978	7,700	NA

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2009 data from the Federal Highway Administration (FHWA, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2009 data from the District DOT (DC DOT, 2011)
[5] County-level VMT was not available for this site
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. However, its 10-mile population ranks fifth highest.

- 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 top third 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 estimate used came from the intersection of Bryant Street and First Street.

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 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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	Sample Day	66.8 ± 5.0	58.8 ± 4.6	43.2 ± 4.6	51.0 ± 4.1	59.2 ± 3.2	1014.9 ± 1.8	7.7 ± 0.8
	183° (S)	2010	67.7 ± 2.1	59.5 ± 1.9	43.5 ± 1.9	51.5 ± 1.7	58.4 ± 1.3	1015.2 ± 0.7	7.6 ± 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 2010. Also included in Table 8-3 is the 95 percent confidence interval for each parameter. As shown in Table 8-3, average meteorological conditions on sample days were representative of average weather conditions throughout the year.

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 2010. Included in Figure 8-3 are four back trajectories per sample day. Figure 8-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the site in Figures 8-3 and 8-4 represents 100 miles.

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

- Back trajectories originated from a variety of directions at WADC. The bulk of trajectories appear to originate from the southwest, west, and northwest, while fewer trajectories originated from the northeast, east, and southeast.

- The 24-hour air shed domain for WADC was comparable in size to many other NMP monitoring sites. The farthest away a trajectory originated was over Lake Michigan, or approximately 550 miles away. However, the average trajectory length was 237 miles and nearly 90 percent of back trajectories originated within 400 miles of the site.

- The cluster analysis shows that 53 percent of trajectories originated from the southwest, west, and northwest of WADC. The short cluster (26 percent) represents trajectories originating within 200 miles of the site and generally from the northwest to north to northeast. Another 12 percent of trajectories originated to the southeast to southwest and also within 200 miles of the site. Trajectories originating to the north to northeast were also common (9 percent).

Figure 8-3. 2010 Composite Back Trajectory Map for WADC
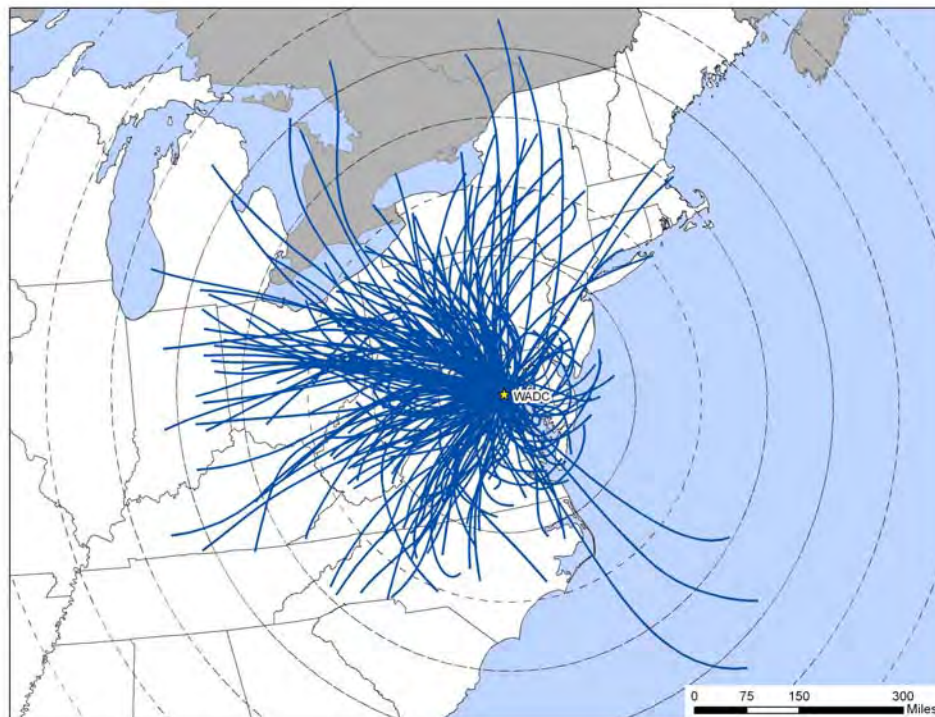
Figure 8-4. Back Trajectory Cluster Map for WADC

8.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the WADC monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location.

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 ($\leq$ 2 knots) were observed for less than 10 percent of the hourly measurements.

- The full-year wind patterns are similar to the wind patterns shown on the historical wind rose, indicating that wind patterns in 2010 were similar to what is expected climatologically near this site. Further, the sample day wind patterns for 2010 are similar to both the full-year and historical wind patterns. This indicates that conditions on sample days were representative of conditions experienced throughout the year and historically.

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

1999-2009 Historical Wind Rose
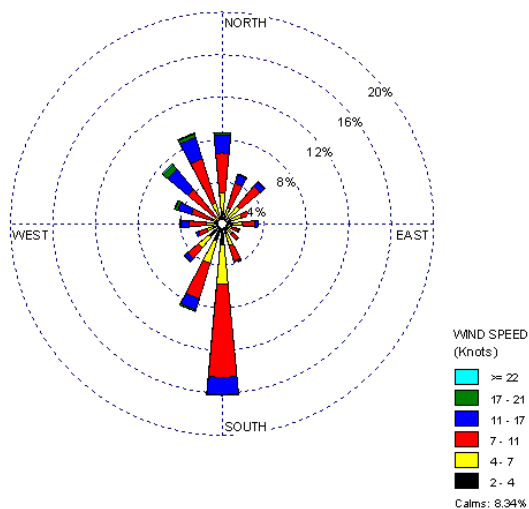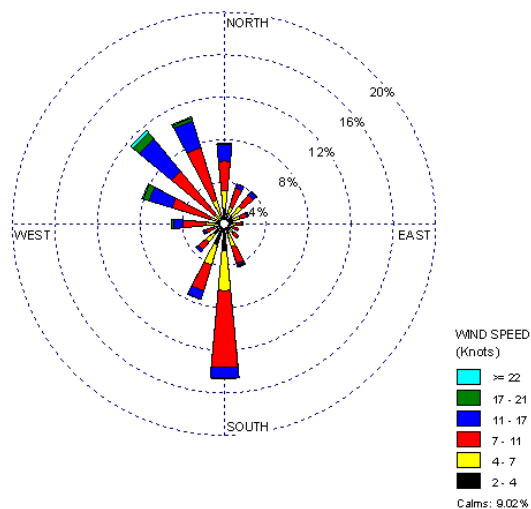
2010 Wind Rose

2010 Sample Day Wind Rose
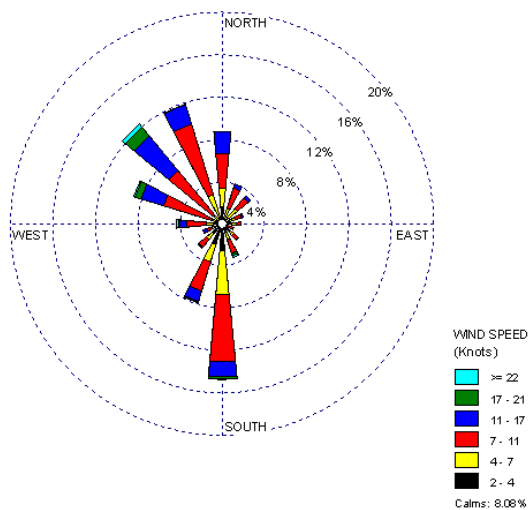
Distance between WADC and NWS Station

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 8-4 presents WADC's pollutants of interest. 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 PAH.

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

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Washington, D.C. - WADC						
Naphthalene	0.029	58	58	100.00	96.67	96.67
Fluorene	0.011	2	58	3.45	3.33	100.00
Total		60	116	51.72		

Observations from Table 8-4 include the following:

- Naphthalene and fluorene failed screens for WADC. Naphthalene failed 100 percent of its screens and contributed to almost 97 percent of the total failed screens for WADC. Fluorene failed only two screens, contributing to roughly 3 percent of the total failed 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.

8.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Washington, D.C. monitoring site. Concentration averages are provided for the pollutants of interest for WADC, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices M and O.

8.4.1 2010 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	22/58	0.13 ± 0.08	0.02 ± 0.02	<0.01 ± 0.01	0.07 ± 0.05	0.05 ± 0.02
Hexavalent Chromium	40/60	0.01 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.02 ± 0.01	0.02 ± <0.01
Naphthalene	58/58	112.31 ± 64.73	91.51 ± 16.18	114.13 ± 26.36	123.21 ± 38.41	110.77 ± 18.56

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 less than half of the PAH samples collected. Hexavalent chromium was detected in two-thirds 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. WADC's annual average concentration ranks sixth highest among NMP sites sampling this pollutant, as shown in Table 4-11.

- While the quarterly average concentrations of naphthalene did not differ significantly across the quarters, the confidence interval for the first quarter average is much higher than the confidence intervals for the other quarterly averages. The highest naphthalene concentration was measured at WADC on January 14, 2010 (454 ng/m^3). The next highest measurement during the first quarter of 2010 was less than half that measurement (215 ng/m^3 on February 1, 2010) and the median concentration for this quarter is 76.7 ng/m^3.

- Benzo(a)pyrene concentrations tended to be higher during the colder months of the year, as indicated by the quarterly averages. However, both the first and fourth quarters have relatively high confidence intervals associated with them, indicating higher variability within these quarters. Note that of the 14 measurements of benzo(a)pyrene greater than or equal to 0.1 ng/m^3, eight were measured during the first quarter and five during the fourth quarter (the one additional measurement was measured during the second quarter). In all, there were 10 measured detections of this pollutant during the first quarter of 2010, three during the second quarter, one during the third quarter, and eight during the fourth quarter.

8.4.2   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 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, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

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 maximum concentration (42.7 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 2 ng/m^3. Also 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 WADC is below the program-level average concentration. Figure 8-6 also shows that the maximum concentration measured at WADC is well below the maximum concentration measured across the program. There were several non-detects of benzo(a)pyrene measured at WADC as the minimum, first quartile, and median (second quartile) concentrations were all zero.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 8-7 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 8-7 shows that WADC's annual average concentration (0.0182 ng/m^3) is half the program-level average (0.0369 ng/m^3). The maximum concentration measured at WADC is well below the program maximum concentration. There were several non-detects of hexavalent chromium measured at WADC as both the minimum and first quartile concentrations are zero.

- Figure 8-8 shows that the annual naphthalene average for WADC is just greater than the program-level average concentration. The maximum naphthalene concentration measured at WADC is well below the program-level maximum concentration. The minimum concentration measured at WADC is greater than the program-level first quartile. There were no non-detects of naphthalene measured at WADC. Compared to other sites sampling naphthalene, this site has one of the highest minimum concentrations of this pollutant.

Figure 8-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Program Max Concentration = 42.7 ng/m3

Program: 1st Quartile 2nd Quartile 3rd Quartile 4th Quartile Average

Site: Site Average Site Minimum/Maximum
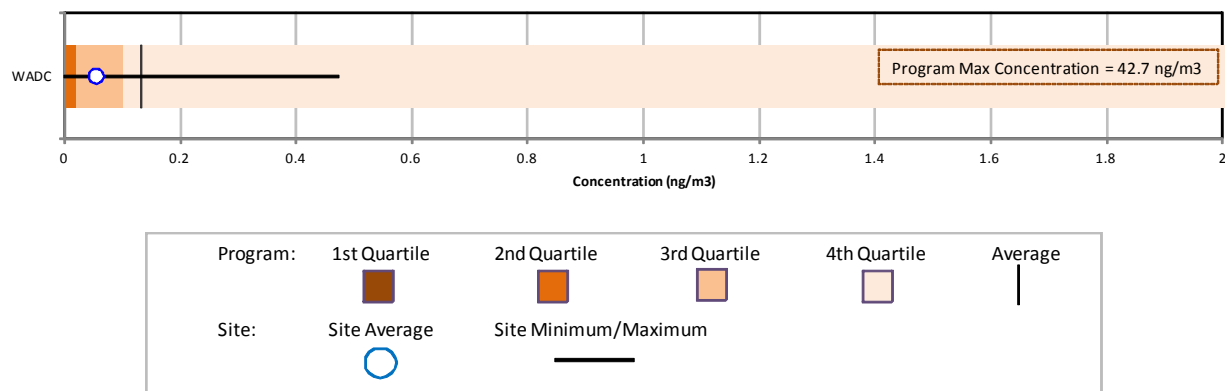
Figure 8-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

Program Max Concentration = 3.51 ng/m3

Program: 1st Quartile 2nd Quartile 3rd Quartile 4th Quartile Average

Site: Site Average Site Minimum/Maximum
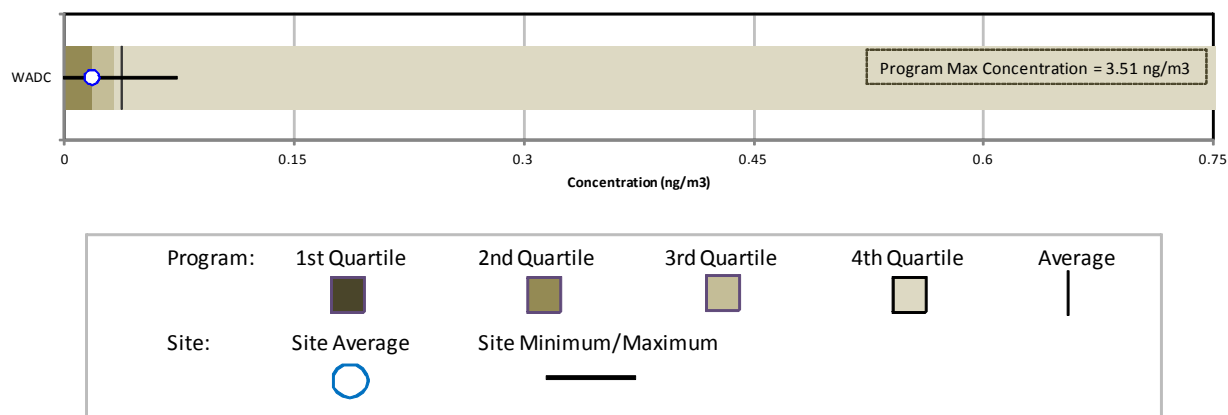
Figure 8-8. Program vs. Site-Specific Average Naphthalene Concentration
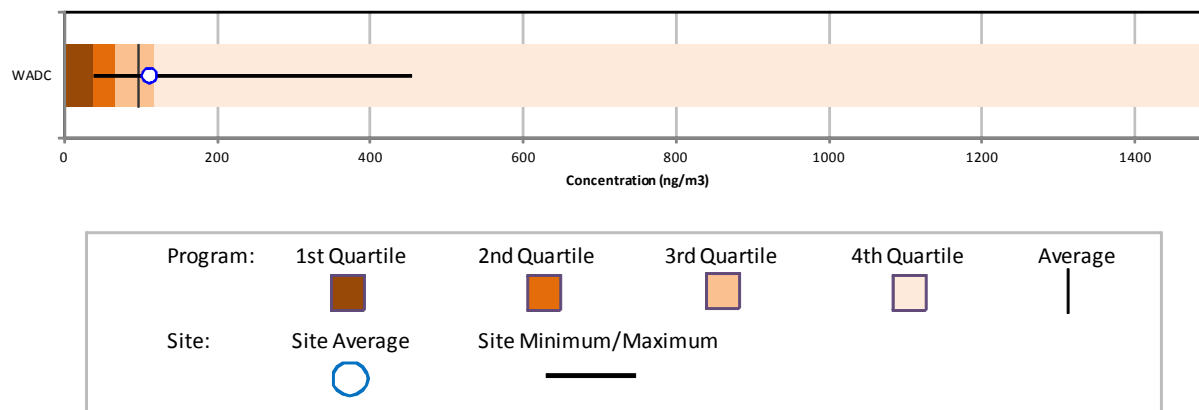
Program: 1st Quartile 2nd Quartile 3rd Quartile 4th Quartile Average

Site: Site Average Site Minimum/Maximum

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 3-year rolling statistical metrics for hexavalent chromium for WADC. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 8-9. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at WADC
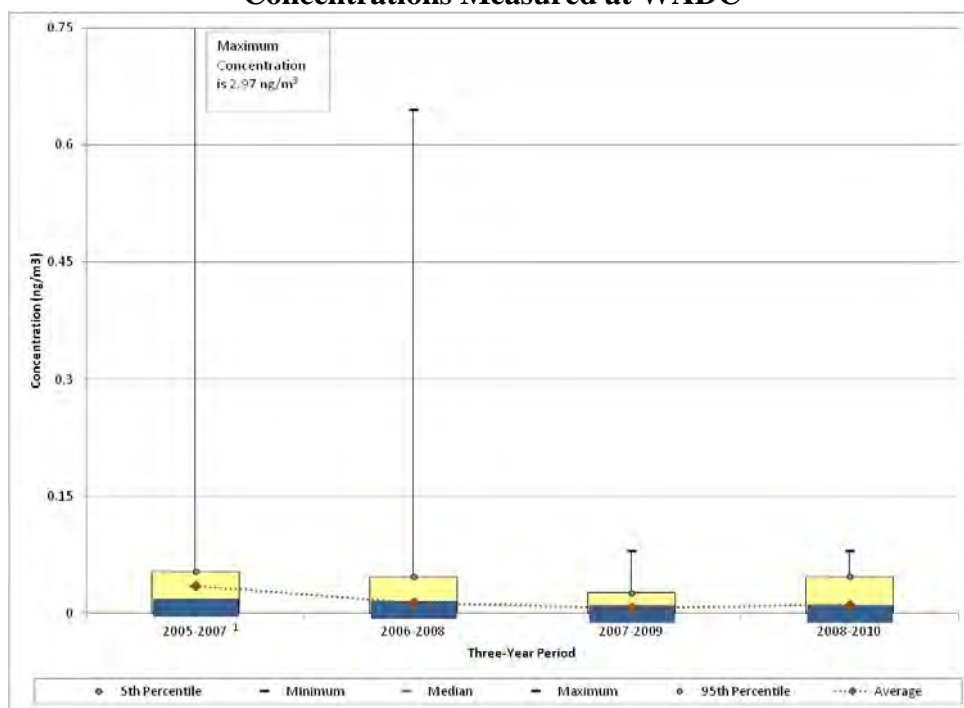
[1]Hexavalent chromium sampling at WADC began in March 2005.

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

- Sampling for hexavalent chromium began in March 2005.

- The maximum hexavalent chromium concentration was measured on August 20, 2005 (2.97 ng/m^3), and is an order of magnitude higher than the next highest measurement (0.645 ng/m^3 measured on July 4, 2006). The August 20, 2005 measurement is also second highest hexavalent chromium measured at any site since the onset of sampling for this pollutant under the NMP (only four total measurements greater than 1 ng/m^3 have been measured). Even the second-highest measurement for WADC is an order of magnitude higher than most other concentrations measured at this site (all but three concentrations measured at WADC are less than 0.1 ng/m^3).

8-17

- Hexavalent chromium concentrations appear to have decreased through the 2007-2009 time frame, with a slight uptick for 2008-2010. Because of the magnitude of the maximum concentrations from 2005 and 2006, it is difficult to determine if the initial changes in the rolling average concentrations are attributable to an actual decrease in concentrations or just the shifting of the data to a 3-year period without one of these high values. However, the maximum, median, and 95th percentile concentrations also exhibit a decreasing trend through 2007-2009. While the most of the statistical parameters stayed the same for 2008-2010, the rolling average and 95th percentile increased slightly.

8.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

8.5.1   Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Washington, D.C monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the WADC monitoring site were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Washington D.C. monitoring site.

8.5.2   Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for WADC and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for calculating annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages,

cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 8-6, where applicable.

Table 8-6. Cancer and Noncancer Surrogate Risk Approximations for the Washington, D.C. Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Washington, D.C. - WADC						
Benzo(a)pyrene	0.00176	--	22/58	0.05 ± 0.02	0.10	--
Hexavalent Chromium	0.012	0.0001	40/60	0.02 ± <0.01	0.22	<0.01
Naphthalene	0.000034	0.003	58/58	110.77 ± 18.56	3.77	0.04

-- = 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 magnitudes 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 (3.77 in-a-million), while its noncancer risk approximation is well below an HQ of 1.0 (0.04).

- Benzo(a)pyrene's cancer risk approximation is much less than naphthalene's (0.10 in-a-million). A noncancer RfC is not available for benzo(a)pyrene, thus a noncancer risk approximation could not be calculated.

- The cancer surrogate risk approximation based on hexavalent chromium's annual average concentration is well below 1.0 in-a-million (0.22 in-a-million). The noncancer surrogate risk approximation is also low (<0.01).

8.5.3   Risk-Based Emissions Assessment

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

The pollutants listed in Tables 8-7 and 8-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 PAH and hexavalent chromium. In addition, the cancer and noncancer surrogate risk 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.

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 lists for the District. POM, Group 2b includes several PAH 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 PAH included in POM, Groups 2b or 6 were identified as pollutants of interest for WADC.

8-20

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 Risk Factors (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	3.77
Formaldehyde	139.99	Benzene	1.17E-03	Hexavalent Chromium	0.22
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 Risk Approximations for Pollutants with Noncancer RfCs for the Washington, D.C. Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Washington, D.C. - WADC					
Toluene	433.60	Acrolein	361,586.14	Naphthalene	0.04
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 8-8 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 risk approximation (albeit low). Naphthalene has the sixth highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) but is not one of the 10 highest emitted pollutants.

- 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 2010 Monitoring Data for WADC

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

- ❖ *Naphthalene and fluorene were the only pollutants to fail screens for WADC. While naphthalene was the only pollutant of interest identified via the risk screening process, hexavalent chromium and benzo(a)pyrene 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.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 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 9-5 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 9-6 and 9-7 identify 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 9-6 through 9-7. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 9-1 describes the area surrounding each monitoring site by providing 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

Figure 9-3. Plant City, Florida (SYFL) Monitoring Site

Figure 9-4. Winter Park, Florida (ORFL) Monitoring Site
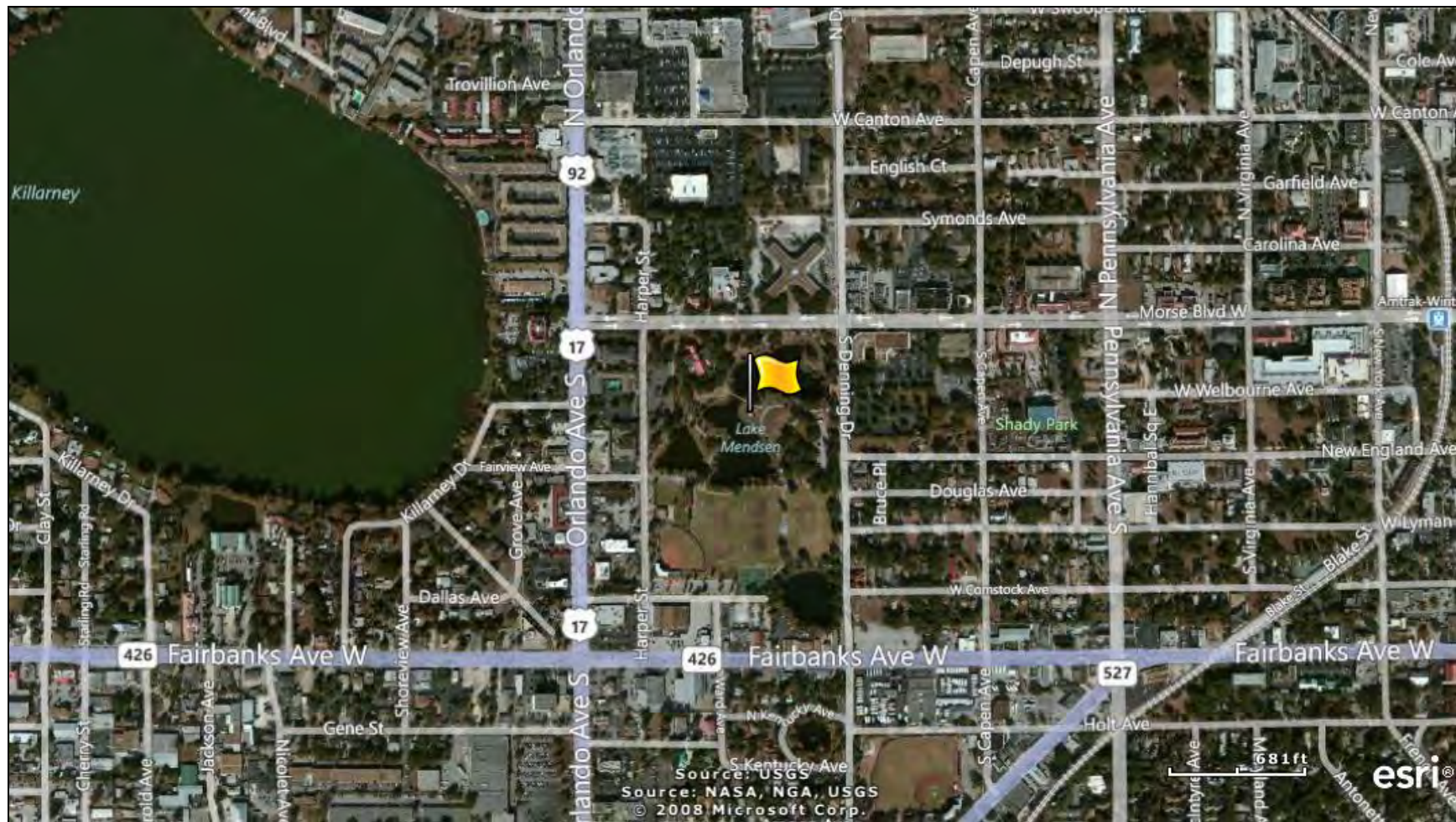
Figure 9-5. Orlando, Florida (PAFL) Monitoring Site
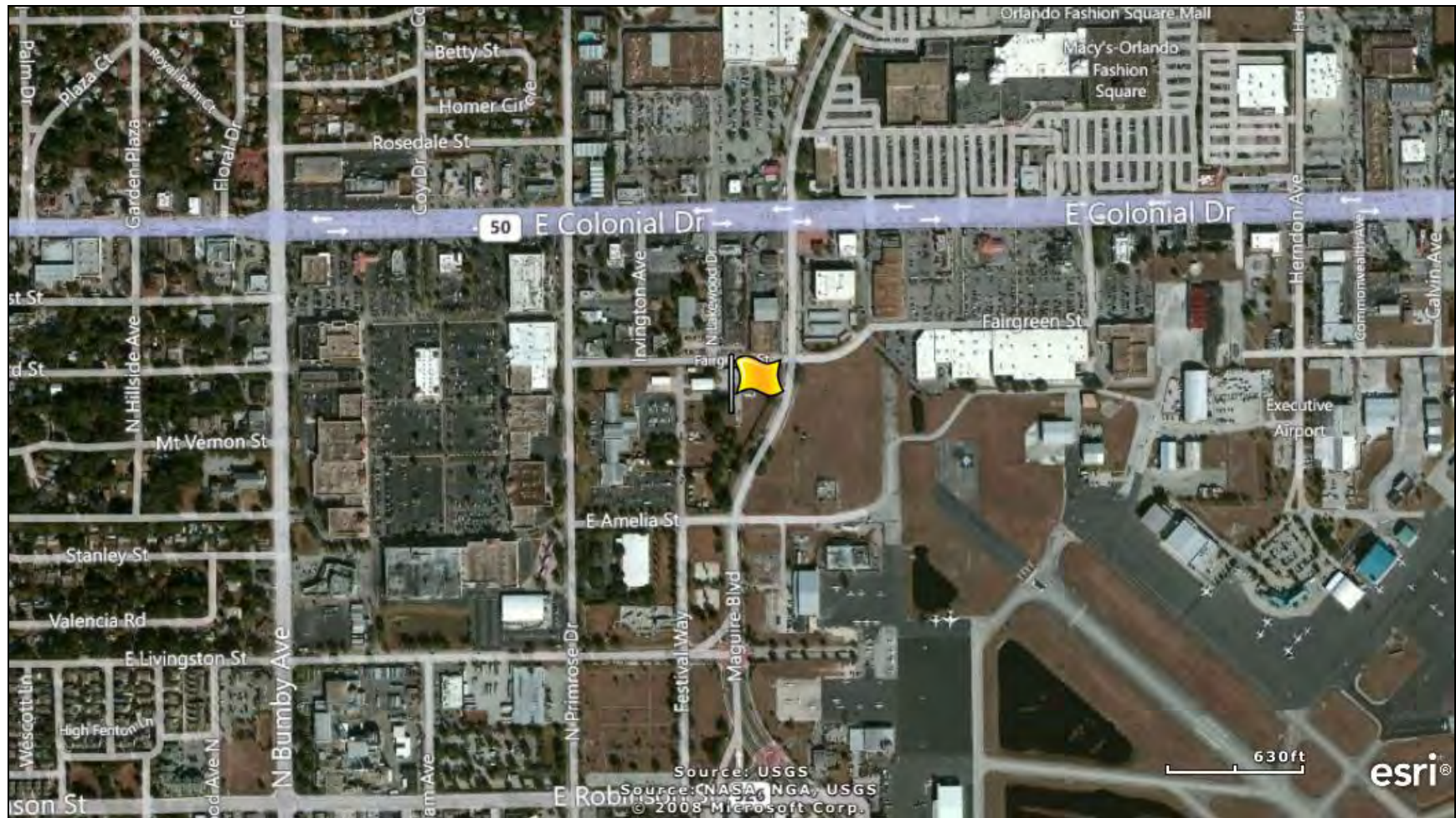
**Figure 9-6. NEI Point Sources Located Within 10 Miles of the
Tampa/St. Petersburg, Florida Monitoring Sites**
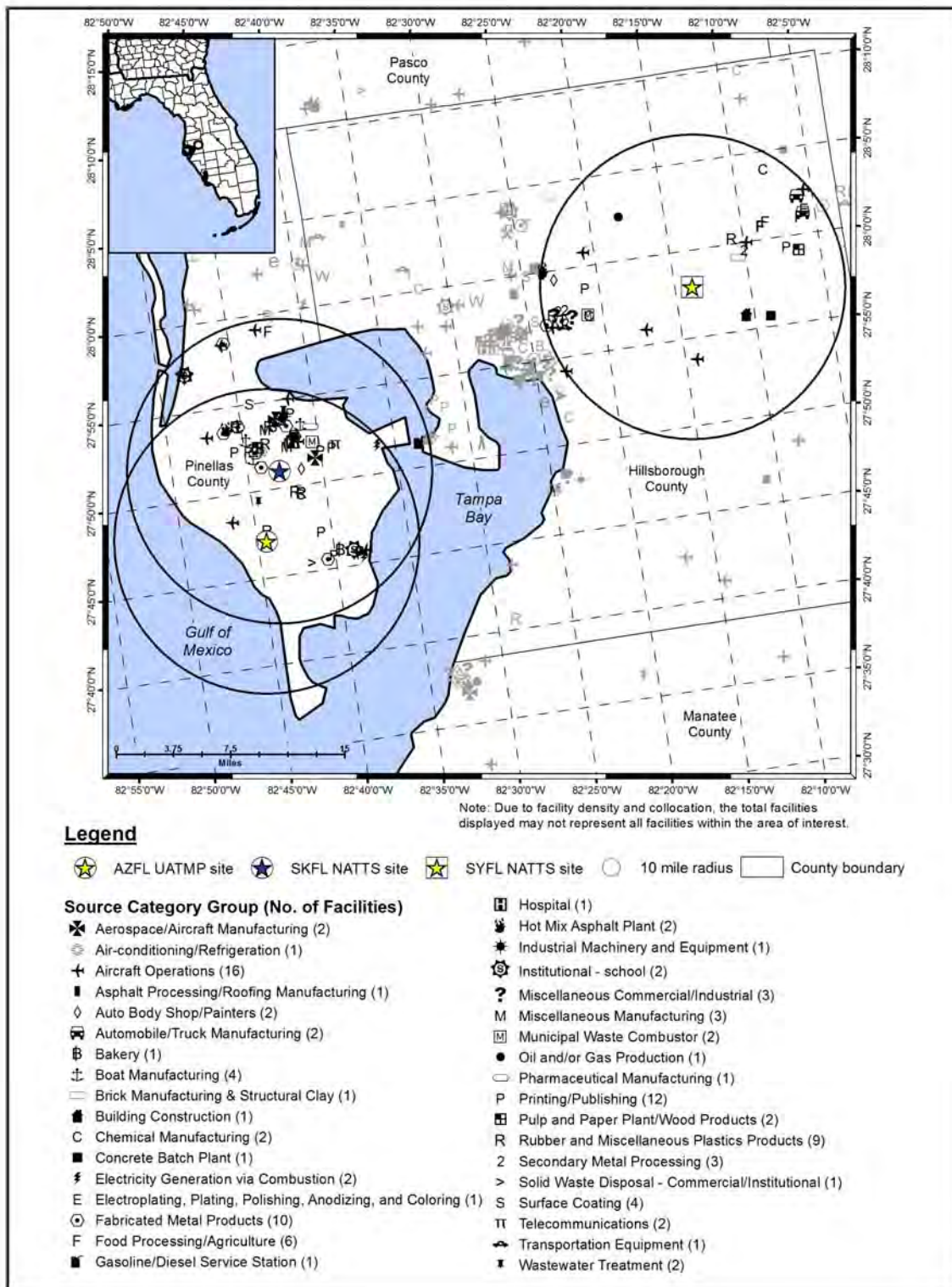
Figure 9-7. NEI Point Sources Located Within 10 Miles of ORFL and PAFL

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

Legend

⭐	ORFL UATMP site	★	PAFL UATMP site	◯	10 mile radius	▢ County boundary

Source Category Group (No. of Facilities)

- ✛ Aircraft Operations (23)
- ▮ Asphalt Processing/Roofing Manufacturing (1)
- ◇ Auto Body Shop/Painters (1)
- 🚚 Automobile/Truck Manufacturing (1)
- Ɓ Bakery (3)
- ± Boat Manufacturing (1)
- ▭ Brick Manufacturing & Structural Clay (1)
- △ Cement Kiln/Dryer (1)
- C Chemical Manufacturing (1)
- ⑪ Dry Cleaning (1)
- e Electrical Equipment (2)
- ⚡ Electricity Generation via Combustion (1)
- E Electroplating, Plating, Polishing, Anodizing, and Coloring (1)
- ⊙ Fabricated Metal Products (2)
- F Food Processing/Agriculture (2)

- ▤ Furniture Plant (2)
- ▪ Gasoline/Diesel Service Station (1)
- ⒣ Hospital (2)
- ♨ Hot Mix Asphalt Plant (4)
- ✳ Industrial Machinery and Equipment (2)
- ⚙ Institutional - school (3)
- ▽ Mineral Products (1)
- ? Miscellaneous Commercial/Industrial (5)
- M Miscellaneous Manufacturing (2)
- ● Oil and/or Gas Production (1)
- P Printing/Publishing (2)
- ▦ Pulp and Paper Plant/Wood Products (3)
- R Rubber and Miscellaneous Plastics Products (3)
- S Surface Coating (5)
- π Telecommunications (1)

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, VOC, 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	VOC, 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, VOC, 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, SO2, NO, NO_2, NO_x, VOC, 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] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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 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 with the Pinellas Park Ditch near a construction company in the bottom left corner of Figure 9-2. Population exposure is the purpose behind monitoring in this location and 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. Just 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 monitor. This site is the Tampa NATTS site.

Figure 9-6 shows the location of the Tampa/St. Petersburg sites in relation to each other. SYFL is located the furthest east and AZFL is the furthest west. 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 9-6. Aircraft operations, which include airports as well as small runways, heliports, or landing pads, printing and publishing facilities, and fabricated metal processing 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 9-4 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 9-5. 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 9-5). 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the Florida monitoring sites. Table 9-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 9-2 also contains annual average daily traffic information. Finally, Table 9-2 presents the daily VMT for Pinellas, Hillsborough, and Orange Counties.

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 is the eleventh most populous county of 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.

- With the exception of Pinellas County (AZFL and SKFL), the vehicle registration counts for the Florida sites are all over 1 million, with Hillsborough County having the most. 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 (Orange County) to 0.96 (Pinellas County).

- The traffic volume near SYFL is the lowest among the Florida sites and highest near SKFL. Traffic volumes near the Florida monitoring sites are mid-range 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
    SYFL – Martin Luther King Jr. Boulevard (574), east of McIntosh Road

- VMT is highest for Orange County and lowest for Pinellas County (among the Florida sites). The Orange, Hillsborough, and Pinellas County VMTs ranked seventh, ninth, and 12th highest among counties with NMP sites, respectively.

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	916,719	879,317	0.96	554,850	532,212	41,500	23,138,726
SKFL				672,114	644,692	49,500	
SYFL	1,233,846	1,125,844	0.91	323,844	295,497	10,700	34,745,256
ORFL	1,149,500	1,037,369	0.90	1,003,746	905,833	31,500	35,657,527
PAFL				872,658	787,532	43,500	

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the FL Dept of Highway Safety & Motor Vehicles (FL DHSMV, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data from the Florida DOT (FL DOT, 2010a)
[5] County-level VMT reflects 2010 data for all public roads from the Florida DOT (FL DOT, 2010b)
BOLD ITALICS = EPA-designated NATTS Site.

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, 2012).

9.2.2 Meteorological Conditions in 2010

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). These data were used to determine how meteorological conditions on sample days vary from normal conditions 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 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 2010. 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 2010 at the Florida monitoring sites were representative of average weather conditions throughout the entire year.

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	Sample Day	78.8 ± 3.2	72.3 ± 3.3	61.3 ± 3.5	65.6 ± 3.1	69.7 ± 2.0	1016.1 ± 1.1	7.3 ± 0.7
	94° (E)	2010	78.7 ± 1.3	72.3 ± 1.3	61.1 ± 1.4	65.5 ± 1.2	69.2 ± 0.9	1016.1 ± 0.4	7.3 ± 0.3
Pinellas Park, Florida - SKFL								
St Petersburg-Clearwater Intl Airport 12873 (27.91, -82.69)	4.46 miles	Sample Day	79.6 ± 3.0	71.3 ± 3.1	60.4 ± 3.3	64.7 ± 2.9	70.4 ± 2.0	1016.4 ± 1.0	7.0 ± 0.7
	12° (NNE)	2010	79.0 ± 1.3	70.7 ± 1.3	59.6 ± 1.4	64.2 ± 1.3	70.0 ± 1.0	1016.5 ± 0.4	6.9 ± 0.3
Plant City, Florida – SYFL								
Plant City Municipal Airport 92824 (28.00, -82.16)	4.56 miles	Sample Day	81.6 ± 3.2	70.4 ± 3.4	59.5 ± 3.6	63.9 ± 3.2	71.8 ± 2.0	NA	4.5 ± 0.5
	50° (NE)	2010	81.4 ± 1.3	70.3 ± 1.4	59.5 ± 1.5	63.9 ± 1.3	72.0 ± 0.9	NA	4.4 ± 0.2
Winter Park, Florida – ORFL								
Orlando Executive Airport 12841 (28.55, -81.33)	3.95 miles	Sample Day	79.8 ± 3.2	70.2 ± 3.2	59.0 ± 3.7	63.7 ± 3.2	70.5 ± 2.5	1016.9 ± 1.2	6.4 ± 0.7
	145° (SE)	2010	79.7 ± 1.3	70.0 ± 1.3	58.7 ± 1.6	63.5 ± 1.3	70.4 ± 1.2	1017.0 ± 0.4	6.1 ± 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 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	Sample Day	80.1 ± 4.4	70.8 ± 4.4	60.9 ± 4.7	64.9 ± 4.2	73.0 ± 3.6	1015.8 ± 1.8	6.3 ± 0.9
	111° (ESE)	2010	79.7 ± 1.3	70.0 ± 1.3	58.7 ± 1.6	63.5 ± 1.3	70.4 ± 1.2	1017.0 ± 0.4	6.1 ± 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 Plant City Municipal Airport

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 2010. Included in Figure 9-8 are four back trajectories per sample day. Figure 9-9 is the corresponding cluster analysis for 2010. 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the sites in Figures 9-8 through 9-17 represents 100 miles.

Figure 9-8. 2010 Composite Back Trajectory Map for AZFL
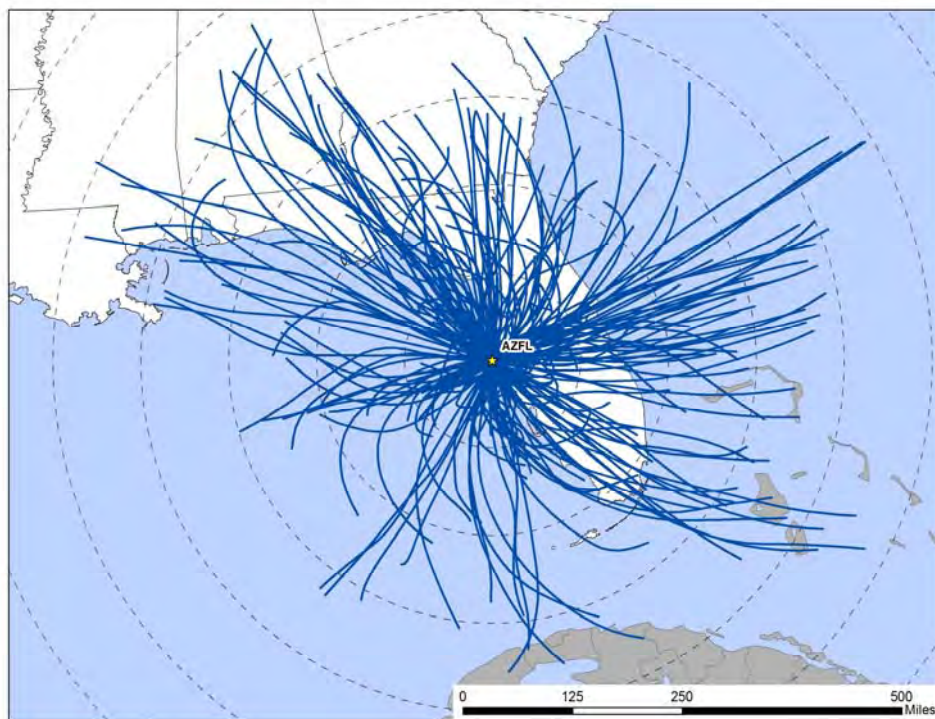
Figure 9-9. Back Trajectory Cluster Map for AZFL

Figure 9-10. 2010 Composite Back Trajectory Map for SKFL
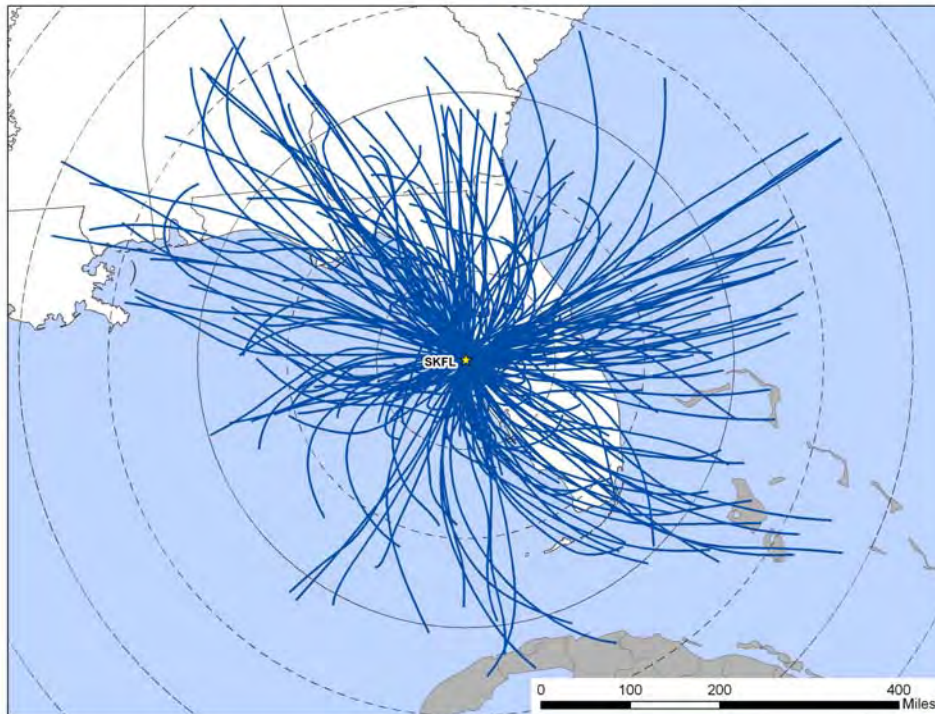
Figure 9-11. Back Trajectory Cluster Map for SKFL

Figure 9-12. 2010 Composite Back Trajectory Map for SYFL
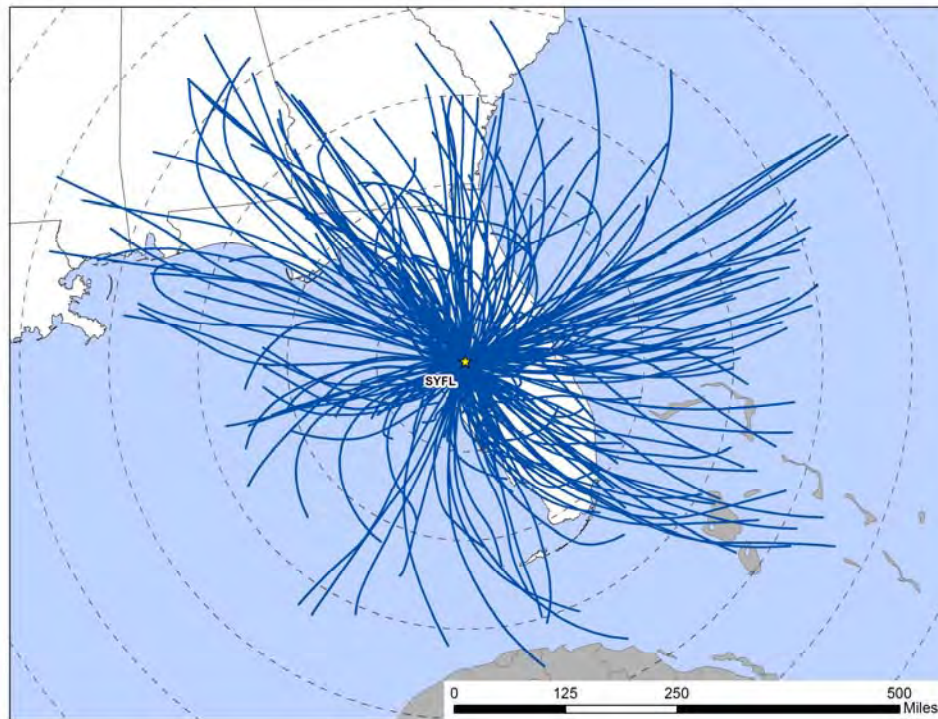
Figure 9-13. Back Trajectory Cluster Map for SYFL

Figure 9-14. 2010 Composite Back Trajectory Map for ORFL
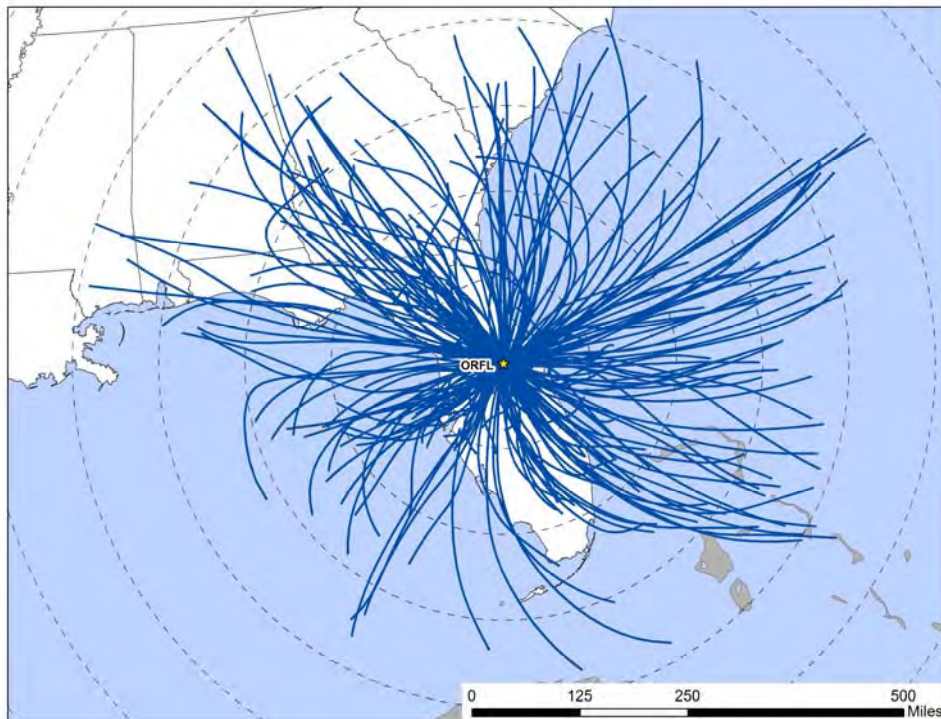
Figure 9-15. Back Trajectory Cluster Map for ORFL

Figure 9-16. 2010 Composite Back Trajectory Map for PAFL
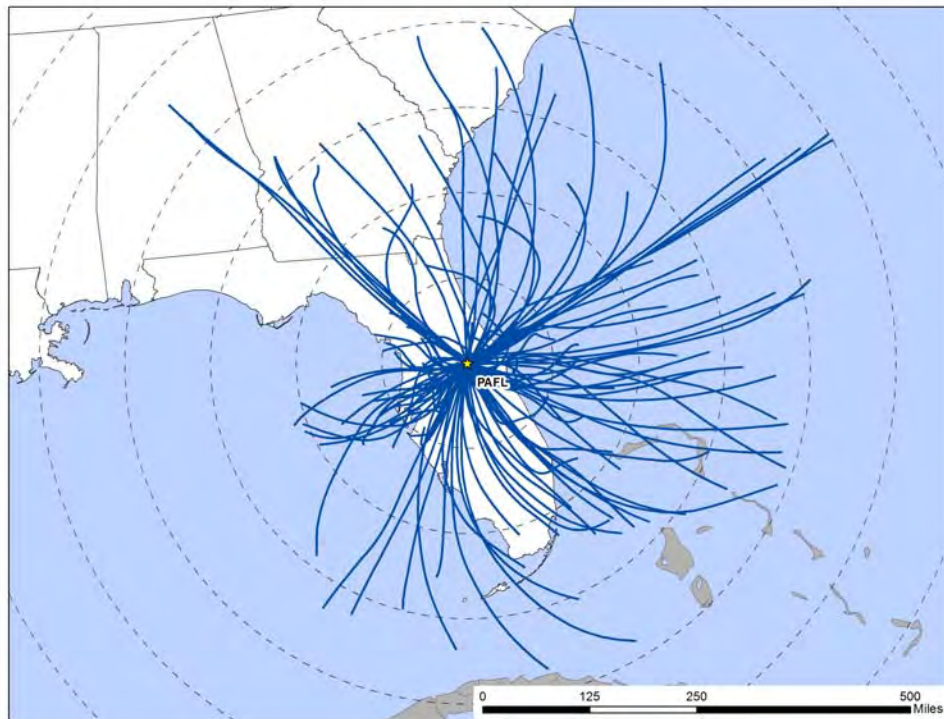
Figure 9-17. Back Trajectory Cluster Map for PAFL

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, even though their representative weather stations were different.

- 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. For all three sites, the farthest away a trajectory originated was just greater than 500 miles away in lower Mississippi. For SYFL, back trajectories of similar distance originated over the Atlantic Ocean.

- Most trajectories (between 88 and 92 percent for each site) originated within 400 miles of the Tampa/St. Petersburg monitoring sites. The average trajectory length ranged from 231 miles to 237 miles for each site.

- The back trajectories for AZFL are broken into four clusters. Forty-one percent of trajectories originated from south Florida westward over the Gulf of Mexico as well as those originating within 100 miles of AZFL. These trajectories were grouped together because many of them were of shorter length (originating less than 200 miles away). Another cluster of trajectories originated over the northern Gulf and southern U.S; these tended to originate farther away. A third cluster presents trajectories originating over Georgia, north Florida, and just off the east coast of north Florida.

9-21

The last cluster represents those originating over south Florida, the Bahamas, and north of the Bahamas and farther over the Atlantic.

- There are six clusters presented on the cluster analysis for SKFL. The division of trajectories for SKFL is similar to AZFL in geographical break up, but with two differences. First, trajectories originating over south Florida, the Bahamas, north of the Bahamas, and farther over the Atlantic are split into two clusters (16 and 9 percent). Second, the trajectory representing both shorter trajectories and ones originating over the Gulf of Mexico to the southwest of the Tampa area for AZFL are split into two back trajectories for SKFL (27 percent and 11 percent, respectively).

- The cluster map for SYFL is similar to AZFL in geographical breakup, but the percentages differ somewhat, particularly for those trajectories originating along the west coast of Florida and the Gulf of Mexico.

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

- Even though they are close in proximity to each other, the trajectory distribution for PAFL appears different than the trajectory distribution 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 other Florida monitoring sites. The farthest away a trajectory originated was approximately 500 miles away and over the Atlantic Ocean for both sites

- Similar to the Tampa/St. Petersburg sites, 90 and 92 percent of back trajectories originated with 400 miles of ORFL and PAFL, respectively. The average trajectory length for ORFL and PAFL varied though, with an average trajectory length of 251 miles for ORFL and 224 miles for PAFL.

- The composite back trajectory map for ORFL shows that back trajectories originated from a variety of directions around ORFL. The corresponding cluster map looks like a pinwheel, confirming that trajectories originated from a variety of directions. The short cluster representing 16 percent of trajectories includes trajectories originating over south-central Florida as well as several shorter trajectories originating from the east, southeast, and south of the site and within 100 miles of ORFL.

- The short cluster representing nearly 40 percent of PAFL's back trajectories includes back trajectories originating from both west-central Florida and the Gulf of Mexico as well as shorter trajectories originating from a variety of directions and within 100 miles of the site. The remaining clusters represent trajectories originating from the northwest and north (9 percent), the northeast (11 percent), the east and over the Atlantic Ocean (23 percent), and south Florida and the surrounding waters (20 percent).

9.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the AZFL monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. 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

1999-2009 Historical Wind Rose
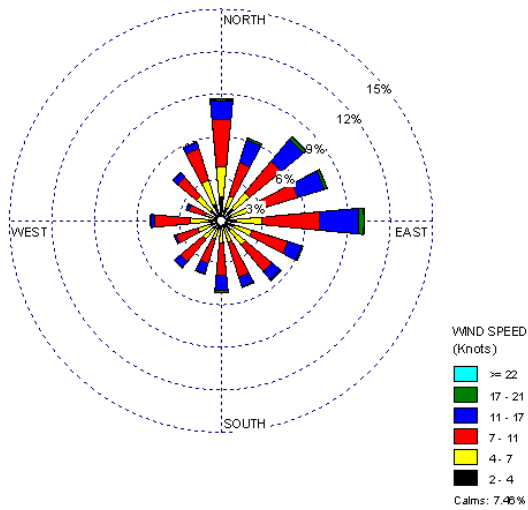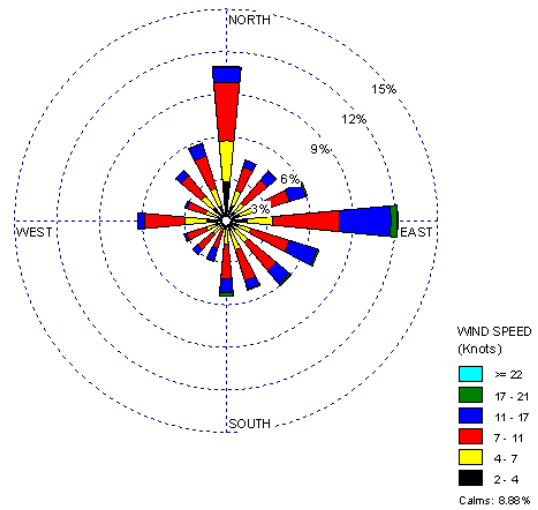
2010 Wind Rose

2010 Sample Day Wind Rose
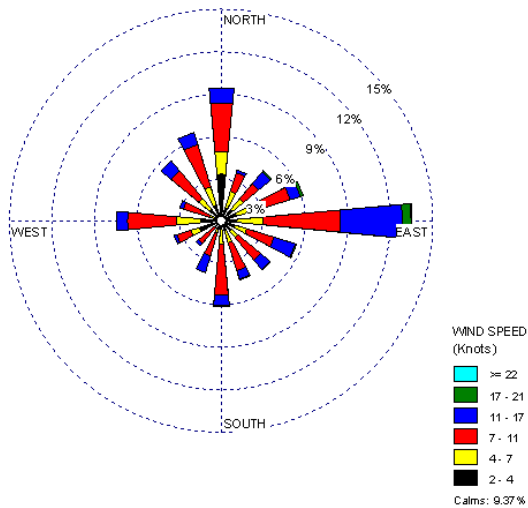
Distance between AZFL and NWS Station
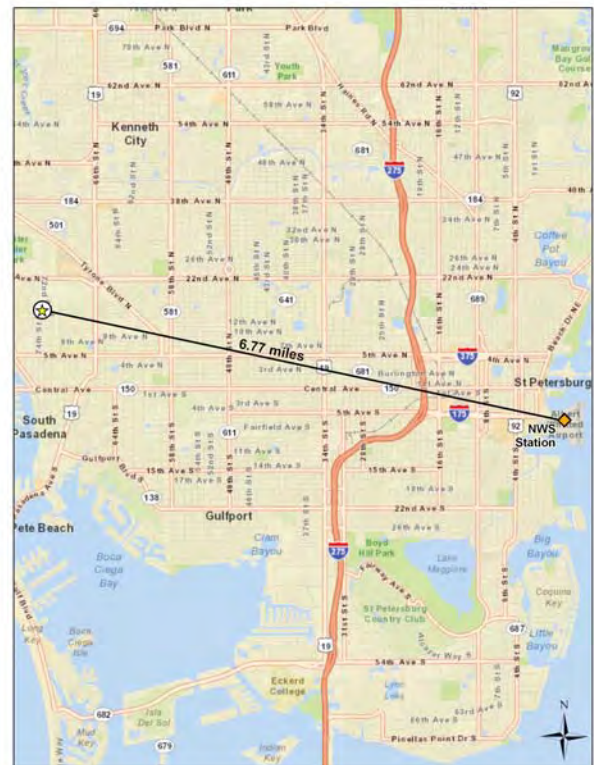
Figure 9-19. Wind Roses for the St. Petersburg/Clearwater International Airport Weather Station near SKFL

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between SKFL and NWS Station
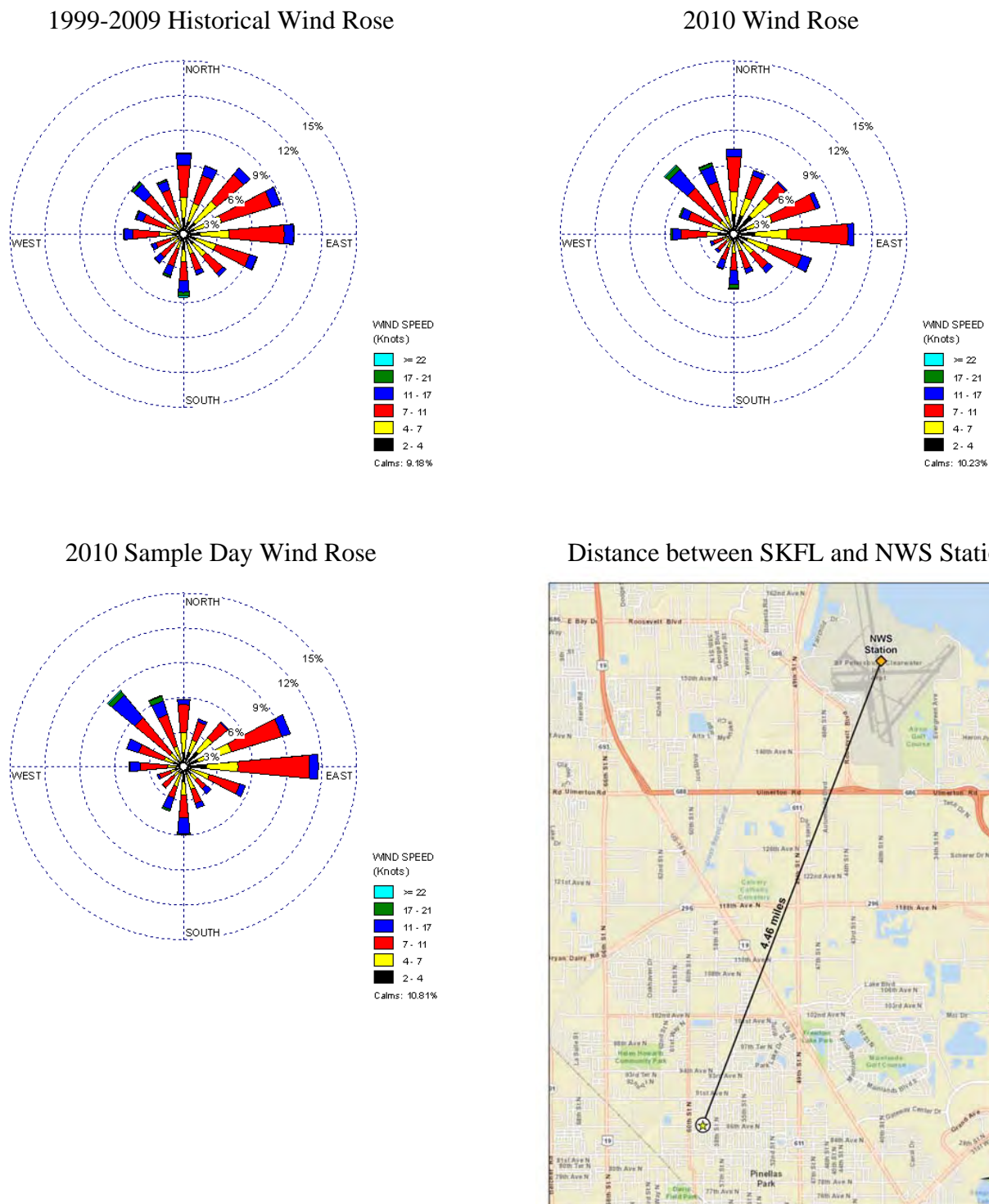
Figure 9-20. Wind Roses for the Plant City Municipal Airport Weather Station near SYFL

2008-2009 Historical Wind Rose
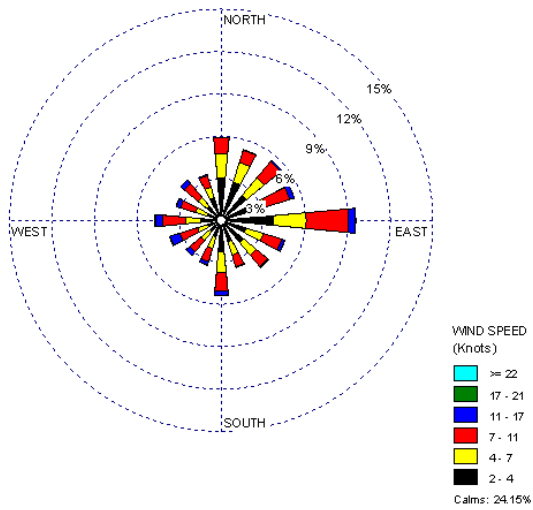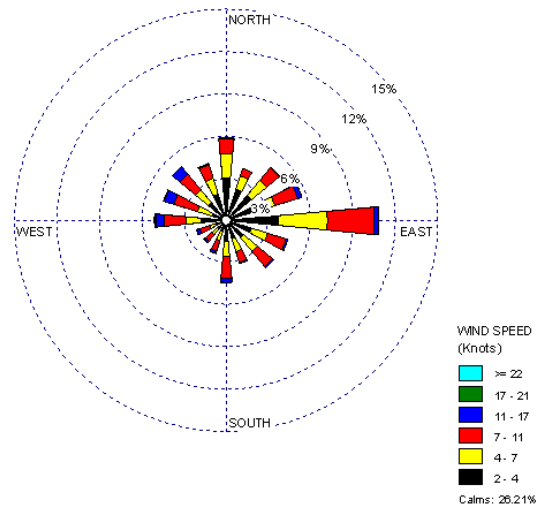
2010 Wind Rose

2010 Sample Day Wind Rose
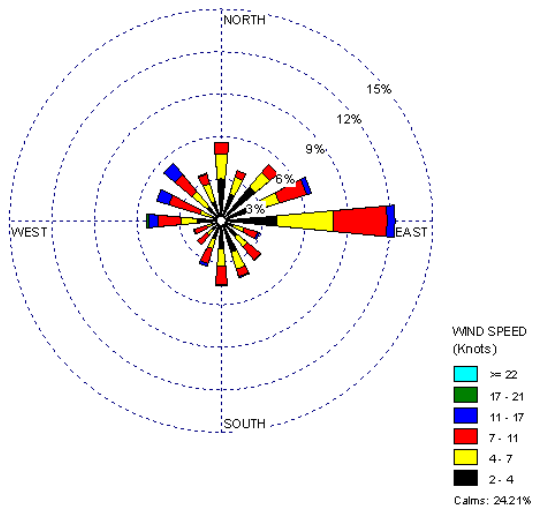
Distance between SYFL and NWS Station

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

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between ORFL and NWS Station
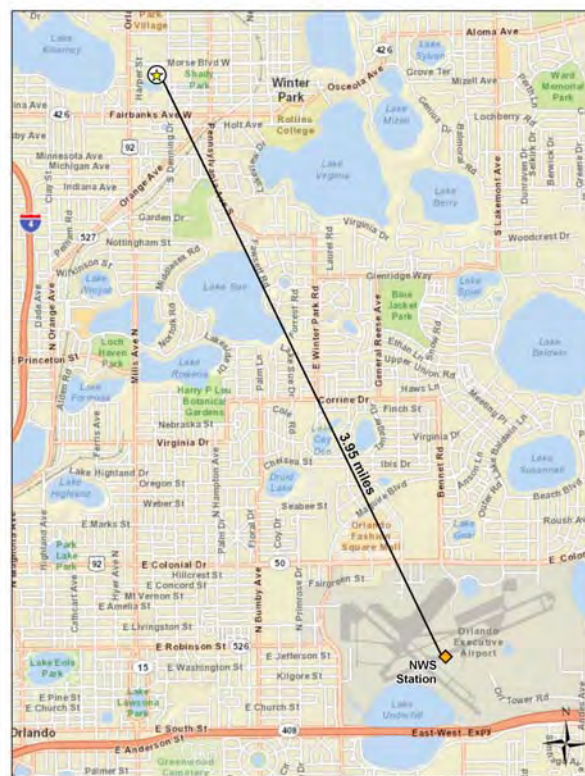
Figure 9-22. Wind Roses for the Orlando Executive Airport Weather Station near PAFL

1999-2009 Historical Wind Rose
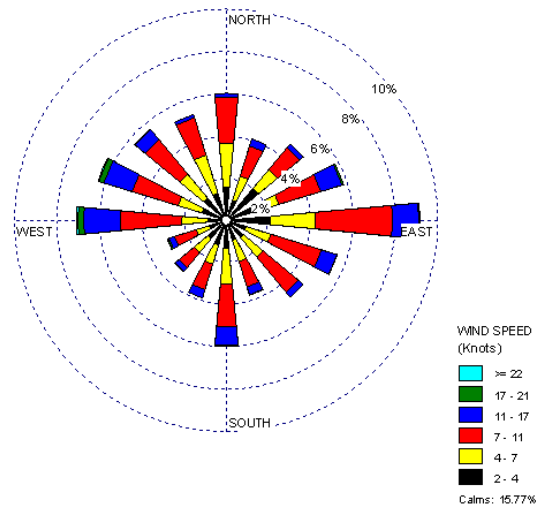
2010 Wind Rose

2010 Sample Day Wind Rose
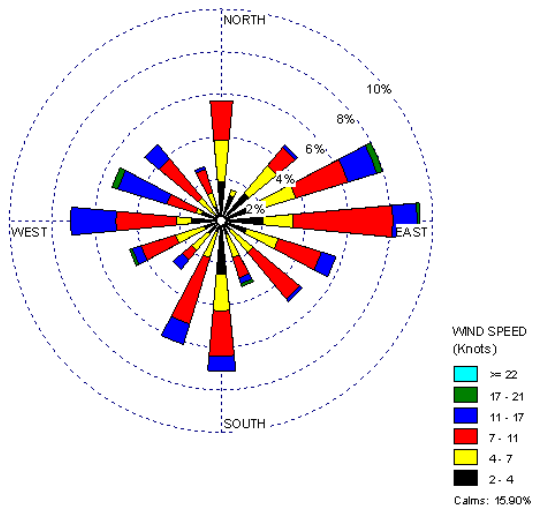
Distance between PAFL and NWS Station

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 from 1999 to 2009. Northerly, northeasterly, and easterly winds 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. There were fewer northeasterly winds observed in 2010 compared to historical observations. The calm rate in 2010 was similar to the historical calm rate, at just below 10 percent.

- The sample day wind patterns favor the full-year wind patterns, indicating the conditions on sample days were representative of wind conditions experienced in 2010.

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 from 1999 to 2009, although winds from the northeastern quadrant were the most commonly observed wind directions. Calm winds accounted for approximately 10 percent of the hourly wind measurements.

- The 2010 wind rose favors the historical wind rose, although there were more northwesterly and north-northwesterly winds and fewer northeasterly winds observed in 2010 than historically. The calm rate in 2010 was just over 10 percent.

- The sample day wind rose exhibits an even higher percentage of east-northeasterly, easterly, and northwesterly winds than the 2010 wind rose. The sample day calm rate was just below 11 percent.

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.

- The historical wind rose shows that calm winds (≤ 2 knots) account for approximately one-quarter of the hourly wind measurements during 2008 and 2009. Similar to SKFL, winds from the eastern quadrants were observed more often than the other 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, although the percentage of winds from due east was higher than the historical wind rose. This indicates 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 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 the same.

- The historical wind rose shows that from 1999 to 2009 winds from all directions were observed near these sites, with easterly winds being observed the most, although winds from the due north, due south, and with an easterly component were observed more often than winds from the remaining directions.

- The full-year wind roses also exhibit an easterly wind prominence, but winds from the northwest quadrant were observed more frequently during 2010.

- The 2010 sample day wind rose for ORFL is similar to the full-year wind rose, although with less southerly winds and more northerly winds. The 2010 sample day for PAFL shows less uniformity in the wind directions than ORFL. 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 screening, that pollutant was

added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 9-4 presents the pollutants of interest for each of the Florida 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. AZFL and ORFL sampled for carbonyl compounds only. SKFL and SYFL sampled hexavalent chromium and PAH in addition to carbonyl compounds. PAFL sampled only PM_{10} metals.

Table 9-4. Risk 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						
Acetaldehyde	0.45	61	61	100.00	50.00	50.00
Formaldehyde	0.077	61	61	100.00	50.00	100.00
Total		122	122	100.00		
Pinellas Park, Florida - SKFL						
Acetaldehyde	0.45	61	61	100.00	34.46	34.46
Formaldehyde	0.077	61	61	100.00	34.46	68.93
Naphthalene	0.029	55	59	93.22	31.07	100.00
Total		177	181	97.79		
Plant City, Florida - SYFL						
Acetaldehyde	0.45	61	61	100.00	38.61	38.61
Formaldehyde	0.077	61	61	100.00	38.61	77.22
Naphthalene	0.029	36	60	60.00	22.78	100.00
Total		158	182	86.81		
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	30	30	100.00	83.33	83.33
Manganese (PM_{10})	0.005	3	30	10.00	8.33	91.67
Nickel (PM_{10})	0.0021	2	30	6.67	5.56	97.22
Lead (PM_{10})	0.015	1	30	3.33	2.78	100.00
Total		36	120	30.00		

Observations from Table 9-4 include the following:

- Acetaldehyde and formaldehyde were the only two pollutants to fail screens for AZFL and ORFL. These two pollutants contributed equally to the total number of failed screens for each site and failed 100 percent of screens. These two sites sampled

only carbonyl compounds; among the carbonyls, only acetaldehyde, formaldehyde, and propionaldehyde have screening values. Propionaldehyde did not fail any screens for these sites.

- Four metals (arsenic, lead, nickel, and manganese) failed screens for PAFL; all of these are NATTS MQO Core Analytes. Arsenic, manganese, and nickel were initially identified as PAFL's pollutants of interest, with arsenic failing the bulk of the screens (83 percent). Lead was added as a pollutant of interest for PAFL because it is a NATTS MQO Core Analyte. Two additional metal NATTS MQO Core Analytes, cadmium and beryllium, were added to PAFL's pollutants of interest, even though they did not fail any screens. These two pollutants are not shown in Table 9-4.

- Three pollutants (acetaldehyde, formaldehyde, and naphthalene) failed screens for SKFL and SYFL, of which all three are NATTS MQO Core Analytes and were identified as pollutants of interest via the risk screening process. Two additional NATTS MQO Core Analytes, hexavalent chromium and benzo(a)pyrene, were added to SKFL and SYFL's pollutants of interest, even though they did not fail any screens. These two pollutants are not shown in Table 9-4 for either site.

- Acetaldehyde and formaldehyde failed 100 percent of screens for all four sites sampling carbonyl compounds. Of the PM_{10} metals sampled at PAFL, arsenic failed 100 percent of its screens.

9.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Florida monitoring sites. Concentration averages are provided for the pollutants of interest for each Florida site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site, where applicable. Additional site-specific statistical summaries are provided in Appendices L, M, N, and O.

9.4.1   2010 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 PAH, 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	61/61	3.69 ± 1.05	2.56 ± 0.50	1.76 ± 0.31	3.84 ± 0.84	2.94 ± 0.40
Formaldehyde	61/61	1.28 ± 0.22	1.58 ± 0.19	1.74 ± 0.44	2.22 ± 0.38	1.71 ± 0.18
Pinellas Park, Florida - SKFL						
Acetaldehyde	61/61	3.94 ± 1.31	2.71 ± 0.48	2.34 ± 0.24	4.53 ± 1.18	3.36 ± 0.48
Formaldehyde	61/61	0.97 ± 0.22	1.59 ± 0.22	1.34 ± 0.16	1.00 ± 0.19	1.23 ± 0.11
Benzo(a)pyrene[a]	36/59	0.11 ± 0.05	0.02 ± 0.01	0.01 ± 0.01	0.08 ± 0.05	0.05 ± 0.02
Hexavalent Chromium[a]	52/61	0.01 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.02 ± <0.01
Naphthalene[a]	59/59	87.45 ± 42.11	69.53 ± 22.27	75.00 ± 22.76	128.98 ± 45.22	90.08 ± 17.04
Plant City, Florida - SYFL						
Acetaldehyde	61/61	1.68 ± 0.36	1.71 ± 0.33	1.41 ± 0.47	1.23 ± 0.20	1.51 ± 0.18
Formaldehyde	61/61	1.65 ± 0.33	3.50 ± 0.99	3.58 ± 1.46	2.23 ± 0.43	2.76 ± 0.49
Benzo(a)pyrene[a]	15/60	0.03 ± 0.02	<0.01 ± 0.01	0	0.03 ± 0.02	0.02 ± 0.01
Hexavalent Chromium[a]	34/57	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	0.01 ± <0.01	0.01 ± <0.01
Naphthalene[a]	60/60	42.41 ± 13.63	38.80 ± 9.98	41.46 ± 11.87	50.68 ± 13.05	43.38 ± 5.88

[a] Average concentrations provided below the black 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Winter Park, Florida - ORFL						
Acetaldehyde	60/60	1.79 ± 0.55	1.08 ± 0.25	1.09 ± 0.46	1.87 ± 0.60	1.45 ± 0.25
Formaldehyde	60/60	1.18 ± 0.34	2.47 ± 0.40	2.25 ± 0.44	1.73 ± 0.54	1.92 ± 0.24
Orlando, Florida - PAFL[a]						
Arsenic (PM$_{10}$)[a]	30/30	0.73 ± 0.26	0.43 ± 0.13	0.43 ± 0.13	0.71 ± 0.24	0.57 ± 0.10
Beryllium (PM$_{10}$)[a]	30/30	<0.01 ± <0.01	<0.01 ± <0.01	0.01 ± 0.01	<0.01 ± <0.01	<0.01 ± <0.01
Cadmium (PM$_{10}$)[a]	30/30	0.08 ± 0.03	0.06 ± 0.02	0.04 ± 0.01	0.07 ± 0.02	0.06 ± 0.01
Lead (PM$_{10}$)[a]	30/30	4.67 ± 4.91	3.41 ± 2.68	1.87 ± 1.78	2.48 ± 1.49	3.08 ± 1.34
Manganese (PM$_{10}$)[a]	30/30	2.08 ± 0.78	2.95 ± 0.97	4.53 ± 3.46	2.41 ± 1.29	3.04 ± 0.97
Nickel (PM$_{10}$)[a]	30/30	0.89 ± 0.38	1.59 ± 0.72	0.78 ± 0.18	0.91 ± 0.32	1.05 ± 0.24

[a] Average concentrations provided below the black line for this site and/or pollutant are presented in ng/m³ for ease of viewing.

Observations from Table 9-5 include the following:

- SKFL's annual average concentration of acetaldehyde is the highest annual average concentration among the Florida sites. The annual average concentrations of acetaldehyde range from 1.45 ± 0.25 µg/m³ (ORFL) to 3.36 ± 0.48 µg/m³ (SKFL).

- The first and fourth quarter acetaldehyde averages for both AZFL and SKFL are greater than the other quarterly average concentrations and have relatively large confidence intervals associated with them. For AZFL, each of the three concentrations (out of 61) greater than 6 µg/m³ was measured during the first and fourth quarters of 2010. Of the seven concentrations (also out of 61) greater than 6 µg/m³ measured at SKFL, all were measured during the first and fourth quarters of 2010.

- Formaldehyde is the only other pollutant with annual average concentration greater than 1 µg/m³. The annual average concentrations of formaldehyde range from 1.23 ± 0.11 µg/m³ (SKFL) to 2.76 ± 0.49 µg/m³ (SYFL).

- The second and third quarter formaldehyde averages for SYFL are greater than the other quarterly average concentrations and have relatively large confidence intervals associated with them. For SYFL, the two highest concentrations of formaldehyde were measured in July (13.9 µg/m³), which is the seventh highest formaldehyde

concentration among all NMP sites sampling this pollutant, and June (9.21 µg/m^3). The next highest measurement, also measured in June, is 4.60 µg/m^3.

- As previously discussed, SKFL and SYFL both sampled hexavalent chromium and PAH 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 roughly twice as high at SKFL than at SYFL.

- Concentrations of benzo(a)pyrene appear higher during the colder months at SKFL. Of the nine concentrations of this pollutant greater than 0.1 ng/m^3, all were measured during the first and fourth quarters of 2010 (five during the first quarter and four during the fourth quarter). Similarly, naphthalene appears to exhibit a quarterly trend, with higher quarterly averages for the colder months of the year. However, the confidence intervals indicate that this difference is not statistically significant.

- For PAFL, lead and manganese have the highest annual average concentrations among the PM$_{10}$ metals. The first quarter lead average for 2010 is much higher than the other quarterly averages and also has a large confidence interval. A review of the data shows that the highest concentration of lead was measured on March 9, 2010 (17.6 ng/m^3) and is 50 percent higher than the next highest concentration measured on April 2, 2010 (11.7 ng/m^3). These are the only two measurements of lead greater than 10 ng/m^3.

- For PAFL, the third quarter manganese average for 2010 is much higher than the other quarterly averages and also has a large confidence interval. A review of the data shows that two highest concentrations of manganese were measured during the summer (13.9 ng/m^3 on August 12, 2010 and 8.20 ng/m^3 on July 19, 2010). The next highest concentration was measured in October (5.39 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:

- As shown in Table 4-10, SKFL and AZFL rank second and third highest, respectively, for acetaldehyde among all NMP sites sampling carbonyl compounds.

- PAFL's annual average concentration of beryllium is the third highest among NMP sites sampling PM$_{10}$ metals, as shown in Table 4-12. PAFL also has the fourth highest annual average concentration of lead and the fifth highest annual average concentration of arsenic and nickel. Note however, that only nine NMP sites sampled PM$_{10}$ metals.

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 and manganese for PAFL. Figures 9-23 through 9-29 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 9-23. Program vs. Site-Specific Average Acetaldehyde Concentration
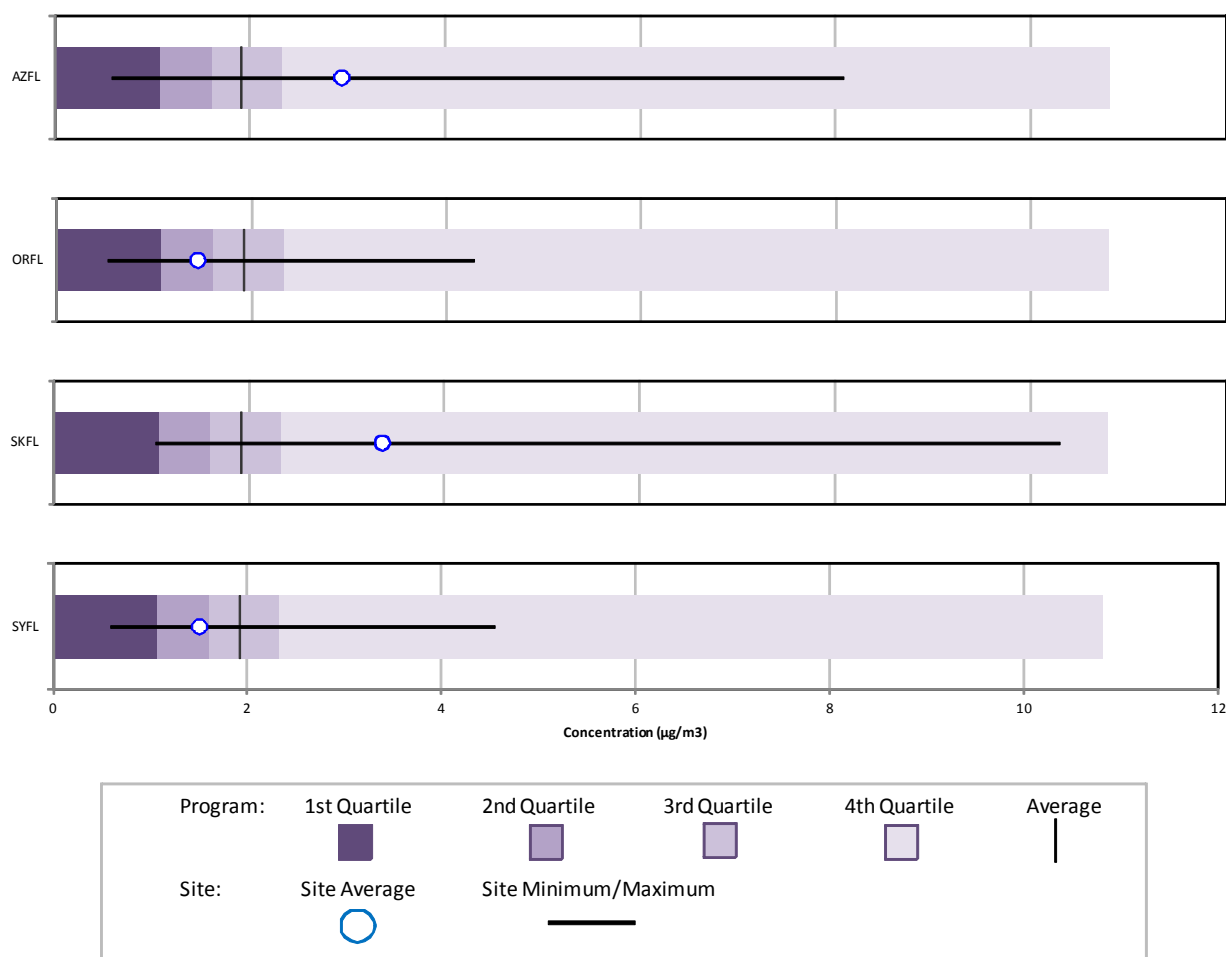
Figure 9-24. Program vs. Site-Specific Average Arsenic (PM$_{10}$) Concentration
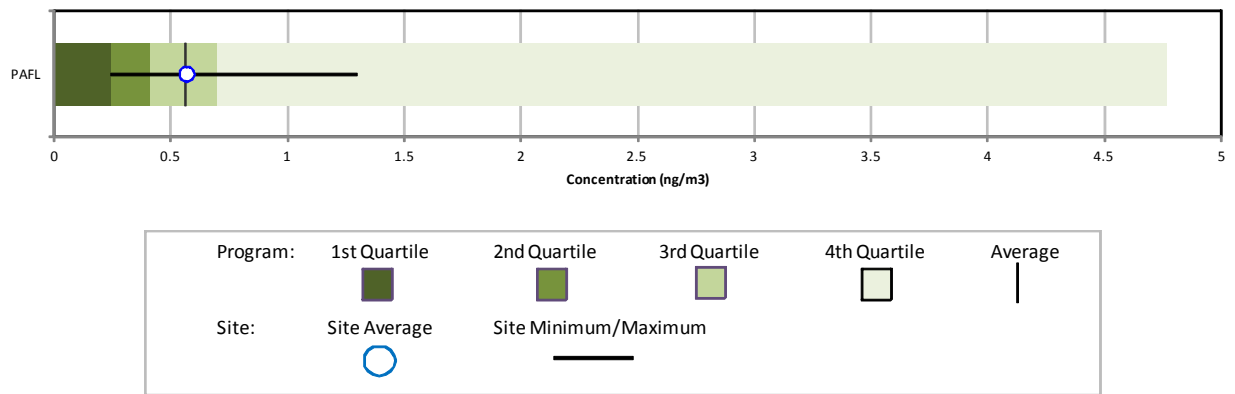
Figure 9-25. Program vs. Site-Specific Average Benzo(a)pyrene Concentration
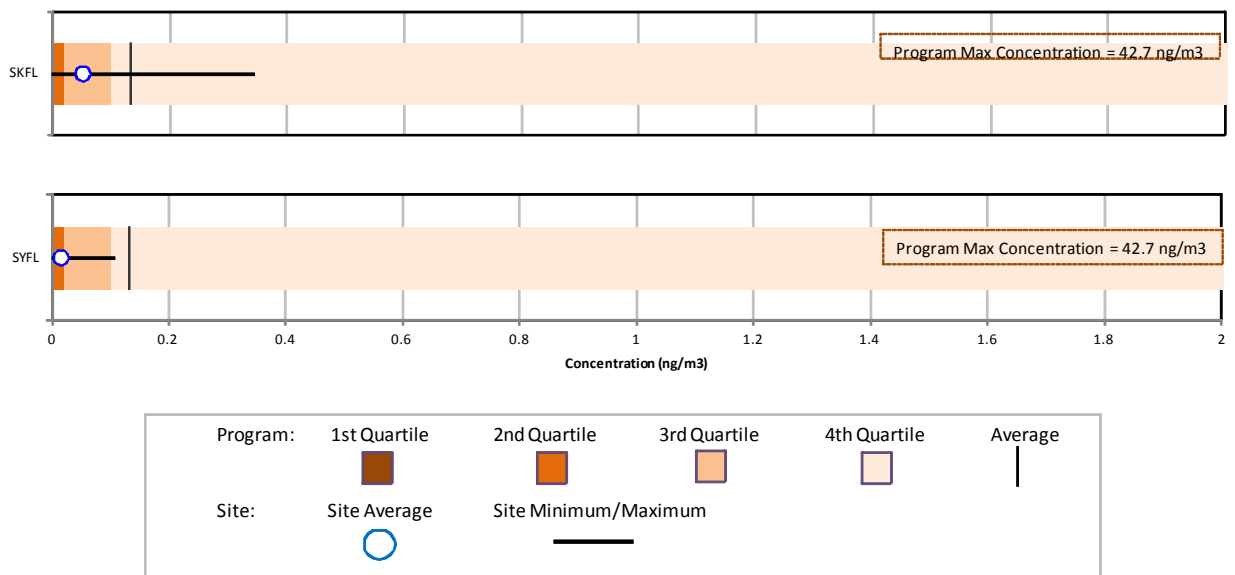
Figure 9-26. Program vs. Site-Specific Average Formaldehyde Concentration
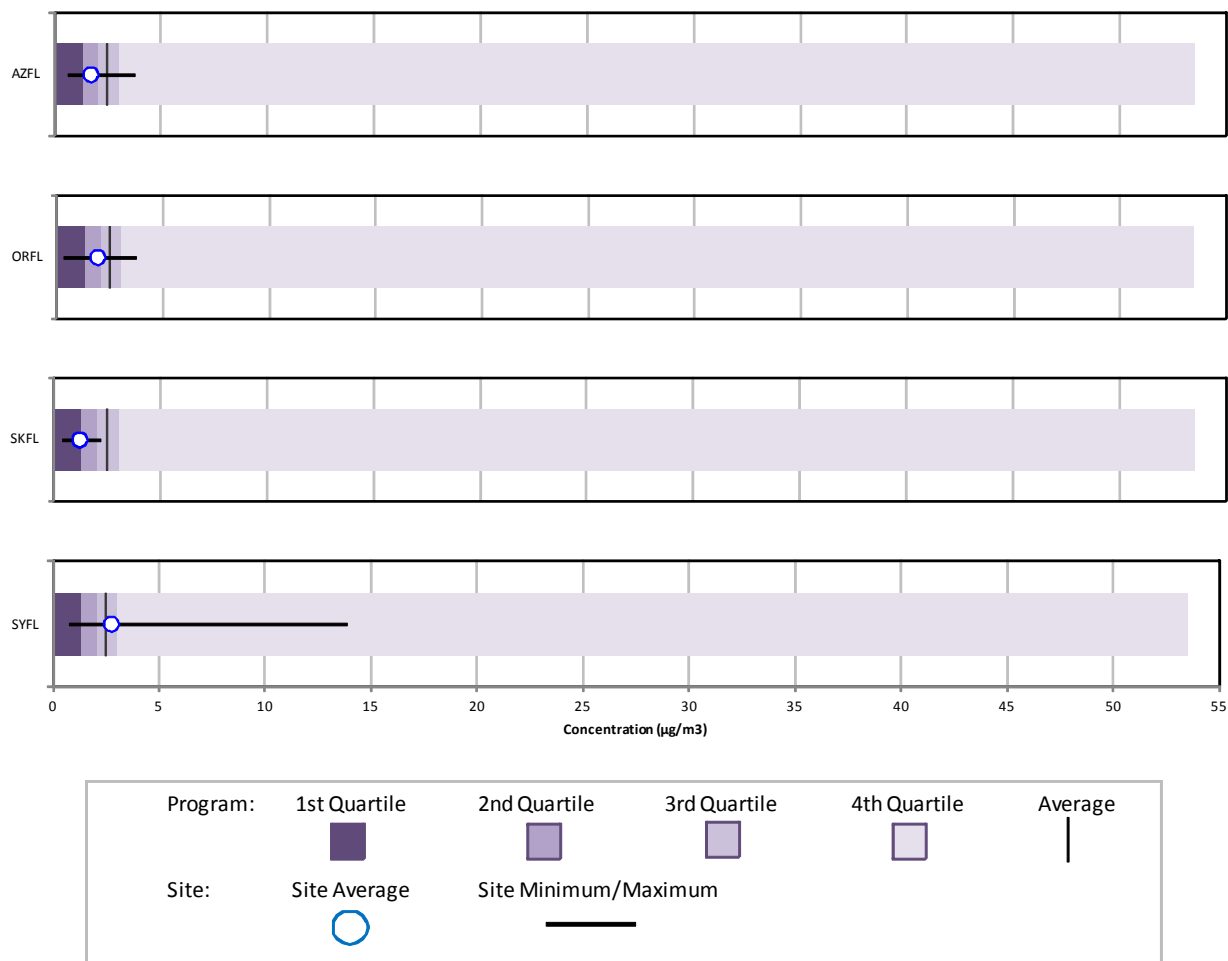
Figure 9-27. Program vs. Site-Specific Average Hexavalent Chromium Concentration
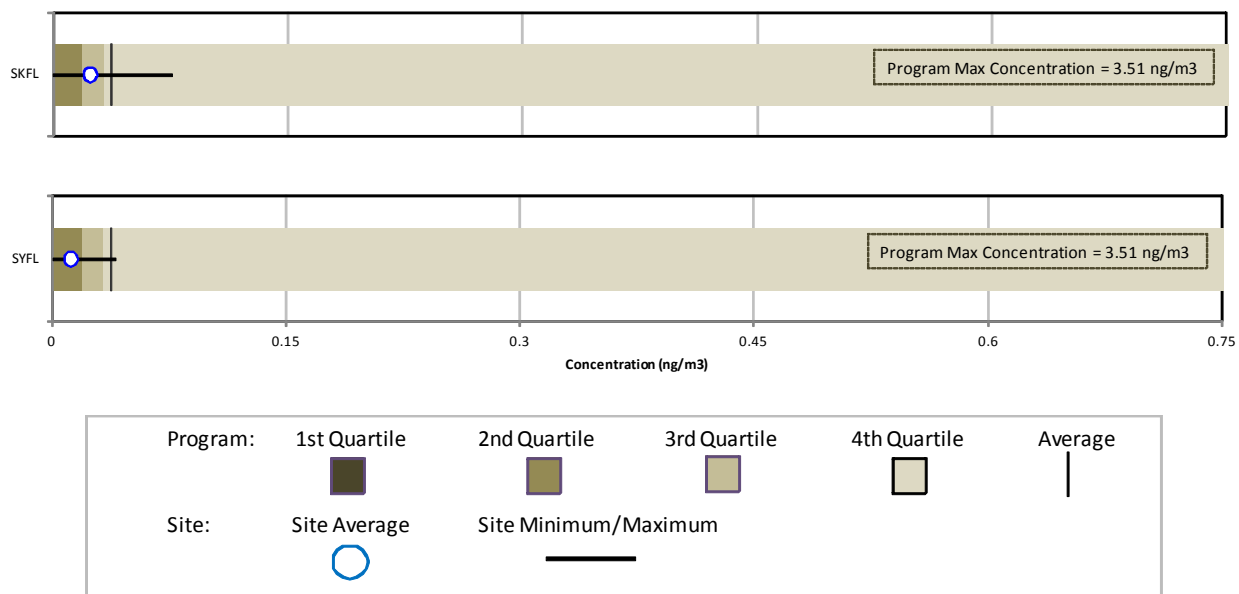
Figure 9-28. Program vs. Site-Specific Average Manganese (PM₁₀) Concentration
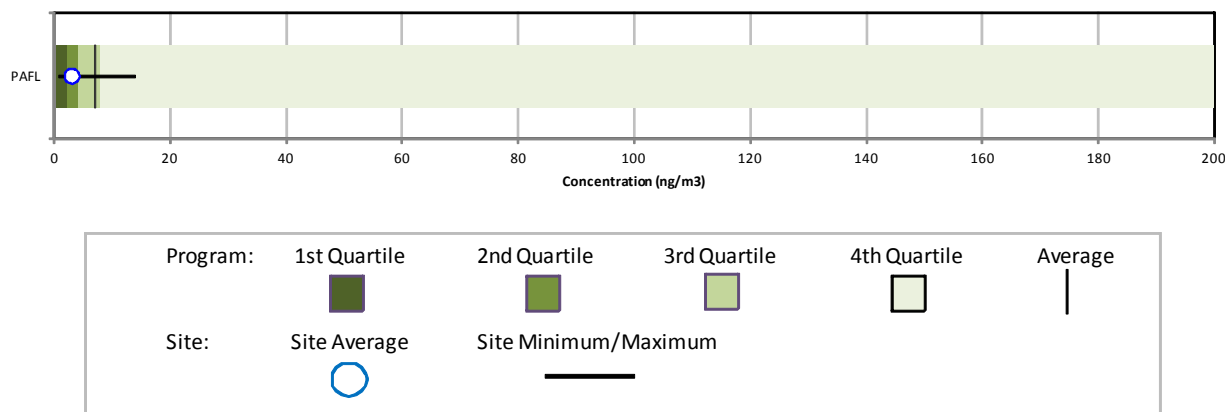
Figure 9-29. Program vs. Site-Specific Average Naphthalene Concentration
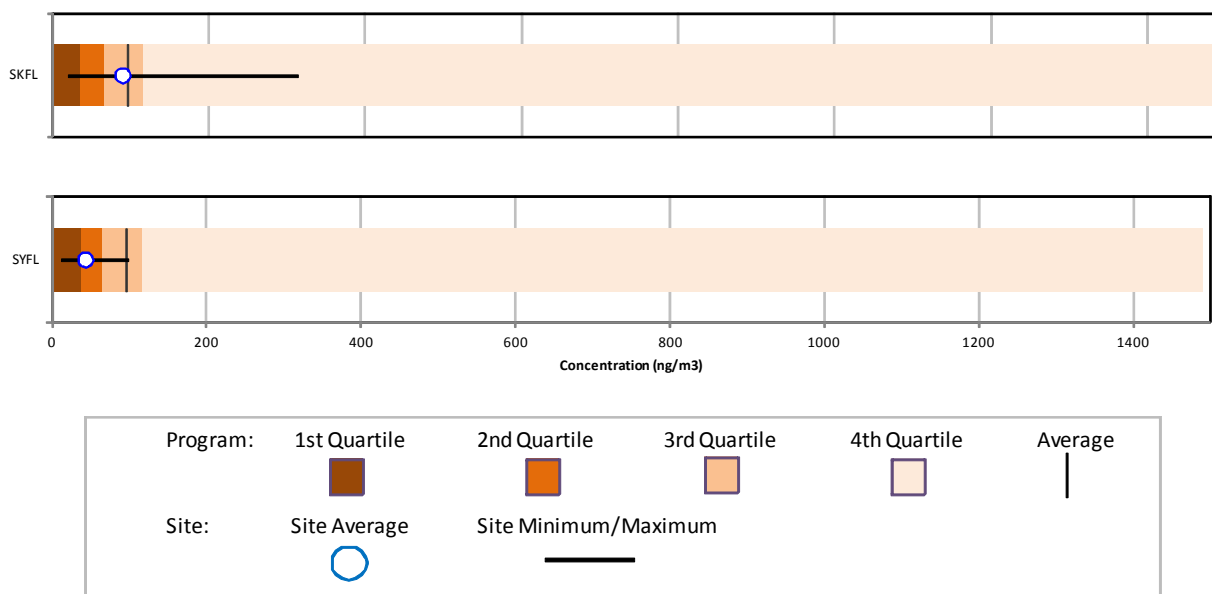
Observations from Figures 9-23 through 9-29 include the following:

- Figure 9-23 for acetaldehyde shows that annual average concentrations for two sites (AZFL and SKFL) are greater than the program-level average while annual averages for the other two sites are less than the program-level average. SKFL's maximum concentration is the second highest concentration measured among NMP sites sampling acetaldehyde. There were no non-detects of acetaldehyde measured at the Florida sites.

- Figure 9-24 for arsenic shows that PAFL's annual average concentration is similar to the program-level average concentration. The minimum arsenic concentration measured at PAFL is just greater than the program-level first quartile (or 25th percentile).

- Figure 9-25 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 SKFL is greater than the annual average concentration for SYFL and that both annual average concentrations are less than the program-level average concentration. Figure 9-25 also shows that the maximum concentration measured at SKFL is well below the maximum concentration measured across the program. The maximum concentration measured at SYFL is less than the program-level average concentration.

- Figure 9-26 for formaldehyde shows that the annual average concentrations of formaldehyde for AZFL, SKFL, and ORFL are less than the program-level average while SYFL's annual average is just greater than the program-level average. Note that the range of formaldehyde concentrations measured at AZFL, SKFL, and ORFL is relatively small compared to SYFL and at the program level.

- Figure 9-27 is the box plot for hexavalent chromium, which was measured at SKFL and SYFL. Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 9-27 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Both sites' annual average concentrations are less than the program-level average and SYFL's annual average concentration is also less than the program-level median concentration. The maximum concentrations measured at SKFL and SYFL are well below the maximum concentration measured among all NMP sites sampling this pollutant. Note that the maximum concentration measured at SYFL is just greater than the average concentration measured at the program level.

- Figure 9-28 for manganese shows that PAFL's annual average concentration is less than the program-level average concentration. PAFL's annual average manganese concentration is roughly half the program-level average. The maximum manganese concentration measured at PAFL is well below the maximum concentration measured among all NMP sites sampling PM$_{10}$ metals.

- Figure 9-29 is the box plot for naphthalene. This box plot shows that the annual average concentration for SKFL is greater than the annual average concentration for SYFL and just below the program-level average concentration. The range of concentrations measured at SKFL is much larger than the range of concentrations measured at SYFL. The maximum concentration measured at SYFL is just greater than the program-level average concentration.

9.4.3   Concentration Trends

A site-specific trends evaluation was completed for sites that have sampled one or more of the 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 9-30 through 9-37 present the 3-year rolling statistical metrics for acetaldehyde and formaldehyde for each of these sites. In addition, SYFL has sampled hexavalent chromium since 2005; thus, Figure 9-38 presents the 3-year rolling statistical metrics for hexavalent chromium for SYFL. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Observations from Figure 9-30 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, but a similar concentration was also measured in 2003.

- The rolling average and median concentrations increased through the 2003-2005 time frame then began to decrease significantly. The rolling average began to increase for the last two time frames, although the median did not begin to increase again until the 2008-2010 time frame. Even with these increases, the rolling average concentrations remained below the levels from the earlier years.

- Prior to 2010, there had been 17 concentrations of acetaldehyde greater than 5 $\mu g/m^3$ measured at AZFL (six of them were measured in 2003, five in 2004, and six in 2009, with none measured in the years in between). With the addition of 2010 data, that number increases to 24, with seven concentrations greater than 5 $\mu g/m^3$ measured in 2010.

- With the exception of the 2001-2003 time frame, the minimum concentration for each 3-year period is greater than zero. Only two non-detects of acetaldehyde have been reported since the onset of carbonyl compound sampling (both in 2001).

Figure 9-30. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at AZFL
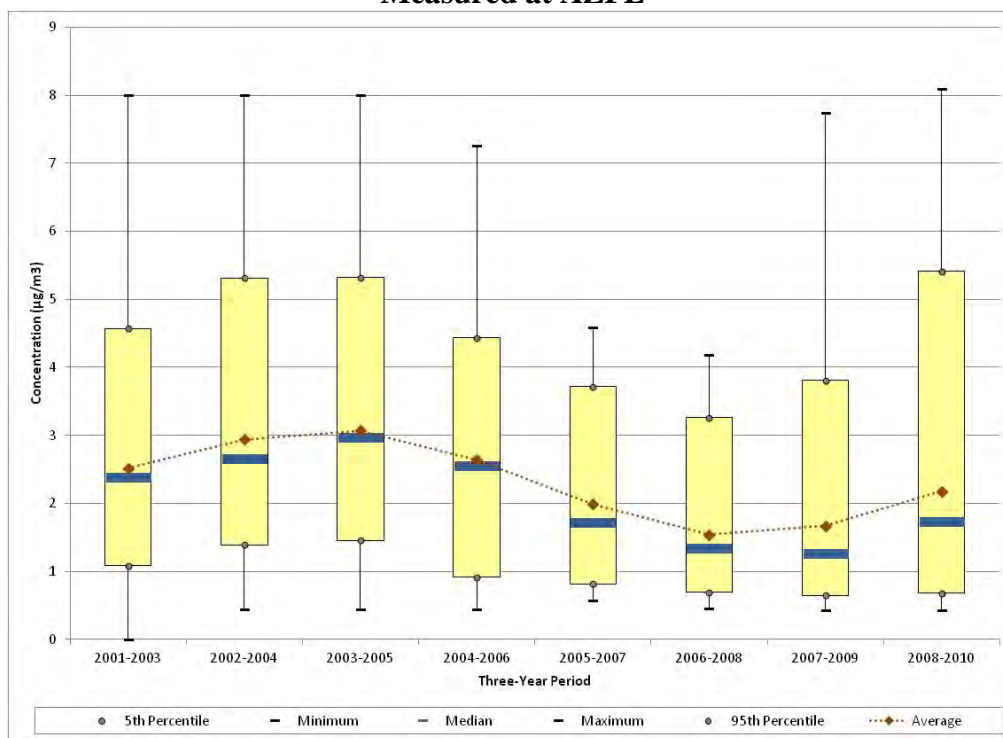
Figure 9-31. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at AZFL
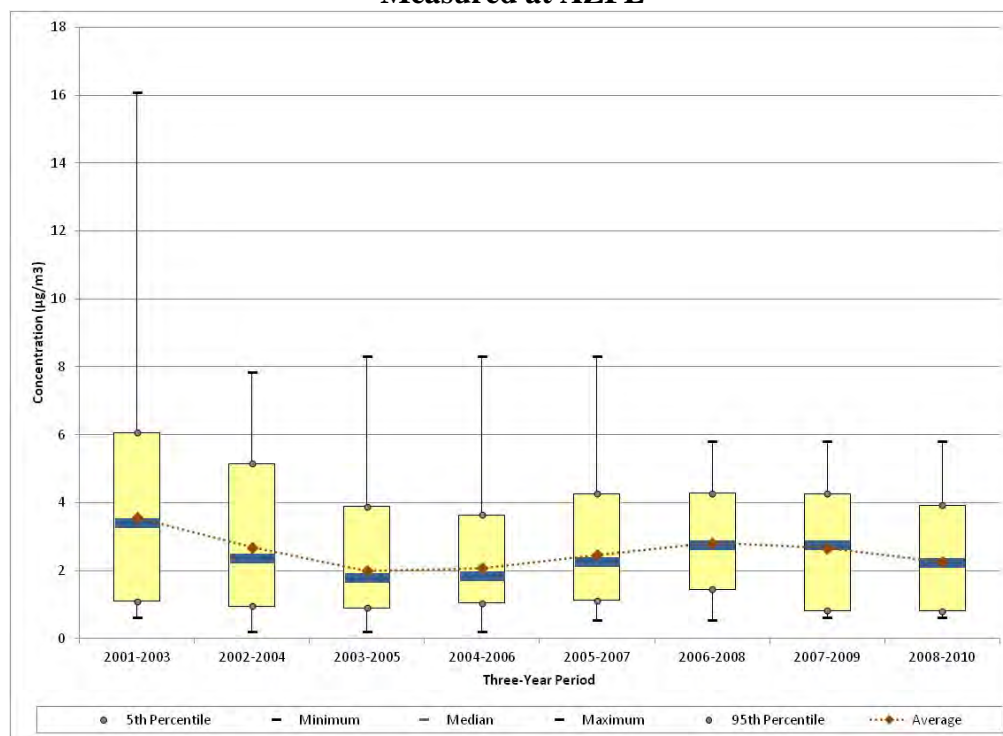
Figure 9-32. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at ORFL
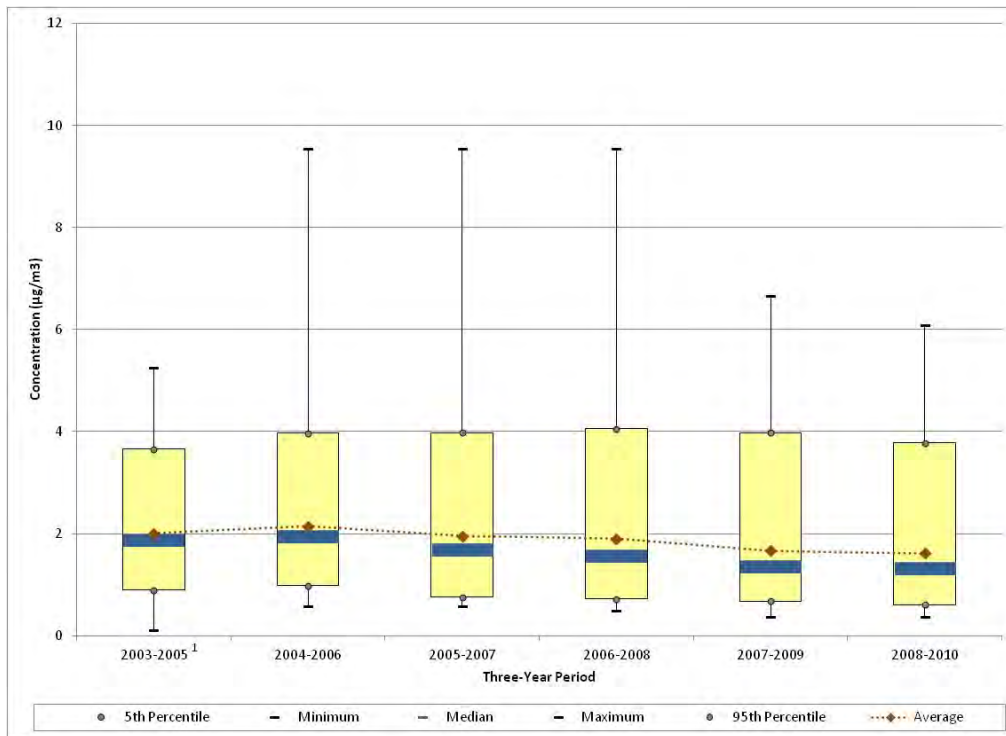
[1]Sampling for carbonyl compounds at ORFL began in April 2003.

Figure 9-33. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at ORFL
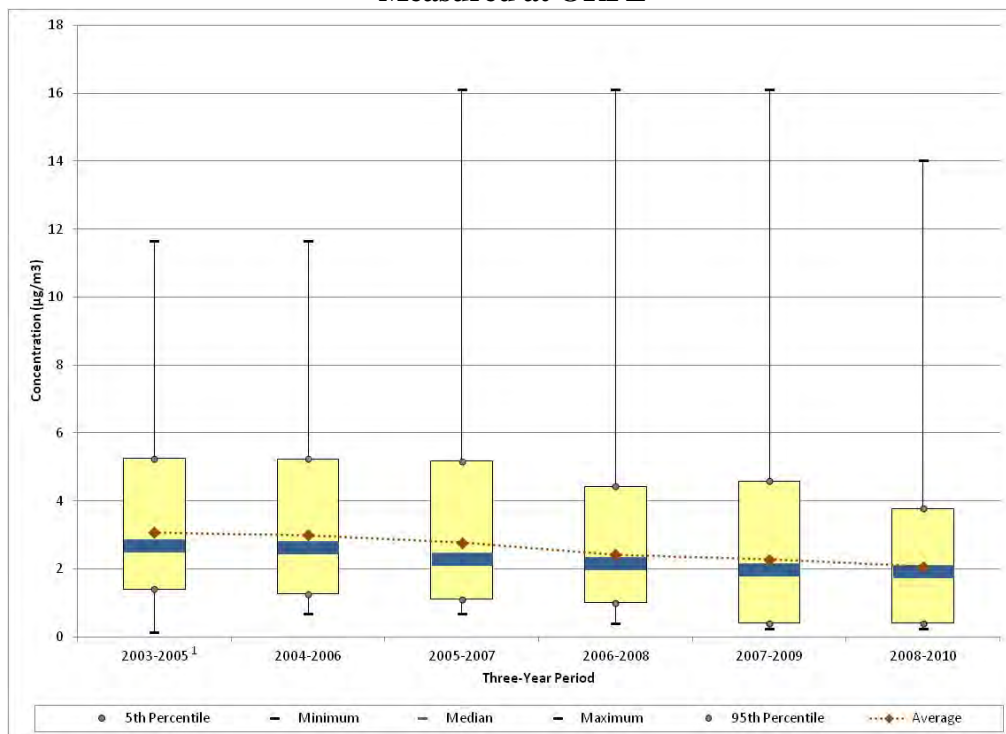
[1]Sampling for carbonyl compounds at ORFL began in April 2003.

Figure 9-34. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at SKFL
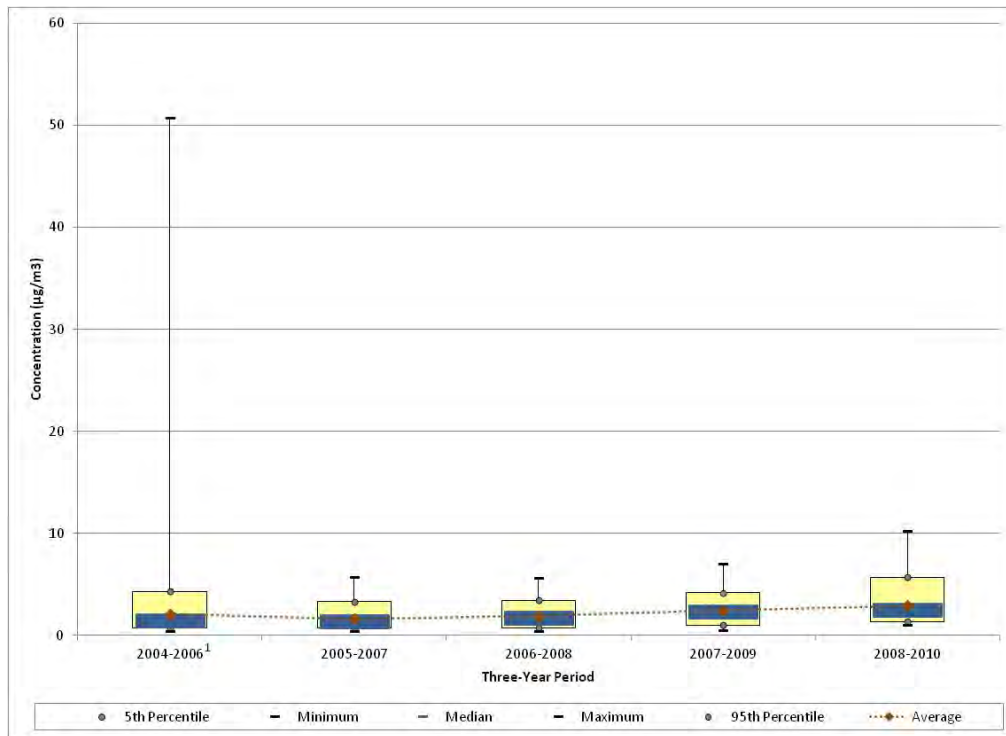
[1]Sampling for carbonyl compounds at SKFL began in July 2004.

Figure 9-35. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at SKFL
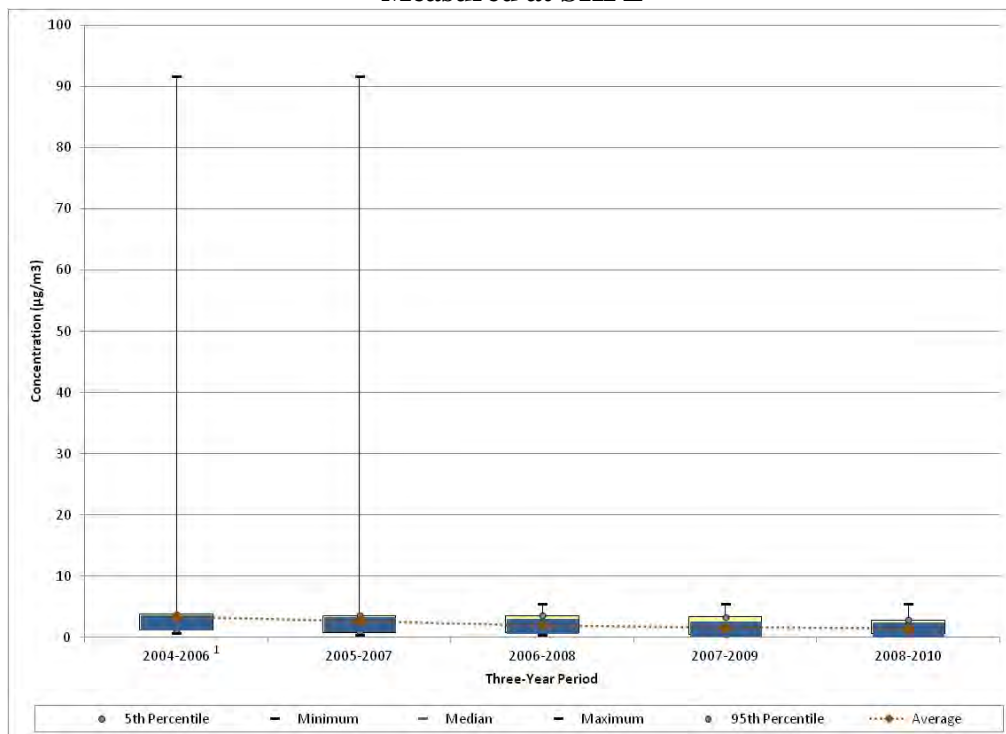
[1]Sampling for carbonyl compounds at SKFL began in July 2004.

Figure 9-36. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at SYFL
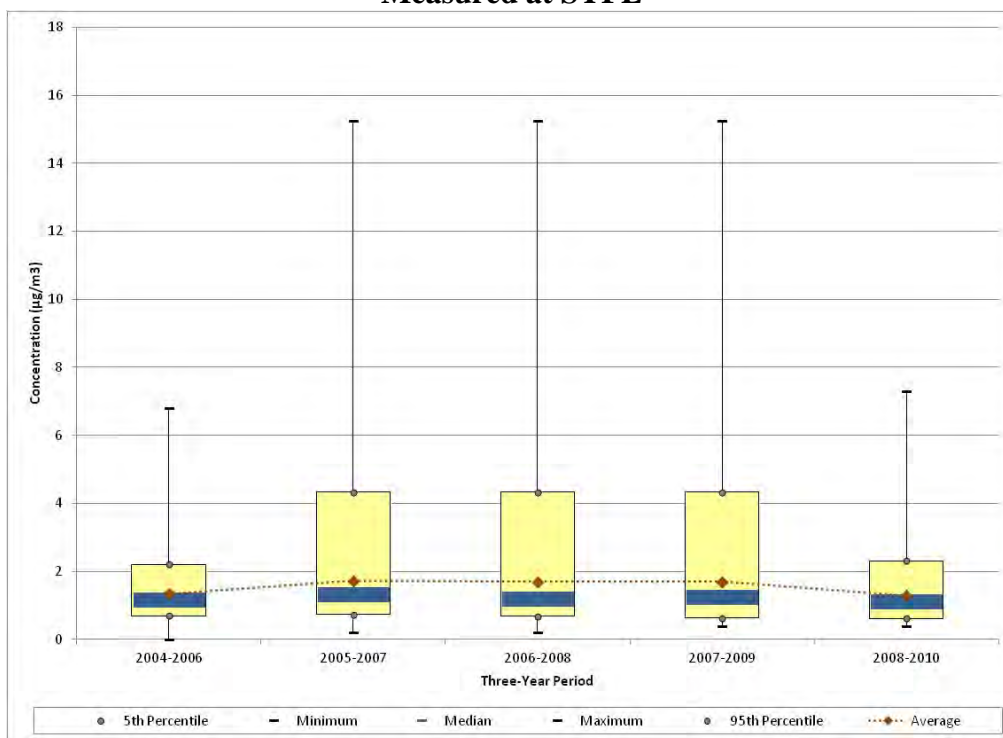
Figure 9-37. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at SYFL
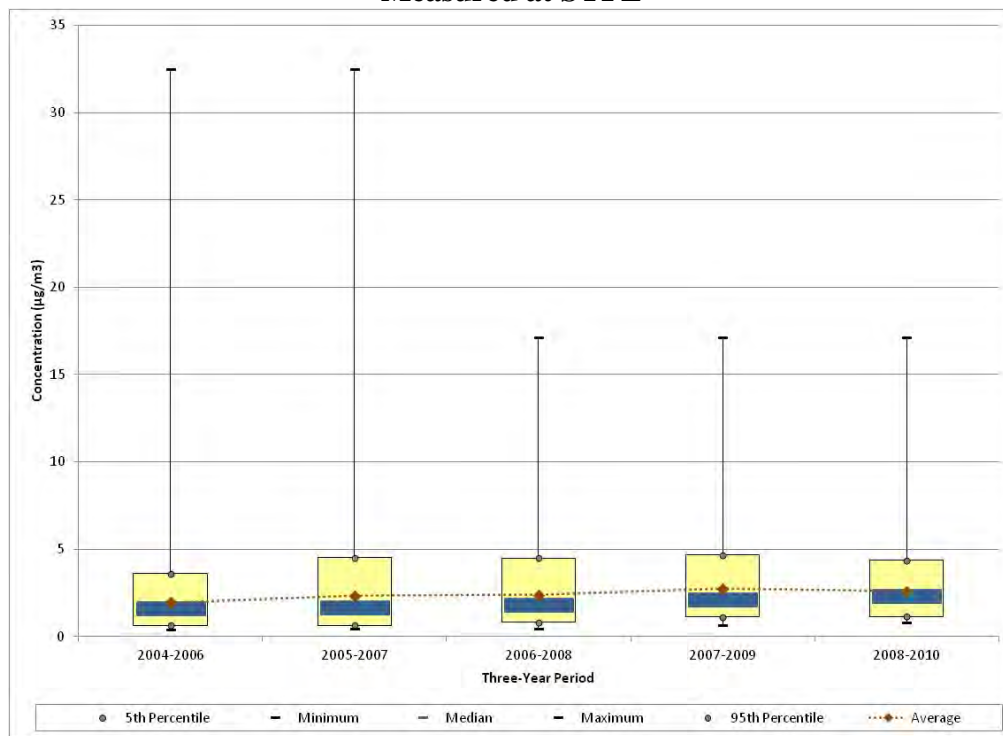
Figure 9-38. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at SYFL
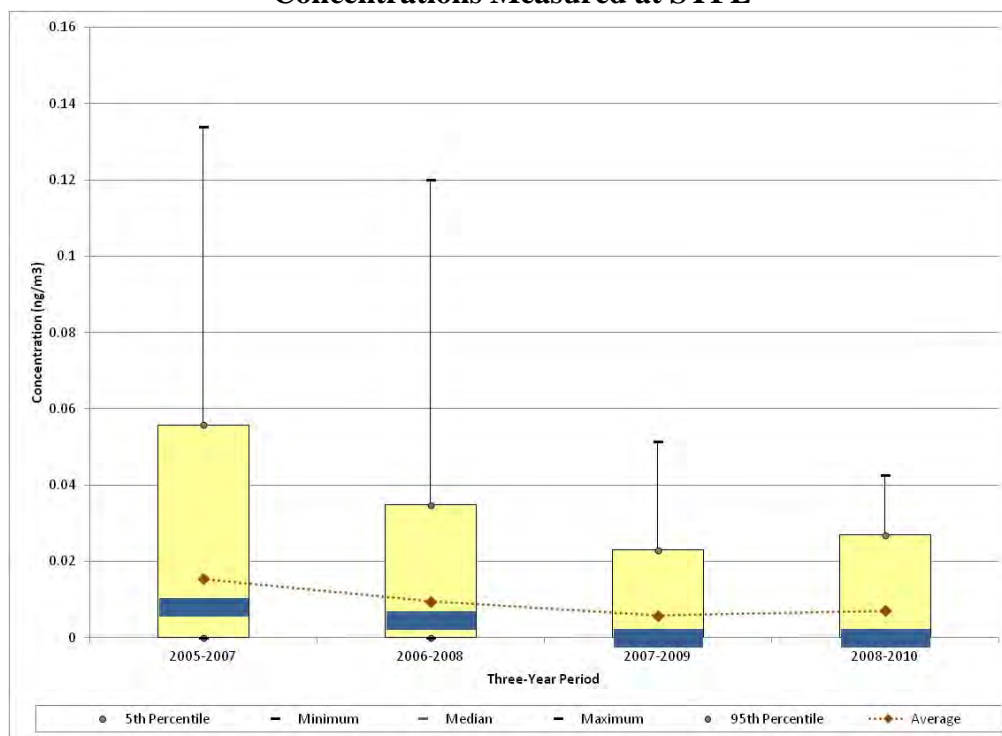
Observations from Figure 9-31 for formaldehyde measurements at AZFL include the following:

- The maximum formaldehyde concentration was measured in 2001, after which the highest concentration measured decreased by nearly half. The three highest concentrations of formaldehyde ranged from 16.1 to 9.30 µg/m^3 and were all measured in 2001.

- The rolling average concentration decreased through the 2003-2005 time frame, increased through 2006-2008, then began to decrease again. The median concentrations follow a similar pattern.

- The trends for formaldehyde in Figure 9-31 are almost the opposite of the trends shown for acetaldehyde in Figure 9-30.

- The minimum concentration for each 3-year 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 9-32 for acetaldehyde measurements at ORFL include the following:

- Carbonyl compounds have been measured at ORFL since April 2003.

- The maximum acetaldehyde concentration was measured in 2006.

- The rolling average concentrations exhibit a slight decreasing trend beginning with the 2005-2007 time frame. The median concentrations also exhibit this trend.

- The spread of concentrations measured is fairly static, as shown by the 5th and 95th percentiles.

- The minimum concentration for each 3-year period is greater than zero. No non-detects of acetaldehyde have been reported since the onset of carbonyl compound sampling in 2003.

Observations from Figure 9-33 for formaldehyde measurements at ORFL include the following:

- The maximum formaldehyde concentration was measured in 2007, although concentrations greater than 10 $\mu g/m^3$ have also been measured in 2005 and 2008.

- Even with the relatively high concentrations measured in the later years of sampling, several of the statistical parameters exhibit a slight decreasing trend over the period of sampling.

- The minimum concentration for each 3-year period is greater than zero. No non-detects of formaldehyde have been reported since the onset of carbonyl compound sampling in 2003.

Observations from Figure 9-34 for acetaldehyde measurements at SKFL include the following:

- Carbonyl compounds have been measured at SKFL since July 2004.

- The maximum acetaldehyde concentration was measured in 2004 (50.7 $\mu g/m^3$) and is more than five times higher than the next highest measurement (10.3 $\mu g/m^3$), which was measured in 2010. Of the 19 concentrations of acetaldehyde greater than or equal to 5 $\mu g/m^3$, 11 were measured in 2010 (with three in 2004, two in 2009, two in 2008, and one in 2005).

- Although difficult to discern in Figure 9-34, the rolling average concentration decreased from 2004-2006 to 2005-2007, then an increasing trend began that continues into the 2008-2010 time frame. The median and 95th percentiles also exhibit this pattern.

- The minimum concentration for each 3-year period is greater than zero. No non-detects of acetaldehyde have been reported since the onset of carbonyl compound sampling in 2004.

Observations from Figure 9-35 for formaldehyde measurements at SKFL include the following:

- Two highest formaldehyde concentrations were measured at SKFL during 2005 (91.7 µg/m^3) and 2004 (70.4 µg/m^3). Aside from these two measurements, all other concentrations measured at this site were at least an order of magnitude lower. The high 2004 formaldehyde concentration corresponded with the high acetaldehyde concentration (both measured on August 31, 2004).

- Although difficult to discern in Figure 9-35, the rolling average and median concentrations show a steady decreasing trend over the periods shown.

- The minimum concentration for each 3-year period is greater than zero. No non-detects of formaldehyde have been reported since the onset of carbonyl compound sampling in 2004.

Observations from Figure 9-36 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 of the highest measured concentration (7.55 µg/m^3).

- The rolling average concentrations exhibit an increase from 2004-2006 to 2005-2007, remain static through 2007-2009, after which a decrease is shown.

- With the exception of the 2004-2006 time frame, the minimum concentration for each 3-year period is greater than zero. Only one non-detect of acetaldehyde has been reported since the onset of carbonyl compound sampling (2004).

Observations from Figure 9-37 for formaldehyde measurements at SYFL include the following:

- The highest formaldehyde concentration measured at SKFL 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.

- Both the rolling average and median concentrations show a slight increasing trend over the periods shown.

- The minimum concentration for each 3-year period is greater than zero. No non-detects of formaldehyde have been reported since the onset of carbonyl compound sampling in 2004.

Observations from Figure 9-38 for hexavalent chromium measurements at SYFL include the following:

- Hexavalent chromium sampling at SYFL began in January 2005.

- The highest hexavalent chromium concentration measured at SYFL was measured on July 3, 2005 and is similar in magnitude to the next highest concentrations, measured on July 4, 2006 and March 17, 2005.

- Both the rolling average and median concentrations exhibit a significant decreasing trend over the first three 3-year periods shown, as do the other statistical parameters. Slight increases in the rolling average and 95th percentiles are noted for 2008-2010 while the median continued to decrease.

- The minimum concentrations, 5th percentiles, and median concentrations for 2007-2009 and 2008-2010 are all zero, indicating that at least 50 percent of the measurements during those 3-year periods are non-detects.

9.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

9.5.1   Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Florida monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Florida monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Florida monitoring sites.

9.5.2   Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Florida sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 of this report regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 9-6, where applicable.

Observations for the Florida sites from Table 9-6 include the following:

- Formaldehyde has the highest cancer surrogate risk approximation among the sites sampling carbonyl compounds, ranging from 15.93 in-a-million (SKFL) to 35.82 in-a-million (for SYFL). The cancer surrogate risk approximations for formaldehyde are an order of magnitude higher than any of the other cancer surrogate risk approximations for AZFL, ORFL, SKFL, and SYFL.

- For PAFL, arsenic has the highest cancer risk approximation (2.44 in-a-million). The cancer surrogate risk approximations are less than 1.0 in-a-million for the remaining pollutants, where a cancer URE is available.

- For the two sites sampling PAH 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.

- All of the noncancer risk approximations for the site-specific pollutants of interest are less than 1.0, indicating no risk of noncancer health effects.

Table 9-6. Cancer and Noncancer Surrogate Risk Approximations for the Florida Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
St. Petersburg, Florida - AZFL						
Acetaldehyde	0.0000022	0.009	61/61	2.94 ± 0.40	6.47	0.33
Formaldehyde	0.000013	0.0098	61/61	1.71 ± 0.18	22.19	0.17
Pinellas Park, Florida - SKFL						
Acetaldehyde	0.0000022	0.009	61/61	3.36 ± 0.48	7.40	0.37
Benzo(a)pyrene	0.00176	--	36/59	<0.01 ± <0.01	0.09	--
Formaldehyde	0.000013	0.0098	61/61	1.23 ± 0.11	15.93	0.13
Hexavalent Chromium	0.012	0.0001	52/61	<0.01 ± <0.01	0.28	<0.01
Naphthalene	0.000034	0.003	59/59	0.09 ± 0.02	3.06	0.03
Plant City, Florida - SYFL						
Acetaldehyde	0.0000022	0.009	61/61	1.51 ± 0.18	3.31	0.17
Benzo(a)pyrene	0.00176	--	15/60	<0.01 ± <0.01	0.03	--
Formaldehyde	0.000013	0.0098	61/61	2.76 ± 0.49	35.82	0.28
Hexavalent Chromium	0.012	0.0001	34/57	<0.01 ± <0.01	0.14	<0.01
Naphthalene	0.000034	0.003	60/60	0.04 ± 0.01	1.47	0.01
Winter Park, Florida - ORFL						
Acetaldehyde	0.0000022	0.009	60/60	1.45 ± 0.25	3.18	0.16
Formaldehyde	0.000013	0.0098	60/60	1.92 ± 0.24	25.02	0.20
Orlando, Florida - PAFL						
Arsenic (PM$_{10}$)	0.0043	0.000015	30/30	<0.01 ± <0.01	2.44	0.04
Beryllium (PM$_{10}$)	0.0024	0.00002	30/30	<0.01 ± <0.01	0.01	<0.01
Cadmium (PM$_{10}$)	0.0018	0.00001	30/30	<0.01 ± <0.01	0.11	0.01
Lead (PM$_{10}$)	--	0.00015	30/30	<0.01 ± <0.01	--	0.02
Manganese (PM$_{10}$)	--	0.00005	30/30	<0.01 ± <0.01	--	0.06
Nickel (PM$_{10}$)	0.00048	0.00009	30/30	<0.01 ± <0.01	0.51	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.

9.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 9-7 and 9-8 present a risk-based 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 9-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 9-7 and 9-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 PAH in addition to carbonyl compounds; and PAFL sampled only PM_{10} metals. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	22.19
Ethylbenzene	261.69	Formaldehyde	2.78E-03	Acetaldehyde	6.47
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	15.93
Ethylbenzene	261.69	Formaldehyde	2.78E-03	Acetaldehyde	7.40
Formaldehyde	214.09	1,3-Butadiene	1.79E-03	Naphthalene	3.06
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	0.09
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 Risk Factors (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	35.82
Ethylbenzene	339.12	Benzene	4.25E-03	Acetaldehyde	3.31
Formaldehyde	333.41	1,3-Butadiene	2.31E-03	Naphthalene	1.47
Acetaldehyde	174.74	Hexavalent Chromium, PM	1.44E-03	Hexavalent Chromium	0.14
1,3-Butadiene	77.10	Nickel, PM	1.38E-03	Benzo(a)pyrene	0.03
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	25.02
Formaldehyde	350.51	Benzene	4.53E-03	Acetaldehyde	3.18
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 Risk Factors (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	2.44
Formaldehyde	350.51	Benzene	4.53E-03	Nickel	0.51
Ethylbenzene	334.02	1,3-Butadiene	2.42E-03	Cadmium	0.11
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 Risk Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
St. Petersburg, Florida (Pinellas County) - AZFL					
Toluene	1,374.54	Acrolein	625,802.58	Acetaldehyde	0.33
Xylenes	1,035.91	Nickel, PM	31,311.86	Formaldehyde	0.17
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	Acetaldehyde	0.37
Xylenes	1,035.91	Nickel, PM	31,311.86	Formaldehyde	0.13
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 Risk Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Plant City, Florida (Hillsborough County) - SYFL					
Toluene	1,643.63	Acrolein	851,462.75	Formaldehyde	0.28
Xylenes	1,310.35	Cyanide Compounds, gas	535,232.13	Acetaldehyde	0.17
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	Formaldehyde	0.20
Xylenes	1,316.88	1,3-Butadiene	40,319.80	Acetaldehyde	0.16
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 Risk Approximations for Pollutants with Noncancer RfCs for the Florida Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Orlando, Florida (Orange County) - PAFL					
Toluene	1,693.63	Acrolein	870,786.72	Manganese	0.06
Xylenes	1,316.88	1,3-Butadiene	40,319.80	Arsenic	0.04
Methanol	629.52	Formaldehyde	35,765.86	Lead	0.02
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.

- For Pinellas and Orange Counties, seven of the highest emitted pollutants also have the highest toxicity-weighted emissions. Eight pollutants also have the highest toxicity-weighted emissions for Hillsborough County.

- Hexavalent chromium and arsenic are among the pollutants with the highest cancer toxicity-weighted emissions for each county, yet are not among the highest emitted pollutants in any of the counties.

- Formaldehyde, which has the highest cancer risk approximations for all sites sampling carbonyl compounds, is one of the highest emitted pollutants and has one of the highest toxicity-weighted emissions for each county.

- PAFL sampled only PM_{10} metals; arsenic and nickel have the highest cancer risk approximations for this site. Arsenic appears on the list of 10 highest toxicity-weighted emissions for Orange County, but does not appear on the list of highest pollutants emitted, indicating the relative toxicity of a low quantity of emissions.

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 does not appear in any county's list of 10 highest emitted pollutants.

- For Pinellas and Orange Counties, four of the highest emitted pollutants also have the highest toxicity-weighted emissions. Five pollutants also have the highest toxicity-weighted emissions for Hillsborough County.

- Formaldehyde and acetaldehyde appear on all three lists for each site/county, with the exception of PAFL, where carbonyl compounds were not sampled. For PAFL, arsenic and lead appear on two of the three lists. No metals are among the highest emitted pollutants in Orange County.

9.6   Summary of the 2010 Monitoring Data for the Florida Sites

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

❖ *Acetaldehyde and formaldehyde failed screens for every site sampling carbonyl compounds (AZFL, SKFL, SYFL, and ORFL). In addition to acetaldehyde and formaldehyde, naphthalene also failed screens for SKFL and SYFL, the only two Florida sites at which PAH were sampled. Four metals failed screens for PAFL.*

❖ *Acetaldehyde had the highest annual average concentration of any of the pollutants of interest among the Florida sites, which was calculated for SKFL. Formaldehyde was the only other pollutant of interest with an annual average concentration greater than 1 μg/m³.*

❖ *The annual average concentrations of acetaldehyde for SKFL and AZFL ranked second and third highest among all NMP sites sampling carbonyl compounds; PAFL's annual average concentration of beryllium was the third highest among NMP sites sampling PM$_{10}$ metals.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest for the Florida sites were greater than their associated MRL noncancer health risk benchmarks.*

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 on 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 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 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 below the map in Figure 10-2. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 10-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 10-1. Decatur, Georgia (SDGA) Monitoring Site

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

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

Legend

⭐ SDGA NATTS site   ◯ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

➤ Aircraft Operations (22)
B Bakery (1)
◉ Fabricated Metal Products (1)
🜨 Flexible Polyurethane Foam Production (2)
F Food Processing/Agriculture (1)
▮ Glass Manufacturing (1)
🅢 Institutional - school (1)
▲ Landfill (2)
? Miscellaneous Commercial/Industrial (3)
● Oil and/or Gas Production (1)
S Surface Coating (1)

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, VOC, O_3, Meteorological parameters, PM_{10}, PM Coarse, PM_{10} Speciation, Black carbon, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Haze.

[1] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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. Figure 10-1 shows that 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 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 highest number of emissions sources within 10 miles of SDGA.

Table 10-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Georgia monitoring site. Table 10-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 10-2 also contains annual average daily traffic information. Finally, Table 10-2 presents the 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	692,902	472,535	0.68	793,817	541,355	145,890	21,057,000

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2011 data from the GA Dept of Revenue (GA DOR, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data from the Georgia DOT (GA DOT, 2010a)
[5] County-level VMT reflects 2010 data for all public roads from the Georgia DOT (GA DOT, 2010b)
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 sixth highest compared to other NMP monitoring sites. The traffic estimate used came from I-285, north of Clifton Spring Road. This is a change in location from the 2008-2009 NMP report.

- 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 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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 2010. 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 were representative of average weather conditions throughout the year.

10.2.3 Back Trajectory Analysis

Figure 10-3 is the composite back trajectory map for days on which samples were collected at the SDGA monitoring site in 2010. Included in Figure 10-3 are four back trajectories per sample day. Figure 10-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, each concentric circle around the site in Figures 10-3 and 10-4 represents 100 miles.

Observations from Figures 10-3 and 10-4 include the following:

- Back trajectories originated from a variety of directions at SDGA.

- The 24-hour air shed domain for SDGA was somewhat smaller in size compared to other NMP monitoring sites. While the farthest away a trajectory originated was central Illinois, or just greater than 550 miles away, the average back trajectory length was 190 miles. Nearly 85 percent of back trajectories originated within 300 miles of the site. The longest trajectories tended to originate from the northwest, over Indiana, Illinois, and Missouri.

- The cluster analysis shows that trajectories originating from the southwest (and within a relatively short distance) were most common. Trajectories also commonly originated from the northwest to north, as well as the southeast and northeast quadrants.

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	Sample Day	71.0 ± 4.6	61.5 ± 4.5	47.7 ± 4.6	54.1 ± 4.1	63.2 ± 2.8	1016.6 ± 1.4	7.2 ± 0.8
	239° (WSW)	2010	71.6 ± 1.9	62.1 ± 1.8	48.5 ± 1.9	54.8 ± 1.7	64.2 ± 1.4	1016.7 ± 0.5	6.8 ± 0.3

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

Figure 10-3. 2010 Composite Back Trajectory Map for SDGA
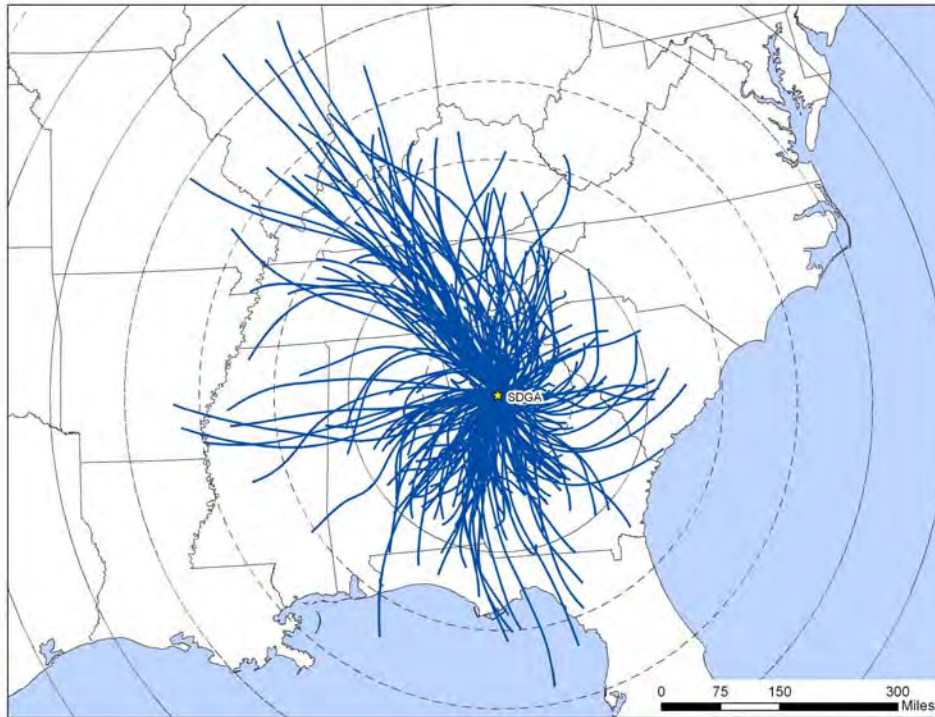
Figure 10-4. Back Trajectory Cluster Map for SDGA
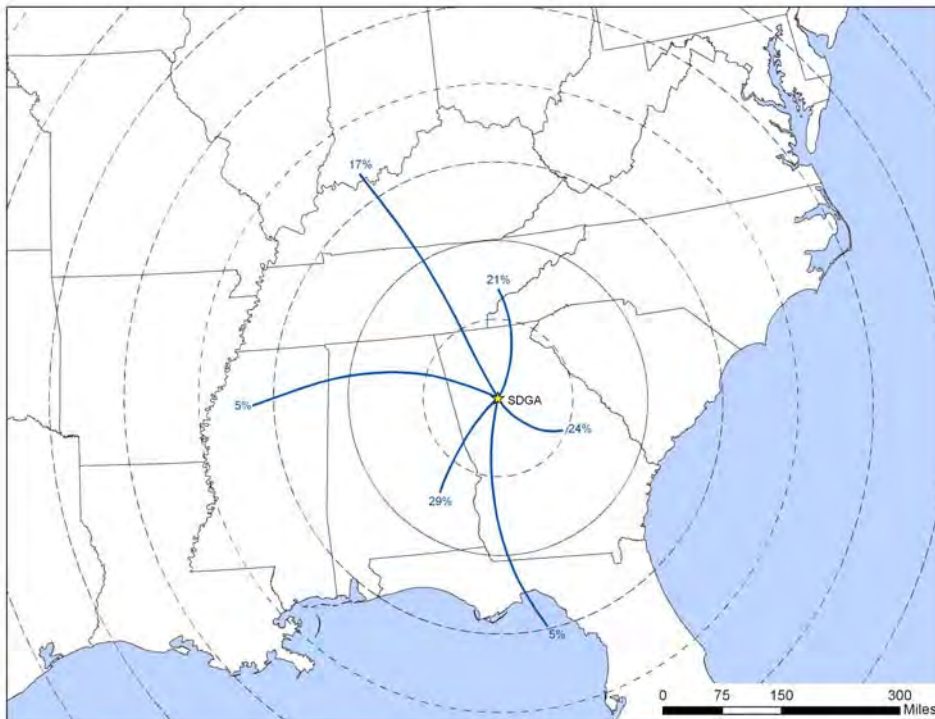
10.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the SDGA monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location.

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 just greater than one-third of wind observations. Easterly winds were also common. Winds from the northeast quadrant were rarely observed. Calm winds ($\leq$ 2 knots) were observed for nearly 10 percent of the hourly wind measurements.

- The wind patterns on both full-year and sample day wind roses exhibit the same wind patterns as those of the historical wind rose, although northwesterly and north-northwesterly winds were observed for a higher percentage of observations and easterly winds for a lower percentage than shown on the historical wind rose.

- The wind patterns on the full-year wind rose resemble the sample day wind rose, indicating the wind conditions on sample days were representative of wind conditions throughout 2010.

Figure 10-5. Wind Roses for the Hartsfield International Airport Weather Station near SDGA

1999-2009 Historical Wind Rose
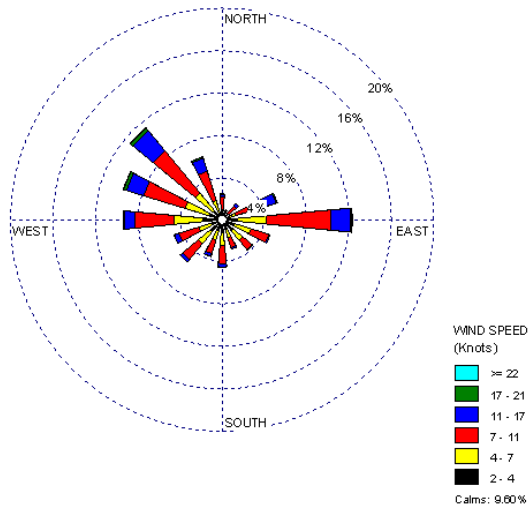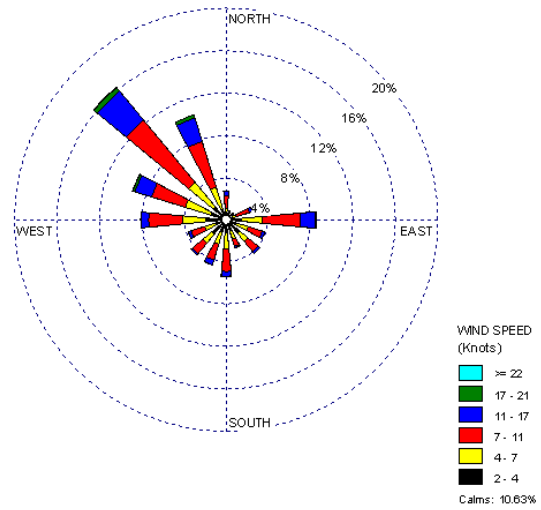
2010 Wind Rose

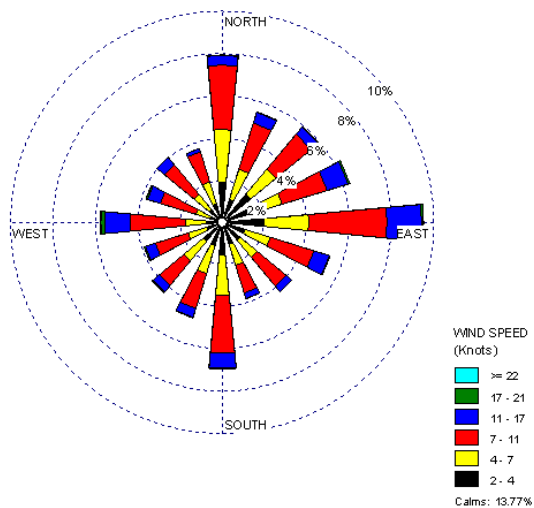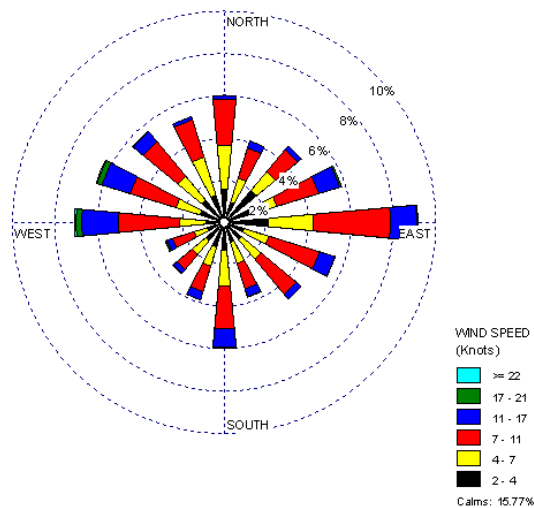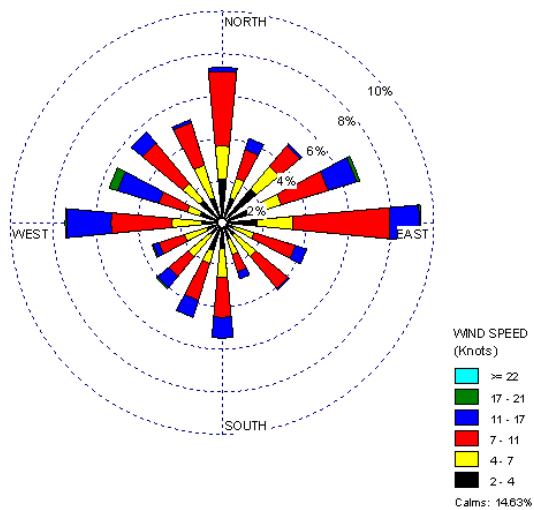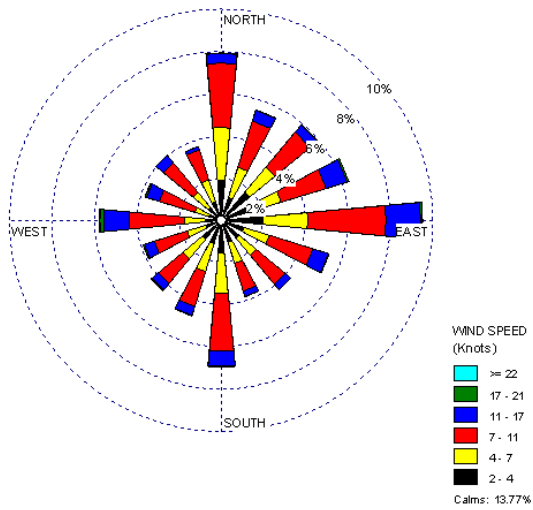2010 Sample Day Wind Rose
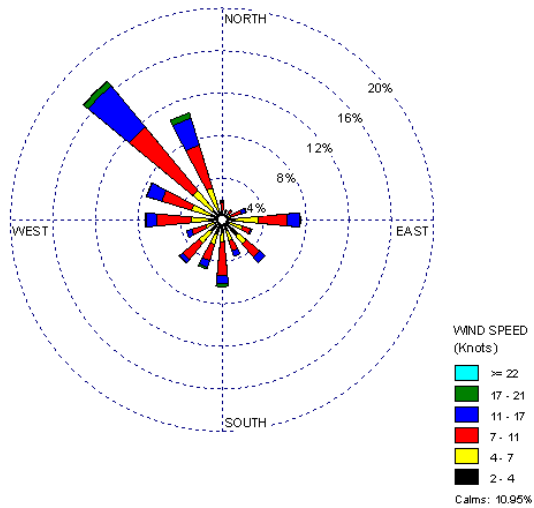
Distance between SDGA and NWS Station
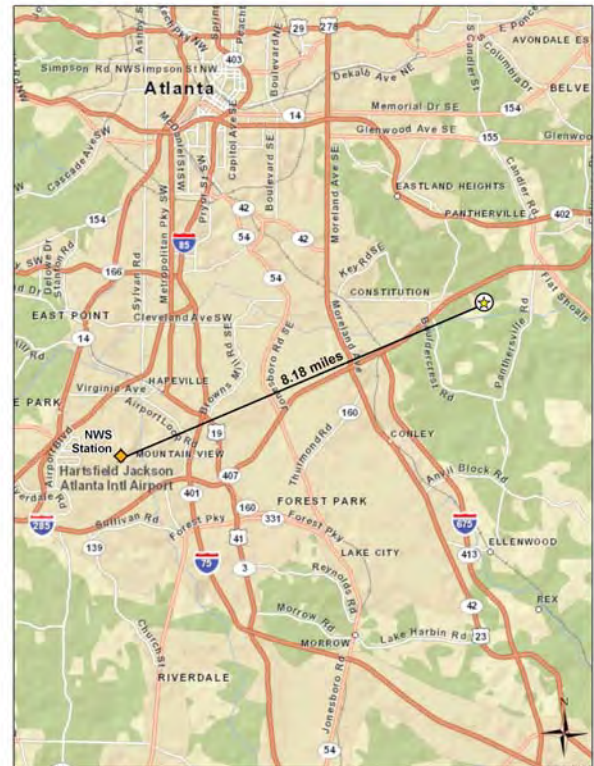
10.3 Pollutants of Interest

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 10-4 presents SDGA's pollutants of interest. 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 PAH and hexavalent chromium only.

Table 10-4. Risk Screening Results for the Georgia Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Decatur, Georgia - SDGA						
Naphthalene	0.029	56	59	94.92	96.55	96.55
Acenaphthene	0.011	1	59	1.69	1.72	98.28
Benzo(a)pyrene	0.00057	1	26	3.85	1.72	100.00
Total		58	144	40.28		

Observations from Table 10-4 for SDGA include the following:

- Naphthalene, acenaphthene, and benzo(a)pyrene failed screens. Naphthalene failed the majority of the screens (roughly 97 percent), accounting for 56 of the 58 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 screening process. Benzo(a)pyrene was added as a pollutant of interest for SDGA because it is a NATTS MQO Core Analyte. Hexavalent chromium was also added as a pollutant of interest for SDGA because it is a NATTS MQO Core Analyte, even though it did not fail any screens. This pollutant is not shown in Table 10-4.

10.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Georgia monitoring site. Concentration averages are provided for the pollutants of interest for the SDGA monitoring site, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices M and O.

10.4.1 2010 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/m³)	2nd Quarter Average (ng/m³)	3rd Quarter Average (ng/m³)	4th Quarter Average (ng/m³)	Annual Average (ng/m³)
Decatur, Georgia - SDGA						
Benzo(a)pyrene	26/59	0.08 ± 0.04	0	0.01 ± 0.01	0.16 ± 0.14	0.06 ± 0.04
Hexavalent Chromium	41/60	0.01 ± 0.01	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.01	0.02 ± <0.01
Naphthalene	59/59	99.73 ± 53.83	136.55 ± 48.93	117.88 ± 24.51	155.34 ± 59.84	127.84 ± 23.35

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. SDGA's annual average concentration of naphthalene ranks fifth highest among NMP sites sampling this pollutant (as shown in Table 4-11).

- The confidence intervals associated with naphthalene's quarterly averages indicate the relative variability in the naphthalene measurements (note how the lowest quarterly average concentration has one of the highest confidence intervals). Concentrations of naphthalene measured at SDGA ranged from 19.1 ng/m³ to 322 ng/m³.

- The first and fourth quarter averages of benzo(a)pyrene are much higher than the other quarterly averages and have relatively large confidence intervals associated with them, which is indicative of the inclusion of potential outliers. The highest concentration of this pollutant (1.01 ng/m³) was measured on December 16, 2010 and is three times greater than the next highest measurement (0.361 ng/m³ measured on December 10, 2010). The measurement on December 16, 2010 is one of 11 concentrations greater than 1 ng/m³ among all NMP sites sampling this pollutant. At SDGA, nine concentrations were greater than 0.1 ng/m³; of these, four were measured during the first quarter of 2010 and five were measured during the fourth quarter of 2010. This pollutant was not detected at all during the second quarter of 2010.

10.4.2 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 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, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 10-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Program Max Concentration = 42.7 ng/m3

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
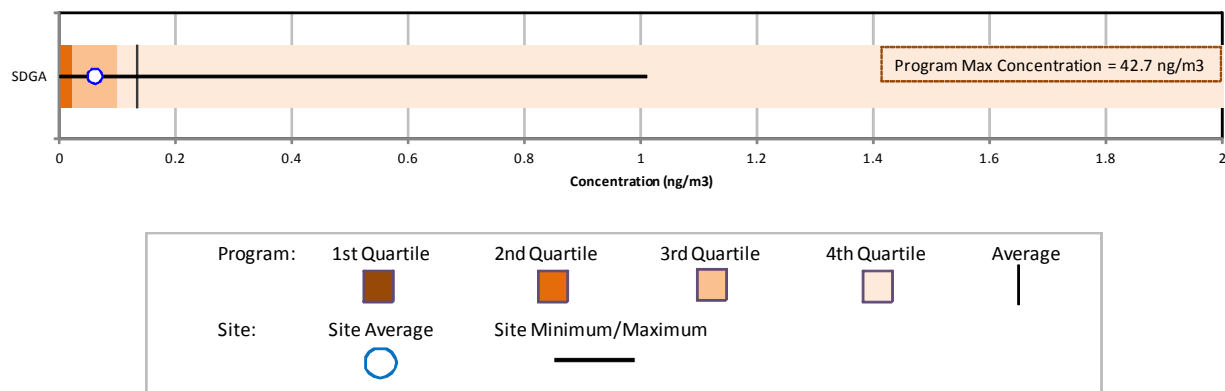
Figure 10-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

Program Max Concentration = 3.51 ng/m3

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
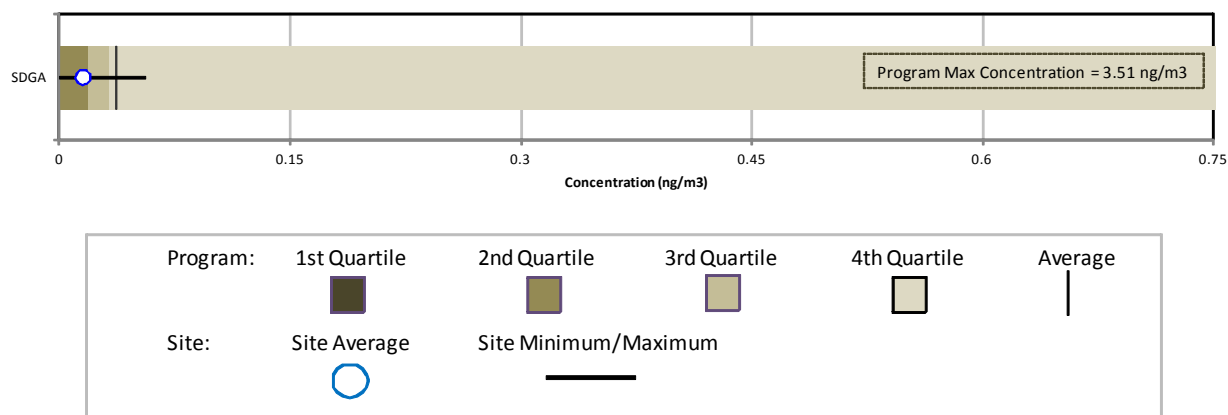
Figure 10-8. Program vs. Site-Specific Average Naphthalene Concentration

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
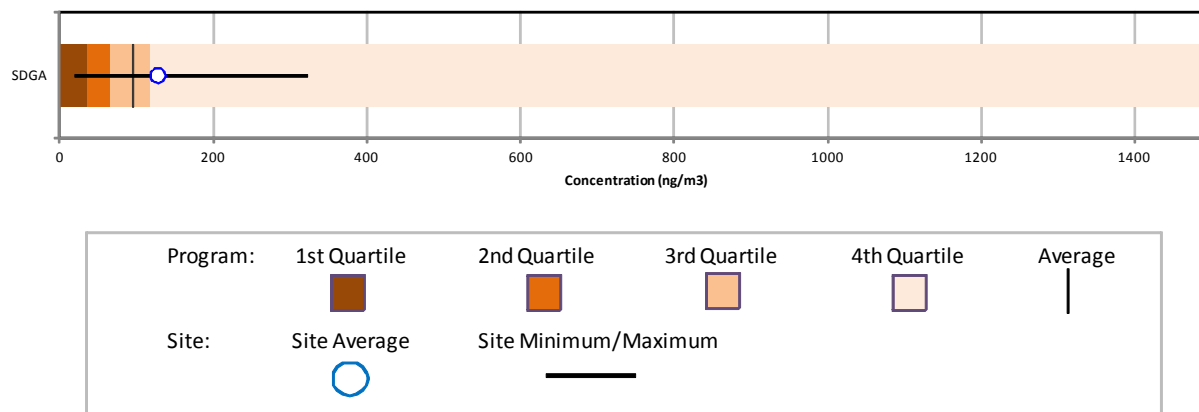
Observations from Figures 10-6 through 10-8 include the following:

- Figure 10-6 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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. Figure 10-6 also shows that the maximum concentration measured at SDGA is well below the maximum concentration measured across the program. However, the maximum concentration measured at SDGA is the 11th highest measurement of this pollutant among all NMP sites. However, most of the "high" concentrations of benzo(a)pyrene across the program ranged from 1-2 ng/m^3, with the exception of the two that exceed the scale in Figure 10-6. Several non-detects of benzo(a)pyrene were measured at SDGA.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 10-7 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 10-7 shows the annual average concentration of hexavalent chromium for SDGA is less than the program-level average (by more than half). 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 average concentration. Several non-detects of hexavalent chromium were measured at SDGA.

- Figure 10-8 shows that the annual naphthalene average for SDGA is greater than the program-level average concentration. As discussed previously, the annual average naphthalene concentration is the fifth highest annual average among NMP sites sampling this pollutant. However, the maximum naphthalene concentration measured at SDGA is well below the program-level maximum concentration. There were no non-detects of naphthalene measured at SDGA.

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 3-year rolling statistical metrics for hexavalent chromium for SDGA. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 10-9. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at SDGA
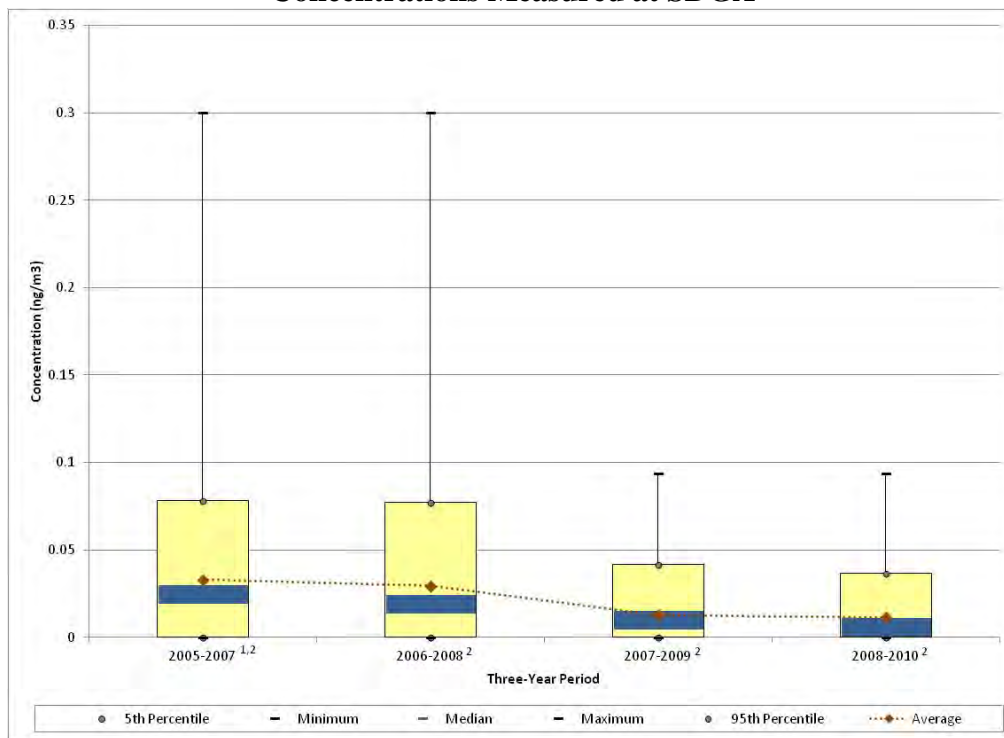
[1]Sampling for hexavalent chromium at SDGA began in February 2005.
[2]Samples were not collected between September 2007 and May 2008.

Observations from Figure 10-9 for hexavalent chromium measurements at SDGA include the following:

- Sampling for hexavalent chromium began in February 2005 at SDGA.

- The maximum hexavalent chromium concentration was measured on November 25, 2006 (0.300 ng/m^3), and thus appears as the maximum concentration for the first two 3-year periods. Only five concentrations measured at SDGA were greater than 0.1 ng/m^3 and four of the five were measured in 2006 (and the other in 2005).

- The rolling average concentration exhibits a slight decrease from 2005-2007 to 2006-2008, and a significant decrease is shown from 2006-2008 to 2007-2009, followed by another slight decrease for 2008-2010. The median concentrations and 95th percentiles exhibit similar trends.

- As denoted in Figure 10-9, there was a gap in sampling from September 2007 to May 2008.

10.5 Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

10.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the SDGA monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; quarterly averages were compared to the intermediate MRL; and annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the SDGA monitoring site were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for SDGA.

10.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the SDGA monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 10-6, where applicable.

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 (4.35 in-a-million).

- Both noncancer risk approximations for naphthalene and hexavalent chromium were well below 1.0. Benzo(a)pyrene does not have a noncancer RfC.

10-18

Table 10-6. Cancer and Noncancer Surrogate Risk Approximations for the Georgia Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Benzo(a)pyrene	0.00176	--	26/59	0.06 ± 0.04	0.11	--
Hexavalent Chromium	0.012	0.0001	41/60	0.02 ± <0.01	0.18	<0.01
Naphthalene	0.000034	0.003	59/59	127.84 ± 23.35	4.35	0.04

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

10.5.3 Risk-Based Emissions Assessment

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

The pollutants listed in Tables 10-7 and 10-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk approximations based on each site's annual average are limited to those pollutants for which each respective site sampled. As discussed in Section 10.3, SDGA sampled for PAH and hexavalent chromium. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	4.35
Ethylbenzene	213.44	Formaldehyde	2.49E-03	Hexavalent Chromium	0.18
Formaldehyde	191.48	1,3-Butadiene	1.39E-03	Benzo(a)pyrene	0.11
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 Risk Approximations for Pollutants with Noncancer RfCs for the Georgia Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Decatur, Georgia (DeKalb County) - SDGA					
Toluene	1,018.74	Acrolein	576,341.15	Naphthalene	0.04
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-based emissions, but is not among one of the highest emitted pollutants in DeKalb County.

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

- Benzo(a)pyrene is part of POM, Group 5a. POM, Group 5a ranks tenth highest for toxicity-based emissions, but is not among one of 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.

- Four 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 toxicity factor in DeKalb County, its toxicity-weighted emissions rank sixth. Neither hexavalent chromium nor POM, Group 5a (benzo(a)pyrene) appear on either emissions-based list.

10.6   Summary of the 2010 Monitoring Data for SDGA

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

❖ *Naphthalene, acenaphthene, and benzo(a)pyrene failed screens for SDGA, although naphthalene accounted for the bulk of failed screens.*

❖ *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for SDGA. SDGA's annual average concentration of naphthalene was the fifth highest among NMP sites sampling this pollutant.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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. More specifically, NBIL is located in Northbrook and SPIL is 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 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. Thus, sources outside each 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 11-1 describes the area surrounding each monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 11-1. Northbrook, Illinois (NBIL) Monitoring Site

Figure 11-2. Schiller Park, Illinois (SPIL) Monitoring Site
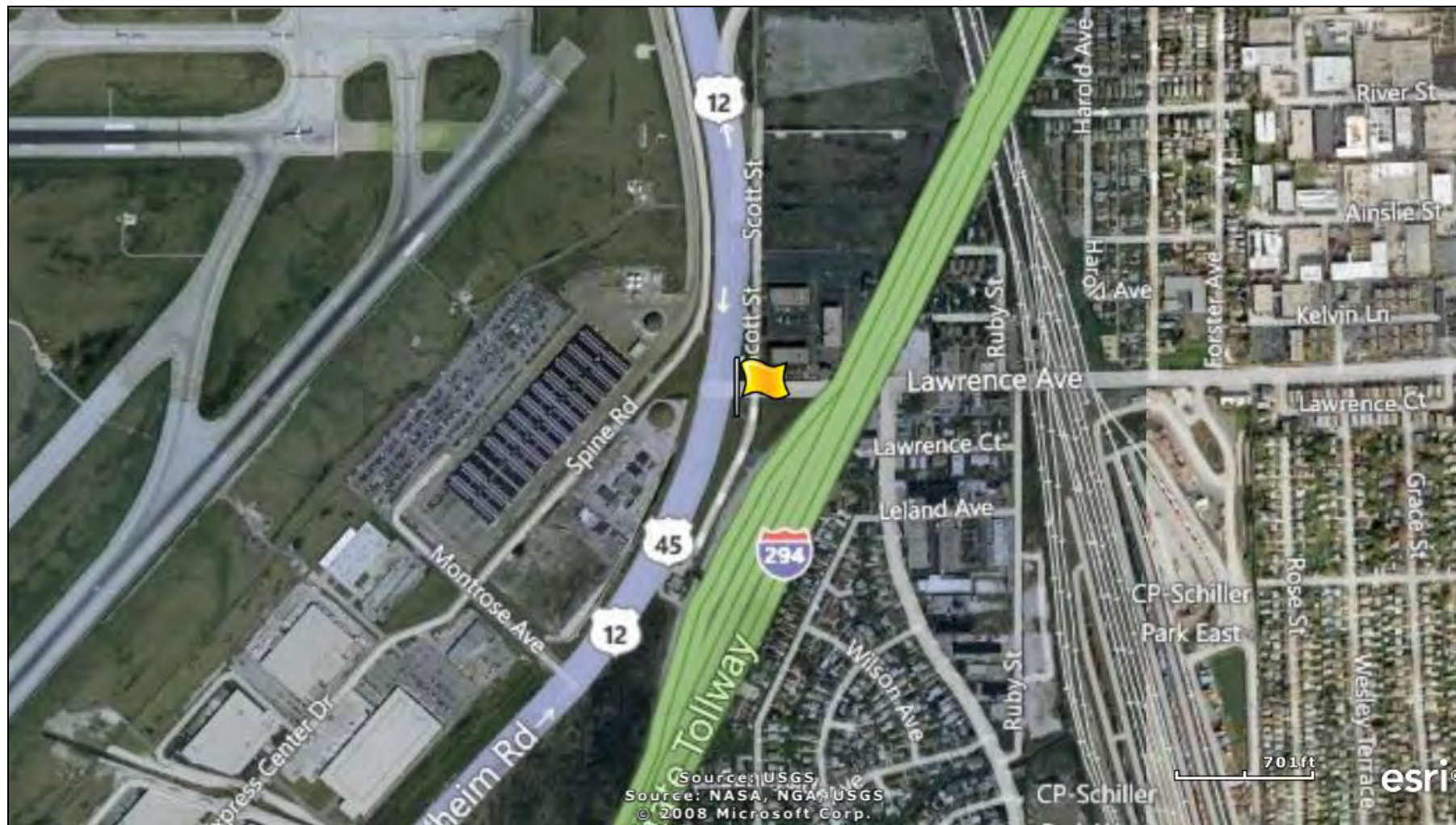
Figure 11-3. NEI Point Sources Located Within 10 Miles of NBIL and SPIL

Legend

| ☆ NBIL NATTS site | ★ SPIL UATMP site | ◯ 10 mile radius | ▭ County boundary |

Source Category Group (No. of Facilities)

⊞	Abrasive Product Manufacturing (2)	⊙	Fabricated Metal Products (63)	M	Miscellaneous Manufacturing (86)
⊘	Air-conditioning/Refrigeration (2)	⬱	Flexible Polyurethane Foam Production (5)	●	Oil and/or Gas Production (1)
✛	Aircraft Operations (32)	F	Food Processing/Agriculture (38)	⬯	Pharmaceutical Manufacturing (8)
▮	Asphalt Processing/Roofing Manufacturing (3)	▥	Furniture Plant (10)	⌁	Pipeline Compressor Station (1)
◊	Auto Body Shop/Painters (3)	▰	Gasoline/Diesel Service Station (8)	1	Primary Metal Production (24)
🚗	Automobile/Truck Manufacturing (9)	⚚	Glass Manufacturing (3)	↑	Printing, Coating & Dyeing of Fabric (1)
Ƀ	Bakery (9)	H	Hospital (5)	P	Printing/Publishing (90)
Ɏ	Brewery/Distillery/Winery (1)	⚘	Hot Mix Asphalt Plant (6)	⊞	Pulp and Paper Plant/Wood Products (18)
⌑	Brick Manufacturing & Structural Clay (3)	✳	Industrial Machinery and Equipment (33)	R	Rubber and Miscellaneous Plastics Products (25)
▲	Building Construction (6)	Ⓢ	Institutional – school (30)	2	Secondary Metal Processing (5)
B	Bulk Terminals/Bulk Plants (10)	I	Iron and Steel Foundry (2)	>	Solid Waste Disposal – Commercial/Institutional (1)
C	Chemical Manufacturing (20)	◕	Laboratory (1)	▼	Steel Mill (9)
■	Concrete Batch Plant (20)	▲	Landfill (7)	S	Surface Coating (41)
⋈	Crematory – Animal/Human (12)	L	Large Appliance Manufacturing (1)	π	Telecommunications (19)
⊕	Dry Cleaning Facility (51)	✕	Mine/Quarry (10)	T	Textile Mill (5)
e	Electrical Equipment (18)	▽	Mineral Products (1)	✿	Transportation Equipment (9)
⚡	Electricity Generation via Combustion (6)	5	Miscellaneous Coating Manufacturing (1)	✻	Transportation and Marketing of Petroleum Products (6)
E	Electroplating, Plating, Polishing, Anodizing, & Coloring (58)	?	Miscellaneous Commercial/Industrial (57)	ꙮ	Wastewater Treatment (8)
4	Engine Testing (2)			W	Woodwork, Furniture, Millwork & Wood Preserving (3)

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] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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 intersects Dundee Road close to 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 with a railyard located on the east side of I-294.

Figure 11-3 shows that NBIL and SPIL are located within approximately 12 miles of each other. Each site is located within 10 miles of numerous point sources. 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. Numerous sources are located in close proximity of SPIL. Besides the airport, the closest point source to SPIL is involved in electroplating, plating, polishing, anodizing, and coloring.

Table 11-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the Illinois monitoring sites. Table 11-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 11-2 also contains annual average daily traffic information. Finally, Table 11-2 presents the 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	5,200,950	2,083,141	0.40	859,738	344,352	34,100	89,621,776
SPIL				2,046,549	819,706	170,700	

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the IL Secretary of State (IL SOS, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2009 data from the Illinois DOT (IL DOT, 2009)
[5] County-level VMT reflects 2010 data from the Illinois DOT (IL DOT, 2010)
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 among the 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 fifth highest among all NMP sites, behind ELNJ, CELA, SEWA, and PXSS, while the traffic volume for NBIL is in the middle of the range among NMP sites. Traffic data for SPIL is from I-294 at Lawrence Avenue; traffic data for NBIL is for Dundee Road near the railroad crossing.

- The Cook County daily VMT ranks second among counties with NMP sites, behind only Los Angeles County (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 2010

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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 2010. Also included in Table 11-3 is the 95 percent confidence interval for each parameter. As shown in Table 11-3, average meteorological conditions on sample days were representative of average weather conditions throughout the year for both sites.

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	Sample Day	60.3 ± 5.3	52.0 ± 4.9	40.5 ± 4.7	46.3 ± 4.4	67.0 ± 2.1	1016.8 ± 1.5	5.8 ± 0.8
	250° (WSW)	2010	59.7 ± 2.3	51.5 ± 2.1	40.2 ± 2.0	45.9 ± 1.9	67.8 ± 1.1	1016.3 ± 0.7	6.3 ± 0.3
Schiller Park, Illinois - SPIL									
O'Hare International Airport 94846 (41.99, -87.91)	2.32 miles	Sample Day	59.2 ± 5.6	51.3 ± 5.1	40.0 ± 4.7	45.7 ± 4.6	67.7 ± 2.5	1016.0 ± 1.6	7.5 ± 0.8
	303° (WNW)	2010	59.7 ± 2.3	51.7 ± 2.1	40.5 ± 2.0	46.1 ± 1.9	68.5 ± 1.3	1015.7 ± 0.7	8.0 ± 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 2010. Included in Figure 11-4 are four back trajectories per sample day. Figure 11-5 is the corresponding cluster analysis for 2010. 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the sites in Figures 11-4 through 11-7 represents 100 miles.

Figure 11-4. 2010 Composite Back Trajectory Map for NBIL
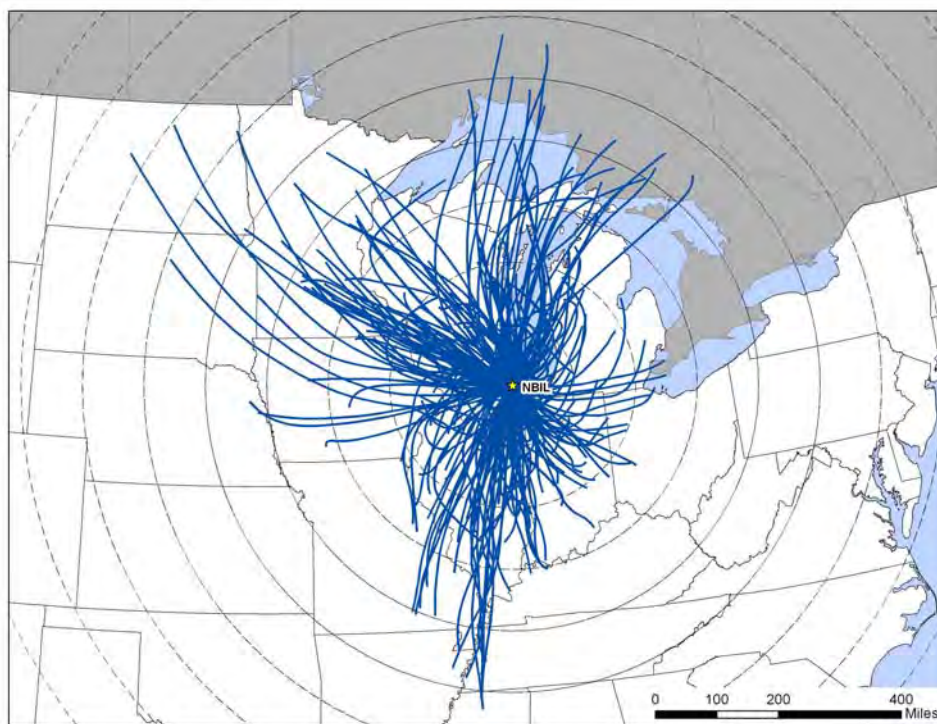
Figure 11-5. Back Trajectory Cluster Map for NBIL
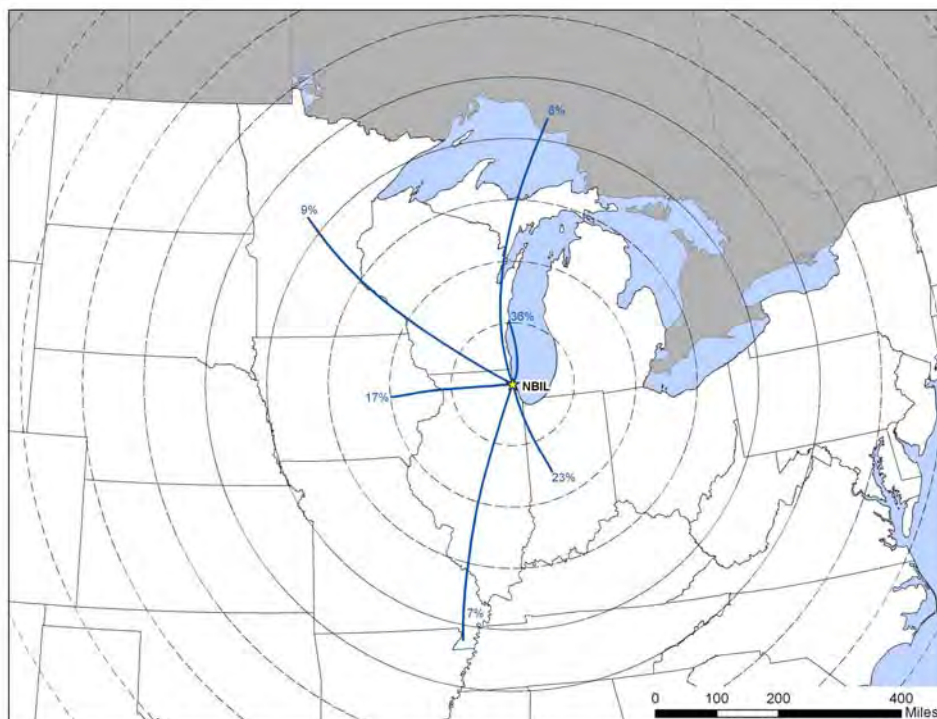
Figure 11-6. 2010 Composite Back Trajectory Map for SPIL
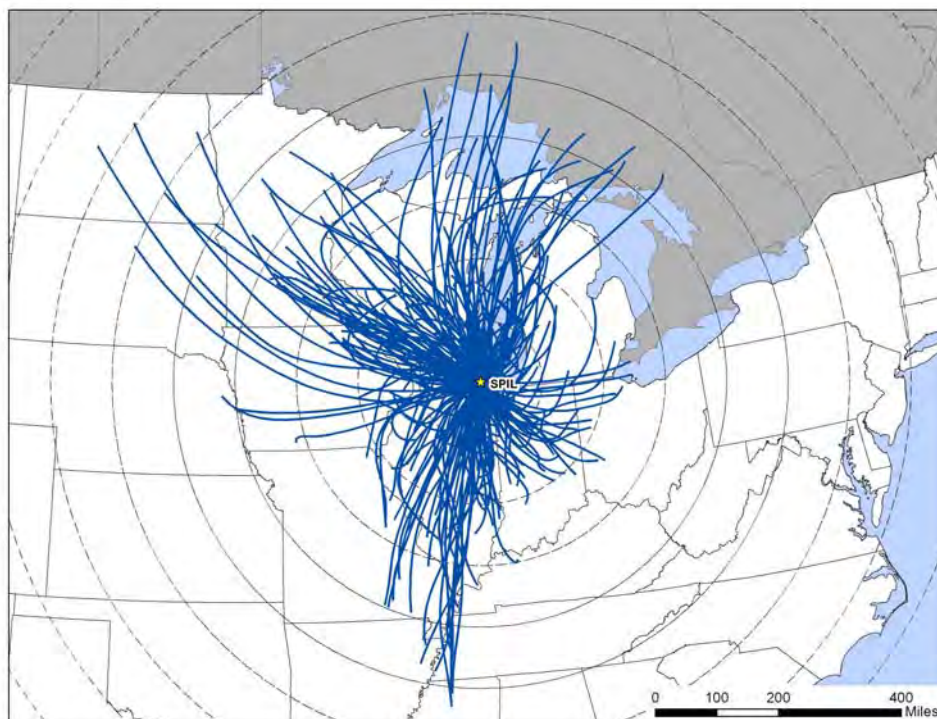
Figure 11-7. Back Trajectory Cluster Map for SPIL
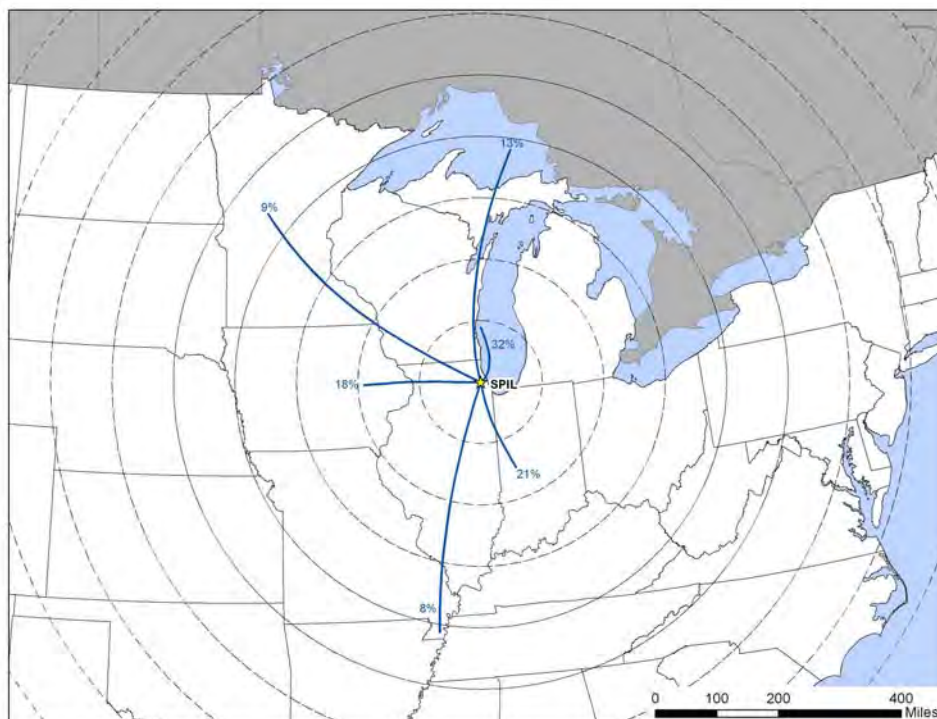
Observations from Figures 11-4 through 11-7 include the following:

- The composite back trajectory maps for NBIL and SPIL are similar to each other in back trajectory distribution. This is expected given their proximity to each other.

- Back trajectories originated from a variety of directions at the sites, although less frequently from a direction with an easterly component. The predominant direction of trajectory origin appears to be from the northwest, north, and south.

- The 24-hour air shed domains for NBIL and SPIL were similar in size compared to other NMP sites. The longest trajectories originated to the northwest, over the Dakotas, generally between 600-700 miles away. However, the average trajectory length for these sites was approximately 250 miles and most (approximately 84 percent) 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 as well as the percentage of trajectories representing each cluster.

- Nearly one-third of back trajectories for both sites originated to the north of the sites, over Wisconsin, Michigan, and/or Lake Michigan. Another one-fourth of back trajectories originated from the east, southeast, and south over Ohio, Indiana, and southern Illinois. One-fifth of back trajectories originated from the northwest and southwest quadrants and generally within 300 miles of NBIL and SPIL. The longest trajectories originated from the northwest towards Minnesota and the Dakotas, from

11-12

the south over the Mississippi Valley region, and to the north of the Great Lakes and into Canada.

11.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the NBIL monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figure 11-9 presents the three wind roses and distance map for SPIL.

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 nearly one-quarter of all observations. Winds from the east to east-southeast were observed the least often. Calm winds (≤2 knots) were observed for approximately 15 percent of the hourly measurements.

- The 2010 wind rose exhibits similar patterns in wind directions as the historical wind rose, although northwesterly and north-northwesterly winds were observed slightly more often and southerly and south-southwesterly winds less often.

- The 2010 sample day wind patterns generally resemble the 2010 full-year wind patterns, although the reduced percentages of some wind directions (such as west-southwest, northeast, and east-northeast) may be reflected in the increased percentage of calm winds.

Figure 11-8. Wind Roses for the Palwaukee Municipal Airport Weather Station near NBIL

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between NBIL and NWS Station
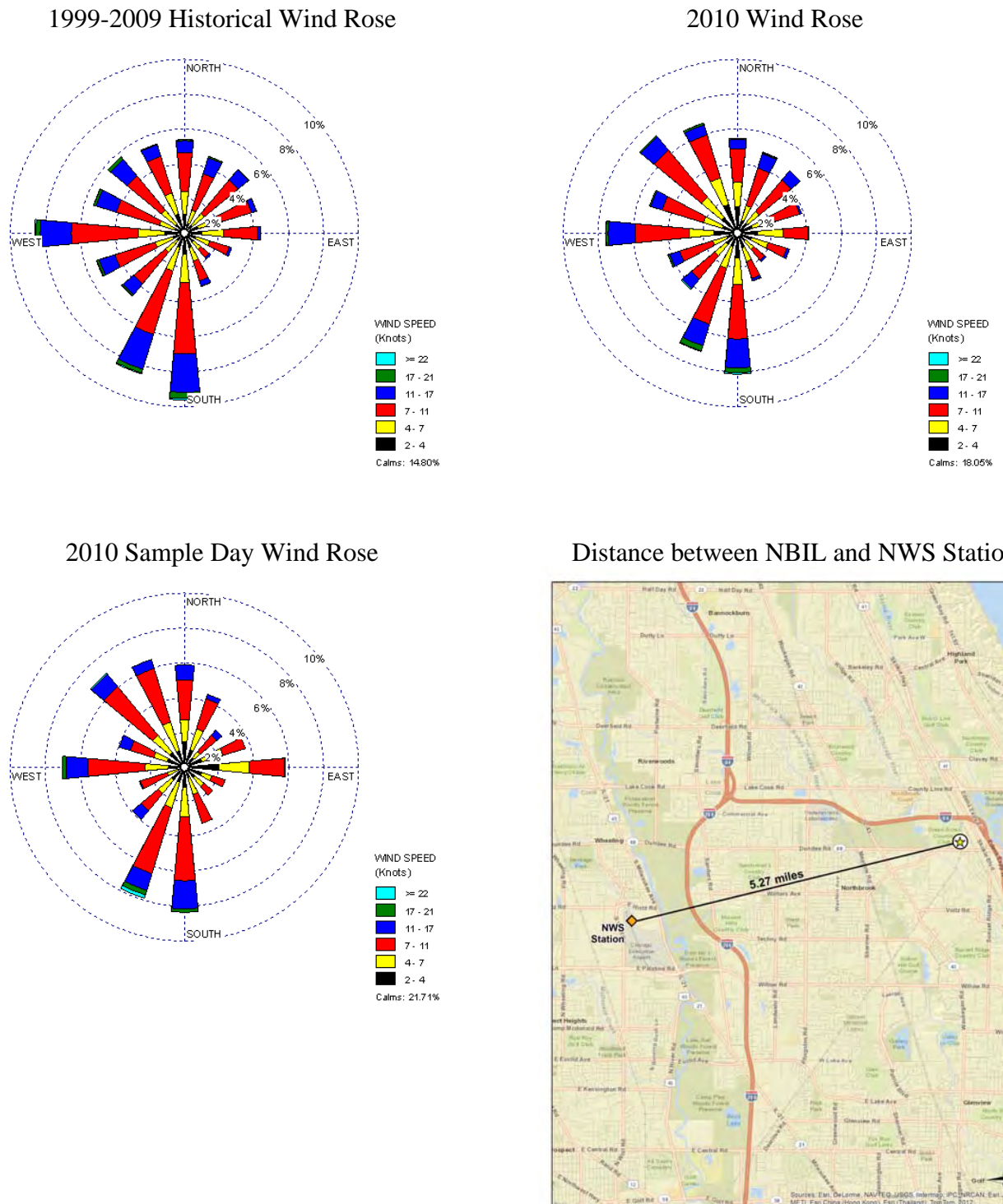
Figure 11-9. Wind Roses for the O'Hare International Airport Weather Station near SPIL

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between SPIL and NWS Station
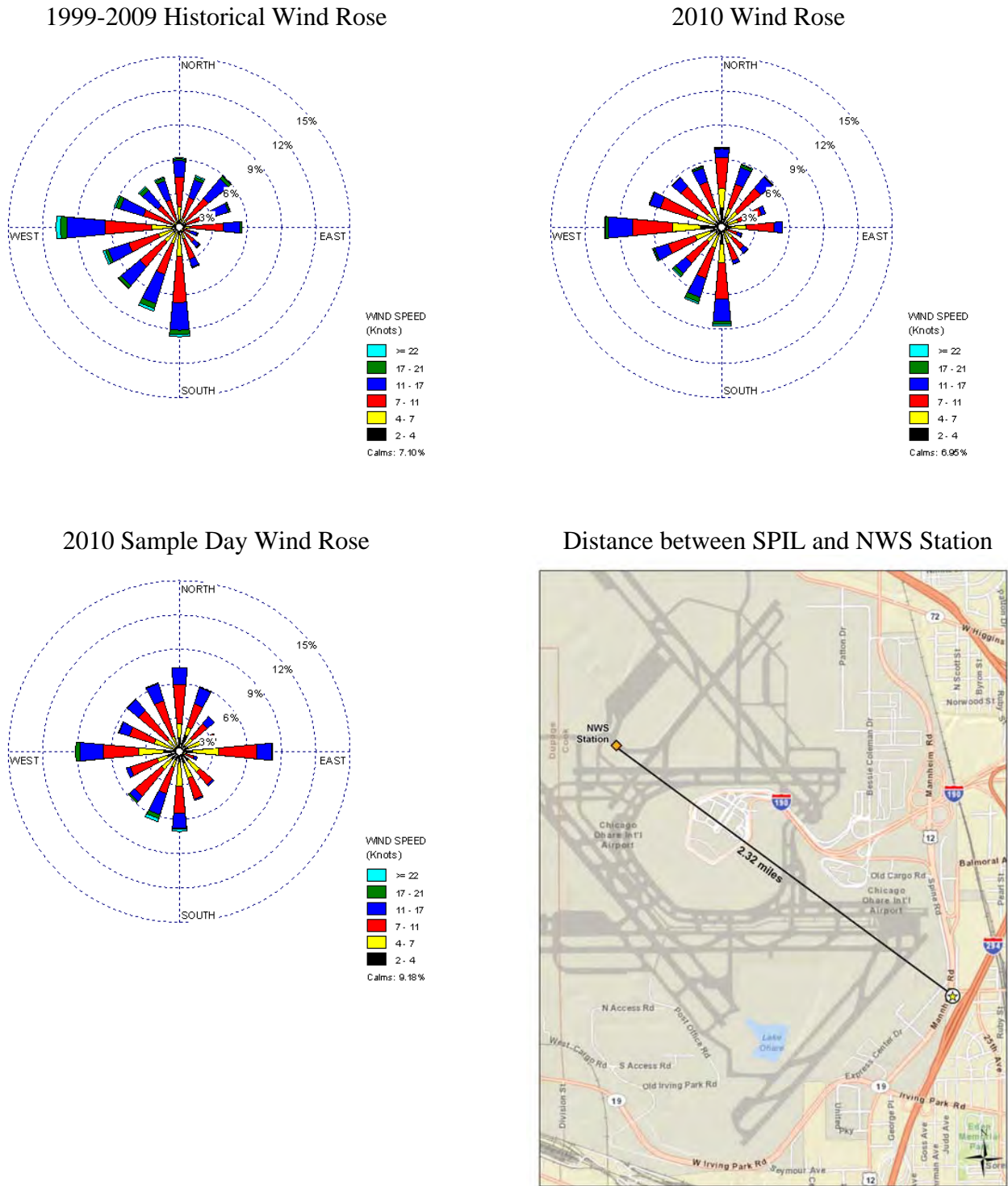
Observations from Figure 11-9 for SPIL include the following:

- 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 often. Calm winds (≤ 2 knots) were observed for less than 10 percent of the hourly measurements.

- The 2010 wind rose exhibits similar patterns in wind directions as the historical wind rose. The 2010 sample day wind patterns resemble the full-year wind patterns, although with a slightly higher percentage of easterly winds and fewer southerly winds. This indicates that conditions on sample days were representative of conditions experienced throughout the year.

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 11-4 presents NBIL's and SPIL's pollutants of interest. 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 VOC, carbonyl compounds, SNMOC, metals (PM$_{10}$), PAH, and hexavalent chromium, and is one of two NMP sites sampling for all six pollutant groups. SPIL sampled for VOC and carbonyl compounds only.

Table 11-4. Risk 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						
Benzene	0.13	55	55	100.00	11.75	11.75
Carbon Tetrachloride	0.17	55	55	100.00	11.75	23.50
Formaldehyde	0.077	55	55	100.00	11.75	35.26
Naphthalene	0.029	52	59	88.14	11.11	46.37
Arsenic (PM$_{10}$)	0.00023	51	61	83.61	10.90	57.26
Acetaldehyde	0.45	47	55	85.45	10.04	67.31
Manganese (PM$_{10}$)	0.005	32	61	52.46	6.84	74.15
1,3-Butadiene	0.03	31	42	73.81	6.62	80.77
Fluorene	0.011	23	59	38.98	4.91	85.68
Acenaphthene	0.011	22	59	37.29	4.70	90.38
p-Dichlorobenzene	0.091	11	26	42.31	2.35	92.74
Fluoranthene	0.011	10	59	16.95	2.14	94.87
1,2-Dichloroethane	0.038	9	9	100.00	1.92	96.79
Ethylbenzene	0.4	4	54	7.41	0.85	97.65
Trichloroethylene	0.2	4	32	12.50	0.85	98.50
Dichloromethane	7.7	2	55	3.64	0.43	98.93
Nickel (PM$_{10}$)	0.0021	2	61	3.28	0.43	99.36
Acrylonitrile	0.015	1	1	100.00	0.21	99.57
Chloroform	9.8	1	55	1.82	0.21	99.79
Hexavalent Chromium	0.000083	1	48	2.08	0.21	100.00
Total		468	961	48.70		
Schiller Park, Illinois - SPIL						
Benzene	0.13	60	60	100.00	16.09	16.09
Carbon Tetrachloride	0.17	60	60	100.00	16.09	32.17
1,3-Butadiene	0.03	59	59	100.00	15.82	47.99
Acetaldehyde	0.45	58	58	100.00	15.55	63.54
Formaldehyde	0.077	58	58	100.00	15.55	79.09
Trichloroethylene	0.2	33	48	68.75	8.85	87.94
1,2-Dichloroethane	0.038	12	12	100.00	3.22	91.15
Ethylbenzene	0.4	11	60	18.33	2.95	94.10
p-Dichlorobenzene	0.091	7	27	25.93	1.88	95.98
Acrylonitrile	0.015	6	6	100.00	1.61	97.59
Propionaldehyde	0.8	4	58	6.90	1.07	98.66
Bromomethane	0.5	2	50	4.00	0.54	99.20
Chloroprene	0.0021	2	2	100.00	0.54	99.73
Dichloromethane	7.7	1	60	1.67	0.27	100.00
Total		373	618	60.36		

Observations from Table 11-4 include the following:

- Twenty pollutants, including 12 NATTS MQO Core Analytes, failed screens for NBIL. Approximately 49 percent of the measured detections of these pollutants failed screens.

- Based on the risk screening process, 13 pollutants, of which eight are NATTS MQO Core Analytes, were identified as pollutants of interest for NBIL. Four additional NATTS MQO Core Analytes (trichloroethylene, nickel, chloroform, and hexavalent chromium) were added to NBIL's list of pollutants of interest, even though they did not contribute to 95 percent of the failed screens for NBIL. In addition, six more NATTS MQO Core Analytes were added to the pollutants of interest for NBIL, even though they did not fail any screens (benzo(a)pyrene, beryllium, cadmium, lead, tetrachloroethylene, and vinyl chloride). These six pollutants are not shown in Table 11-4.

- Benzene, carbon tetrachloride, and formaldehyde were detected in every VOC or carbonyl compound sample collected at NBIL and failed 100 percent of screens. While acrylonitrile and 1,2-dichloroethane also failed 100 percent of screens for NBIL, these pollutants were detected in few of the 55 valid samples collected.

- Fourteen pollutants, including six NATTS MQO Core Analytes, failed screens for SPIL. Note that NBIL sampled four additional methods than SPIL but only failed six additional screens.

- Based on the risk 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 SPIL's list of pollutants of interest, even though they did not fail any screens (chloroform, tetrachloroethylene, and vinyl chloride). These pollutants are not shown in Table 11-4.

- 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. Four additional 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 screening process. As NBIL sampled both VOC (TO-15) and SNMOC, 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. Concentration averages are provided for the pollutants of interest for each Illinois site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations

compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site, where applicable. Additional site-specific statistical summaries are provided in Appendices J through O.

11.4.1 2010 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 PAH, 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	55/55	0.71 ± 0.18	0.85 ± 0.21	1.01 ± 0.19	NA	1.02 ± 0.16
Benzene	55/55	0.56 ± 0.09	0.58 ± 0.15	0.79 ± 0.18	NA	0.70 ± 0.10
1,3-Butadiene	42/55	0.02 ± 0.01	0.04 ± 0.02	0.05 ± 0.02	NA	0.05 ± 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 black 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Carbon Tetrachloride	55/55	0.76 ± 0.06	0.73 ± 0.05	0.72 ± 0.06	NA	0.72 ± 0.03
Chloroform	55/55	0.20 ± 0.07	0.95 ± 0.64	1.92 ± 1.65	NA	1.06 ± 0.53
p-Dichlorobenzene	26/55	0.01 ± 0.01	0.03 ± 0.02	0.07 ± 0.04	NA	0.06 ± 0.03
1,2-Dichloroethane	9/55	0.03 ± 0.02	0.02 ± 0.02	0	NA	0.01 ± 0.01
Formaldehyde	55/55	0.95 ± 0.23	1.35 ± 0.33	1.74 ± 0.33	NA	3.59 ± 2.18
Tetrachloroethylene	50/55	0.11 ± 0.05	0.17 ± 0.06	0.27 ± 0.08	NA	0.21 ± 0.05
Trichloroethylene	32/55	0.04 ± 0.03	0.05 ± 0.03	0.11 ± 0.04	NA	0.07 ± 0.02
Vinyl Chloride	1/55	0	<0.01 ± <0.01	0	NA	<0.01 ± <0.01
Acenaphthene[a]	59/59	1.90 ± 0.72	10.28 ± 4.49	22.91 ± 8.83	7.58 ± 4.42	10.46 ± 3.16
Arsenic (PM$_{10}$)[a]	61/61	0.38 ± 0.12	0.77 ± 0.38	0.91 ± 0.41	0.95 ± 0.36	0.75 ± 0.17
Benzo(a)pyrene[a]	53/59	0.18 ± 0.07	0.09 ± 0.04	0.07 ± 0.04	0.12 ± 0.04	0.11 ± 0.03
Beryllium (PM$_{10}$)[a]	56/61	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	0.01 ± <0.01	<0.01 ± <0.01
Cadmium (PM$_{10}$)[a]	61/61	0.12 ± 0.04	0.11 ± 0.04	0.11 ± 0.03	0.19 ± 0.08	0.13 ± 0.02
Fluoranthene[a]	59/59	1.88 ± 0.61	8.05 ± 4.10	13.05 ± 3.54	2.46 ± 1.01	6.25 ± 1.74
Fluorene[a]	59/59	2.57 ± 0.85	11.56 ± 5.42	22.43 ± 7.62	6.98 ± 3.57	10.69 ± 2.98
Hexavalent Chromium[a]	48/61	0.01 ± 0.01	0.03 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.02 ± <0.01
Lead (PM$_{10}$)[a]	61/61	2.19 ± 0.56	3.15 ± 1.20	2.89 ± 0.81	4.25 ± 1.48	3.11 ± 0.53
Manganese (PM$_{10}$)[a]	61/61	3.56 ± 1.30	7.62 ± 3.16	6.58 ± 1.94	9.19 ± 5.00	6.74 ± 1.57
Naphthalene[a]	59/59	46.23 ± 14.21	79.31 ± 28.65	183.29 ± 114.27	118.51 ± 49.53	105.54 ± 31.79
Nickel (PM$_{10}$)[a]	61/61	0.71 ± 0.12	1.61 ± 0.69	1.04 ± 0.19	0.89 ± 0.15	1.06 ± 0.19
Schiller Park, Illinois - SPIL						
Acetaldehyde	58/58	1.37 ± 0.32	1.38 ± 0.36	1.64 ± 0.15	2.05 ± 0.46	1.62 ± 0.18
Benzene	60/60	0.80 ± 0.14	0.96 ± 0.32	0.99 ± 0.21	1.03 ± 0.19	0.94 ± 0.11

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
[a] Average concentrations provided for the pollutants below the black line are presented in ng/m³ 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
1,3-Butadiene	59/60	0.13 ± 0.04	0.14 ± 0.05	0.12 ± 0.03	0.17 ± 0.05	0.14 ± 0.02
Carbon Tetrachloride	60/60	0.76 ± 0.07	0.70 ± 0.07	0.71 ± 0.06	0.68 ± 0.06	0.71 ± 0.03
Chloroform	55/60	0.06 ± 0.02	0.14 ± 0.06	0.14 ± 0.02	0.09 ± 0.02	0.11 ± 0.02
p-Dichlorobenzene	27/60	0.01 ± 0.01	0.07 ± 0.05	0.06 ± 0.03	0.03 ± 0.02	0.04 ± 0.02
1,2-Dichloroethane	12/60	0.02 ± 0.02	0.03 ± 0.02	<0.01 0.01	0.01 ± 0.02	0.02 ± 0.01
Ethylbenzene	60/60	0.18 ± 0.06	0.29 ± 0.15	0.32 ± 0.08	0.30 ± 0.09	0.27 ± 0.05
Formaldehyde	58/58	1.65 ± 0.37	2.12 ± 0.54	2.77 ± 0.31	3.52 ± 1.42	2.53 ± 0.42
Tetrachloroethylene	58/60	0.26 ± 0.15	0.34 ± 0.13	0.39 ± 0.13	0.31 ± 0.13	0.32 ± 0.06
Trichloroethylene	48/60	0.20 ± 0.15	0.98 ± 0.87	1.57 ± 1.30	0.42 ± 0.21	0.79 ± 0.40
Vinyl Chloride	2/60	<0.01 ± <0.01	<0.01 ± <0.01	0	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 black line are presented in ng/m³ 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 formaldehyde (3.59 ± 2.18 µg/m³), chloroform (1.06 ± 0.53 µg/m³), and acetaldehyde (1.02 ± 0.16 µg/m³). None of the annual average concentrations for any of the pollutants of interest were greater than 1.00 µg/m³ in 2008 or 2009.

- Fourth quarter average concentrations could not be calculated for the VOC or carbonyl compounds because there were fewer than 75 percent of samples were valid during this quarter.

- Note how much higher the annual average concentration of formaldehyde is compared to the first, second, and third quarter averages. This indicates that the measurements driving the annual average were measured during the fourth quarter. A review of the data shows that the seven highest concentrations of this pollutant were measured between October and December 2010. The highest concentration was measured on December 4, 2010 (53.5 µg/m³). The next highest formaldehyde concentration was roughly half that (24.2 µg/m³) and was measured on November 4, 2010. Three additional formaldehyde concentrations between 10 and 20 µg/m³ were also measured during this quarter. Of the 10 formaldehyde

concentrations greater than 10 µg/m^3 measured across the NMP sites sampling carbonyl compounds, five were measured at NBIL, including the top four.

- Chloroform's third quarter average is significantly higher than the other available quarterly average concentrations and has a relatively large confidence interval associated with it, indicating the likely presence of outliers. The highest concentration of chloroform was measured on September 17, 2010 (12.1 µg/m^3). This is also the highest measurement of this pollutant among all NMP sites sampling VOC. The second highest concentration of chloroform was measured on the previous sample day (7.14 µg/m^3 on September 11, 2010) and is also the third highest chloroform measurement among all NMP sites. Of the 10 highest concentrations of chloroform among NMP sites, eight were measured at NBIL. Similar findings have been found in previous NMP reports.

- Concentrations of most of the pollutants of interest for NBIL did not vary significantly from quarter to quarter. However, fourth quarter average concentrations could not be calculated for the VOC and carbonyl compounds, making a quarterly trend harder to determine. Several of the PAH exhibited higher concentrations during the warmer months of the year. For example, fluoranthene's second and third quarterly average concentrations are greater than the first and fourth quarterly averages. Acenaphthene, flourene, and naphthalene exhibit this trend too, although the fourth quarter averages of these pollutants are also relatively high. Many of the quarterly averages of the PAHs also have large confidence intervals associated with them, indicating a relatively high level of variability in the measurements.

- Naphthalene's third quarter average is significantly higher than the other available quarterly average concentrations and has a relatively large confidence interval associated with it, indicating the likely presence of outliers. The highest concentration of naphthalene was measured on September 23, 2010 (869 ng/m^3). This concentration is among the 10 highest measurements of this pollutant among NMP sites sampling PAH. The second highest concentration of naphthalene was measured two weeks later but is significantly less, by more than half (363 ng/m^3 on October 11, 2010). The median naphthalene concentration for NBIL is 84.0 ng/m^3.

- Several of the quarterly averages for the PM$_{10}$ metals are highest for the fourth quarter, although the difference is not statistically significant among the quarters. This is most notable for manganese. The highest concentration of manganese was measured on November 10, 2010 (40.2 ng/m^3). The next highest concentration of manganese measured during this quarter was much less (13.7 ng/m^3 on October 23, 2010), indicating that this high measurement is driving the quarterly average. The median manganese concentration for this quarter is 6.90 ng/m^3.

Observations for SPIL from Table 11-5 include the following:

- The pollutants with the highest annual average concentrations by mass are formaldehyde (2.53 ± 0.42 µg/m^3) and acetaldehyde (1.62 ± 0.18 µg/m^3). These are the only pollutants with annual average concentrations greater than 1 µg/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 second and third quarterly average concentrations of trichloroethylene are higher than the other quarters and have rather large confidence intervals associated with them, particularly the third quarter of 2010, indicating that outliers are likely influencing these averages. The highest trichloroethylene concentration was measured on September 17, 2010 (9.64 $\mu g/m^3$) and is the highest trichloroethylene concentration measured among NMP sites sampling VOC. Of the 18 concentrations of trichloroethylene greater than 1 $\mu g/m^3$ across the program, 15 of these were measured at SPIL. The bulk of these were measured during the third quarter of 2010.

- The fourth quarter average concentration of formaldehyde also has a high confidence interval associated with it. The five highest concentrations of formaldehyde were all measured during the fourth quarter of 2010, and ranged from 10.8 $\mu g/m^3$ (measured on December 22, 2010) to 3.98 $\mu g/m^3$ (measured on October 11, 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 NBIL and SPIL from those tables include the following:

- NBIL and SPIL appear in Tables 4-9 through 4-12 a total of 22 times.

- As shown in Table 4-9, NBIL's annual average concentration of chloroform is the highest among all NMP sites sampling this pollutant. SPIL has the highest annual average concentration of trichloroethylene, which is more than eight times greater than the next highest annual average of this pollutant. NBIL also has the fourth highest annual average concentration of trichloroethylene. NBIL and SPIL have the second and third highest annual average concentrations of carbon tetrachloride, respectively. SPIL has the fourth highest annual average concentrations of 1,3-butadiene and tetrachloroethylene.

- NBIL has the third highest annual average concentration of formaldehyde among sites sampling carbonyl compounds, as shown in Table 4-10. However, the high confidence interval indicates that there are outliers driving this average, as opposed to the site measuring higher concentrations on a regular basis, which, based on the confidence intervals, would be expected for the sites ranking first and second highest (ELNJ and BTUT) for formaldehyde.

- NBIL has the second highest annual average concentrations of acenaphthene and fluorene and the fifth highest annual average concentration of benzo(a)pyrene among NMP sites sampling PAH, as shown in Table 4-11.

- As shown in Table 4-12, the annual average concentrations for NBIL were among the top four for all of the program-level PM_{10} metals 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 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, 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, manganese, and naphthalene for NBIL. Figures 11-10 through 11-18 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 11-10. Program vs. Site-Specific Average Acetaldehyde Concentration
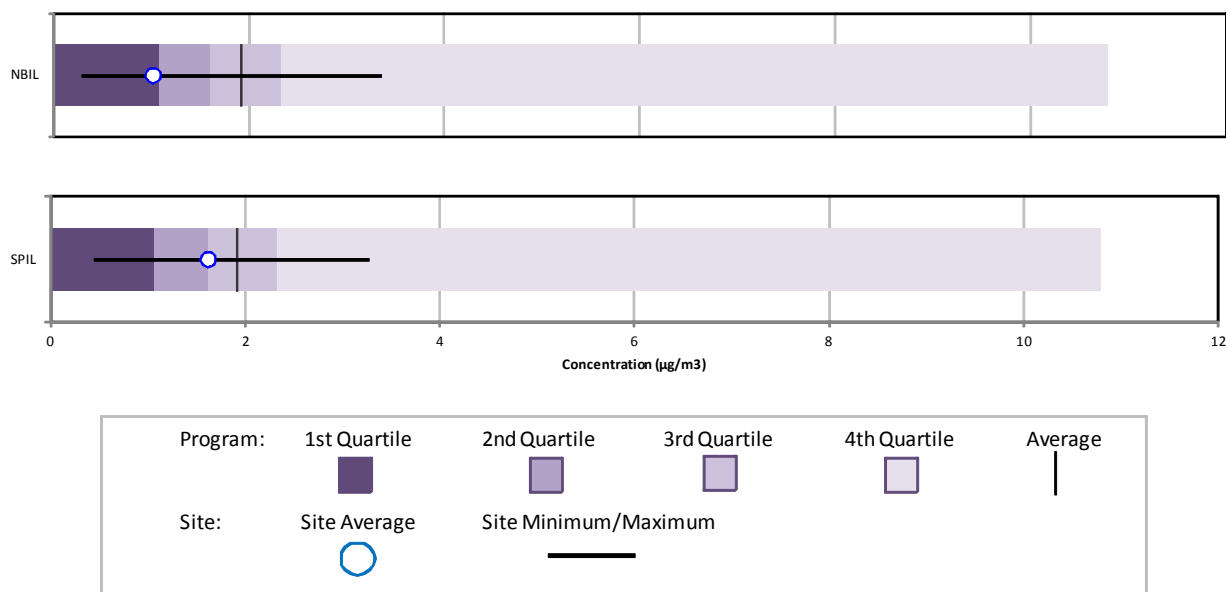
Figure 11-11. Program vs. Site-Specific Average Arsenic (PM$_{10}$) Concentration
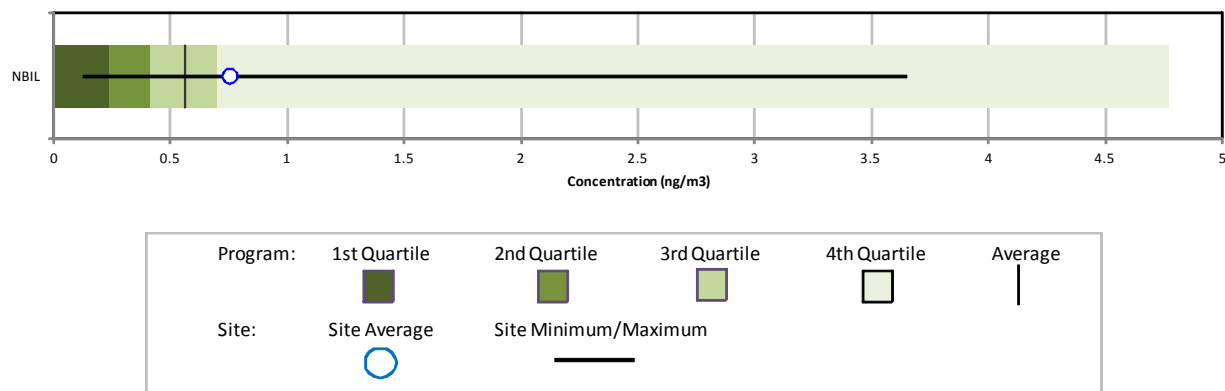
Figure 11-12. Program vs. Site-Specific Average Benzene Concentration
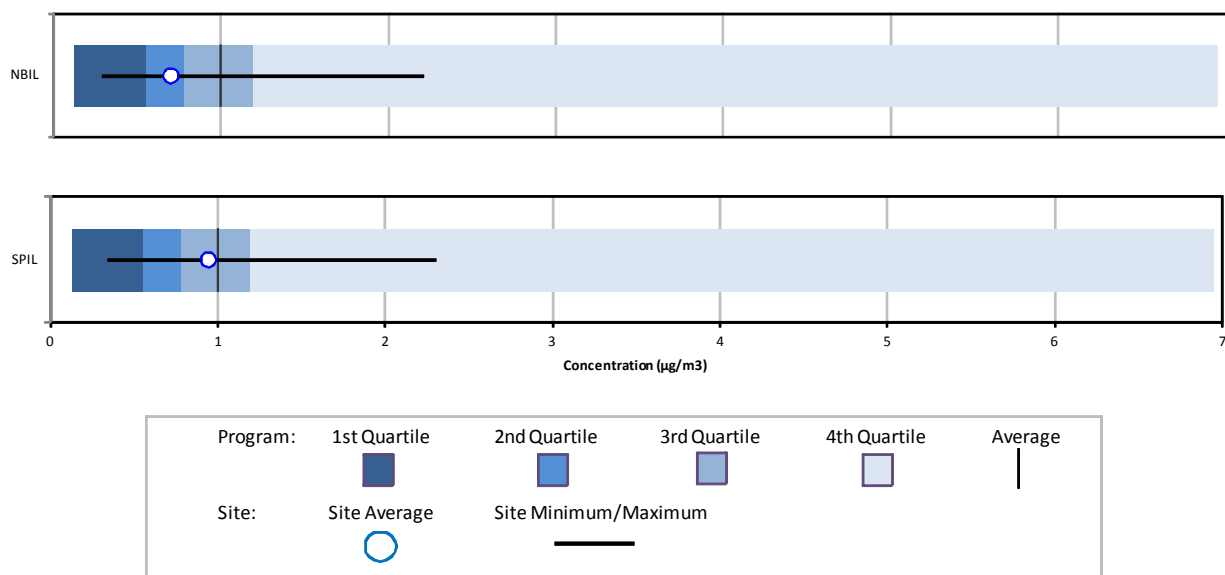
Figure 11-13. Program vs. Site-Specific Average Benzo(a)pyrene Concentration
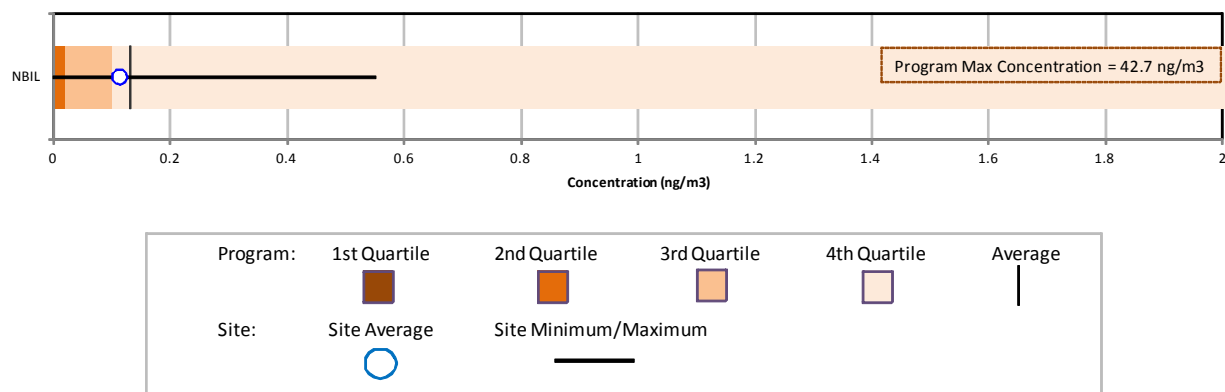
Figure 11-14. Program vs. Site-Specific Average 1,3-Butadiene Concentration
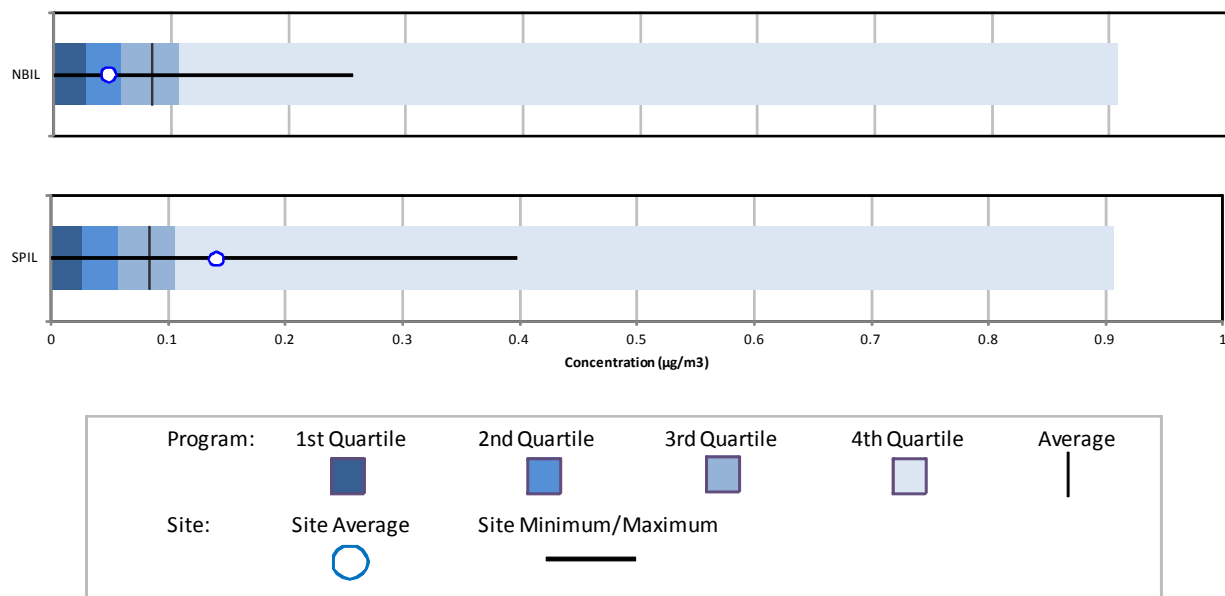
Figure 11-15. Program vs. Site-Specific Average Formaldehyde Concentration
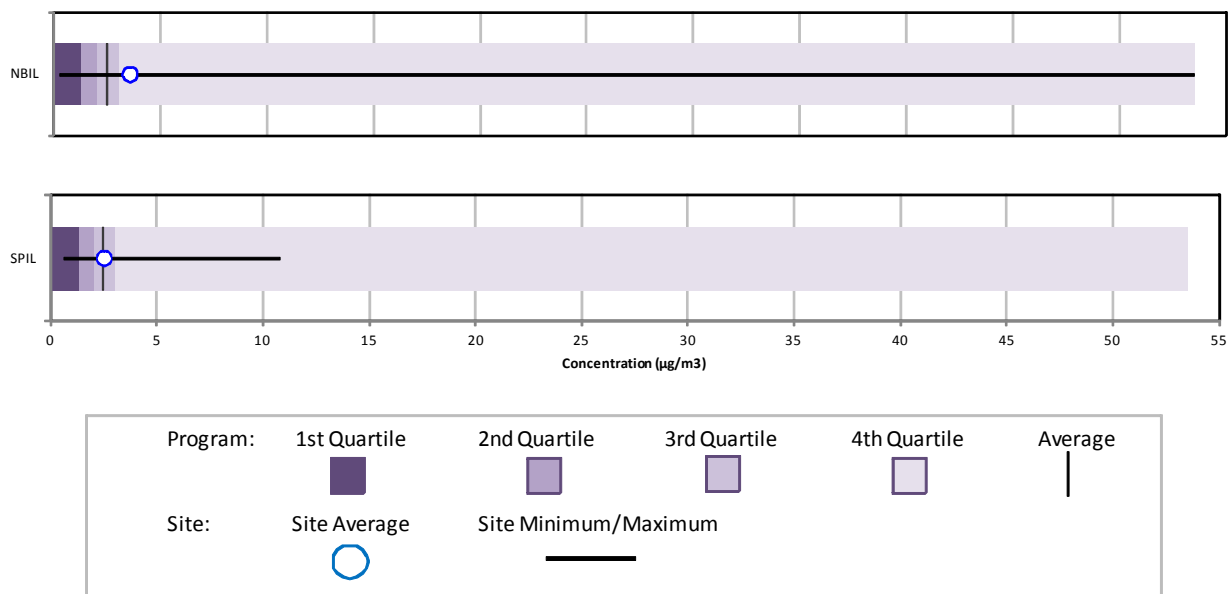
Figure 11-16. Program vs. Site-Specific Average Hexavalent Chromium Concentration
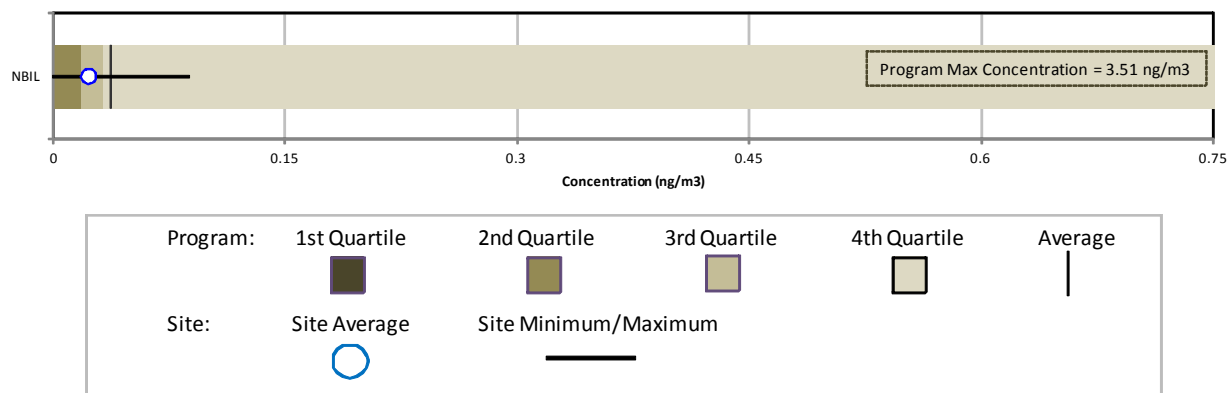
Figure 11-17. Program vs. Site-Specific Average Manganese (PM$_{10}$) Concentration
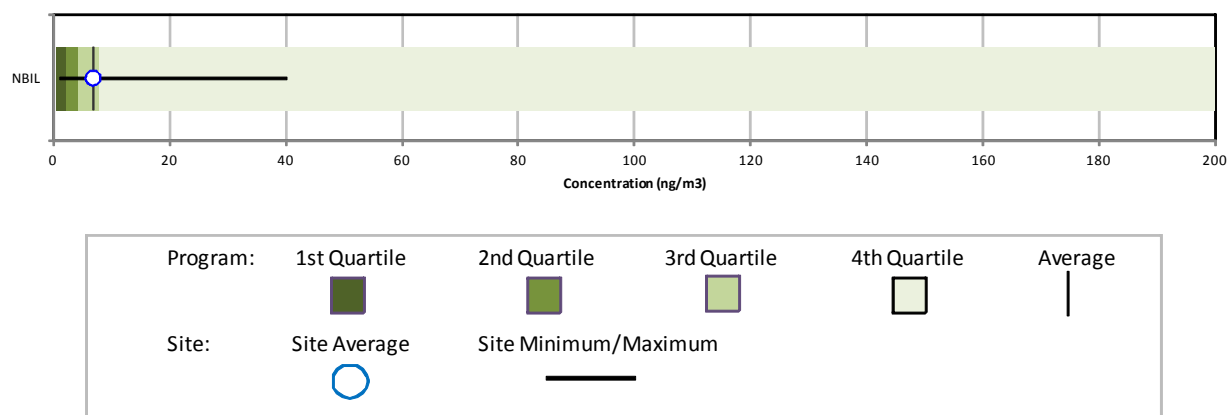
Figure 11-18. Program vs. Site-Specific Average Naphthalene Concentration
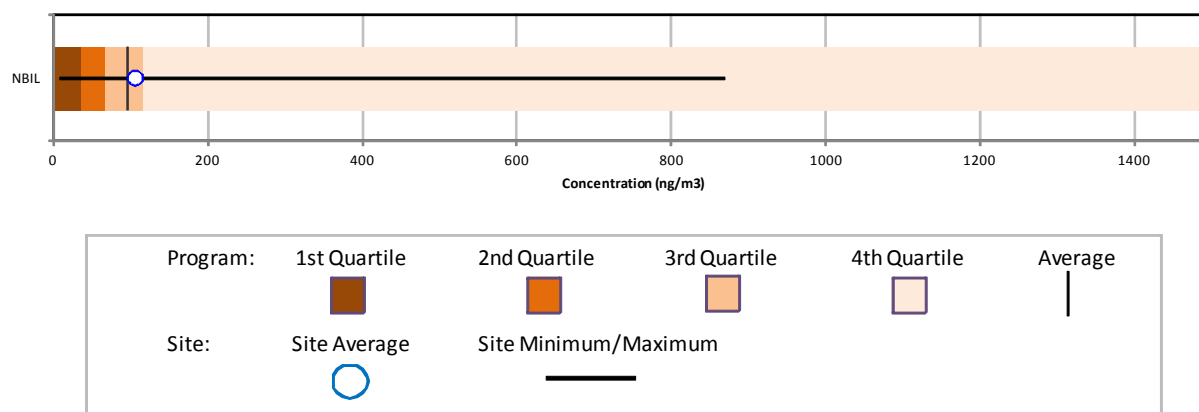
Observations from Figures 11-10 through 11-18 include the following:

- Figure 11-10 shows that while SPIL's annual average acetaldehyde concentration is greater than NBIL's annual average acetaldehyde concentration, both annual averages are less than the program-level average. NBIL's annual average is less than the program-level first quartile while SPIL's annual average is equivalent to the program-level median (or second quartile). There were no non-detects of acetaldehyde measured at either site.

- 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. The annual average for NBIL is also greater than the program-level third quartile. While the maximum concentration measured at NBIL is not the maximum measured across the program, it is the second highest arsenic concentration measured among NMP sites sampling PM_{10} metals.

- Figure 11-12 shows that SPIL's annual average benzene concentration is greater than NBIL's annual average benzene concentration. Although both annual averages are less than the program-level average, the difference is minimal for SPIL. The maximum benzene concentrations measured at the Illinois sites are well below the program-level maximum concentration. There were no non-detects of benzene measured at either site.

- Figure 11-13 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 benzo(a)pyrene concentration for NBIL is just less than the program-level average concentration. Figure 11-13 also shows that the maximum concentration measured at NBIL is well below the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at NBIL.

- Figure 11-14 for 1,3-butadiene also shows both sites. Figure 11-14 shows that NBIL's annual average 1,3-butadiene concentration is less than both the program-level average and median concentrations. Conversely, SPIL's annual average 1,3-butadiene concentration is nearly twice the program-level average for 1,3-butadiene. Non-detects of 1,3-butadiene were measured at both sites.

- Figure 11-15 presents the box plots for formaldehyde. The box plots show that while NBIL's annual average formaldehyde concentration is greater than the program-level average, SPIL's annual average formaldehyde concentration is roughly equal to program-level average. However, what is most prominent in Figure 11-15 is that NBIL's maximum concentration of formaldehyde is the maximum concentration measured across the program. As discussed in the previous section, the four highest concentrations of this pollutant measured among all NMP sites sampling carbonyl compounds were all measured at NBIL.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 11-16 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 11-16 shows that the annual average concentration of hexavalent chromium for NBIL is less than the program-level average. The maximum concentration measured at NBIL is well below the program-level maximum concentration. There were several non-detects of hexavalent chromium measured at NBIL.

- Figure 11-17 is the box plot for manganese, which was measured at NBIL. The box plot shows that the annual average concentration for NBIL is roughly equivalent to the program-level average concentration. While the maximum concentration measured at NBIL is not the maximum measured across the program, it is among the higher manganese concentrations measured among NMP sites sampling PM$_{10}$ metals. There were no non-detects of manganese measured at NBIL.

- Figure 11-18 shows that the annual naphthalene average for NBIL is greater than the program-level average concentration. While the maximum naphthalene concentration measured at NBIL is well below the program-level maximum concentration, NBIL's maximum concentration is among the highest concentrations measured at the program-level. There were no non-detects of naphthalene measured at NBIL.

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 VOC under the NMP since 2003. Both sites have also sampled carbonyl compounds since 2005. Additionally, NBIL has also sampled PM$_{10}$ metals and hexavalent chromium since 2005. Figures 11-19 through 11-25 present the 3-year rolling statistical metrics for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, and manganese for NBIL, respectively. Figures 11-26 through 11-29 present the 3-year rolling 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.

Figure 11-19. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at NBIL
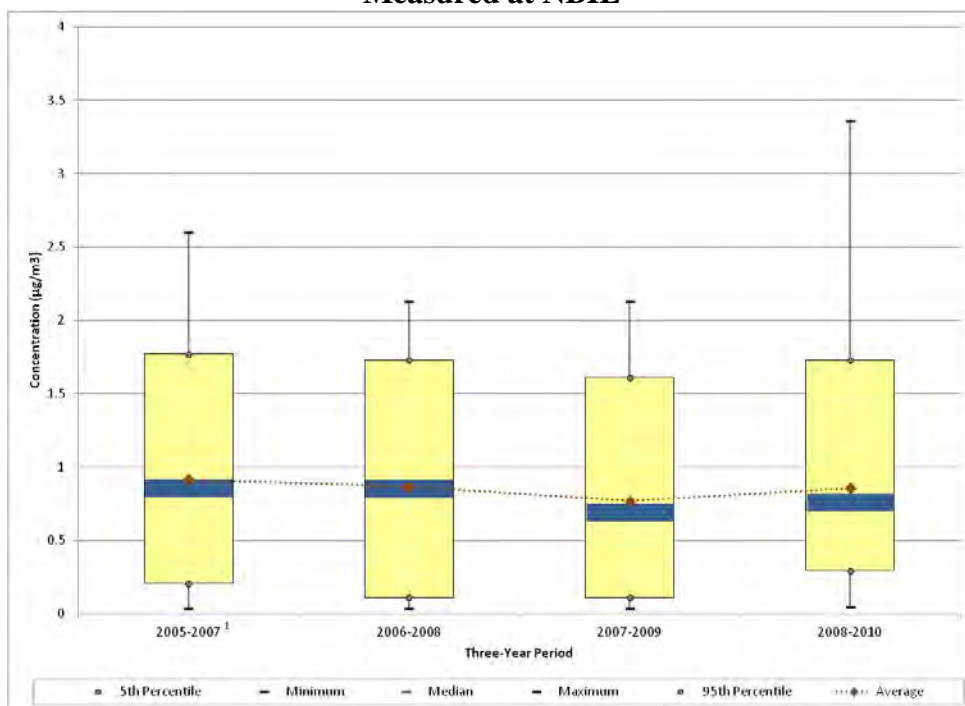
[1]Carbonyl compound sampling at NBIL began in March 2005.

Figure 11-20. Three-Year Rolling Statistical Metrics for Arsenic (PM$_{10}$) Concentrations Measured at NBIL
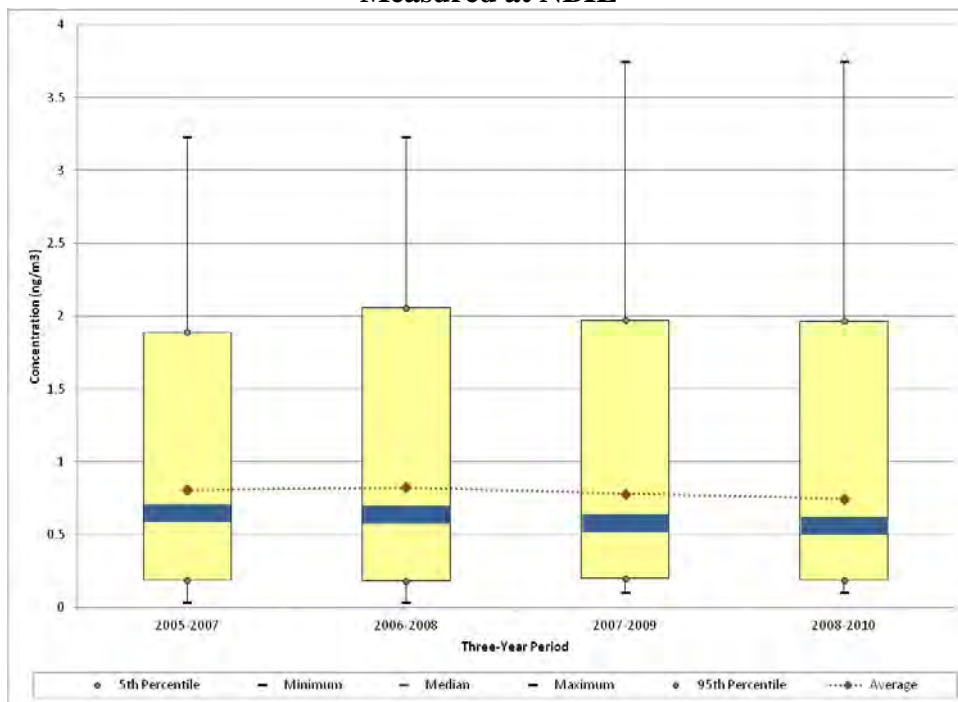
Figure 11-21. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at NBIL
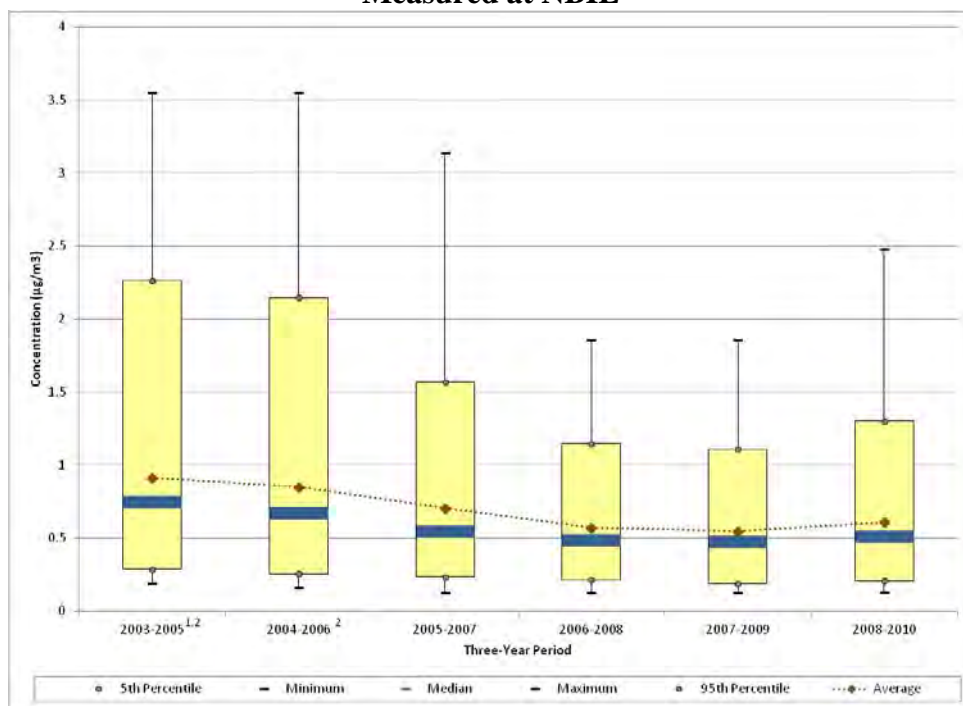
[1]VOC sampling at NBIL began in April 2003.
[2]No VOC samples were collected in November and December 2004.

Figure 11-22. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at NBIL
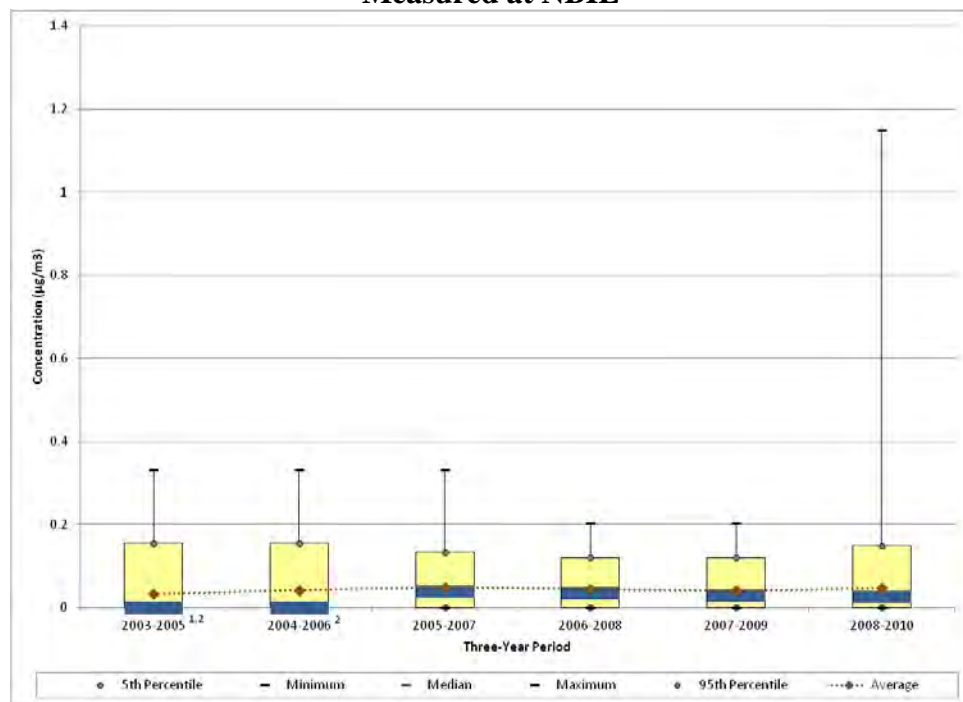
[1]VOC sampling at NBIL began in April 2003.
[2]No VOC samples were collected from November to December 2004.

Figure 11-23. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at NBIL
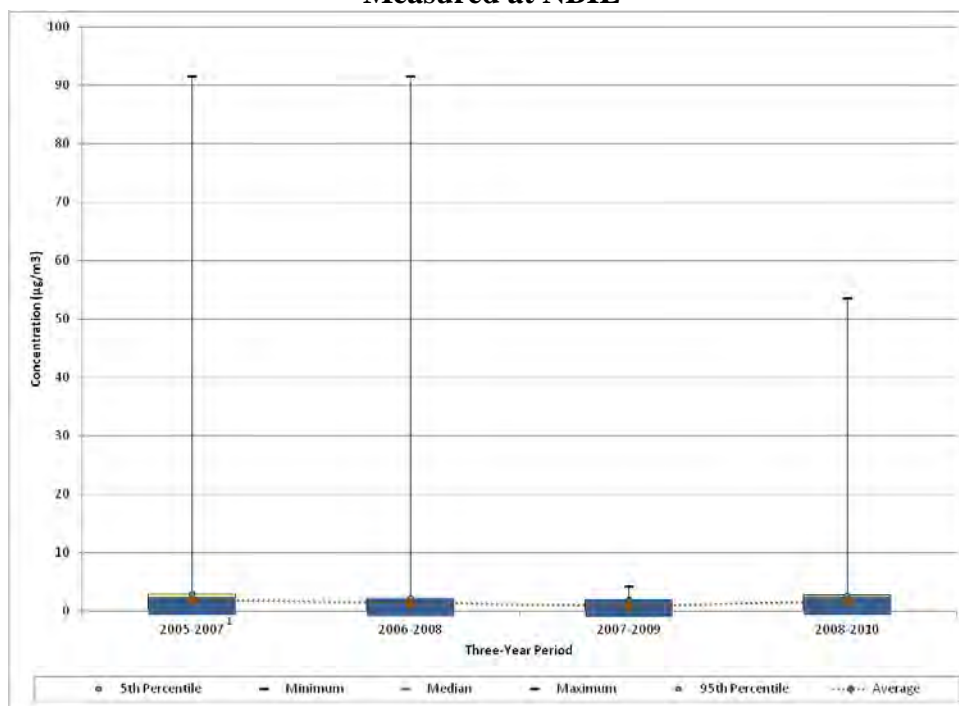
[1]Carbonyl compound sampling at NBIL began in March 2005.

Figure 11-24. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at NBIL
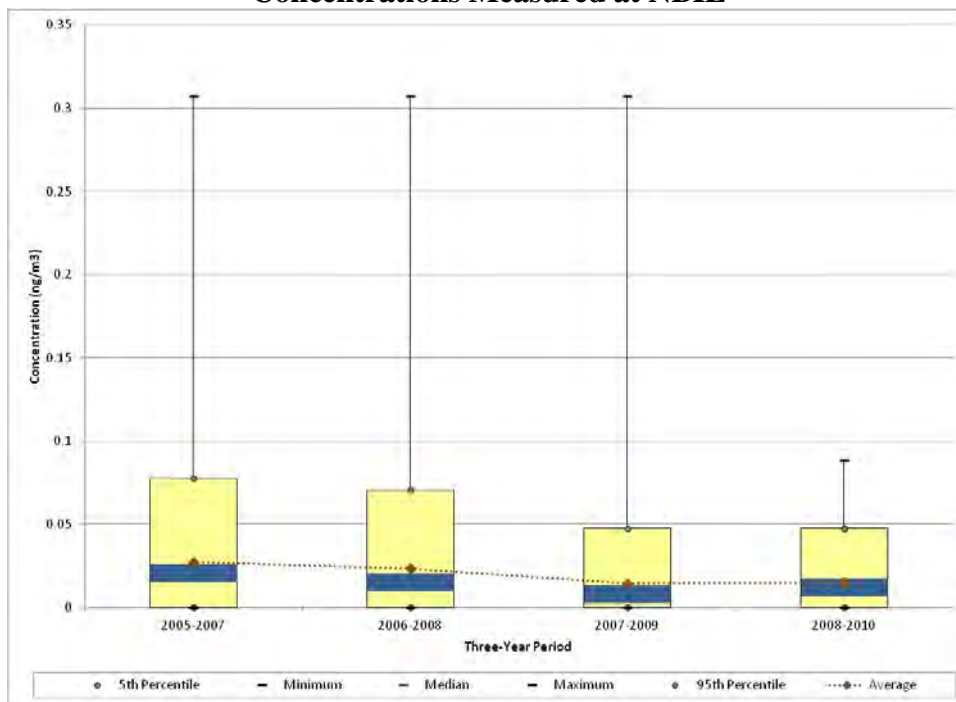
Figure 11-25. Three-Year Rolling Statistical Metrics for Manganese (PM$_{10}$) Concentrations Measured at NBIL
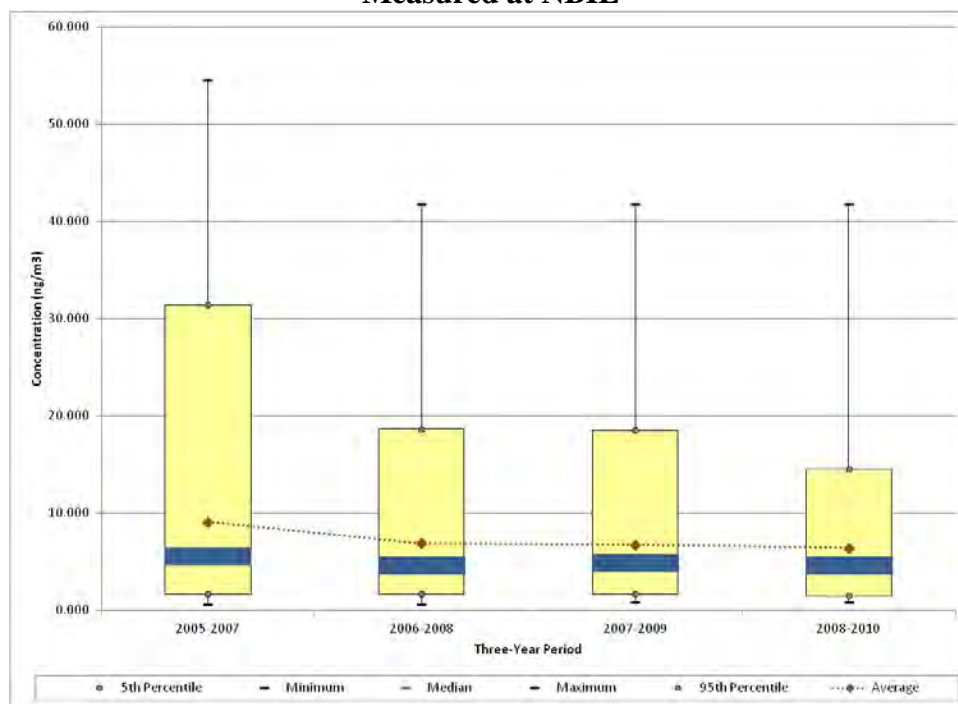
Figure 11-26. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at SPIL
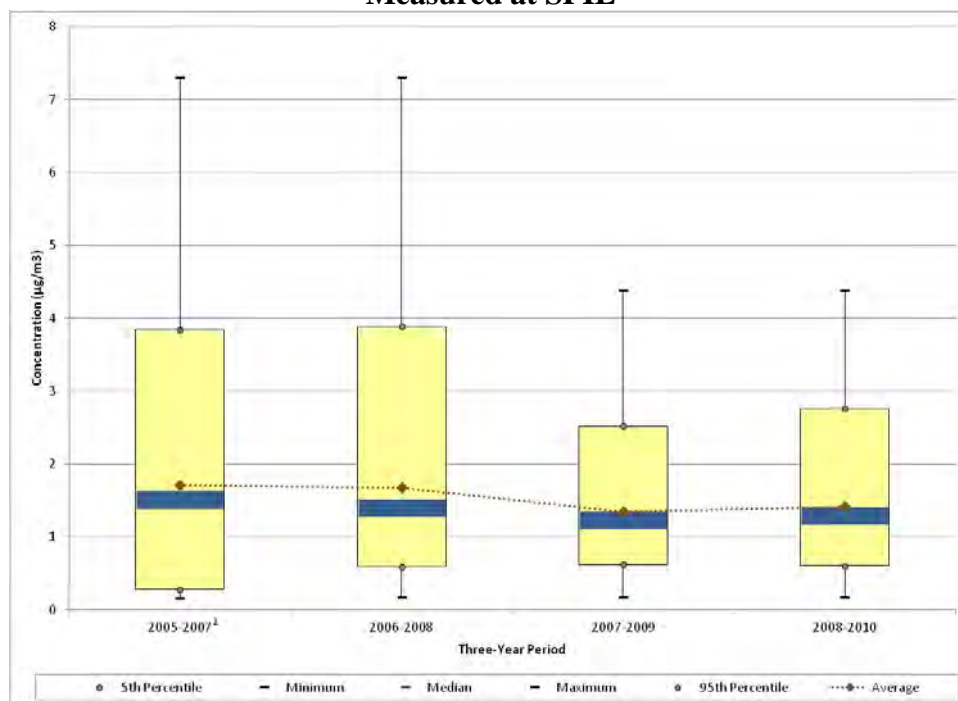
[1]Carbonyl compound sampling at SPIL began in February 2005.

Figure 11-27. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at SPIL
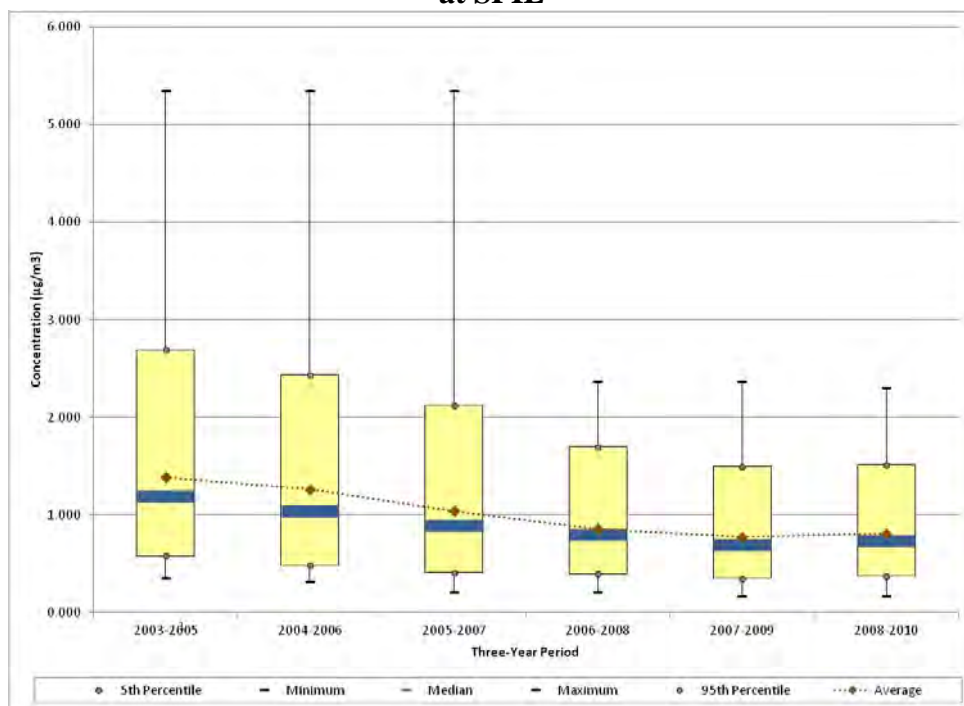
[1]VOC sampling at SPIL began in April 2003.

Figure 11-28. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at SPIL
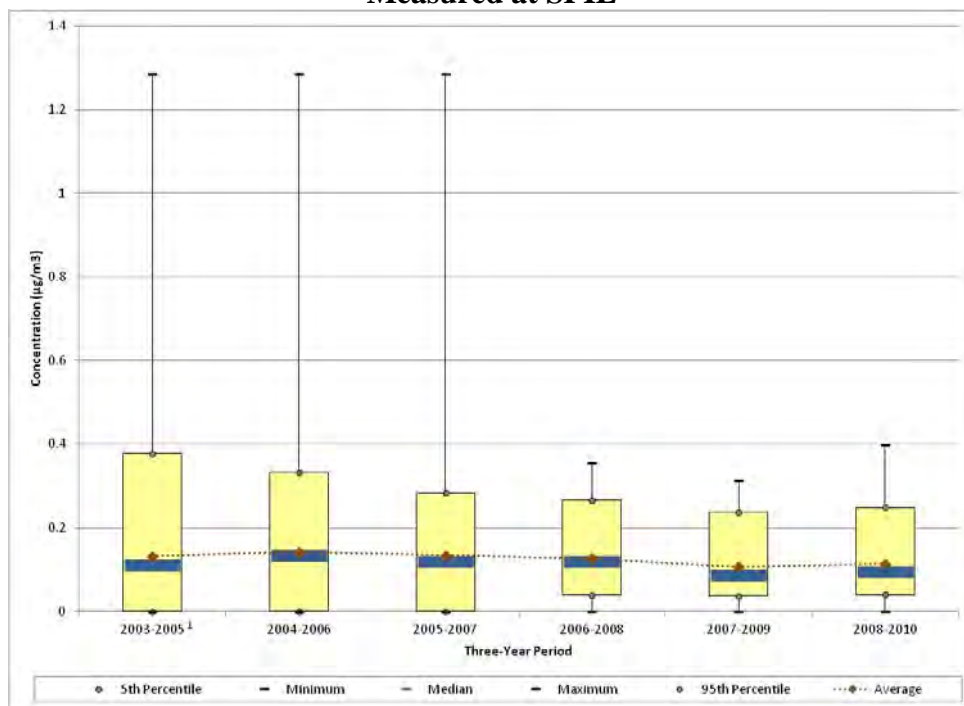
[1]VOC sampling at SPIL began in April 2003.

Figure 11-29. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at SPIL
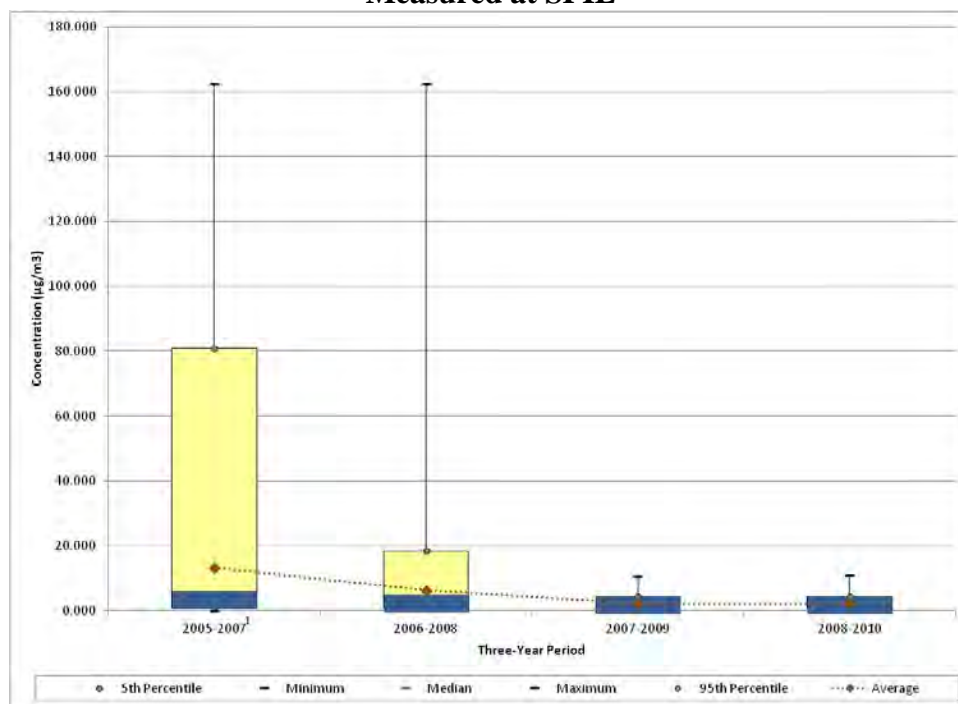
[1]Carbonyl compound sampling at SPIL began in February 2005.

Observations from Figure 11-19 for acetaldehyde measurements at NBIL include the following:

- Carbonyl compound sampling at NBIL began in March 2005, as denoted in Figure 11-19.

- The maximum acetaldehyde concentration was measured in 2010, as was the second highest concentration.

- The rolling average and median concentrations, as well as the other statistical parameters, have a slight decreasing trend through 2007-2009, after which most of the statistical parameters exhibit an increase.

- The minimum concentration for each 3-year period is greater than zero, indicating that there were no non-detects of acetaldehyde reported since the onset of carbonyl compound sampling.

Observations from Figure 11-20 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 rolling average concentrations exhibit a slight decreasing trend from 2006-2008 through 2008-2010, although the confidence intervals indicate that the decrease is not statistically significant.

- Note that the minimum concentration for each 3-year period is greater than zero, indicating that there were no non-detects of arsenic reported since the onset of metals sampling.

Observations from Figure 11-21 for benzene measurements at NBIL include the following:

- VOC sampling at NBIL began in April 2003, as denoted in Figure 11-21. However, VOC samples were not collected during November and December 2004.

- The maximum benzene concentration was measured on September 18, 2004, although similar measurements were also measured in 2005.

- The rolling average and median concentrations, as well as the other statistical parameters, have a decreasing trend through the 2007-2009 time frame, after which an increase is shown.

- Note that the minimum concentration for each 3-year period is greater than zero, indicating that there were no non-detects of benzene reported since the onset of VOC sampling.

Observations from Figure 11-22 for 1,3-butadiene measurements at NBIL include the following:

- The maximum 1,3-butadiene concentration was measured on December 16, 2010; this concentration is more than three times greater than the next highest concentration measured at NBIL (2005).

- Although fluctuations in the rolling average concentrations are shown in Figure 11-22, confidence intervals calculated on these averages indicate that the differences are not statistically significant.

- The minimum, 5th percentile, and median concentrations were all zero for the first two 3-year periods, indicating the presence of non-detects (at least 50 percent). The number of non-detects reported has fluctuated from year to year, from as high as 87 percent (2004) to as low as seven percent (2007). From the 2005-2007 time frame forward, the median is greater than zero and exhibits a similar trend as the rolling average.

Observations from Figure 11-23 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 53.5 µg/m^3 to 14.4 µg/m^3, were all measured in 2010.

- Although difficult to discern in Figure 11-23, the rolling average concentrations exhibited a decreasing trend through 2007-2009, after which the rolling average concentration increased. However, the high variability associated with three of the four 3-year periods make it difficult to determine if any of these changes are statistically significant.

- Although difficult to discern in Figure 11-23, the minimum concentration for each 3-year period is greater than zero, indicating that there were no non-detects of formaldehyde reported since the onset of carbonyl compound sampling.

Observations from Figure 11-24 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, with the others ranging from 0.235 ng/m^3 to 0.108 ng/m^3 (of which four of the five were measured in 2006).

- The rolling average concentrations of hexavalent chromium exhibit a decreasing trend through the 2007-2009 time frame, as do the medians and 95th percentiles. A slight increase is shown for these parameters for the 2008-2010 time frame, even though the maximum concentration shown for this time period decreased substantially.

- Both the minimum concentration and 5th percentile for all 3-year periods shown are zero, indicating the presence of non-detects.

Observations from Figure 11-25 for manganese (PM$_{10}$) measurements at NBIL include the following:

- Metals sampling at NBIL began in January 2005.

- The maximum manganese concentration was measured on August 26, 2005 (54.6 ng/m^3). However, concentrations in the 40-45 ng/m^3 range have been measured in 2005, 2008, and 2010.

- The rolling average exhibits a significant decrease from 2005-2007 to 2006-2008, with more subtle decreases afterward. The 95th percentile exhibits a similar trend over

the period of sampling. The median decreased from 2005-2007 to 2006-2008, increased slightly for 2007-2009, then returned to previous levels for 2008-2010.

- The rolling average and median concentrations became more similar to each other over time, indicating less variability in the central tendency of manganese measurements at NBIL.

- The minimum concentration for each 3-year period is greater than zero, indicating that there were no non-detects of manganese reported since the onset of metals sampling.

Observations from Figure 11-26 for acetaldehyde measurements at SPIL include the following:

- Carbonyl compound sampling at SPIL began in February 2005, as denoted in Figure 11-26.

- The maximum acetaldehyde concentration was measured on May 29, 2006. Of the eight acetaldehyde concentrations greater than 4.0 $\mu g/m^3$, all but one was measured in 2006.

- The rolling average concentrations for the 2005-2007 and 2006-2008 periods were similar to each other, the 2007-2009 rolling average exhibited a decrease from the previous 3-year periods, then the rolling average increased slightly for 2008-2010. Although difficult to discern in Figure 11-26, the median concentrations exhibit a similar trend across the periods.

- Note that the minimum concentration for each 3-year period is greater than zero, indicating that there were no non-detects of acetaldehyde reported since the onset of carbonyl compound sampling at SPIL.

Observations from Figure 11-27 for benzene measurements at SPIL include the following:

- VOC sampling at SPIL began in April 2003, as denoted in Figure 11-27.

- The maximum benzene concentration was measured on October 13, 2005, although a similar concentration was also measured in February 2005.

- Similar to NBIL, the median and average rolling concentrations have a decreasing trend over the time periods shown, although a slight increase is shown for the final time frame.

- The differences between the 5th and 95th percentiles and the rolling average and median concentrations have generally decreased over time, both indicators of decreasing variability in the central tendency.

- The minimum concentration for each 3-year period is greater than zero, indicating that no non-detects of benzene have been reported since the onset of VOC sampling.

Observations from Figure 11-28 for 1,3-butadiene measurements at SPIL include the following:

- The maximum concentration of 1,3-butadiene (1.29 µg/m^3) was measured on February 3, 2005. Only three concentrations greater than 0.5 µg/m^3 have been measured at SPIL, one in 2004 and two in 2005. This explains the large decrease in the maximum concentration from the 2005-2007 to 2006-2008.

- Although there have been fluctuations in the rolling average and median concentrations of 1,3-butadiene, the changes are not statistically significant.

- 1,3-Butadiene's detection rate has increased over time, ranging from approximately 45 percent non-detects in 2003 and 2004 to zero or one non-detects during the 2007-2010 years of sampling.

Observations from Figure 11-29 for formaldehyde measurements at SPIL include the following:

- The maximum formaldehyde concentration was measured on May 29, 2006, which is the same day the highest acetaldehyde concentration was measured. Three additional formaldehyde concentrations greater than 100 µg/m^3 were measured in 2005. The 35 highest formaldehyde concentrations (those greater than 11 µg/m^3), all were measured in 2005 and 2006.

- The rolling average concentrations exhibit a dramatic decreasing trend. Although difficult to discern in Figure 11-29, the median concentration decreased as well.

11.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

11.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Illinois monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL. The results of this risk screening are summarized in Table 11-6. Where a quarterly or annual average exceeds the applicable MRL, the concentration is bolded.

Observations from Table 11-6 include the following:

- Formaldehyde was the only pollutant for NBIL where a preprocessed daily measurement and/or time-period average was greater than one or more of the MRL noncancer health risk benchmarks.

- One out of 55 measured detections of formaldehyde is greater than the ATSDR acute MRL for this pollutant (50 µg/m^3). As discussed in Section 11.4.1, this concentration was measured on December 4, 2010. This measurement (53.5 µg/m^3) is the highest concentration of formaldehyde measured among all NMP sites sampling this pollutant and is the only formaldehyde concentration to exceed the acute MRL, as discussed in Section 3.3.

- Although none of the quarterly average concentrations of formaldehyde are greater than the ATSDR intermediate MRL of 40 µg/m^3 (where they could be calculated), the highest concentrations of formaldehyde were measured during the fourth quarter of 2010, for which no fourth quarter average could be calculated. There were not enough valid samples during the fourth quarter to meet the completeness requirements for a quarterly average to be calculated.

- The annual average concentration of formaldehyde for NBIL (3.59 ± 2.18 µg/m^3) is less than the ATSDR chronic MRL for this pollutant (10 µg/m^3).

For the pollutants whose concentrations are greater than their respective ATSDR acute MRL noncancer health risk benchmark(s), the concentrations are further examined by developing pollution roses for these pollutants. A pollution rose is a plot of concentration vs. wind speed and wind direction, as described in Section 3.5.5.1. Figure 11-30 is the formaldehyde pollution rose for NBIL.

Table 11-6. Noncancer Risk Screening Summary for the Illinois Monitoring Sites

Pollutant	Acute			Intermediate					Chronic	
	ATSDR Acute MRL[1] ($\mu g/m^3$)	# of Concentrations > MRL	# of Measured Detections	ATSDR Intermediate MRL[1] ($\mu g/m^3$)	1st Quarter Average ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	ATSDR Chronic MRL[1] ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Northbrook, Illinois - NBIL										
Formaldehyde	50	1	55	40	0.95 ± 0.23	1.35 ± 0.23	1.74 ± 0.33	NA	10	3.59 ± 2.18

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

Figure 11-30. Formaldehyde Pollution Rose for NBIL

ATSDR MRL = 50 µg/m^3, which corresponds to the upper end of the 10-50 µg/m^3 (or yellow) concentration range

0-10 µg/m3   10-50 µg/m3   >50 µg/m3

11-42
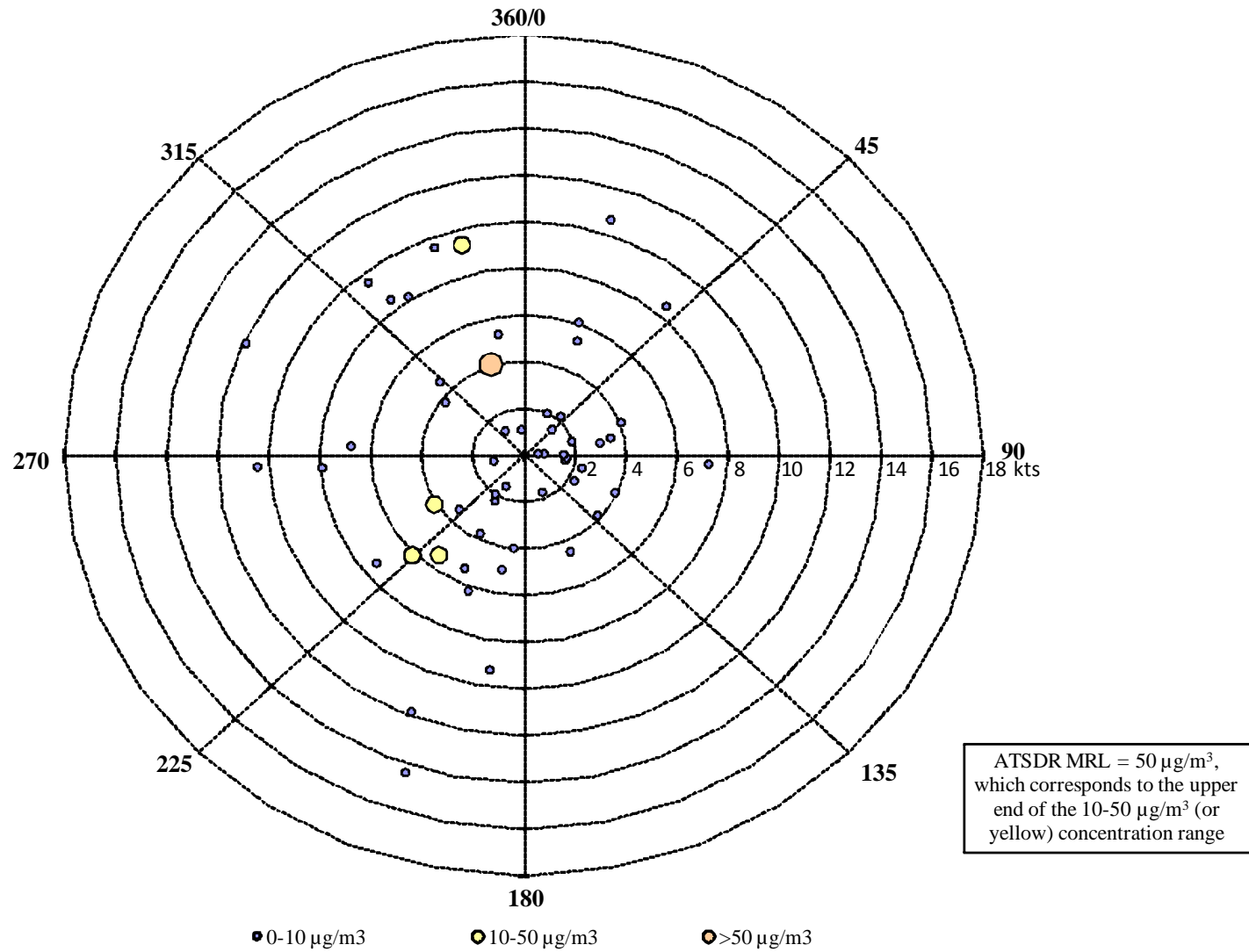
Observations from the Figure 11-30 include the following:

- There was only one measured detection that is greater than the ATSDR acute MRL (50 µg/m^3) for formaldehyde (shown in orange).

- The concentration greater than the ATSDR acute MRL was measured on a day with light winds blowing from the north-northwest, as was NBIL's second highest concentration (24.2 µg/m^3, shown in yellow). However, there were other measurements of formaldehyde that were much less and measured on days with average winds out of the north-northwest.

- The three next highest concentrations, ranging from 14.4 µg/m^3 to 16.9 µg/m^3, were measured on days with winds from the southwest. However, other measurements of formaldehyde were less and were measured on days with average winds out of the southwest.

- Figure 11-3 shows that there are many point sources located to the north-northwest and southwest of NBIL.

11.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Illinois monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 11-7, where applicable.

Observations for NBIL from Table 11-7 include the following:

- Formaldehyde, chloroform, and acetaldehyde are the pollutants with the highest annual average concentrations for NBIL.

- Formaldehyde, benzene, and carbon tetrachloride have the highest cancer surrogate risk approximations. NBIL's cancer risk approximation for formaldehyde (46.66 in-a-million) is the third highest cancer risk approximation calculated among all site-specific pollutants of interest for NMP sites (the other two were also for formaldehyde).

- None of NBIL's pollutants of interest have noncancer surrogate risk approximations greater than 1.0. The pollutant with the highest noncancer surrogate risk approximation is formaldehyde (0.37).

11-43

Table 11-7. Cancer and Noncancer Surrogate Risk Approximations for the Illinois Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Northbrook, Illinois - NBIL						
Acenaphthene	0.000088	--	59/59	0.01 ± <0.01	0.92	--
Acetaldehyde	0.0000022	0.009	55/55	1.02 ± 0.16	2.24	0.11
Arsenic (PM$_{10}$)[a]	0.0043	0.000015	61/61	<0.01 ± <0.01	3.24	0.05
Benzene	0.0000078	0.03	55/55	0.70 ± 0.10	5.45	0.02
Benzo(a)pyrene [a]	0.00176	--	53/59	<0.01 ± <0.01	0.20	--
Beryllium (PM$_{10}$) [a]	0.0024	0.00002	56/61	<0.01 ± <0.01	0.01	<0.01
1,3-Butadiene	0.00003	0.002	42/55	0.05 ± 0.01	1.41	0.02
Cadmium (PM$_{10}$) [a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.23	0.01
Carbon Tetrachloride	0.000006	0.1	55/55	0.72 ± 0.03	4.32	0.01
Chloroform	--	0.098	55/55	1.06 ± 0.53	--	0.01
p-Dichlorobenzene	0.000011	0.8	26/55	0.06 ± 0.03	0.62	<0.01
1,2-Dichloroethane	0.000026	2.4	9/55	0.01 ± 0.01	0.31	<0.01
Fluoranthene [a]	0.000088	--	59/59	0.01 ± <0.01	0.55	--
Fluorene [a]	0.000088	--	59/59	0.01 ± <0.01	0.94	--
Formaldehyde	0.000013	0.0098	55/55	3.59 ± 2.18	46.66	0.37
Hexavalent Chromium [a]	0.012	0.0001	48/61	<0.01 ± <0.01	0.27	<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	--	0.13
Naphthalene [a]	0.000034	0.003	59/59	0.11 ± 0.03	3.59	0.04
Nickel (PM$_{10}$) [a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.51	0.01
Tetrachloroethylene	2.6E-07	0.04	50/55	0.21 ± 0.05	0.05	0.01
Trichloroethylene	0.0000048	0.002	32/55	0.07 ± 0.02	0.35	0.04
Vinyl Chloride	0.0000088	0.1	1/55	<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 11-5.

Table 11-7. Cancer and Noncancer Surrogate Risk Approximations for the Illinois Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Schiller Park, Illinois - SPIL						
Acetaldehyde	0.0000022	0.009	58/58	1.62 ± 0.18	3.56	0.18
Benzene	0.0000078	0.03	60/60	0.94 ± 0.11	7.36	0.03
1,3-Butadiene	0.00003	0.002	59/60	0.14 ± 0.02	4.25	0.07
Carbon Tetrachloride	0.000006	0.1	60/60	0.71 ± 0.03	4.28	0.01
Chloroform	--	0.098	55/60	0.11 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	27/60	0.04 ± 0.02	0.45	<0.01
1,2-Dichloroethane	0.000026	2.4	12/60	0.02 ± 0.01	0.42	<0.01
Ethylbenzene	0.0000025	1	60/60	0.27 ± 0.05	0.68	<0.01
Formaldehyde	0.000013	0.0098	58/58	2.53 ± 0.42	32.86	0.26
Tetrachloroethylene	2.6E-07	0.04	58/60	0.32 ± 0.06	0.08	0.01
Trichloroethylene	0.0000048	0.002	48/60	0.79 ± 0.40	3.79	0.39
Vinyl Chloride	0.0000088	0.1	2/60	<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 11-5.

Observations for SPIL from Table 11-7 include the following:

- Formaldehyde, acetaldehyde, and benzene are the pollutants with the highest annual average concentrations for SPIL.

- Formaldehyde has the highest cancer surrogate risk approximation for SPIL (32.86 in-a-million), followed by benzene and carbon tetrachloride.

- None of SPIL's pollutants of interest have noncancer surrogate risk approximations greater than 1.0. The pollutant with the highest noncancer surrogate risk approximation is trichloroethylene (0.39), which is the fourth highest noncancer surrogate risk approximation calculated among all site-specific pollutants of interest for NMP sites.

11.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 11-8 and 11-9 present a risk-based evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 11-8 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 surrogate risk approximations (in-a-million), as calculated from annual averages. Table 11-9 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 11-8 and 11-9 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 VOC and carbonyl compounds. NBIL sampled for these pollutants as well, but also sampled for SNMOC, PM_{10} metals, PAH, and hexavalent chromium. In addition, the cancer and noncancer risk 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.

Table 11-8. 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 Risk Factors (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	46.66
Formaldehyde	1,055.89	Benzene	1.13E-02	Benzene	5.45
Ethylbenzene	791.28	Hexavalent Chromium, PM	6.92E-03	Carbon Tetrachloride	4.32
Acetaldehyde	689.38	1,3-Butadiene	6.28E-03	Naphthalene	3.59
1,3-Butadiene	209.30	Naphthalene	4.30E-03	Arsenic	3.24
Tetrachloroethylene	190.73	Cadmium, PM	2.67E-03	Acetaldehyde	2.24
Trichloroethylene	134.75	Nickel, PM	2.44E-03	1,3-Butadiene	1.41
Naphthalene	126.41	Arsenic, PM	2.17E-03	Fluorene	0.94
Dichloromethane	93.18	Ethylbenzene	1.98E-03	Acenaphthene	0.92
POM, Group 2b	20.55	POM, Group 2b	1.81E-03	p-Dichlorobenzene	0.62
Schiller Park, Illinois (Cook County) - SPIL					
Benzene	1,445.06	Formaldehyde	1.37E-02	Formaldehyde	32.86
Formaldehyde	1,055.89	Benzene	1.13E-02	Benzene	7.36
Ethylbenzene	791.28	Hexavalent Chromium, PM	6.92E-03	Carbon Tetrachloride	4.28
Acetaldehyde	689.38	1,3-Butadiene	6.28E-03	1,3-Butadiene	4.25
1,3-Butadiene	209.30	Naphthalene	4.30E-03	Trichloroethylene	3.79
Tetrachloroethylene	190.73	Cadmium, PM	2.67E-03	Acetaldehyde	3.56
Trichloroethylene	134.75	Nickel, PM	2.44E-03	Ethylbenzene	0.68
Naphthalene	126.41	Arsenic, PM	2.17E-03	p-Dichlorobenzene	0.45
Dichloromethane	93.18	Ethylbenzene	1.98E-03	1,2-Dichloroethane	0.42
POM, Group 2b	20.55	POM, Group 2b	1.81E-03	Tetrachloroethylene	0.08

Table 11-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Illinois Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Northbrook, Illinois (Cook County) - NBIL					
Toluene	5,432.03	Acrolein	3,705,826.42	Formaldehyde	0.37
Xylenes	3,804.27	Manganese, PM	161,905.82	Manganese	0.13
Methanol	3,800.86	Cadmium, PM	148,156.47	Acetaldehyde	0.11
1,1,1-Trichloroethane	3,014.08	Formaldehyde	107,743.48	Arsenic	0.05
Methyl isobutyl ketone	2,290.29	1,3-Butadiene	104,651.38	Trichloroethylene	0.04
Benzene	1,445.06	Acetaldehyde	76,598.28	Naphthalene	0.04
Formaldehyde	1,055.89	Trichloroethylene	67,372.78	1,3-Butadiene	0.02
Hexane	1,006.50	Nickel, PM	56,590.58	Benzene	0.02
Ethylbenzene	791.28	Benzene	48,168.61	Lead	0.02
Acetaldehyde	689.38	Naphthalene	42,137.52	Cadmium	0.01
Schiller Park, Illinois (Cook County) - SPIL					
Toluene	5,432.03	Acrolein	3,705,826.42	Trichloroethylene	0.39
Xylenes	3,804.27	Manganese, PM	161,905.82	Formaldehyde	0.26
Methanol	3,800.86	Cadmium, PM	148,156.47	Acetaldehyde	0.18
1,1,1-Trichloroethane	3,014.08	Formaldehyde	107,743.48	1,3-Butadiene	0.07
Methyl isobutyl ketone	2,290.29	1,3-Butadiene	104,651.38	Benzene	0.03
Benzene	1,445.06	Acetaldehyde	76,598.28	Tetrachloroethylene	0.01
Formaldehyde	1,055.89	Trichloroethylene	67,372.78	Carbon Tetrachloride	0.01
Hexane	1,006.50	Nickel, PM	56,590.58	Chloroform	<0.01
Ethylbenzene	791.28	Benzene	48,168.61	Ethylbenzene	<0.01
Acetaldehyde	689.38	Naphthalene	42,137.52	*p*-Dichlorobenzene	<0.01

Observations from Table 11-8 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 has the highest cancer surrogate risk approximation. This pollutant ranks high on all three lists shown in Table 11-8. For NBIL, benzene, naphthalene, and 1,3-butadiene also appear on all three lists. For SPIL, benzene, 1,3-butadiene, and ethylbenzene appear on all three lists.

- Carbon tetrachloride, which appears among the highest cancer risk approximations for both sites, did not appear on either emissions-based list.

- Several metals appear among the pollutants with the highest toxicity-weighted emissions, including arsenic, which has the fifth highest cancer risk approximation for NBIL. SPIL did not sample metals.

- 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 on the list of highest toxicity-weighted emissions.

Observations from Table 11-9 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 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 risk approximations for NBIL (albeit well below an HQ of 1.0). Formaldehyde and acetaldehyde appear on both emissions-based lists while manganese has the second highest toxicity-weighted emissions, but does appear on the list of highest emitted pollutants in Cook County.

11-49

- Trichloroethylene has the highest noncancer risk approximation for SPIL (albeit well below an HQ of 1.0). This pollutant has the seventh highest toxicity-weighted emissions, but does appear on the list of highest emitted pollutants in Cook County.

11.6   Summary of the 2010 Monitoring Data for NBIL and SPIL

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

❖ *Twenty pollutants, including 12 NATTS MQO Core Analytes, failed screens for NBIL. Fourteen 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 both sites was formaldehyde. The four highest concentrations of formaldehyde measured among all NMP sites were measured at NBIL.*

❖ *One preprocessed daily measurement of formaldehyde from NBIL was greater than its associated acute MRL noncancer health risk benchmark. None of the quarterly or annual average concentrations of the pollutants of interest, where they could be calculated, were greater than their associated intermediate or chronic MRL noncancer health risk benchmarks.*

12.0   Sites in Indiana

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the UATMP and CSATAM 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 12-2 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban locations. Figures 12-3 and 12-4 identify point source emissions locations by source category for 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 12-3 and 12-4. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 12-1 describes the area surrounding each monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 12-1. Gary, Indiana (INDEM) Monitoring Site
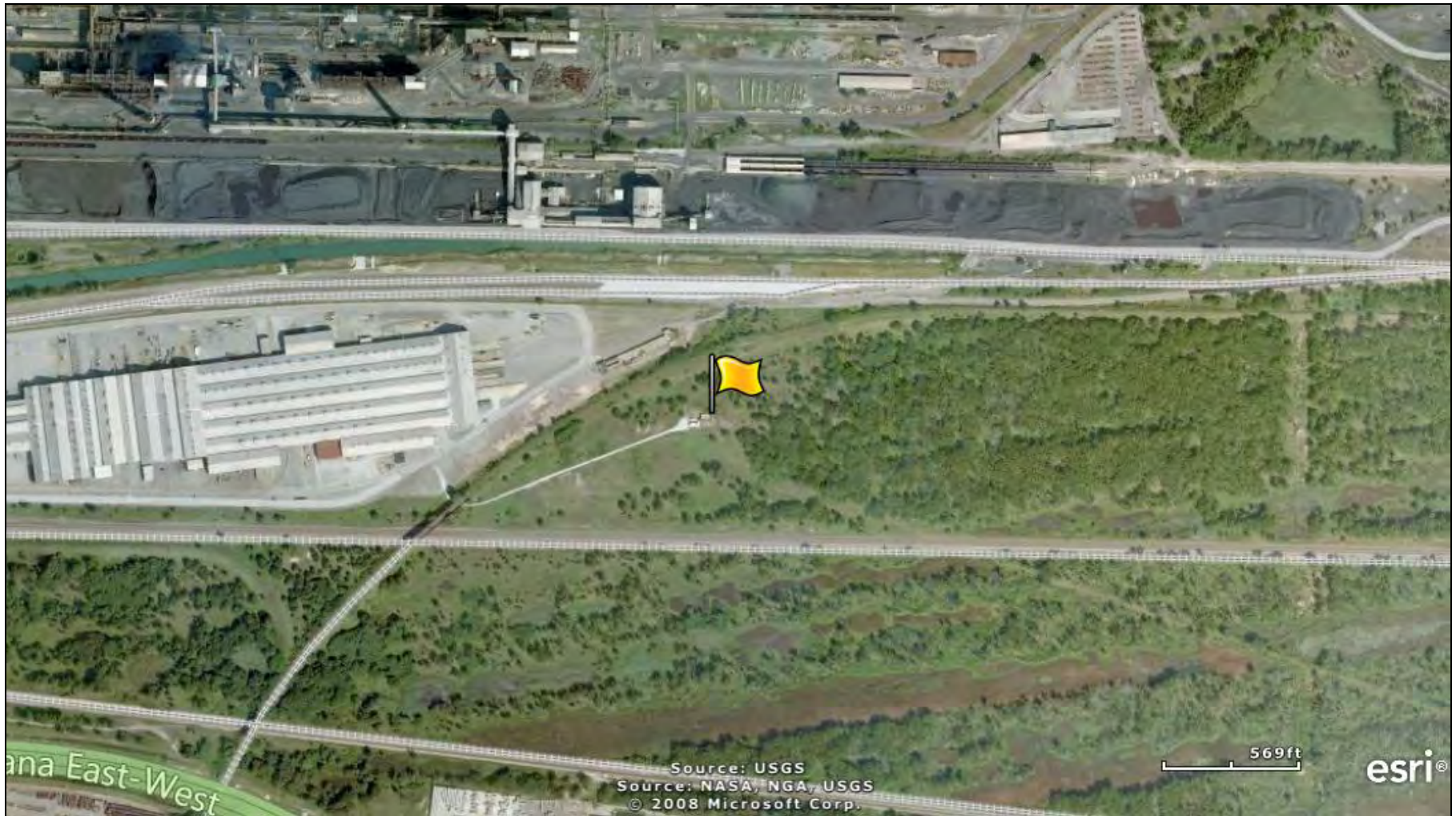
Figure 12-2. Indianapolis, Indiana (WPIN) Monitoring Site
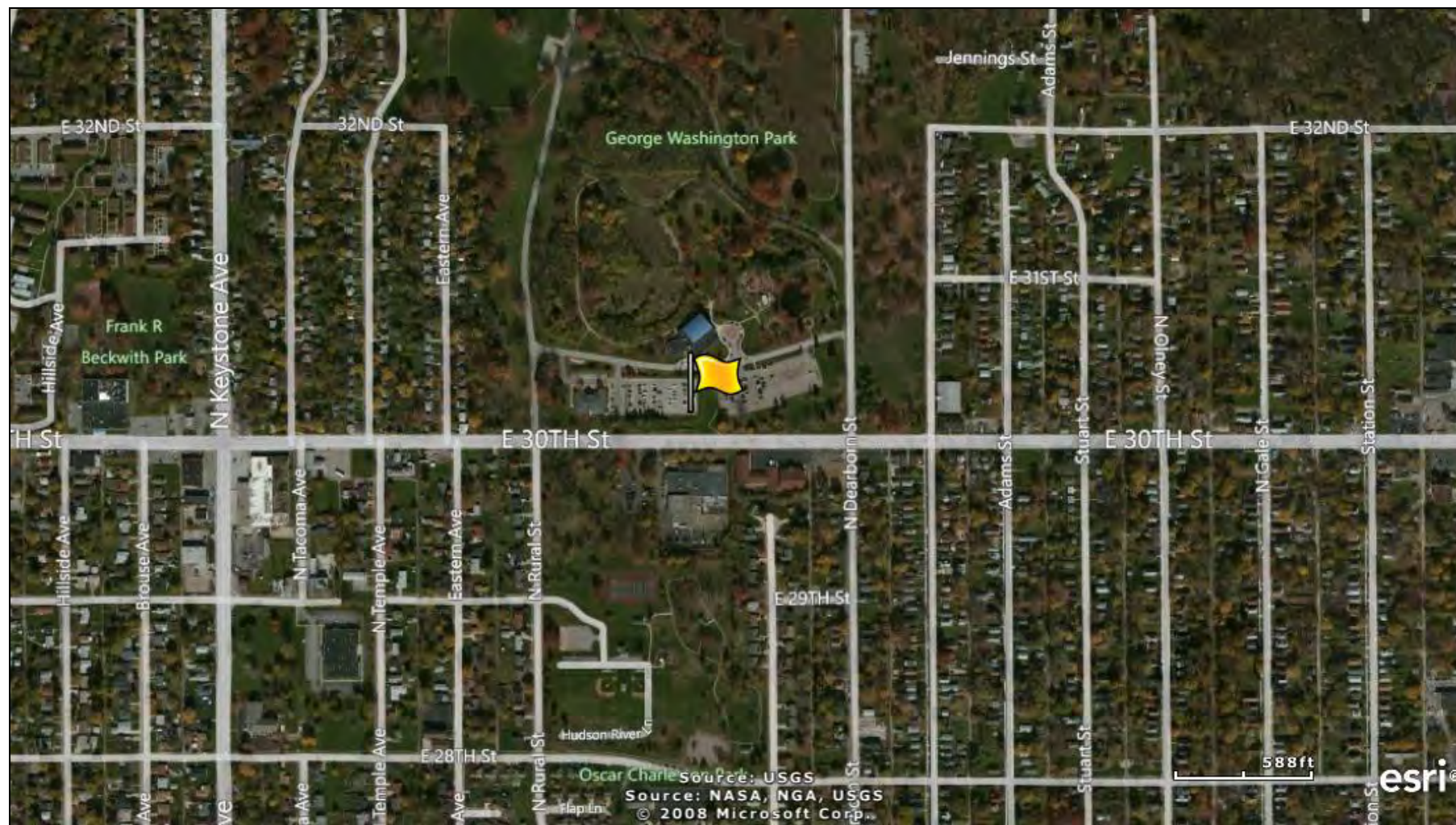
Figure 12-3. NEI Point Sources Located Within 10 Miles of INDEM

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

Legend

⭐ INDEM UATMP site   ⭕ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

✛	Aircraft Operations (14)	✕	Mine/Quarry (3)
▪	Asphalt Processing/Roofing Manufacturing (1)	▽	Mineral Products (7)
B	Bulk Terminals/Bulk Plants (7)	?	Miscellaneous Commercial/Industrial (24)
C	Chemical Manufacturing (5)	M	Miscellaneous Manufacturing (1)
▣	Coke Battery (1)	●	Oil and/or Gas Production (3)
⚡	Electricity Generation via Combustion (6)	◪	Petroleum Refinery (1)
⊙	Fabricated Metal Products (3)	1	Primary Metal Production (1)
F	Food Processing/Agriculture (1)	⊞	Pulp and Paper Plant/Wood Products (1)
✛	Gypsum Manufacturing (1)	R	Rubber and Miscellaneous Plastics Products (1)
👋	Hot Mix Asphalt Plant (1)	>	Solid Waste Disposal - Commercial/Institutional (1)
▲	Landfill (1)	▼	Steel Mill (14)
➤	Lime Manufacturing (1)	S	Surface Coating (1)
		❋	Transportation and Marketing of Petroleum Products (6)

Figure 12-4. NEI Point Sources Located Within 10 Miles of WPIN

Legend

⭐ WPIN UATMP site   ◯ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

✠	Aerospace/Aircraft Manufacturing (2)	I	Iron and Steel Foundry (1)
+	Aircraft Operations (26)	▲	Landfill (1)
B	Bulk Terminals/Bulk Plants (1)	?	Miscellaneous Commercial/Industrial (1)
C	Chemical Manufacturing (1)	Ⓜ	Municipal Waste Combustor (1)
⚡	Electricity Generation via Combustion (3)	●	Oil and/or Gas Production (1)
⊙	Fabricated Metal Products (2)	�	Pharmaceutical Manufacturing (2)
⬠	Flexible Polyurethane Foam Production (2)	▼	Steel Mill (1)
Λ	Grain Handling (2)	S	Surface Coating (4)
Ⓢ	Institutional - school (1)	⌐	Transportation Equipment (1)
		▮	Wastewater Treatment (1)

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	VOC, 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, VOC, SNMOC, 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] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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 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 12-3 shows that the majority of point sources are located to the west of INDEM. The sources closest to INDEM are a mine/quarry, a steel mill, and a facility that falls into the miscellaneous commercial/industrial category. The 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 12-2 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the Indiana monitoring sites. Table 12-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 12-2 also contains annual average daily traffic information. Finally, Table 12-2 presents the daily VMT for Lake and Marion Counties.

Table 12-2. Population, Motor Vehicle, and Traffic Information for the Indiana Monitoring Sites

Site	Estimated County Population[1]	County-level Vehicle Registration[2]	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	495,981	182,989	0.37	406,979	150,152	52,440	11,801,000
WPIN	904,878	204,908	0.23	787,003	178,215	143,410	35,081,000

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the IN Bureau of Motor Vehicles (IN BMV, 2011)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2009 data from the Indiana DOT (IN DOT, 2009)
[5] County-level VMT reflects 2010 data from the Indiana DOT (IN DOT, 2010)

Observations from Table 12-2 include the following:

- Marion County has almost twice the county population as Lake County. The difference between the two counties decreases significantly for the county-level vehicle registration. 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. The county-level and 10-mile vehicle registrations are in the bottom third among the NMP sites.

- The vehicle-per-person ratios for both Indiana sites are among the lowest ratios among the 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 eighth highest among NMP sites.

- The VMT for Marion County is more than three times higher than the VMT for Lake County. Marion County VMT ranked eighth among counties with NMP sites, while the VMT for Lake County is in the middle of the range, at 17th.

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, 2012; 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 2010

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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 2010. 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 INDEM and WPIN.

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	Sample Day	60.7 ± 5.5	51.8 ± 5.1	39.6 ± 4.7	45.8 ± 4.5	66.2 ± 2.6	NA	5.5 ± 0.9
	241° (WSW)	2010	60.9 ± 2.3	52.1 ± 2.1	39.9 ± 2.0	46.1 ± 1.9	66.6 ± 1.2	NA	6.0 ± 0.4
Indianapolis, Indiana - WPIN									
Eagle Creek Airpark 53842 (39.83, -86.30)	9.13 miles	Sample Day	62.2 ± 5.6	53.5 ± 5.3	41.4 ± 4.7	47.3 ± 4.7	66.7 ± 2.8	1016.2 ± 1.6	5.3 ± 0.8
	270° (W)	2010	62.9 ± 2.3	54.1 ± 2.2	42.1 ± 2.0	47.9 ± 1.9	67.4 ± 1.2	1016.0 ± 0.7	5.4 ± 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 2010. Included in Figure 12-5 are four back trajectories per sample day. Figure 12-6 is the corresponding cluster analysis for 2010. 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the sites in Figures 12-5 through 12-8 represents 100 miles.

Figure 12-5. 2010 Composite Back Trajectory Map for INDEM
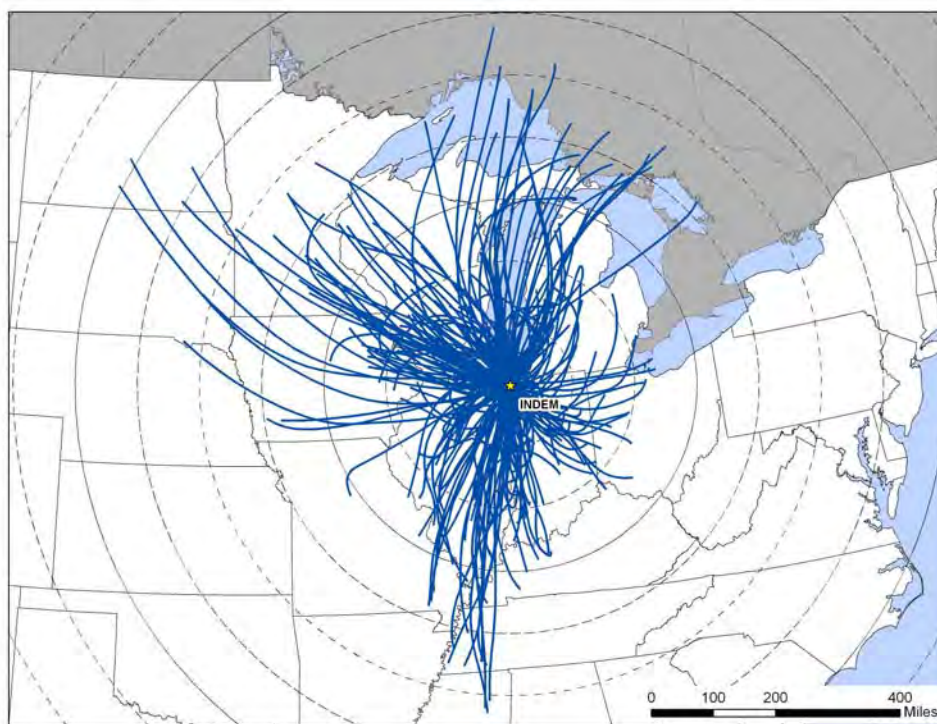
Figure 12-6. Back Trajectory Cluster Map for INDEM
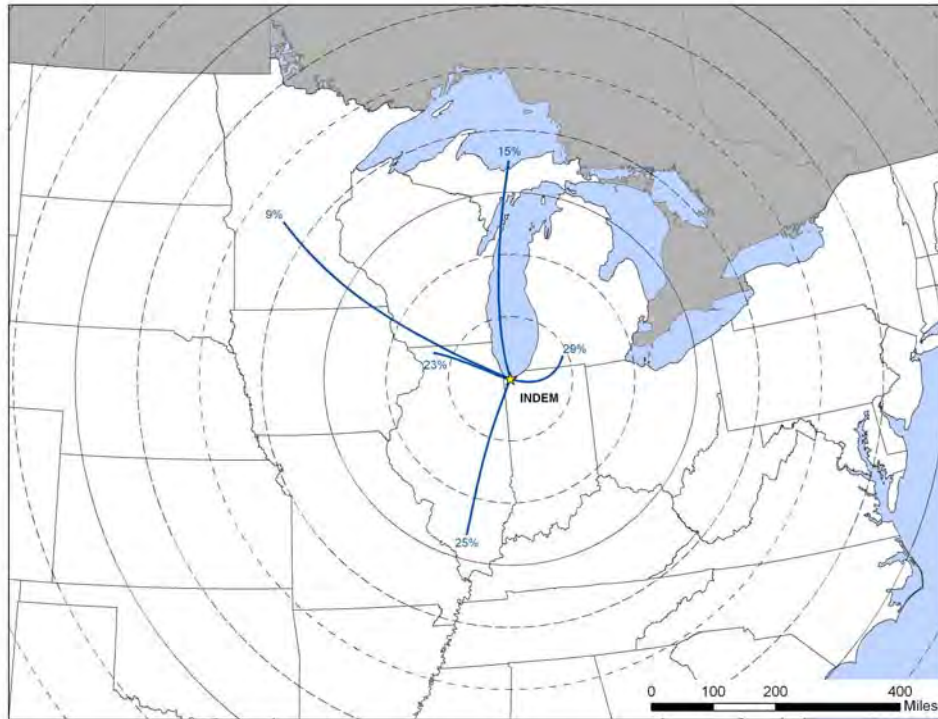
Figure 12-7. 2010 Composite Back Trajectory Map for WPIN
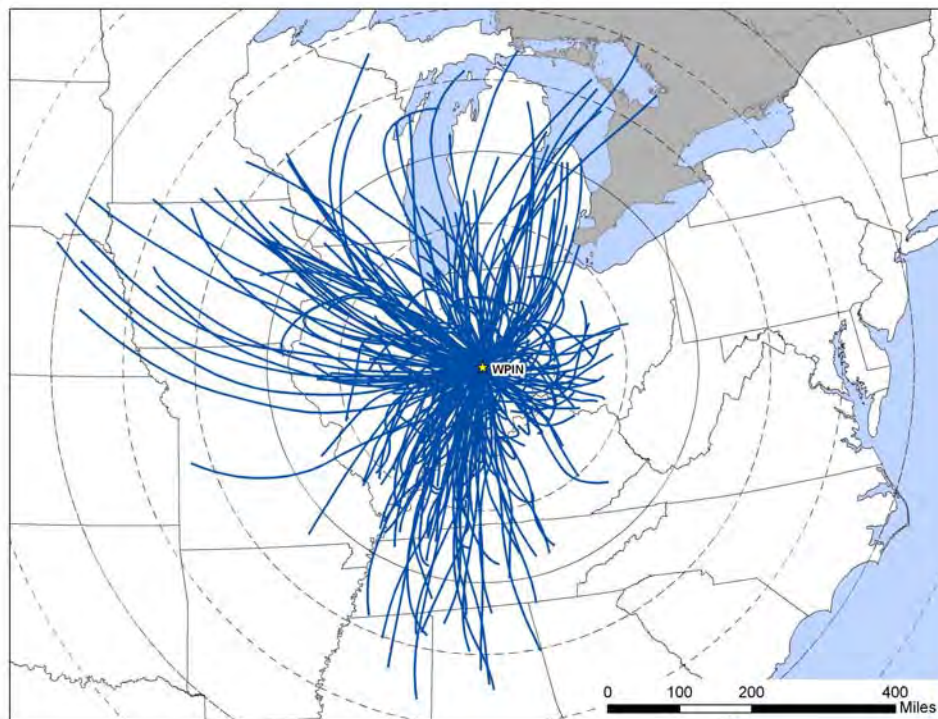
Figure 12-8. Back Trajectory Cluster Map for WPIN
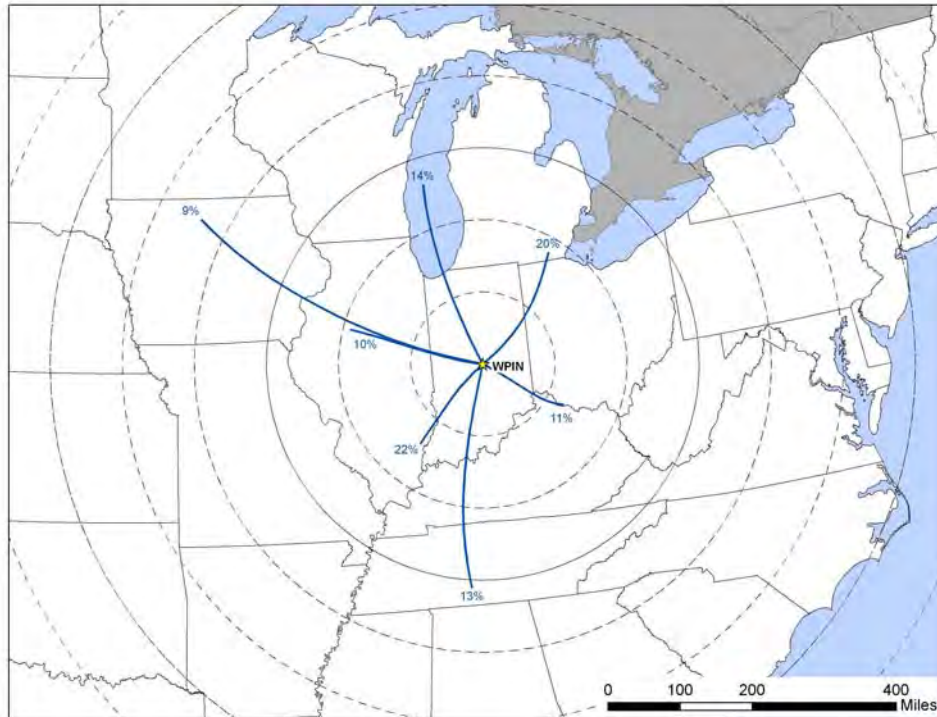
Observations from Figures 12-5 and 12-6 for INDEM include the following:

- Back trajectories originated from a variety of directions at INDEM, although less frequently from the southeast.

- The 24-hour air shed domain was similar in size to other NMP sites, as the farthest away a trajectory originated was over central North Dakota, or greater than 700 miles away. However, the average trajectory length was 246 miles, and most trajectories (90 percent) originated within 450 miles of INDEM.

- The longest trajectories originated to the northwest, as represented by the trajectory originating over Minnesota (9 percent), with additional trajectories also originating from this direction, but of shorter length (23 percent). Longer trajectories also originated to north over the Great Lakes and into Canada. Back trajectories from the south and southwest are combined into one cluster (25 percent). Back trajectories from the northeast and southeast are represented by the short cluster (11 percent). Trajectories with an easterly component were often shorter than trajectories originating from other directions.

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, although less frequently from the southeast, similar to INDEM.

12-13

- The 24-hour air shed domain was similar in size compared to many other NMP monitoring sites as the farthest away a trajectory originated was over southeast South Dakota, or greater than 600 miles away. The trajectories originating to the northwest tended to be the longest. The average trajectory length was 234 miles, while most trajectories (88 percent) originated within 400 miles of WPIN.

- The cluster analysis for WPIN confirms that the longest trajectories originated to the northwest, as represented by the trajectory originating over Iowa (9 percent). Additional trajectories also originated from this direction, but were of shorter length (10 percent). Trajectories originating from the south and southwest account for another 35 percent of trajectories. Trajectories with an easterly component were often shorter than trajectories originating from other directions.

12.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the INDEM monitoring site. First, a historical wind rose representing 2003 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figure 12-10 presents the three wind roses and distance map for WPIN.

Figure 12-9. Wind Roses for the Lansing Municipal Airport Weather Station near INDEM

2003-2009 Historical Wind Rose
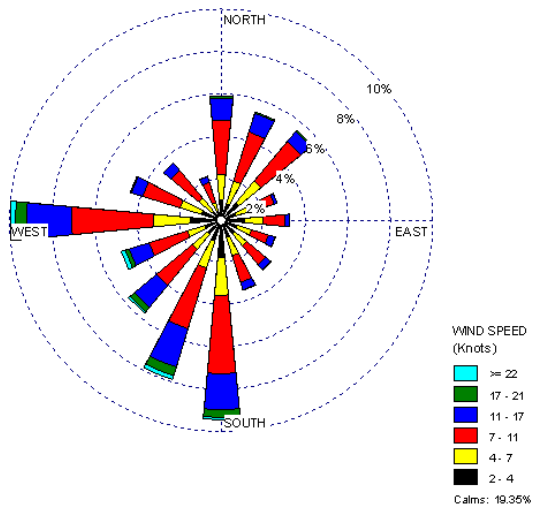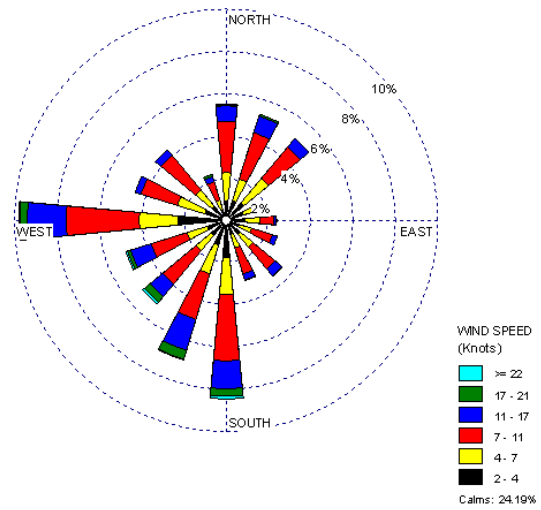
2010 Wind Rose

2010 Sample Day Wind Rose
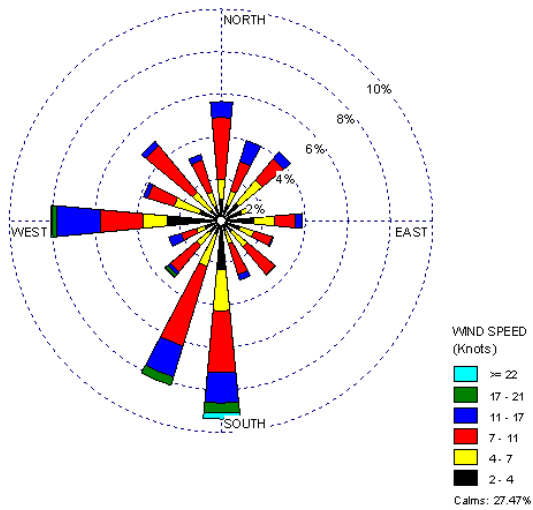
Distance between INDEM and NWS Station

Figure 12-10. Wind Roses for the Indianapolis International Airport Weather Station near WPIN

1999-2009 Historical Wind Rose
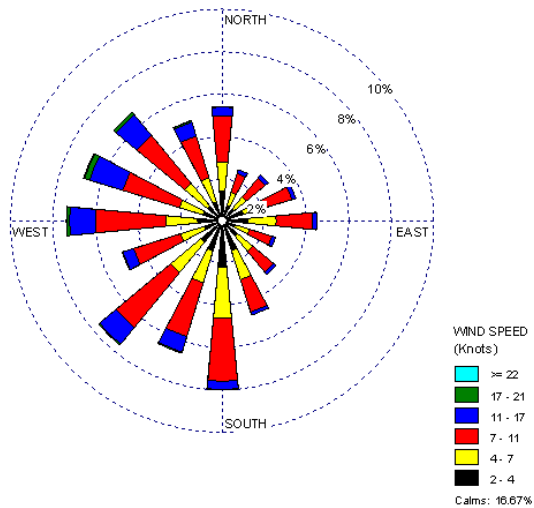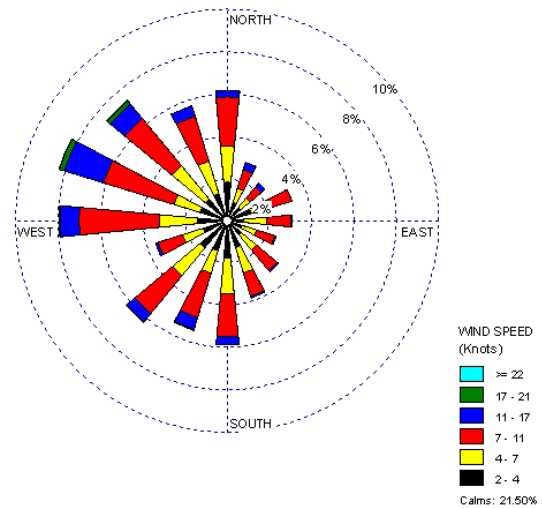
2010 Wind Rose

2010 Sample Day Wind Rose
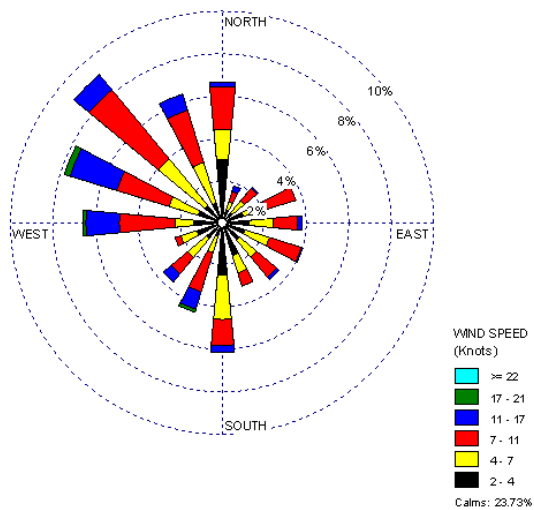
Distance between WPIN and NWS Station
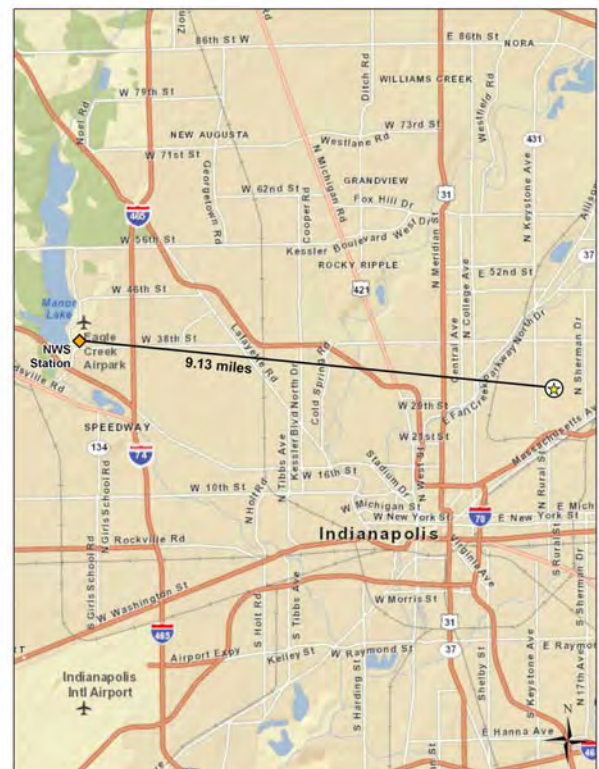
Observations from Figure 12-9 for INDEM include the following:

- 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 2003-2009 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, southwest, and west of INDEM.

- The wind patterns shown on the 2010 wind rose resemble the wind patterns shown on the historical wind rose, although the calm rate was just over 24 percent in 2010.

- The sample day wind rose also has predominant southerly, south-southwesterly, and westerly winds, although there were fewer wind observations from the north-northeast and northeast. In addition, the calm rate is higher on the sample day wind rose, with greater than 27 percent of winds speeds less than 2 knots.

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.

- Winds from the south, from the western quadrants, and from the north account for the majority (greater than 55 percent) of wind observations from 1999-2009, while winds from the eastern quadrants were observed less than one-third of the time. Calm winds (≤ 2 knots) were observed for nearly 17 percent of observations. The strongest winds tended to flow from the northwest.

- The wind patterns on the 2010 wind rose resemble the historical wind patterns, although the calm rate was higher, at greater than 21 percent, and there were fewer southerly to southwesterly winds.

- The sample day wind rose has a higher calm rate (24 percent) than the historical wind rose, as the full-year wind rose does, but there were also fewer wind observations from the southwest quadrant and more wind observations from the northwest 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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 12-4 presents the pollutants of interest 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 Screening Results for the Indiana Monitoring Sites

Pollutant	Screening Value (μg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Gary, Indiana - INDEM						
Acetaldehyde	0.45	61	61	100.00	50.00	50.00
Formaldehyde	0.077	61	61	100.00	50.00	100.00
Total		122	122	100.00		
Indianapolis, Indiana - WPIN						
Acetaldehyde	0.45	56	56	100.00	49.56	49.56
Formaldehyde	0.077	56	56	100.00	49.56	99.12
Propionaldehyde	0.8	1	56	1.79	0.88	100.00
Total		113	168	67.26		

Observations from Table 12-4 include the following:

- Formaldehyde, acetaldehyde, and propionaldehyde are the only carbonyl compounds with risk screening values.

- Acetaldehyde and formaldehyde failed screens for INDEM. They contributed equally to the total number of failed screens. Both pollutants failed 100 percent of the total failed screens.

- All three carbonyl compounds with risk screening values failed screens for WPIN. Acetaldehyde and formaldehyde failed 100 percent of the total failed screens while propionaldehyde failed only one screen.

12.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Indiana monitoring sites. Concentration averages are provided for the pollutants of interest for each Indiana site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site, where applicable. Additional site-specific statistical summaries are provided in Appendix L.

12.4.1 2010 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 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Gary, Indiana - INDEM						
Acetaldehyde	61/61	1.23 ± 0.29	1.17 ± 0.24	1.61 ± 0.22	1.53 ± 0.34	1.39 ± 0.14
Formaldehyde	61/61	1.63 ± 0.33	2.08 ± 0.48	3.10 ± 0.41	2.76 ± 0.54	2.41 ± 0.26
Indianapolis, Indiana - WPIN						
Acetaldehyde	56/56	1.76 ± 0.32	2.39 ± 0.46	2.66 ± 0.78	3.46 ± 0.76	2.56 ± 0.33
Formaldehyde	56/56	2.28 ± 0.36	3.54 ± 0.69	4.09 ± 1.13	4.51 ± 0.97	3.58 ± 0.45

Observations for the Indiana sites from Table 12-5 include the following:

- Formaldehyde has the highest annual average concentration by mass of the pollutants of interest for both INDEM and WPIN.

- The annual average concentrations of acetaldehyde and formaldehyde are higher for WPIN than INDEM.

- Concentrations of both acetaldehyde and formaldehyde tended to be highest during the third and fourth quarters of 2010 for both sites; however, the difference is not statistically significant.

- The confidence interval for WPIN's third and fourth quarter formaldehyde averages are rather large, indicating the potential influence of outliers. A review of the data shows that the highest concentration for WPIN was measured on October 11, 2010 (5.21 µg/m³). The four concentrations of formaldehyde greater than 4 µg/m³ were measured in July, August, October, and November.

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:

- As shown in Table 4-10, WPIN's annual average concentration of formaldehyde is the fourth highest average among NMP sites sampling this pollutant. WPIN also has the sixth highest annual average concentration of acetaldehyde.

- INDEM does not appear in Table 4-10. Its annual average concentration of formaldehyde ranks 15th and its annual average concentration of acetaldehyde ranks 19th among NMP sites sampling carbonyl compounds.

12.4.2 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 both INDEM and WPIN. Figures 12-11 and 12-12 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 12-11. Program vs. Site-Specific Average Acetaldehyde Concentration
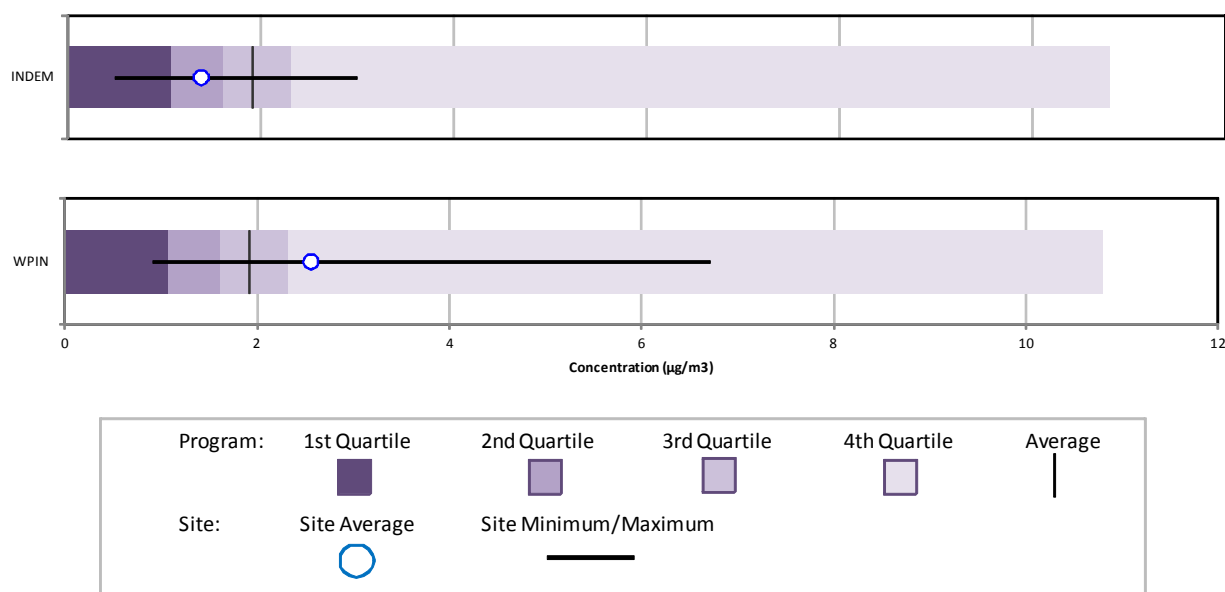
Figure 12-12. Program vs. Site-Specific Average Formaldehyde Concentration
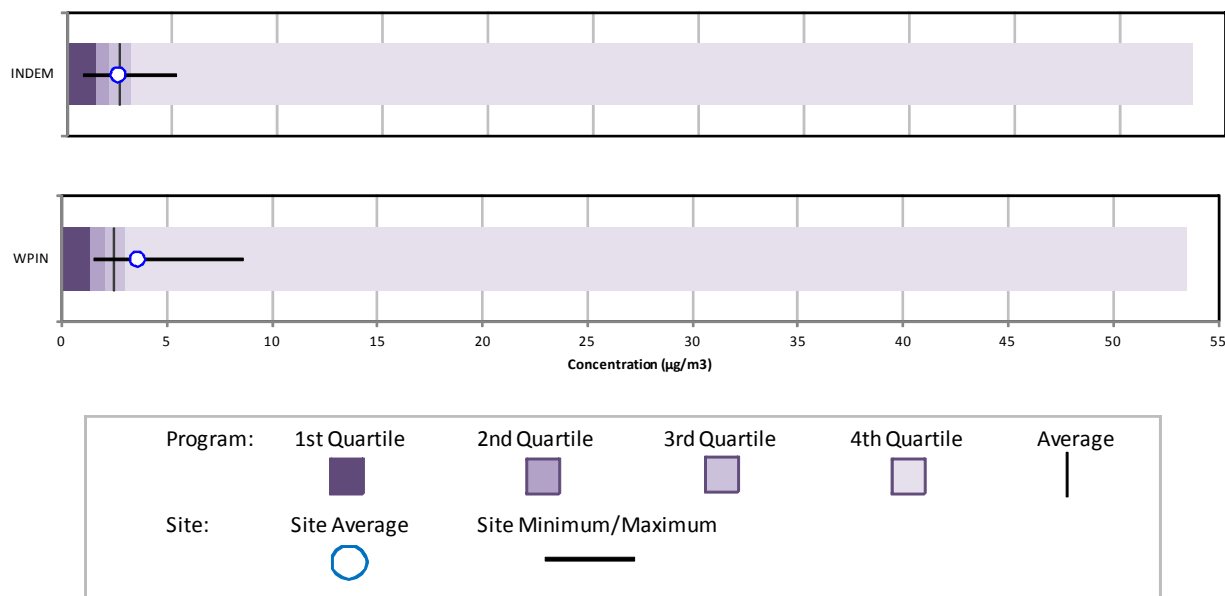
Observations from Figures 12-11 and 12-12 include the following:

- Figure 12-11 shows that WPIN's annual average acetaldehyde concentration is greater than the annual average acetaldehyde concentration for INDEM. WPIN's annual average concentration is greater than program-level average for acetaldehyde as well as the third quartile for the program. Conversely, INDEM's annual average concentration is less than program-level average as well as the median for the program. There were no non-detects of acetaldehyde measured at either site.

- Figure 12-12 shows that WPIN's annual average formaldehyde concentration is greater than the program average formaldehyde concentration while INDEM's annual average concentration is very similar to the program-level average. The maximum concentrations for both sites are well below the maximum concentration measured across the program. There were no non-detects of formaldehyde measured at either site.

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 3-year rolling statistical metrics for acetaldehyde and formaldehyde for INDEM, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 12-13. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at INDEM
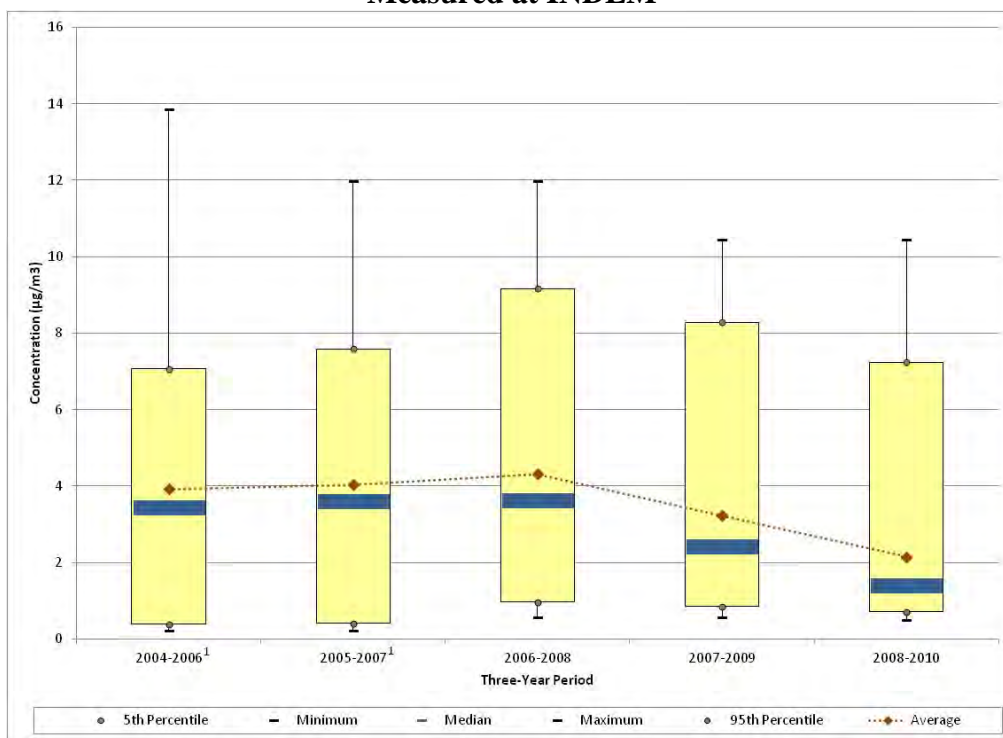
[1]Carbonyl compound samples were not collected from September to November 2005.

Figure 12-14. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at INDEM
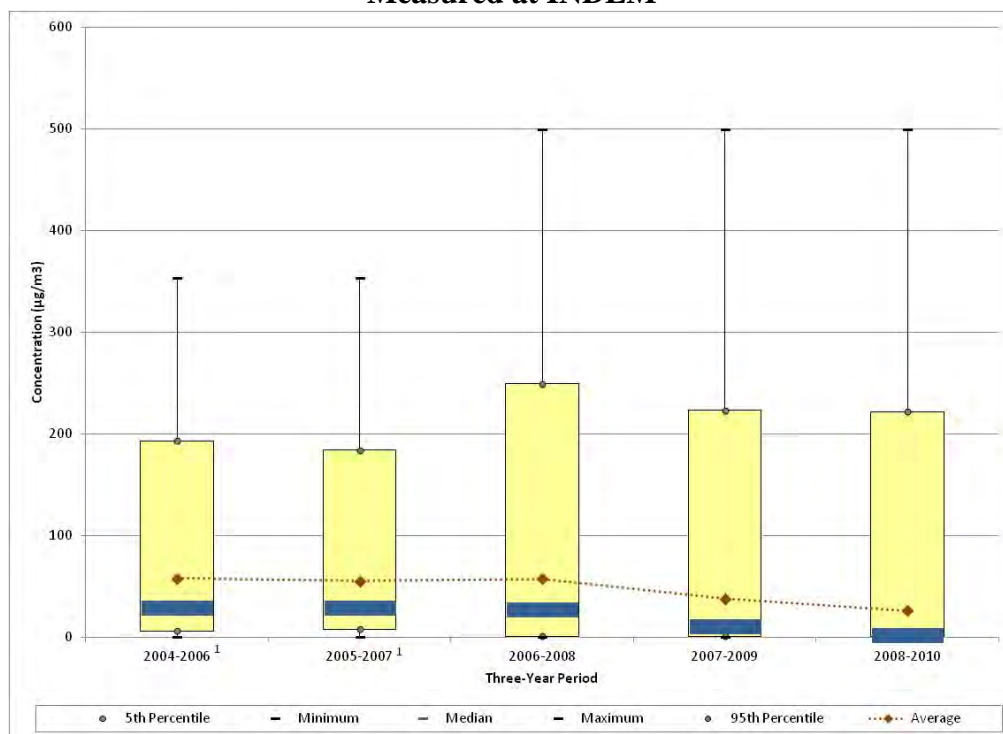
[1]Carbonyl compound samples were not collected from September to November 2005.

Observations from Figure 12-13 for acetaldehyde measurements at INDEM include the following:

- The maximum acetaldehyde concentration (13.8 µg/m^3) was measured on June 14, 2004. An additional four concentrations measured at INDEM were greater than 10 µg/m^3 (one in 2006 and three in 2008).

- Most of the statistical parameters show a slight increasing trend through the 2006-2008 time frame, but show fairly substantial decreases thereafter. The average and median concentrations for the last two 3-year periods decreased below 2004-2006 levels.

- 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.

- There was a 3-month gap in sampling between September and November 2005 at the INDEM site, which is denoted in Figure 12-13.

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 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 38 measurements of formaldehyde greater than 100 µg/m^3, ranging from one in 2007 up to 13 in 2005 (and none measured during 2009 or 2010).

- The rolling average and the median concentrations are not similar to each other; the median is roughly half of the average for each time period. This reflects the influence of the outliers on the average concentrations compared to the median concentrations, which are influenced less by outliers.

- The rolling average and median concentrations changed little through the 2006-2008 time frame, but exhibit fairly substantial decreases afterward. Note, however, that the confidence intervals are wide for each of the averages shown due to the large range of concentrations measured at this site. The addition of future years not including years with the higher concentrations will be more telling.

- The rolling averages shown for INDEM are the highest of any rolling averages calculated for any other NMP site measuring formaldehyde. 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 is 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 and 2010 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 the ambient air. The annual average concentrations for 2010 for both acetaldehyde and formaldehyde were similar in magnitude to those reported for 2009 in the 2008-2009 NMP report. The addition of future years not including years with the higher concentrations will be more telling.

12.5 Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

12.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Indiana monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for each site 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.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Indiana monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Indiana monitoring sites.

12.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Indiana monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated).

Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 12-6, where applicable.

Table 12-6. Cancer and Noncancer Surrogate Risk Approximations for the Indiana Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Gary, Indiana - INDEM						
Acetaldehyde	0.0000022	0.009	61/61	1.39 ± 0.14	3.05	0.15
Formaldehyde	0.000013	0.0098	61/61	2.41 ± 0.26	31.27	0.25
Indianapolis, Indiana - WPIN						
Acetaldehyde	0.0000022	0.009	56/56	2.56 ± 0.33	5.63	0.28
Formaldehyde	0.000013	0.0098	56/56	3.58 ± 0.45	46.56	0.37

Observations for the Indiana sites from Table 12-6 include the following:

- For both sites, the annual average concentration of formaldehyde is greater than the annual average concentrations of acetaldehyde.

- For each site, the cancer risk approximation for formaldehyde is an order of magnitude higher than the cancer risk approximation for acetaldehyde.

- The cancer risk approximation for formaldehyde for WPIN (46.56 in-a-million) is the fourth highest calculated cancer risk approximation among all site-specific pollutants of interest (INDEM's ranked 15th).

- None of the noncancer risk approximations are greater than 1.0 for the pollutants of interest for INDEM and WPIN.

12.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 12-7 and 12-8 present a risk-based 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 12-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

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 Risk Factors (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	31.27
Formaldehyde	157.04	Formaldehyde	2.04E-03	Acetaldehyde	3.05
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	46.56
Formaldehyde	356.47	Benzene	3.82E-03	Acetaldehyde	5.63
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 Risk Approximations for Pollutants with Noncancer RfCs for the Indiana Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Gary, Indiana (Lake County) - INDEM					
Toluene	676.97	Acrolein	503,495.00	Formaldehyde	0.25
Xylenes	528.24	Manganese, PM	468,665.08	Acetaldehyde	0.15
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	Formaldehyde	0.37
Xylenes	935.63	Formaldehyde	36,374.58	Acetaldehyde	0.28
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		

The pollutants listed in Tables 12-7 and 12-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 and noncancer surrogate risk 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.

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.

- 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 while 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 Lake County also have the highest toxicity-weighted emissions. For Marion County, five of the highest emitted pollutants also have the highest toxicity-weighted emissions.

- 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 appear on the list of 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 the Indiana monitoring sites. Acetaldehyde and formaldehyde appear on both emissions-based lists for INDEM and WPIN, with formaldehyde ranking relatively high on both lists.

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 quantities of emissions.

- 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 on the list of 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).

- Acetaldehyde and formaldehyde appear on both emissions-based lists for INDEM and WPIN.

12.6 Summary of the 2010 Monitoring Data for INDEM and WPIN

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

- ❖ *Two carbonyl compounds failed screens for INDEM and three failed screens for WPIN.*

- ❖ *Formaldehyde had the highest annual average concentration for each of the Indiana monitoring sites. The annual averages concentrations for WPIN were higher than the annual average concentrations for INDEM.*

- ❖ *Concentrations of formaldehyde and acetaldehyde exhibit a decreasing trend at INDEM.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 13-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 13-1. Grayson, Kentucky (GLKY) Monitoring Site

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.

Legend

⊛ GLKY NATTS site ○ 10 mile radius ▢ County boundary

Source Category Group (No. of Facilities)

+ Aircraft Operations (1)

▭ Brick Manufacturing & Structural Clay (2)

B Bulk Terminals/Bulk Plants (1)

F Food Processing/Agriculture (1)

🖐 Hot Mix Asphalt Plant (1)

✕ Mine/Quarry (1)

? Miscellaneous Commercial/Industrial (1)

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] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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, 2012 and ACE, 2012). 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 radii 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Kentucky monitoring site. Table 13-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for GLKY. In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 13-2 also contains annual average daily traffic information. Finally, Table 13-2 presents the 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	27,675	36,031	1.30	16,880	21,977	428	1,164,000

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Kentucky Transportation Cabinet (KYTC, 2011a)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2009 data from the Kentucky Transportation Cabinet (KYTC, 2009)
[5] County-level VMT reflects 2010 data from the Kentucky Transportation Cabinet (KYTC, 2011b)
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). 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 came from 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 Carter County daily VMT is the second lowest compared to other counties with NMP sites (where VMT data were available), behind only Union County, South Dakota.

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 pleasant. Precipitation is well distributed throughout the year, although fall tends to be driest and spring wettest (NCDC, 2012).

13.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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	64.4 ± 5.4	54.9 ± 4.8	43.9 ± 4.8	49.3 ± 4.4	70.0 ± 3.2	1016.4 ± 1.6	3.9 ± 0.5
		2010	64.9 ± 2.2	55.4 ± 1.9	44.2 ± 1.9	49.7 ± 1.8	69.5 ± 1.2	1016.3 ± 0.6	4.0 ± 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 2010. 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 2010. Included in Figure 13-3 are four back trajectories per sample day. Figure 13-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, 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, the majority of which originated to the south, west and northwest, and north.

- The farthest away a back trajectory originated was north-central Missouri, or nearly 500 miles away; however, the average trajectory length was 194 miles and 88 percent of trajectories originated within 350 miles of the monitoring site.

- The cluster program grouped the trajectories originating from the northwest to northeast to southeast and within 200 miles of the site together, which are represented by the short cluster originating over West Virginia (29 percent). The trajectories originated over southern Ohio, West Virginia, southwest Virginia, and northeast Kentucky. Another 21 percent of back trajectories originated from the west, although these trajectories are represented by two cluster trajectories (6 percent and 15 percent) to represent the different lengths of the trajectories. One quarter of trajectories originated to the south of GLKY.

Figure 13-3. 2010 Composite Back Trajectory Map for GLKY
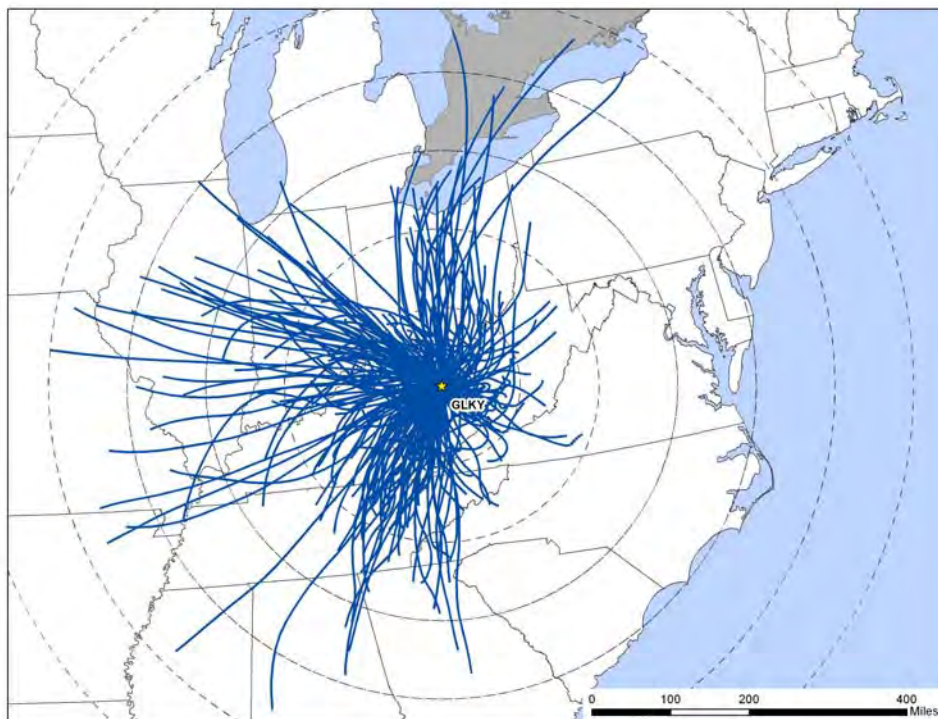
Figure 13-4. Back Trajectory Cluster Map for GLKY

13.2.4 Wind Rose Comparison

        Hourly 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" around a 16-point compass, and uses different colors to represent wind speeds.

        Figure 13-5 presents three different wind roses for the GLKY monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location.

        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 22 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 2010 wind rose are similar to those on the historical wind rose, but calm winds accounted for a higher percentage of the wind observations in 2010 (28 percent).

- The sample day wind rose has an even higher percentage of calm winds (30 percent) than the historical and full-year wind roses. Although winds from the south-southwest were still observed the most, the percentage of wind observations is more evenly distributed between the northwest and southwest quadrants, as well as a northeasterly direction.

Figure 13-5. Wind Roses for the Tri-State/M.J. Ferguson Field Airport Weather Station near GLKY

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between GLKY and NWS Station
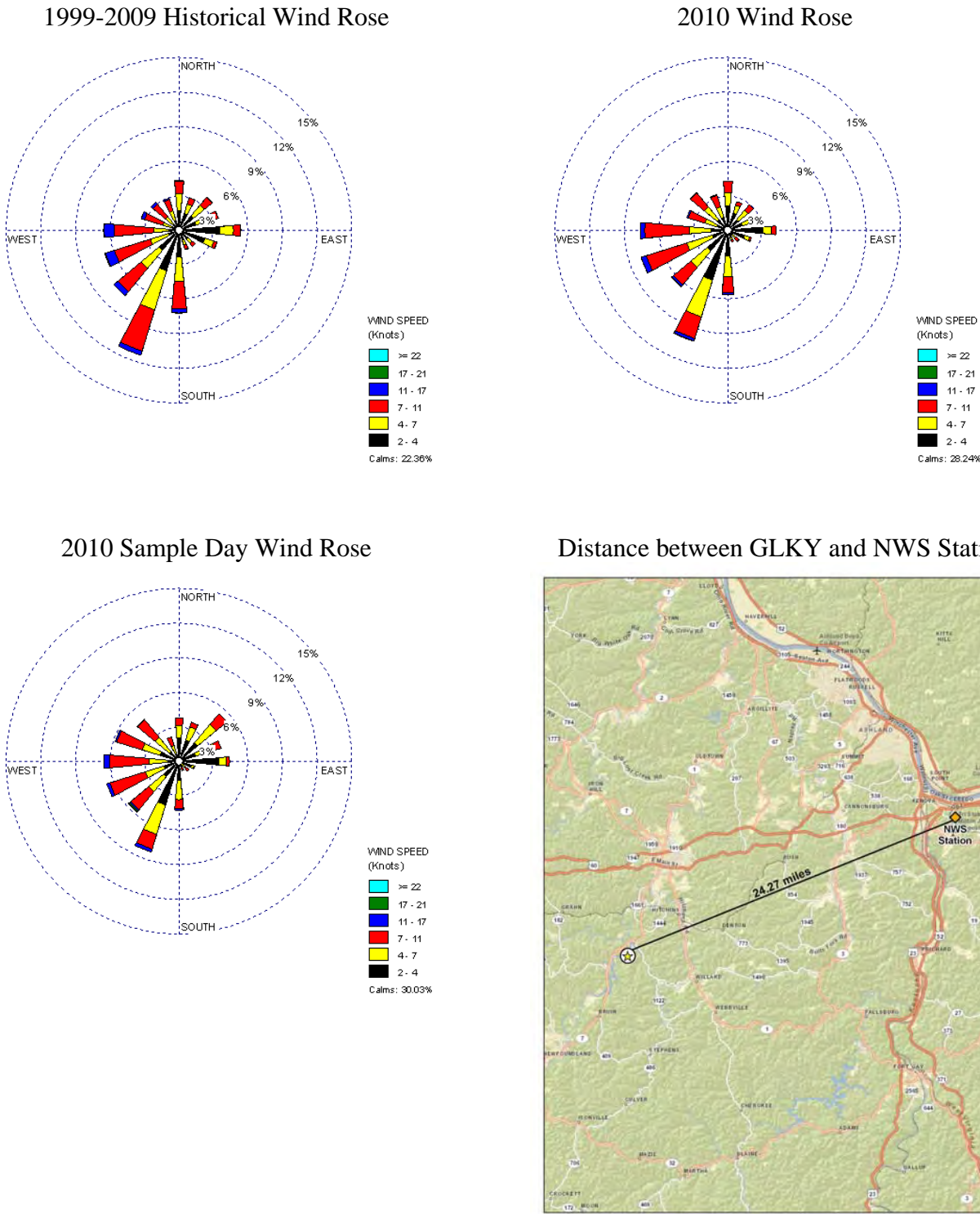
13.3 Pollutants of Interest

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 13-4 presents GLKY's pollutants of interest. 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, PAH, and VOC.

Table 13-4. Risk Screening Results for the Kentucky Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Grayson, Kentucky - GLKY						
Benzene	0.13	35	35	100.00	33.98	33.98
Carbon Tetrachloride	0.17	35	35	100.00	33.98	67.96
1,3-Butadiene	0.03	19	25	76.00	18.45	86.41
Naphthalene	0.029	12	60	20.00	11.65	98.06
p-Dichlorobenzene	0.091	1	7	14.29	0.97	99.03
1,2-Dichloroethane	0.038	1	1	100.00	0.97	100.00
Total		103	163	63.19		

Observations from Table 13-4 include the following:

- GLKY sampled hexavalent chromium and PAH throughout 2010, but did not begin sampling VOC through the NMP until June. Even though VOC samples were only collected half the year in 2010, VOC make up the majority of failed screens in Table 13-4.

- Six pollutants failed screens for GLKY, including four NATTS MQO Core Analytes.

- Four pollutants were initially identified as pollutants of interest via the risk screening process. All four of these pollutants are NATTS MQO Core Analytes. Hexavalent chromium, benzo(a)pyrene, chloroform, and tetrachloroethylene were added to GLKY'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 13-4. Trichloroethylene and vinyl chloride are also NATTS MQO Core Analytes, but were not detected at this site and were therefore not added to the list of pollutants of interest.

- Benzene, carbon tetrachloride, and 1,2-dichloroethane each failed 100 percent of screens at GLKY. While benzene and carbon tetrachloride were detected in every valid VOC sample collected at GLKY, 1,2-dichloroethane was detected only once.

13.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Kentucky monitoring site. Concentration averages are provided for the pollutants of interest for GLKY, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices J, M, and O.

13.4.1 2010 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 PAH and hexavalent chromium for GLKY are presented in ng/m^3 for ease of viewing. Also note

13-13

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 ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Grayson, Kentucky - GLKY						
Benzene	35/35	NA	NA	0.69 ± 0.27	0.66 ± 0.15	NA
1,3-Butadiene	25/35	NA	NA	0.02 ± 0.01	0.04 ± 0.01	NA
Carbon Tetrachloride	35/35	NA	NA	0.71 ± 0.07	0.57 ± 0.06	NA
Chloroform	28/35	NA	NA	0.10 ± 0.02	0.05 ± 0.02	NA
Tetrachloroethylene	15/35	NA	NA	0.02 ± 0.02	0.03 ± 0.02	NA
Benzo(a)pyrene[a]	30/60	0.13 ± 0.08	0.03 ± 0.03	<0.01 ± <0.01	0.06 ± 0.03	0.06 ± 0.02
Hexavalent Chromium[a]	34/61	0.01 ± 0.01	0.01 ± 0.01	0.02 ± <0.01	0.01 ± <0.01	0.01 ± <0.01
Naphthalene[a]	60/60	28.61 ± 9.44	17.00 ± 5.35	17.84 ± 4.57	27.39 ± 9.49	22.71 ± 3.80

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
[a] Average concentrations provided for the pollutants below the black 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 VOC because sampling did not begin until June 2010. However, Appendix J provides the pollutant-specific average concentration for all valid VOC samples collected over the entire sample period.

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

- Concentrations of benzo(a)pyrene were highest during the first and fourth quarters of 2010. These quarterly averages also have relatively high confidence intervals associated with them (as does the second quarter average). The three concentrations greater than 0.25 ng/m^3 were all measured in January and February 2010. Of the 30 measured detections of benzo(a)pyrene, 14 were measured during the first quarter, six were measured during the second quarter, one was measured during the third quarter, and nine were measured during the fourth quarter.

- Similar to benzo(a)pyrene, naphthalene concentrations tended to be lower during the warmer months and higher during the colder months. However, the confidence intervals indicate that the difference is not statistically significant.

- The annual average concentrations of naphthalene and hexavalent chromium are among the lowest compared to NMP sites sampling these pollutants. The annual average concentration of benzo(a)pyrene for GLKY is in the middle of the range compared to other sites sampling PAH.

13.4.2 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 benzo(a)pyrene, hexavalent chromium, and naphthalene were created for GLKY. Figures 13-6 through 13-8 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 13-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration
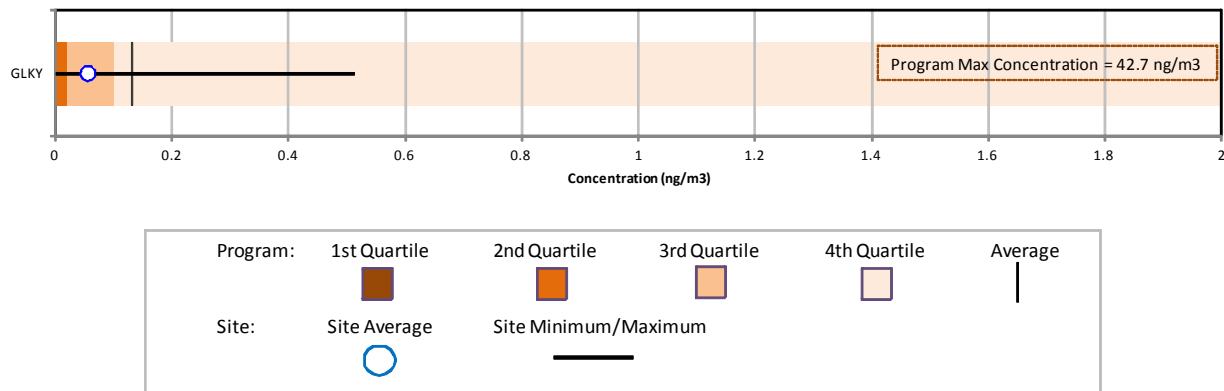
Figure 13-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration
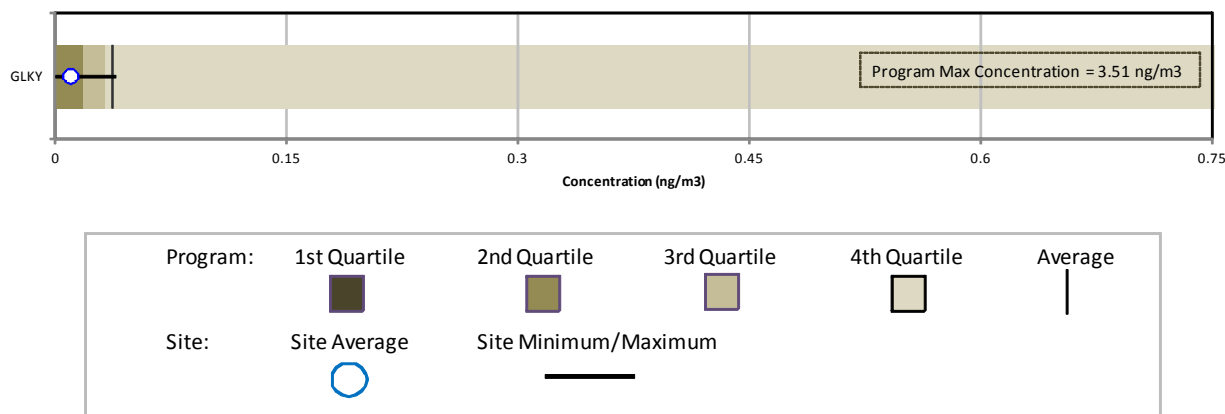
Figure 13-8. Program vs. Site-Specific Average Naphthalene Concentration
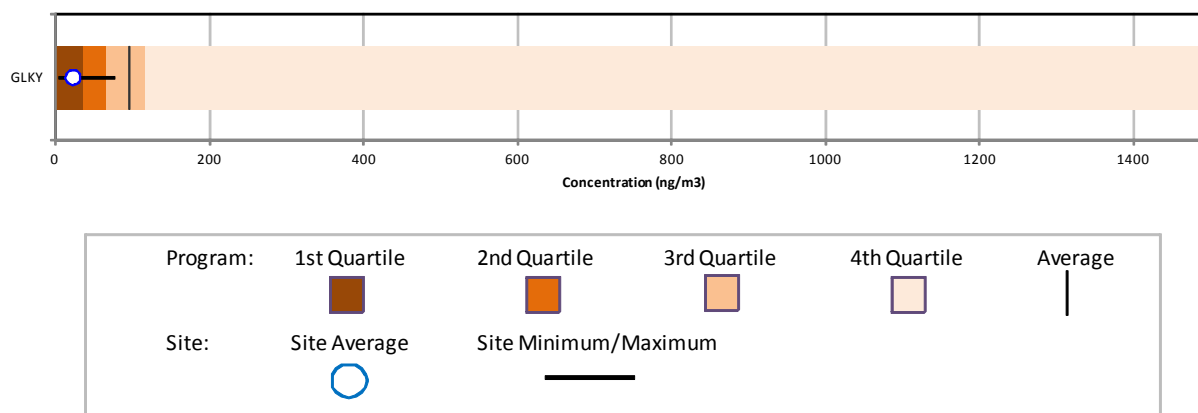
Observations from Figures 13-6 through 13-8 include the following:

- Figure 13-6 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 13-7 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 13-7 shows the annual average concentration of hexavalent chromium for

GLKY is well below the program-level average and median concentrations. The maximum hexavalent chromium concentration measured at GLKY is just greater than the program-level average concentration. Several non-detects of hexavalent chromium were measured at GLKY.

- Figure 13-8 shows that the annual naphthalene average for GLKY is well below the program-level average concentration. The maximum naphthalene concentration measured at GLKY is also less than the program-level average concentration, but just greater than the median concentration for the program. There were no non-detects of naphthalene at GLKY.

- Recall that annual averages for GLKY could not be calculated for the VOC, as discussed in Section 13.4.1.

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 Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

13.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Kentucky monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Kentucky monitoring site were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Kentucky monitoring site.

13.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Kentucky monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations for GLKY are presented in Table 13-6, where applicable.

Table 13-6. Cancer and Noncancer Surrogate 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 (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Grayson, Kentucky - GLKY						
Benzene	0.0000078	0.03	35/35	NA	NA	NA
Benzo(a)pyrene	0.00176	--	30/60	0.06 ± 0.02	0.10	--
1,3-Butadiene	0.00003	0.002	25/35	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	35/35	NA	NA	NA
Chloroform	--	0.098	28/35	NA	NA	NA
Hexavalent Chromium	0.012	0.0001	34/61	0.01 ± <0.01	0.12	<0.01
Naphthalene	0.000034	0.003	60/60	22.71 ± 3.80	0.77	0.01
Tetrachloroethylene	0.00000026	0.04	15/35	NA	NA	NA

NA = Not available due to the criteria for calculating an annual average.
-- = a Cancer URE or Noncancer RfC is not available.

Observations for GLKY from Table 13-6 include the following:

- The cancer risk approximations for the pollutants of interest for GLKY are all less than 1.0 in-a-million (ranging from 0.10 in-a-million for benzo(a)pyrene to 0.77 in-a-million for naphthalene).

- The noncancer risk approximations for naphthalene and hexavalent chromium are well below an HQ of 1.0 (0.01 or less). A noncancer risk approximation for benzo(a)pyrene could not be calculated because there is not a noncancer RfC for this pollutant.

- The cancer and noncancer risk approximations for hexavalent chromium and naphthalene for GLKY are among the lowest calculated for these pollutants of interest across the NMP.

- Annual averages, and therefore cancer and noncancer risk approximations, could not be calculated for the VOC pollutants of interest.

13.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 13-7 and 13-8 present a risk-based 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 13-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 13-7 and 13-8 are limited to those that have cancer and noncancer risk 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 and noncancer risk 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, PAH, and VOC. In addition, the cancer and noncancer surrogate risk 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 VOC, cancer and noncancer surrogate risk approximations were also not calculated. A more in-depth discussion of this analysis is provided in Section 3.5.5.3.

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 Risk Factors (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	Naphthalene	0.77
Formaldehyde	15.19	Formaldehyde	1.97E-04	Hexavalent Chromium	0.12
Ethylbenzene	11.80	1,3-Butadiene	9.09E-05	Benzo(a)pyrene	0.10
Acetaldehyde	9.53	Naphthalene	7.00E-05		
1,3-Butadiene	3.03	POM, Group 2b	3.56E-05		
Naphthalene	2.06	Hexavalent Chromium, PM	3.33E-05		
POM, Group 2b	0.40	Ethylbenzene	2.95E-05		
Dichloromethane	0.25	POM, Group 3	2.47E-05		
POM, Group 6	0.04	Acetaldehyde	2.10E-05		
POM, Group 1a	0.02	POM, Group 5a	1.78E-05		

Table 13-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Kentucky Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Grayson, Kentucky (Carter County) - GLKY					
Toluene	59.99	Acrolein	52,572.66	Naphthalene	0.01
Xylenes	44.41	Formaldehyde	1,549.95	Hexavalent Chromium	<0.01
Benzene	26.56	1,3-Butadiene	1,514.80		
Methanol	15.98	Cyanide Compounds, gas	1,335.64		
Hexane	15.43	Acetaldehyde	1,058.92		
Formaldehyde	15.19	Benzene	885.42		
Ethylbenzene	11.80	Naphthalene	686.00		
Acetaldehyde	9.53	Xylenes	444.15		
1,3-Butadiene	3.03	Arsenic, PM	138.10		
Styrene	2.50	Propionaldehyde	111.83		

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.

- Naphthalene appears on both emissions-based lists for Carter County and has the highest cancer risk approximation for this county. Hexavalent chromium 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 measured with Method TO-13 are part of POM, Group 2b, which appears on both emissions-based lists.

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. Acrolein did not appear on Carter County's list of highest emitted pollutants.

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

- While naphthalene does not appear among the pollutants with the highest emissions (of the pollutants with noncancer RfCs), it ranks seventh on the list of highest toxicity-weighted emissions for Carter County. Hexavalent chromium does not appear on either emissions-based list.

13.6   Summary of the 2010 Monitoring Data for GLKY

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

❖ *Six pollutants, five VOC and one PAH, failed screens for GLKY, including four NATTS MQO Core Analytes.*

❖ *Naphthalene had the highest annual average concentration among the pollutants of interest for GLKY.*

❖ *Because VOC sampling did not begin until June 2010, annual average concentrations could not be calculated for these pollutants.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest, where they could be calculated, were greater than their associated MRL noncancer health risk benchmarks.*

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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 14-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 14-1. Boston, Massachusetts (BOMA) Monitoring Site
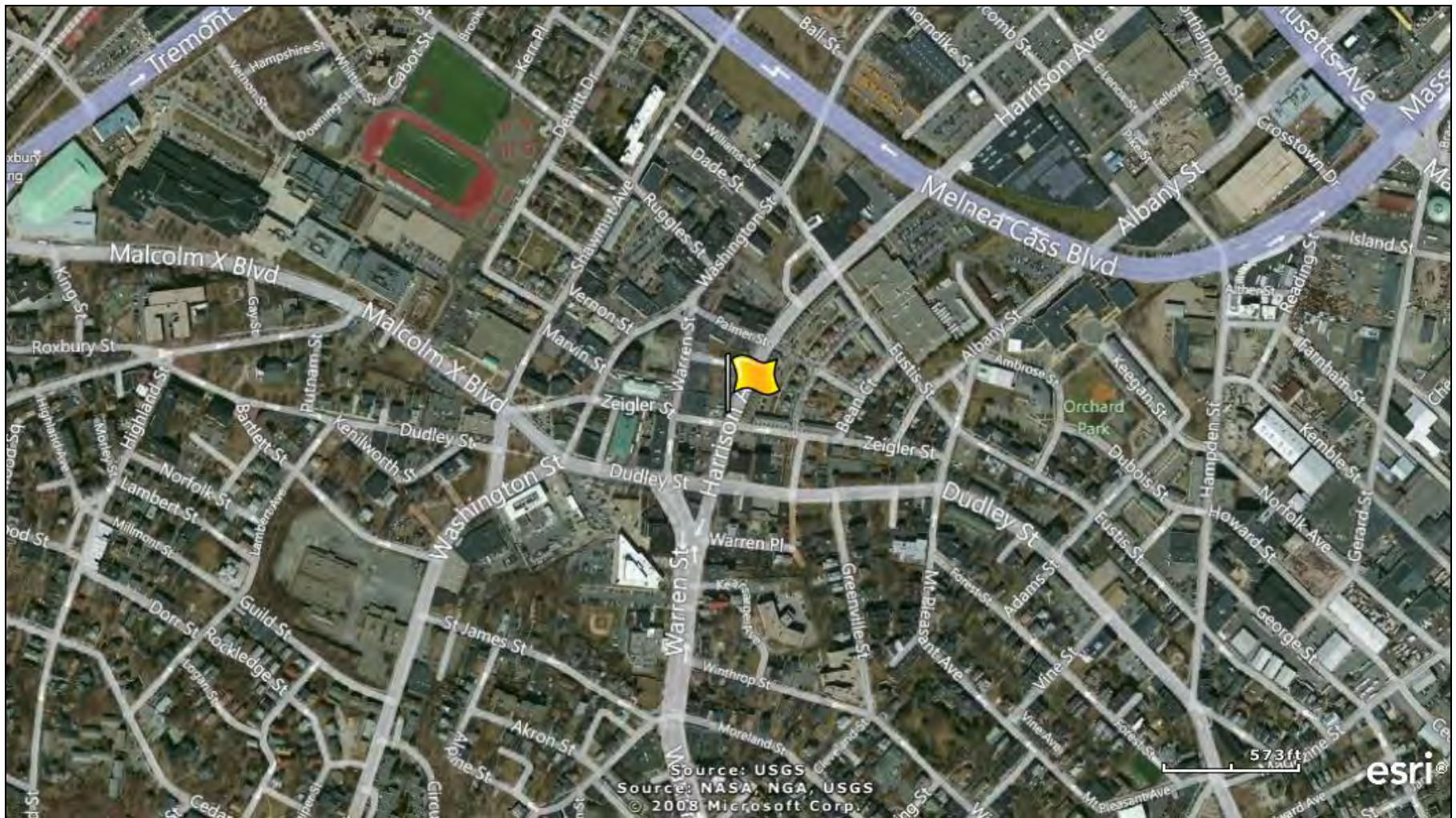
Figure 14-2. NEI Point Sources Located Within 10 Miles of BOMA

Legend

⭐ BOMA NATTS site ◯ 10 mile radius ▭ County boundary

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

Source Category Group (No. of Facilities)

- �ள Aerospace/Aircraft Manufacturing (1)
- ❄ Air-conditioning/Refrigeration (3)
- ✚ Aircraft Operations (18)
- ◇ Auto Body Shop/Painters (1)
- 🚗 Automobile/Truck Manufacturing (1)
- Ƀ Bakery (4)
- B Bulk Terminals/Bulk Plants (7)
- C Chemical Manufacturing (1)
- ■ Concrete Batch Plant (1)
- ⊕ Dry Cleaning (2)
- e Electrical Equipment (3)
- ⚡ Electricity Generation via Combustion (8)
- E Electroplating, Plating, Polishing, Anodizing, and Coloring (4)
- ⊙ Fabricated Metal Products (5)
- F Food Processing/Agriculture (1)
- ▣ Furniture Plant (1)
- ▪ Gasoline/Diesel Service Station (2)
- Ⓗ Hospital (4)

- ⚒ Hot Mix Asphalt Plant (2)
- Ⓢ Institutional - school (39)
- I Iron and Steel Foundry (1)
- ◕ Laboratory (2)
- ▲ Landfill (1)
- L Large Appliance Manufacturing (1)
- ▽ Mineral Products (1)
- ? Miscellaneous Commercial/Industrial (38)
- M Miscellaneous Manufacturing (6)
- Ⓜ Municipal Waste Combustor (1)
- ⬭ Pharmaceutical Manufacturing (1)
- P Printing/Publishing (1)
- ⊞ Pulp and Paper Plant/Wood Products (1)
- R Rubber and Miscellaneous Plastics Products (2)
- ⚓ Ship Building and Repairing (2)
- > Solid Waste Disposal - Commercial/Institutional (2)
- S Surface Coating (3)
- π Telecommunications (4)
- ⚜ Wastewater Treatment (2)

14-3

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, VOC, SO_2, NO, NO_2, NO_x, PAMS/NMOC, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, Black carbon, $PM_{2.5}$, $PM_{2.5}$ Speciation.

[1] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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 within 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Massachusetts monitoring site. Table 14-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 14-2 also contains annual average daily traffic information. County-level VMT was not readily available; thus, daily VMT for Suffolk County is not shown in Table 14-2.

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	723,323	501,587	0.69	1,670,959	1,158,723	31,400	NA

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Massachusetts Registry of Motor Vehicles (MA RMV, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2007 data from the Massachusetts DOT (MA DOT, 2007)
[5] County-level VMT was not available for this site
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.

- 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 ownership is among the higher estimates.

- The vehicle-per-person ratio is among the bottom-third of ratios when compared to other NMP sites.

- The traffic volume experienced near BOMA ranks in the middle of the range compared to other NMP sites. The traffic estimate used came from Melnea Cass Boulevard between Washington Street and Harrison Avenue.

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, 2012a).

14.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2010 (NCDC, 2010). 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 normal conditions throughout the year.

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	Sample Day	59.8 ± 4.8	53.0 ± 4.4	40.0 ± 4.6	47.0 ± 4.0	64.9 ± 4.2	1012.1 ± 2.0	9.9 ± 0.8
	42° (NE)	2010	60.6 ± 1.9	53.6 ± 1.8	40.0 ± 1.9	47.3 ± 1.6	63.6 ± 1.7	1012.2 ± 0.8	9.8 ± 0.4

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

Table 14-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for the entire year for 2010. 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 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 2010. Included in Figure 14-3 are four back trajectories per sample day. Figure 14-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, each concentric circle around the site in Figures 14-3 and 14-4 represents 100 miles.

Figure 14-3. 2010 Composite Back Trajectory Map for BOMA
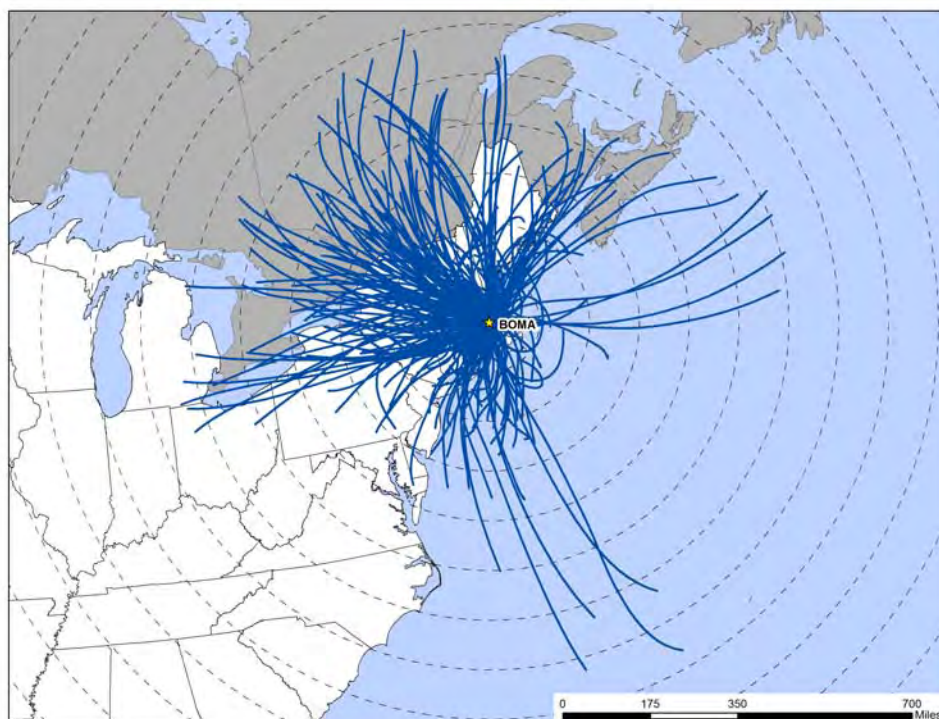
Figure 14-4. Back Trajectory Cluster Map for BOMA

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 longest trajectories originated from the south-southeast and are associated with a strong low pressure system that moved through the region January 25-26, 2010.

- The 24-hour air shed domain for BOMA is larger in size compared to other NMP monitoring sites. The farthest away a trajectory originated was nearly 800 miles, off the North Carolina coast and over the Atlantic Ocean. However, the average trajectory length was 310 miles. Most trajectories (85 percent) originated within 500 miles of the monitoring site.

- Nearly half of back trajectories originated to the west, northwest, and north of BOMA, as shown by the 32 percent and 14 percent trajectories on the cluster analysis. Another 32 percent of trajectories originated within approximately 250 miles of BOMA, as represented by the short cluster approximately 50 miles long. This cluster represents several trajectories originating from a variety of directions but within 200 or so miles of the site. It is important to recall that the HYSPLIT model includes both distance and direction when determining clusters. Another 13 percent originated from south of BOMA, and includes the longest trajectories in Figure 14-3. Finally, 10 percent of trajectories originated to the northeast over Quebec, New Brunswick, or Nova Scotia, Canada, or over the Atlantic Ocean.

14.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the BOMA monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location.

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 sits 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 the 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 2010 wind rose resemble the historical wind patterns, although there was a higher percentage of westerly to northwesterly winds, indicating that wind conditions during 2010 were typical of conditions normally experienced.

- The sample day wind patterns resemble the full-year wind patterns, with an even higher percentage of west-northwesterly and northwesterly winds, indicating that conditions on sample days were representative of those experienced over the entire year.

Figure 14-5. Wind Roses for the Logan International Airport Weather Station near BOMA

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between BOMA and NWS Station
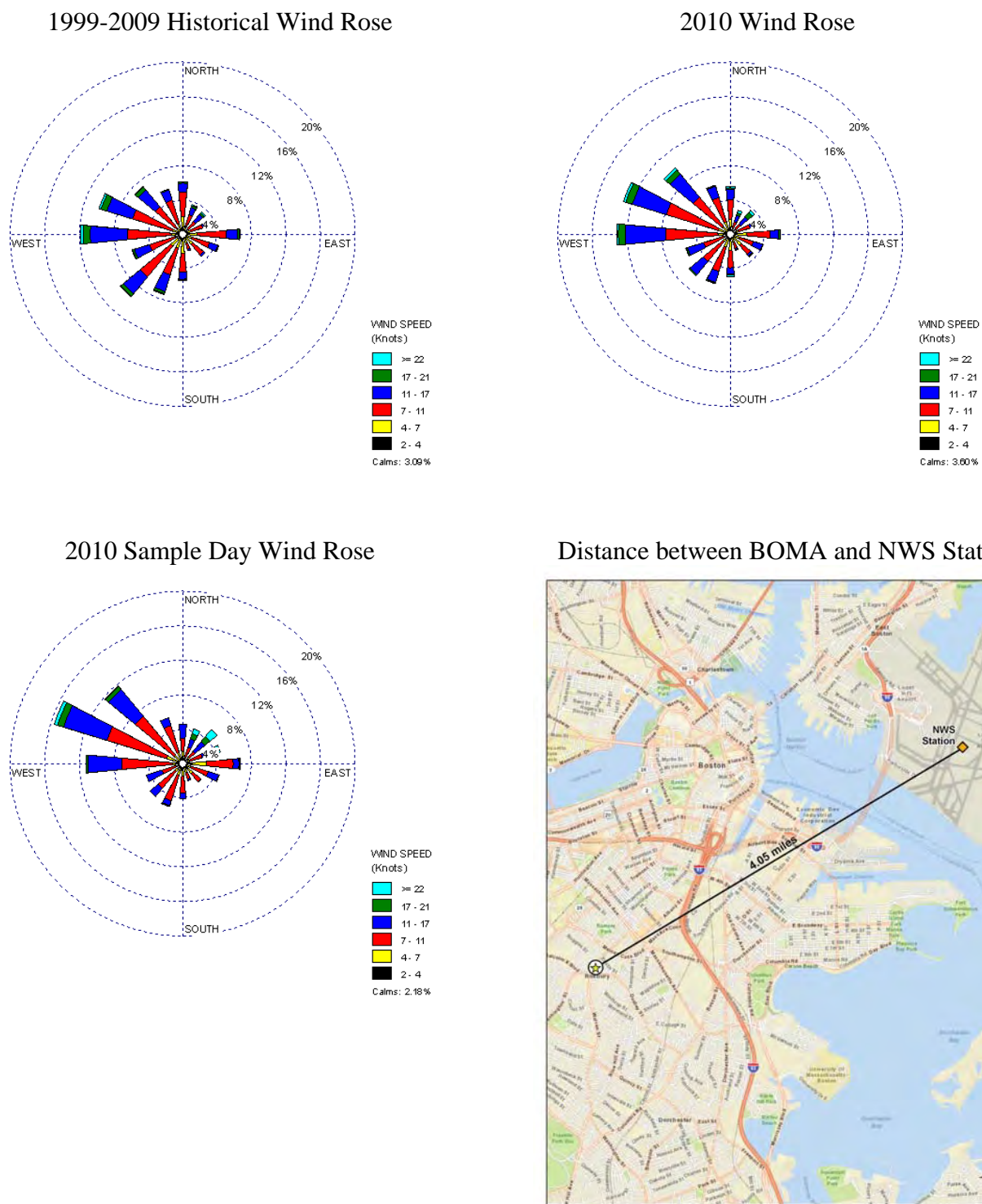
14.3   Pollutants of Interest

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 14-4 presents BOMA's pollutants of interest. 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 metals (PM_{10}), PAH, and hexavalent chromium.

Table 14-4. Risk 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	57	60	95.00	50.00	50.00
Arsenic (PM$_{10}$)	0.00023	43	61	70.49	37.72	87.72
Manganese (PM$_{10}$)	0.005	6	61	9.84	5.26	92.98
Nickel (PM$_{10}$)	0.0021	5	61	8.20	4.39	97.37
Hexavalent Chromium	0.000083	3	43	6.98	2.63	100.00
Total		114	286	39.86		

Observations from Table 14-4 include the following:

- Five pollutants failed at least one screen for BOMA; all five are NATTS MQO Core Analytes.

- Nearly 40 percent of the measured detections (of the pollutants that failed at least one screen) failed screens for BOMA. Naphthalene accounted for half of the total failed screens for BOMA.

- Four of the five pollutants failing screens were initially identified as pollutants of interest for BOMA based on the risk screening process. Hexavalent chromium was

added to BOMA's pollutants of interest because it is a NATTS MQO Core Analyte, even though they 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.

14.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Massachusetts monitoring site. Concentration averages are provided for the pollutants of interest for BOMA, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices M through O.

14.4.1 2010 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$_{10}$)	61/61	0.27 ± 0.06	0.48 ± 0.14	0.40 ± 0.09	0.28 ± 0.09	0.36 ± 0.05
Benzo(a)pyrene	52/60	0.17 ± 0.05	0.07 ± 0.02	0.06 ± 0.03	0.10 ± 0.04	0.10 ± 0.02
Beryllium (PM$_{10}$)	55/61	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Cadmium (PM$_{10}$)	61/61	0.24 ± 0.04	0.20 ± 0.03	0.17 ± 0.03	0.15 ± 0.03	0.19 ± 0.02
Hexavalent Chromium	43/61	0.01 ± 0.01	0.02 ± 0.01	0.04 ± 0.02	0.02 ± 0.01	0.02 ± 0.01
Lead (PM$_{10}$)	61/61	2.57 ± 0.75	3.14 ± 0.98	2.47 ± 0.61	1.96 ± 0.39	2.53 ± 0.35
Manganese (PM$_{10}$)	61/61	2.52 ± 0.61	4.18 ± 0.89	3.69 ± 1.37	2.31 ± 0.48	3.18 ± 0.48
Naphthalene	60/60	57.43 ± 13.04	67.38 ± 11.04	82.35 ± 14.24	64.94 ± 19.91	68.31 ± 7.30
Nickel (PM$_{10}$)	61/61	1.46 ± 0.39	1.31 ± 0.21	1.04 ± 0.21	1.20 ± 0.33	1.25 ± 0.14

Observations for BOMA from Table 14-5 include the following:

- Naphthalene is the pollutant with the highest annual average concentration by mass (68.31 ± 7.30 ng/m^3). The annual average concentrations for the remaining pollutants of interest are at least an order of magnitude lower.

- Benzo(a)pyrene concentrations appear to be highest during the colder months of the year, as indicated by the first and fourth quarter average concentrations. Of the 12 concentrations greater than 0.15 ng/m^3, only one was measured outside the first or fourth quarter of 2010 and the six highest concentrations measured at BOMA were from samples collected in January, February, or December.

- The second and third quarter manganese average concentrations are higher than the other quarterly averages and the third quarter has a relatively large confidence interval associated with it. Of the six manganese concentrations greater than 5 ng/m^3, four were measured during the second quarter of 2010 and two were measured during the third quarter of 2010, including the highest concentration of manganese measured on July 7, 2010 (12.3 ng/m^3).

- The hexavalent chromium average for the third quarter of 2010 is twice the average concentration of the other quarterly averages. A review of the data shows that the two highest concentrations of hexavalent chromium were measured during this quarter (0.138 ng/m^3 on July 7, 2010 and 0.103 ng/m^3 on August 24, 2010). These two concentrations are the only concentrations greater than 0.10 ng/m^3 measured at

BOMA. Note that the highest concentration of hexavalent chromium was measured on the same day as the highest concentration of manganese.

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 sixth highest among sites sampling PAH.

- BOMA's annual average concentrations of cadmium and nickel rank second highest among other sites sampling PM_{10} metals.

- BOMA's annual average concentration of hexavalent chromium ranks tenth highest among sites sampling this pollutant.

14.4.2 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 arsenic, benzo(a)pyrene, hexavalent chromium, manganese, and naphthalene were created for BOMA. Figures 14-6 through 14-10 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 14-6. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration
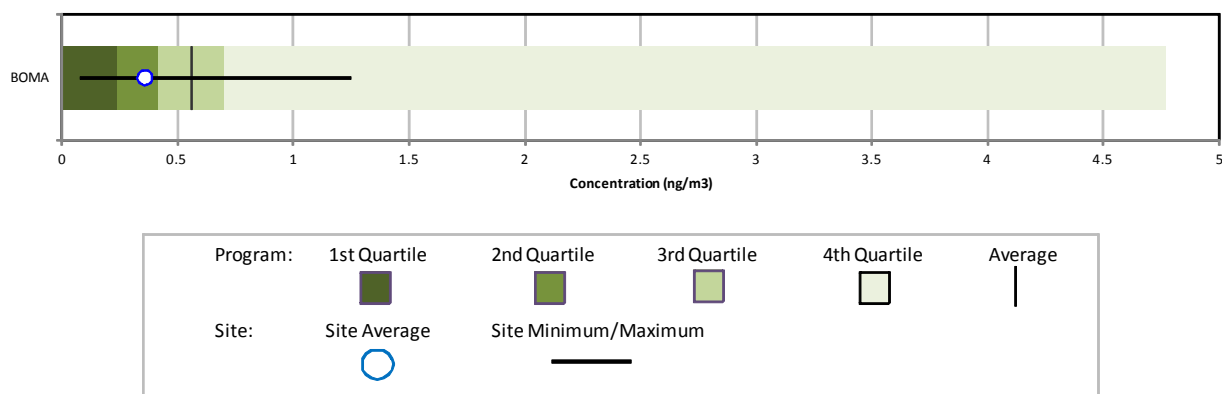
Figure 14-7. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Program Max Concentration = 42.7 ng/m3

Legend:
Program: 1st Quartile, 2nd Quartile, 3rd Quartile, 4th Quartile, Average
Site: Site Average, Site Minimum/Maximum
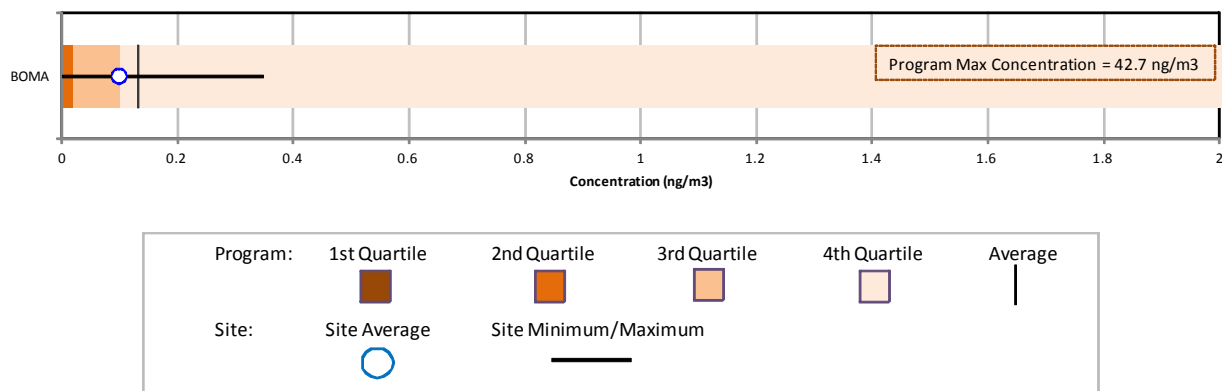
Figure 14-8. Program vs. Site-Specific Average Hexavalent Chromium Concentration

Program Max Concentration = 3.51 ng/m3

Legend:
Program: 1st Quartile, 2nd Quartile, 3rd Quartile, 4th Quartile, Average
Site: Site Average, Site Minimum/Maximum
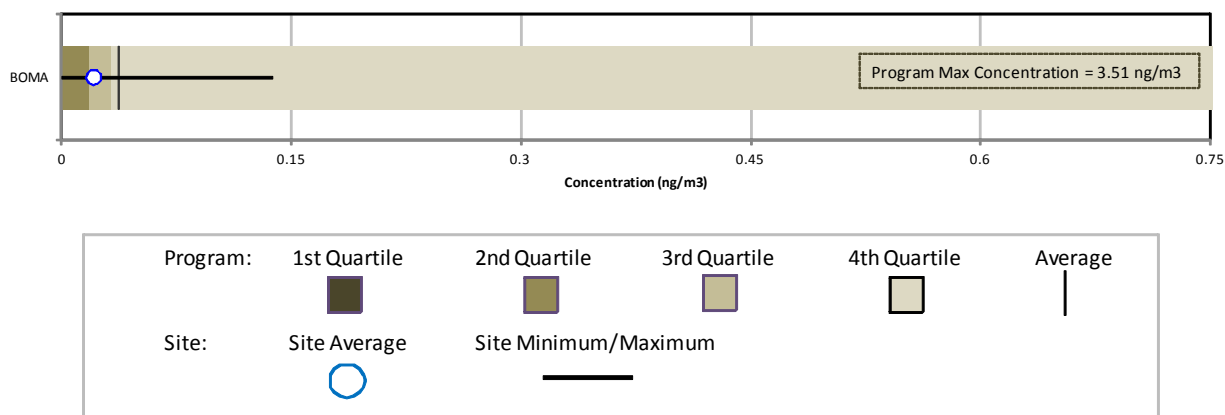
Figure 14-9. Program vs. Site-Specific Average Manganese (PM$_{10}$) Concentration

Legend:
Program: 1st Quartile, 2nd Quartile, 3rd Quartile, 4th Quartile, Average
Site: Site Average, Site Minimum/Maximum
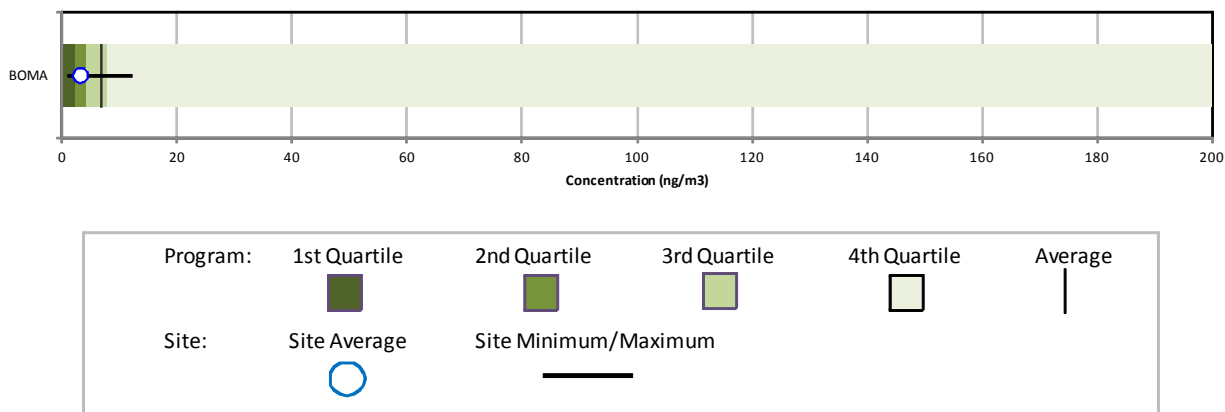
Figure 14-10. Program vs. Site-Specific Average Naphthalene Concentration
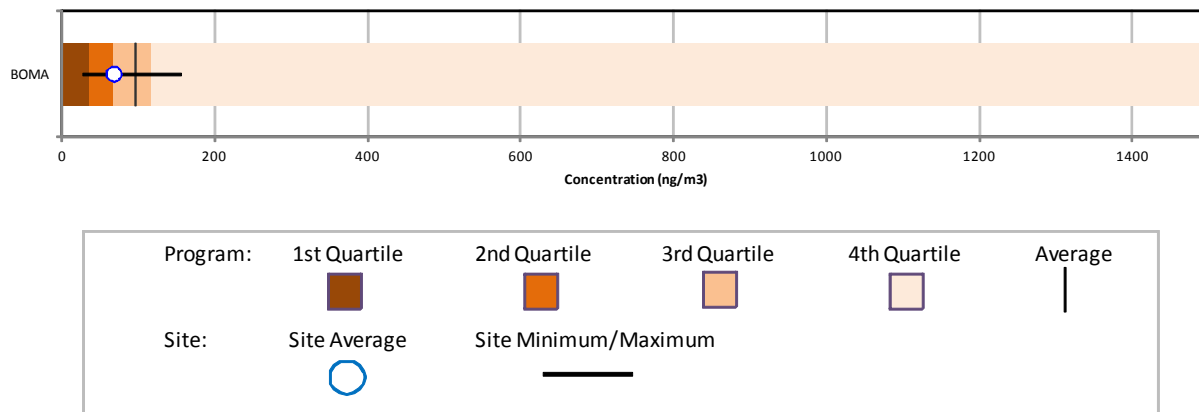
Observations from Figures 14-6 through 14-10 include the following:

- Figure 14-6 shows that BOMA's annual average arsenic (PM_{10}) concentration is below both the program-level average and median concentrations for arsenic (PM_{10}). There were no non-detects of arsenic measured at BOMA.

- Figure 14-7 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 below the program-level average concentration of benzo(a)pyrene and roughly equivalent to the program-level third quartile. Figure 14-7 also shows that the maximum concentration measured at BOMA is well below the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at BOMA.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 14-8 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 14-8 shows the annual average concentration of hexavalent chromium for BOMA is below the program-level average concentration. The maximum concentration measured at BOMA is well below the maximum concentration measured at the program level. Several non-detects of hexavalent chromium were measured at BOMA.

- Figure 14-9 shows that BOMA's annual average manganese (PM_{10}) concentration is below the program-level average concentration, as well as the median concentration, for manganese (PM_{10}). There were no non-detects of manganese at BOMA.

14-17

- Similar to BOMA's other pollutants of interest, Figure 14-10 shows that the annual naphthalene average for BOMA is less than the program-level average concentration. 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 14-11 through 14-13 present the 3-year rolling statistical metrics for arsenic, hexavalent chromium, and manganese for BOMA, respectively. The statistical metrics presented for calculating trends include the substitution of zeros for non-detects.

Figure 14-11. Three-Year Rolling Statistical Metrics for Arsenic (PM$_{10}$) Concentrations Measured at BOMA
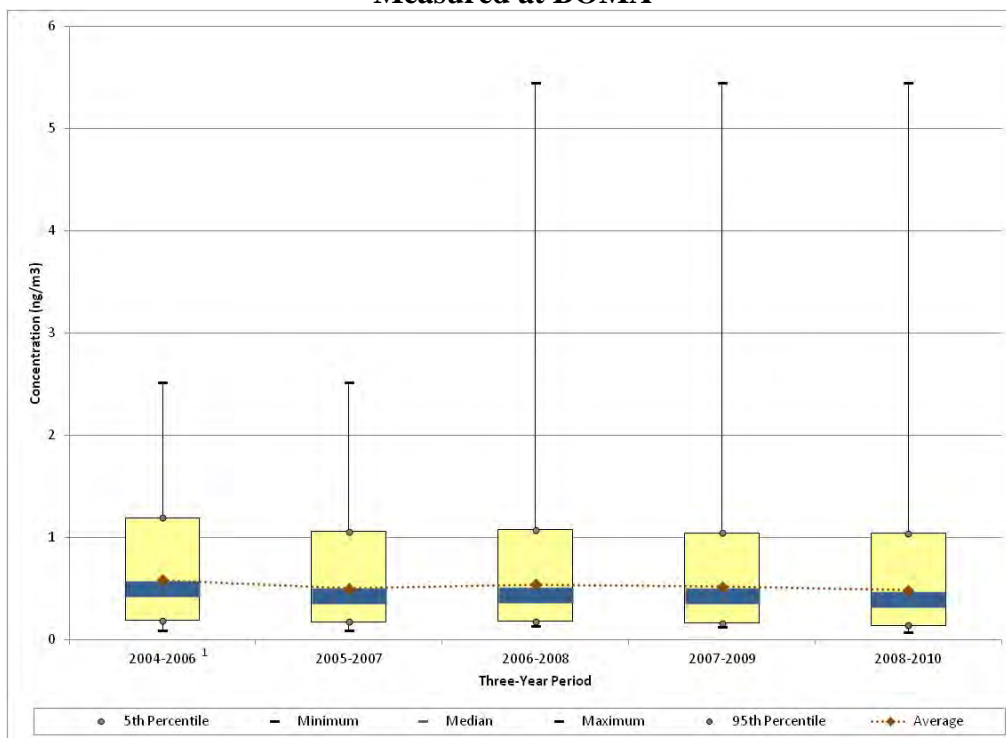
[1]Samples were not collected between April 3 and May 21 and September 24 through November 6 in 2004.

Figure 14-12. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at BOMA
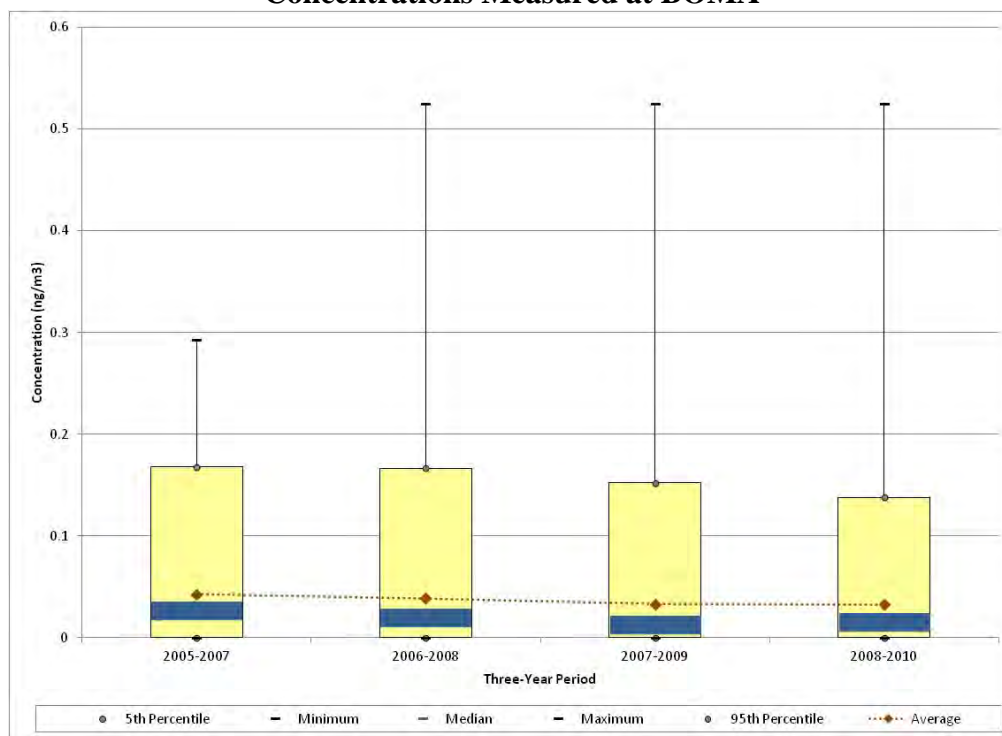
Figure 14-13. Three-Year Rolling Statistical Metrics for Manganese (PM$_{10}$) Concentrations Measured at BOMA
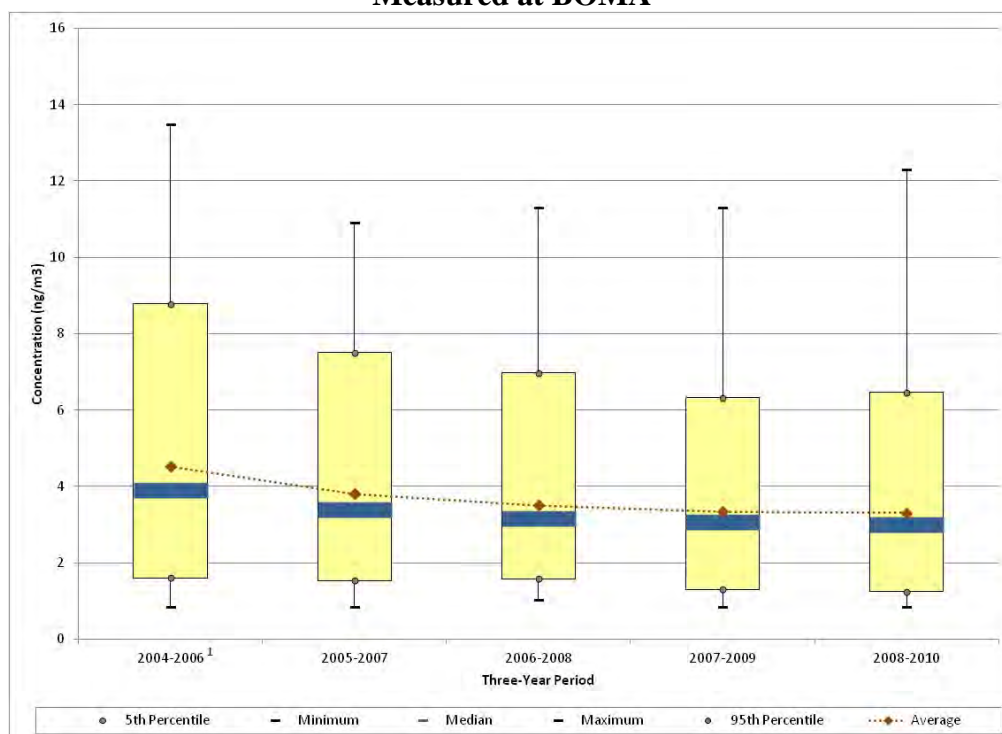
[1]Samples were not collected between April 3 and May 21 and September 24 through November 6 in 2004.

Observations from Figure 14-11 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 is denoted in Figure 14-11.

- 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 (and is shown as the maximum concentration for the first two 3-year periods).

- The rolling average concentrations exhibit very little change over the years of sampling, which is also true for most of the other statistical parameters.

- The minimum concentration measured for each 3-year period is greater than zero, indicating that there were no non-detects of arsenic measured at BOMA since the onset of sampling.

Observations from Figure 14-12 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 were greater than 0.1 ng/m^3; of these, at least two have been measured in each year since the onset of sampling.

- While the rolling average concentration has been decreasing slightly since the onset of sampling, this decrease is not statistically significant. The medians and 95th percentiles also show slight decreases.

- The minimum and 5th percentile are both zero for each 3-year period of sampling, indicating the presence of non-detects.

Observations from Figure 14-13 for manganese measurements at BOMA include the following:

- The maximum manganese concentration was measured in 2004. Of the six manganese measurements greater than 10 ng/m^3, two were measured in 2004, two in 2005, and one each in 2008 and 2010. Consequently, the second highest manganese concentration was measured on July 7, 2010, as discussed in the previous section.

- The rolling average and median concentrations exhibit a steady decreasing trend over the years of sampling. Other statistical measures, such as the median and 95th percentile, also show a downward trend.

- The minimum concentration measured for each 3-year period is greater than zero, indicating that there were no non-detects of manganese measured at BOMA since the onset of sampling.

14.5 Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

14.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Massachusetts monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for BOMA were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Massachusetts monitoring site.

14.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Massachusetts monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 14-6, where applicable.

Table 14-6. Cancer and Noncancer Surrogate Risk Approximations for the Massachusetts Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Boston, Massachusetts - BOMA						
Arsenic (PM$_{10}$)	0.0043	0.000015	61/61	0.36 ± 0.05	1.54	0.02
Benzo(a)pyrene	0.00176	--	52/60	0.10 ± 0.02	0.17	--
Beryllium (PM$_{10}$)	0.0024	0.00002	55/61	<0.01 ± <0.01	0.01	<0.01
Cadmium (PM$_{10}$)	0.0018	0.00001	61/61	0.19 ± 0.02	0.34	0.02
Hexavalent Chromium	0.012	0.0001	43/61	0.02 ± 0.01	0.25	<0.01
Lead (PM$_{10}$)	--	0.00015	61/61	2.53 ± 0.35	--	0.02
Manganese (PM$_{10}$)	--	0.00005	61/61	3.18 ± 0.48	--	0.06
Naphthalene	0.000034	0.003	60/60	68.31 ± 7.30	2.32	0.02
Nickel (PM$_{10}$)	0.00048	0.00009	61/61	1.25 ± 0.14	0.60	0.01

-- = 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 surrogate risk approximations greater than 1.0 in-a-million (2.32 in-a-million and 1.54 in-a-million, respectively).

- None of BOMA's pollutants of interest have noncancer risk approximations greater than 1.0, indicating little risk of noncancer effects due to these pollutants.

14.5.3 Risk-Based Emissions Assessment

In addition to the risk 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 14-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

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 Risk Factors (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	2.32
Formaldehyde	164.08	Benzene	1.31E-03	Arsenic	1.54
Ethylbenzene	83.84	Nickel, PM	8.99E-04	Nickel	0.60
Acetaldehyde	79.23	1,3-Butadiene	7.99E-04	Cadmium	0.34
1,3-Butadiene	26.64	POM, Group 3	6.36E-04	Hexavalent Chromium	0.25
Naphthalene	14.54	Naphthalene	4.94E-04	Benzo(a)pyrene	0.17
Dichloromethane	5.42	Hexavalent Chromium, PM	4.31E-04	Beryllium	0.01
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 Risk Approximations for Pollutants with Noncancer RfCs for the Massachusetts Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Boston, Massachusetts (Suffolk County) - BOMA					
Toluene	456.02	Acrolein	313,612.93	Manganese	0.06
Xylenes	372.68	Nickel, PM	20,816.71	Arsenic	0.02
Benzene	168.18	Formaldehyde	16,743.22	Naphthalene	0.02
Formaldehyde	164.08	1,3-Butadiene	13,322.42	Cadmium	0.02
Hexane	97.07	Acetaldehyde	8,803.49	Lead	0.02
Ethylbenzene	83.84	Benzene	5,606.08	Nickel	0.01
Acetaldehyde	79.23	Naphthalene	4,847.85	Hexavalent Chromium	<0.01
Ethylene glycol	44.58	Arsenic, PM	4,440.73	Beryllium	<0.01
1,3-Butadiene	26.64	Xylenes	3,726.77		
Glycol ethers, gas	18.42	Cadmium, PM	2,204.94		

The pollutants listed in Tables 14-7 and 14-8 are limited to those that have cancer and noncancer risk 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 and noncancer risk approximations based on each site's annual averages are limited to those pollutants for which each respective site sampled. As discussed in Section 14.3, BOMA sampled for PAH, PM_{10} metals, and hexavalent chromium. In addition, the cancer and noncancer risk 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.

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 surrogate risk approximations for BOMA. Naphthalene ranks sixth on the list of 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 also appears on both emissions-based lists and has the third highest cancer risk approximation (albeit low) for BOMA. Hexavalent chromium ranks seventh on the list of highest toxicity-weighted emissions but is not among the highest emitted.

- POM, Group 2b is among the 10 highest emitted "pollutants" in Suffolk County and also ranks among the 10 highest for toxicity-weighted emissions. POM, Group 2b includes several PAH sampled for at BOMA including acenaphthylene, fluoranthene, and perylene. None of the PAH included in POM, Group 2b were identified as pollutants of interest for BOMA. 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 several metals 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 for Suffolk County, has a negligible noncancer risk approximation, as do the remaining pollutants of interest for BOMA.

14.6   Summary of the 2010 Monitoring Data for BOMA

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

- ❖ *Five pollutants failed screens for BOMA, of which all are NATTS MQO Core Analytes.*

- ❖ *Naphthalene had the highest annual average concentration for 2010 among the pollutants of interest for BOMA.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

15.0   Site in Michigan

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS site 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 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 DEMI monitoring site is located in the Detroit-Warren-Livonia, MI MSA. Figure 15-1 is the composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its urban location. Figure 15-2 identifies 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 15-2. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 15-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 15-1. Dearborn, Michigan (DEMI) Monitoring Site
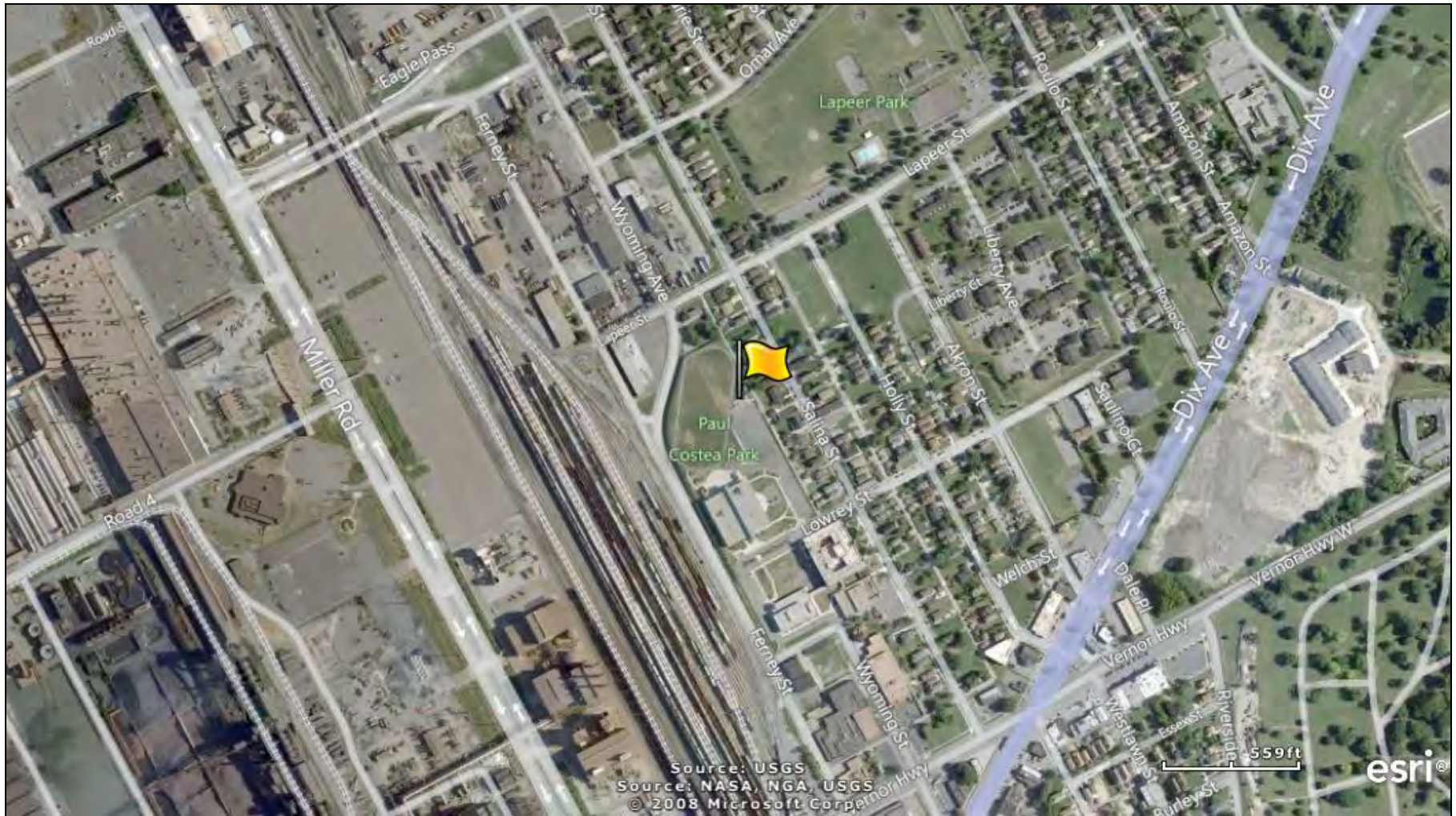
Figure 15-2. NEI Point Sources Located Within 10 Miles of DEMI

Legend

⭐ DEMI NATTS site	○ 10 mile radius	▭ County boundary

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

Source Category Group (No. of Facilities)

- ◈ Air-conditioning/Refrigeration (5)
- ✈ Aircraft Operations (9)
- ▮ Asphalt Processing/Roofing Manufacturing (2)
- 🚗 Automobile/Truck Manufacturing (4)
- B Bulk Terminals/Bulk Plants (8)
- △ Cement Kiln/Dryer (1)
- C Chemical Manufacturing (2)
- e Electrical Equipment (1)
- ⚡ Electricity Generation via Combustion (7)
- E Electroplating, Plating, Polishing, Anodizing, and Coloring (6)
- 4 Engine Testing (1)
- ⊙ Fabricated Metal Products (6)
- ∞ Flexible Polyurethane Foam Production (1)
- F Food Processing/Agriculture (2)
- ✢ Gypsum Manufacturing (1)
- H Hospital (2)
- 🖐 Hot Mix Asphalt Plant (2)
- ✴ Industrial Machinery and Equipment (1)
- Ⓢ Institutional - school (7)
- I Iron and Steel Foundry (1)
- 🌐 Laboratory (4)
- ➤ Lime Manufacturing (1)
- ✕ Mine/Quarry (3)
- ▽ Mineral Products (4)
- ? Miscellaneous Commercial/Industrial (12)
- Ⓜ Municipal Waste Combustor (1)
- ● Oil and/or Gas Production (2)
- ◢ Petroleum Refinery (1)
- P Printing/Publishing (1)
- R Rubber and Miscellaneous Plastics Products (2)
- 2 Secondary Metal Processing (1)
- > Solid Waste Disposal - Commercial/Institutional (4)
- ▼ Steel Mill (2)
- S Surface Coating (7)
- π Telecommunications (1)
- ⌐ Transportation Equipment (3)
- ❋ Transportation and Marketing of Petroleum Products (2)
- ▮ Wastewater Treatment (1)
- W Woodwork, Furniture, Millwork & Wood Preserving (1)

15-3

Table 15-1. Geographical Information for the Michigan 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]
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.

[1] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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 to the 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. As Figure 15-2 shows, numerous point sources surround DEMI, a cluster of which is located just southwest of the site. The source categories with the most point sources within 10 miles of DEMI 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; institutional facilities (schools); and surface coating facilities.

Table 15-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Michigan monitoring site. Table 15-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 15-2 also contains annual average daily traffic information. Finally, Table 15-2 presents the daily VMT for Wayne County.

Table 15-2. Population, Motor Vehicle, and Traffic Information for the Michigan 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]
DEMI	1,815,734	1,336,940	0.74	1,082,362	796,952	106,900	47,115,093

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Michigan Dept of State (MDS, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data from the Michigan DOT (MI DOT, 2010)
[5] County-level VMT reflects 2010 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 ranks seventh highest and its vehicle registration ranks eighth among counties with NMP sites.

- The vehicle-per-person ratio for DEMI is in the bottom third among NMP sites.

- The 10-mile population and estimated 10-mile vehicle ownership for DEMI are in the top third among NMP sites.

- Similar to several other characterizing statistics, the traffic volume near DEMI is in the top third among NMP sites. Traffic for DEMI was obtained from I-94, between Ford Plant Road and Rotunda Drive.

- The Wayne County daily VMT is the fifth highest 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 site 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, 2012).

15.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2010 (NCDC, 2010). The closest weather station to DEMI is located at Detroit City Airport (WBAN 14822). Additional information about this weather station, such as the distance between the site and the weather station, is provided in Table 15-3. These data were used to determine how meteorological conditions on sample days vary from normal conditions throughout the year.

Table 15-3. Average Meteorological Conditions near the Michigan 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)
Dearborn, Michigan - DEMI									
Detroit City Airport 14822 (42.41, -83.01)	9.70 miles	Sample Day	59.3 ± 5.2	52.0 ± 4.9	40.2 ± 4.4	46.1 ± 4.3	66.8 ± 2.7	1016.0 ± 1.6	6.3 ± 0.6
	54° (NE)	2010	59.2 ± 2.2	51.8 ± 2.0	40.2 ± 1.9	46.1 ± 1.8	67.3 ± 1.3	1015.7 ± 0.7	6.6 ± 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 2010. Also included in Table 15-3 is the 95 percent confidence interval for each parameter. As shown in Table 15-3, average meteorological conditions on sample days at DEMI were representative of average weather conditions throughout the year.

15.2.3 Back Trajectory Analysis

Figure 15-3 is the composite back trajectory map for days on which samples were collected at the DEMI monitoring site in 2010. Included in Figure 15-3 are four back trajectories per sample day. Figure 15-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, each concentric circle around the site in Figures 15-3 and 15-4 represents 100 miles.

Observations from Figures 15-3 and 15-4 for DEMI include the following:

- Back trajectories originated from a variety of directions at the DEMI site, although fewer trajectories originated from the east and southeast.

- The 24-hour air shed domain for DEMI was similar in size compared to other NMP monitoring sites. The farthest away a trajectory originated was west-central Minnesota, or less than 650 miles away. However, the average trajectory length was 250 miles and 88 percent of trajectories originated within 400 miles of the site.

- The cluster analysis shows that nearly 40 percent of back trajectories originated northward over the Great Lakes and parts of Ontario and Quebec, Canada. Another 30 percent originated from a direction with a westerly component, from Minnesota and Wisconsin to Illinois and Missouri. Nearly 20 percent of trajectories originated from the south of DEMI, over Indiana, Ohio, Kentucky, and Tennessee. The remaining back trajectories originated eastward over Lakes Ontario and Erie, southern Ontario, Canada, western New York and Pennsylvania, and northeast Ohio.

Figure 15-3. 2010 Composite Back Trajectory Map for DEMI
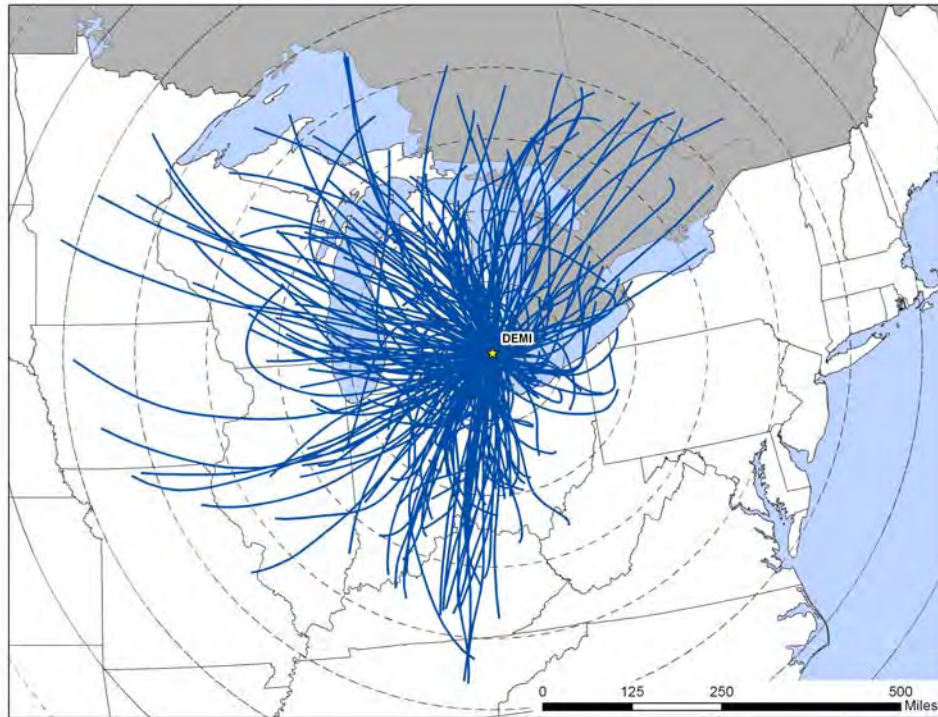
Figure 15-4. Back Trajectory Cluster Map for DEMI

15.2.4 Wind Rose Comparison

Hourly 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 15-5 presents three different wind roses for the DEMI monitoring site. First, a historical wind rose representing 2001 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location.

Observations from Figures 15-5 for DEMI include the following:

- The NWS weather station at Detroit City Airport is located 9.7 miles northeast of DEMI. Downtown Detroit lies between the weather station and the site.

- The historical wind rose for DEMI shows that winds from a variety of directions were observed near DEMI, although winds from the southeastern quadrant were observed less frequently than winds from other directions. Calm winds (≤ 2 knots) were observed for approximately 10 percent of the hourly measurements. The strongest winds were observed with southwesterly and westerly winds.

- The wind patterns on the 2010 wind rose resemble the historical wind patterns, indicating that conditions during 2010 were consistent with those experienced historically.

- The sample day wind rose generally resembles the full-year wind rose, although there were fewer west-northwesterly to northwesterly winds and more northerly to north-northeasterly winds on sample days.

15-10

Figure 15-5. Wind Roses for the Detroit City Airport Weather Station near DEMI

2001-2009 Historical Wind Rose
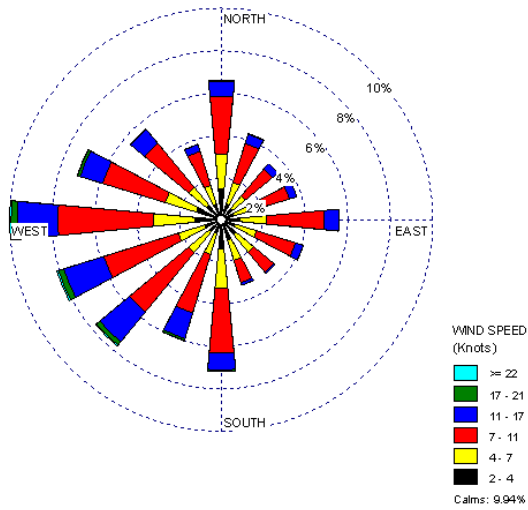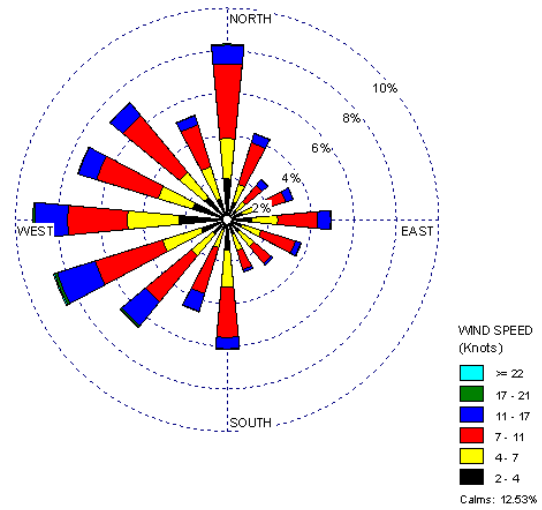
2010 Wind Rose

2010 Sample Day Wind Rose
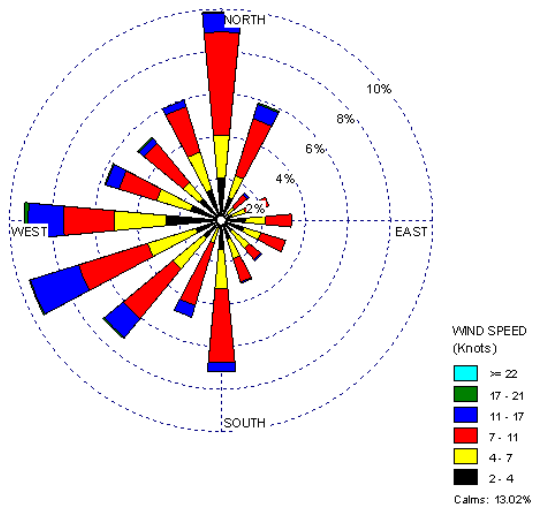
Distance between DEMI and NWS Station

15.3 Pollutants of Interest

Site-specific "pollutants of interest" were determined for the Michigan 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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 15-4 presents the pollutants of interest for DEMI. 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. DEMI sampled for VOC, PAH, carbonyl compounds, and hexavalent chromium.

Table 15-4. Risk Screening Results for the Michigan Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Dearborn, Michigan - DEMI						
Benzene	0.13	61	61	100.00	13.09	13.09
Carbon Tetrachloride	0.17	61	61	100.00	13.09	26.18
Acetaldehyde	0.45	60	60	100.00	12.88	39.06
Formaldehyde	0.077	60	60	100.00	12.88	51.93
Naphthalene	0.029	59	59	100.00	12.66	64.59
1,3-Butadiene	0.03	58	60	96.67	12.45	77.04
Ethylbenzene	0.4	33	61	54.10	7.08	84.12
Acenaphthene	0.011	18	59	30.51	3.86	87.98
Fluorene	0.011	17	59	28.81	3.65	91.63
1,2-Dichloroethane	0.038	12	12	100.00	2.58	94.21
p-Dichlorobenzene	0.091	8	29	27.59	1.72	95.92
Hexavalent Chromium	0.000083	7	53	13.21	1.50	97.42
Fluoranthene	0.011	4	59	6.78	0.86	98.28
Acrylonitrile	0.015	3	3	100.00	0.64	98.93
Benzo(a)pyrene	0.00057	3	55	5.45	0.64	99.57
Trichloroethylene	0.2	2	15	13.33	0.43	100.00
Total		466	766	60.84		

Observations from Table 15-4 for DEMI include the following:

- Sixteen pollutants, of which nine are NATTS MQO Core Analytes, failed at least one screen for DEMI.

- Eleven pollutants contributed to 95 percent of all failed screens for DEMI; of these six are NATTS MQO Core Analytes. Hexavalent chromium, benzo(a)pyrene, and trichloroethylene were added to DEMI'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. Three additional pollutants (chloroform, tetrachloroethylene, and vinyl chloride) were also added to the list, even though they did not fail any screens. These three pollutants are not shown in Table 15-4.

- Of the pollutants failing screens, nearly 60 percent of their measured detections failed screens. Seven pollutants failed 100 percent of their screens.

- The six pollutants failing the most screens contributed to over 75 percent of the total failed screens, are all NATTS MQO Core Analytes, and, with the exception of 1,3-butadiene, failed 100 percent of their screens.

15.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Michigan monitoring site. Concentration averages are provided for the pollutants of interest for DEMI, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices J, L, M, and O.

15.4.1 2010 Concentration Averages

Quarterly and annual concentration averages were calculated for the pollutants of interest for the Michigan 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 DEMI are presented in Table 15-5, where applicable. Note that concentrations of the PAH 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 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)
Dearborn, Michigan - DEMI						
Acetaldehyde	60/60	1.25 ± 0.28	1.57 ± 0.32	1.77 ± 0.25	1.64 ± 0.36	1.56 ± 0.15
Benzene	61/61	0.82 ± 0.27	0.82 ± 0.19	1.04 ± 0.18	1.06 ± 0.26	0.94 ± 0.11
1,3-Butadiene	60/61	0.08 ± 0.04	0.06 ± 0.02	0.08 ± 0.02	0.12 ± 0.05	0.09 ± 0.02
Carbon Tetrachloride	61/61	0.67 ± 0.07	0.70 ± 0.06	0.71 ± 0.08	0.69 ± 0.06	0.69 ± 0.03
Chloroform	61/61	0.39 ± 0.08	0.89 ± 0.17	0.79 ± 0.17	0.43 ± 0.06	0.63 ± 0.08
p-Dichlorobenzene	29/61	0.01 ± 0.01	0.05 ± 0.03	0.04 ± 0.02	0.03 ± 0.03	0.03 ± 0.01
1,2-Dichloroethane	12/61	0.03 ± 0.02	0.03 ± 0.02	0	0.01 ± 0.01	0.01 ± 0.01
Ethylbenzene	61/61	0.33 ± 0.19	0.63 ± 0.34	0.59 ± 0.16	0.45 ± 0.14	0.50 ± 0.11
Formaldehyde	60/60	2.34 ± 0.40	3.26 ± 0.86	3.36 ± 0.63	2.26 ± 0.41	2.80 ± 0.31
Tetrachloroethylene	56/61	0.16 ± 0.06	0.17 ± 0.06	0.21 ± 0.04	0.32 ± 0.17	0.21 ± 0.05
Trichloroethylene	15/61	<0.01 ± <0.01	0.01 ± 0.01	0.02 ± 0.01	0.06 ± 0.05	0.02 ± 0.01
Vinyl Chloride	7/61	<0.01 ± <0.01	<0.01 ± <0.01	0	0.01 ± 0.01	<0.01 ± <0.01
Acenaphthene[a]	59/59	3.05 ± 2.20	13.29 ± 6.75	32.42 ± 27.93	7.43 ± 2.90	13.74 ± 7.06
Benzo(a)pyrene[a]	55/59	0.23 ± 0.10	0.08 ± 0.05	0.22 ± 0.14	0.16 ± 0.03	0.17 ± 0.04
Fluorene[a]	59/59	3.69 ± 1.77	11.78 ± 5.55	29.47 ± 24.73	6.66 ± 2.21	12.62 ± 6.23
Hexavalent Chromium[a]	53/59	0.03 ± 0.02	0.05 ± 0.02	0.05 ± 0.01	0.05 ± 0.02	0.04 ± 0.01
Naphthalene[a]	59/59	108.88 ± 41.82	120.78 ± 32.56	179.91 ± 43.40	144.59 ± 48.05	137.84 ± 20.80

[a] Average concentrations provided for the pollutants below the black 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.

- Although the averages for formaldehyde appear higher during the warmer months of the year, the confidence intervals indicate that the difference is not significant.

- The second and third quarter averages of chloroform are significantly higher than the first and fourth quarter averages for this pollutant. A review of the data shows that the eight highest concentrations (those greater than 1 µg/m^3) were measured between June and August 2010.

- The second quarter average of ethylbenzene 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 June 19, 2010 (2.52 µg/m^3) and was nearly twice the next highest concentration (1.39 µg/m^3 measured on August 18, 2010).

- The fourth quarter average of tetrachloroethylene also 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 November 10, 2010 (1.09 µg/m^3) and was the only concentration of this pollutant greater than 1.0 µg/m^3 measured at DEMI. In addition, it is one of only 13 concentrations of tetrachloroethylene measured among NMP sites sampling VOC that was greater than 1.0 µg/m^3 (and ranked 10th highest among these 13).

- The fourth quarter average of trichloroethylene is higher than the other quarterly averages and has a relatively high confidence interval associated with it. The four highest concentrations of this pollutant were all measured during the fourth quarter of 2010 and were the only measurements greater than 0.1 µg/m^3 measured. Note that this pollutant was detected at DEMI in only 15 out of 61 valid samples.

- Fluorene and acenaphthene have relatively high confidence intervals for the third quarter of 2010. The highest concentrations of these pollutants were measured on the same days, August 18, 2010 (152 and 175 ng/m^3, respectively) and August 30, 2010 (114 and 121 ng/m^3, respectively). These concentrations are two and three times higher than the next highest concentrations measured for these pollutants (which were also measured on the same day, June 19, 2010) and are the top two concentrations of these pollutants among NMP sites sampling PAH. The third and fourth highest concentrations of naphthalene measured at DEMI were also measured on these two sample days in August.

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 DEMI from those tables include the following:

- DEMI has the highest concentration of vinyl chloride among the NMP sites sampling VOC. However, it should be noted that this pollutant was detected in only seven out of 61 valid samples. Yet this was also the highest number of measured detections of vinyl chloride among the sites sampling VOC.

- DEMI has the second highest annual average concentration of chloroform, behind NBIL, and the fourth highest annual average concentration of carbon tetrachloride.

- DEMI's annual average concentrations of acenaphthene and fluorene are the highest among NMP sites sampling PAH. DEMI's annual average concentrations of benzo(a)pyrene and naphthalene both rank third highest.

- The annual average concentration of hexavalent chromium for DEMI ranks fourth highest among sites sampling this pollutant.

15.4.2 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, benzene, benzo(a)pyrene, 1,3-butadiene, formaldehyde, hexavalent chromium, and naphthalene were created for DEMI. Figures 15-6 through 15-12 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 15-6. Program vs. Site-Specific Average Acetaldehyde Concentration
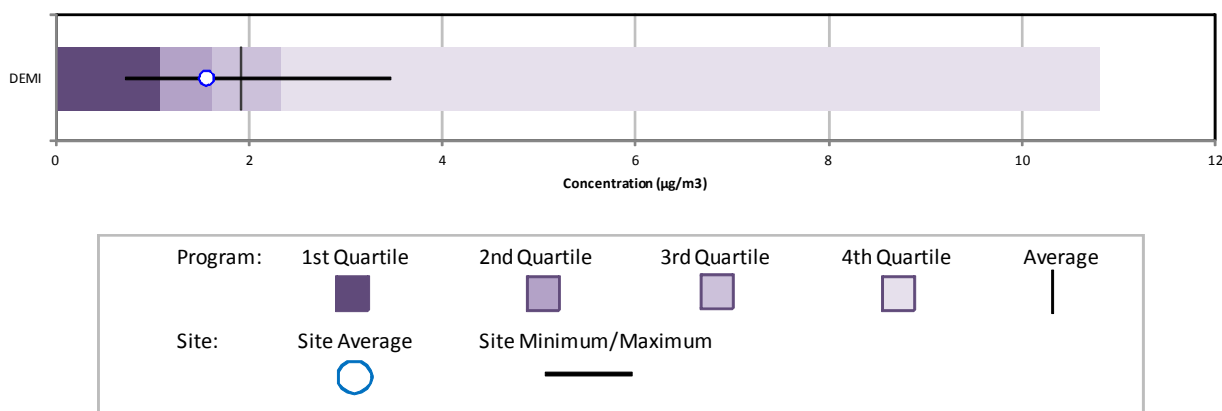
Figure 15-7. Program vs. Site-Specific Average Benzene Concentration
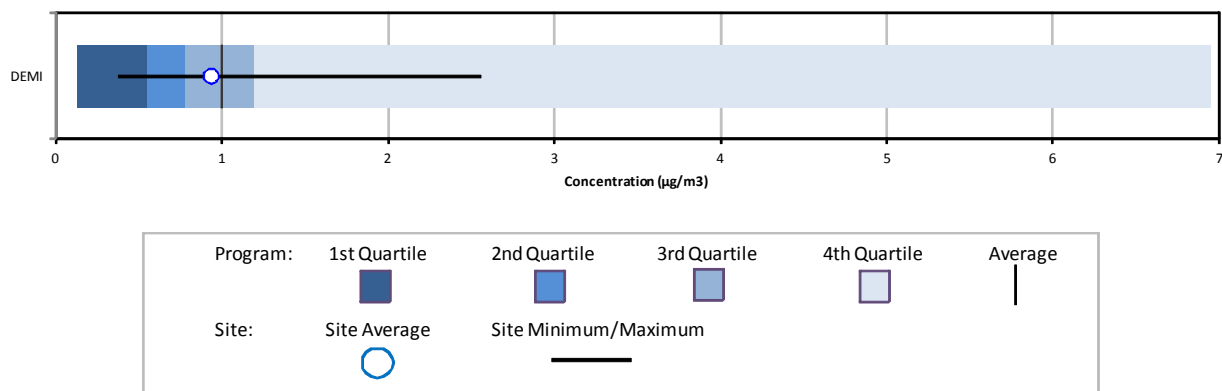
Figure 15-8. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Figure 15-9. Program vs. Site-Specific Average 1,3-Butadiene Concentration

Figure 15-10. Program vs. Site-Specific Average Formaldehyde Concentration

Figure 15-11. Program vs. Site-Specific Average Hexavalent Chromium Concentration

Figure 15-12. Program vs. Site-Specific Average Naphthalene Concentration
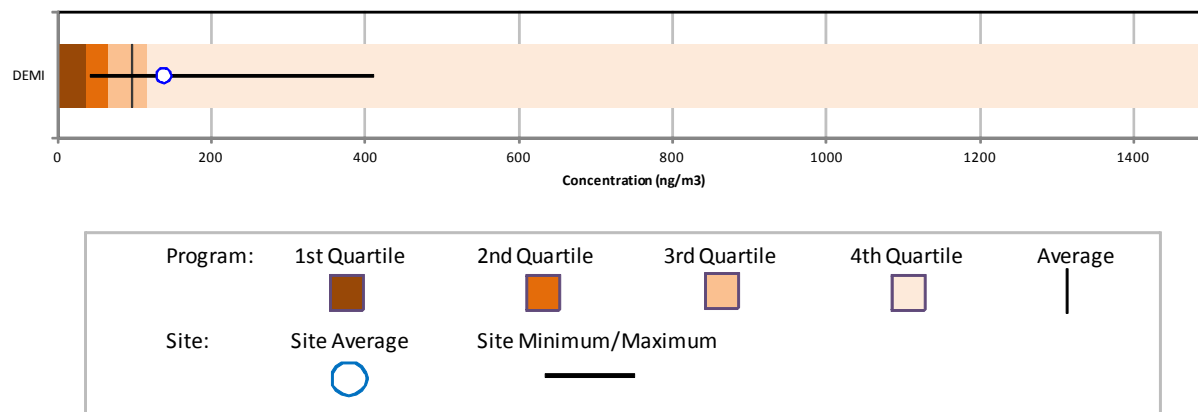
Observations from Figures 15-6 through 15-12 include the following:

- Figure 15-6 shows that DEMI's annual average acetaldehyde concentration is below the program-level average and median concentration. The maximum concentration measured at DEMI is well below the maximum concentration measured at the program level. There were no non-detects of acetaldehyde measured at DEMI.

- Figure 15-7 shows that DEMI's annual average benzene concentration is just below the program-level average concentration. The maximum concentration of benzene measured at DEMI is well below the maximum concentration measured at the program level. There were no non-detects of benzene measured at DEMI.

- Figure 15-8 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 DEMI is greater than the program-level average concentration. Although Figure 15-8 shows that the maximum concentration measured at DEMI is well below the maximum concentration measured across the program, this concentration is the ninth highest concentration of benzo(a)pyrene measured among NMP sites sampling this pollutant.

- Figure 15-9 for 1,3-butadiene shows that the annual average concentration for DEMI is just greater than the program-level average concentration. The maximum concentration of 1,3-butadiene measured at DEMI is well below the maximum concentration measured at the program level. One non-detect of 1,3-butadiene was measured at DEMI.

- Figure 15-10 shows that DEMI's annual average formaldehyde concentration is greater than the program-level average and median concentrations. The maximum concentration measured at DEMI is well below the maximum concentration measured at the program level. The minimum concentration of formaldehyde measured at DEMI is greater than the program-level first quartile (25th percentile).

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 15-11 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. The box plot shows that the annual average concentration of hexavalent chromium for DEMI is greater than the program-level average concentration. The maximum concentration measured at DEMI is well below the maximum concentration measured across the program. There were a few non-detects of this pollutant measured at DEMI.

- Figure 15-12 shows that the annual naphthalene average for DEMI is greater than the program-level average concentration. Recall from the previous section that DEMI's annual average concentration is the third highest annual average among NMP sites sampling this pollutant. The maximum naphthalene concentration measured at DEMI is well below the program-level maximum concentration. The minimum concentration of naphthalene 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 VOC and carbonyl compounds under the NMP since 2003 and hexavalent chromium since 2005. However, a trends analysis was not conducted for the carbonyl compounds. 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. Thus, Figures 15-13 through 15-15 present the 3-year rolling statistical metrics for benzene, 1,3-butadiene, and hexavalent chromium for DEMI. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Observations from Figure 15-13 for benzene measurements at DEMI include the following:

- The three highest benzene concentrations were measured in 2004, and ranged from 7.62 μg/m^3 to 5.44 μg/m^3.

- Both the median and rolling average concentrations exhibit a decreasing trend over the time periods shown. The difference between these two parameters decreased over the years, indicating a decrease in the variability of concentrations measured.

- The 5th and 95th percentiles show a steady decreasing trend as does the difference between the two percentiles, although the decrease slowed in later years.

- Sampling increased from a 1-in-12 day sampling schedule in 2003 to a 1-in-6 day sampling schedule in 2004, which continues into 2010.

- The minimum concentration is greater than zero for all 3-year periods, indicating that this pollutant has been detected in every sample collected at DEMI.

Figure 15-13. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at DEMI
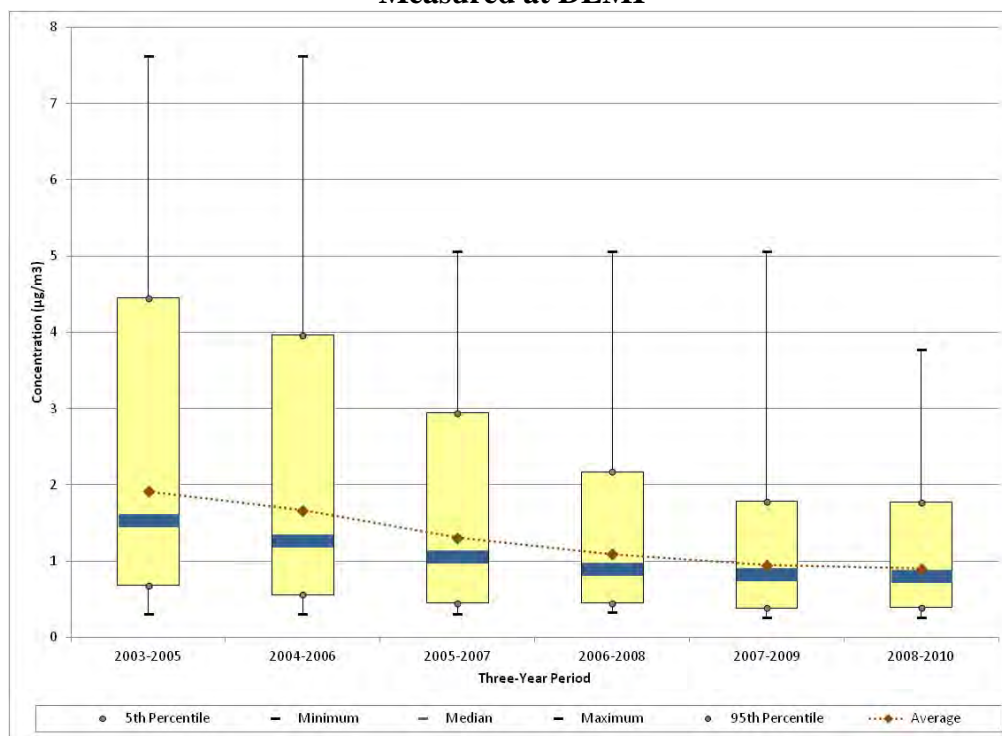
Figure 15-14. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at DEMI
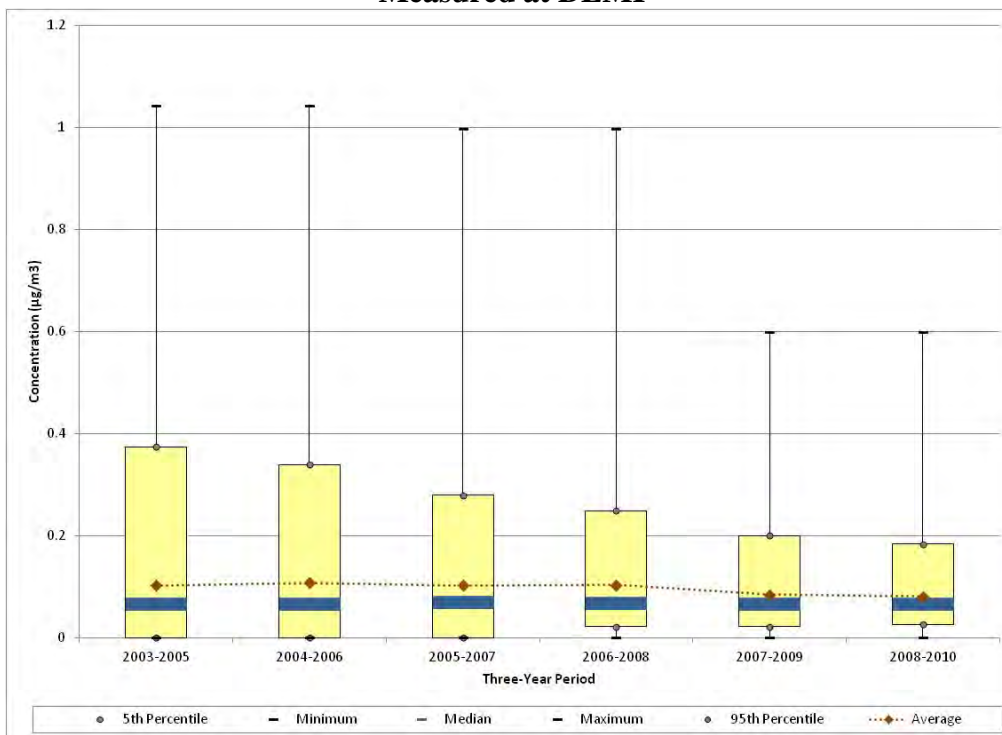
Figure 15-15. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at DEMI
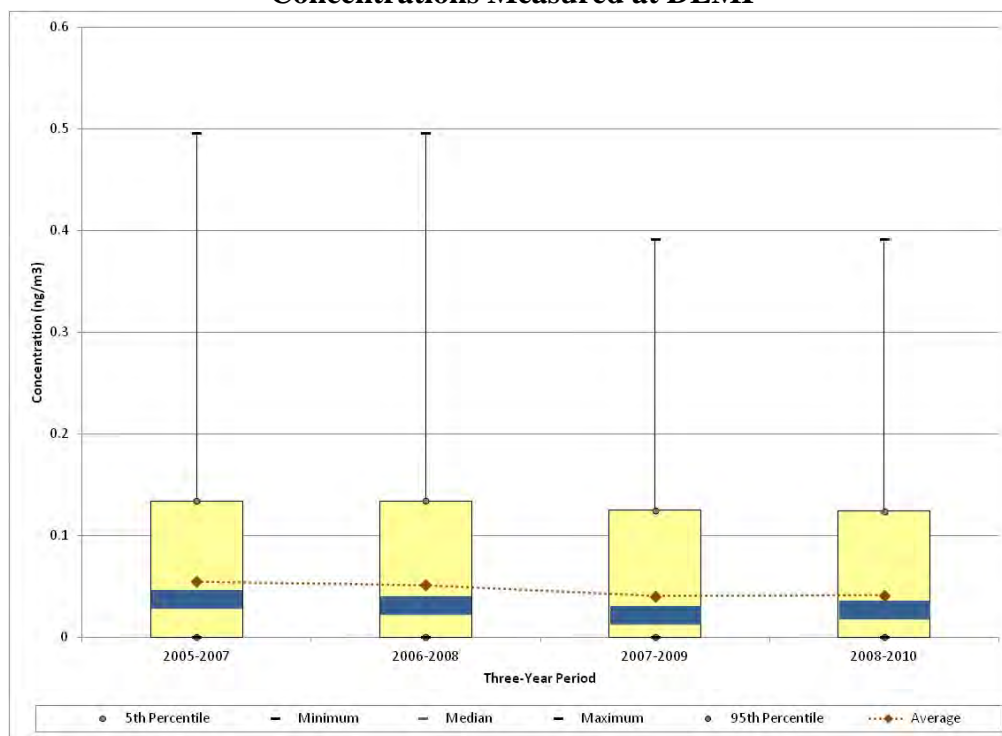
Observations from Figure 15-14 for 1,3-butadiene measurements at DEMI include the following:

- The maximum concentration was measured in 2004, although similar concentrations were also measured in 2006.

- The rolling average concentrations have been fairly steady over the time periods shown, although a slight decrease is shown for the 2007-2009 period. A review of the confidence intervals calculated for these averages indicates that this decrease is not statistically significant, although the confidence intervals calculated for the first two 3-year periods are relatively large.

- The maximum concentrations and 95th percentiles exhibit a decreasing trend throughout the period of sampling, indicating a decrease in the range of concentrations measured at DEMI.

- The minimum and 5th percentile are both zero for the first three 3-year periods shown, indicating the presence of non-detects. However, the number of non-detects has been decreasing since 2005, with only one to two non-detects reported per year since 2007.

- Sampling increased from a 1-in-12 day sampling schedule in 2003 to a 1-in-6 day sampling schedule in 2004, which continues into 2010.

Observations from Figure 15-15 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 both measured around July 4th – 0.496 ng/m^3 on July 4, 2006 and 0.392 ng/m^3 on July 5, 2008.

- A slight decrease in the rolling average concentrations is shown through the 2007-2009 period. However, the confidence intervals calculated indicate that these changes are not statistically significant.

- The minimum concentrations and 5th percentiles for all 3-year periods are zero, indicating the presence of non-detects.

15.5 Additional Risk Screening Evaluations

The following risk screening evaluations were conducted to characterize risk at the Michigan monitoring site. Refer to Sections 3.3 and 3.5.5 for definitions and explanations regarding the various risk factors, time frames, and calculations associated with these risk screenings.

15.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Michigan monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for DEMI were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Michigan monitoring site were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for DEMI.

15.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Michigan monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and

noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 15-6, where applicable.

Table 15-6. Cancer and Noncancer Surrogate Risk Approximations for the Michigan Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Dearborn, Michigan - DEMI						
Acenaphthene[a]	0.000088	--	59/59	0.01 ± 0.01	1.21	--
Acetaldehyde	0.0000022	0.009	60/60	1.56 ± 0.15	3.42	0.17
Benzene	0.0000078	0.03	61/61	0.94 ± 0.11	7.30	0.03
Benzo(a)pyrene[a]	0.00176	--	55/59	<0.01 ± <0.01	0.30	--
1,3-Butadiene	0.00003	0.002	60/61	0.09 ± 0.02	2.65	0.04
Carbon Tetrachloride	0.000006	0.1	61/61	0.69 ± 0.03	4.17	0.01
Chloroform	--	0.098	61/61	0.63 ± 0.08	--	0.01
p-Dichlorobenzene	0.000011	0.8	29/61	0.03 ± 0.01	0.37	<0.01
1,2-Dichloroethane	0.000026	2.4	12/61	0.01 ± 0.01	0.38	<0.01
Ethylbenzene	0.0000025	1	61/61	0.50 ± 0.11	1.25	<0.01
Fluorene[a]	0.000088	--	59/59	0.01 ± 0.01	1.11	--
Formaldehyde	0.000013	0.0098	60/60	2.80 ± 0.31	36.45	0.29
Hexavalent Chromium[a]	0.012	0.0001	53/59	<0.01 ± <0.01	0.53	<0.01
Naphthalene[a]	0.000034	0.003	59/59	0.14 ± 0.02	4.69	0.05
Tetrachloroethylene	2.6E-07	0.04	56/61	0.21 ± 0.05	0.06	0.01
Trichloroethylene	0.0000048	0.002	15/61	0.02 ± 0.01	0.11	0.01
Vinyl Chloride	0.0000088	0.1	7/61	<0.01 ± <0.01	0.02	<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 15-5.

Observations from Table 15-6 include the following:

- The pollutants with the highest annual average concentrations for DEMI are formaldehyde, acetaldehyde, and benzene.

- The pollutants with the highest cancer surrogate risk approximations for DEMI are formaldehyde, benzene, and naphthalene (36.45, 7.30, and 4.69 in-a-million, respectively). The cancer risk approximation for formaldehyde is an order of magnitude higher than the other cancer risk approximations.

- None of the pollutants of interest have associated noncancer risk approximations greater than 1.0 for DEMI. The pollutant with the highest noncancer risk approximation for DEMI was formaldehyde (0.29).

15.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 15-7 and 15-8 present a risk-based 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 15-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Table 15-7 and 15-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk approximations based on the site's annual averages are limited to those pollutants for which each respective site sampled. As discussed in Section 15.3, DEMI sampled for VOC, PAH, carbonyl compounds, and hexavalent chromium. In addition, the cancer and noncancer risk 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.

Table 15-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the Michigan Monitoring Site

Top 10 Total Emissions for Pollutants with Cancer Risk Factors (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	36.45
Formaldehyde	612.43	Benzene	8.85E-03	Benzene	7.30
Ethylbenzene	500.03	Formaldehyde	7.96E-03	Naphthalene	4.69
Acetaldehyde	334.62	POM, Group 5a	7.57E-03	Carbon Tetrachloride	4.17
1,3-Butadiene	134.38	Hexavalent Chromium, PM	6.69E-03	Acetaldehyde	3.42
Naphthalene	74.43	1,3-Butadiene	4.03E-03	1,3-Butadiene	2.65
Dichloromethane	52.69	Arsenic, PM	3.81E-03	Ethylbenzene	1.25
Tetrachloroethylene	47.69	Naphthalene	2.53E-03	Acenaphthene	1.21
Coke Oven Emissions, PM	35.72	Nickel, PM	1.42E-03	Fluorene	1.11
Trichloroethylene	13.67	Ethylbenzene	1.25E-03	Hexavalent Chromium	0.53

Table 15-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Michigan Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Dearborn, Michigan (Wayne County) - DEMI					
Hydrochloric acid	3,765.69	Acrolein	1,866,893.10	Formaldehyde	0.29
Toluene	2,480.93	Hydrochloric acid	188,284.52	Acetaldehyde	0.17
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	0.04
Benzene	1,134.11	Cyanide Compounds, gas	64,535.63	Benzene	0.03
Formaldehyde	612.43	Formaldehyde	62,493.26	Trichloroethylene	0.01
Hexane	551.94	Arsenic, PM	58,998.69	Carbon Tetrachloride	0.01
Ethylbenzene	500.03	Benzene	37,803.81	Chloroform	0.01
Acetaldehyde	334.62	Acetaldehyde	37,180.09	Tetrachloroethylene	0.01
Methyl isobutyl ketone	277.33	Nickel, PM	32,767.48	Ethylbenzene	<0.01

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, benzene, and naphthalene have the highest cancer surrogate risk approximations. For DEMI, these three pollutants, as well as ethylbenzene and 1,3-butadiene, appear on both emissions-based lists. Acetaldehyde is one of the highest emitted pollutants but does not appear among those with the highest toxicity-weighted emissions. 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 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.

- 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 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 risk approximation for DEMI is formaldehyde (0.29), although none of the pollutants of interest have associated noncancer risk approximations greater than 1.0. Formaldehyde emissions rank sixth for Wayne County and sixth for toxicity-weighted emissions.

15.6   Summary of the 2010 Monitoring Data for DEMI

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

❖ *Sixteen pollutants, of which nine are NATTS MQO Core Analytes, failed screens for DEMI.*

❖ *Of the site-specific pollutants of interest, formaldehyde had the highest annual average concentration for DEMI, followed by acetaldehyde and benzene.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than any of the associated MRL noncancer health risk benchmarks.*

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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 16-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 16-1. St. Louis, Missouri (S4MO) Monitoring Site
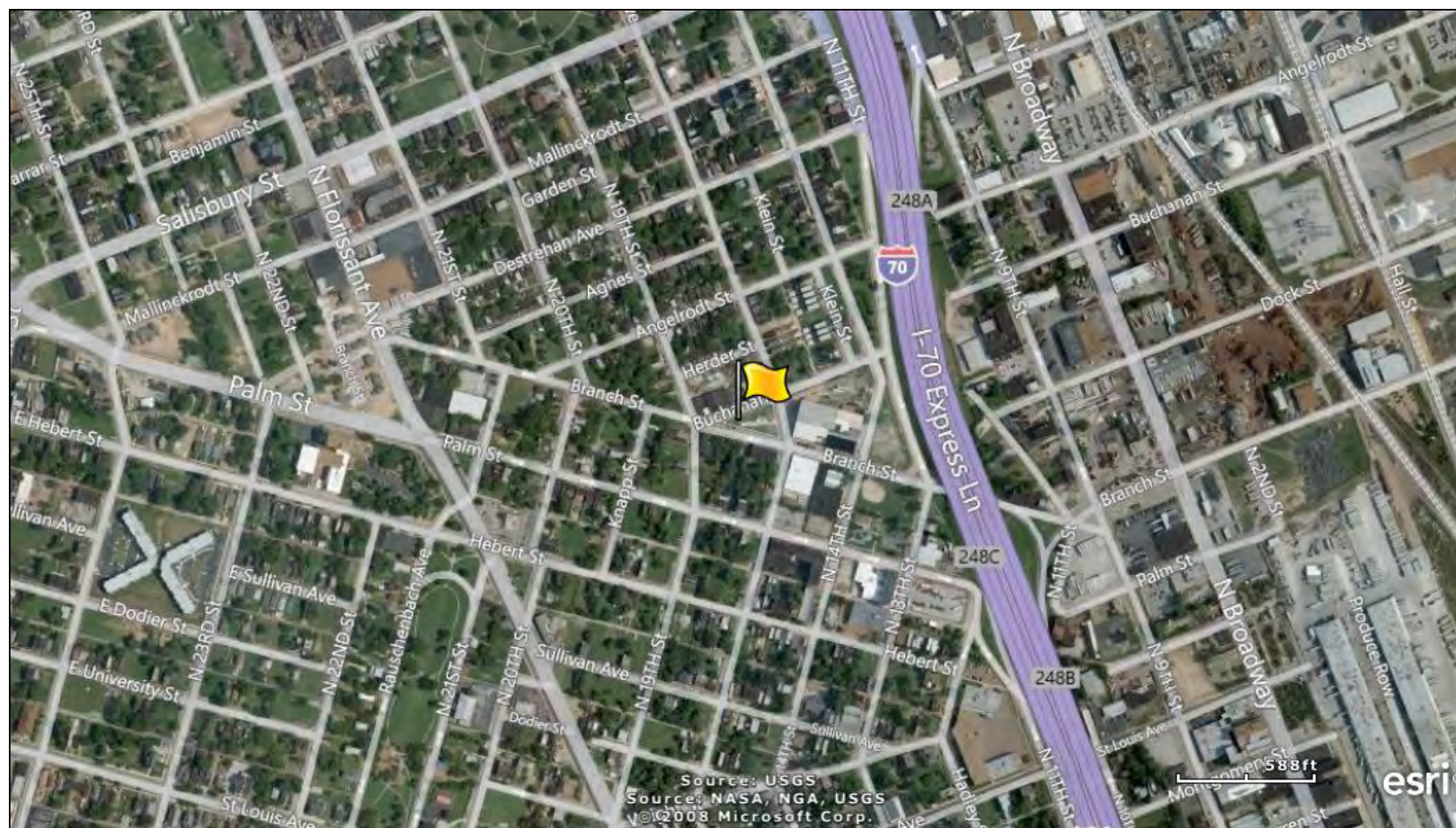
Figure 16-2. NEI Point Sources Located Within 10 Miles of S4MO

Legend

⭐ S4MO NATTS site   ○ 10 mile radius   ☐ County boundary

Source Category Group (No. of Facilities)

Symbol	Category
❄	Air-conditioning/Refrigeration (1)
✛	Aircraft Operations (21)
▮	Asphalt Processing/Roofing Manufacturing (1)
🚐	Automobile/Truck Manufacturing (1)
ℬ	Bakery (1)
ⵑ	Brewery/Distillery/Winery (1)
⬤	Building Construction (2)
B	Bulk Terminals/Bulk Plants (6)
C	Chemical Manufacturing (9)
■	Concrete Batch Plant (11)
⋈	Crematory - Animal/Human (1)
⊕	Dry Cleaning Facility (4)
e	Electrical Equipment (2)
⚡	Electricity Generation via Combustion (4)
E	Electroplating, Plating, Polishing, Anodizing, & Coloring (2)
⊙	Fabricated Metal Products (2)
≋	Flexible Polyurethane Foam Production (1)

Symbol	Category
F	Food Processing/Agriculture (16)
▮	Gasoline/Diesel Service Station (2)
∧	Grain Handling (2)
⸓	Heating Equipment Manufacturing (1)
⊞	Hospital (1)
⚇	Hot Mix Asphalt Plant (4)
☀	Industrial Machinery and Equipment (1)
⬚	Institutional - prison (1)
⊚	Institutional - school (7)
I	Iron and Steel Foundry (1)
▲	Landfill (3)
◕	Leather and Leather Products (1)
⬻	Marine Port (5)
Λ	Military Base/National Security Facility (1)
⚒	Mine/Quarry (6)
▽	Mineral Products (1)
?	Miscellaneous Commercial/Industrial (25)

Symbol	Category
M	Miscellaneous Manufacturing (12)
●	Oil and/or Gas Production (3)
⬭	Pharmaceutical Manufacturing (2)
1	Primary Metal Production (4)
↑	Printing, Coating & Dyeing of Fabric (1)
P	Printing/Publishing (5)
⊞	Pulp and Paper Plant/Wood Products (2)
R	Rubber and Miscellaneous Plastics Products (2)
2	Secondary Metal Processing (2)
<	Site Remediation Activity (1)
>	Solid Waste Disposal - Commercial/Institutional (2)
♥	Steel Mill (3)
S	Surface Coating (8)
π	Telecommunications (1)
T	Textile Mill (2)
✳	Transportation and Marketing of Petroleum Products (3)
▮	Wastewater Treatment (5)

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

16-3

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] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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 from 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 highest 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Missouri monitoring site. Table 16-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of the 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 16-2 also contains annual average daily traffic information. Finally, Table 16-2 presents the daily VMT for St. Louis City and County.

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	1,318,037	1,121,528	0.85	811,927	690,875	81,174	23,385,327

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Missouri Dept of Revenue (MO DOR, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2009 data from the Missouri DOT (MO DOT, 2009)
[5] County-level VMT reflects 2010 data for all public roads from the Missouri DOT (MO DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site.

Observations from Table 16-2 include the following:

- S4MO's county population and vehicle registration are in the upper third of the range compared to other counties with NMP sites. This is also true for its 10-mile vehicle ownership, but its 10-mile population ranked 18th compared to other sites.

- The vehicle-per-person ratio is in the middle of the range compared to other NMP sites.

- The traffic volume experienced near S4MO ranks 18th among other NMP monitoring sites. The traffic estimate used came from I-70 near Exit 250.

- The St. Louis City and County daily VMT ranks 11th 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 does experience the urban heat island effect, retaining more heat within the city than outlying areas (Bair, 1992 and MCC, 2012).

16.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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	65.6 ± 5.0	55.5 ± 4.7	45.2 ± 4.6	50.2 ± 4.3	70.9 ± 2.5	1016.7 ± 1.6	5.6 ± 0.8
		2010	65.7 ± 2.2	55.8 ± 2.1	45.1 ± 2.0	50.3 ± 1.9	70.5 ± 1.1	1016.2 ± 0.7	5.6 ± 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 2010. Also included in Table 16-3 is the 95 percent confidence interval for each parameter. As shown in Table 16-3, average meteorological conditions on sample days were representative of average weather conditions throughout the year.

16.2.3 Back Trajectory Analysis

Figure 16-3 is the composite back trajectory map for days on which samples were collected at the S4MO monitoring site in 2010. Included in Figure 16-3 are four back trajectories per sample day. Figure 16-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, each concentric circle around the site in Figures 16-3 and 16-4 represents 100 miles.

Figure 16-3. 2010 Composite Back Trajectory Map for S4MO
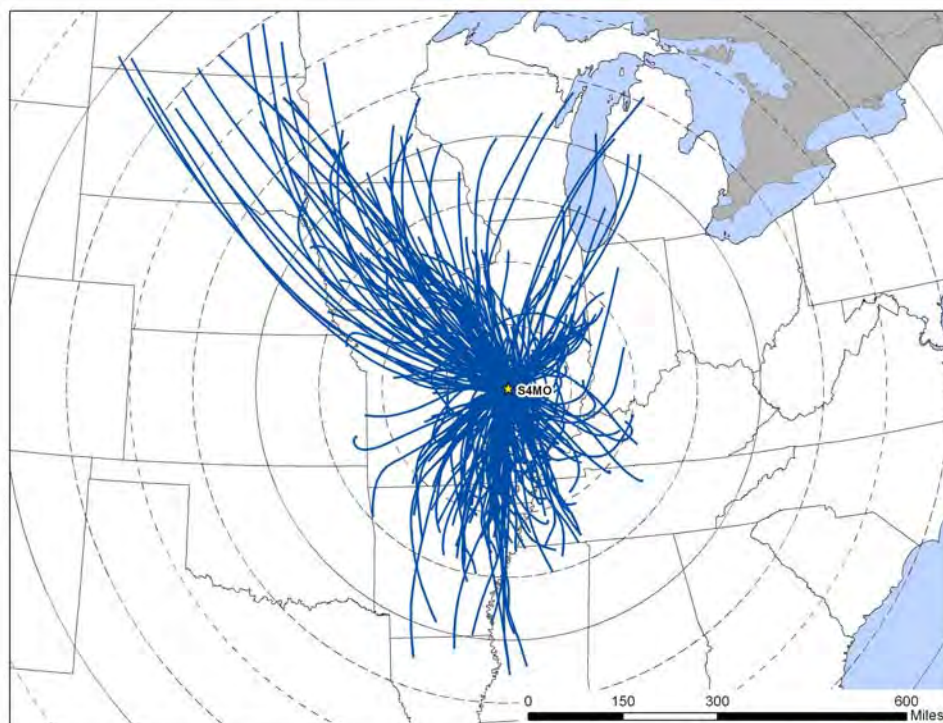
Figure 16-4. Back Trajectory Cluster Map for S4MO
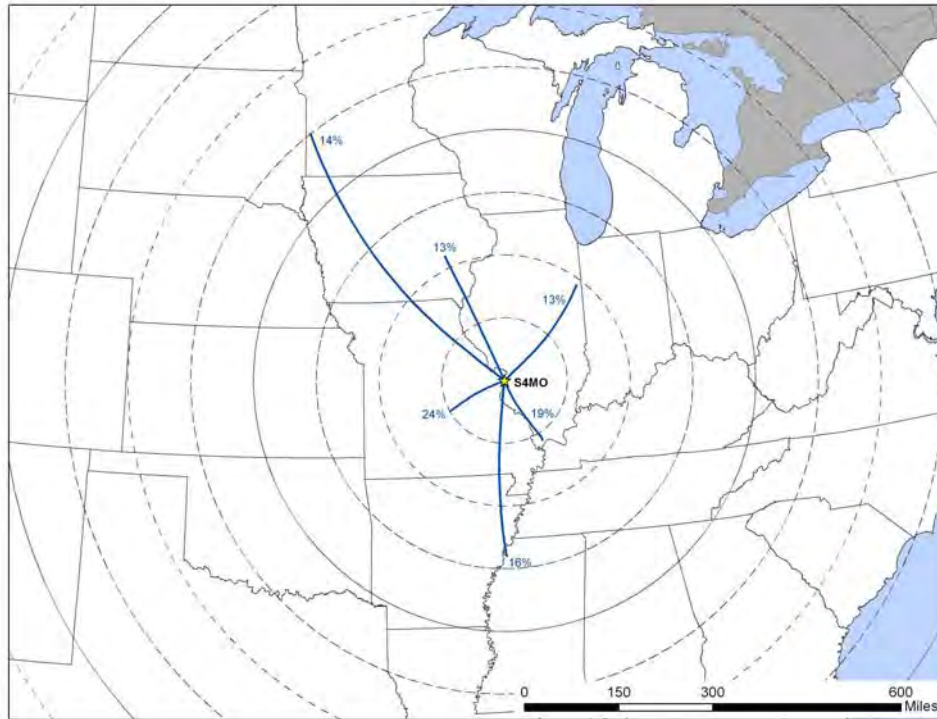
Observations from Figures 16-3 and 16-4 for S4MO include the following:

- Back trajectories originated from a variety of directions at S4MO, although trajectories from the northwest and south-southeast to south-southwest were most common.

- The 24-hour air shed domain for S4MO was among the larger in size compared to other NMP sites. The farthest away a trajectory originated was greater than 800 miles, over southwest North Dakota. However, the average trajectory length was 235 miles. Most trajectories (85 percent) originated within 400 miles of the monitoring site.

- The cluster analysis shows that many (27 percent) trajectories originated to the northwest of S4MO, although of varying lengths. The cluster trajectory originating from the southwest of S4MO (24 percent) represents trajectories originating over western Illinois, Missouri, and northern Arkansas and within 250 miles of the site. The cluster trajectory originating over southern Illinois (19 percent) represents trajectories originating from the east, southeast, and south of the monitoring site and within 200 miles of S4MO. Trajectories also originated from the south and northeast of S4MO.

16.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the S4MO monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location.

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 accounted for approximately 28 percent of observations. Calm winds (≤2 knots) were observed for approximately 18 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-northwest and northwest.

- The wind patterns shown on the 2010 wind rose generally resemble those shown on the historical wind rose, although there were fewer southeasterly winds and more northerly winds. The calms rate in 2010 was nearly 23 percent.

- The sample day wind patterns also resemble the historical and full-year wind patterns, although the calm rate on sample days was greater than 25 percent.

Figure 16-5. Wind Roses for the St. Louis Downtown Airport Weather Station near S4MO

1999-2009 Historical Wind Rose
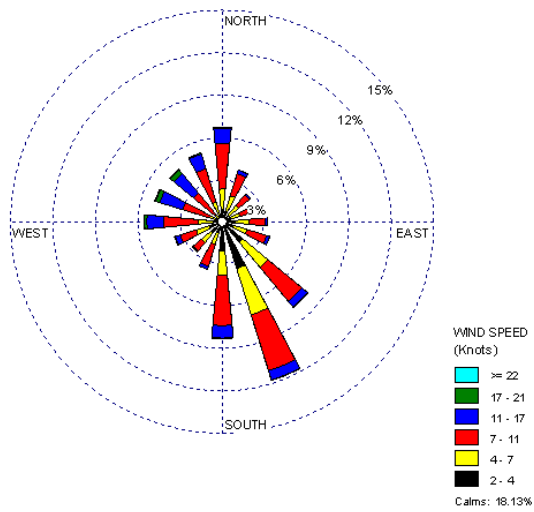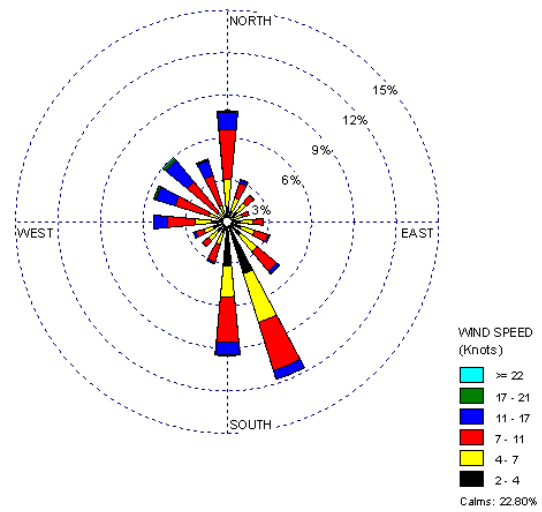
2010 Wind Rose

2010 Sample Day Wind Rose
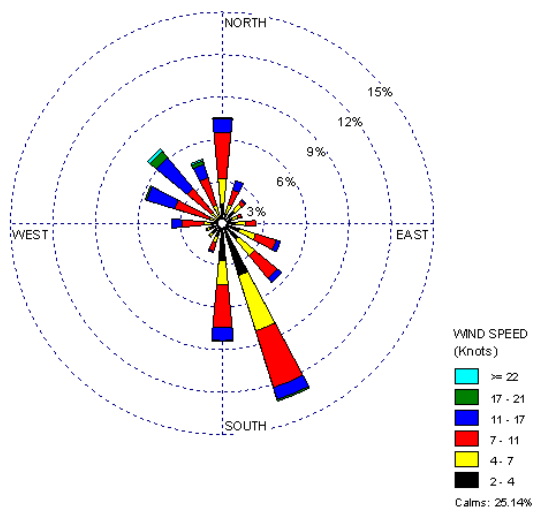
Distance between S4MO and NWS Station
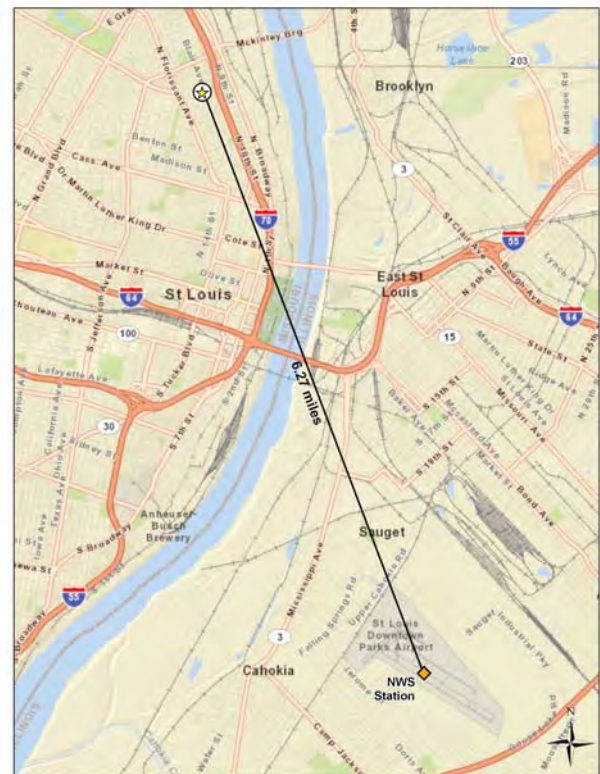
16.3   Pollutants of Interest

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 16-4 presents S4MO's pollutants of interest. 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 VOC, PAH, carbonyl compounds, metals (PM$_{10}$), and hexavalent chromium.

Observations from Table 16-4 include the following:

- Twenty-four pollutants, of which 14 are NATTS MQO Core Analytes, failed at least one screen for S4MO.

- S4MO failed the highest number of screens among all NMP sites. More than 50 percent of measured detections failed screens (of the pollutants that failed at least one screen) for S4MO.

- Seven pollutants failed 100 percent of screens for S4MO: acetaldehyde, formaldehyde, benzene, acrylonitrile, 1,2-dichloroethane, 1,2-dibromoethane and 1,1,2,2-tetrachloroethane. The last three pollutants were detected in only a few samples.

- Sixteen pollutants were identified as pollutants of interest for S4MO based on the risk screening process; of these, 10 are NATTS MQO Core Analytes. Four additional pollutants (nickel, hexavalent chromium, trichloroethylene, and benzo(a)pyrene) 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. Four more pollutants (beryllium, chloroform, tetrachloroethylene, 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 four pollutants are not shown in Table 16-4.

Table 16-4. Risk Screening Results for the Missouri Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
St. Louis, Missouri - S4MO						
Arsenic (PM₁₀)	0.00023	58	60	96.67	10.10	10.10
Naphthalene	0.029	57	58	98.28	9.93	20.03
Acetaldehyde	0.45	54	54	100.00	9.41	29.44
Formaldehyde	0.077	54	54	100.00	9.41	38.85
Benzene	0.13	53	53	100.00	9.23	48.08
1,3-Butadiene	0.03	52	53	98.11	9.06	57.14
Carbon Tetrachloride	0.17	52	53	98.11	9.06	66.20
Manganese (PM₁₀)	0.005	48	60	80.00	8.36	74.56
Cadmium (PM₁₀)	0.00056	26	60	43.33	4.53	79.09
p-Dichlorobenzene	0.091	23	45	51.11	4.01	83.10
Ethylbenzene	0.4	16	53	30.19	2.79	85.89
Acrylonitrile	0.015	14	14	100.00	2.44	88.33
Fluorene	0.011	14	58	24.14	2.44	90.77
Lead (PM₁₀)	0.015	12	60	20.00	2.09	92.86
Acenaphthene	0.011	11	58	18.97	1.92	94.77
1,2-Dichloroethane	0.038	10	10	100.00	1.74	96.52
Hexavalent Chromium	0.000083	5	46	10.87	0.87	97.39
Trichloroethylene	0.2	4	20	20.00	0.70	98.08
Nickel (PM₁₀)	0.0021	3	60	5.00	0.52	98.61
Benzo(a)pyrene	0.00057	2	50	4.00	0.35	98.95
Fluoranthene	0.011	2	58	3.45	0.35	99.30
Propionaldehyde	0.8	2	54	3.70	0.35	99.65
1,2-Dibromoethane	0.0017	1	1	100.00	0.17	99.83
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.17	100.00
Total		574	1093	52.52		

16.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Missouri monitoring site. Concentration averages are provided for the pollutants of interest for S4MO, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices J, L, M, N, and O.

16.4.1 2010 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 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 PAH, 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	54/54	4.10 ± 1.26	4.13 ± 1.23	4.07 ± 1.29	4.09 ± 1.26	4.10 ± 0.59
Acrylonitrile	14/53	0.04 ± 0.03	0.01 ± 0.02	NA	0.37 ± 0.29	0.17 ± 0.14
Benzene	53/53	0.94 ± 0.24	0.90 ± 0.23	NA	1.26 ± 0.38	1.03 ± 0.15
1,3-Butadiene	53/53	0.10 ± 0.05	0.10 ± 0.04	NA	0.16 ± 0.08	0.12 ± 0.03
Carbon Tetrachloride	53/53	0.54 ± 0.10	0.60 ± 0.07	NA	0.59 ± 0.08	0.58 ± 0.05
Chloroform	52/53	0.13 ± 0.04	0.20 ± 0.08	NA	0.19 ± 0.08	0.19 ± 0.04
p-Dichlorobenzene	45/53	0.09 ± 0.14	0.27 ± 0.26	NA	0.42 ± 0.41	0.35 ± 0.18
1,2-Dichloroethane	10/53	0.02 ± 0.02	0.03 ± 0.02	NA	0.01 ± 0.02	0.02 ± 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 black 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 ($\mu g/m^3$)
Ethylbenzene	53/53	0.30 ± 0.13	0.41 ± 0.19	NA	0.51 ± 0.25	0.44 ± 0.11
Formaldehyde	54/54	1.69 ± 0.39	2.97 ± 0.83	3.42 ± 0.57	2.99 ± 0.46	2.74 ± 0.33
Tetrachloroethylene	51/53	0.17 ± 0.10	0.21 ± 0.09	NA	0.30 ± 0.16	0.23 ± 0.06
Trichloroethylene	20/53	0.02 ± 0.04	0.04 ± 0.03	NA	0.07 ± 0.05	0.05 ± 0.02
Vinyl Chloride	4/53	0	<0.01 ± <0.01	NA	<0.01 ± 0.01	<0.01 ± <0.01
Acenaphthene[a]	58/58	2.06 ± 0.78	5.77 ± 2.13	10.55 ± 3.00	4.92 ± 2.91	5.76 ± 1.35
Arsenic (PM$_{10}$)[a]	60/60	0.81 ± 0.17	0.89 ± 0.25	1.12 ± 0.58	1.26 ± 0.51	1.02 ± 0.20
Benzo(a)pyrene[a]	50/58	0.25 ± 0.14	0.07 ± 0.03	0.10 ± 0.05	0.22 ± 0.09	0.16 ± 0.05
Beryllium (PM$_{10}$)[a]	59/60	<0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01
Cadmium (PM$_{10}$)[a]	60/60	0.64 ± 0.22	0.48 ± 0.17	0.58 ± 0.18	0.78 ± 0.31	0.62 ± 0.11
Fluorene[a]	58/58	2.81 ± 0.93	7.06 ± 2.56	11.17 ± 3.18	5.47 ± 2.65	6.57 ± 1.39
Hexavalent Chromium[a]	46/57	0.02 ± 0.01	0.03 ± 0.01	0.05 ± 0.02	0.04 ± 0.02	0.03 ± 0.01
Lead (PM$_{10}$)[a]	60/60	9.60 ± 4.22	8.59 ± 4.35	12.84 ± 6.39	15.63 ± 5.96	11.66 ± 2.60
Manganese (PM$_{10}$)[a]	60/60	11.33 ± 6.62	13.06 ± 6.07	11.63 ± 3.69	32.58 ± 26.78	17.15 ± 7.07
Naphthalene[a]	58/58	133.57 ± 102.60	106.80 ± 30.37	151.96 ± 60.47	150.34 ± 82.45	135.13 ± 35.06
Nickel (PM$_{10}$)[a]	60/60	0.93 ± 0.22	0.96 ± 0.16	0.92 ± 0.16	1.35 ± 0.48	1.04 ± 0.14

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
[a] Average concentrations provided for the pollutants below the black 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 acetaldehyde ($4.10 \pm 0.59\ \mu g/m^3$), formaldehyde ($2.74 \pm 0.33\ \mu g/m^3$), and benzene ($1.03 \pm 0.15\ \mu g/m^3$).

- The annual average acetaldehyde concentration for S4MO is the third highest annual average concentration for any site-specific pollutant of interest (not just carbonyl compounds) among all NMP sites. Fifteen concentrations of acetaldehyde measured at S4MO were greater than 5 $\mu g/m^3$, which is the highest among NMP sites sampling

this pollutant (SKFL has the second highest at 11). The median acetaldehyde concentration for S4MO is 3.81 $\mu g/m^3$.

- Third quarter averages could not be calculated for the VOC pollutants of interest because there were not enough valid samples to meet the quarterly completeness criteria. Several canisters returned to the laboratory under excess vacuum, including several duplicate pairs. There was also an invalid sample attributed to a sampling error.

- Several of the VOC have relatively large fourth quarter average concentrations as well as large associated confidence intervals, including acrylonitrile, benzene, 1,3-butadiene, *p*-dichlorobenzene, ethylbenzene, tetrachloroethylene, and trichloroethylene. The data for these pollutants are discussed below.

- The highest concentration of acrylonitrile was measured during the third quarter on September 29, 2010 (2.94 $\mu g/m^3$). This is the second highest concentration of this pollutant among all NMP sites sampling VOC. As discussed above, third quarter average concentrations could not be calculated for S4MO. However, five of the six highest concentrations of acrylonitrile were measured at S4MO during December 2010. This pollutant was detected in only 14 of 53 samples collected at S4MO, with most measured during the first quarter and fourth quarter of 2010.

- The five highest concentrations of the remaining VOC discussed above were reviewed to see if correlations exist among the sample dates. Two dates appear in the top five for each pollutant: September 29, 2010 and October 5, 2010. The September 29, 2010 sample has the highest concentrations of *p*-dichlorobenzene and ethylbenzene measured at this site, the second highest concentrations of benzene, 1,3-butadiene, and trichloroethylene, and the third highest concentrations of tetrachloroethylene. Because third quarter average concentrations could not be calculated for S4MO, how the third quarter averages may have been affected by these results cannot be determined. The October 5, 2010 sample has the highest concentrations of benzene and 1,3-butadiene measured at this site, the second highest concentrations of ethylbenzene and tetrachloroethylene, and the fifth highest concentrations of *p*-dichlorobenzene and trichloroethylene. Benzene, 1,3-butadiene, and tetrachloroethylene also have relatively high concentrations on December 28, 2010 while *p*-dichlorobenzene, ethylbenzene, and trichloroethylene have relatively high concentrations on October 11, 2010.

- The highest hexavalent chromium concentration for S4MO was measured on July 4, 2010. There were only four concentrations of hexavalent chromium greater than 0.1 ng/m^3 measured at S4MO, two of which were measured in July 2010 (with the others measured in October and November).

- The first quarter naphthalene average has a very large confidence interval associated with it. The highest concentration of naphthalene was measured on January 20, 2010 (784 ng/m^3), which was the 11th highest naphthalene concentration measured among NMP sites sampling PAH. However, the third and fourth quarter 2010 averages of naphthalene are higher than the other quarterly averages and also have large confidence intervals associated with them. The second and third highest concentrations of this pollutant (554 ng/m^3 and 483 ng/m^3) were measured on October 5, 2010 and September 29, 2010, respectively, corresponding to the dates of some of the highest VOC measurements.

- The third quarter average concentrations of fluorene and acenaphthene are higher than the other quarterly average and have relatively large confidence intervals associated with them. The highest concentrations of both pollutants were measured on August 12, 2010. Of the six highest concentrations of each of these pollutants, five occurred on the same sample days, of which most were collected during the third quarter.

- The first and fourth quarter averages of benzo(a)pyrene also exhibit large confidence intervals. The highest concentration of this pollutant (1.03 ng/m^3) was the ninth highest concentration of this pollutant measured among all NMP sites sampling PAH. The two highest concentrations of this pollutant were both measured in February 2010 at S4MO. Of the 15 highest concentrations of benzo(a)pyrene for S4MO, five were measured during the first quarter of 2010, none were measured during the second quarter, three were measured during the third quarter, and seven were measured during the fourth quarter.

- Several of the quarterly averages for the PM$_{10}$ metals are highest for the third or fourth quarters of 2010. Some of these have rather large confidence intervals associated with outliers, as described in the next several bullets.

- The fourth quarter average of manganese for S4MO is almost three times higher than the other quarterly averages and has a large confidence interval associated with it. On November 16, 2010, the concentration of manganese measured at S4MOs was 200 ng/m^3, which is also the highest manganese measurement among all NMP sites sampling metals. The next highest manganese concentration measured at S4MO was half as high (84.5 ng/m^3 on December 10, 2010), but is still the second highest manganese concentration among all sites sampling metals. Of the 13 concentrations of manganese greater than 20 ng/m^3, the majority were measured during the fourth quarter.

- The third and fourth quarter averages of lead for 2010 are higher than the other quarterly averages. The two highest concentrations of lead were measured at S4MO on August 6, 2010 (47.8 ng/m^3) and October 6, 2010 (42.6 ng/m^3). Of the 12 highest concentrations measured at S4MO, three were measured during the first half of 2010 and nine were measured during the second. Twelve of the 13 highest concentrations of lead among all NMP sites were measured at S4MO.

- The highest concentration of arsenic was also measured at S4MO on August 6, 2010 (4.77 ng/m^3). This is also the highest concentration of arsenic measured among all NMP sites sampling metals. The other three concentrations arsenic greater than 2 ng/m^3 were measured during the fourth quarter of 2010, including October 6, 2010, which is the day the second highest lead measurement was collected.

- The fourth quarter average of nickel for S4MO is higher than the other quarterly averages and has a relatively large confidence interval associated with it. The highest concentration of nickel (3.59 ng/m^3) was measured on October 11, 2010, and is the 11th highest concentration of nickel measured among all NMP sites sampling metals. Four of the five highest concentrations were measured in October and November.

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 has the second highest annual average concentrations of acrylonitrile and *p*-dichlorobenzene (although both have relatively large confidence intervals), and the fifth highest annual average concentrations of tetrachloroethylene and trichloroethylene.

- S4MO has the highest annual average concentration of acetaldehyde and the tenth highest concentration of formaldehyde.

- S4MO's annual average concentrations of the four PAHs ranked among the top five compared to other sites sampling the program-level PAH pollutants of interest.

- S4MO has the highest annual average concentrations of arsenic, beryllium, cadmium, lead, and manganese among NMP sites sampling PM$_{10}$ metals (and in some cases, those sampling TSP metals).

16.4.2 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, arsenic, benzene, benzo(a)pyrene, 1,3-butadiene, formaldehyde, hexavalent chromium, manganese, and naphthalene were created for S4MO. Figures 16-6 through 16-14 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.
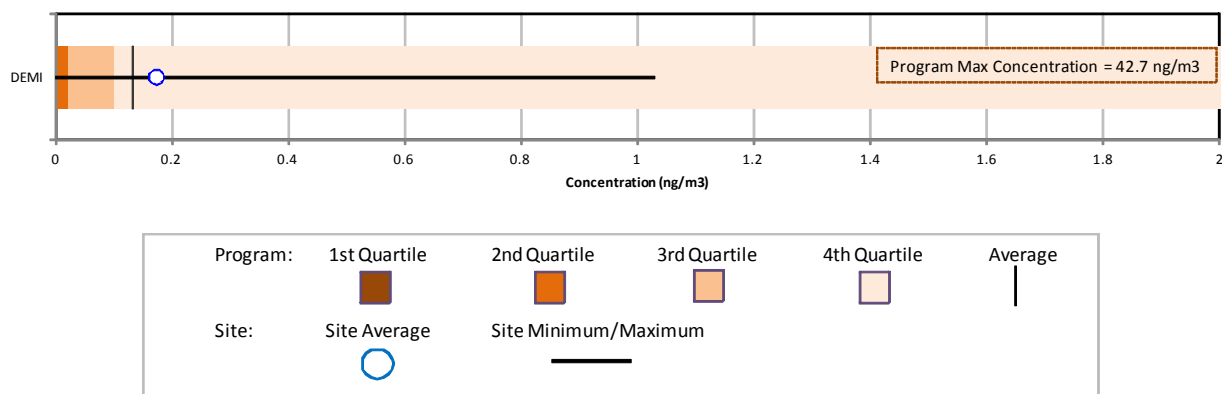
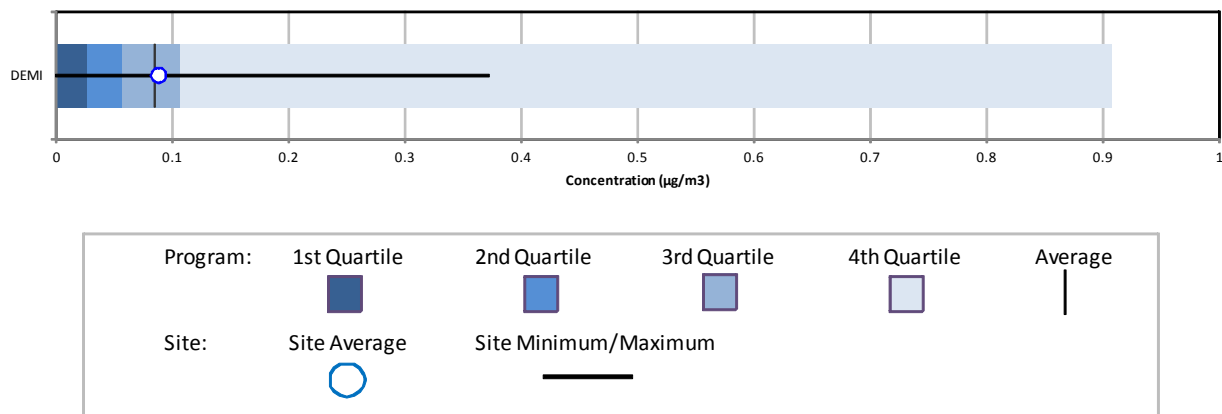**Figure 16-6. Program vs. Site-Specific Average Acetaldehyde Concentration**
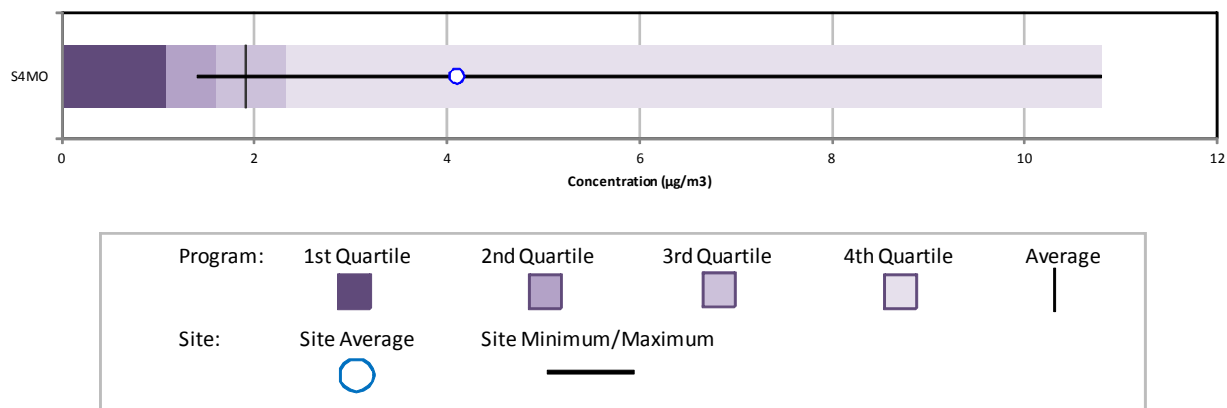
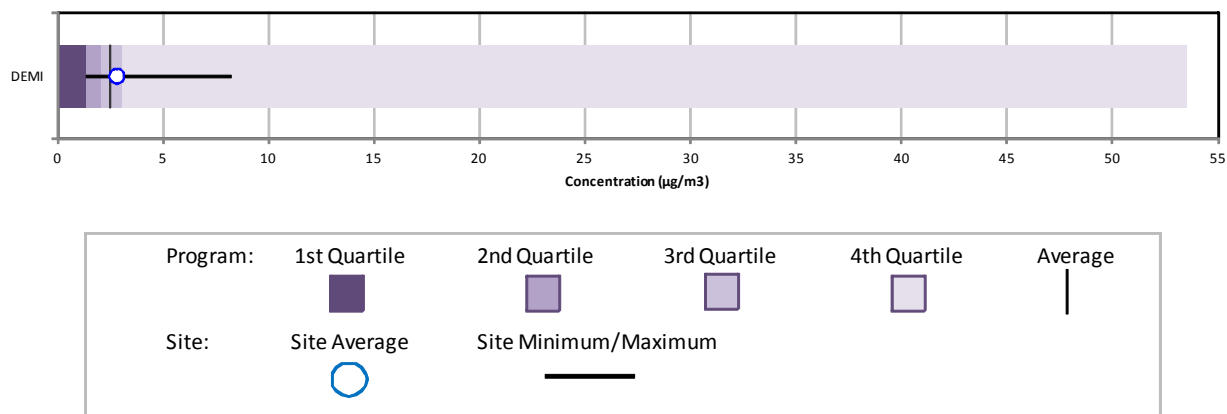**Figure 16-7. Program vs. Site-Specific Average Arsenic (PM$_{10}$) Concentration**
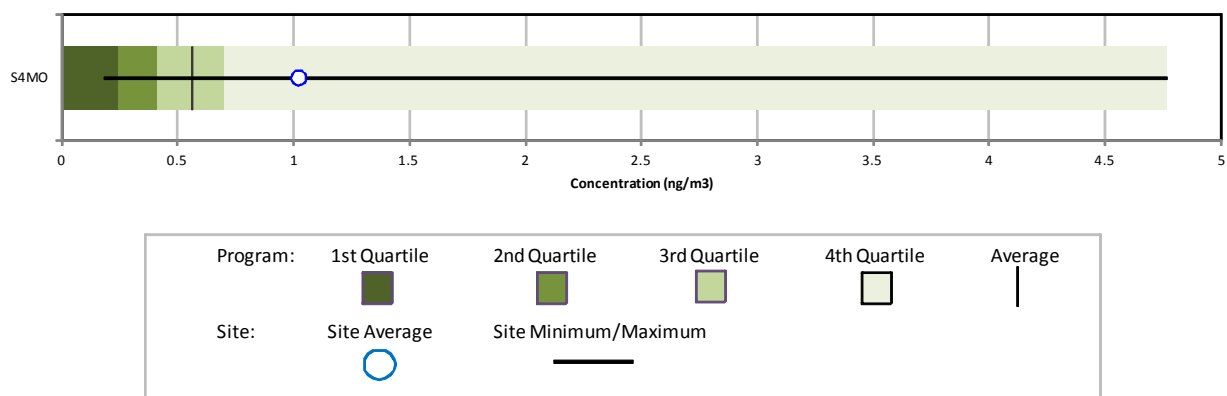
Figure 16-8. Program vs. Site-Specific Average Benzene Concentration
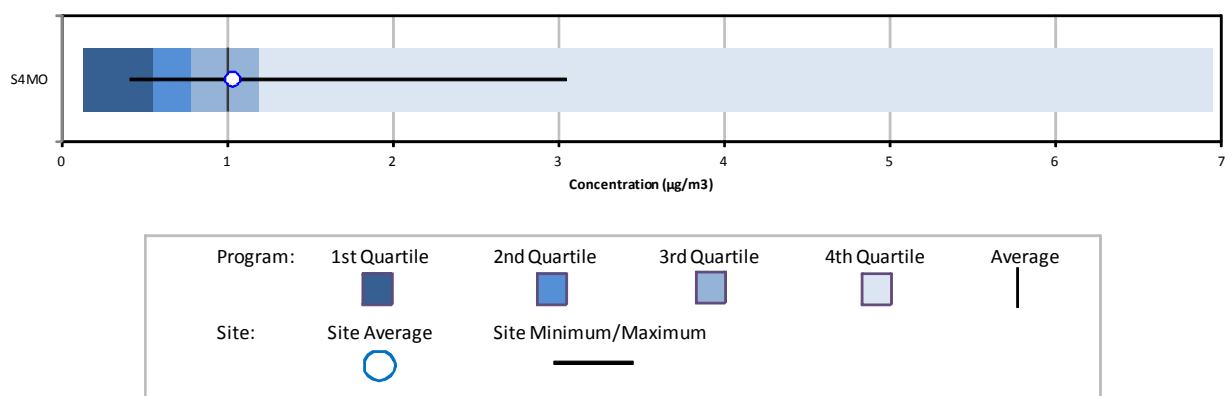
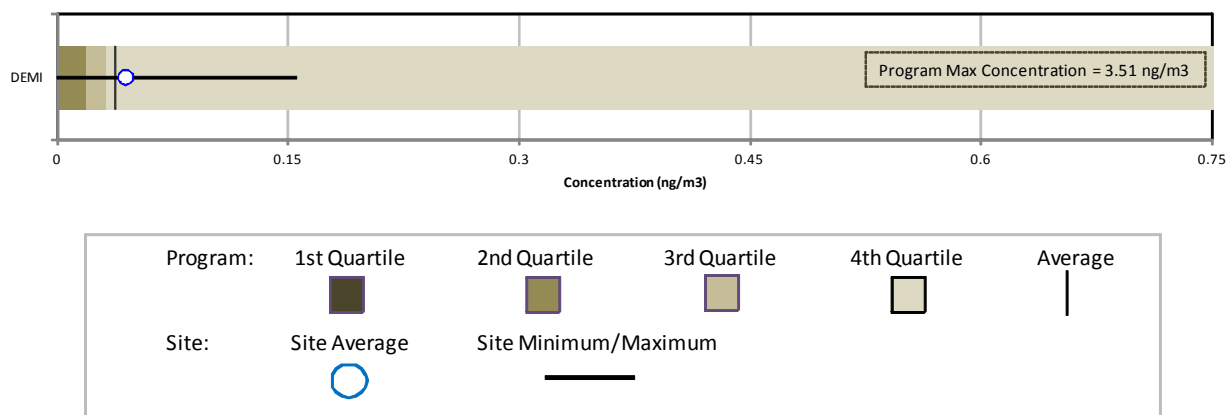**Figure 16-9. Program vs. Site-Specific Average Benzo(a)pyrene Concentration**

Program Max Concentration = 42.7 ng/m3

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
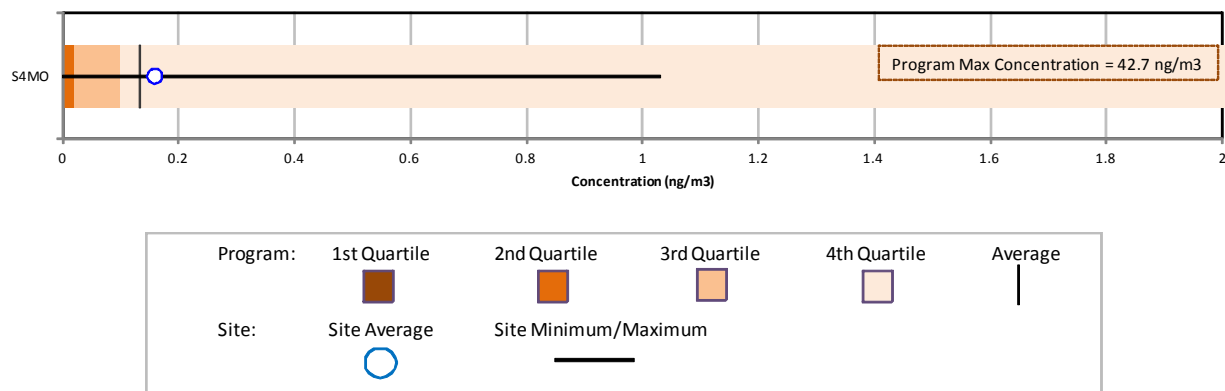
Figure 16-10. Program vs. Site-Specific Average 1,3-Butadiene Concentration

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
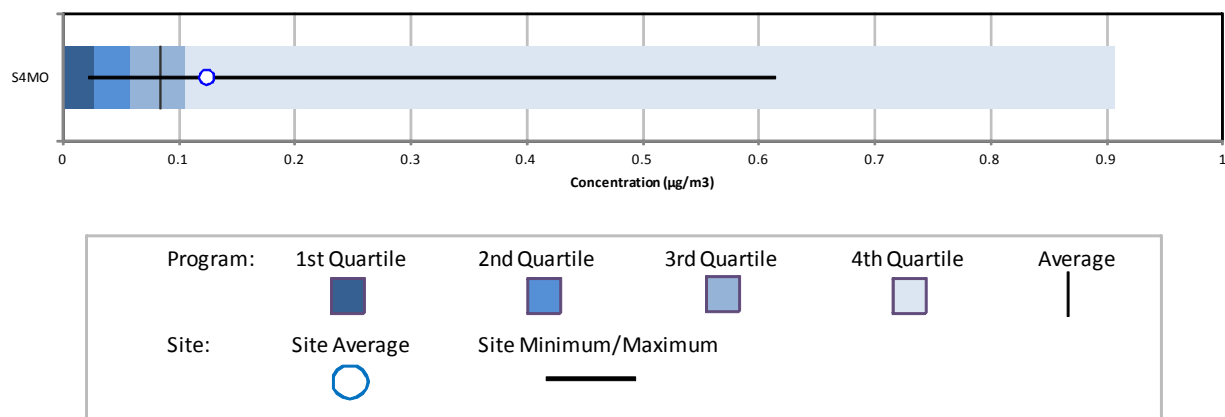
Figure 16-11. Program vs. Site-Specific Average Formaldehyde Concentration

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
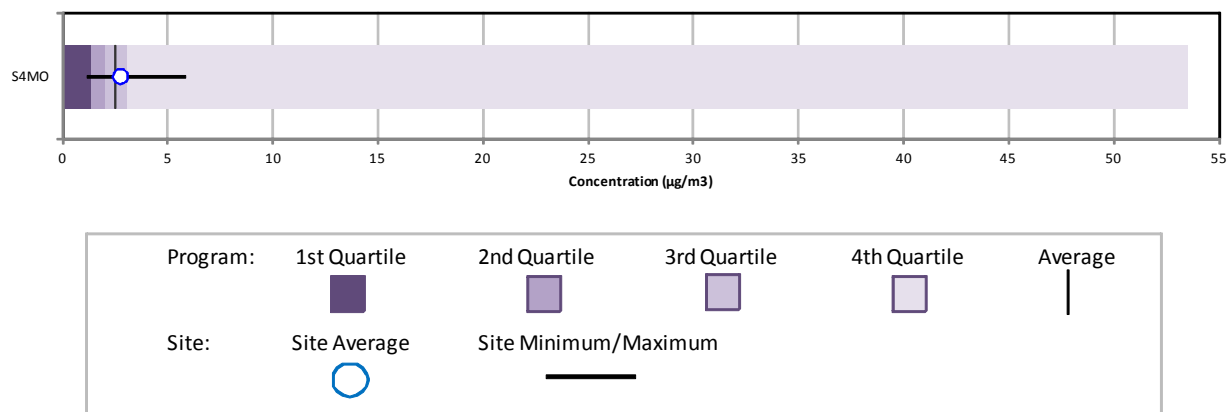
Figure 16-12. Program vs. Site-Specific Average Hexavalent Chromium Concentration
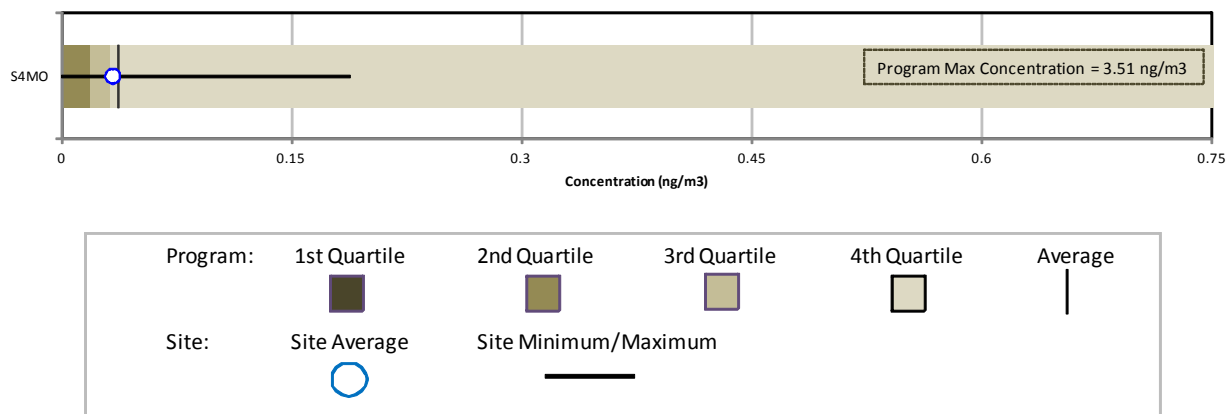
Figure 16-13. Program vs. Site-Specific Average Manganese (PM$_{10}$) Concentration
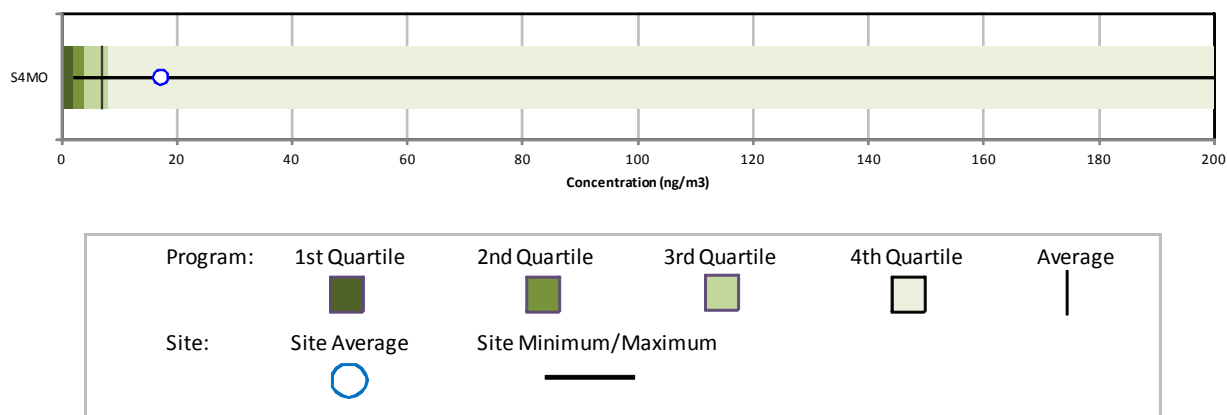
Figure 16-14. Program vs. Site-Specific Average Naphthalene Concentration
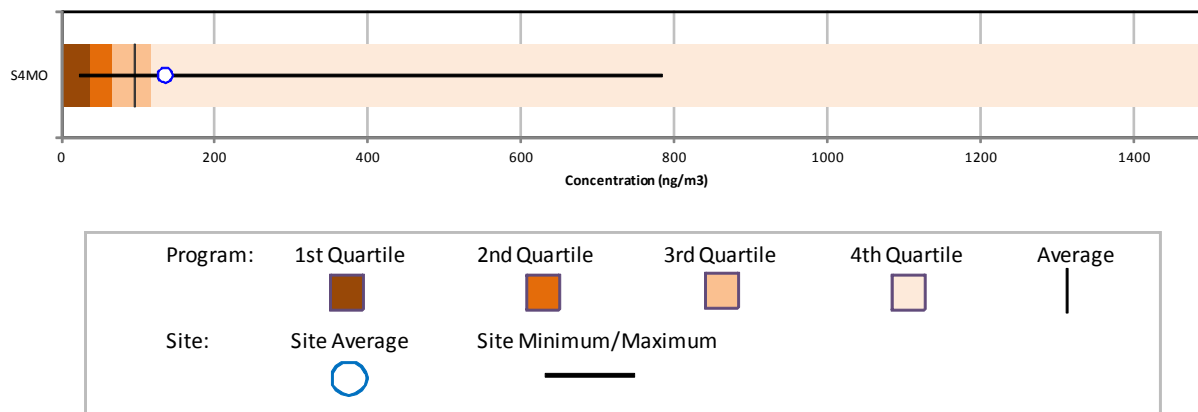
Observations from Figures 16-6 through 16-14 include the following:

- Figure 16-6 shows that S4MO's annual average acetaldehyde concentration is more than twice the program-level average. Recall from the previous section that this site has the highest annual average concentration of acetaldehyde among sites sampling carbonyl compounds. The maximum concentration measured at S4MO is the highest concentration measured across the program. The minimum acetaldehyde concentration measured at S4MO is greater than the program-level first quartile (25th percentile).

- Figure 16-7 shows that S4MO's annual average arsenic (PM$_{10}$) concentration is greater than the program-level average for arsenic (PM$_{10}$). Recall from the previous section that this site has the highest annual average arsenic concentration among sites sampling metals. The maximum concentration measured at S4MO is the highest concentration measured across the program. There were no non-detects of arsenic measured at S4MO.

- Figure 16-8 for benzene shows that the annual average benzene concentration for S4MO is just greater than the program-level average concentration. The maximum benzene concentration measured at S4MO is well below the maximum concentration measured at the program level. There were no non-detects of benzene measured at S4MO.

- Figure 16-9 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 concentration. Figure 16-9 also shows that the maximum concentration measured at S4MO is well below the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at S4MO.

- Figure 16-10 for 1,3-butadiene shows that the annual average concentration for S4MO is greater than the program-level average concentration. Although the maximum concentration measured at S4MO is less than the maximum concentration measured across the program, it is among the highest 1,3-butadiene concentrations measured across the program. There were no non-detects of 1,3-butadiene measured at S4MO.

- Figure 16-11 for formaldehyde shows that the annual average concentration for S4MO is just greater than the program-level average concentration. The maximum formaldehyde concentration measured at S4MO is well below the maximum concentration measured across the program. There were no non-detects of formaldehyde measured at S4MO.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 16-12 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 16-12 shows the annual average concentration of hexavalent chromium for S4MO is just less than the program-level average concentration and that both are greater than the program-level third quartile. The maximum concentration measured at S4MO is well below the program-level maximum concentration. There were several non-detects of hexavalent chromium measured at S4MO.

- Figure 16-13 shows that S4MO's annual average manganese (PM$_{10}$) concentration is greater than the program-level average for manganese (PM$_{10}$). Recall from the previous section that this site has the highest annual average manganese concentration among sites sampling metals. The maximum concentration measured at S4MO is the highest concentration measured across the program. There were no non-detects of manganese measured at S4MO.

- Figure 16-14 shows that the annual naphthalene average for S4MO is greater than both the program-level average concentration and third quartile. Although the maximum naphthalene concentration measured at S4MO is well below the program-level maximum concentration, this concentration is among the top 1 percent of concentrations measured across the program. There were no non-detects of naphthalene measured at S4MO.

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 VOC and carbonyl compounds under the NMP since 2002, PM$_{10}$ metals since 2003, and hexavalent chromium since 2005. Thus, Figures 16-15 through 16-21 present the 3-year rolling statistical metrics for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, and manganese (respectively) for S4MO. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 16-15. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at S4MO
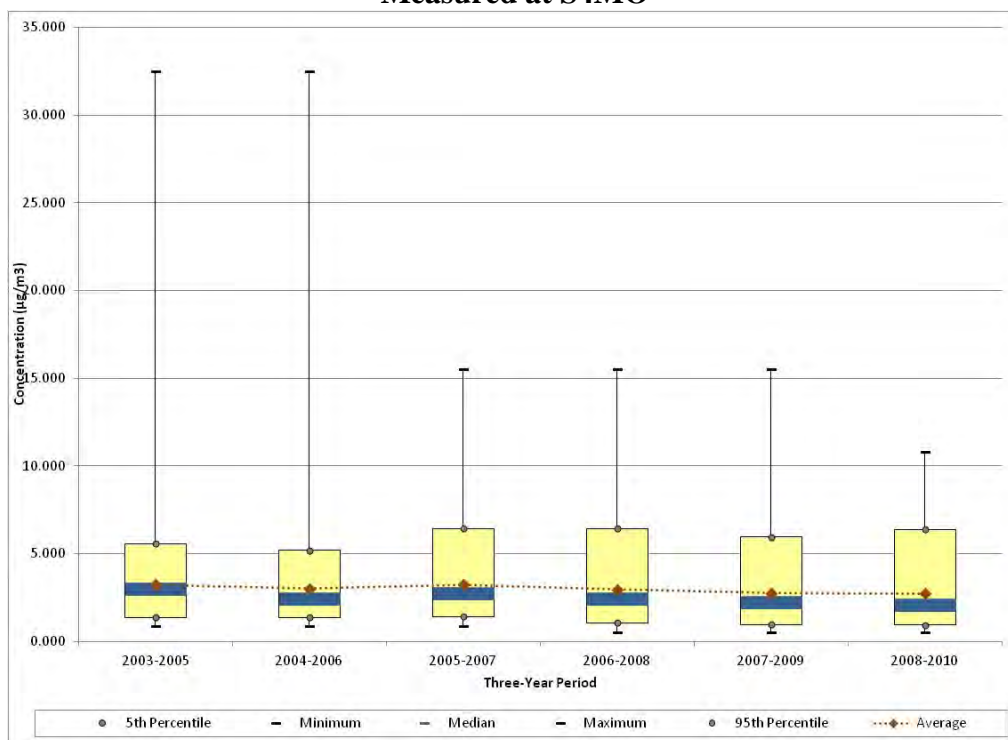
Figure 16-16. Three-Year Rolling Statistical Metrics for Arsenic (PM$_{10}$) Concentrations Measured at S4MO
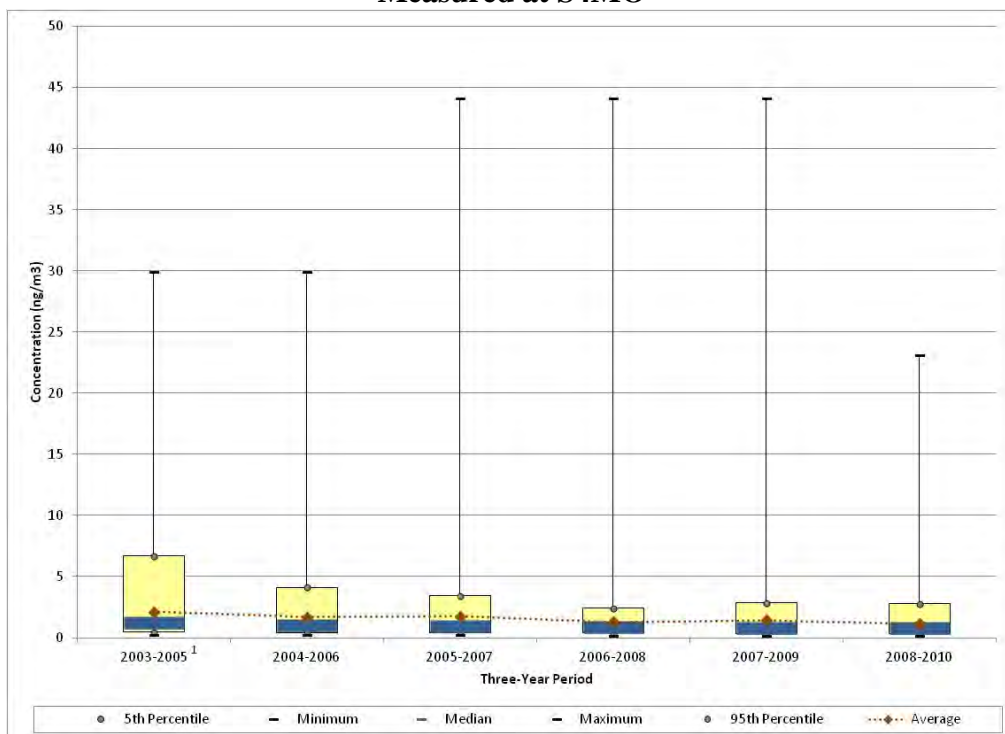
[1]Metals sampling at S4MO began in July 2003.

Figure 16-17. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at S4MO
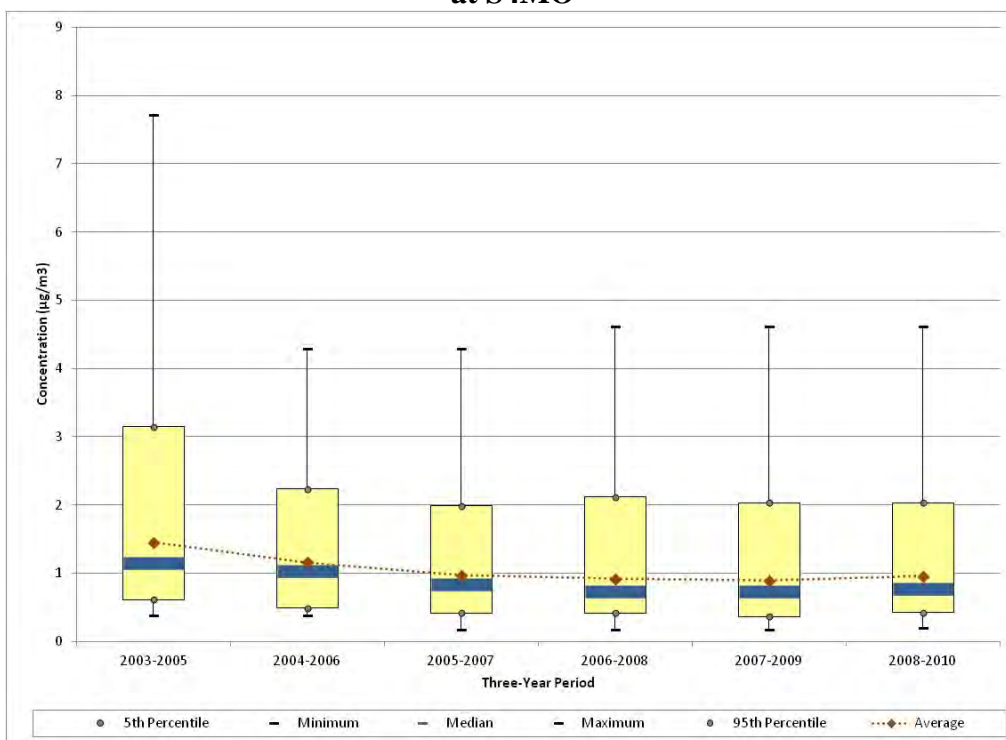
Figure 16-18. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at S4MO
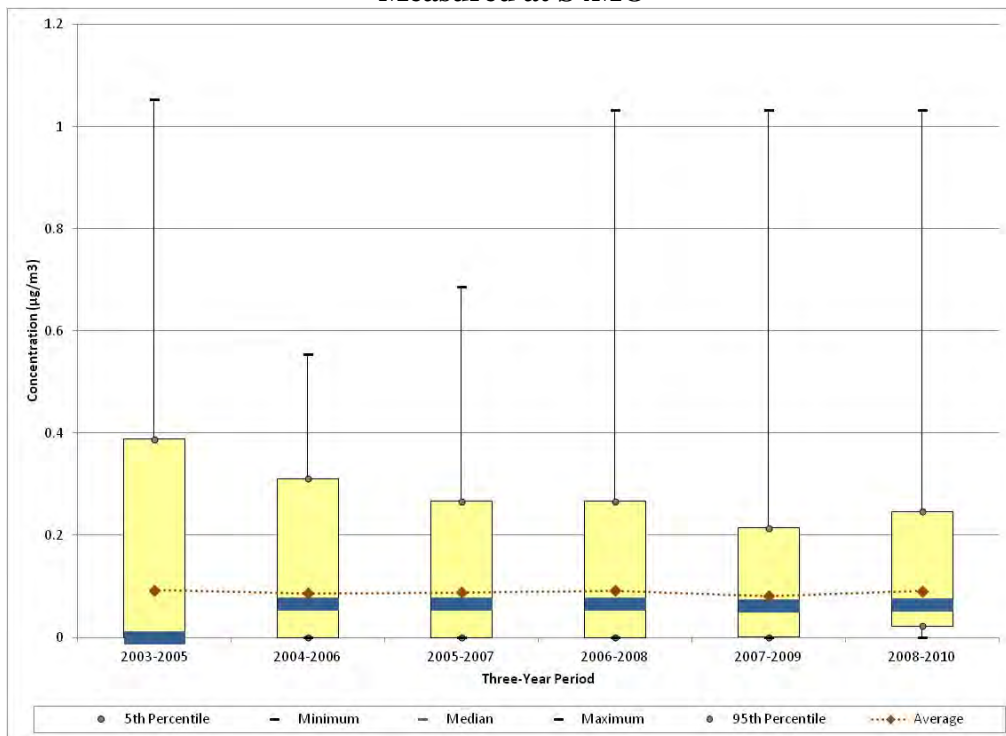
Figure 16-19. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at S4MO
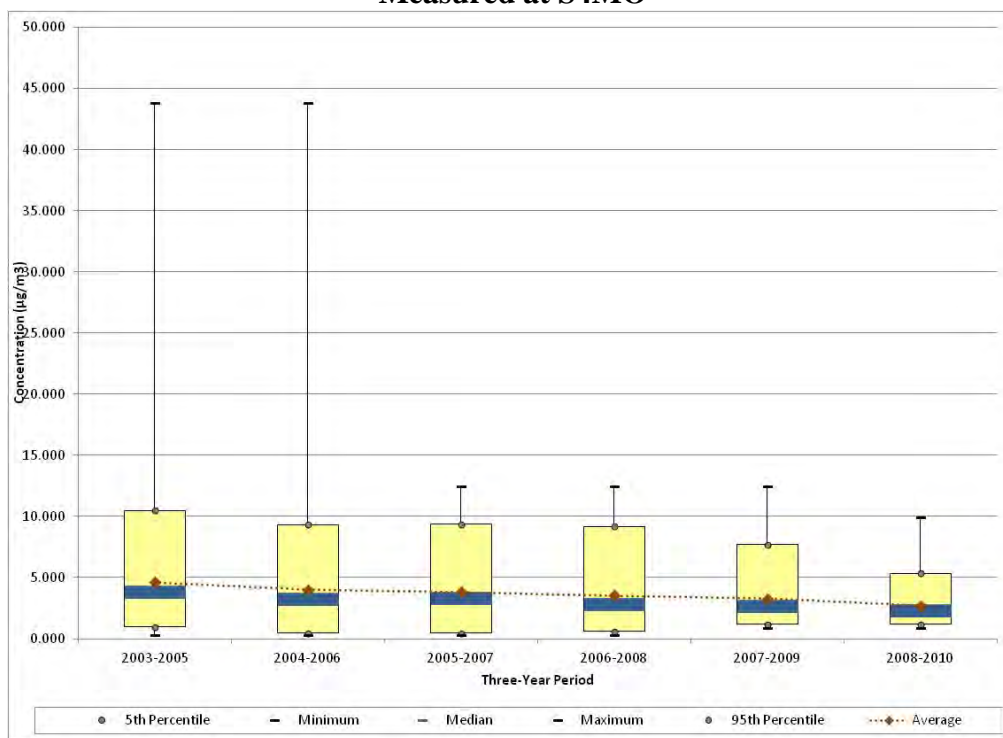
Figure 16-20. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at S4MO
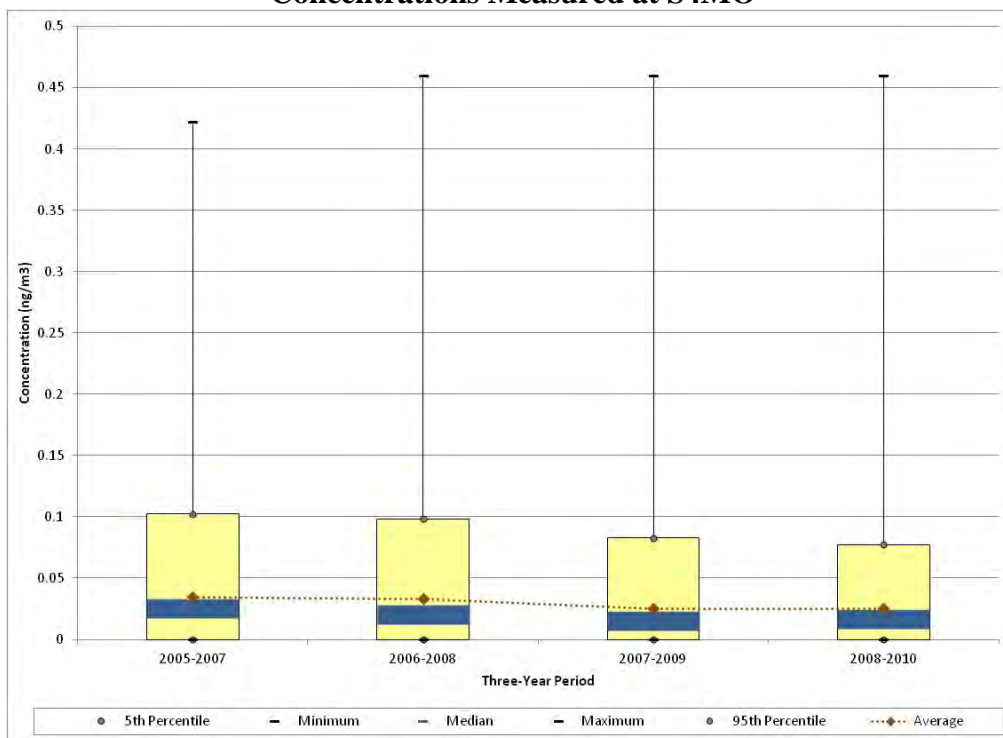
Figure 16-21. Three-Year Rolling Statistical Metrics for Manganese (PM$_{10}$) Concentrations Measured at S4MO
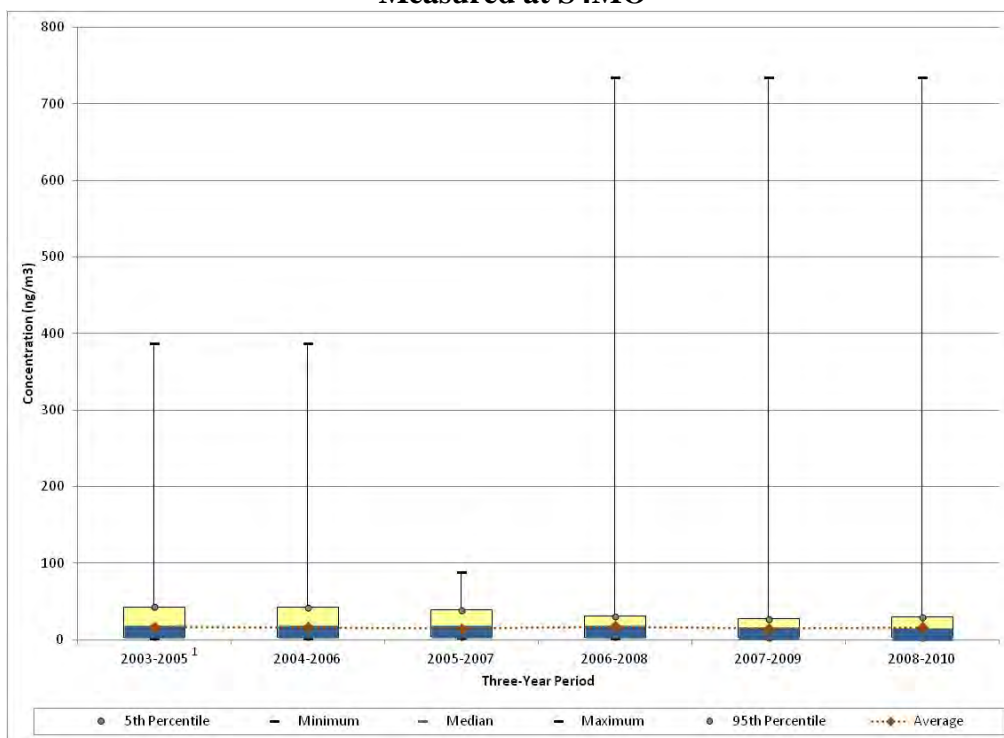
[1]Metals sampling at S4MO began in July 2003.

Observations from Figure 16-15 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).

- The rolling average concentration has fluctuated between approximately 2.70 µg/m^3 and 3.25 µg/m^3 across the period of sampling and corresponding confidence intervals confirm that a significant increasing or decreasing trend is not apparent.

- Even though the maximum concentration has decreased over the sampling period, the variability of the concentrations measured has increased, as indicated by the increasing spread between the 5th and 95th percentiles.

- Note that the minimum concentration measured is greater than zero for all 3-year periods, indicating that there were no non-detects reported for acetaldehyde since the onset of sampling.

Observations from Figure 16-16 for arsenic include the following:

- S4MO began sampling metals in July 2003, as denoted in Figure 16-16.

- The maximum arsenic concentration was measured on December 26, 2007, and therefore affects the 2005-2007, 2006-2008, and 2007-2009 time frames. The maximum arsenic concentration has varied significantly by year, ranging from 3.39 ng/m^3 in 2006 to 44.1 ng/m^3 in 2007.

- Several of the statistical parameters exhibit a slight decreasing trend since the onset of sampling. However, confidence intervals calculated for the rolling average concentrations show that the decrease in the rolling averages is not statistically significant.

Observations from Figure 16-17 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 rolling average and median concentrations exhibit a decreasing trend over time. Although both statistical parameters increase slightly for the 2008-2010 time frame, the increase is not statistically significant.

- The minimum concentration measured is greater than zero for all 3-year periods, indicating that there were no non-detects reported for benzene since the onset of sampling.

Observations from Figure 16-18 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-butaidene concentrations greater than 1.0 µg/m^3 that have been measured at S4MO.

- The rolling average concentrations have fluctuated from approximately 0.8 µg/m^3 to 0.9 µg/m^3 over the years of sampling.

- The median concentration has remained relatively unchanged since sampling began for 1,3-butadiene at S4MO, with the exception of the increase following the first 3-year period. During the 2003-2005 sample period, the median concentration was zero, indicating that at least half of the measurements were non-detects. The percentage of non-detects has been decreasing over the years of sampling, from as high as 66 percent in 2004 to zero percent in 2010.

Observations from Figure 16-19 for formaldehyde include the following:

- The maximum formaldehyde concentration was measured in 2004 and is more than three times the next highest concentration (also measured in 2004).

- Although difficult to discern in Figure 16-19 due to the relatively high concentration measured in 2004, both the median and average concentrations exhibit a decreasing trend. The 95th percentile also exhibits a decreasing trend, while the 5th percentile has increased for the last three periods of sampling.

- The minimum concentration measured for all 3-year periods is greater than zero, indicating that there were no non-detects of formaldehyde reported since the onset of sampling.

Observations from Figure 16-20 for hexavalent chromium include the following:

- The maximum hexavalent chromium concentration was measured on July 5, 2008; the second and third highest hexavalent chromium concentrations were measured on July 4, 2006 and July 4, 2010, respectively. These three concentrations support the potential correlation between hexavalent chromium concentrations and fireworks discussed in Section 4.1.2. However, the maximum concentration measured in 2010 (0.188 ng/m^3) is less than the maximum concentrations measured in 2008 (0.460 ng/m^3) and 2006 (0.422 ng/m^3).

- The rolling average concentration exhibits a decreasing trend. However, confidence intervals calculated for the rolling averages indicate that this decrease is not statistically significant. The confidence intervals, though, are relatively large due to the rather high maximum concentrations factored into them.

- For each 3-year period shown, both the minimums and 5th percentiles are zero, indicating the presence of non-detects. The percentage of non-detects has ranged from 16 percent (2007) to 43 percent (2009).

Observations from Figure 16-21 for manganese include the following:

- The maximum manganese concentration was measured on November 26, 2008 and is nearly twice the next highest concentration (measured in 2004).

- No significant increase or decrease in the rolling average concentrations is shown in Figure 16-21. Yet, the medians and 5th and 95th percentiles exhibit decreases for several periods, indicating a general decrease in the majority of concentrations measured since sampling began in 2003.

16.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

16.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the S4MO monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

Even with all of the relatively high concentrations of the pollutants of interest measured at S4MO, as discussed in Section 16.4.1, none of the measured detections or time-period average concentrations of the pollutants of interest for the S4MO monitoring site were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for S4MO.

16.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the S4MO monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 16-6, where applicable.

Table 16-6. Cancer and Noncancer Surrogate Risk Approximations for the Missouri Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
St. Louis, Missouri - S4MO						
Acenaphthene[a]	0.000088	--	58/58	0.01 ± <0.01	0.51	--
Acetaldehyde	0.0000022	0.009	54/54	4.10 ± 0.59	9.02	0.46

-- = 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. Cancer and Noncancer Surrogate 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 Risk Approximation (HQ)
Acrylonitrile	0.000068	0.002	14/53	0.17 ± 0.14	11.42	0.08
Arsenic (PM$_{10}$) [a]	0.0043	0.000015	60/60	<0.01 ± <0.01	4.39	0.07
Benzene	0.0000078	0.03	53/53	1.03 ± 0.15	8.05	0.03
Benzo(a)pyrene[a]	0.00176	--	50/58	<0.01 ± <0.01	0.28	--
Beryllium (PM$_{10}$) [a]	0.0024	0.00002	59/60	<0.01 ± <0.01	0.02	<0.01
1,3-Butadiene	0.00003	0.002	53/53	0.12 ± 0.03	3.72	0.06
Cadmium (PM$_{10}$) [a]	0.0018	0.00001	60/60	<0.01 ± <0.01	1.12	0.06
Carbon Tetrachloride	0.000006	0.1	53/53	0.58 ± 0.05	3.48	0.01
Chloroform	--	0.098	52/53	0.19 ± 0.04	--	<0.01
p-Dichlorobenzene	0.000011	0.8	45/53	0.35 ± 0.18	3.82	<0.01
1,2-Dichloroethane	0.000026	2.4	10/53	0.02 ± 0.01	0.42	<0.01
Ethylbenzene	0.0000025	1	53/53	0.44 ± 0.11	1.10	<0.01
Fluorene[a]	0.000088	--	58/58	0.01 ± <0.01	0.58	--
Formaldehyde	0.000013	0.0098	54/54	2.74 ± 0.33	35.66	0.28
Hexavalent Chromium[a]	0.012	0.0001	46/57	<0.01 ± <0.01	0.40	<0.01
Lead (PM$_{10}$) [a]	--	0.00015	60/60	0.01 ± <0.01	--	0.08
Manganese (PM$_{10}$) [a]	--	0.00005	60/60	0.02 ± 0.01	--	0.34
Naphthalene[a]	0.000034	0.003	58/58	0.14 ± 0.04	4.59	0.05
Nickel (PM$_{10}$) [a]	0.00048	0.00009	60/60	<0.01 ± <0.01	0.50	0.01
Tetrachloroethylene	2.6E-07	0.04	51/53	0.23 ± 0.06	0.06	0.01
Trichloroethylene	0.0000048	0.002	20/53	0.05 ± 0.02	0.22	0.02
Vinyl Chloride	0.0000088	0.1	4/53	<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 16-5.

Observations for S4MO from Table 16-6 include the following:

- The pollutants with the highest annual average concentrations for S4MO are acetaldehyde, formaldehyde, and benzene.

- Formaldehyde, acrylonitrile, and acetaldehyde have the highest cancer risk approximations for 2010. The cancer risk approximation for formaldehyde (35.66 in-a-million) is more than three times higher than the pollutant with the next highest cancer risk approximation (acrylonitrile at 11.42 in-a-million).

- Note how low the annual average concentration of acrylonitrile is compared to the annual average concentrations of many of the other pollutants of interest. Yet acrylonitrile has the second highest cancer risk approximation, indicating the relative toxicity of this pollutant.

- None of the pollutants of interest for S4MO have noncancer risk approximations greater than 1.0. The pollutant with the highest noncancer risk approximation is acetaldehyde (0.46), which is the second highest noncancer risk approximation calculated for a site-specific pollutant interest among NMP sites.

16.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 16-7 and 16-8 present a risk-based 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. Table 16-8 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 16-7 and 16-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 VOC, PAH, carbonyl compounds, metals (PM$_{10}$), and hexavalent chromium. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	35.66
Formaldehyde	118.03	Formaldehyde	1.53E-03	Acrylonitrile	11.42
Ethylbenzene	78.65	Arsenic, PM	1.49E-03	Acetaldehyde	9.02
Acetaldehyde	74.93	Benzene	1.16E-03	Benzene	8.05
1,3-Butadiene	20.98	1,3-Butadiene	6.29E-04	Naphthalene	4.59
Trichloroethylene	15.79	Naphthalene	4.47E-04	Arsenic	4.39
Naphthalene	13.16	Nickel, PM	3.92E-04	*p*-Dichlorobenzene	3.82
Dichloromethane	7.23	POM, Group 3	3.24E-04	1,3-Butadiene	3.72
POM, Group 2b	2.53	POM, Group 2b	2.22E-04	Carbon Tetrachloride	3.48
Methyl *tert* butyl ether	0.86	Ethylbenzene	1.97E-04	Cadmium	1.12

Table 16-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Missouri Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
St. Louis, Missouri (St. Louis City) - S4MO					
Toluene	522.43	Acrolein	316,721.93	Acetaldehyde	0.46
Xylenes	358.32	Manganese, PM	34,593.25	Manganese	0.34
Methanol	289.83	Arsenic, PM	23,029.98	Formaldehyde	0.28
Benzene	148.92	Formaldehyde	12,043.75	Acrylonitrile	0.08
Formaldehyde	118.03	1,3-Butadiene	10,489.20	Lead	0.08
Hexane	116.82	Chlorine	9,452.80	Arsenic	0.07
Hydrochloric acid	109.87	Nickel, PM	9,073.56	Cadmium	0.06
Ethylbenzene	78.65	Acetaldehyde	8,325.31	1,3-Butadiene	0.06
Acetaldehyde	74.93	Trichloroethylene	7,895.27	Naphthalene	0.05
Methyl isobutyl ketone	73.11	Lead, PM	6,587.56	Benzene	0.03

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.

- Four of the pollutants with the highest cancer risk approximations for S4MO also appear on both emissions-based lists (formaldehyde, benzene, 1,3-butadiene, and naphthalene). While arsenic is not one of the highest emitted pollutants, it does appear on the list of highest toxicity-weighted emissions. While acetaldehyde does not appear on the list of highest toxicity-weighted emissions, it is one of the highest emitted pollutants in the city of St. Louis. Acrylonitrile, which has the second highest cancer surrogate risk approximation for S4MO, appears on neither emissions-based list.

- POM, Group 2b is the ninth highest emitted "pollutant" in St. Louis and ranks ninth for toxicity-weighted emissions. POM, Group 2b includes several PAH sampled for at S4MO including acenaphthene and fluorene, which are pollutants of interest for S4MO. These pollutants are not among those with the 10 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 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.

- Acetaldehyde and formaldehyde are the pollutants with the highest and third highest noncancer risk 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 risk approximation, is the pollutant with the second highest toxicity-weighted emissions but is not one of the highest emitted.

16.6   Summary of the 2010 Monitoring Data for S4MO

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

❖ *Twenty-four pollutants, of which 14 are NATTS MQO Core Analytes, failed screens
for S4MO.*

❖ *Acetaldehyde and formaldehyde had the highest annual average concentrations for
S4MO. S4MO had the highest annual average concentration of acetaldehyde,
arsenic, beryllium, cadmium, lead, and manganese among all NMP sites sampling
these pollutants.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual
average concentrations of the pollutants of interest for S4MO, where they could be
calculated, were greater than their associated MRL noncancer health risk
benchmarks.*

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. Figures 17-1 through 17-4 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 17-5 through 17-7 identify 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 17-5 through 17-7. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 17-1 describes the area surrounding each monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 17-1. Chester, New Jersey (CHNJ) Monitoring Site
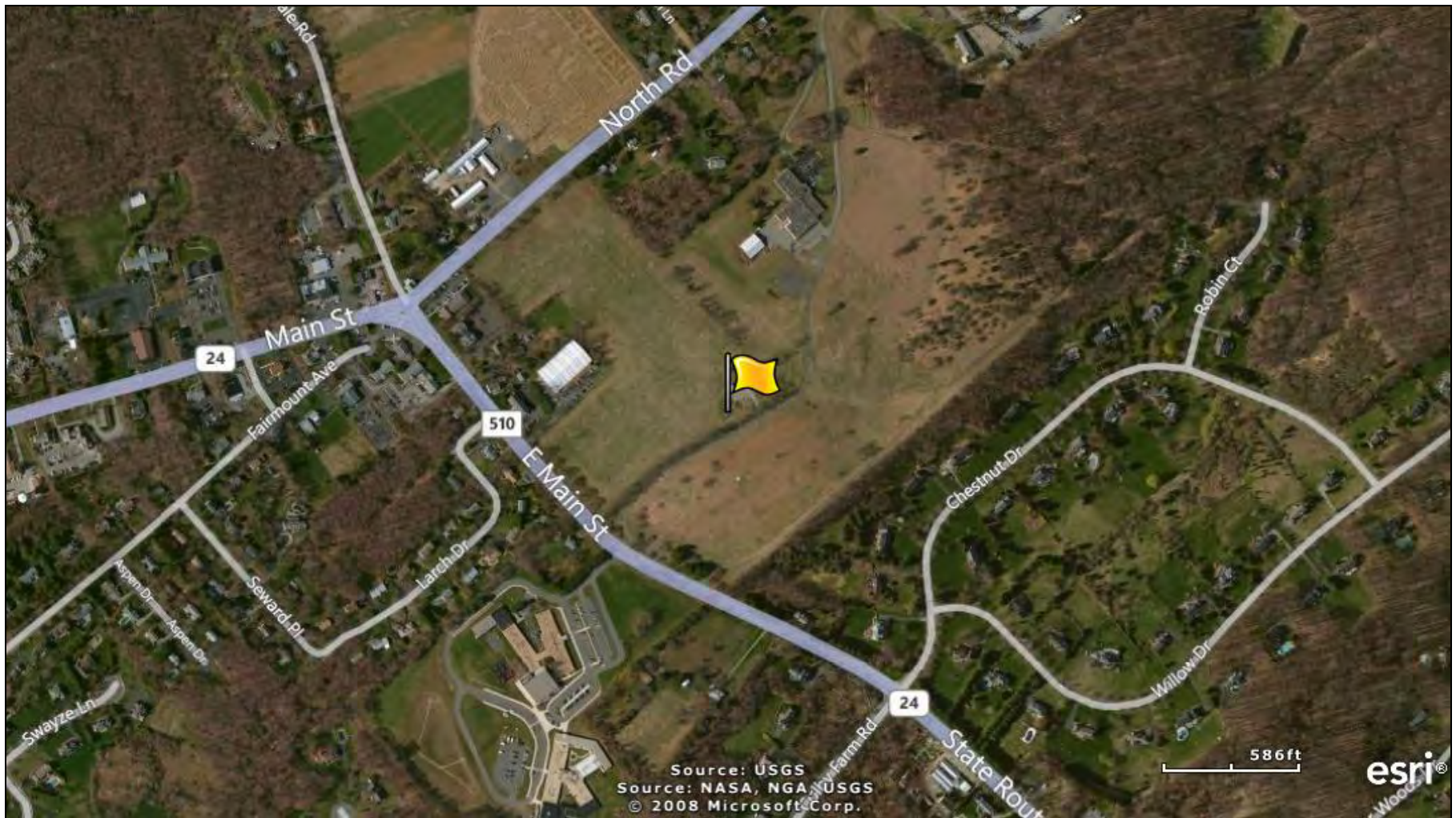
Figure 17-2. Elizabeth, New Jersey (ELNJ) Monitoring Site

Figure 17-3. New Brunswick, New Jersey (NBNJ) Monitoring Site

Figure 17-4. Paterson, New Jersey (PANJ) Monitoring Site
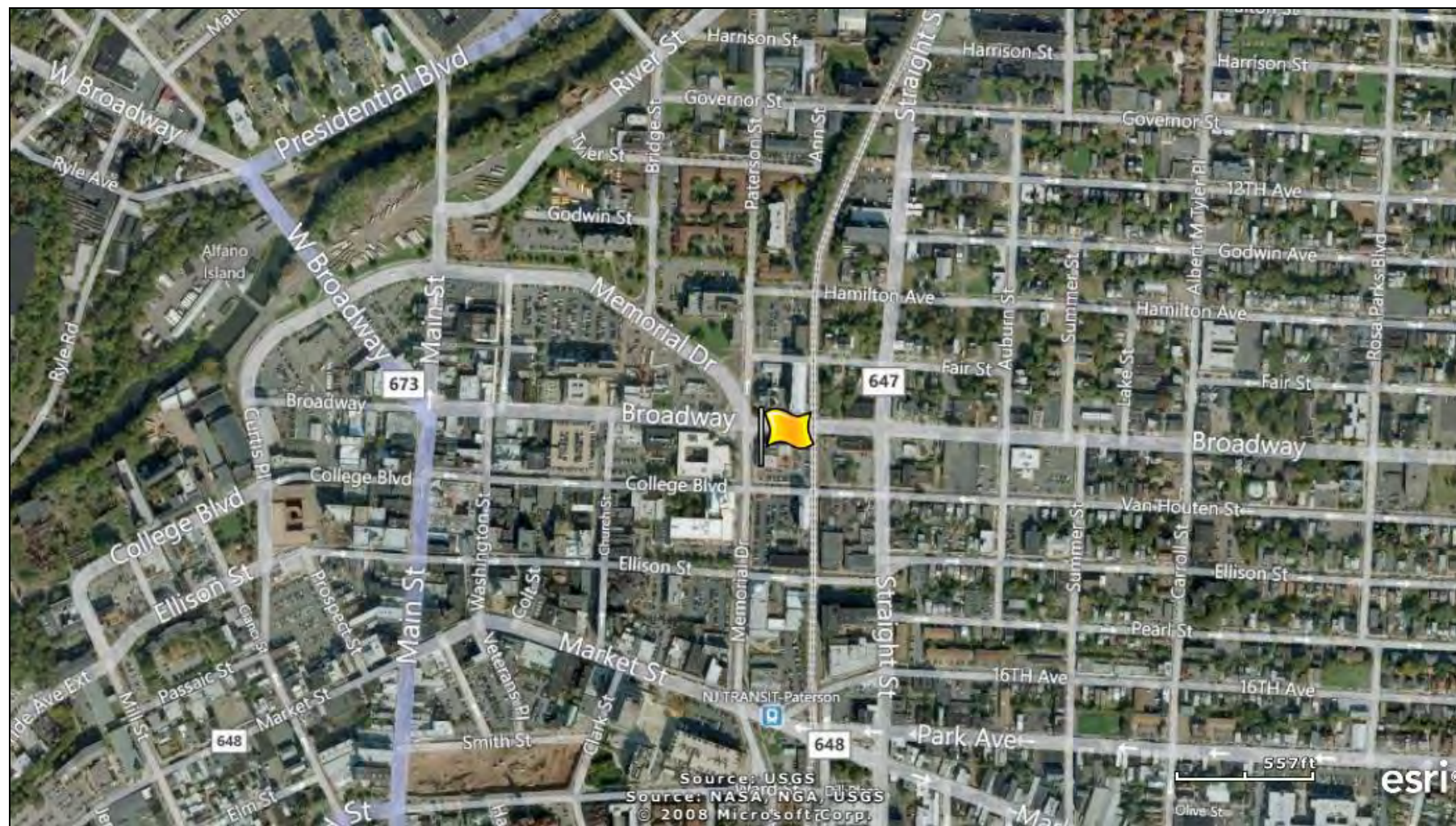
Figure 17-5. NEI Point Sources Located Within 10 Miles of CHNJ

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

Legend

⭐ CHNJ UATMP site   ◯ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

✦	Aircraft Operations (12)	F	Food Processing/Agriculture (1)
▪	Asphalt Processing/Roofing Manufacturing (1)	⊞ H	Hospital (1)
○	Clay Ceramics Manufacturing (3)	✕	Mine/Quarry (1)
■	Concrete Batch Plant (1)	M	Miscellaneous Manufacturing (2)
⊙	Fabricated Metal Products (1)	▭	Pharmaceutical Manufacturing (1)
		⊞	Pulp and Paper Plant/Wood Products (2)

Figure 17-6. NEI Point Sources Located Within 10 Miles of ELNJ and NBNJ

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

Legend

⭐ ELNJ UATMP site   ⭐ NBNJ UATMP site   ◯ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

- ✛ Aircraft Operations (44)
- ▮ Asphalt Processing/Roofing Manufacturing (3)
- ◇ Auto Body Shop/Painters (1)
- Ḃ Bakery (2)
- Ⴘ Brewery/Distillery/Winery (1)
- ⬟ Building Construction (1)
- B Bulk Terminals/Bulk Plants (13)
- C Chemical Manufacturing (24)
- O Clay Ceramics Manufacturing (3)
- ⚡ Electricity Generation via Combustion (21)
- E Electroplating, Plating, Polishing, Anodizing, and Coloring (2)
- ◉ Fabricated Metal Products (12)
- ⬭ Flexible Polyurethane Foam Production (2)
- F Food Processing/Agriculture (6)
- ▱ Furniture Plant (2)

- ▪ Gasoline/Diesel Service Station (1)
- ✛ Gypsum Manufacturing (1)
- ⁄⁄ Heating Equipment Manufacturing (1)
- Ⓗ Hospital (2)
- ❄ Hot Mix Asphalt Plant (2)
- ✳ Industrial Machinery and Equipment (5)
- Ⓢ Institutional - school (14)
- 🌐 Laboratory (1)
- ▲ Landfill (2)
- ⨍ Lumber/sawmill (1)
- ⛟ Marine Port (1)
- ▷ Marine Vessel Loading Rack (1)
- ✕ Mine/Quarry (1)
- ? Miscellaneous Commercial/Industrial (24)
- M Miscellaneous Manufacturing (13)
- Ⓜ Municipal Waste Combustor (2)

- ● Oil and/or Gas Production (1)
- ◪ Petroleum Refinery (3)
- ⌣ Pharmaceutical Manufacturing (7)
- 1 Primary Metal Production (1)
- ↑ Printing, Coating & Dyeing of Fabrics (1)
- P Printing/Publishing (10)
- ⊞ Pulp and Paper Plant/Wood Products (13)
- R Rubber and Miscellaneous Plastics Products (12)
- 2 Secondary Metal Processing (1)
- > Solid Waste Disposal - Commercial/Institutional (4)
- ▼ Steel Mill (2)
- S Surface Coating (16)
- ◎ Tire Manufacture (1)
- ✾ Transportation and Marketing of Petroleum Products (2)
- ⊤ Wastewater Treatment (8)
- W Woodwork, Furniture, Millwork & Wood Preserving (2)

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.

Legend

★ PANJ CSATAM site   ◯ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

✈	Aircraft Operations (21)	?	Miscellaneous Commercial/Industrial (3)
฿	Bakery (1)	M	Miscellaneous Manufacturing (20)
B	Bulk Terminals/Bulk Plants (1)	●	Oil and/or Gas Production (1)
C	Chemical Manufacturing (8)	⬯	Pharmaceutical Manufacturing (4)
O	Clay Ceramics Manufacturing (1)	1	Primary Metal Production (3)
e	Electrical Equipment (4)	↑	Printing, Coating & Dyeing of Fabric (1)
⚡	Electricity Generation via Combustion (4)	P	Printing/Publishing (13)
E	Electroplating, Plating, Polishing, Anodizing, & Coloring (1)	⊞	Pulp and Paper Plant/Wood Products (10)
⊙	Fabricated Metal Products (3)	R	Rubber and Miscellaneous Plastics Products (4)
⬳	Flexible Polyurethane Foam Production (3)	‹	Site Remediation Activity (1)
F	Food Processing/Agriculture (3)	▼	Steel Mill (1)
H	Hospital (3)	S	Surface Coating (5)
☀	Hot Mix Asphalt Plant (3)	T	Textile Mill (4)
☀	Industrial Machinery and Equipment (2)	✈	Transportation Equipment (1)
ⓢ	Institutional - school (2)	∎	Wastewater Treatment (1)
		W	Woodwork, Furniture, Millwork & Wood Preserving (1)

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] These monitoring sites report additional pollutants to AQS (EPA, 2012h); however, these data are not generated by ERG and are therefore not included in this report.

CHNJ is located in northern New Jersey, 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 17-5 shows that few sources are close to CHNJ and that the source category with the highest number of emissions sources surrounding CHNJ is the aircraft operations category, which includes airports as well as small runways, heliports, or landing pads.

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 17-2 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 west and southwest, 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 17-3. 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.

Figure 17-6 shows that the outer portions of NBNJ and ELNJ's 10-mile radii 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 highest 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 17-4. The Passaic River runs northeast-southwest just north of PANJ and is shown in the upper left corner of Figure 17-4. 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 southwest of the site. Although the majority of sources near PANJ are involved in aircraft operations, printing and publishing, or pulp and paper products, the source closest to PANJ falls in the miscellaneous industries category.

Table 17-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the New Jersey monitoring sites. 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 (FHWA, 2011), was allocated to the county level using the county-level proportion of the state population. State-level and county-level population information for these counties was obtained from the U.S. Census Bureau. Table 17-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 17-2 also contains annual average daily traffic information. Finally, Table 17-2 presents the daily VMT for Middlesex, Morris, Passaic, and Union Counties.

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. But ELNJ has the highest 10-mile population among the four New Jersey sites. 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 fourth among NMP sites while PANJ rounds out the top 10. While NBNJ's 10-mile population is in the middle of the range, CHNJ's 10-mile population is in the bottom third compared to other NMP sites.

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	492,694	389,359	0.79	244,577	193,281	12,917	14,256,044
ELNJ	537,661	424,894	0.79	2,180,662	1,723,298	250,000	12,485,902
NBNJ	810,986	640,893	0.79	783,724	619,349	114,322	20,415,685
PANJ	501,860	396,602	0.79	1,332,800	1,053,264	22,272	8,178,167

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects ratios based on 2010 state-level vehicle registration data from the FHWA and the county-level proportion of the state population data (FHWA, 2011)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2006 data from for ELNJ 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)

- The estimated county-level vehicle ownership 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 are in the middle of the range compared to other NMP sites. ELNJ and PANJ have two of the highest 10-mile vehicle ownership estimates compared to other NMP sites.

- ELNJ experiences a significantly higher average traffic volume than other New Jersey sites, while CHNJ experiences the least. Traffic data for ELNJ were obtained for I-95, between Exit 13 and 13A; this is the highest traffic volume among all NMP sites. Traffic data for CHNJ were obtained for Main Street (County Road 513) near Highway 206 in downtown Chester; traffic data for NBNJ were obtained for US-1 near State Road 617 (Ryders Lane); and traffic data for PANJ were obtained for Memorial Drive between Ellison Street and College Boulevard.

- Among the New Jersey counties with monitoring sites, VMT for Middlesex County is highest while 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. 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, 2012).

17.2.2 Meteorological Conditions in 2010

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). 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 normal conditions throughout the year.

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 2010. 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 warmer and wetter than for the entire year as a whole. However, sampling did not begin at PANJ until April 2010, thereby missing the coldest months of 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	Sample Day	64.1 ± 5.2	53.6 ± 4.6	42.5 ± 4.9	48.2 ± 4.3	69.7 ± 3.3	1012.9 ± 1.9	3.3 ± 0.5
	165° (SSE)	2010	64.0 ± 2.1	53.5 ± 1.8	42.1 ± 2.0	48.0 ± 1.7	69.3 ± 1.3	1013.3 ± 0.7	3.6 ± 0.3
Elizabeth, New Jersey - ELNJ									
Newark International Airport 14734 (40.68, -74.17)	3.45 miles	Sample Day	64.9 ± 5.1	57.2 ± 4.7	40.8 ± 4.8	49.2 ± 4.2	57.6 ± 3.6	1013.1 ± 1.9	8.4 ± 0.8
	20° (NNE)	2010	65.0 ± 2.0	57.2 ± 1.9	40.2 ± 1.9	49.0 ± 1.7	56.6 ± 1.5	1013.4 ± 0.7	8.5 ± 0.4
New Brunswick, New Jersey - NBNJ									
Somerville, New Jersey/Somerset Airport 54785 (40.62, -74.67)	16.06 miles	Sample Day	64.1 ± 5.2	53.6 ± 4.6	42.5 ± 4.9	48.2 ± 4.3	69.7 ± 3.3	1012.9 ± 1.9	3.3 ± 0.5
	297° (WNW)	2010	64.0 ± 2.1	53.5 ± 1.8	42.1 ± 2.0	48.0 ± 1.7	69.3 ± 1.3	1013.3 ± 0.7	3.6 ± 0.3
Passaic, New Jersey - PANJ									
Essex County Airport 54743 (40.88, -74.28)	6.39 miles	Sample Day	70.3 ± 6.5	61.5 ± 5.8	49.6 ± 5.7	55.0 ± 5.2	68.3 ± 5.0	1013.6 ± 2.7	3.4 ± 0.7
	229° (SW)	2010	63.3 ± 2.0	54.3 ± 1.9	40.9 ± 2.0	47.9 ± 1.7	64.2 ± 1.5	1014.2 ± 0.7	4.0 ± 0.3

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

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 2010. Included in Figure 17-8 are four back trajectories per sample day. Figure 17-9 is the corresponding cluster analysis for 2010. Similarly, Figures 17-10 through 17-15 are the composite back trajectory maps and corresponding cluster analyses for the remaining New Jersey 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the sites in Figures 17-8 through 17-15 represents 100 miles.

Observations from Figures 17-8 through 17-15 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 fewer back trajectories as this site did not begin sampling until April 2010.

- Back trajectories originated from a variety of directions at the sites, although fewer from the east and southeast. In general, trajectories originating from the south, west, or north were longer than trajectories originating from the east.

- 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 Michigan, off the coast of North Carolina and South Carolina, or over the Atlantic Ocean south of Newfoundland, Canada. The average trajectory length for these sites ranged from 267 miles (PANJ) to 279 miles (ELNJ).

- The cluster trajectories for the New Jersey sites are similar to each other, although the percentages vary. The cluster maps show a propensity for trajectories to originate from the northwest quadrant, including west and north, at these sites, although of varying lengths. Trajectories also originated from the south and east, although the trajectories with an easterly component tended to be relatively short.

Figure 17-8. 2010 Composite Back Trajectory Map for CHNJ
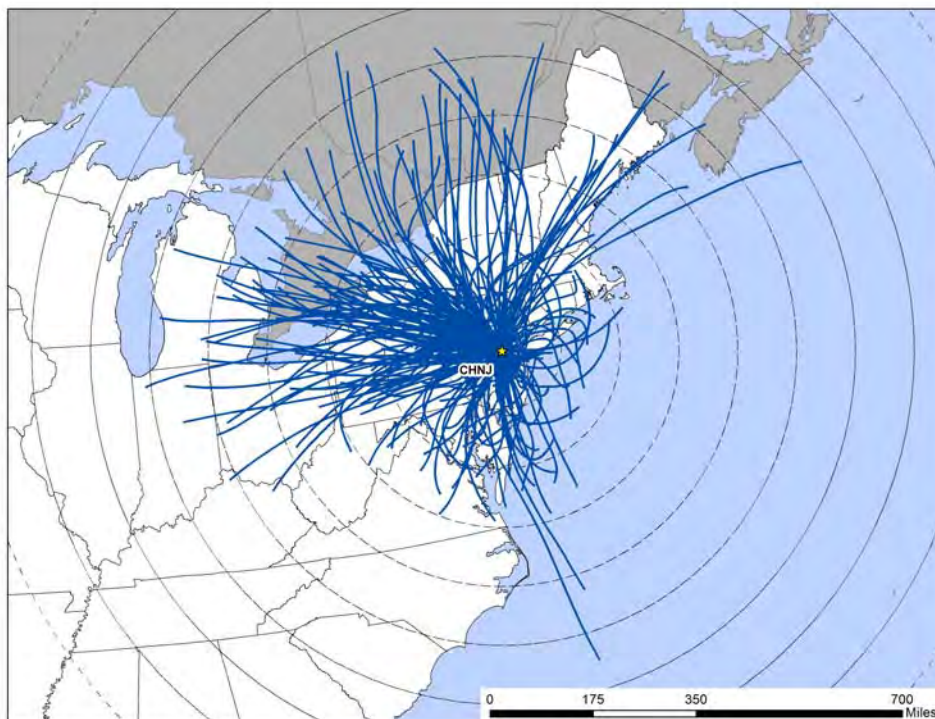
Figure 17-9. Back Trajectory Cluster Map for CHNJ

Figure 17-10. 2010 Composite Back Trajectory Map for ELNJ
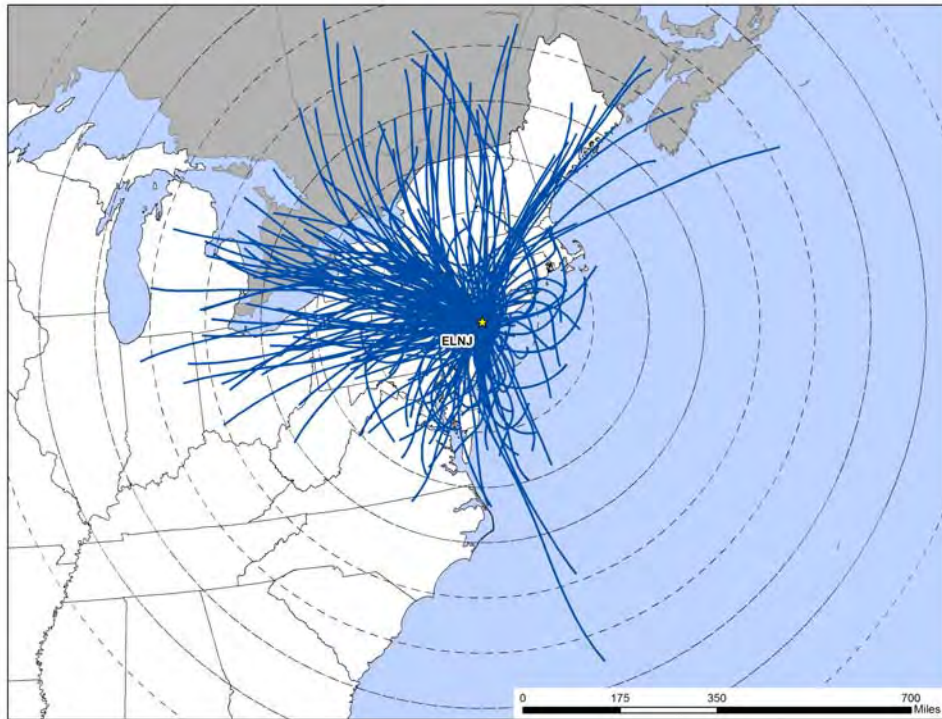
Figure 17-11. Back Trajectory Cluster Map for ELNJ

Figure 17-12. 2010 Composite Back Trajectory Map for NBNJ
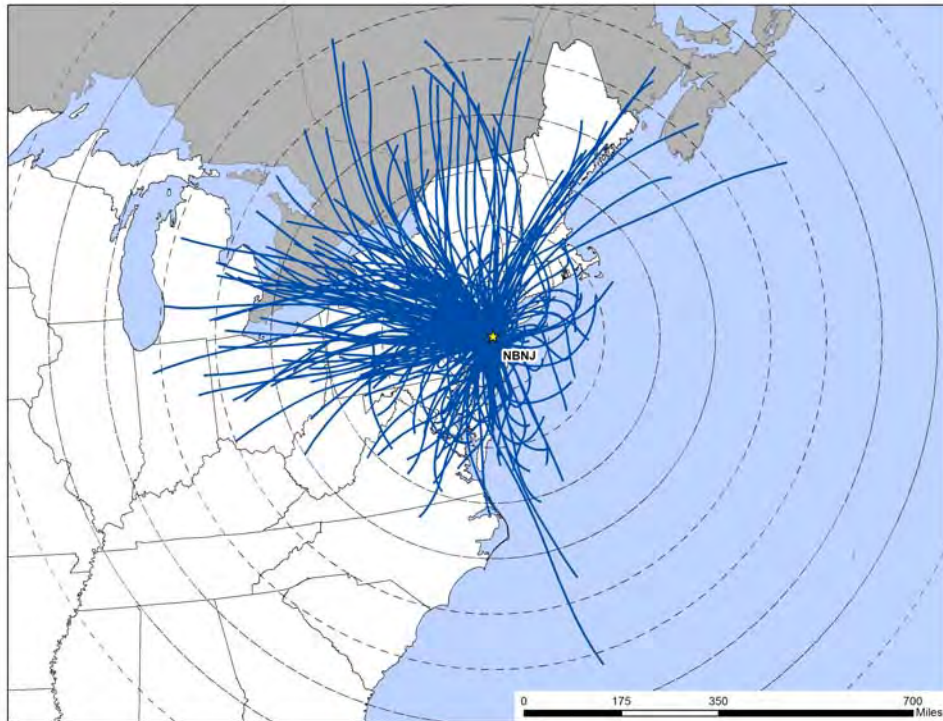
Figure 17-13. Back Trajectory Cluster Map for NBNJ

Figure 17-14. 2010 Composite Back Trajectory Map for PANJ
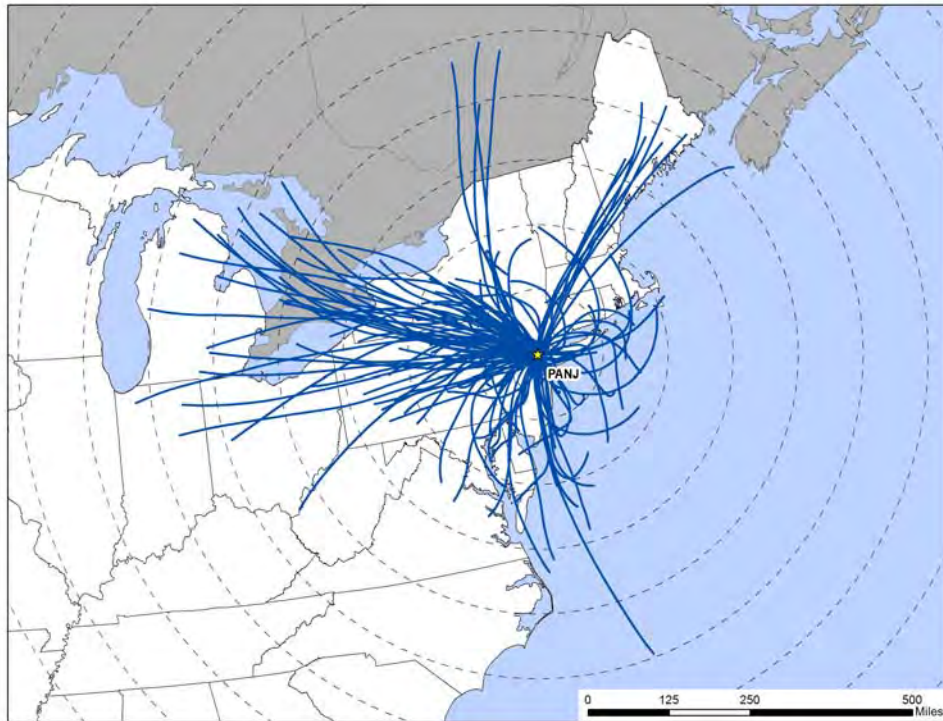
Figure 17-15. Back Trajectory Cluster Map for PANJ

17.2.4 Wind Rose Comparison

Hourly 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 17-16 presents three different wind roses for the CHNJ monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figures 17-17 through 17-19 present the three wind roses and distance maps for ELNJ, NBNJ, and PANJ, respectively.

Figure 17-16. Wind Roses for the Summerville-Somerset Airport Weather Station near CHNJ

1999-2009 Historical Wind Rose
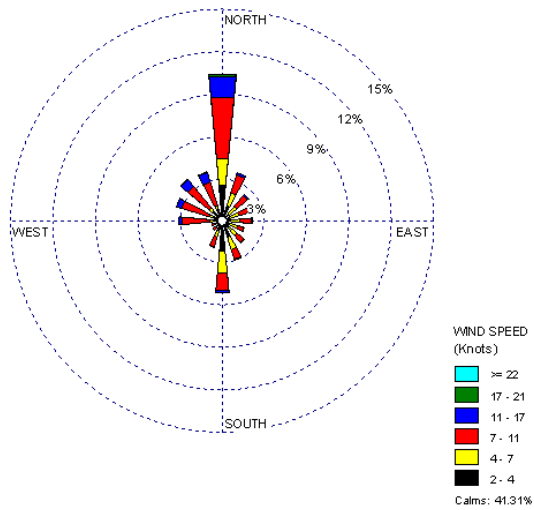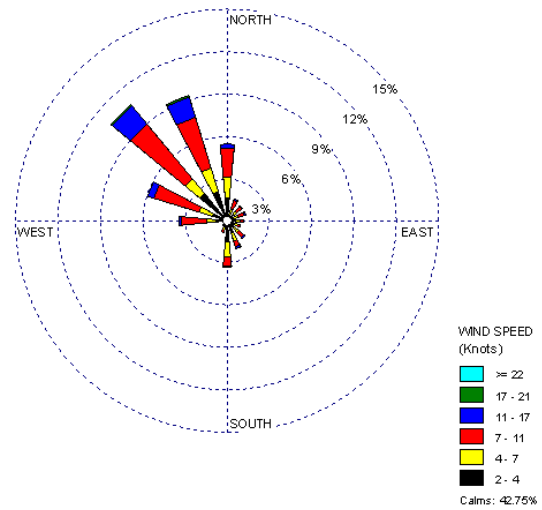
2010 Wind Rose

2010 Sample Day Wind Rose
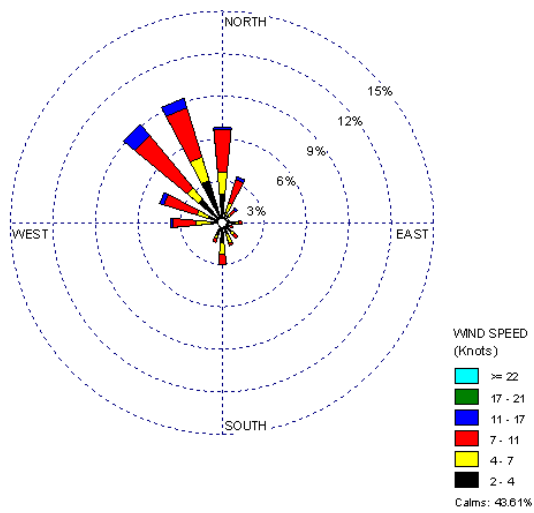
Distance between CHNJ and NWS Station

Figure 17-17. Wind Roses for the Newark International Airport Weather Station near ELNJ

1999-2009 Historical Wind Rose
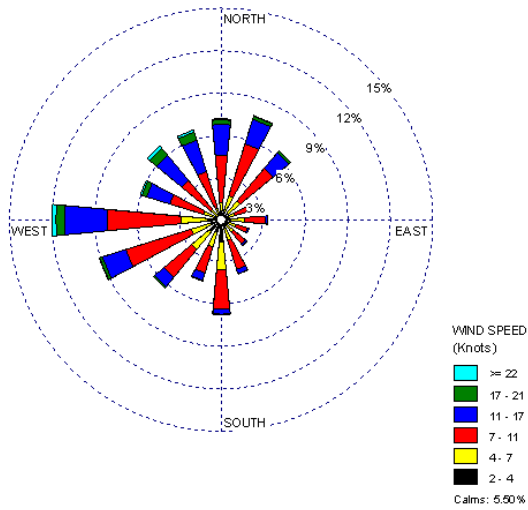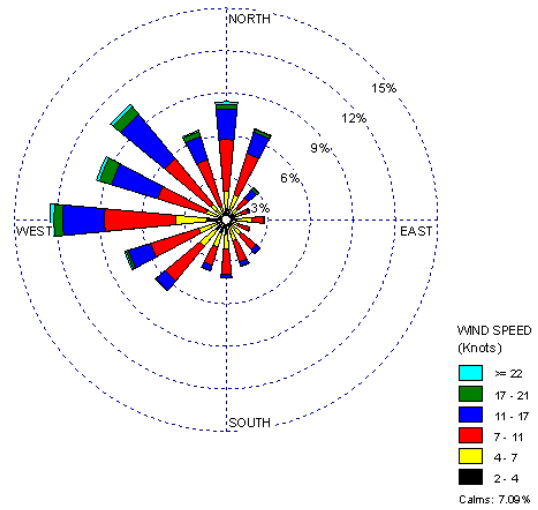
2010 Wind Rose

2010 Sample Day Wind Rose
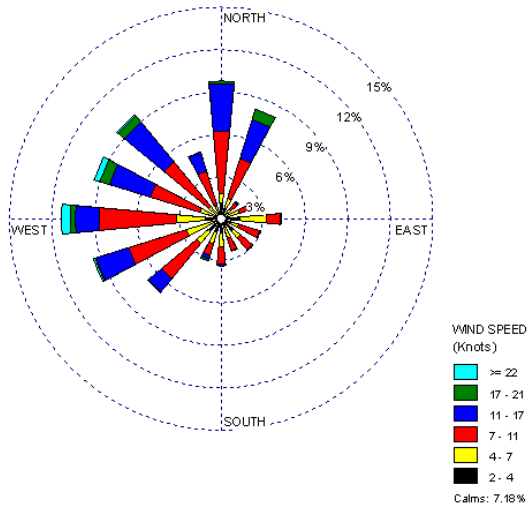
Distance between ELNJ and NWS Station
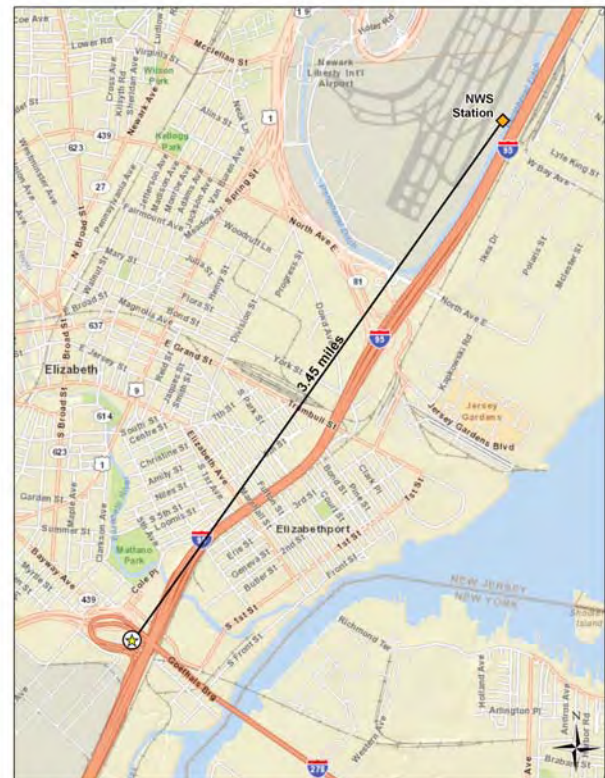
Figure 17-18. Wind Roses for the Summerville-Somerset Airport Weather Station near NBNJ

1999-2009 Historical Wind Rose
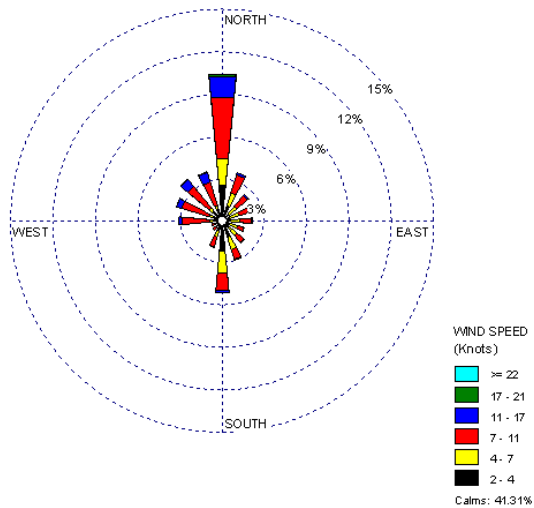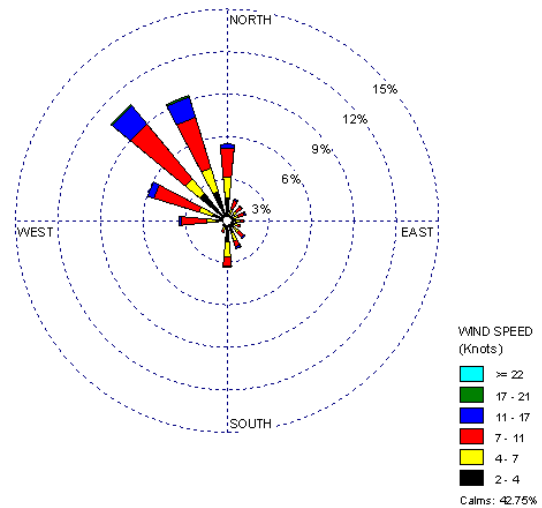
2010 Wind Rose

2010 Sample Day Wind Rose
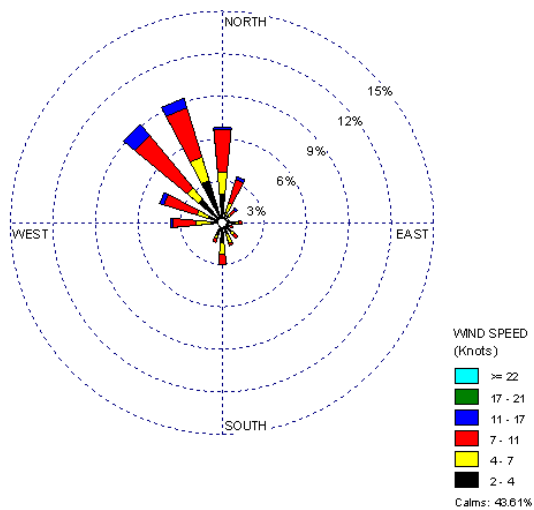
Distance between NBNJ and NWS Station
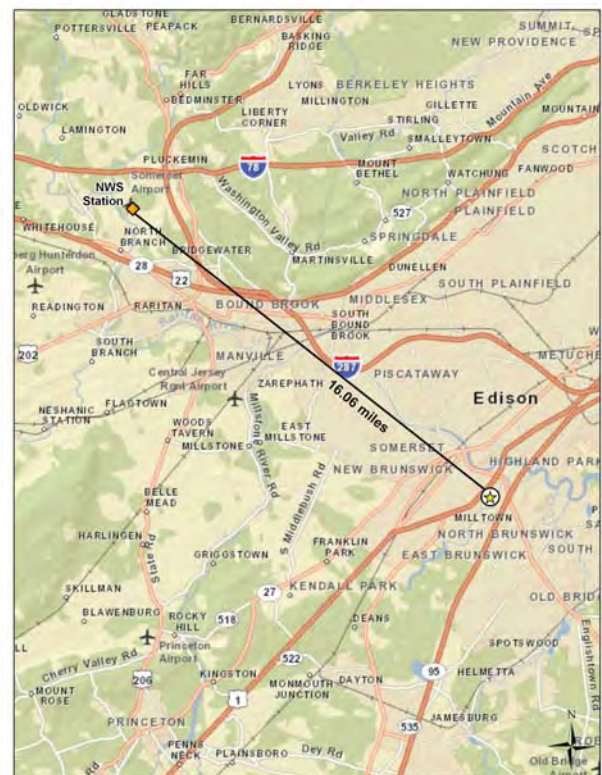
Figure 17-19. Wind Roses for the Essex County Airport Weather Station near PANJ

1999-2009 Historical Wind Rose
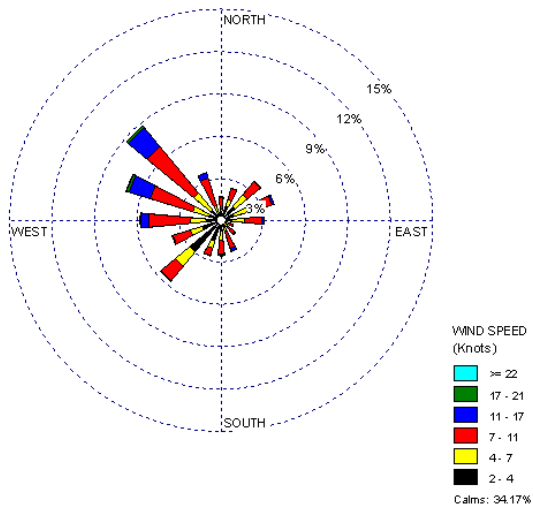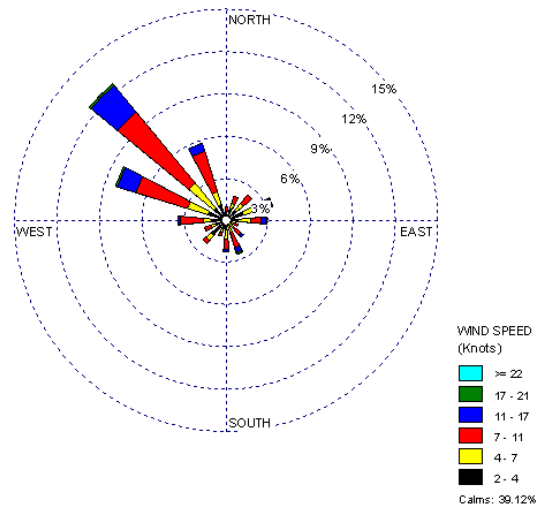
2010 Wind Rose

2010 Sample Day Wind Rose
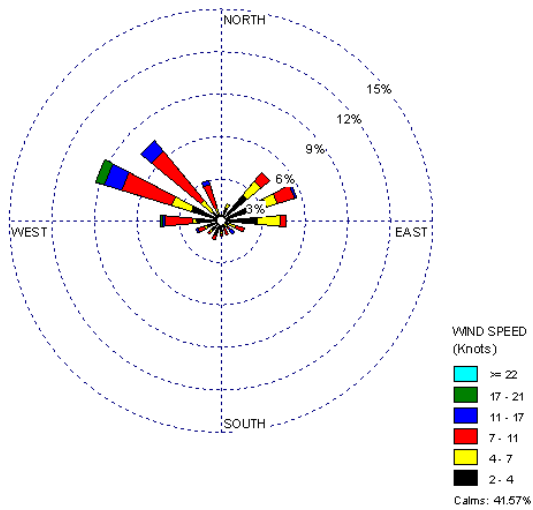
Distance between PANJ and NWS Station
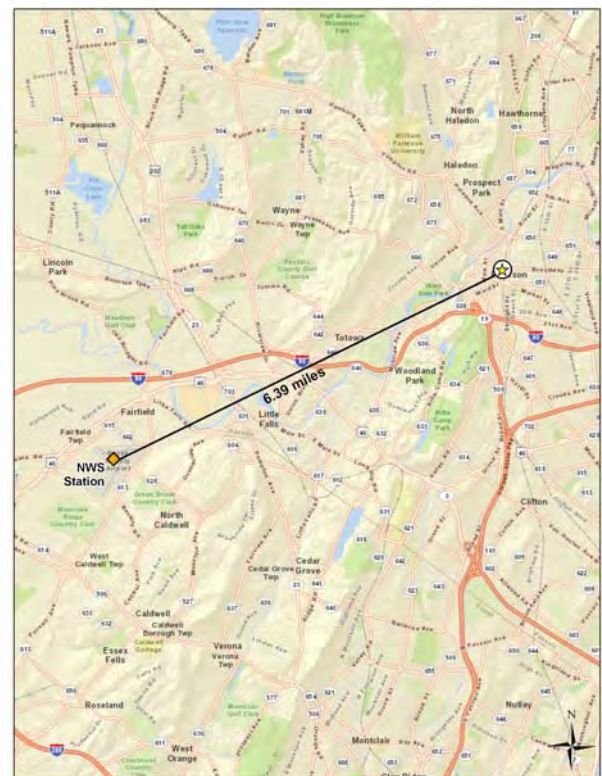
Observations from Figures 17-16 and 17-18 for CHNJ and NBNJ include the following:

- 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 the same because they are from the same weather station; thus, the wind roses are identical.

- 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, while winds from the southwest quadrant were rarely observed.

- Calm winds account for more than 40 percent of the wind observations throughout 2010 and on sample days in 2010. Winds from the northwest quadrant, including northerly and westerly winds, account for another one-third of wind observations throughout 2010 and on sample days. Winds on sample days resemble the full-year wind patterns, indicating that conditions in 2010 were similar to conditions experienced near these sites over the course of 2010.

- While the 2010 wind roses and 2010 sample day wind roses do exhibit the same prevalence for calm winds as the historical wind roses, 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 is made for 2009 in the 2008-2009 NMP report.

Observations from Figure 17-17 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 and southeasterly winds were observed less frequently. Calm winds were observed for just less than six percent of observations. The strongest winds were associated with westerly and northwesterly winds.

- The wind patterns shown on the 2010 wind rose generally resemble the historical wind patterns, as do the sample day wind patterns for 2010, although the percentages vary slightly across the wind directions. This indicates that conditions on sample days were representative of those experienced over the entire year and historically.

Observations from Figure 17-19 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 bulk of winds greater than 2 knots, particularly winds from the west-northwest to northwest. The strongest winds were associated with westerly to northwesterly winds.

- The 2010 wind rose shows that calm winds accounted for nearly 40 percent of wind observations in 2010 and that west-northwesterly to north-northwesterly winds account for the bulk of wind observations greater than 2 knots. This represents a northward shift in the predominant wind direction from the historical wind patterns near PANJ.

- The sample day wind rose for PANJ exhibits several differences from the historical and full-year wind roses. The sample day wind rose has an even higher percentage of calm winds. There is also a higher percentage of winds from the northeast to east and fewer from the west and northwest. This wind rose likely reflects a seasonal pattern and is the result of the exclusion of wind observations from the first quarter (and part of April) 2010 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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 17-4 presents the pollutants of interest 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 VOC and carbonyl compounds while PANJ sampled for VOC only.

Table 17-4. Risk Screening Results for the New Jersey Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Chester, New Jersey - CHNJ						
Formaldehyde	0.077	59	59	100.00	21.38	21.38
Acetaldehyde	0.45	58	59	98.31	21.01	42.39
Benzene	0.13	57	57	100.00	20.65	63.04
Carbon Tetrachloride	0.17	57	57	100.00	20.65	83.70
Acrylonitrile	0.015	16	16	100.00	5.80	89.49
1,2-Dichloroethane	0.038	14	14	100.00	5.07	94.57
1,3-Butadiene	0.03	8	17	47.06	2.90	97.46
1,2-Dibromoethane	0.0017	2	2	100.00	0.72	98.19
p-Dichlorobenzene	0.091	2	12	16.67	0.72	98.91
Chloromethylbenzene	0.02	1	1	100.00	0.36	99.28
Hexachloro-1,3-butadiene	0.045	1	1	100.00	0.36	99.64
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.36	100.00
Total		276	296	93.24		
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	0.45	59	59	100.00	15.25	15.25
Benzene	0.13	59	59	100.00	15.25	30.49
1,3-Butadiene	0.03	59	59	100.00	15.25	45.74
Formaldehyde	0.077	59	59	100.00	15.25	60.98
Carbon Tetrachloride	0.17	58	58	100.00	14.99	75.97
Ethylbenzene	0.4	32	59	54.24	8.27	84.24
p-Dichlorobenzene	0.091	25	44	56.82	6.46	90.70
1,2-Dichloroethane	0.038	11	11	100.00	2.84	93.54
Acrylonitrile	0.015	10	10	100.00	2.58	96.12
Propionaldehyde	0.8	10	59	16.95	2.58	98.71
1,2-Dibromoethane	0.0017	2	2	100.00	0.52	99.22
Chloroprene	0.0021	1	1	100.00	0.26	99.48
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.26	99.74
Trichloroethylene	0.2	1	22	4.55	0.26	100.00
Total		387	503	76.94		
New Brunswick, New Jersey - NBNJ						
Acetaldehyde	0.45	58	58	100.00	18.13	18.13
Formaldehyde	0.077	58	58	100.00	18.13	36.25
Benzene	0.13	55	55	100.00	17.19	53.44
Carbon Tetrachloride	0.17	54	54	100.00	16.88	70.31
1,3-Butadiene	0.03	46	53	86.79	14.38	84.69
Acrylonitrile	0.015	23	23	100.00	7.19	91.88
1,2-Dichloroethane	0.038	11	11	100.00	3.44	95.31
p-Dichlorobenzene	0.091	9	33	27.27	2.81	98.13
Ethylbenzene	0.4	3	55	5.45	0.94	99.06
1,2-Dibromoethane	0.0017	1	1	100.00	0.31	99.38
Hexachloro-1,3-butadiene	0.045	1	1	100.00	0.31	99.69
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.31	100.00
Total		320	403	79.40		

Table 17-4. Risk Screening Results for the New Jersey Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Paterson, New Jersey - PANJ						
Benzene	0.13	21	21	100.00	20.00	20.00
1,3-Butadiene	0.03	21	21	100.00	20.00	40.00
Carbon Tetrachloride	0.17	21	21	100.00	20.00	60.00
p-Dichlorobenzene	0.091	21	21	100.00	20.00	80.00
Ethylbenzene	0.4	17	21	80.95	16.19	96.19
1,2-Dichloroethane	0.038	2	2	100.00	1.90	98.10
1,2-Dibromoethane	0.0017	1	1	100.00	0.95	99.05
Trichloroethylene	0.2	1	8	12.50	0.95	100.00
Total		105	116	90.52		

Observations from Table 17-4 include the following:

- Twelve pollutants failed at least one screen for CHNJ, of which five are NATTS MQO Core Analytes; 14 failed screens for ELNJ (six are NATTS MQO Core Analytes); 12 failed screens for NBNJ (five are NATTS MQO Core Analytes); and eight failed screens for PANJ (four are NATTS MQO Core Analytes).

- The risk screening process identified seven pollutants of interest for CHNJ (of which five are NATTS MQO Core Analytes). Chloroform, tetrachloroethylene, and trichloroethylene 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.Vinyl chloride is also a NATTS MQO Core Analyte, but was not added as a pollutant of interest because it was not detected at CHNJ.

- The risk 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.

- The risk screening process identified seven 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.

- The risk screening process identified five pollutants of interest for PANJ (of which three 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 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.

- The total failure rate ranged from 76.94 percent for ELNJ to 93.24 percent for CHNJ (of the pollutants with at least one failed screen).

17.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the New Jersey monitoring sites. Concentration averages are provided for the pollutants of interest for each New Jersey site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site, where applicable. Additional site-specific statistical summaries are provided in Appendices J and L.

17.4.1 2010 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Chester, New Jersey - CHNJ						
Acetaldehyde	59/59	1.72 ± 0.43	1.76 ± 0.36	0.90 ± 0.21	0.83 ± 0.21	1.31 ± 0.19
Acrylonitrile	16/57	0.01 ± 0.02	0.03 ± 0.03	0.06 ± 0.05	0.04 ± 0.03	0.04 ± 0.02
Benzene	57/57	0.51 ± 0.09	0.48 ± 0.1	0.41 ± 0.05	0.50 ± 0.07	0.48 ± 0.04
1,3-Butadiene	17/57	<0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.01	0.01 ± <0.01
Carbon Tetrachloride	57/57	0.66 ± 0.08	0.66 ± 0.07	0.65 ± 0.06	0.60 ± 0.05	0.64 ± 0.03
Chloroform	48/57	0.04 ± 0.02	0.11 ± 0.01	0.13 ± 0.02	0.07 ± 0.02	0.08 ± 0.01
1,2-Dichloroethane	14/57	0.04 ± 0.02	0.03 ± 0.02	0	0	0.02 ± 0.01
Formaldehyde	59/59	0.93 ± 0.32	2.20 ± 0.71	2.29 ± 0.76	1.19 ± 0.32	1.64 ± 0.31
Tetrachloroethylene	39/57	0.03 ± 0.02	0.09 ± 0.02	0.10 ± 0.05	0.06 ± 0.03	0.07 ± 0.02
Trichloroethylene	4/57	0	<0.01 ± 0.01	0.01 ± 0.01	0	<0.01 ± <0.01
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	59/59	2.27 ± 0.97	3.62 ± 0.87	2.75 ± 0.53	2.24 ± 0.61	2.73 ± 0.39
Acrylonitrile	10/59	0.03 ± 0.03	0.01 ± 0.03	0.02 ± 0.03	0.02 ± 0.02	0.02 ± 0.01
Benzene	59/59	0.87 ± 0.14	1.18 ± 0.28	1.02 ± 0.38	1.01 ± 0.15	1.02 ± 0.13
1,3-Butadiene	59/59	0.11 ± 0.03	0.14 ± 0.02	0.10 ± 0.01	0.14 ± 0.03	0.12 ± 0.01
p-Dichlorobenzene	44/59	0.04 ± 0.03	0.11 ± 0.03	0.13 ± 0.03	0.06 ± 0.04	0.09 ± 0.02
Carbon Tetrachloride	58/59	0.60 ± 0.12	0.59 ± 0.06	0.61 ± 0.06	0.60 ± 0.09	0.60 ± 0.04
Chloroform	51/59	0.06 ± 0.04	0.16 ± 0.02	0.19 ± 0.03	0.10 ± 0.03	0.13 ± 0.02
1,2-Dichloroethane	11/59	0.03 ± 0.02	0.03 ± 0.02	0	0	0.02 ± 0.01
Ethylbenzene	59/59	0.28 ± 0.07	0.51 ± 0.08	0.49 ± 0.07	0.39 ± 0.07	0.42 ± 0.04
Formaldehyde	59/59	3.83 ± 1.73	5.64 ± 1.35	4.82 ± 1.06	3.47 ± 0.71	4.46 ± 0.64
Propionaldehyde	59/59	0.40 ± 0.21	0.78 ± 0.19	0.59 ± 0.13	0.38 ± 0.09	0.54 ± 0.09
Tetrachloroethylene	58/59	0.15 ± 0.05	0.22 ± 0.05	0.25 ± 0.07	0.18 ± 0.05	0.20 ± 0.03

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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Trichloroethylene	22/59	0.02 ± 0.03	0.04 ± 0.02	0.05 ± 0.03	0.01 ± 0.01	0.03 ± 0.01
Vinyl Chloride	2/59	<0.01 ± <0.01	<0.01 ± <0.01	0	0	<0.01 ± <0.01
New Brunswick, New Jersey - NBNJ						
Acetaldehyde	58/58	2.15 ± 0.45	3.65 ± 0.77	3.42 ± 0.80	2.47 ± 0.77	2.92 ± 0.37
Acrylonitrile	23/55	0.04 ± 0.04	0.11 ± 0.07	0.35 ± 0.39	0.05 ± 0.04	0.14 ± 0.11
Benzene	55/55	0.72 ± 0.10	0.55 ± 0.07	0.59 ± 0.08	0.75 ± 0.12	0.65 ± 0.05
1,3-Butadiene	53/55	0.05 ± 0.02	0.04 ± 0.01	0.04 ± 0.01	0.07 ± 0.02	0.05 ± 0.01
Carbon Tetrachloride	54/55	0.56 ± 0.17	0.54 ± 0.06	0.61 ± 0.06	0.53 ± 0.10	0.56 ± 0.05
Chloroform	49/55	0.07 ± 0.06	0.12 ± 0.01	0.18 ± 0.03	0.12 ± 0.02	0.12 ± 0.02
1,2-Dichloroethane	11/55	0.03 ± 0.02	0.03 ± 0.02	<0.01 ± 0.01	0	0.02 ± 0.01
Formaldehyde	58/58	1.86 ± 0.34	2.36 ± 0.54	1.30 ± 0.32	1.01 ± 0.14	1.63 ± 0.22
Tetrachloroethylene	52/55	0.10 ± 0.03	0.12 ± 0.02	0.14 ± 0.03	0.13 ± 0.04	0.12 ± 0.01
Trichloroethylene	18/55	<0.01 ± 0.01	0.02 ± 0.02	0.03 ± 0.02	0.02 ± 0.02	0.02 ± 0.01
Vinyl Chloride	6/55	0	<0.01 ± <0.01	<0.01 ± <0.01	0.01 ± 0.01	<0.01 ± <0.01
Paterson, New Jersey - PANJ						
Benzene	21/21	NA	NA	1.15 ± 0.27	1.66 ± 0.33	NA
1,3-Butadiene	21/21	NA	NA	0.17 ± 0.05	0.32 ± 0.09	NA
Carbon Tetrachloride	21/21	NA	NA	0.63 ± 0.16	0.61 ± 0.09	NA
Chloroform	18/21	NA	NA	0.21 ± 0.09	0.20 ± 0.12	NA
p-Dichlorobenzene	21/21	NA	NA	0.33 ± 0.14	0.30 ± 0.10	NA
Ethylbenzene	21/21	NA	NA	0.75 ± 0.16	0.65 ± 0.20	NA
Tetrachloroethylene	20/21	NA	NA	0.26 ± 0.19	0.41 ± 0.16	NA
Trichloroethylene	8/21	NA	NA	0.04 ± 0.04	0.04 ± 0.06	NA
Vinyl Chloride	2/21	NA	NA	0	<0.01 ± 0.01	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. Note that only the two carbonyl compounds have annual average concentrations greater than 1 $\mu g/m^3$.

- Some of the pollutants of interest for CHNJ exhibit a quarterly trend, such as chloroform, which tended to be higher during the warmer months. Formaldehyde and tetrachloroethylene exhibit similar tendencies, although the confidence intervals indicate the differences are not statistically significant.

- The first and second quarter average concentrations for acetaldehyde are higher than the third and fourth quarter average concentrations. Of the nine concentrations of acetaldehyde greater than 2 $\mu g/m^3$, all but one was measured during the first or second quarter of 2010 (five in the first quarter and three in the second).

- 1,2-Dichloroethane exhibits a quarterly tendency similar to acetaldehyde, although it is reflected in Table 17-5 in a different way. 1,2-Dichloroethane was detected at total of 14 times in 2010, of which all were measured during the first and second quarters of 2010; thus, this pollutant was not detected at all during the second half of the year.

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 $\mu g/m^3$. The annual average concentration of formaldehyde for ELNJ is nearly three times higher than the annual average concentrations of formaldehyde for CHNJ and NBNJ.

- 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 second and third quarter average concentrations. However, most of the differences are not statistically significant. Chloroform is the only pollutant for which the differences are deemed significant.

- Concentrations of the three carbonyl compound pollutants of interest are greatest for the second quarter of 2010. A review of the data shows that the two highest concentrations of each of these pollutants were measured on March 21, 2010 and May 20, 2010. ELNJ's March 21, 2010 concentration (14.7 $\mu g/m^3$) is the fifth highest formaldehyde concentration among all NMP sites sampling formaldehyde (and its May 20, 2010 concentration, 12.6 $\mu g/m^3$ ranks ninth). ELNJ's acetaldehyde concentrations for these two dates rank similarly among the program-wide measurements of this pollutant. The propionaldehyde concentrations rank third and fourth highest among NMP sites sampling carbonyl compounds.

- 1,2-Dichloroethane exhibited a quarterly tendency for ELNJ as it did for CHNJ; this pollutant was detected at total of 11 times at ELNJ, of which all were measured during the first and second quarters of 2010; thus, this pollutant was not detected at

all during the second half of the year. Nine of the 11 measured detections of 1,2-dichloroethane at ELNJ were measured between February and April 2010.

Observations for NBNJ from Table 17-5 include the following:

- The pollutants of interest with the highest annual average concentrations by mass are acetaldehyde, formaldehyde, and benzene. Acetaldehyde and formaldehyde are the only pollutants with annual average concentrations greater than 1 µg/m^3. The annual average concentration of acetaldehyde for NBNJ is the highest among the three New Jersey sites sampling this pollutant.

- The third quarter average concentration of acrylonitrile is significantly higher than the other quarterly averages and has a large confidence interval associated with it, indicating that the concentration average is likely influenced by outliers. The maximum concentration of acrylonitrile is 2.96 µg/m^3 and was measured on July 7, 2010. This concentration is seven times the next highest concentration measured at NBNJ (0.422 µg/m^3 measured on August 6, 2010). The July 7, 2010 acrylonitrile concentration for NBNJ is the highest concentration of this pollutant measured among NMP sites sampling VOC. The highest concentration of acetaldehyde was also measured at NBNJ on this date.

- Chloroform concentrations also appear higher during the summer months at NBNJ compared to the rest of the year, although the relatively high confidence interval for the first quarter 2010 average indicates that there is more variability in the chloroform measurements at NBNJ than the other New Jersey sites. A review of the data shows that the highest concentration of chloroform was measured on February 7, 2010 (0.391 µg/m^3). However, of the eight concentrations greater than 0.175 µg/m^3 measured at NBNJ, most were measured during the third quarter of 2010.

- 1,2-Dichloroethane exhibited the same quarterly tendency at NBNJ as it did for CHNJ and ELNJ, although there was one measured detection in the third quarter of 2010. The bulk of the measured detections of 1,2-dichloroethane at NBNJ were measured between March and April 2010.

Observations for PANJ from Table 17-5 include the following:

- VOC sampling at PANJ began at the end of April 2010. Thus, first quarter average concentrations could not be calculated. Second quarter concentrations were also not calculated because there were not enough samples collected to meet the completeness criteria. Although enough make-up samples were collected during the second half of 2010 for third and fourth quarter average concentrations to be calculated, annual average concentrations were not calculated for PANJ because there were not at least three quarterly averages available. However, Appendix J provides the pollutant-specific average concentration for all valid samples collected at PANJ 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 New Jersey sites from those tables include the following:

- The New Jersey sites appear in Table 4-9 for VOC a total of 13 times (CHNJ - 3; ELNJ - 6; and NBNJ - 4). However, the highest rankings for the New Jersey sites are for NBNJ, which has the third highest annual average concentration of acrylonitrile among NMP sites sampling VOC and CHNJ, which has the third highest annual average concentration of 1,2-dichloroethane among NMP sites sampling VOC.

- The New Jersey sites appear in Table 4-10 for carbonyl compounds three times. NBNJ and ELNJ have the fourth and fifth highest annual average concentrations of acetaldehyde, respectively, while ELNJ has the highest annual average concentration of formaldehyde.

17.4.2 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, 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 17-20 through 17-23 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 17-20. Program vs. Site-Specific Average Acetaldehyde Concentration
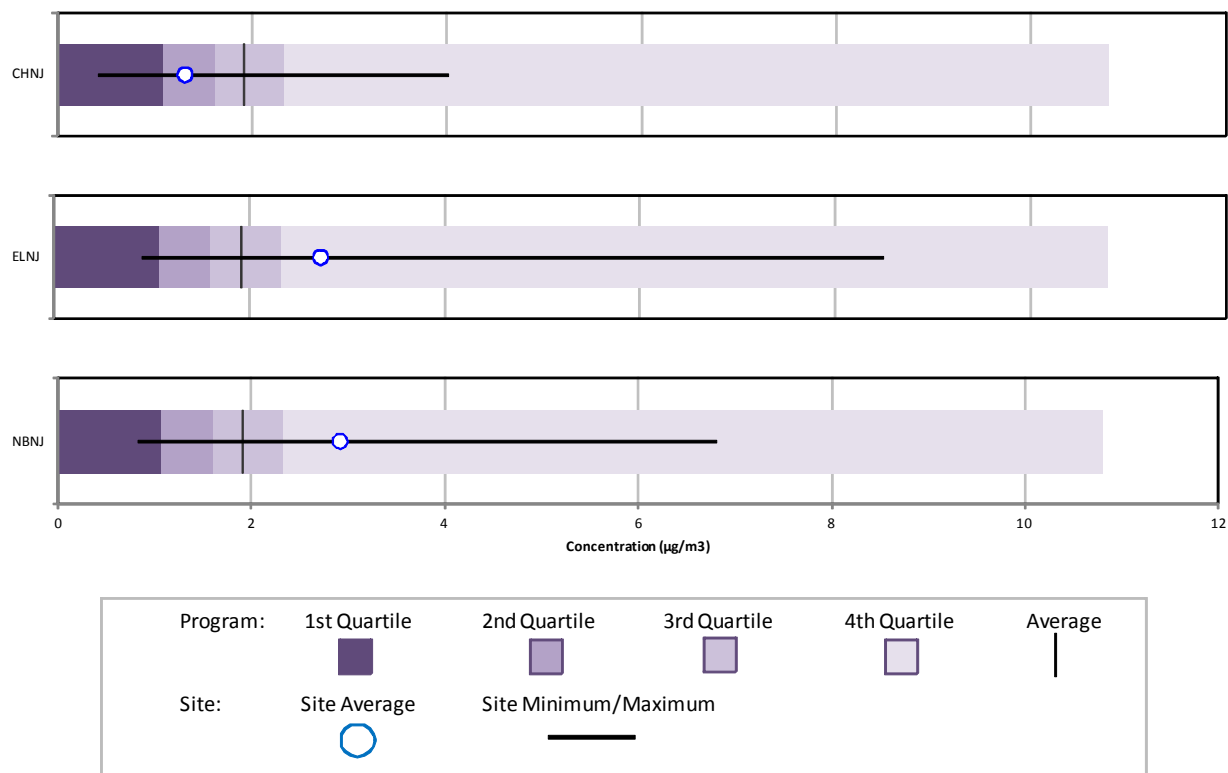
Figure 17-21. Program vs. Site-Specific Average Benzene Concentration
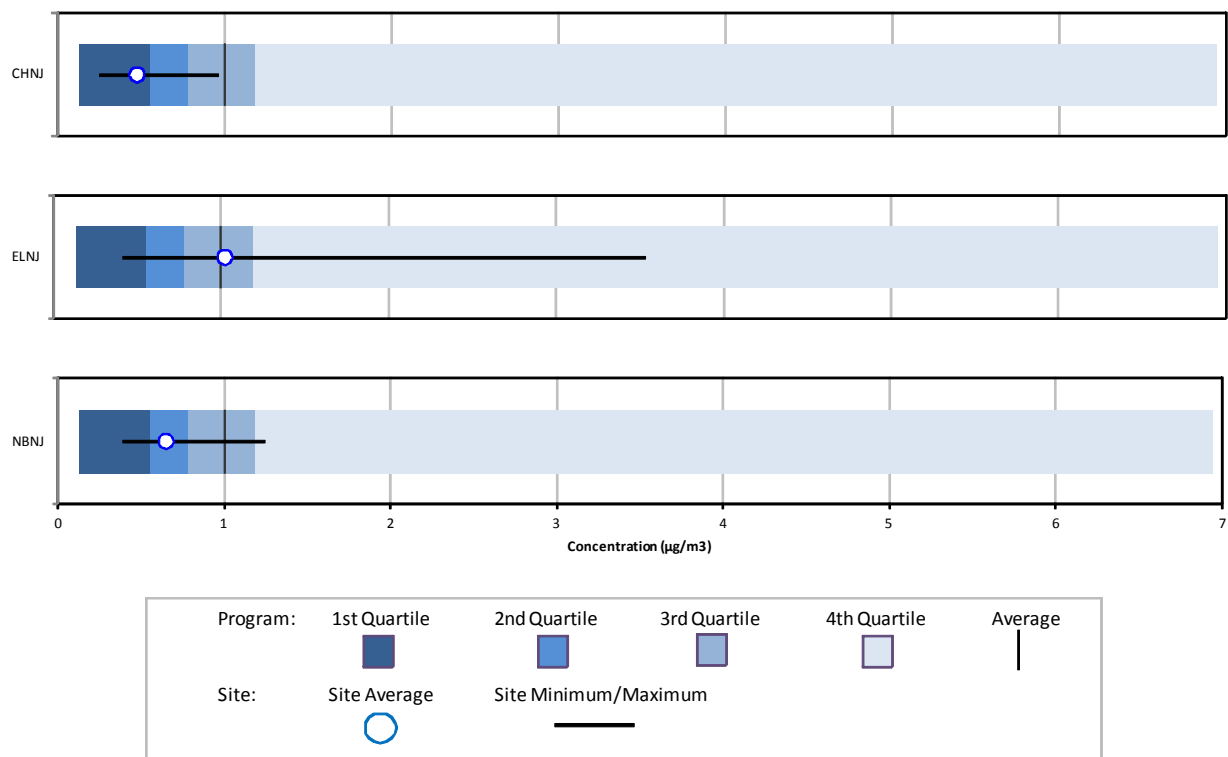
Figure 17-22. Program vs. Site-Specific Average 1,3-Butadiene Concentration
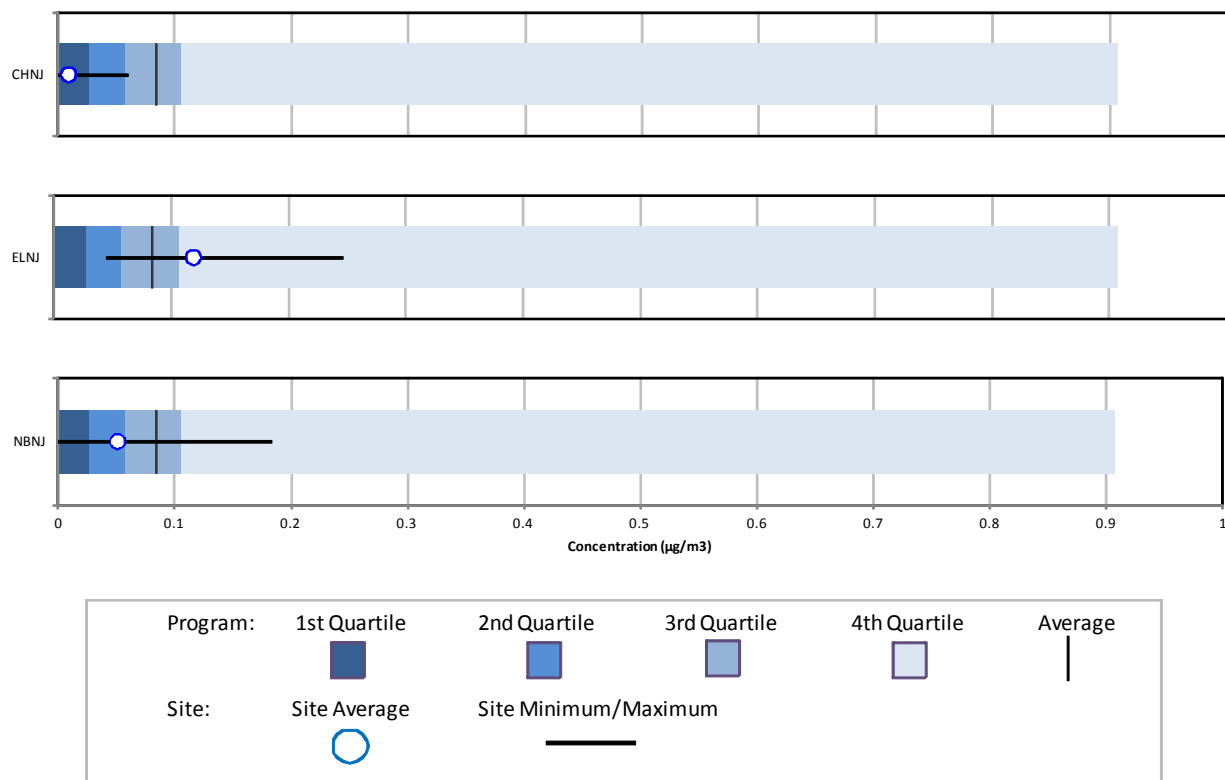
Figure 17-23. Program vs. Site-Specific Average Formaldehyde Concentration
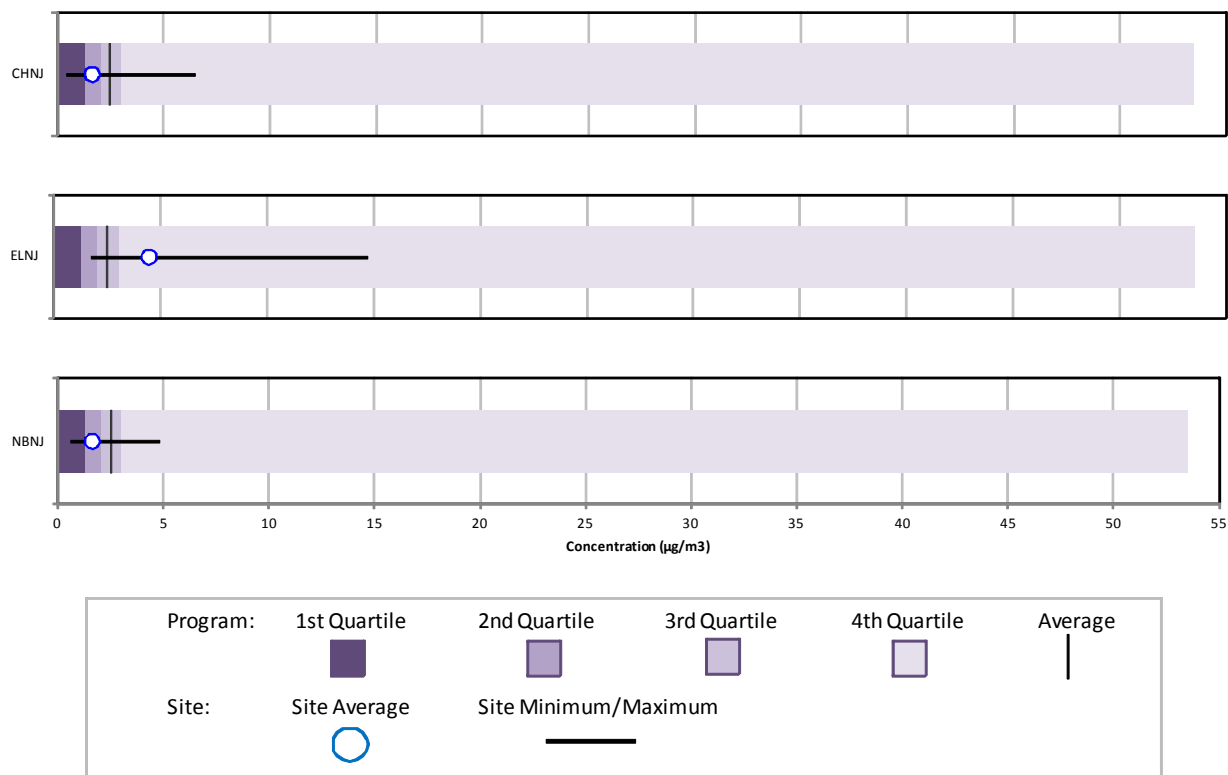
Observations from Figures 17-20 through 17-23 include the following:

- Figure 17-20 shows that while CHNJ's annual average acetaldehyde concentration is below the program-level average for acetaldehyde, the annual averages for ELNJ and NBNJ are greater than the program-level average concentration. The range of acetaldehyde measurements is greatest for ELNJ and least for CHNJ. There were no non-detects of acetaldehyde measured at any of these sites.

- Figure 17-21 for benzene shows that both the annual average and maximum benzene concentration for CHNJ are less than the program-level average. This site has the second lowest annual average benzene concentration among sites sampling benzene. NBNJ's annual average benzene concentration is also below the program-level average while ELNJ's annual average is just greater than the program-level average concentration. There were no non-detects of benzene measured at any of these sites.

- Figure 17-22 for 1,3-butadiene resembles Figure 17-21 for benzene. Both the annual average and maximum 1,3-butadiene concentrations for CHNJ are less than the program-level average concentration. Further, the maximum 1,3-butadiene concentration for CHNJ is just greater than the program-level median (or 50th percentile). This site has the third lowest annual average 1,3-butadiene concentration among sites sampling this pollutant. NBNJ's annual average 1,3-butadiene concentration is also less than the program-level average. Although ELNJ's annual average concentration is greater than the program-level average, the maximum benzene concentration measured at ELNJ is well below the program-level maximum concentration. Several non-detects of 1,3-butaidene were measured at CHNJ and NBNJ, but there were no non-detects of 1,3-butadiene measured at ELNJ.

- Figure 17-23 for formaldehyde shows that while the annual average concentrations of formaldehyde for CHNJ and NBNJ are below the program-level average, the annual average for ELNJ is greater than the program-level average concentration. Although ELNJ has the highest annual average formaldehyde concentration among NMP sites sampling carbonyl compounds, the maximum concentration of formaldehyde was not measured at ELNJ. There were no non-detects of formaldehyde measured at any of these sites.

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 VOC 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 17-24 through 17-35 present the 3-year rolling 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.

Figure 17-24. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at CHNJ
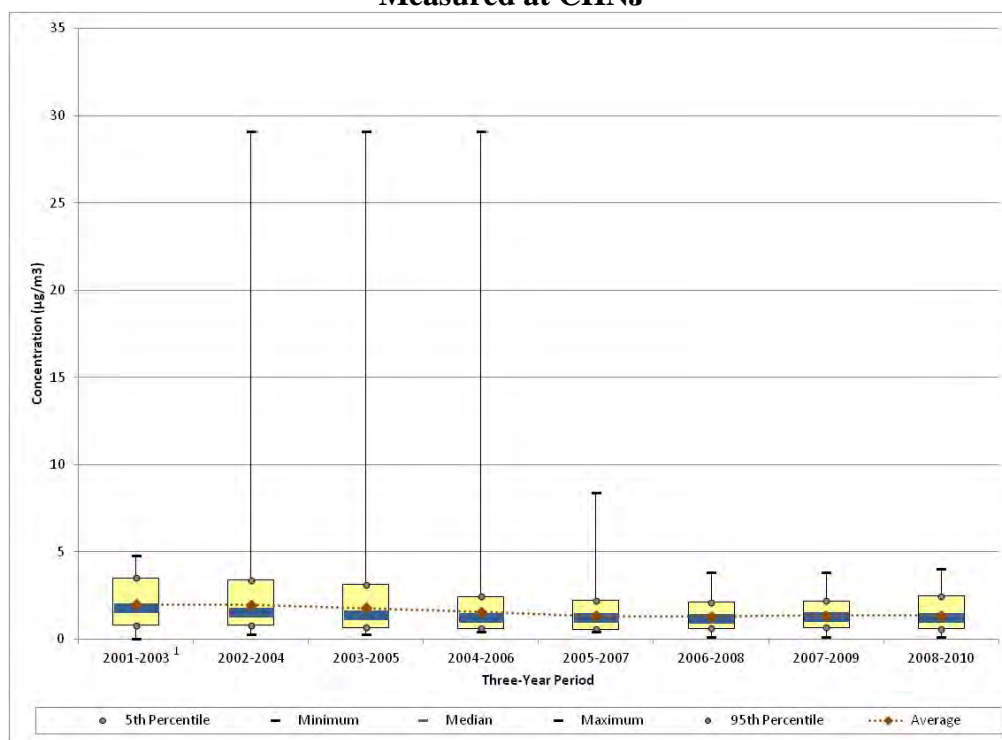
[1]Carbonyl compound sampling began in May 2001.

Figure 17-25. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at CHNJ
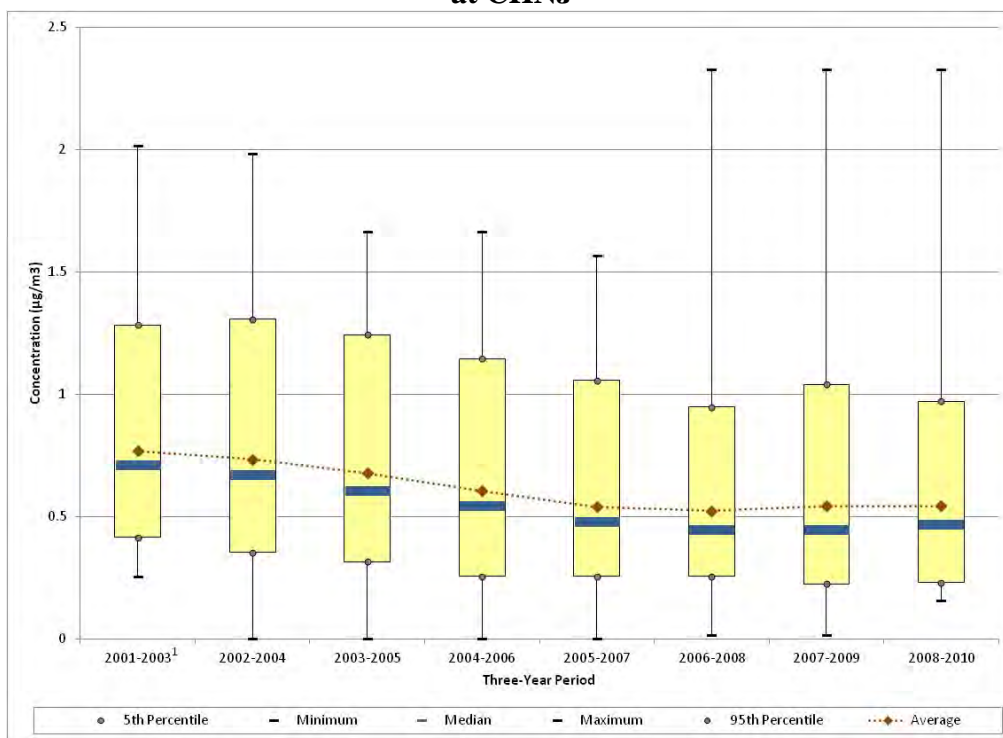
[1]VOC sampling began in May 2001.

Figure 17-26. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at CHNJ
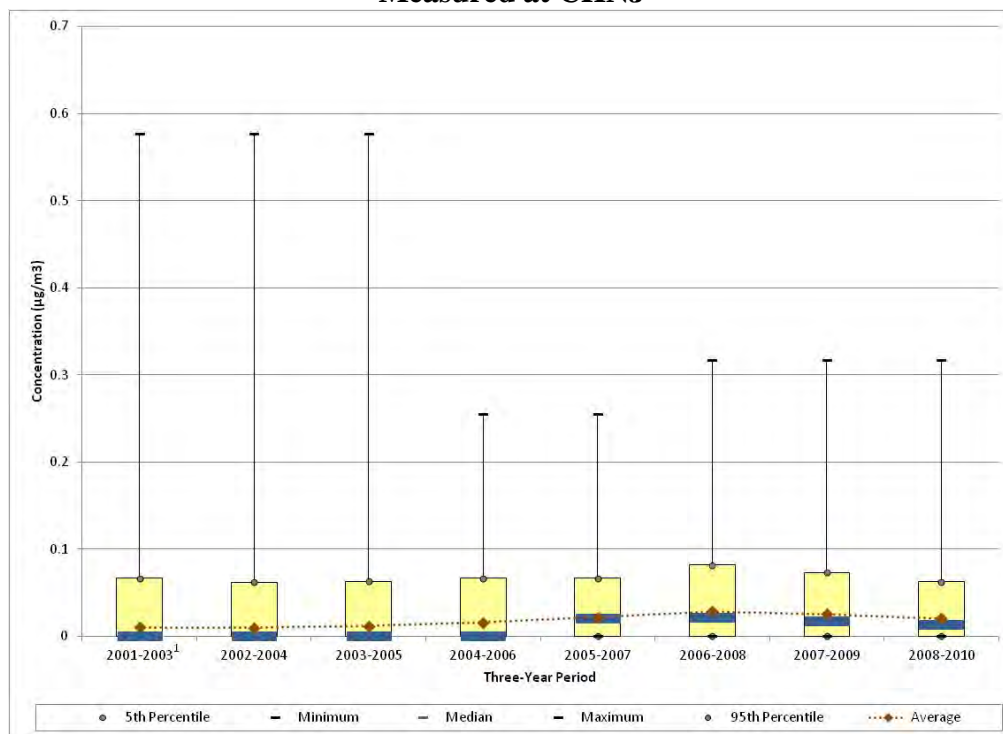
[1]VOC sampling began in May 2001.

Figure 17-27. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at CHNJ
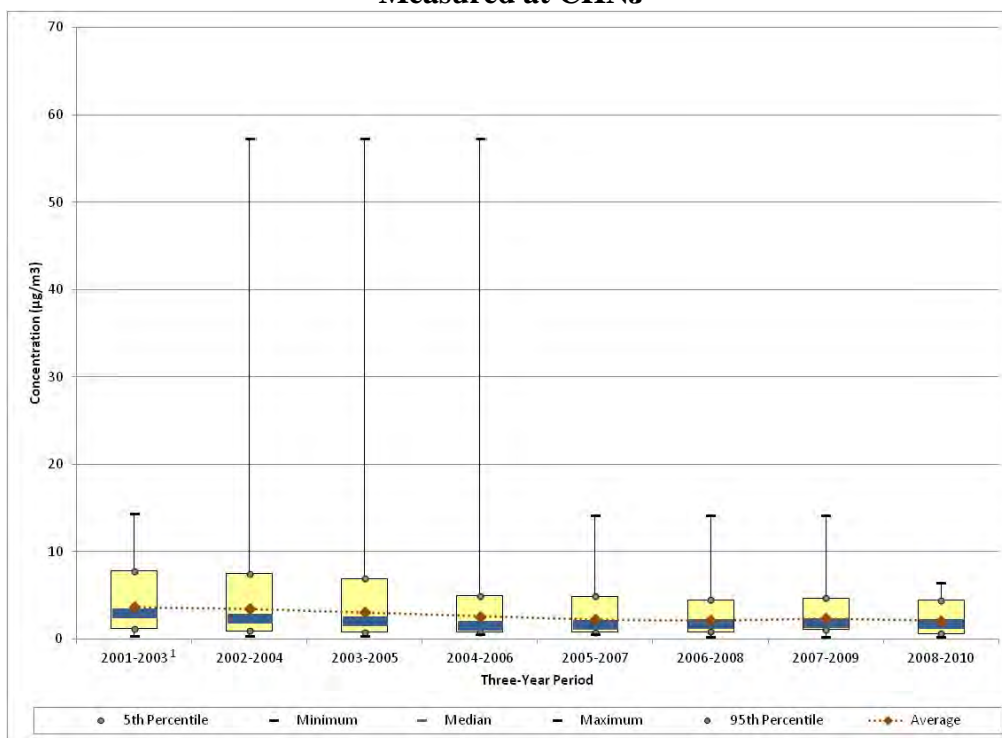
[1]Carbonyl compound sampling began in May 2001.

Figure 17-28. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at ELNJ
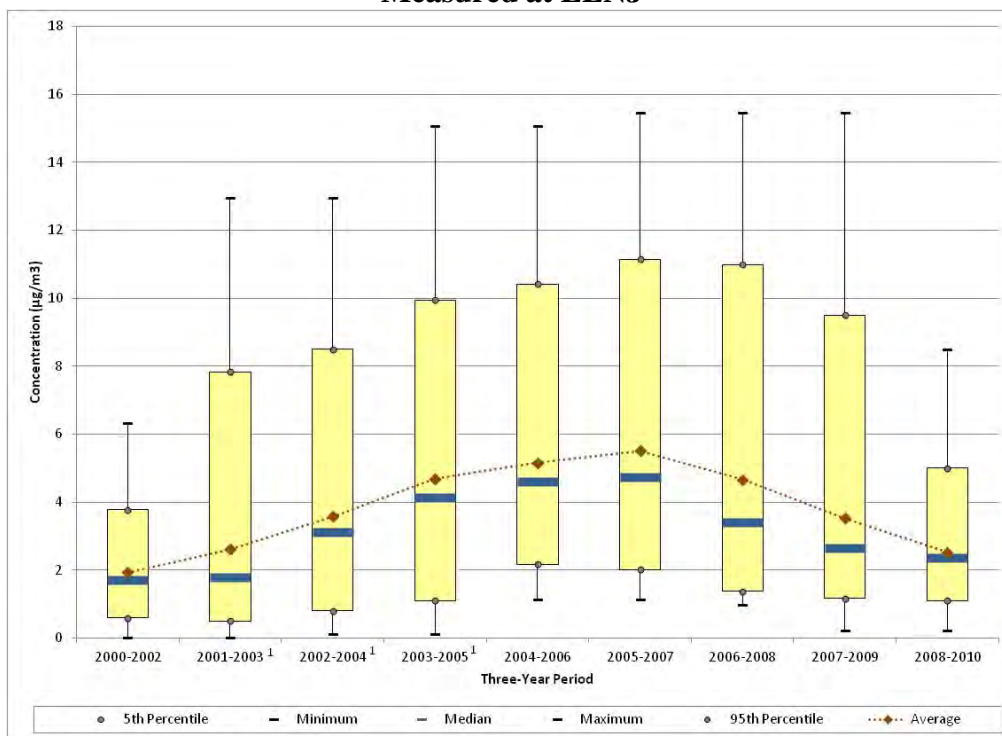
[1]Carbonyl compound samples were not collected in January 2003.

Figure 17-29. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at ELNJ
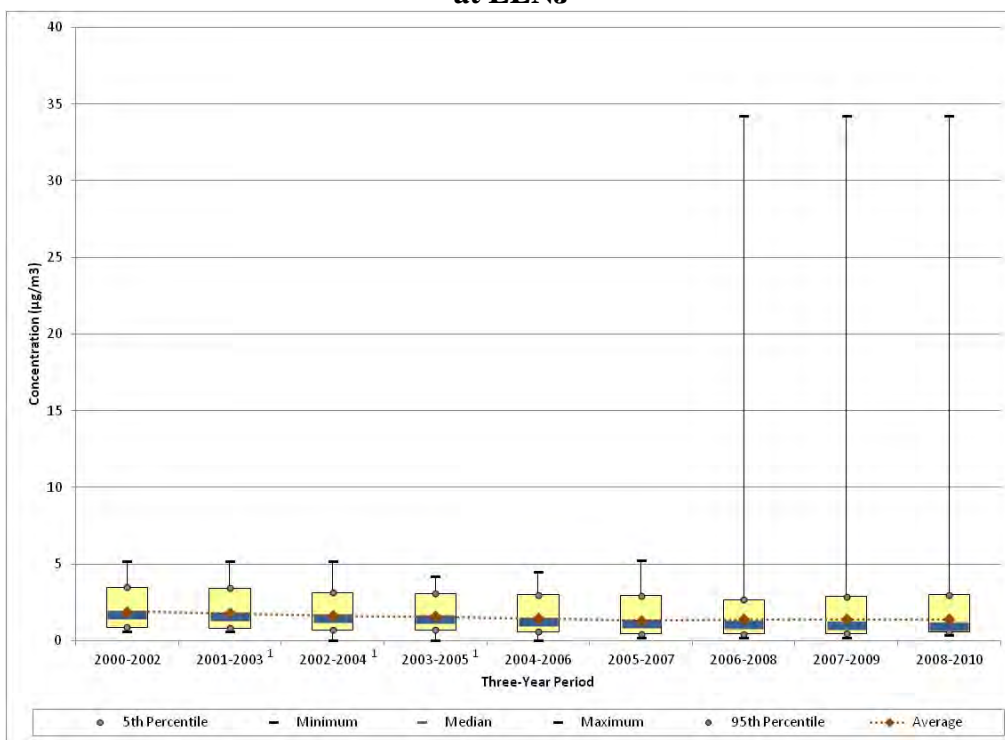
[1]VOC samples were not collected in January 2003.

Figure 17-30. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at ELNJ
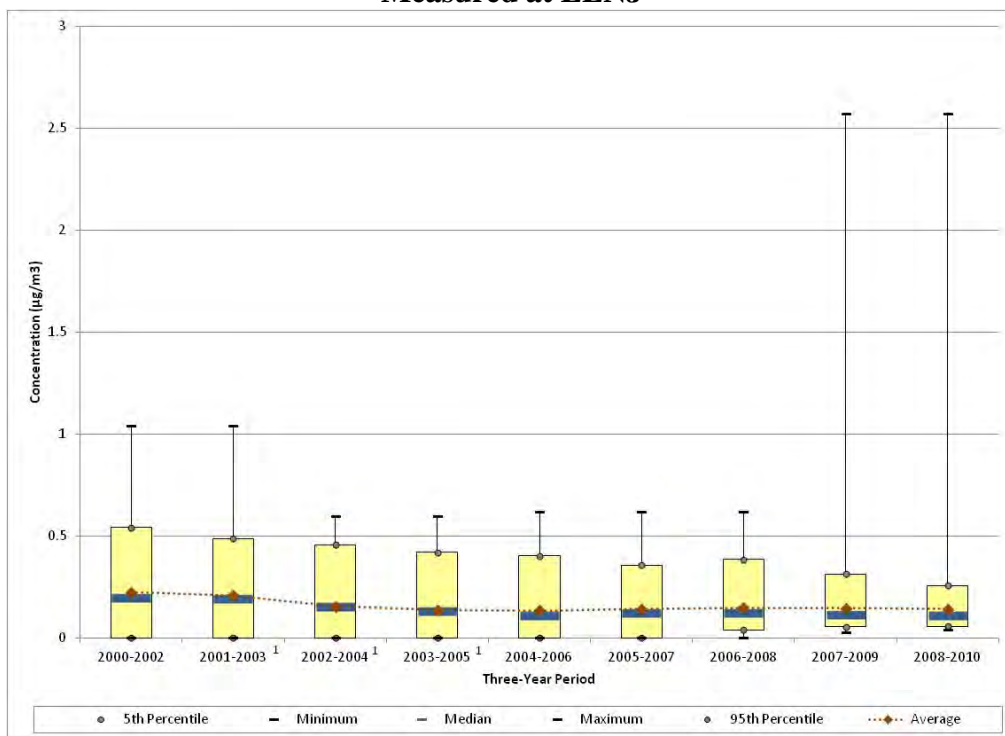
[1]VOC samples were not collected in January 2003.

Figure 17-31. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at ELNJ
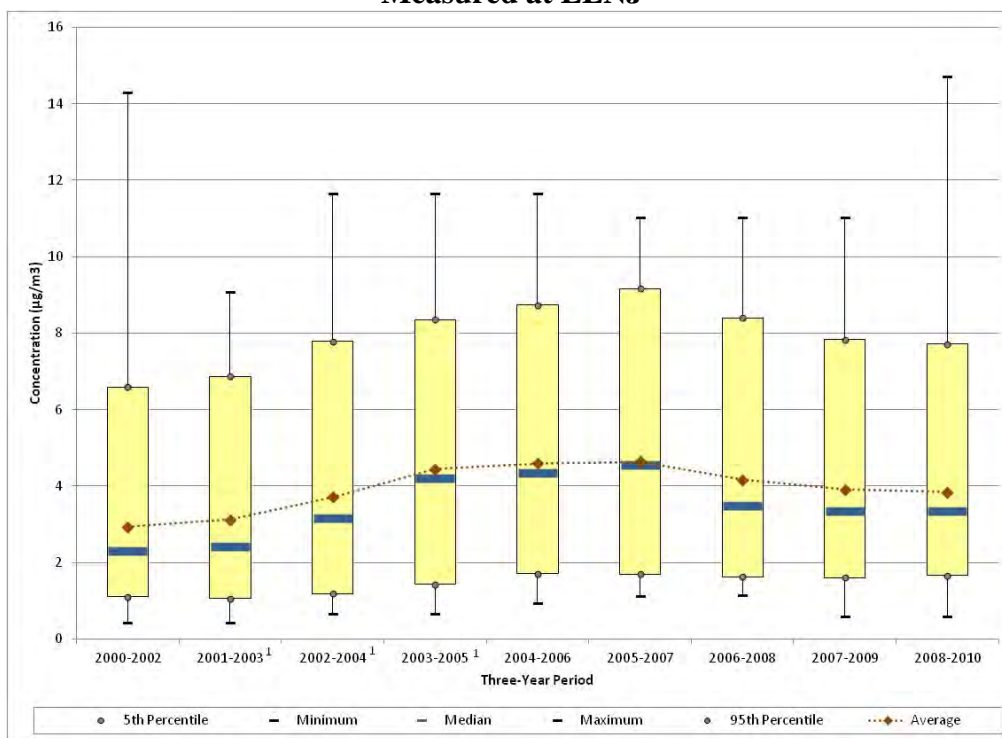
[1]Carbonyl compound samples were not collected in January 2003.

Figure 17-32. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at NBNJ
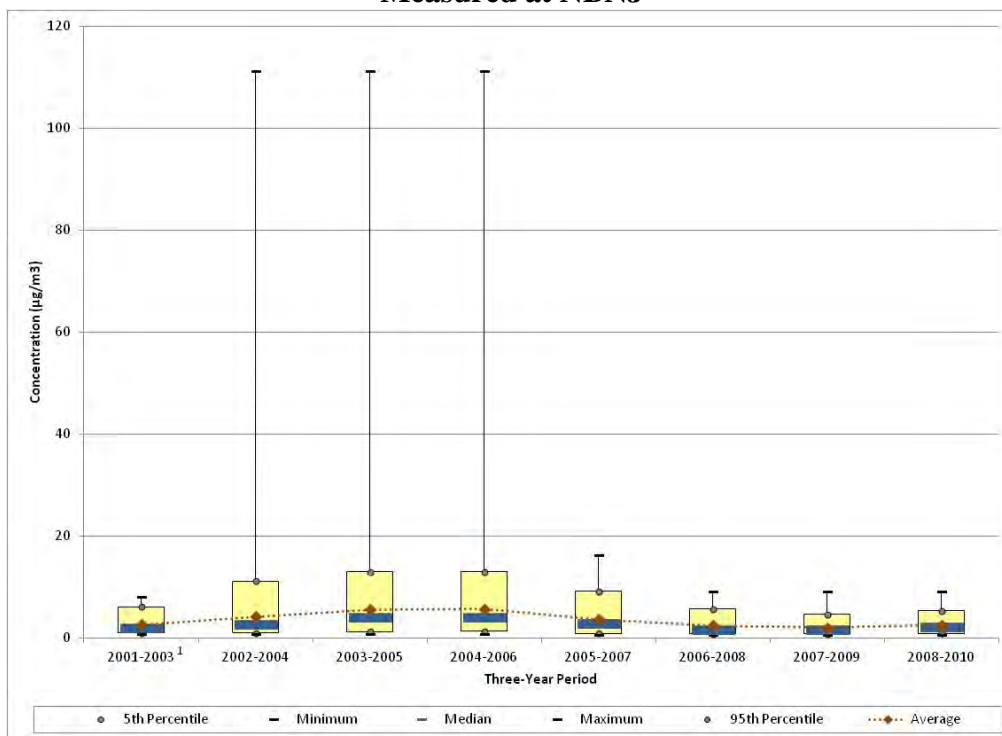
[1]Carbonyl compound sampling began May 2001.

Figure 17-33. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at NBNJ
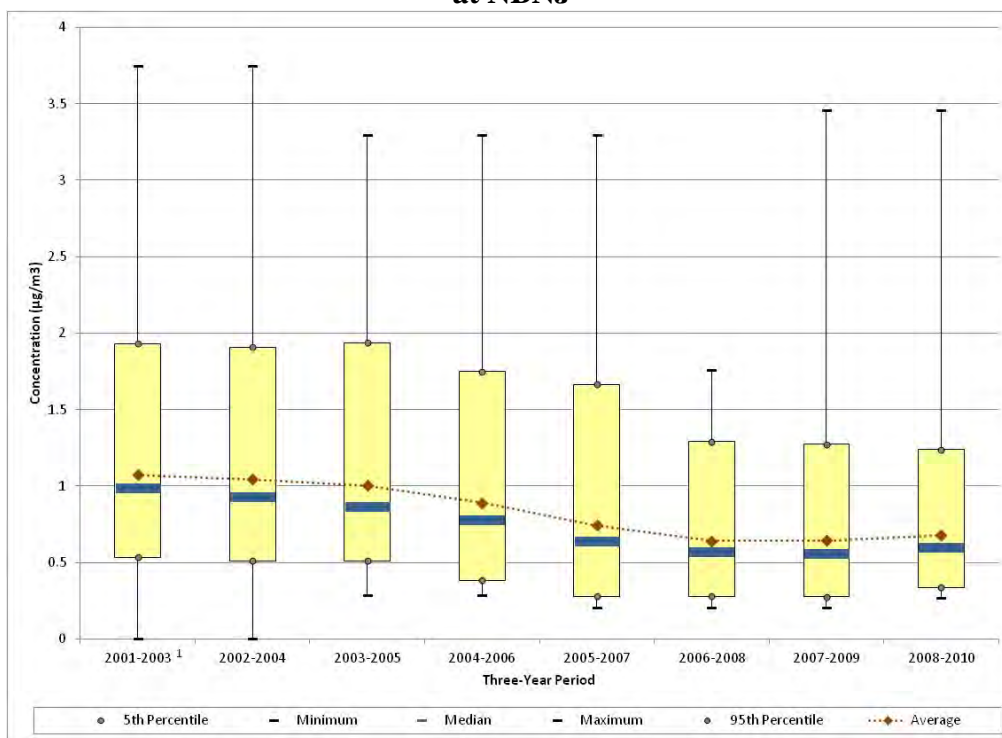
[1]VOC sampling began May 2001.

Figure 17-34. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at NBNJ
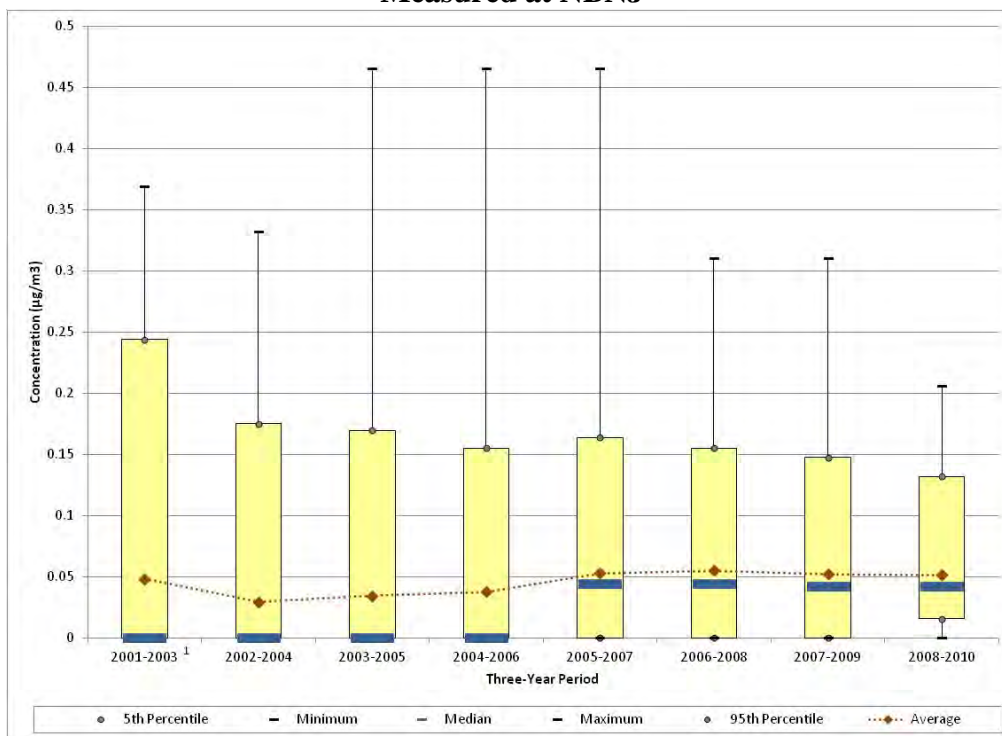
[1]VOC sampling began May 2001.

Figure 17-35. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at NBNJ
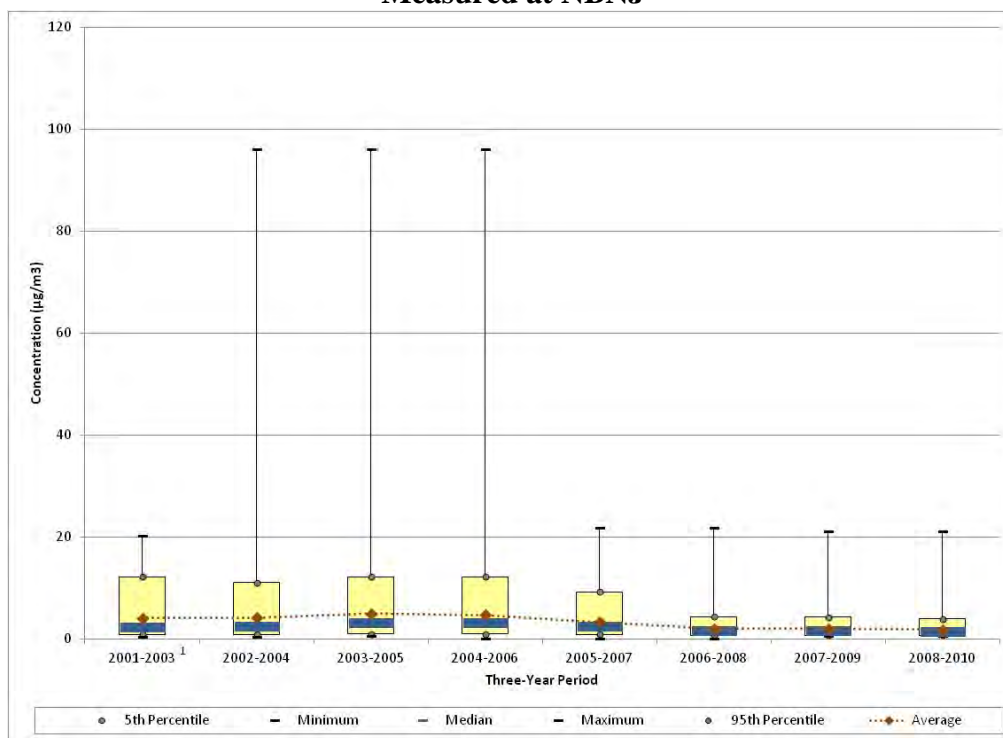
[1]Carbonyl compound sampling began May 2001.

Observations from Figure 17-24 for acetaldehyde measurements at CHNJ include the following:

- Carbonyl compound sampling at CHNJ began in May 2001.

- 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/m³.

- The rolling average and the median values were similar to each other for each time period after 2004-2006. This indicates decreasing variability in the central tendency of acetaldehyde concentrations measured at CHNJ over the periods shown.

- Although difficult to discern in Figure 17-24, a decreasing trend in the average and median acetaldehyde concentrations is shown since the onset of sampling, although both the median and average concentrations leveled out across the last few periods.

Observations from Figure 17-25 for benzene measurements at CHNJ include the following:

- Similar to carbonyl compounds, VOC sampling at CHNJ began in May 2001.

- The five highest benzene concentrations were measured in 2008 and 2009, although no benzene measurement at CHNJ was greater than 2.5 µg/m^3.

- The average and median concentrations exhibit a decreasing trend that levels out over the last few 3-year periods.

Observations from Figure 17-26 for 1,3-butadiene measurements at CHNJ include the following:

- The maximum 1,3-butadiene concentration was measured in 2003 and was nearly twice the next highest concentration, which was measured in 2008.

- The rolling average and median concentrations have an increasing trend through the 2006-2008 time frame and then begin a slight decreasing trend for the final time frames.

- The minimum, 5th percentile, and median concentrations were all zero through the 2004-2006 time frame, indicating the presence of non-detects (at least 50 percent). The number of non-detects reported has decreased through the years as the MDL has improved, from as high as 97 percent in 2001 to as low as 17 percent in 2008. The number of non-detects for 2010 is 70 percent.

Observations from Figure 17-27 for formaldehyde measurements at CHNJ include the following:

- The statistical metrics presented for formaldehyde are similar to those for acetaldehyde in Figure 17-24.

- The maximum formaldehyde concentration was measured in 2004. This concentration of formaldehyde is nearly four times the maximum concentrations shown for other periods not including 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 acetaldehyde maximum concentrations.

- Although difficult to discern in Figure 17-27, a decreasing trend in the average formaldehyde concentrations is shown through 2005-2007, after which the average concentrations leveled out.

Observations from Figure 17-28 for acetaldehyde measurements at ELNJ include the following:

- Carbonyl compound sampling at ELNJ began in January 2000. A 1-month period when samples were not collected occurred in January 2003, as denoted in Figure 17-28.

- The maximum acetaldehyde concentration was measured in 2007, although concentrations of similar magnitude were also measured in 2005 and 2006.

- The rolling average and the median concentrations have steadily increased through the 2005-2007 time frame, after which a decreasing trend begins and continues through the 2008-2010 time frame.

- The difference between the rolling average and the median values decreased significantly for the 2008-2010 period. The decreasing difference between these statistical parameters indicates decreasing variability in the central tendency.

Observations from Figure 17-29 for benzene measurements at ELNJ include the following:

- VOC sampling at ELNJ also began in January 2000. A 1-month period when samples were not collected occurred in January 2003, as denoted in Figure 17-29.

- The maximum benzene concentration was measured in 2008 and is more than four times higher than the next highest concentration (measured in 2009).

- Although difficult to discern in Figure 17-29, a decreasing trend in the rolling average and median concentrations is shown across all time frames through 2005-2007. Even with the higher concentrations measured in 2008 and 2009, the average concentrations for the 2006-2008 through 2008-2010 time frames were similar to the average concentration for the 2005-2007 time frame and the median concentration continued its decreasing trend through these periods. If the maximum concentration from 2008 were removed from the calculations, the rolling average would continue its downward trend through 2006-2008, then hold steady for the final two 3-year periods.

- The difference between the rolling average and the median concentrations for the 2006-2008 through 2008-2010 time frames illustrates the effect of outliers on the average concentration that is not apparent in the median concentration.

Observations from Figure 17-30 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 measurements of 1,3-butadiene from ELNJ greater than $1 \ \mu g/m^3$.

- Figure 17-30 shows a decreasing trend in the earlier years of sampling, then a leveling off of average concentrations that continues through the 2008-2010 time frame. Even with the higher concentration measured in 2009, the average concentration for the 2007-2009 and 2008-2010 time frames were similar to the average concentrations for the previous four 3-year periods. The median concentrations exhibit a similar pattern.

- Even with the maximum concentration measured in 2009, the difference between the 5th and 95th percentiles has been decreasing since the onset of sampling, indicating an overall decrease in the range of concentrations measured at ELNJ.

Observations from Figure 17-31 for formaldehyde measurements at ELNJ include the following:

- The maximum formaldehyde concentration was measured in 2010, although a similar concentration was also measured in 2000.

- Similar to acetaldehyde, the rolling average and the median concentrations of formaldehyde have steadily increased over much of the sampling period, although a decreasing trend begins with 2006-2008 and continues through the 2008-2010 time frame, even with the maximum concentration measured in 2010.

Observations from Figure 17-32 for acetaldehyde measurements at NBNJ include the following:

- Carbonyl compound sampling at NBNJ began in May 2001.

- Similar to CHNJ, the maximum acetaldehyde concentration was measured in 2004. This concentration of acetaldehyde (111 $\mu g/m^3$) is nearly seven times higher, and an order of magnitude higher, than the next highest concentration (16.2 $\mu g/m^3$ measured in 2005). Of the 29 concentrations greater than 8 $\mu g/m^3$, 28 were measured in 2004 or 2005.

- The rolling average concentration appears to increase beginning with the inclusion of 2004 data then decreases after. However, the median concentrations follow a similar increasing then decreasing pattern as the rolling average.

Observations from Figure 17-33 for benzene measurements at NBNJ include the following:

- VOC sampling at NBNJ also began in May 2001.

- The maximum benzene concentration was measured in 2002, but similar concentrations were also measured in 2005 and 2009.

- The rolling averages and the medians are similar to each other for each time period shown. The difference between them was less than 0.15 µg/m^3 for each 3-year period. This indicates relatively little variability in the central tendency.

- A decreasing trend in the rolling average and median concentrations is shown across much of the sampling period, although the concentrations leveled out for the last three 3-year periods.

Observations from Figure 17-34 for 1,3-butadiene measurements at NBNJ include the following:

- The maximum 1,3-butadiene concentration was measured in 2005.

- The rolling average concentrations of 1,3-butadiene at NBNJ have fluctuated over the years of sampling, ranging from 0.030 µg/m^3 (2002-2004) to 0.055 µg/m^3 (2006-2008). The increase shown in Figure 17-34 is likely a result of fewer non-detects, and thus zeros, included in the calculation, as discussed below. The rolling average concentration of 1,3-butadiene leveled out for the last several time frames shown.

- The minimum, 5th percentile, and median concentrations were all zero through the 2004-2006 time frame, indicating the presence of non-detects (at least 50 percent). The number of non-detects reported has decreased through the later years, from as high as 93 percent in 2004 to as low as two percent in 2008. Between one and three non-detects has been reported each year between 2008 and 2010.

Observations from Figure 17-35 for formaldehyde measurements at NBNJ include the following:

- The statistical metrics presented in Figure 17-35 for formaldehyde are similar to those presented in Figure 17-32 for acetaldehyde.

- The maximum formaldehyde concentration was measured on the same day in 2004 that the highest acetaldehyde concentration was measured. This concentration of formaldehyde is more than four times the next highest concentration (measured in 2006). Note that at least one concentration of about 20 µg/m^3 was measured in 2001, 2003, 2006, and 2009.

- The rolling average concentration appears to increase beginning with the 2002-2004 time frame then decreases after the 2004-2006 time frame. The decrease from the 2005-2007 to the 2006-2008 time frame is significant, although this is difficult to discern in Figure 17-35 because of the outlier. The rolling average concentrations for the 2007-2009 and 2008-2010 time frames are similar to the average concentration for the 2006-2008 period. The median concentrations over the period of sampling follow the same trend as the rolling averages.

17.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

17.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the New Jersey monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for each site were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the New Jersey monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the New Jersey monitoring sites.

17.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the New Jersey monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 17-6, where applicable.

Table 17-6. Cancer and Noncancer Surrogate Risk Approximations for the New Jersey Monitoring Sites

Pollutant	Cancer URE (µg/m³)⁻¹	Noncancer RfC (mg/m³)	# of Measured Detections vs. # of Samples	Annual Average (µg/m³)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Chester, New Jersey - CHNJ						
Acetaldehyde	0.0000022	0.009	59/59	1.31 ± 0.19	2.88	0.15
Acrylonitrile	0.000068	0.002	16/57	0.04 ± 0.02	2.51	0.02
Benzene	0.0000078	0.03	57/57	0.48 ± 0.04	3.72	0.02
1,3-Butadiene	0.00003	0.002	17/57	0.01 ± <0.01	0.29	<0.01
Carbon Tetrachloride	0.000006	0.1	57/57	0.64 ± 0.03	3.85	0.01
Chloroform	--	0.098	48/57	0.08 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	14/57	0.02 ± 0.01	0.47	<0.01
Formaldehyde	0.000013	0.0098	59/59	1.64 ± 0.31	21.32	0.17
Tetrachloroethylene	2.6E-07	0.04	39/57	0.07 ± 0.02	0.02	<0.01
Trichloroethylene	0.0000048	0.002	4/57	<0.01 ± <0.01	0.01	<0.01
Elizabeth, New Jersey - ELNJ						
Acetaldehyde	0.0000022	0.009	59/59	2.73 ± 0.39	6.01	0.30
Acrylonitrile	0.000068	0.002	10/59	0.02 ± 0.01	1.34	0.01
Benzene	0.0000078	0.03	59/59	1.02 ± 0.13	7.97	0.03
1,3-Butadiene	0.00003	0.002	59/59	0.12 ± 0.01	3.57	0.06
Carbon Tetrachloride	0.000006	0.1	58/59	0.60 ± 0.04	3.60	0.01
Chloroform	--	0.098	51/59	0.13 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	44/59	0.09 ± 0.02	0.94	<0.01
1,2-Dichloroethane	0.000026	2.4	11/59	0.02 ± 0.01	0.39	<0.01
Ethylbenzene	0.0000025	1	59/59	0.42 ± 0.04	1.05	<0.01
Formaldehyde	0.000013	0.0098	59/59	4.46 ± 0.64	57.93	0.45
Propionaldehyde	--	0.008	59/59	0.54 ± 0.09	--	0.07
Tetrachloroethylene	2.6E-07	0.04	58/59	0.20 ± 0.03	0.05	0.01

NA = Not available due to the criteria for calculating an annual average.

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

Table 17-6. Cancer and Noncancer Surrogate Risk Approximations for the New Jersey Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Trichloroethylene	0.0000048	0.002	22/59	0.03 ± 0.01	0.14	0.02
Vinyl Chloride	0.0000088	0.1	2/59	<0.01 ± <0.01	<0.01	<0.01
New Brunswick, New Jersey - NBNJ						
Acetaldehyde	0.0000022	0.009	58/58	2.92 ± 0.37	6.42	0.32
Acrylonitrile	0.000068	0.002	23/55	0.14 ± 0.11	9.60	0.07
Benzene	0.0000078	0.03	55/55	0.65 ± 0.05	5.07	0.02
1,3-Butadiene	0.00003	0.002	53/55	0.05 ± 0.01	1.53	0.03
Carbon Tetrachloride	0.000006	0.1	54/55	0.56 ± 0.05	3.37	0.01
Chloroform	--	0.098	49/55	0.12 ± 0.02	--	<0.01
1,2-Dichloroethane	0.000026	2.4	11/55	0.02 ± 0.01	0.40	<0.01
Formaldehyde	0.000013	0.0098	58/58	1.63 ± 0.22	21.24	0.17
Tetrachloroethylene	2.6E-07	0.04	52/55	0.12 ± 0.01	0.03	<0.01
Trichloroethylene	0.0000048	0.002	18/55	0.02 ± 0.01	0.08	0.01
Vinyl Chloride	0.0000088	0.1	6/55	<0.01 ± <0.01	0.02	<0.01
Paterson, New Jersey - PANJ						
Benzene	0.0000078	0.03	21/21	NA	NA	NA
1,3-Butadiene	0.00003	0.002	21/21	NA	NA	NA
Carbon Tetrachloride	0.000006	0.1	21/21	NA	NA	NA
Chloroform	--	0.098	18/21	NA	NA	NA
p-Dichlorobenzene	0.000011	0.8	21/21	NA	NA	NA
Ethylbenzene	0.0000025	1	21/21	NA	NA	NA
Tetrachloroethylene	2.6E-07	0.04	20/21	NA	NA	NA
Trichloroethylene	0.0000048	0.002	8/21	NA	NA	NA
Vinyl Chloride	0.0000088	0.1	2/21	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 carbon tetrachloride and benzene. The cancer risk approximations for formaldehyde are 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 risk approximations greater than 1.0.

- 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. The cancer risk approximation for formaldehyde for ELNJ (57.93 in-a-million) is the highest calculated cancer risk approximation among NMP sites. None of the pollutants of interest for ELNJ have noncancer risk approximations greater than 1.0, although the noncancer risk approximation for formaldehyde for ELNJ (0.45) is the third highest among NMP sites.

- For NBNJ, the pollutants with the highest annual averages are acetaldehyde, formaldehyde, and benzene. Formaldehyde has the highest cancer risk approximation for NBNJ, followed by acrylonitrile and acetaldehyde. None of the pollutants of interest for NBNJ have noncancer risk approximations greater than 1.0.

- Because annual averages could not be calculated for PANJ, cancer and noncancer risk approximations could not be calculated either.

17.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 17-7 and 17-8 present a risk-based 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. Table 17-8 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

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 Risk Factors (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	21.32
Ethylbenzene	118.39	Formaldehyde	1.45E-03	Carbon Tetrachloride	3.85
Formaldehyde	111.67	1,3-Butadiene	9.72E-04	Benzene	3.72
Acetaldehyde	75.87	Naphthalene	4.41E-04	Acetaldehyde	2.88
1,3-Butadiene	32.41	Hexavalent Chromium, PM	3.11E-04	Acrylonitrile	2.51
Naphthalene	12.97	Ethylbenzene	2.96E-04	1,2-Dichloroethane	0.47
Dichloromethane	9.08	POM, Group 2b	1.74E-04	1,3-Butadiene	0.29
POM, Group 2b	1.98	Acetaldehyde	1.67E-04	Tetrachloroethylene	0.02
POM, Group 1a	0.32	Arsenic, PM	1.31E-04	Trichloroethylene	0.01
POM, Group 6	0.16	POM, Group 3	1.24E-04		
Elizabeth, New Jersey (Union County) - ELNJ					
Benzene	160.93	Formaldehyde	1.45E-03	Formaldehyde	57.93
Formaldehyde	111.28	Benzene	1.26E-03	Benzene	7.97
Ethylbenzene	89.90	1,3-Butadiene	7.04E-04	Acetaldehyde	6.01
Acetaldehyde	67.31	Nickel, PM	6.52E-04	Carbon Tetrachloride	3.60
Dichloromethane	41.31	Hexavalent Chromium, PM	6.03E-04	1,3-Butadiene	3.57
1,3-Butadiene	23.48	Naphthalene	3.88E-04	Acrylonitrile	1.34
Naphthalene	11.41	Arsenic, PM	2.37E-04	Ethylbenzene	1.05
POM, Group 2b	1.57	Ethylbenzene	2.25E-04	p-Dichlorobenzene	0.94
Nickel, PM	1.36	Acetaldehyde	1.48E-04	1,2-Dichloroethane	0.39
Propylene oxide	0.70	POM, Group 2b	1.38E-04	Trichloroethylene	0.14

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 Risk Factors (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	21.24
Formaldehyde	175.06	Benzene	2.05E-03	Acrylonitrile	9.60
Ethylbenzene	146.78	1,3-Butadiene	1.20E-03	Acetaldehyde	6.42
Acetaldehyde	107.72	Naphthalene	7.01E-04	Benzene	5.07
1,3-Butadiene	40.00	Hexavalent Chromium, PM	4.61E-04	Carbon Tetrachloride	3.37
Naphthalene	20.62	Ethylbenzene	3.67E-04	1,3-Butadiene	1.53
Dichloromethane	7.26	Nickel, PM	2.67E-04	1,2-Dichloroethane	0.40
POM, Group 2b	2.82	POM, Group 2b	2.48E-04	Trichloroethylene	0.08
Ethylene oxide	1.05	Acetaldehyde	2.37E-04	Tetrachloroethylene	0.03
Tetrachloroethylene	0.96	Arsenic, PM	1.84E-04	Vinyl Chloride	0.02
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 Risk Approximations for Pollutants with Noncancer RfCs for the New Jersey Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Chester, New Jersey (Morris County) - CHNJ					
Toluene	624.27	Acrolein	302,596.87	Formaldehyde	0.17
Xylenes	493.82	1,3-Butadiene	16,206.30	Acetaldehyde	0.15
Benzene	207.44	Formaldehyde	11,395.19	Acrylonitrile	0.02
Hexane	131.84	Acetaldehyde	8,429.94	Benzene	0.02
Ethylbenzene	118.39	Benzene	6,914.65	Carbon Tetrachloride	0.01
Formaldehyde	111.67	Xylenes	4,938.24	1,3-Butadiene	<0.01
Acetaldehyde	75.87	Lead, PM	4,349.55	Tetrachloroethylene	<0.01
1,3-Butadiene	32.41	Naphthalene	4,323.69	Trichloroethylene	<0.01
Ethylene glycol	29.66	Arsenic, PM	2,026.03	Chloroform	<0.01
Naphthalene	12.97	Propionaldehyde	1,006.84	1,2-Dichloroethane	<0.01
Elizabeth, New Jersey (Union County) - ELNJ					
Toluene	471.64	Acrolein	267,278.15	Formaldehyde	0.45
Xylenes	352.06	Nickel, PM	15,081.94	Acetaldehyde	0.30
Benzene	160.93	1,3-Butadiene	11,739.58	Propionaldehyde	0.07
Formaldehyde	111.28	Formaldehyde	11,354.92	1,3-Butadiene	0.06
Hexane	109.81	Acetaldehyde	7,478.86	Benzene	0.03
Ethylbenzene	89.90	Benzene	5,364.23	Trichloroethylene	0.02
Acetaldehyde	67.31	Naphthalene	3,803.12	Acrylonitrile	0.01
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 Risk Approximations for Pollutants with Noncancer RfCs for the New Jersey Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
New Brunswick, New Jersey (Middlesex County) - NBNJ					
Toluene	776.52	Acrolein	445,148.01	Acetaldehyde	0.32
Xylenes	593.79	1,3-Butadiene	20,000.36	Formaldehyde	0.17
Benzene	263.33	Formaldehyde	17,862.97	Acrylonitrile	0.07
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	<0.01
1,3-Butadiene	40.00	Nickel, PM	6,175.26	Chloroform	<0.01
Glycol ethers, gas	37.20	Xylenes	5,937.95	Vinyl Chloride	<0.01
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		

The pollutants listed in Tables 17-7 and 17-8 are limited to those that have cancer and noncancer risk 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 and noncancer risk 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 VOC and carbonyl compounds. In addition, the cancer and noncancer surrogate risk 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; as a result, annual averages, and thus cancer and noncancer risk approximations, were not calculated for this site. A more in-depth discussion of this analysis is provided in Section 3.5.5.3.

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 appeared 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 these three New Jersey sites but appeared 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. Toluene did not appear on any county's list of highest toxicity-weighted emissions and is not a pollutant of interest for any site.

- 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 screening evaluations, due to questions about the consistency and reliability of the measurements, as discussed in Section 3.2.

- 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 risk 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 counties. Benzene also appears on all three lists.

17.6   Summary of the 2010 Monitoring Data for the New Jersey Monitoring Sites

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

- ❖ *Twelve pollutants failed at least one screen for CHNJ; 14 failed screens for ELNJ; 12 failed screens for NBNJ; and eight failed screens for PANJ.*

- ❖ *Formaldehyde had the highest annual average concentration for CHNJ and ELNJ while acetaldehyde had the highest annual average concentration for NBNJ. Annual average concentrations could not be calculated for PANJ.*

- ❖ *The annual average formaldehyde concentration for ELNJ is the highest annual average among NMP sites sampling this pollutant.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest, where they could be calculated, were greater than their associated MRL noncancer health risk benchmarks.*

18.0   Sites in New York

This section examines the spatial and temporal characteristics of the ambient monitoring concentrations measured at the NATTS and CSATAM 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 (BXNY and MONY), Rochester (ROCH), and Tonawanda (TONY). Figures 18-1 through 18-4 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban locations. Figures 18-5 through 18-7 identify 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 18-5 through 18-7. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 18-1 describes the area surrounding each monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 18-1. Public School 52, New York City, New York (BXNY) Monitoring Site
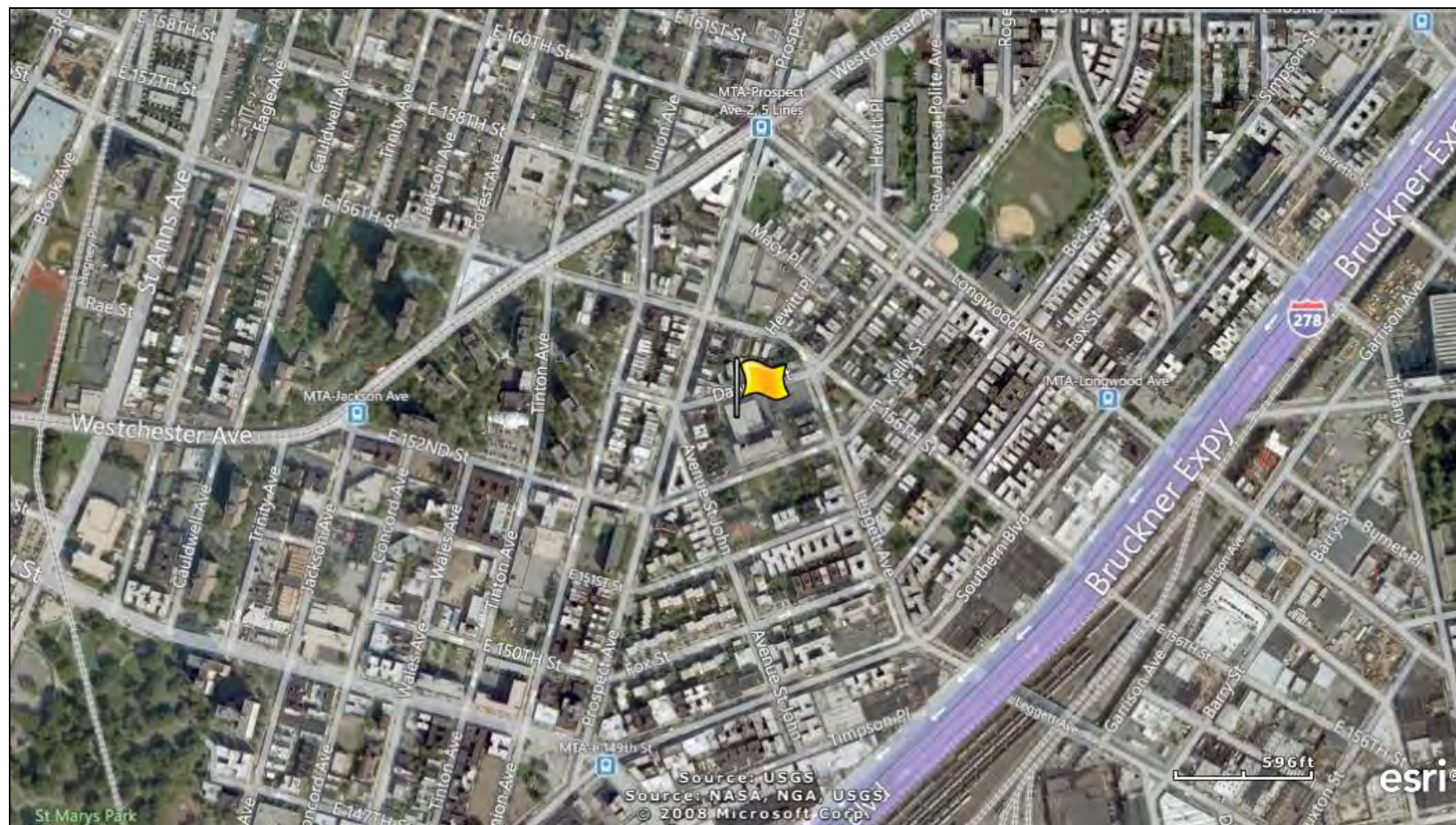
Figure 18-2. Morrisania, New York City, New York (MONY) Monitoring Site
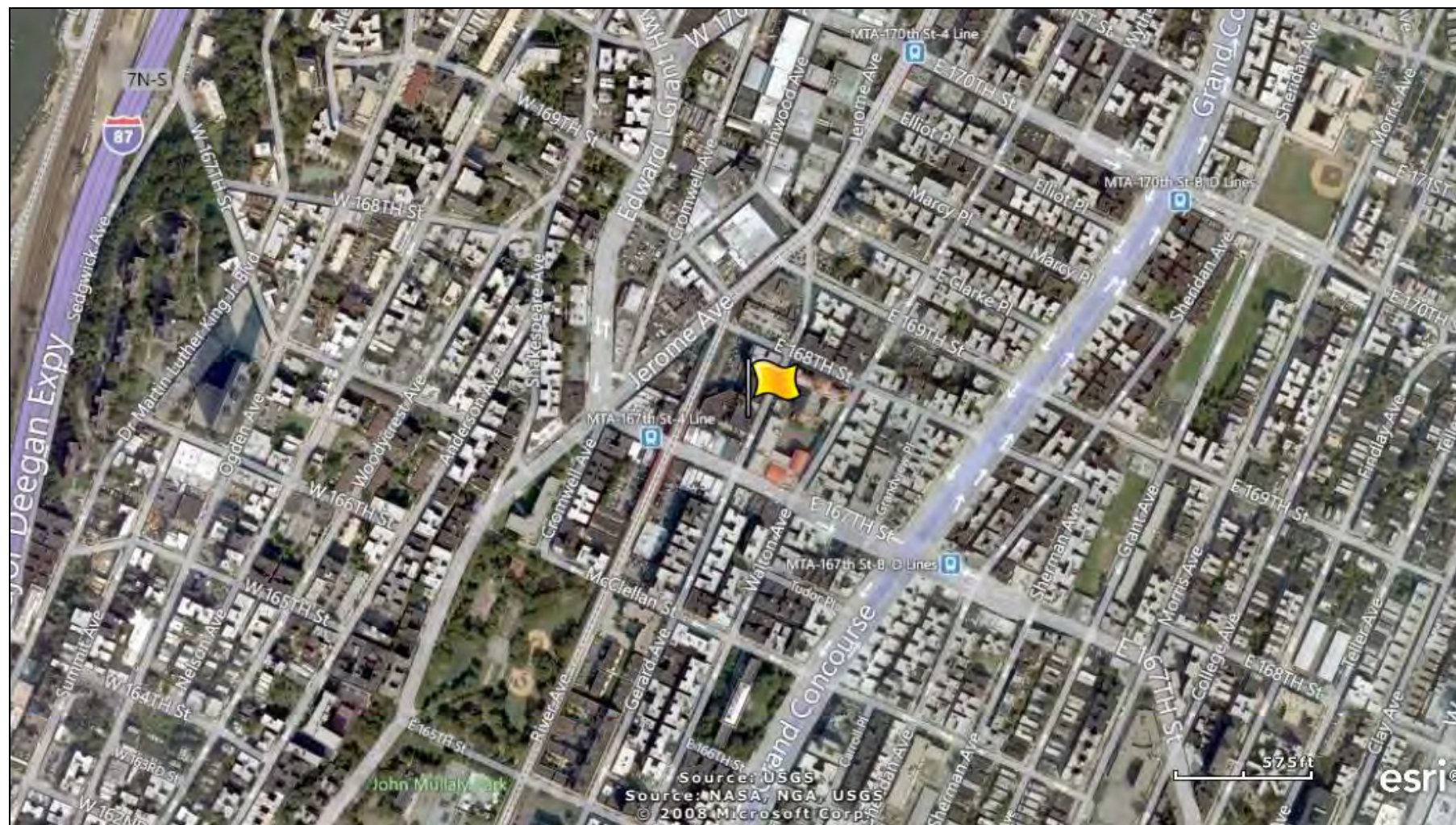
Figure 18-3. Rochester, New York (ROCH) Monitoring Site
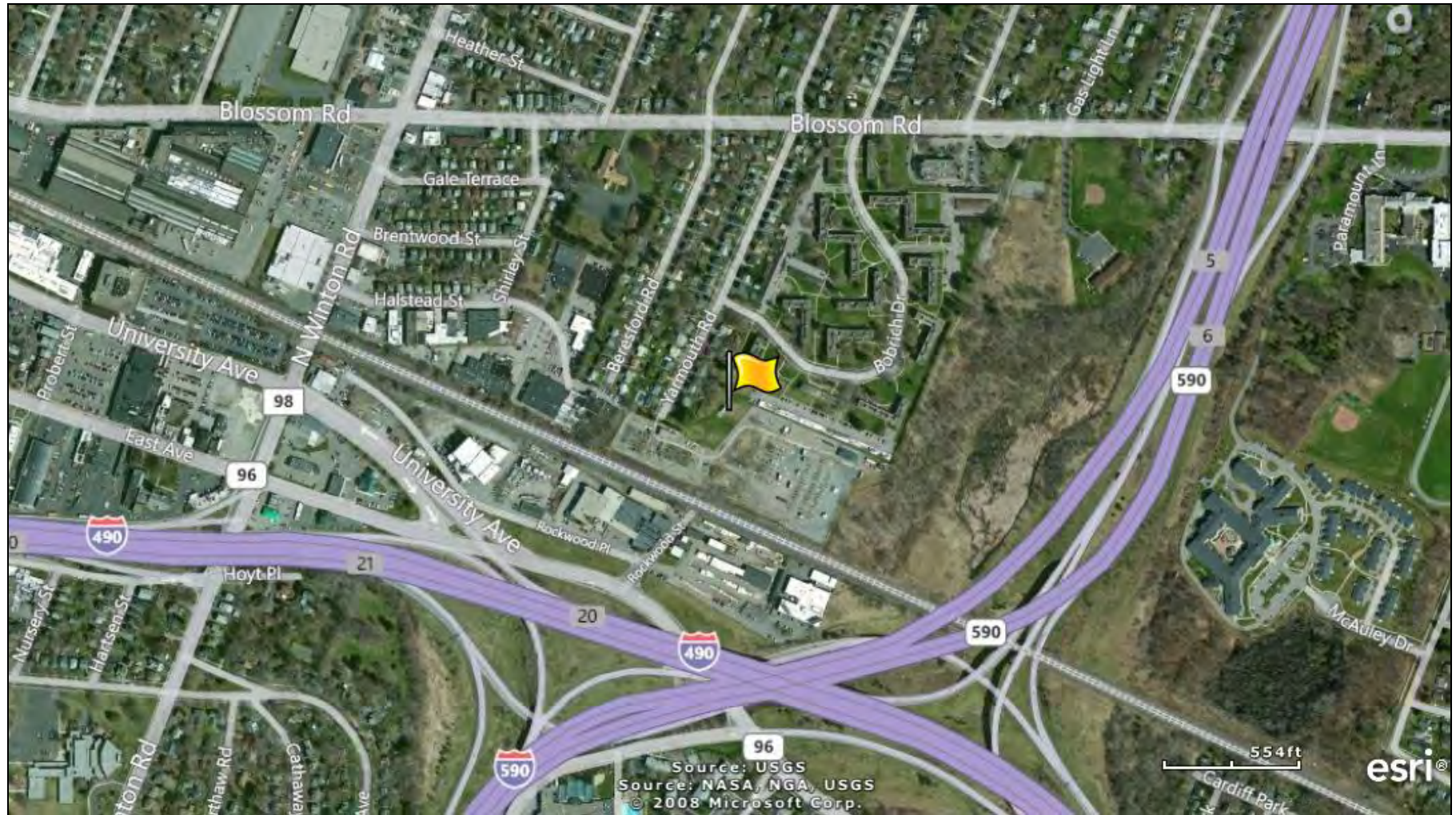
Figure 18-4. Tonawanda, New York (TONY) Monitoring Site
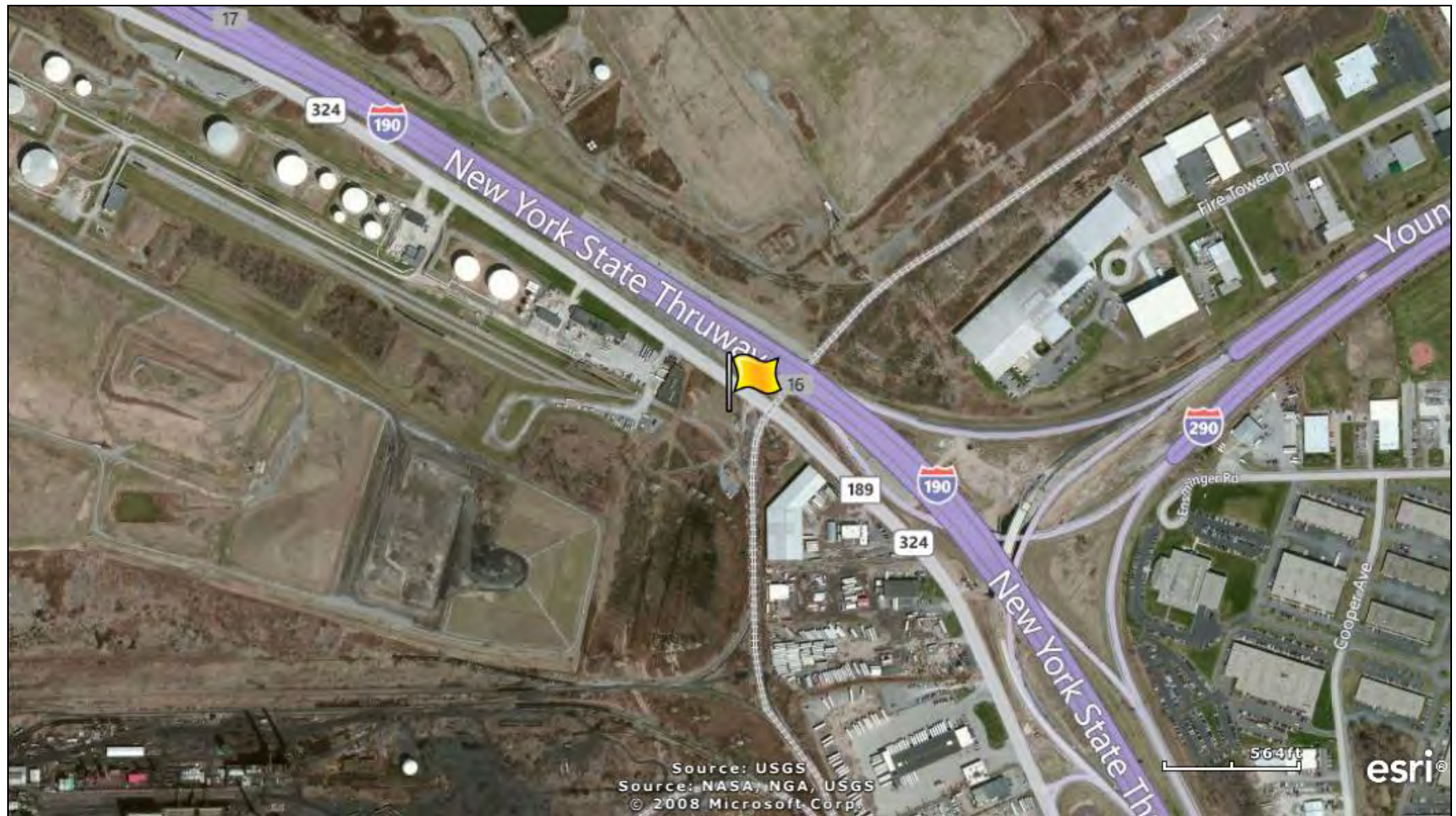
Figure 18-5. NEI Point Sources Located Within 10 Miles of BXNY and MONY

Legend

⭐ BXNY NATTS site   ⭐ MONY NATTS site   ◯ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

⊟ Abrasive Product Manufacturing (1)	☀ Industrial Machinery and Equipment (1)
◎ Air-conditioning/Refrigeration (3)	Ū Institutional - prison (1)
✛ Aircraft Operations (25)	Ⓢ Institutional - school (21)
🚗 Automobile/Truck Manufacturing (1)	? Miscellaneous Commercial/Industrial (28)
Ⓑ Bakery (2)	M Miscellaneous Manufacturing (11)
B Bulk Terminals/Bulk Plants (2)	✱ Oil and/or Gas Production (1)
C Chemical Manufacturing (5)	⊖ Pharmaceutical Manufacturing (2)
e Electrical Equipment (2)	↑ Printing, Coating & Dyeing of Fabric (1)
⚡ Electricity Generation via Combustion (16)	P Printing/Publishing (10)
E Electroplating, Plating, Polishing, Anodizing, & Coloring (1)	⊞ Pulp and Paper Plant/Wood Products (5)
⊙ Fabricated Metal Products (2)	R Rubber and Miscellaneous Plastics Products (2)
≋ Flexible Polyurethane Foam Production (2)	⚠ Ship Building and Repairing (1)
F Food Processing/Agriculture (3)	> Solid Waste Disposal - Commercial/Institutional (1)
▪ Gasoline/Diesel Service Station (3)	S Surface Coating (5)
⁄⁄ Heating Equipment Manufacturing (2)	T Textile Mill (2)
Ⓗ Hospital (5)	Ⅰ Wastewater Treatment (6)

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

Figure 18-6. 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.

Legend

⭐ ROCH NATTS site   ◯ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

- Air-conditioning/Refrigeration (1)
- Aircraft Operations (6)
- C   Chemical Manufacturing (2)
- Electricity Generation via Combustion (1)
- Heating Equipment Manufacturing (2)
- Landfill (2)
- P   Printing/Publishing (2)
- R   Rubber and Miscellaneous Plastics Products (1)
- Wastewater Treatment (1)

18-7

Figure 18-7. NEI Point Sources Located Within 10 Miles of TONY

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

Legend

⭐ TONY CSATAM site   ◯ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

- ⊕ Abrasive Product Manufacturing (1)
- ◎ Air-conditioning/Refrigeration (1)
- ✛ Aircraft Operations (13)
- 🚗 Automobile/Truck Manufacturing (1)
- C Chemical Manufacturing (4)
- ◲ Coke Battery (1)
- ⚡ Electricity Generation via Combustion (4)
- F Food Processing/Agriculture (1)
- ◊ Heating Equipment Manufacturing (3)

- ◈ Institutional - school (1)
- ? Miscellaneous Commercial/Industrial (7)
- Ⓜ Municipal Waste Combustor (1)
- 1 Primary Metal Production (1)
- ⊞ Pulp and Paper Plant/Wood Products (1)
- R Rubber and Miscellaneous Plastics Products (4)
- ◎ Tire Manufacturing (1)
- ➥ Transportation Equipment (1)
- ⚑ Wastewater Treatment (1)

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]
BXNY	36-005-0110	New York	Bronx	New York-Northern New Jersey-Long Island, NY-NJ-PA MSA (New York Div)	40.81616, -73.90207	Residential	Urban/City Center	Haze, SO_2, NO, NO_2, NO_x, O_3, VOC, Carbonyl compounds, Meteorological parameters, PM Coarse, Black Carbon, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation.
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, VOC, 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, VOC, Carbonyl compounds, O_3, Meteorological parameters, Black Carbon, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation.
TONY	36-029-1013	Tonawanda	Erie	Buffalo-Niagara Falls, NY MSA	42.988443, -78.918589	Industrial	Urban/City Center	VOC, $PM_{2.5}$, Carbonyl compounds.

[1] These monitoring sites report additional pollutants to AQS (EPA, 2012h); however, these data are not generated by ERG and are therefore not included in this report.
BOLD ITALICS = EPA-designated NATTS Site.

BXNY is located on the property of Public School 52 (PS 52) in the Bronx Borough of New York City, northeast of Manhattan. The site was established in 1999 and is considered one of the premier particulate sampling sites in New York City and is the Bronx (#1) NATTS site. The surrounding area is urban and residential, as shown in Figure 18-1. The Bruckner Expressway (I-278) is located a few blocks east of the monitoring site and other heavily traveled roadways are also located within a few miles of the site. A freight yard and other industries lie on the southeast and south side of I-278, part of which can be seen in the lower right-hand side of Figure 18-1. BXNY is less than 1/2 mile from the East River.

In June 2010, the monitoring instruments at BXNY were moved to a new location nearby due to roofing construction at the previous location. The new location (MONY) is located at the Morrisania Neighborhood Family Care center and is 1.65 miles east of the old location. This is considered the Bronx (#2) NATTS site. 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 18-2. The Hudson River is just a few blocks farther west. The area surrounding MONY is primarily residential, although commercial areas are located along Jerome Avenue and East 167th Street.

Figure 18-5 shows the proximity of BXNY to MONY, as well as the numerous point sources that are located within 10 miles of the sites. The bulk of the emissions sources are located to the south and west of the sites, with another cluster to the north. The source categories with the highest number of emissions sources surrounding BXNY 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 BXNY is a wastewater treatment facility while the 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 18-6 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.

TONY is located in Tonawanda, New York, north of Buffalo, along the eastern branch of the Niagara River. The area is wedged between Lake Erie to the south and Lake Ontario to the north, with the river flowing in-between the two. The monitoring site is located off Grand Island Boulevard (324), which parallels I-190, and is less than 1/2 mile from the I-190 and I-290 interchange. The surrounding area is industrial and the site itself resides under high power transmission lines. There are 45 companies regulated by the state of New York within close proximity of this monitoring site (NYS DEC, 2009), including chemical manufacturers, bulk terminals/plants, landfills, facilities generating electricity via combustion, a concrete batch plant, an iron and steel foundry, and a steel mill. Figure 18-7 shows this cluster of point sources immediately south of TONY. Although the source category with the most sources within 10 miles of TONY is the aircraft operations category, other nearby source categories include a coke battery, chemical manufacturers, a heating equipment manufacturer, and a rubber and miscellaneous plastics manufacturer. Note that any possible emissions sources located in Canada are not provided in Figure 18-7.

Table 18-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the New York monitoring sites. Table 18-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 18-2 also contains annual average daily traffic information. County-level VMT was not readily available for these sites; thus, daily VMT is not provided in Table 18-2.

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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[3,4]	Estimated 10-mile Vehicle Ownership	Annual Average Daily Traffic[5]	County-level Daily VMT[6]
BXNY	1,386,657	248,600	0.18	6,590,357	1,181,520	100,230	NA
MONY						134,421	
ROCH	744,389	552,184	0.74	639,090	474,074	116,725	NA
TONY	918,652	669,746	0.73	598,180	436,105	74,406	NA

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the New York State Department of Motor Vehicles (NYS DMV, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] The 10-mile population estimate for BXNY was used as a surrogate for MONY.
[5] Annual Average Daily Traffic reflects 2008 data from the New York State DOT (NYS DOT, 2008)
[6] County-level VMT was not available for these sites
BOLD ITALICS = EPA-designated NATTS Site.

Observations from Table 18-2 include the following:

- Bronx County has the ninth highest county population among counties with NMP sites, but the 10-mile radius populations for BXNY and MONY are the highest among all NMP sites. Note that the 10-mile radius for BXNY is used as a surrogate for MONY. These sites are located 1.65 miles apart.

- County-level vehicle ownership for Bronx County is in the middle of the range among NMP sites. Although the 10-mile ownership estimate is among the highest for all NMP sites, given the large population living within 10 miles, the vehicle-per-person ratio is very low (0.18), which is the lowest vehicle-per-person ratio calculated. This might seem surprising given the high population, but may be explained by the use of mass transportation systems.

- The populations surrounding ROCH and TONY are lower than BXNY and MONY. However, the county-level vehicle ownership is much higher near these sites. The same is not true of the 10-mile ownership estimate. The population and vehicle ownership data for ROCH and TONY are in the middle of the range compared to NMP other sites.

- Among the New York sites, the traffic volume near MONY is the highest and near TONY is the lowest. Compared to other NMP sites, the traffic volumes near BXNY, MONY, and ROCH are in the top third while the traffic volume for TONY is just outside the top third. The traffic data for BXNY were obtained from I-278 between I-87 and I-895; the traffic data for MONY were obtained from I-87 between the Bronx Expressway and Macombs Bridge; the traffic data for ROCH were obtained from I-490 at I-590; and the traffic data for TONY were obtained from I-190 between Exits 16 and 17.

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 is 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. In addition 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, 2012c).

Cloudy conditions prevail over the Buffalo area from late autumn through early spring, and snowy conditions are common. Lake-effect snow events may lead to heavy snowfall, with heavier snowfalls to the south of Buffalo and closer to the shore than towards the Tonawanda area. Lake-effect snows tend to diminish after Lake Erie freezes. Because Lake Erie is so cold (and eventually frozen) during the winter, areas immediately near the shore may be much colder than farther inland, especially during the spring and summer. Due to the stabilizing effects of the Lake, the Buffalo area experiences one of the sunniest and driest summers along the northeast coast. Cooler air passes over the warmer Lake with the arrival of autumn, increasing cloud cover. Southwesterly winds prevail over the area, but winds off Lake Erie tend to be stronger than farther inland. Wind direction in Tonawanda can be altered by its proximity to the Niagara River.

Summer temperature extremes are tempered by the area's location between Lake Erie and Lake Ontario (Bair, 1992 and NOAA, 2012d).

18.2.2 Meteorological Conditions in 2010

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). The closest weather stations are located at La Guardia International Airport (near BXNY), Central Park (near MONY), Greater Rochester International Airport (near ROCH), and Niagara Falls International Airport (near TONY), WBAN 14732, 94728, 14768, and 04724, 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 normal conditions throughout the year.

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 2010. Also included in Table 18-3 is the 95 percent confidence interval for each parameter. As shown in Table 18-3, the sample day averages for both BXNY and MONY exhibit differences in the average meteorological parameters from the full-year averages. Note that the monitoring instruments at BXNY were moved to MONY in June 2010. Thus, conditions on sample days at BXNY appear cooler while conditions at MONY appear warmer than conditions experienced throughout 2010. While sampling was discontinued at TONY in July, the differences between the sample day and full-year averages are less noticeable than for the New York City sites, with the dew point exhibiting the largest difference. Table 18-3 also shows that meteorological conditions near ROCH, the only New York monitoring site to sample year-round, were representative of average weather conditions 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)
Public School 52, New York City, New York - BXNY									
La Guardia Airport 14732 (40.78, -73.88)	2.77 miles 144° (SE)	Sample Day	57.7 ± 7.6	50.5 ± 6.5	35.5 ± 6.5	43.8 ± 5.7	59.4 ± 5.6	1010.8 ± 3.5	10.0 ± 1.4
		2010	60.8 ± 1.8	54.5 ± 1.7	40.5 ± 1.9	48.0 ± 1.6	61.7 ± 1.5	1016.4 ± 0.8	9.2 ± 0.4
Morrisania, New York City, New York - MONY									
Central Park 94728 (40.78, 73.97)	4.35 miles 199° (SSW)	Sample Day	66.9 ± 6.8	60.3 ± 6.4	46.2 ± 6.5	53.0 ± 5.8	62.1 ± 5.3	1014.3 ± 2.1	5.1 ± 0.6
		2010	60.8 ± 1.8	54.5 ± 1.7	40.5 ± 1.9	48.0 ± 1.6	61.7 ± 1.5	1016.4 ± 0.8	9.2 ± 0.4
Rochester, New York - ROCH									
Greater Rochester Intl Airport 14768 (43.12, -77.68)	6.46 miles 240° (WSW)	Sample Day	56.7 ± 5.2	49.1 ± 4.7	40.0 ± 4.5	44.7 ± 4.3	73.2 ± 2.4	1014.4 ± 1.7	7.2 ± 0.8
		2010	55.4 ± 1.9	47.3 ± 1.7	37.7 ± 1.9	43.0 ± 1.7	71.9 ± 1.2	1016.5 ± 0.8	7.0 ± 0.3
Tonawanda, New York - TONY									
Niagara Falls Intl Airport 04724 (43.11, -78.95)	8.28 miles 340° (NNW)	Sample Day	54.2 ± 7.8	45.9 ± 7.0	35.4 ± 6.3	41.0 ± 6.2	70.1 ± 3.8	1014.0 ± 2.9	8.4 ± 1.5
		2010	55.6 ± 2.0	47.8 ± 1.8	38.3 ± 1.8	43.4 ± 1.7	72.1 ± 1.1	1016.7 ± 0.8	7.9 ± 0.4

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

18.2.3 Back Trajectory Analysis

Figure 18-8 is the composite back trajectory map for days on which samples were collected at the BXNY monitoring site in 2010. Included in Figure 18-8 are four back trajectories per sample day. A cluster analysis for BXNY was not performed because there were fewer than 30 sample days. Figure 18-9 is the composite back trajectory map for days on which samples were collected at MONY and Figure 18-10 is the corresponding cluster analysis. Similarly, Figures 18-11 through 18-14 are the composite back trajectory maps for days on which samples were collected at ROCH and TONY 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the sites in Figures 18-8 through 18-14 represents 100 miles.

Figure 18-8. 2010 Composite Back Trajectory Map for BXNY
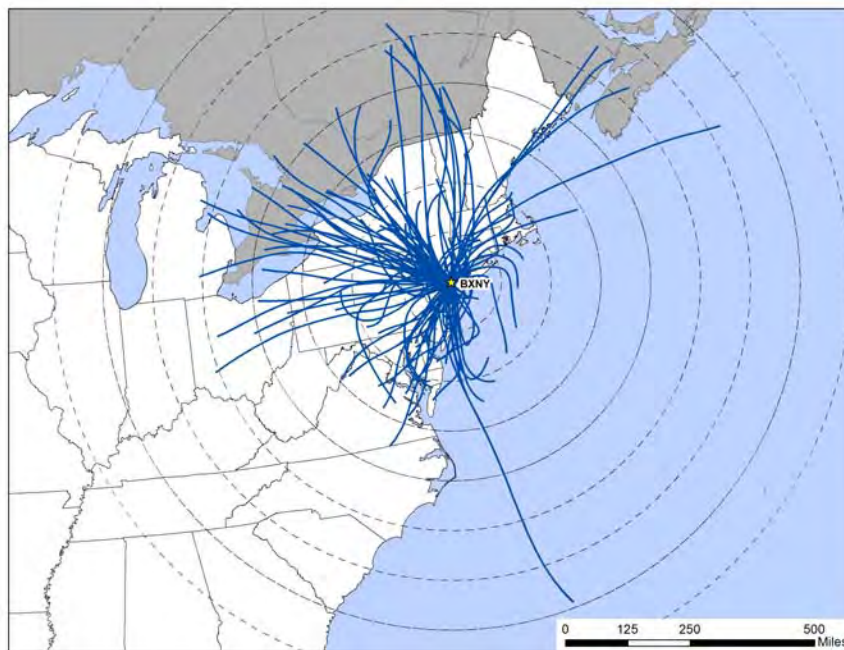
Figure 18-9. 2010 Composite Back Trajectory Map for MONY
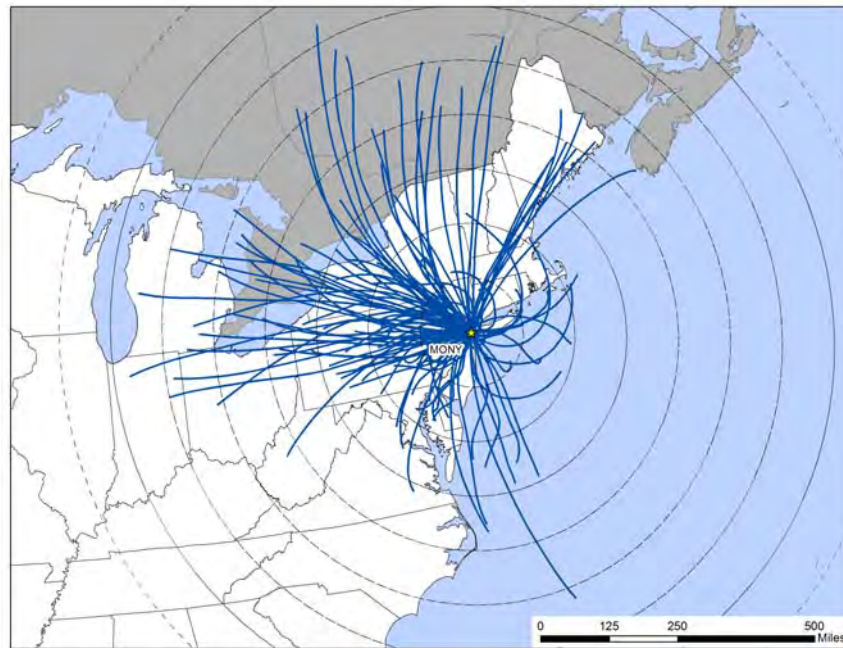
Figure 18-10. Back Trajectory Cluster Map for MONY

Figure 18-11. 2010 Composite Back Trajectory Map for ROCH
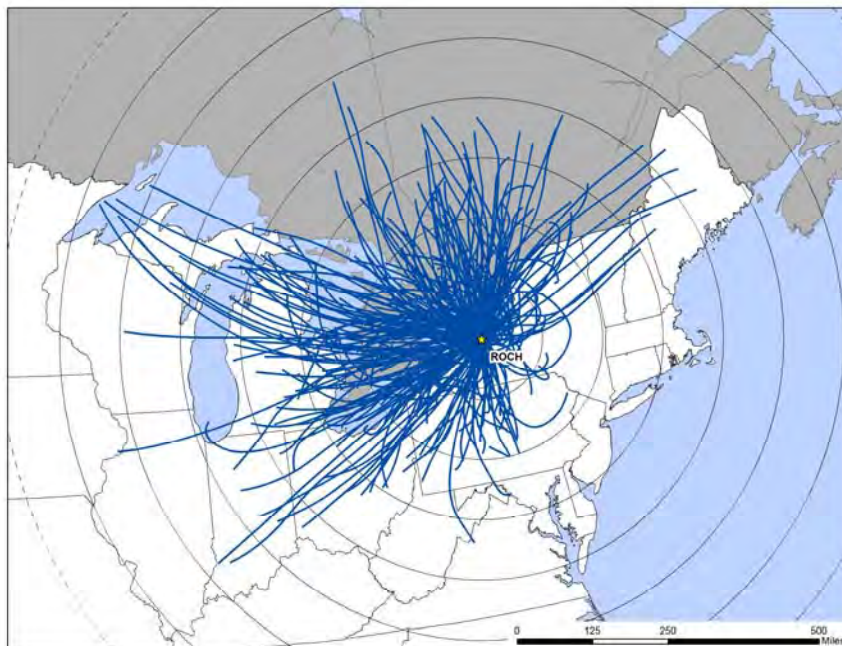
Figure 18-12. Back Trajectory Cluster Map for ROCH

Figure 18-13. 2010 Composite Back Trajectory Map for TONY
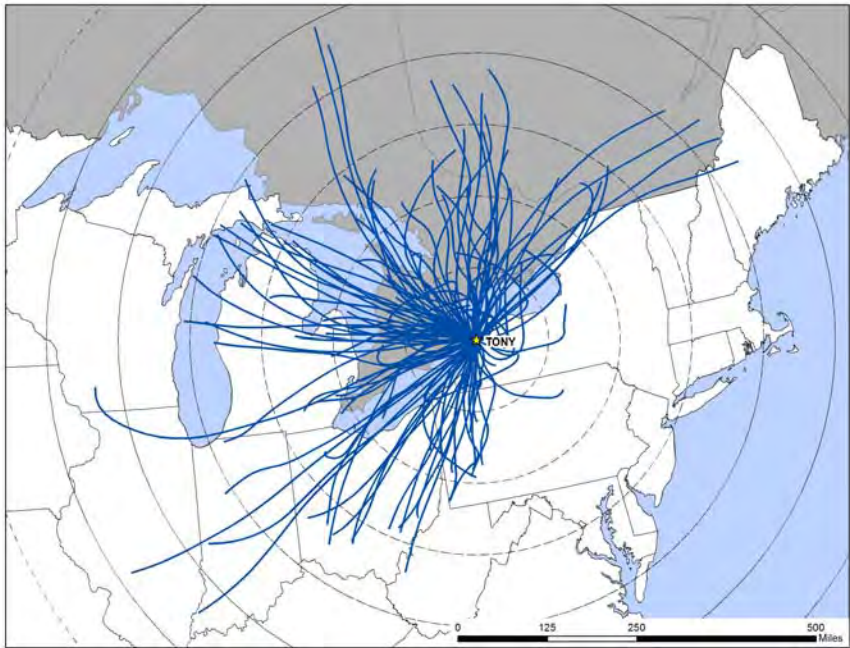
Figure 18-14. Back Trajectory Cluster Map for TONY

Observations from Figure 18-8 for BXNY include the following:

- Back trajectories originated from a variety of directions at BXNY, although less frequently from the east and southeast. A cluster of trajectories originated from the west to northwest and a second cluster originated from the south. Note that sampling at BXNY was discontinued in June 2010.

- The 24-hour air shed domain for BXNY was somewhat larger in size compared to other NMP sites, as the farthest away a trajectory originated was nearly 700 miles to the southeast, off the North Carolina coast and over the Atlantic Ocean. The longest trajectory originated from the south-southeast and is associated with a strong low pressure system that moved through the region January 25-26, 2010. However, the average trajectory length was 263 miles and more than 81 percent of trajectories originated within 400 miles of the site.

Observations from Figures 18-9 and 18-10 for MONY include the following:

- Back trajectories originated from a variety of directions at MONY.

- The 24-hour air shed domain for MONY is among the largest in size compared to other NMP sites. Although the farthest away a trajectory originated was over northwest Indiana, or less than 650 miles away, the average trajectory length was 300 miles and 86 percent of trajectories originated within 500 miles of the site.

- The cluster analysis shows that nearly 40 percent of back trajectories originated to the west of MONY over western New York and Pennsylvania and generally within 300 miles of the site. Longer trajectories originating to the west of MONY and over the Great Lakes, Michigan, and northern Ohio account for another 14 percent of trajectories. Trajectories originating from the northwest, north, and east were also common.

- Figures 18-9 and 18-10 include back trajectories from June to December 2010 only, based on the start date of the sampling effort at MONY.

Observations from Figures 18-11 and 18-12 for ROCH include the following:

- Back trajectories originated from a variety of directions at ROCH, although very few originated from the southeast of ROCH.

- The 24-hour air shed domain for ROCH was comparable in size to other NMP sites. The farthest away a trajectory originated was over western Lake Superior, or less than 700 miles away. However, the average trajectory length was 264 miles and 86 percent of trajectories originated within 400 miles of the site.

- The cluster analysis shows that the bulk (43 percent) of trajectories originated to the west of ROCH. These include shorter trajectories originating over the Great Lakes and within 300 miles of ROCH (as shown by the 30 percent cluster) and longer trajectories originating over Lake Superior, Michigan (including the Upper

Peninsula), and Lake Michigan (as shown by the 13 percent cluster). Back trajectories originating from the southwest of ROCH accounted for another 19 percent of trajectories, with shorter trajectories (15 percent) originating over western Pennsylvania, northeastern Ohio, and northern West Virginia, and longer trajectories (4 percent) originating over western Ohio and Indiana. Back trajectories also originated over Ontario and Quebec, Canada and the eastern half of New York.

Observations from Figures 18-13 and 18-14 for TONY include the following:

- Similar to ROCH, back trajectories originated from a variety of directions at TONY, although infrequently from the east and southeast.

- The 24-hour air shed domain for TONY was comparable in size to ROCH as well as other NMP sites. The farthest away a trajectory originated was over central Illinois, or less than 600 miles away. However, the average trajectory length was 251 miles and 88 percent of trajectories originated within 400 miles of the site.

- The cluster analysis shows that trajectories originating from the southwest, west, northwest of TONY account for the bulk of back trajectories. Back trajectories also originated from the north and northeast over Ontario and Quebec, Canada, as well as a few originating over western New York State, which are included in the cluster trajectory accounting for 33 percent of trajectories.

- Figures 18-13 and 18-14 include back trajectories from January to July 2010 only, based on the stop date of the sampling effort at TONY.

18.2.4 Wind Rose Comparison

Hourly wind data from the weather stations at La Guardia International Airport (for BXNY), Central Park (for MONY), Greater Rochester International Airport (for ROCH), and Niagara Falls International Airport (for TONY) 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 18-15 presents three different wind roses for the BXNY monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the

monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figures 18-16 through 18-18 presents the three wind roses and distance maps for MONY, ROCH, and TONY.

Observations from Figure 18-15 for BXNY include the following:

- The La Guardia International Airport weather station is located across the East River from BXNY, approximately 2.75 miles southeast of the monitoring site.

- The historical wind rose shows that winds from the southwest, northwest, and northeast quadrants were frequently observed, while winds from the southeast quadrant were rarely observed. Among these wind directions, northwesterly and southerly winds were observed the most. Calm winds (≤2 knots) were observed for less than four percent of the hourly measurements near BXNY, while the strongest winds were most frequently observed with westerly to northwesterly winds.

- Although west-northwesterly and northwesterly winds accounted for a higher percentage of wind observations in 2010 and east-northeasterly winds were hardly observed at all, these differences do not detract from the many similarities in the wind patterns between the 2010 wind rose and the historical wind rose.

- An even higher percentage of west-northwesterly and northwesterly winds were observed on sample days in 2010 compared to throughout 2010 and historically, as were northeasterly winds. However, the sample day wind rose includes sample days from January to June 2010 only, and may reflect a seasonal pattern.

Observations from Figure 18-16 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 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 greater than 12 percent of the hourly measurements near MONY. Note the wind speed differences between the wind roses for BXNY and MONY. The Central Park weather station is more protected by the city than the La Guardia weather station, which is located right on the East River bank.

- The 2010 full-year wind rose shares many similarities with the historical wind rose, although westerly and west-northwesterly winds accounted for approximately 36 percent of wind observations in 2010, compared to 25 percent historically. There were hardly any northwesterly or southerly wind observations in 2010 compared to the historical wind rose.

- While westerly and west-northwesterly winds accounted for the majority of wind observations on sample days in 2010, the percentage (30 percent) is a less than for the

18-22

full-year wind rose (36 percent). The number of northeasterly wind observations is higher on samples, which may be a seasonal pattern as the sample day wind rose includes sample days from June to December 2010 only.

Observations from Figure 18-17 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, while winds from other directions were infrequently observed. Calm winds were observed for less than 10 percent of the hourly measurements near ROCH, while the strongest winds were most frequently observed with west-southwesterly and westerly winds.

- The wind patterns shown on the 2010 wind rose are similar to the historical wind patterns for ROCH, although westerly and west-northwesterly winds were observed more frequently and south-southwesterly winds were observed less often. A slightly higher percentage of calm winds were observed in 2010.

- The sample day wind patterns are similar to those shown on the full-year wind rose, indicating that conditions on sample days were representative of those experienced over the entire year in 2010.

Observations from Figure 18-18 for TONY include the following:

- The Niagara Falls weather station is located 8.3 miles north-northwest of TONY. Grand Island and the Niagara River lie between the site and the weather station.

- The wind patterns for TONY resemble the wind patterns for ROCH.

- The historical wind rose shows that winds from the south to southwest to west were the most frequently observed wind directions. Calm winds account for approximately 10 percent of the hourly measurements near TONY. The strongest winds were most frequently observed with southwesterly, west-southwesterly, and westerly winds, those generally flowing off Lake Erie.

- The wind patterns shown on the 2010 wind rose are similar to the historical wind patterns for TONY, although there were fewer southerly and south-southwesterly winds and a higher percentage of calms. This indicates that conditions in 2010 were similar to those experienced historically.

- While southwest was also the prevalent wind direction on sample days in 2010, winds from the northwest quadrant accounted for roughly the same percentage of wind observations as the southwest quadrant. Recall the sampling at TONY was discontinued in July 2010, thereby missing half of the year and perhaps revealing a seasonal pattern.

18-23

Figure 18-15. Wind Roses for the LaGuardia International Airport Weather Station near BXNY

1999-2009 Historical Wind Rose
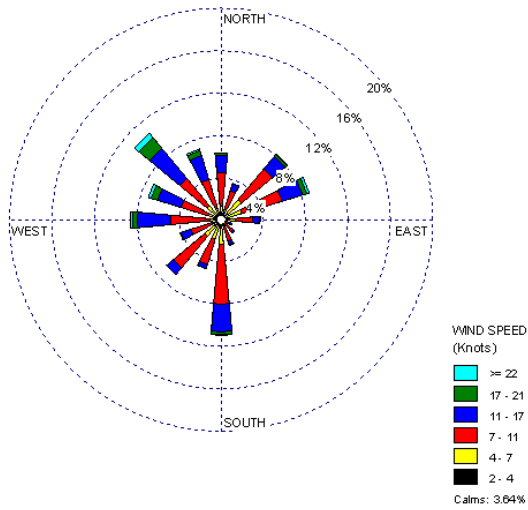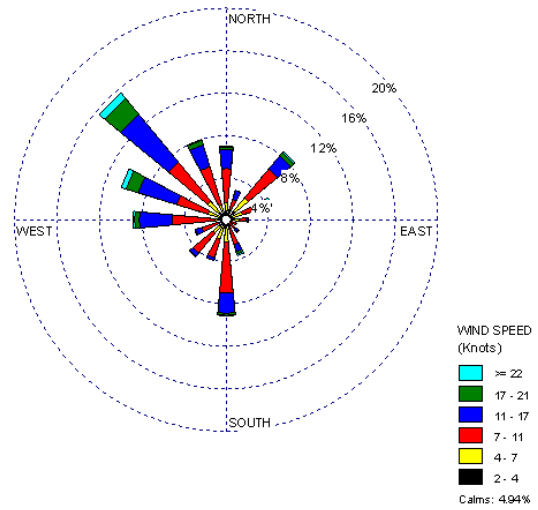
2010 Wind Rose

2010 Sample Day Wind Rose
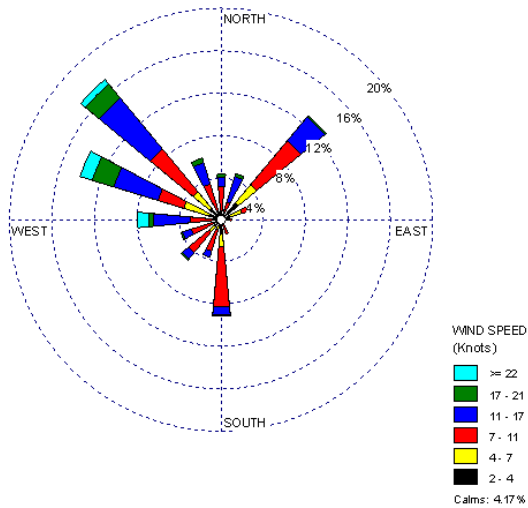
Distance between BXNY and NWS Station

Figure 18-16. Wind Roses for the Central Park Weather Station near MONY

1999-2009 Historical Wind Rose
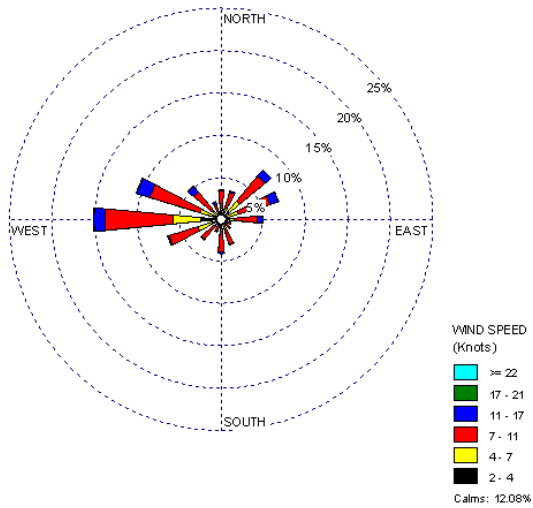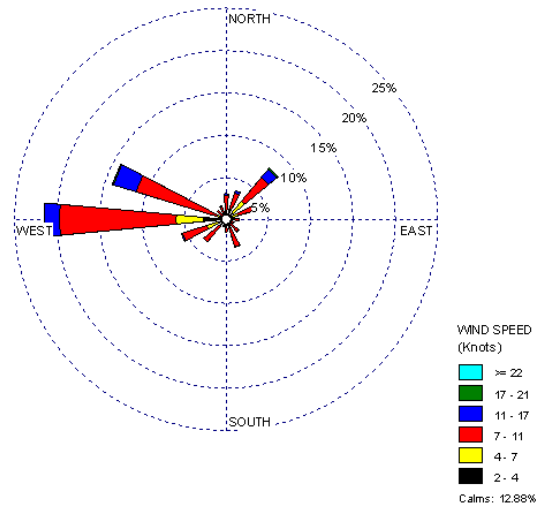
2010 Wind Rose

2010 Sample Day Wind Rose
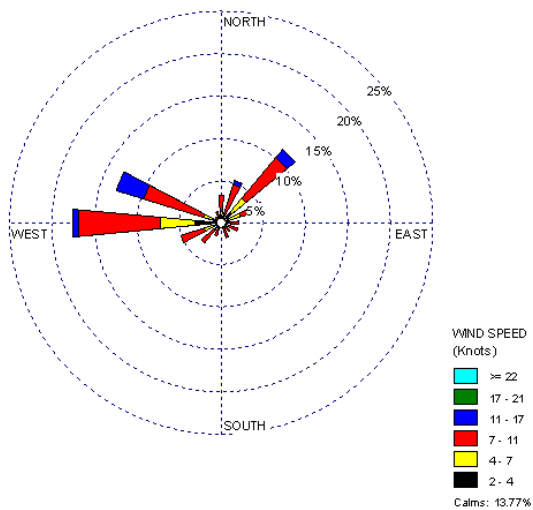
Distance between MONY and NWS Station

Figure 18-17. Wind Roses for the Greater Rochester International Airport Weather Station near ROCH

1999-2009 Historical Wind Rose
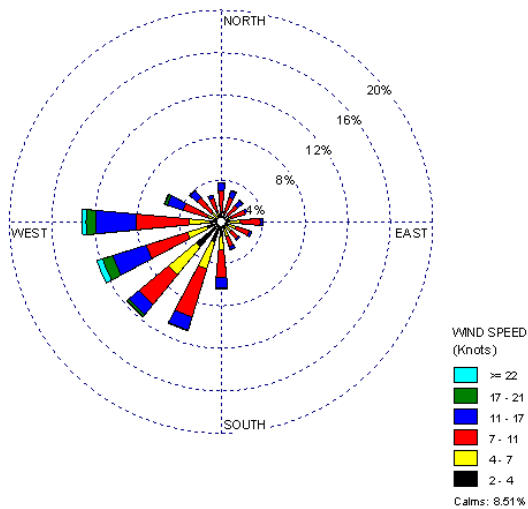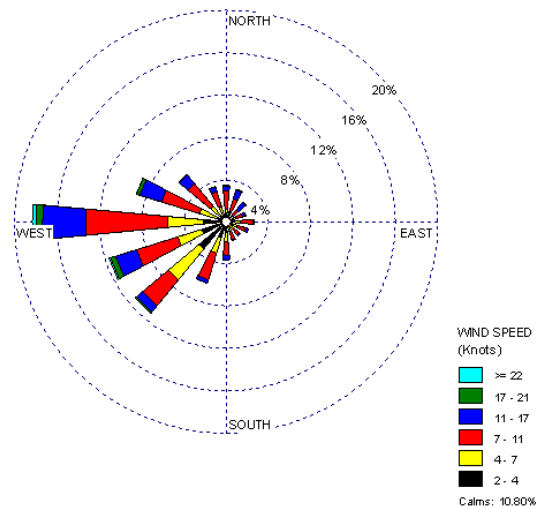
2010 Wind Rose

2010 Sample Day Wind Rose
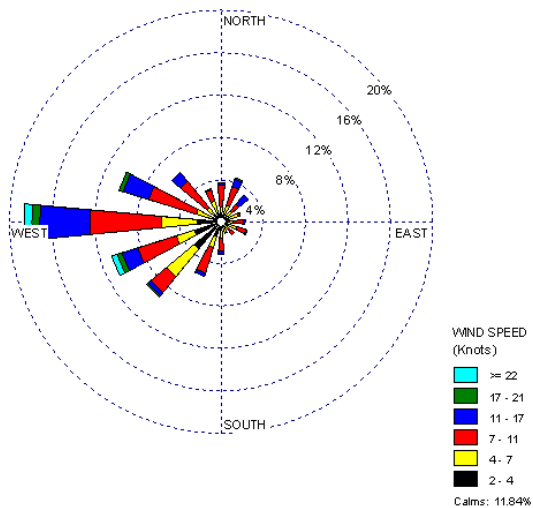
Distance between ROCH and NWS Station
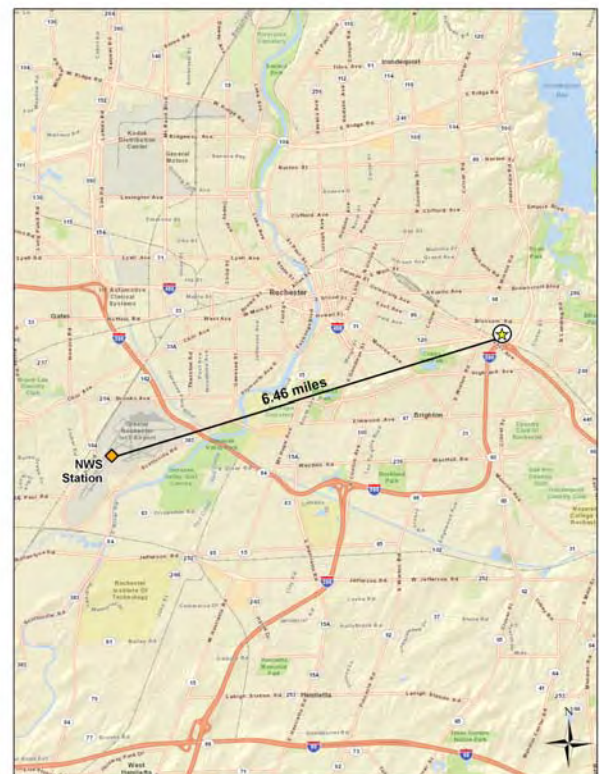
Figure 18-18. Wind Roses for the Niagara Falls International Airport Weather Station near TONY

2002-2009 Historical Wind Rose
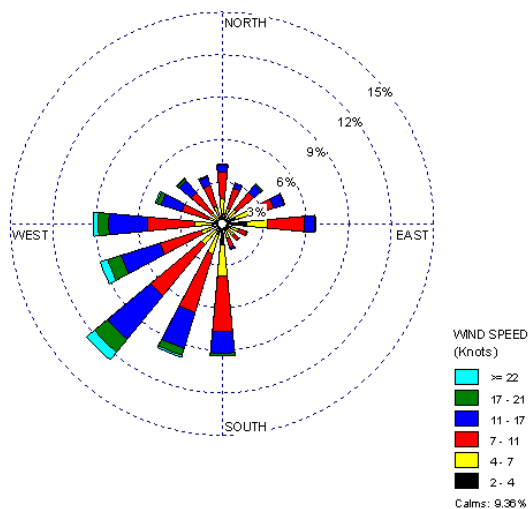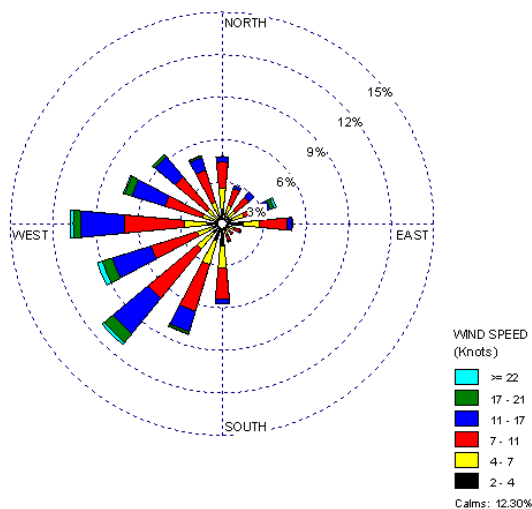
2010 Wind Rose

2010 Sample Day Wind Rose
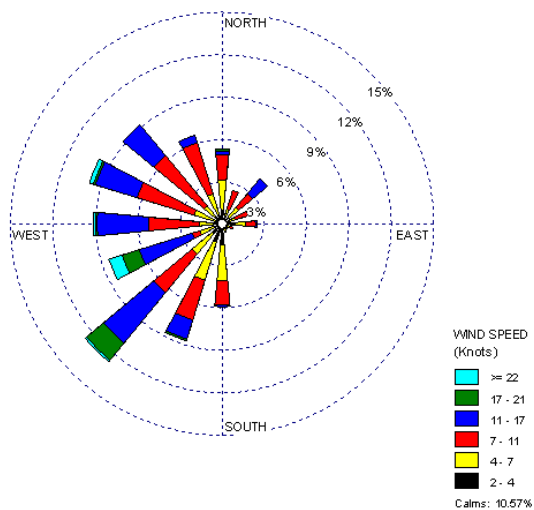
Distance between TONY and NWS Station

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 18-4 presents the pollutants of interest 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. BXNY, MONY, and ROCH sampled for hexavalent chromium and PAH while TONY sampled only for PAH.

Observations from Table 18-4 include the following:

- The number of failed screens is significantly higher for the two New York City sites than for ROCH and TONY. However, many of the pollutants that failed screens for the New York City sites only failed one screen. A review of the data shows that the majority of these failed screens were from a single sample. For BXNY, the January 14, 2010 sample resulted in many failed screens; for MONY, it was the December 28, 2010 sample. These two samples are discussed in further detail in the next section.

- Naphthalene failed the most screens for each site. Naphthalene accounts for between 40 percent (MONY) and 100 percent (ROCH) of each site's total failed screens.

- For BXNY and MONY, 14 pollutants, of which three are NATTS MQO Core Analytes, failed screens. For these sites, the risk screening process identified all of the pollutants that failed a screen as pollutants of interest. This is because so many pollutants contributed equally to the total number of failed screens (by failing only one screen, in this instance) leading up to the 95 percent criteria that they are all considered pollutants of interest. This criterion is discussed in more detail in Section 3.2.

Table 18-4. Risk Screening Results for the New York Monitoring Sites

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
PS 52, New York City, New York - BXNY						
Naphthalene	0.029	28	28	100.00	51.85	51.85
Fluorene	0.011	6	28	21.43	11.11	62.96
Acenaphthene	0.011	5	28	17.86	9.26	72.22
Benzo(a)pyrene	0.00057	3	26	11.54	5.56	77.78
Fluoranthene	0.011	3	28	10.71	5.56	83.33
Acenaphthylene	0.011	1	20	5.00	1.85	85.19
Benzo(a)anthracene	0.0057	1	25	4.00	1.85	87.04
Benzo(b)fluoranthene	0.0057	1	28	3.57	1.85	88.89
Benzo(e)pyrene	0.011	1	28	3.57	1.85	90.74
Benzo(g,h,i)perylene	0.011	1	28	3.57	1.85	92.59
Benzo(k)fluoranthene	0.0057	1	24	4.17	1.85	94.44
Dibenz(a,h)anthracene	0.00052	1	10	10.00	1.85	96.30
Hexavalent Chromium	0.000083	1	25	4.00	1.85	98.15
Indeno(1,2,3-cd)pyrene	0.0057	1	28	3.57	1.85	100.00
Total		54	354	15.25		
Morrisania, New York City, New York - MONY						
Naphthalene	0.029	29	29	100.00	39.73	39.73
Fluorene	0.011	13	29	44.83	17.81	57.53
Acenaphthene	0.011	12	29	41.38	16.44	73.97
Fluoranthene	0.011	7	29	24.14	9.59	83.56
Acenaphthylene	0.011	2	20	10.00	2.74	86.30
Benzo(a)pyrene	0.00057	2	25	8.00	2.74	89.04
Benzo(a)anthracene	0.0057	1	15	6.67	1.37	90.41
Benzo(b)fluoranthene	0.0057	1	29	3.45	1.37	91.78
Benzo(e)pyrene	0.011	1	29	3.45	1.37	93.15
Benzo(g,h,i)perylene	0.011	1	29	3.45	1.37	94.52
Benzo(k)fluoranthene	0.0057	1	24	4.17	1.37	95.89
Dibenz(a,h)anthracene	0.00052	1	6	16.67	1.37	97.26
Hexavalent Chromium	0.000083	1	27	3.70	1.37	98.63
Indeno(1,2,3-cd)pyrene	0.0057	1	28	3.57	1.37	100.00
Total		73	348	20.98		
Rochester, New York - ROCH						
Naphthalene	0.029	2	3	66.67	100.00	100.00
Total		2	3	66.67		
Tonawanda, New York - TONY						
Naphthalene	0.029	26	29	89.66	42.62	42.62
Fluorene	0.011	13	29	44.83	21.31	63.93
Fluoranthene	0.011	9	29	31.03	14.75	78.69
Acenaphthene	0.011	7	29	24.14	11.48	90.16
Benzo(a)pyrene	0.00057	4	29	13.79	6.56	96.72
Acenaphthylene	0.011	2	29	6.90	3.28	100.00
Total		61	174	35.06		

- For ROCH, only naphthalene failed screens. 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.

- Note the relatively low number of measured detections shown in Table 18-4 for ROCH compared to the other sites. Recall from Section 2.4 that problems with the PAH sampler at ROCH led to the invalidation of nearly all of ROCH's PAH data for 2010. The sampler was re-certified at the end of 2010 and the final three samples from 2010 were retained.

- Six PAH, of which two are NATTS MQO Core Analytes, failed screens for TONY. Five of the six pollutants were identified as pollutants of interest by the risk screening process, including the two NATTS MQO Core Analytes, naphthalene and benzo(a)pyrene.

18.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the New York monitoring sites. Concentration averages are provided for the pollutants of interest for each New York site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site, where applicable. Additional site-specific statistical summaries are provided in Appendices M and O.

18.4.1 2010 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)
PS 52, New York City, New York - BXNY						
Acenaphthene	28/28	3.69 ± 2.21	9.85 ± 3.21	NA	NA	NA
Acenaphthylene	20/28	12.37 ± 19.84	0.51 ± 0.46	NA	NA	NA
Benzo(a)anthracene	25/28	1.69 ± 2.82	0.16 ± 0.08	NA	NA	NA
Benzo(a)pyrene	26/28	1.82 ± 3.04	0.16 ± 0.08	NA	NA	NA
Benzo(b)fluoranthene	28/28	2.20 ± 3.12	0.38 ± 0.12	NA	NA	NA
Benzo(e)pyrene	28/28	1.14 ± 1.53	0.22 ± 0.07	NA	NA	NA
Benzo(g,h,i)perylene	28/28	1.89 ± 2.41	0.31 ± 0.10	NA	NA	NA
Benzo(k)fluoranthene	24/28	0.75 ± 1.12	0.08 ± 0.03	NA	NA	NA
Dibenz(a,h)anthracene	10/28	0.12 ± 0.19	0.01 ± 0.01	NA	NA	NA
Fluoranthene	28/28	11.67 ± 14.69	5.61 ± 1.49	NA	NA	NA
Fluorene	28/28	11.83 ± 15.07	11.14 ± 3.28	NA	NA	NA
Hexavalent Chromium	25/28	0.04 ± 0.01	0.04 ± 0.02	NA	NA	NA
Indeno(1,2,3-cd)pyrene	28/28	1.58 ± 2.31	0.23 ± 0.08	NA	NA	NA
Naphthalene	28/28	174.96 ± 148.30	141.95 ± 32.05	NA	NA	NA

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

Table 18-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the New York Monitoring Sites (Continued)

Pollutant	# of Measured Detections vs. # of Samples	1st Quarter Average (ng/m³)	2nd Quarter Average (ng/m³)	3rd Quarter Average (ng/m³)	4th Quarter Average (ng/m³)	Annual Average (ng/m³)
Morrisania, New York, New York - MONY						
Acenaphthene	29/29	NA	NA	16.52 ± 3.48	5.95 ± 2.00	NA
Acenaphthylene	20/29	NA	NA	0.37 ± 0.31	14.87 ± 23.63	NA
Benzo(a)anthracene	15/29	NA	NA	0.02 ± 0.03	2.60 ± 4.88	NA
Benzo(a)pyrene	25/29	NA	NA	0.05 ± 0.02	3.06 ± 5.83	NA
Benzo(b)fluoranthene	29/29	NA	NA	0.21 ± 0.04	3.11 ± 5.24	NA
Benzo(e)pyrene	29/29	NA	NA	0.12 ± 0.03	1.80 ± 3.00	NA
Benzo(g,h,i)perylene	29/29	NA	NA	0.19 ± 0.05	2.51 ± 3.93	NA
Benzo(k)fluoranthene	24/29	NA	NA	0.04 ± 0.02	1.04 ± 1.83	NA
Dibenz(a,h)anthracene	6/29	NA	NA	0	0.25 ± 0.48	NA
Fluoranthene	29/29	NA	NA	9.66 ± 1.94	9.88 ± 11.20	NA
Fluorene	29/29	NA	NA	16.79 ± 3.87	11.93 ± 12.35	NA
Hexavalent Chromium	27/27	NA	NA	0.03 ± 0.01	0.05 ± 0.01	NA
Indeno(1,2,3-cd)pyrene	28/29	NA	NA	0.12 ± 0.04	2.41 ± 4.16	NA
Naphthalene	29/29	NA	NA	146.07 ± 18.90	198.66 ± 155.29	NA
Rochester, New York - ROCH						
Benzo(a)pyrene	2/3	NA	NA	NA	NA	NA
Hexavalent Chromium	35/59	<0.01 ± <0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± <0.01
Naphthalene	3/3	NA	NA	NA	NA	NA
Tonawanda, New York - TONY						
Acenaphthene	29/29	1.31 ± 0.52	12.02 ± 5.16	NA	NA	NA
Benzo(a)pyrene	29/29	0.12 ± 0.07	0.40 ± 0.18	NA	NA	NA
Fluoranthene	29/29	4.46 ± 3.29	10.91 ± 4.46	NA	NA	NA
Fluorene	29/29	8.56 ± 6.11	17.39 ± 6.13	NA	NA	NA
Naphthalene	29/29	354.79 ± 266.39	519.06 ± 197.95	NA	NA	NA

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

Observations from Table 18-5 include the following:

- Annual average concentrations for the pollutants of interest for BXNY, MONY, and TONY could not be calculated due to the abbreviated sampling period at each site. Recall that the sampling equipment was moved from BXNY to MONY in mid-2010 while sampling was discontinued at TONY in July 2010. In addition, annual average concentrations for the PAH for ROCH could not be calculated due to problems with the sampler. Thus, the only pollutant for which an annual average concentration could be calculated is hexavalent chromium for ROCH. However, Appendices M and O provide the pollutant-specific average concentration for all valid samples collected over the entire sample period for each site.

- Both the annual average and the quarterly average concentrations of hexavalent chromium for ROCH were approximately 0.01 ng/m^3. Among NMP sites sampling hexavalent chromium, the annual average concentration for ROCH is among the lowest, ranking 16th.

- With the exception of acenaphthene, fluorene, and naphthalene, the first quarter average concentrations of the PAH for BXNY are an order of magnitude higher than the second quarter averages and the confidence intervals indicate the inclusion of outliers. The concentrations of the PAH for the sample collected January 14, 2010 are the maximum concentrations for most of these pollutants and in many cases is an order of magnitude higher than any other measurement and, in many cases, is one of the highest concentrations among all NMP sites sampling PAH. For example, the concentration of benzo(a)pyrene on January 14, 2010 was 22.4 ng/m^3, and is more than 12 times the next highest concentration of this pollutant measured at BXNY (1.85 ng/m^3 measured on February 1, 2010). This is also the second highest measurement of this pollutant among all NMP sites sampling PAH (behind only MONY, discussed below). The concentration of acenaphthyelene on January 14, 2010 was 147 ng/m^3, and is more than 18 times the next highest concentration of this pollutant measured at BXNY (8.04 ng/m^3 measured on February 25, 2010). This is also the second highest measurement of this pollutant among all NMP sites sampling PAH (also behind MONY).

- Although the first and second quarter average concentrations of naphthalene and fluorene for BXNY were not significantly different, the highest concentrations of these pollutants were also measured on January 14, 2010. The concentration of naphthalene on January 14, 2010 was 1,170 ng/m^3, and is more than four times the next highest concentration of this pollutant (255 ng/m^3 measured on April 8, 2010). This is the fourth highest measurement of this pollutant among all NMP sites sampling PAH (behind two concentrations from TONY and one from MONY). The concentration of fluorene on January 14, 2010 was 114 ng/m^3, and is more than five times the next highest concentration of this pollutant (22.2 ng/m^3 measured on May 26, 2010). This is the third highest measurement of this pollutant among all NMP sites sampling PAH (behind two concentrations from DEMI).

- The only pollutant for which the maximum concentration was not measured on January 14, 2010 at BXNY was acenaphthene. The difference is evident in the quarterly averages, where the second quarter average is nearly three times the first

quarter average. The maximum concentration of acenaphthene was measured on May 26, 2010 and was 20.9 ng/m^3, although a similar concentration was also measured on April 8, 2010 (19.3 ng/m^3). Note that these are the same days that the second highest concentrations of naphthalene and fluorene were measured, respectively. The third highest measurement of this pollutant was measured on January 14, 2010 (16.2 ng/m^3).

- In most cases, the fourth quarter average concentrations of the PAH for MONY are an order of magnitude higher than the third quarter averages and the confidence intervals indicate the inclusion of outliers. The concentrations of the PAH for the sample collected December 28, 2010 are the maximum concentrations for most of these pollutants and in many cases are an order of magnitude higher than any other measurements and are among the highest concentrations measured at NMP sites sampling PAH. For example, the concentration of benzo(a)pyrene on December 28, 2010 was 42.7 ng/m^3, and is two orders of magnitude higher than the next highest concentration of this pollutant (0.597 ng/m^3 measured on October 5, 2010). This is also the highest measurement of this pollutant among all NMP sites sampling PAH . The concentration of acenaphthyelene on December 28, 2010 was 175 ng/m^3, and is nearly 13 times the next highest concentration of this pollutant (13.7 ng/m^3 measured on December 10, 2010). This is also the highest measurement of this pollutant among all NMP sites sampling PAH.

- Although the third and fourth quarter average concentrations of naphthalene, fluoranthene, and fluorene for MONY were not as drastically different, the highest concentrations of these pollutants were also measured on December 28, 2010. The concentration of naphthalene on December 28, 2010 was 1,240 ng/m^3, and is more than six times the next highest concentration of this pollutant (200 ng/m^3 measured on August 18, 2010). This is the third highest measurement of this pollutant among all NMP sites sampling PAH (behind two concentrations from TONY). The concentration of fluorene on December 28, 2010 was 95.2 ng/m^3, and is more than three times the next highest concentration of this pollutant (29.7 ng/m^3 measured on July 19, 2010). This is the fourth highest measurement of this pollutant among all NMP sites sampling PAH (behind two concentrations from DEMI and one from BXNY). The concentration of fluoranthene on December 28, 2010 was 85.3 ng/m^3, and is more than five times the next highest concentration of this pollutant (15.6 ng/m^3 also measured on July 19, 2010). This is the second highest measurement of this pollutant among all NMP sites sampling PAH (behind only BXNY).

- The only pollutant for which the maximum concentration was not measured on December 28, 2010 at MONY was acenaphthene. The difference is evident in the quarterly averages, where the third quarter average is nearly three times the fourth quarter average. The maximum concentration of acenaphthene was measured on July 29, 2010 and was 29.3 ng/m^3. Note that this is the same day that the second highest concentration of fluorene and fluoranthene were measured.

- Even with the outliers of naphthalene measured at BXNY and MONY, the quarterly average naphthalene concentrations for TONY are significantly higher than for BXNY and MONY, although very large confidence intervals are associated with

18-34

them. The highest concentration of naphthalene was measured at TONY on January 26, 2010 (1,490 ng/m^3), although the next highest concentration of this pollutant was of a similar magnitude (1,390 ng/m^3 measured on May 14, 2010). These are the two highest measurements of this pollutant among all NMP sites sampling PAH. Of the 15 concentrations of naphthalene greater than 500 ng/m^3, nine were measured at TONY.

- The second quarter average concentrations of several pollutants of interest for TONY were higher than the first quarter averages and have relatively large confidence intervals associated with them. The highest concentration of acenaphthene was measured on May 26, 2010 (38.3 ng/m^3). Of the 12 concentrations of acenaphthene greater than 5 ng/m^3 measured at TONY, 11 were measured during the second quarter of 2010. Of the 14 concentrations of fluorene greater than 10 ng/m^3 measured at TONY, all were measured during the second quarter of 2010. Similar patterns exist for the remaining pollutants of interest.

18.4.2 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, a box plot for hexavalent chromium was created for ROCH. Recall that annual average concentrations for the other sites' pollutants of interest could not be calculated. Figure 18-19 overlays the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 18-19. Program vs. Site-Specific Average Hexavalent Chromium Concentration
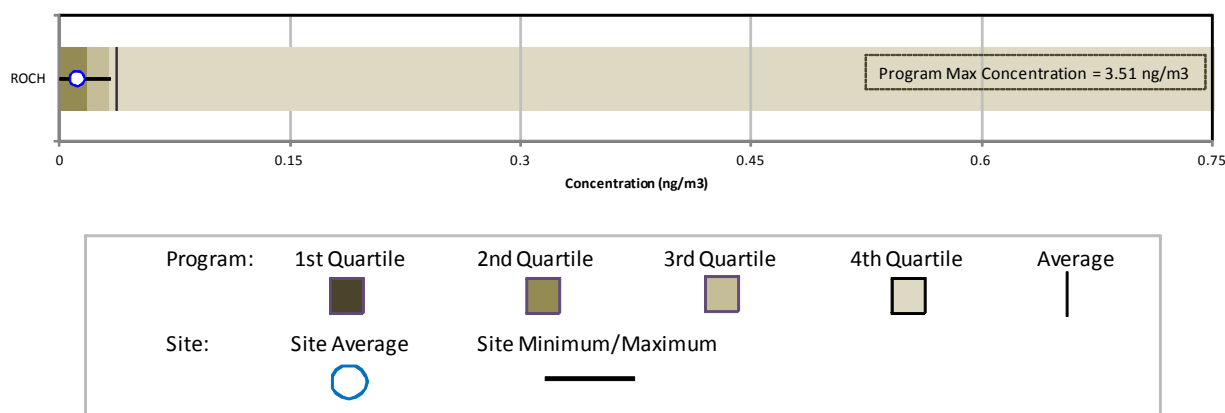
Observations from Figure 18-19 include the following:

- Figure 18-19 is the box plot for hexavalent chromium. The scale has been adjusted as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on the box plot.

- The annual average concentration of hexavalent chromium for ROCH is well below the program-level average. The maximum concentration measured at ROCH is less than the average concentration at the program level and is just greater than the program-level 75th percentile. Several non-detects of hexavalent chromium were measured at ROCH.

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. The New York monitoring sites have not sampled continuously for 5 years as part of the NMP; therefore, a trends analysis was not conducted.

18.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

18.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the New York monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

Of the pollutants sampled for at the New York sites, only naphthalene and hexavalent chromium have ATSDR MRLs. None of the measured detections or time-period average concentrations of naphthalene and hexavalent chromium, where they could be calculated for the New York monitoring sites, were greater than their respective MRL noncancer health risk benchmarks.

18.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the New York monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 18-6, where applicable.

Observations for New York sites from Table 18-6 include the following:

- As discussed in previous sections, annual average concentrations, and thus cancer and noncancer risk approximations, could not be calculated for BXNY, MONY, or TONY.

- In addition, annual average concentrations, and thus cancer and noncancer risk approximations, could not be calculated for the PAH for ROCH.

- Based on the annual average hexavalent chromium concentration for ROCH, the cancer and noncancer surrogate risk approximations are well below the levels of concern.

Table 18-6. Cancer and Noncancer Surrogate Risk Approximations for the New York Monitoring Sites

Pollutant	Cancer URE (µg/m³)⁻¹	Noncancer RfC (mg/m³)	# of Measured Detections vs. # of Samples	Annual Average (µg/m³)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
PS 52, New York City, New York - BXNY						
Acenaphthene	0.000088	--	28/28	NA	NA	NA
Acenaphthylene	0.000088	--	20/28	NA	NA	NA
Benzo(a)anthracene	0.000176	--	25/28	NA	NA	NA
Benzo(a)pyrene	0.00176	--	26/28	NA	NA	NA
Benzo(b)fluoranthene	0.000176	--	28/28	NA	NA	NA
Benzo(e)pyrene	0.000088	--	28/28	NA	NA	NA
Benzo(g,h,i)perylene	0.000088	--	28/28	NA	NA	NA
Benzo(k)fluoranthene	0.000176	--	24/28	NA	NA	NA
Dibenz(a,h)anthracene	0.0019184	--	10/28	NA	NA	NA
Fluoranthene	0.000088	--	28/28	NA	NA	NA
Fluorene	0.000088	--	28/28	NA	NA	NA
Hexavalent Chromium	0.012	0.0001	25/28	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.000176	--	28/28	NA	NA	NA
Naphthalene	0.000034	0.003	28/28	NA	NA	NA
Morrisania, New York City, New York - MONY						
Acenaphthene	0.000088	--	29/29	NA	NA	NA
Acenaphthylene	0.000088	--	20/29	NA	NA	NA
Benzo(a)anthracene	0.000176	--	15/29	NA	NA	NA
Benzo(a)pyrene	0.00176	--	25/29	NA	NA	NA
Benzo(b)fluoranthene	0.000176	--	29/29	NA	NA	NA
Benzo(e)pyrene	0.000088	--	29/29	NA	NA	NA
Benzo(g,h,i)perylene	0.000088	--	29/29	NA	NA	NA
Benzo(k)fluoranthene	0.000176	--	24/29	NA	NA	NA

NA = Not available due to the duration criteria for calculating an annual average.

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

Table 18-6. Cancer and Noncancer Surrogate Risk Approximations for the New York Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Dibenz(a,h)anthracene	0.0019184	--	6/29	NA	NA	NA
Fluoranthene	0.000088	--	29/29	NA	NA	NA
Fluorene	0.000088	--	29/29	NA	NA	NA
Hexavalent Chromium	0.012	0.0001	27/27	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.000176	--	28/29	NA	NA	NA
Naphthalene	0.000034	0.003	29/29	NA	NA	NA
Rochester, New York - ROCH						
Benzo(a)pyrene	0.00176	--	2/3	NA	NA	NA
Hexavalent Chromium	0.012	0.0001	35/59	0.01 ± <0.01	0.14	<0.01
Naphthalene	0.000034	0.003	3/3	NA	NA	NA
Tonawanda, New York - TONY						
Acenaphthene	0.000088	--	29/29	NA	NA	NA
Benzo(a)pyrene	0.00176	--	29/29	NA	NA	NA
Fluoranthene	0.000088	--	29/29	NA	NA	NA
Fluorene	0.000088	--	29/29	NA	NA	NA
Naphthalene	0.000034	0.003	29/29	NA	NA	NA

NA = Not available due to the duration criteria for calculating an annual average.
-- = a Cancer URE or Noncancer RfC is not available.

18.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 18-7 and 18-8 present a risk-based 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. Table 18-8 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

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 Risk Factors (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
PS 52, New York City, New York (Bronx County) - BXNY					
Benzene	225.51	Benzene	1.76E-03		
Ethylbenzene	171.25	Formaldehyde	1.36E-03		
Formaldehyde	104.61	Naphthalene	7.97E-04		
Acetaldehyde	62.07	1,3-Butadiene	6.86E-04		
Naphthalene	23.44	Ethylbenzene	4.28E-04		
1,3-Butadiene	22.86	POM, Group 3	3.35E-04		
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		
Morrisania, New York City, New York (Bronx County) - MONY					
Benzene	225.51	Benzene	1.76E-03		
Ethylbenzene	171.25	Formaldehyde	1.36E-03		
Formaldehyde	104.61	Naphthalene	7.97E-04		
Acetaldehyde	62.07	1,3-Butadiene	6.86E-04		
Naphthalene	23.44	Ethylbenzene	4.28E-04		
1,3-Butadiene	22.86	POM, Group 3	3.35E-04		
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		

Table 18-7. Top 10 Emissions, Toxicity-Weighted Emissions, and Cancer Risk Approximations for Pollutants with Cancer UREs for the New York Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Cancer Risk Factors (County-Level)		Top 10 Cancer Toxicity-Weighted Emissions (County-Level)		Top 10 Cancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Cancer Toxicity Weight	Pollutant	Cancer Risk Approximation (in-a-million)
Rochester, New York (Monroe County) - ROCH					
Benzene	397.57	Benzene	3.10E-03	Hexavalent Chromium	0.14
Ethylbenzene	198.79	Formaldehyde	2.57E-03		
Formaldehyde	197.58	1,3-Butadiene	1.59E-03		
Acetaldehyde	106.73	POM, Group 3	1.36E-03		
1,3-Butadiene	53.16	Naphthalene	1.02E-03		
Dichloromethane	47.06	Hexavalent Chromium, PM	7.52E-04		
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		
Tonawanda, New York (Erie County) - TONY					
Benzene	556.67	Coke Oven Emissions, PM	8.27E-03		
Formaldehyde	260.72	Benzene	4.34E-03		
Ethylbenzene	240.93	Formaldehyde	3.39E-03		
Acetaldehyde	131.01	1,3-Butadiene	1.87E-03		
1,3-Butadiene	62.38	Hexavalent Chromium, PM	1.59E-03		
Naphthalene	38.68	POM, Group 3	1.56E-03		
Dichloromethane	18.34	Naphthalene	1.32E-03		
Coke Oven Emissions, PM	8.35	POM, Group 2b	6.83E-04		
POM, Group 2b	7.77	Ethylbenzene	6.02E-04		
Tetrachloroethylene	2.20	Arsenic, PM	4.26E-04		

Table 18-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the New York Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
PS 52, New York City, New York (Bronx County) - BXNY					
Methanol	808.80	Acrolein	999,876.74		
Toluene	801.90	1,3-Butadiene	11,427.60		
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		
Morrisania, New York City, New York (Bronx County) - MONY					
Methanol	808.80	Acrolein	999,876.74		
Toluene	801.90	1,3-Butadiene	11,427.60		
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		

Table 18-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the New York Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Rochester, New York (Monroe County) - ROCH					
Toluene	944.15	Acrolein	641,820.42	Hexavalent Chromium	<0.01
Xylenes	669.05	1,3-Butadiene	26,578.28		
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		
Tonawanda, New York (Erie County) - TONY					
Toluene	1,219.83	Acrolein	858,961.34		
Xylenes	794.76	1,3-Butadiene	31,188.33		
Benzene	556.67	Formaldehyde	26,603.88		
Methanol	532.33	Benzene	18,555.79		
Hexane	275.55	Acetaldehyde	14,556.63		
Formaldehyde	260.72	Naphthalene	12,893.95		
Ethylbenzene	240.93	Cadmium, PM	12,029.93		
Carbon disulfide	175.99	Manganese, PM	10,377.91		
Acetaldehyde	131.01	Lead, PM	10,244.59		
Ethylene glycol	127.73	Xylenes	7,947.63		

The pollutants in these tables are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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, all four New York sites sampled PAH; BXNY, MONY, and ROCH also sampled hexavalent chromium. In addition, the cancer and noncancer risk approximations are limited to those pollutants with enough data to meet the criteria for annual averages to be calculated. Because annual average concentrations could not be calculated for BXNY, MONY, and TONY, cancer and noncancer risk approximations were not calculated. This is also true for the PAH for ROCH; thus, cancer and noncancer risk approximations are presented only for hexavalent chromium for ROCH.

Observations from Table 18-7 include the following:

- Benzene, ethylbenzene, and formaldehyde are the highest emitted pollutants with cancer UREs in all three New York counties. The magnitudes of the emissions are highest in Erie County and lowest in Bronx County.

- Benzene and formaldehyde are the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for Bronx and Monroe Counties. Coke oven emissions have the highest toxicity-weighted emissions for Erie County, followed by benzene and formaldehyde.

- Seven of the highest emitted pollutants also have the highest toxicity-weighted emissions for Bronx County and Erie County; six of the highest emitted pollutants also have the highest toxicity-weighted emissions for Monroe County.

- Hexavalent chromium, which was sampled for at three of the four New York sites, appears among the pollutants with the highest toxicity-weighted emissions for all three counties, but is not among the highest emitted.

- Emissions of several POM Groups rank among the 10 highest emitted pollutant as well as the highest toxicity-weighted emissions for all three New York counties. POM, Group 2b includes several PAH sampled for at these sites, including acenaphthylene, fluoranthene, fluorene, and perylene. POM, Group 5a includes benzo(a)pyrene. POM, Group 6 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; toluene, xylenes, and benzene are the highest emitted pollutants with noncancer RfCs in Erie County. The magnitudes of the emissions are highest in Erie County.

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

- Between four and five of the highest emitted pollutants in Bronx, Monroe, and Erie Counties are also among the pollutants with the highest toxicity-weighted emissions for each county.

- Naphthalene, which was sampled for at all four New York sites, is among the pollutants with the highest toxicity-weighted emissions, but not among the highest emitted pollutants. Hexavalent chromium, which was sampled for at three of the four sites, does not appear on either emissions-based list for any of the New York Counties.

18.6   Summary of the 2010 Monitoring Data for the New York Monitoring Sites

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

- ❖ *Fourteen pollutants failed screens for BXNY and MONY, although a single sample for each site contributed to the bulk of these failed screens. Only naphthalene failed screens for ROCH. Six pollutants failed screens for TONY.*

- ❖ *The sampling equipment was moved from BXNY to MONY in mid-2010 due to roofing construction while sampling was discontinued at TONY in July 2010.*

- ❖ *Problems with the PAH sampler at ROCH led to the invalidation of a majority of PAH samples for ROCH.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest, where they could be calculated, were greater than their associated MRL noncancer health risk benchmarks.*

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 location of the sites and the surrounding areas. This information is provided to give the reader insight regarding factors that may influence the air quality near the sites and assist in the interpretation of the ambient monitoring measurements.

Two Oklahoma sites (TOOK and TMOK) are located in the Tulsa, OK MSA. Another site, PROK, is located east of the Tulsa area in Pryor Creek, Oklahoma. There are also two sites in the Oklahoma City, OK MSA; one site is located in Oklahoma City (OCOK) and another is located just outside Oklahoma City in Midwest City (MWOK).

Figures 19-1 through 19-5 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 19-6 through 19-8 identify 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 19-6 through 19-8. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 19-1 describes the area surrounding each monitoring site by providing 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
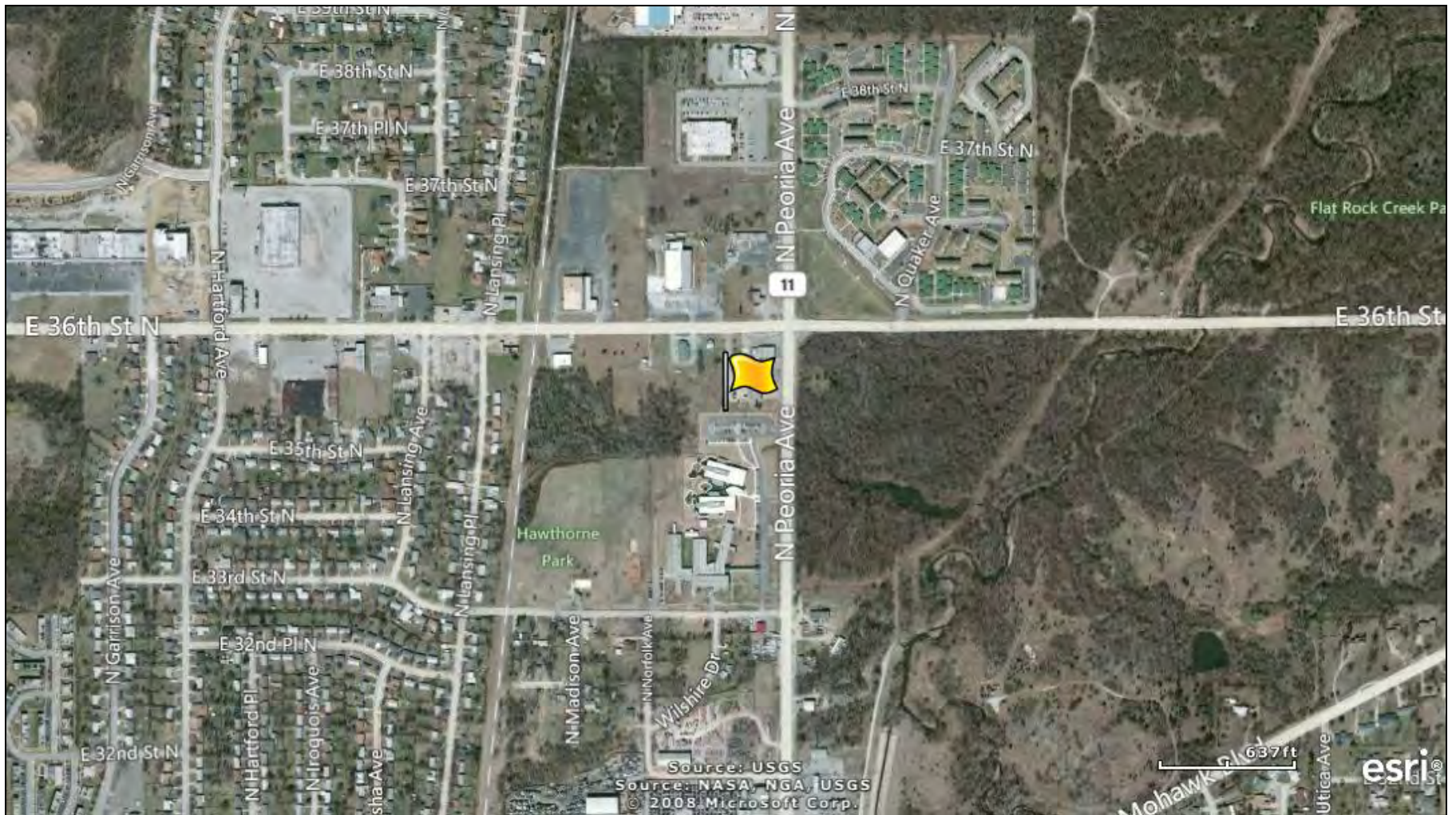
Figure 19-3. Pryor Creek, Oklahoma (PROK) Monitoring Site
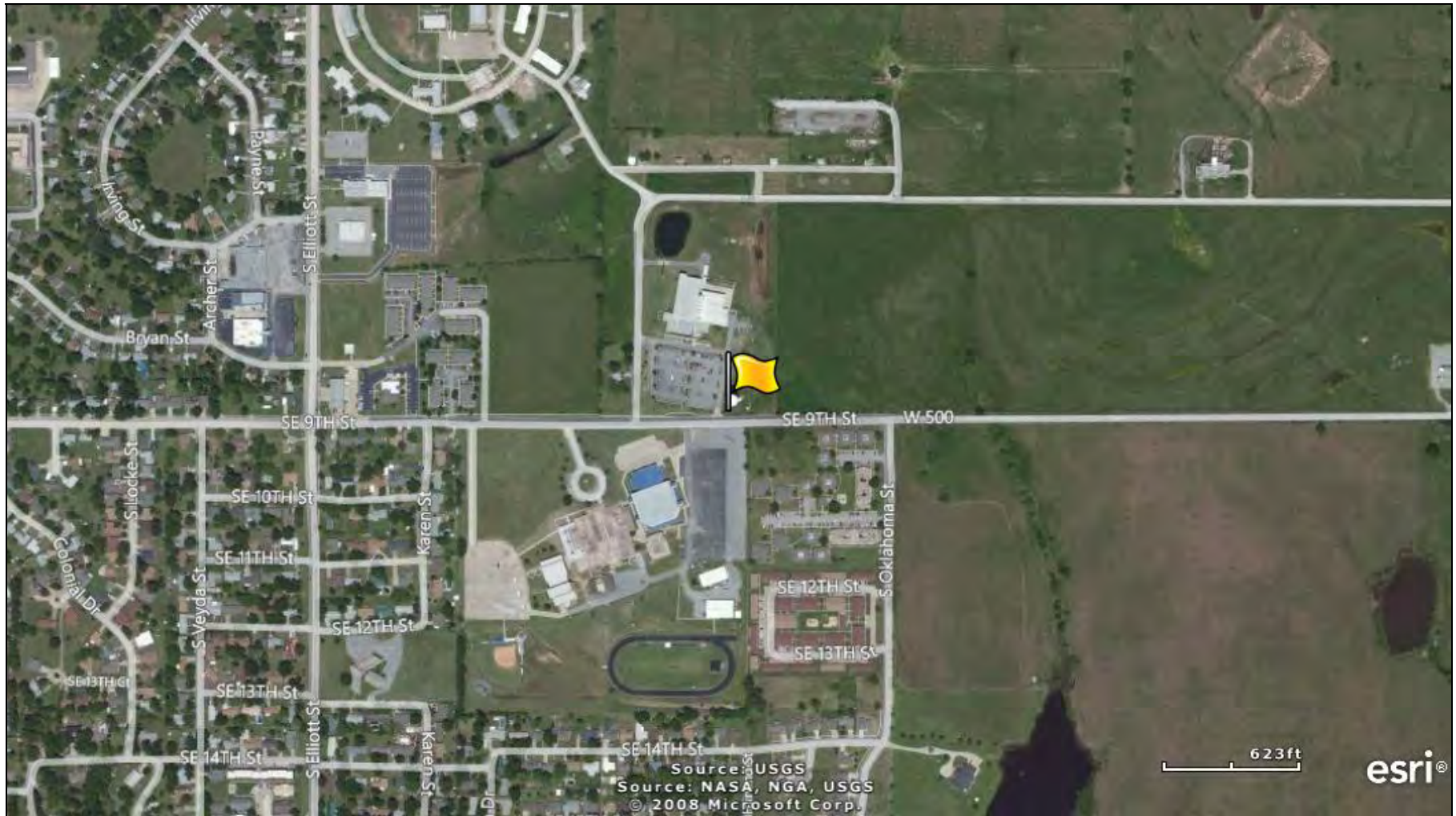
Figure 19-4. Midwest City, Oklahoma (MWOK) Monitoring Site

Figure 19-5. Oklahoma City, Oklahoma (OCOK) Monitoring Site

Figure 19-6. 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.

Legend

⭐ TMOK UATMP site   ★ TOOK UATMP site   ○ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

�֍ Aerospace/Aircraft Manufacturing (1)

⊹ Aircraft Operations (14)

🚘 Automobile/Truck Manufacturing (1)

ƒ Electricity Generation via Combustion (2)

🔩 Glass Manufacturing (2)

? Miscellaneous Commercial/Industrial (1)

Ⓜ Municipal Waste Combustor (1)

◢ Petroleum Refinery (2)

7 Portland Cement Manufacturing (1)

▼ Steel Mill (1)

※ Transportation and Marketing of Petroleum Products (1)

Figure 19-7. 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.

Legend

⭐ PROK UATMP site   ◯ 10 mile radius   ▭ County boundary

Source Category Group (No. of Facilities)

+ Aircraft Operations (5)

c Chemical Manufacturing (1)

⚡ Electricity Generation via Combustion (2)

F Food Processing/Agriculture (1)

7 Portland Cement Manufacturing (1)

Figure 19-8. NEI Point Sources Located Within 10 Miles of MWOK and OCOK

Legend

⭐ MWOK UATMP site   ★ OCOK UATMP site   ○ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

+ Aircraft Operations (19)

B Bakery (1)

F Food Processing/Agriculture (1)

⋀ Military Base/National Security Facility (1)

• Oil and/or Gas Production (2)

P Printing/Publishing (1)
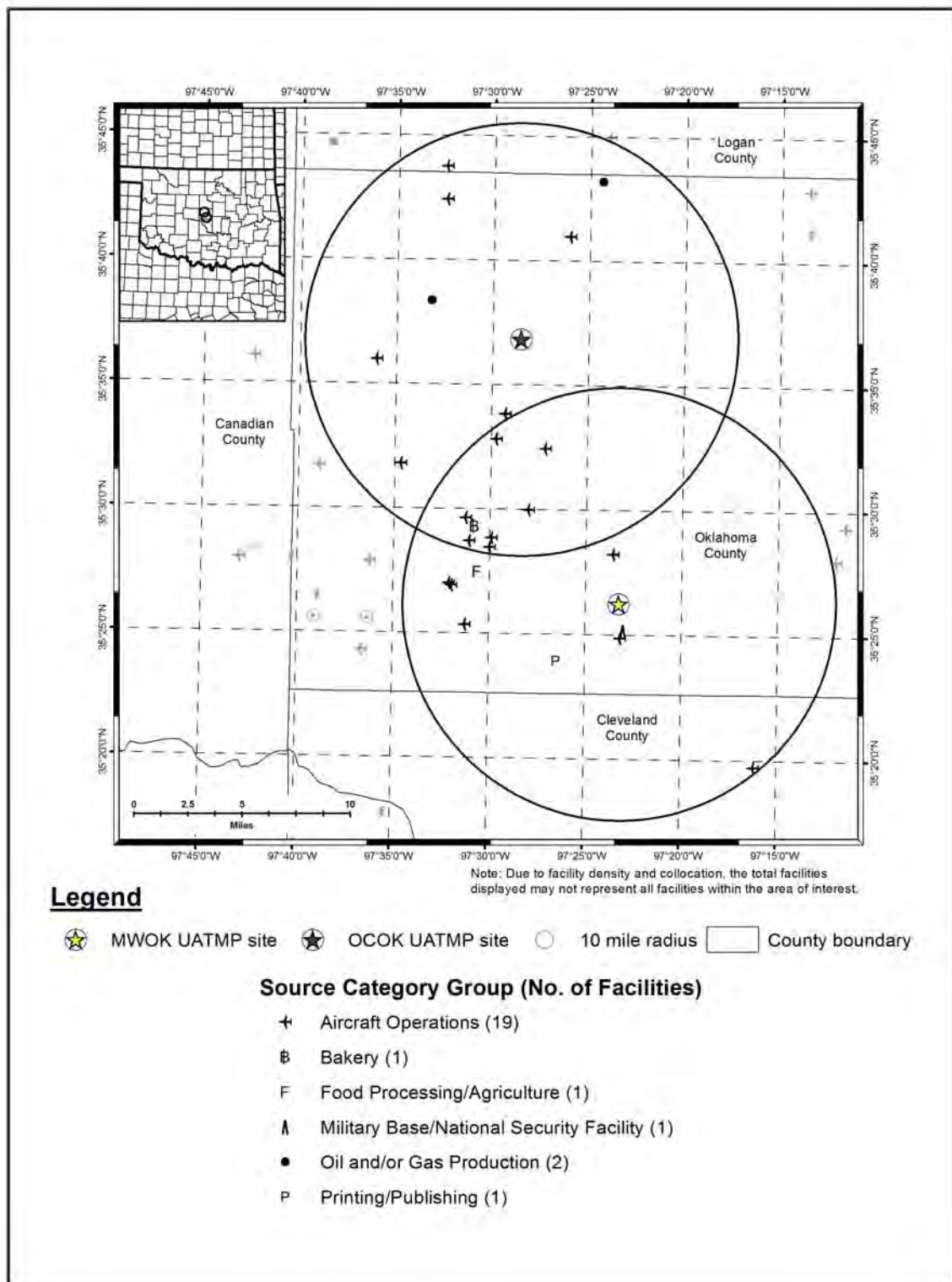
Table 19-1. Geographical Information for the Oklahoma Monitoring Sites

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] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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 19-6 shows that the Tulsa sites are located approximately 5 miles apart, with the TMOK site 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 highest 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 19-3. The monitoring site is located due north (and downwind) of an industrial park located a few miles to the south. Figure 19-7 shows that there are relatively few emissions sources surrounding PROK and that the aircraft operations source category has the highest 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 19-7. The aforementioned industrial park is represented in Figure 19-7 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, although residential areas lie to the west. 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 19-4. 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 19-5.

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 highest number of sources surrounding the two sites is the aircraft operations source category. The source closest to MWOK is the military base; the source closest to OCOK is a heliport.

Table 19-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the Oklahoma monitoring sites. Table 19-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 19-2 also contains annual average daily traffic information. County-level VMT was not readily available; thus, daily VMT for the Oklahoma sites is not shown in Table 19-2.

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	605,418	604,284	1.00	456,229	455,374	62,566	NA
TMOK				320,319	319,719	12,700	
PROK	41,283	40,832	0.99	26,739	26,447	15,900	NA
MWOK	721,178	809,783	1.12	361,698	406,137	41,200	NA
OCOK				380,090	426,788	41,600	

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Oklahoma Tax Commission (OKTC, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data from the Oklahoma DOT (OK DOT, 2010)
[5] County-level VMT was not available for these sites
NA = Data unavailable.

Observations from Table 19-2 include the following:

- The Mayes County population is significantly lower than the Tulsa and Oklahoma County populations. 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 populations are 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 ownership estimates follow a similar pattern as the populations.

- The average daily 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. The traffic data for TMOK and PROK are in the bottom third among NMP 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, 2012; and NOAA, 2012e).

19.2.2 Meteorological Conditions in 2010

Hourly meteorological data from NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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 2010. 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 near TOOK, TMOK, and PROK. Sample days at MWOK and OCOK appear slightly cooler than conditions experienced throughout the year, but the difference is not statistically significant. A few extra samples were collected during first part of the year at MWOK and OCOK in order to make up a few invalid samples, which may result in these subtle differences.

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	Sample Day	71.8 ± 5.0	61.4 ± 4.8	49.0 ± 4.8	54.7 ± 4.4	67.0 ± 2.8	1016.3 ± 1.7	5.2 ± 0.7
	172° (S)	2010	72.0 ± 2.1	61.2 ± 2.0	48.8 ± 2.0	54.5 ± 1.8	67.2 ± 1.2	1016.3 ± 0.7	5.3 ± 0.3
Tulsa, Oklahoma - TMOK									
Tulsa International Airport 13968 (36.20, -95.89)	4.81 miles	Sample Day	70.9 ± 4.9	61.4 ± 4.7	48.5 ± 4.8	54.5 ± 4.3	65.6 ± 2.9	1015.2 ± 1.8	7.8 ± 0.9
	96° (E)	2010	71.1 ± 2.1	61.3 ± 2.0	48.1 ± 2.0	54.2 ± 1.8	65.3 ± 1.3	1015.3 ± 0.7	7.9 ± 0.4
Pryor Creek, Oklahoma - PROK									
Claremore Regional Airport 53940 (36.29, -95.47)	8.66 miles	Sample Day	68.6 ± 5.0	58.8 ± 4.8	48.7 ± 4.9	53.3 ± 4.5	73.0 ± 3.0	NA	6.4 ± 0.9
	270° (W)	2010	69.0 ± 2.0	58.7 ± 2.0	49.0 ± 2.0	53.5 ± 1.8	73.3 ± 1.3	NA	6.4 ± 0.3
Midwest City, Oklahoma - MWOK									
Tinker AFB/Airport 13919 (35.42, -97.39)	1.57 miles	Sample Day	68.8 ± 4.8	59.6 ± 4.5	47.9 ± 4.6	53.4 ± 4.1	68.7 ± 3.6	1015.3 ± 1.7	9.2 ± 0.9
	178° (S)	2010	70.8 ± 2.0	60.7 ± 1.9	48.5 ± 1.9	54.1 ± 1.7	68.0 ± 1.6	1015.2 ± 0.7	9.5 ± 0.4
Oklahoma City, Oklahoma - OCOK									
Wiley Post Airport 03954 (35.53, -97.65)	10.68 miles	Sample Day	69.6 ± 4.9	60.2 ± 4.7	46.3 ± 4.4	52.7 ± 4.1	63.3 ± 3.0	1015.1 ± 1.7	9.7 ± 1.0
	240° (WSW)	2010	71.3 ± 2.0	61.2 ± 2.0	46.9 ± 1.8	53.4 ± 1.7	62.9 ± 1.4	1015.0 ± 0.8	10.2 ± 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.

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 2010. Included in Figure 19-9 are four back trajectories per sample day. Figure 19-10 is the corresponding cluster analysis for 2010. 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the sites in Figures 19-9 through 19-18 represents 100 miles.

Figure 19-9. 2010 Composite Back Trajectory Map for TOOK
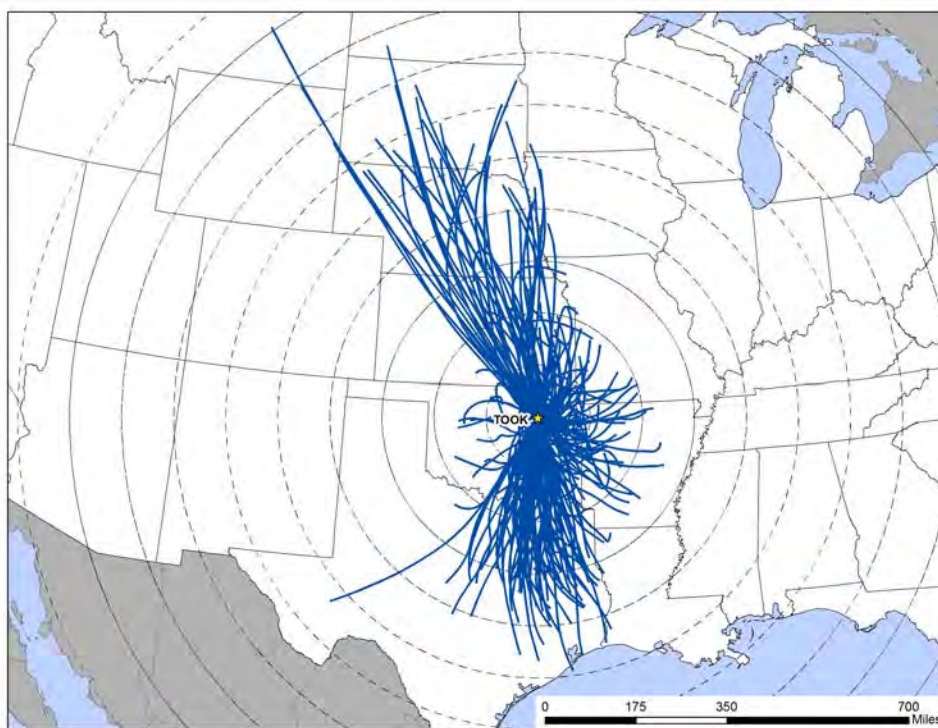
Figure 19-10. Back Trajectory Cluster Map for TOOK

Figure 19-11. 2010 Composite Back Trajectory Map for TMOK
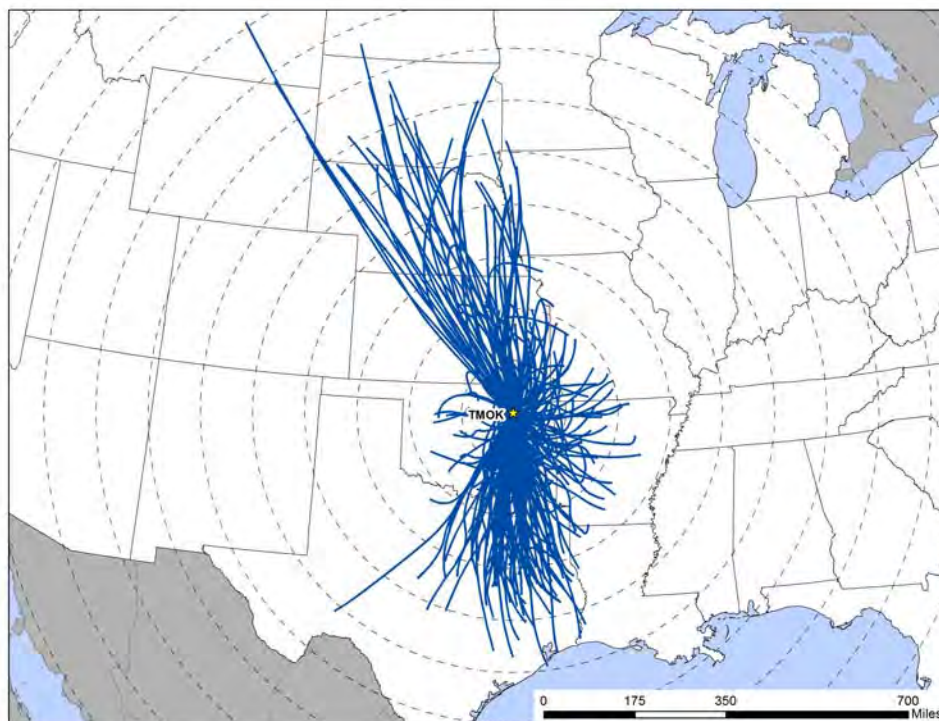
Figure 19-12. Back Trajectory Cluster Map for TMOK
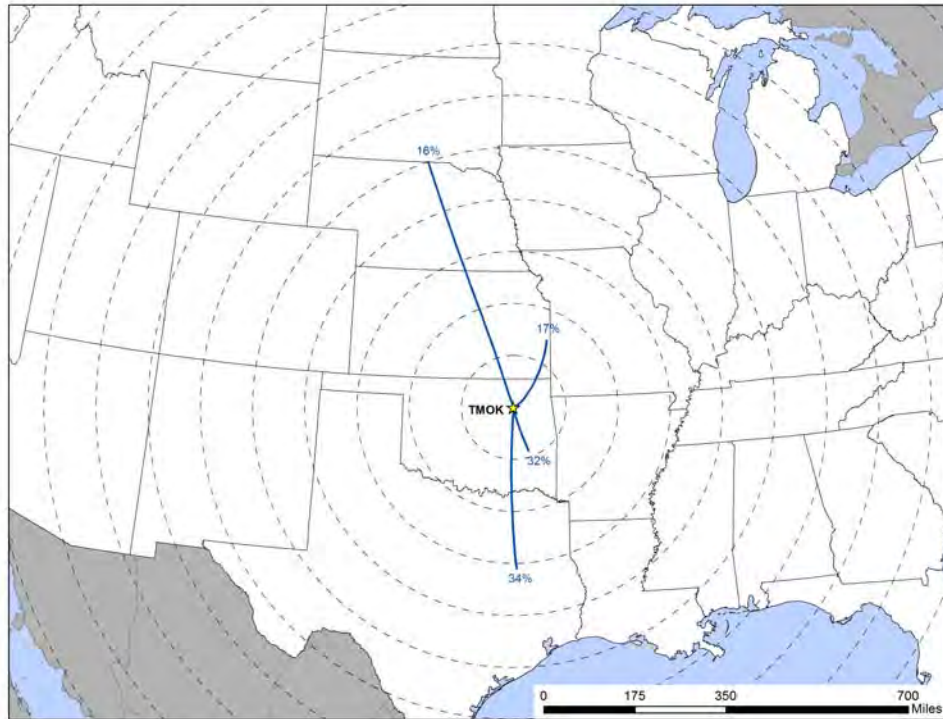
Figure 19-13. 2010 Composite Back Trajectory Map for PROK
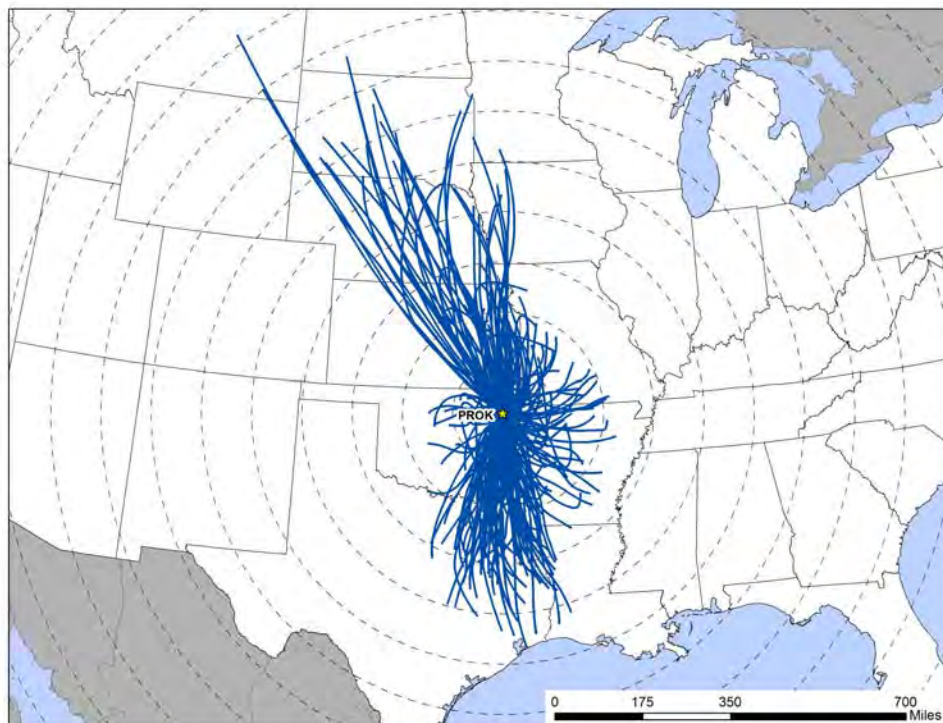
Figure 19-14. Back Trajectory Cluster Map for PROK
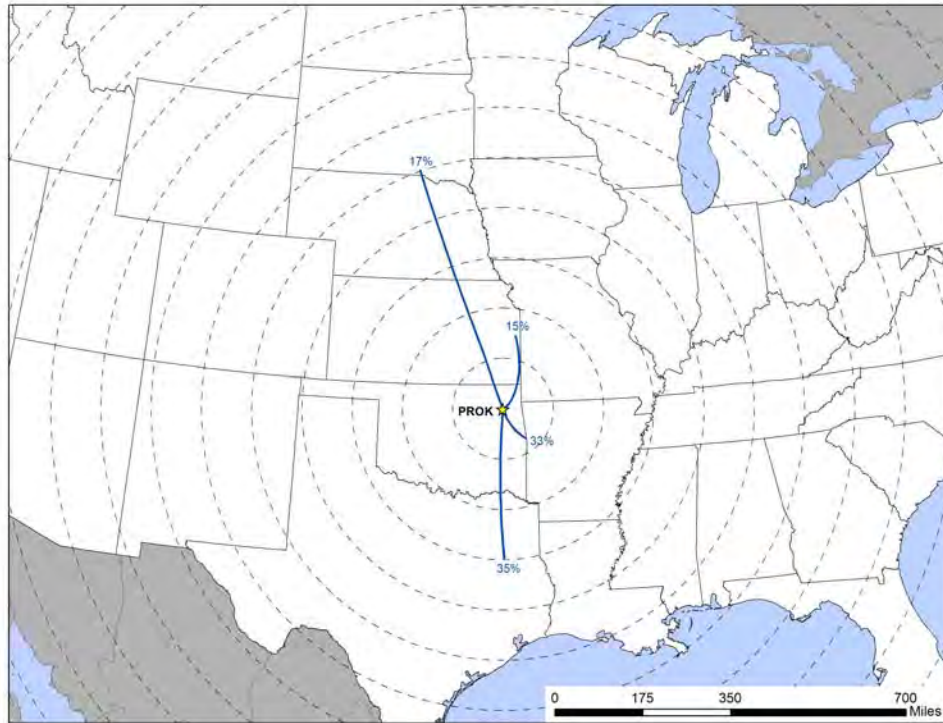
Figure 19-15. 2010 Composite Back Trajectory Map for MWOK
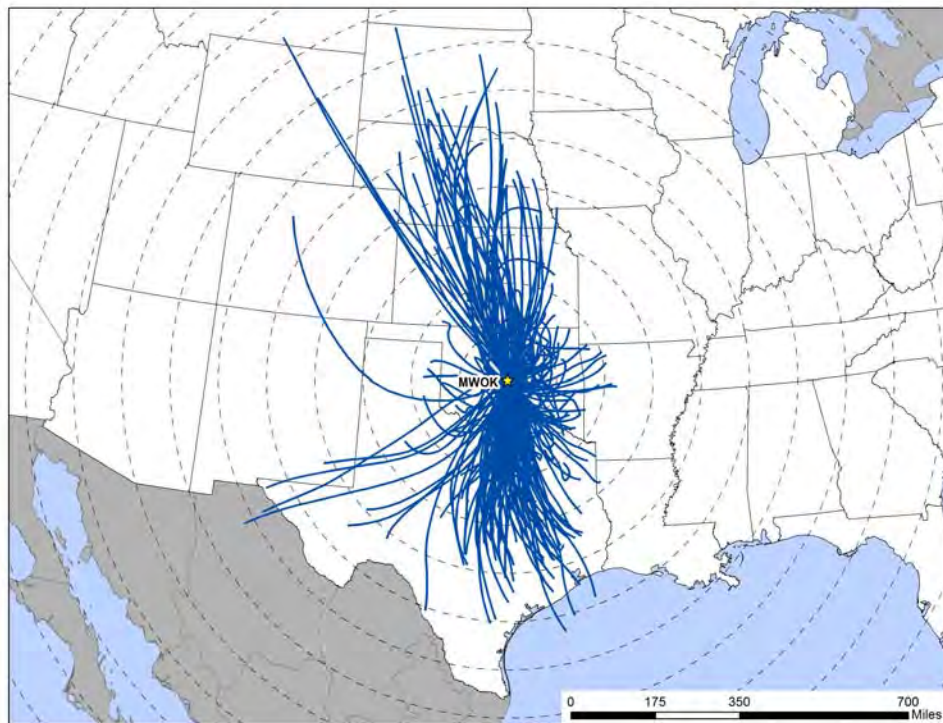
Figure 19-16. Back Trajectory Cluster Map for MWOK
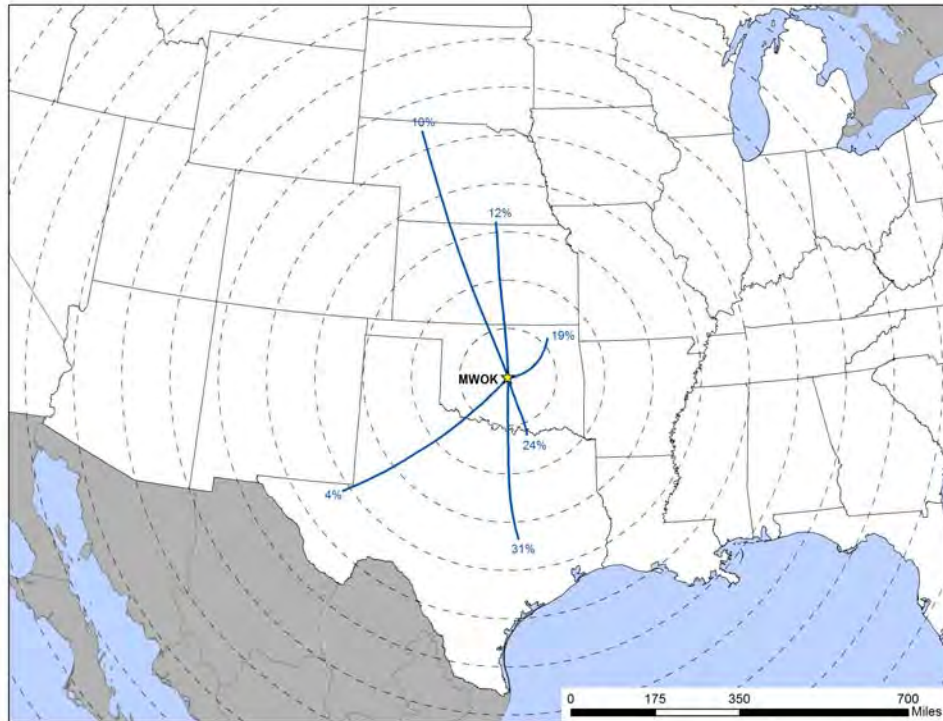
Figure 19-17. 2010 Composite Back Trajectory Map for OCOK
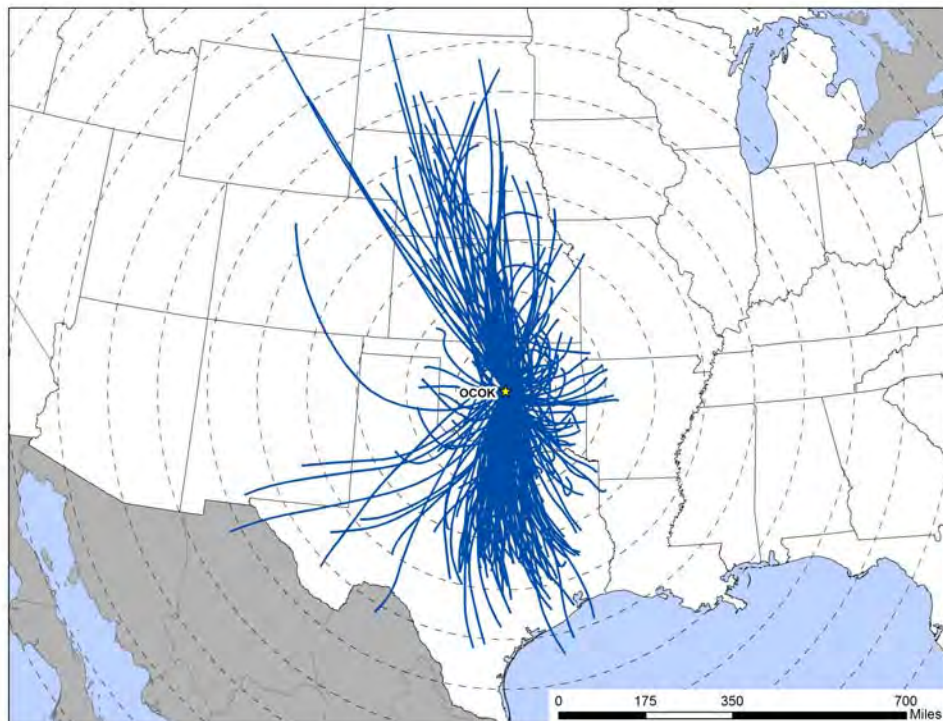
Figure 19-18. Back Trajectory Cluster Map for OCOK
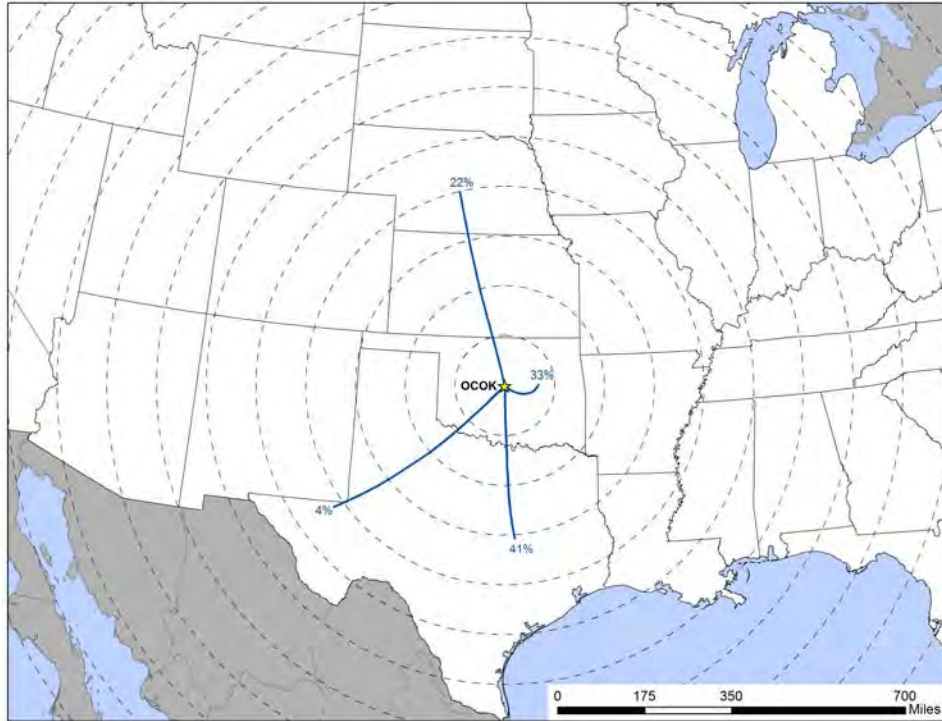
Observations from Figures 19-9 through 19-18 include the following:

- The back trajectory maps for the Tulsa sites, the Pryor Creek site, and the Oklahoma City sites are similar to each other in 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 Tulsa and Pryor Creek sites were among the largest compared to other NMP sites. The farthest away a trajectory originated was over central Montana, or greater than 900 miles away and ranking second, third, and fourth longest for PROK, TMOK, and TOOK, respectively, among NMP sites. However, the average trajectory length for these sites ranged from 268 to 272 miles, which is still in the top third among NMP sites.

- For the Oklahoma City sites, the farthest away a trajectory originated was also over Montana, or nearly 850 miles away. The average trajectory length for these sites ranged from 286 to 290 miles, ranking fourth and sixth highest among NMP sites for average trajectory length.

- Each of the sites show a strong tendency for trajectories to originate from the south-southeast to south-southwest of the sites, and from the northwest to north of the sites. Back trajectories also originated from the east to southeast, but they infrequently originated from the west.

- For the Tulsa and Pryor Creeks sites, approximately one-third of back trajectories originated from the southeast to southwest over Texas. Another one-third of trajectories originated generally from the east to southeast and within 200 miles of the sites, but also includes shorter trajectories originating from the south and west. The remaining back trajectories originated from the northwest to northeast, with the trajectories originating from a northwesterly direction being longer than those originating from the northeast.

- The cluster analysis maps for the Oklahoma City sites are similar to the cluster maps for the Tulsa and Pryor Creeks sites in cluster distribution patterns, although there were more trajectories originating from west Texas for MWOK and OCOK, thus there is an additional cluster trajectory in Figures 19-16 and 19-18 to represent these back trajectories.

19.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the TOOK monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figures 19-20 through 19-23 presents the three wind roses and distance maps for the remaining Oklahoma monitoring sites.

Figure 19-19. Wind Roses for the Richard Lloyd Jones Jr. Airport Weather Station near TOOK

1999-2009 Historical Wind Rose
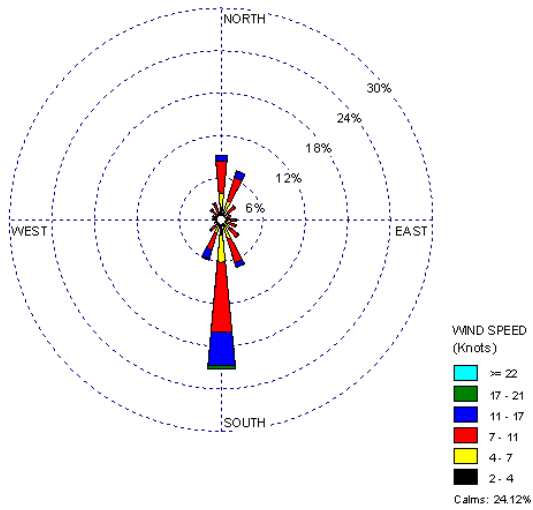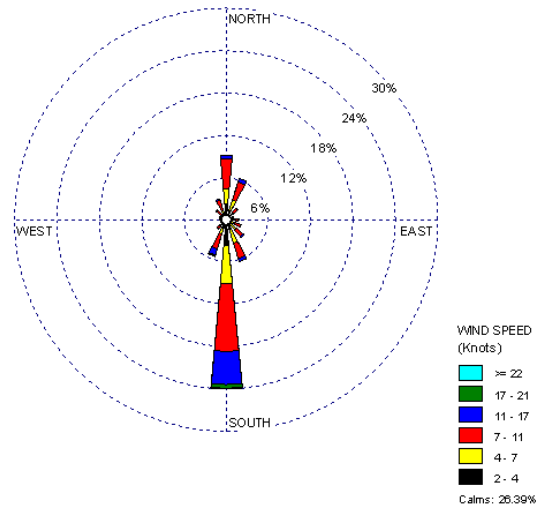
2010 Wind Rose

2010 Sample Day Wind Rose
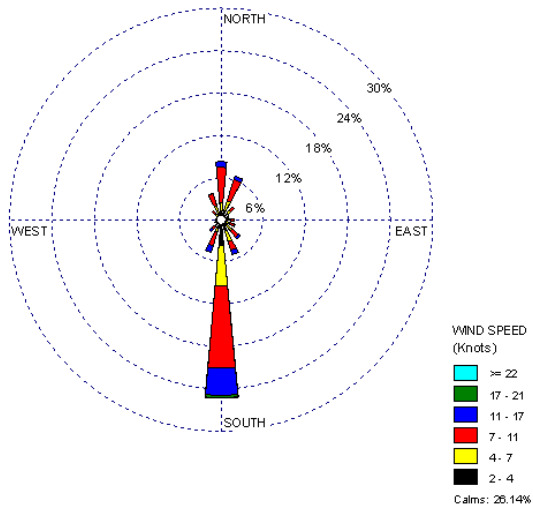
Distance between TOOK and NWS Station

Figure 19-20. Wind Roses for the Tulsa International Airport Weather Station near TMOK

1999-2009 Historical Wind Rose
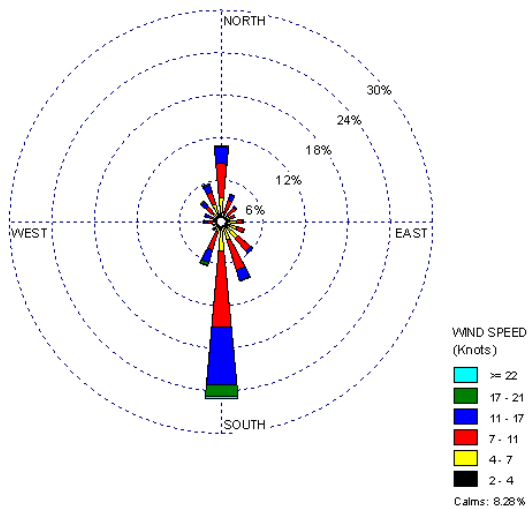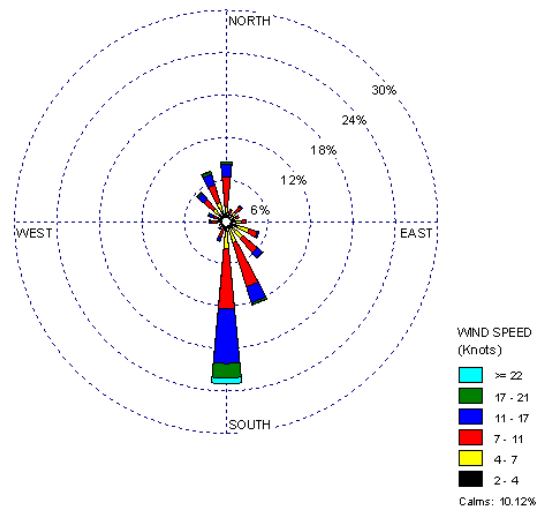
2010 Wind Rose

2010 Sample Day Wind Rose
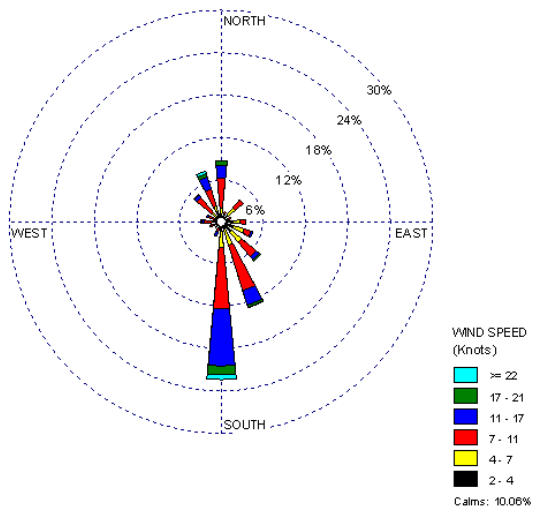
Distance between TMOK and NWS Station
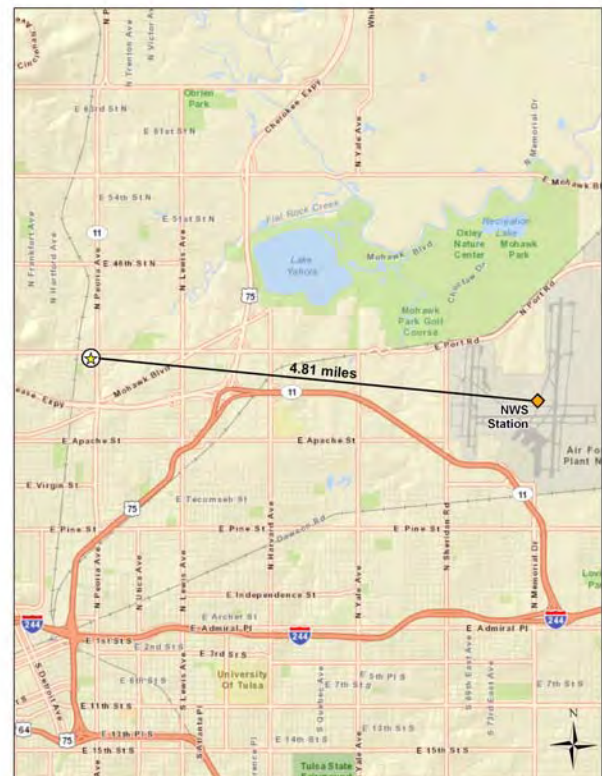
Figure 19-21. Wind Roses for the Claremore Regional Airport Weather Station near PROK

2003-2009 Historical Wind Rose
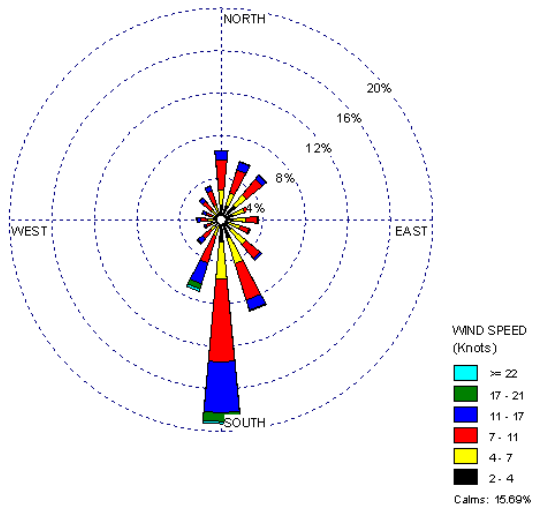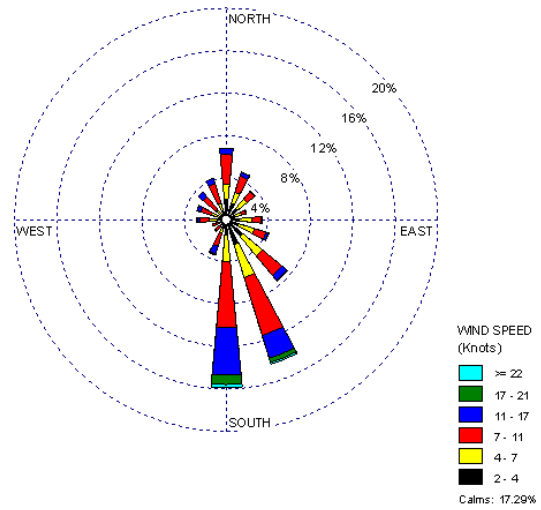
2010 Wind Rose

2010 Sample Day Wind Rose
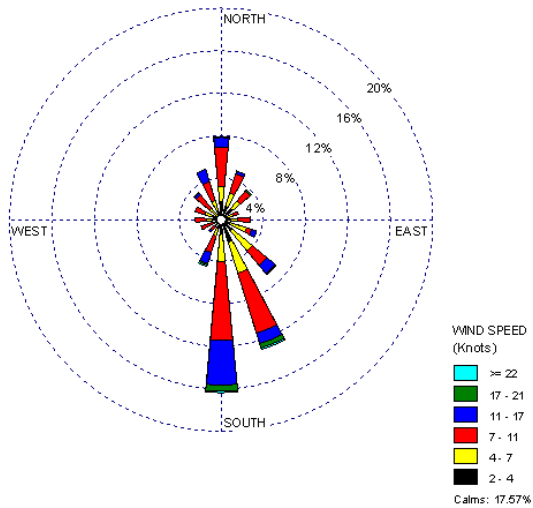
Distance between PROK and NWS Station

Figure 19-22. Wind Roses for the Tinker Air Force Base Airport Weather Station near MWOK

2006-2009 Historical Wind Rose
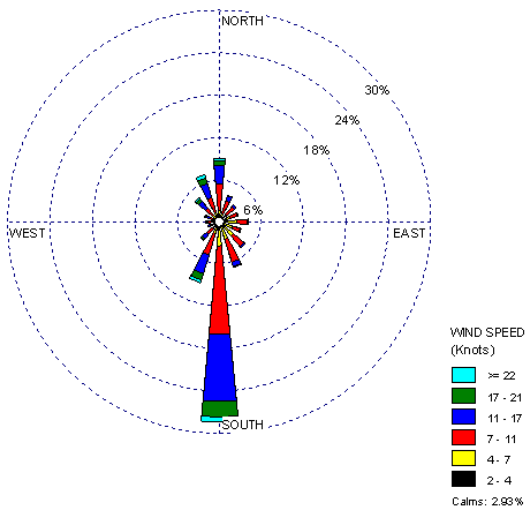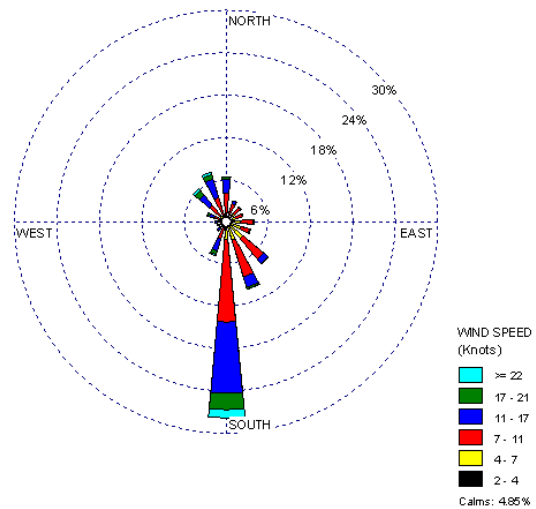
2010 Wind Rose

2010 Sample Day Wind Rose
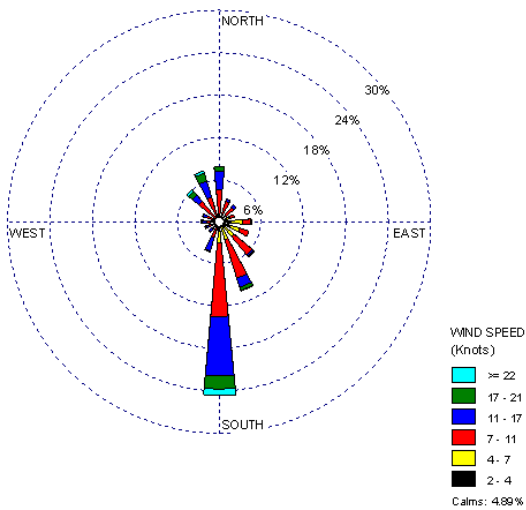
Distance between MWOK and NWS Station
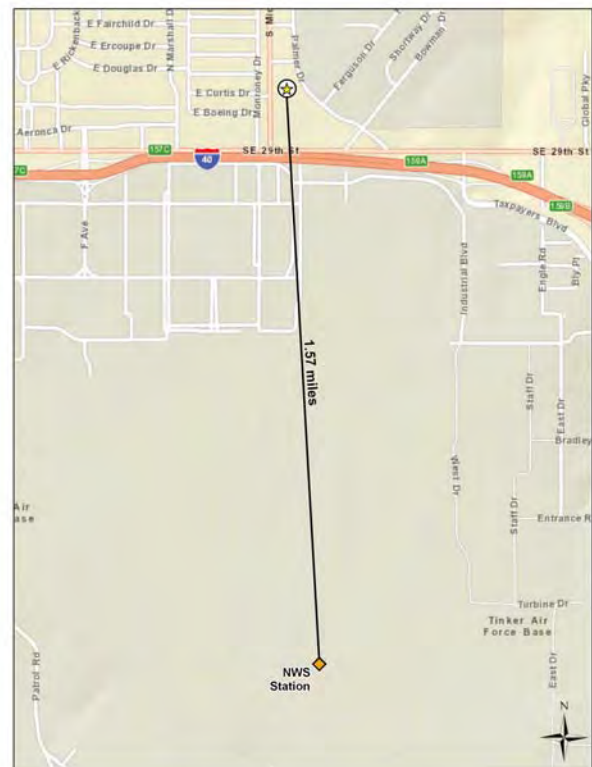
Figure 19-23. Wind Roses for the Wiley Post Airport Weather Station near OCOK

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between OCOK and NWS Station
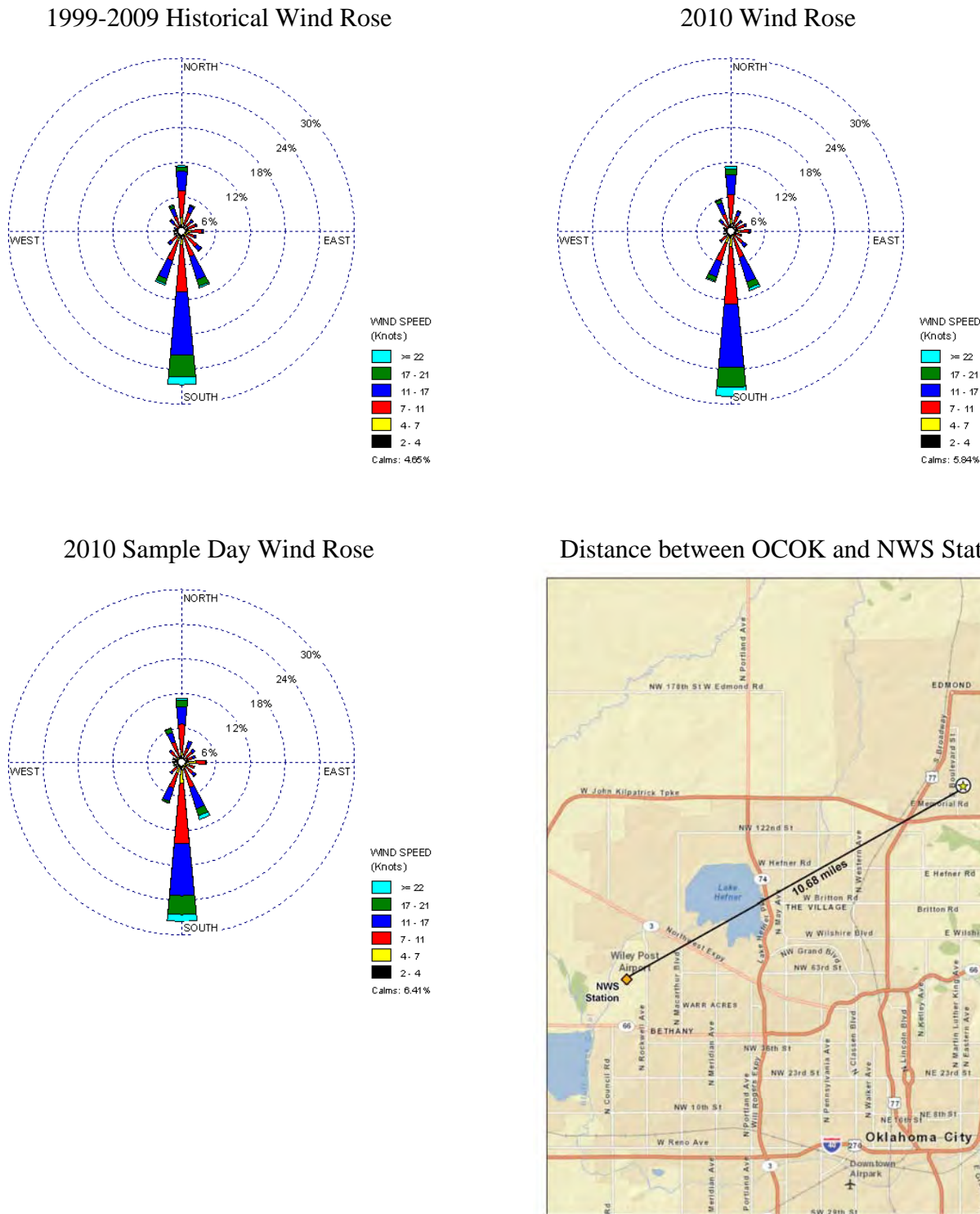
Observations from Figures 19-19 through 19-23 include the following:

- 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 shown 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 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 24 percent at the Richard Lloyd Jones Jr. Airport (TOOK). Further, calm winds, winds from the south-southeast through south-southwest, and winds from the north-northwest to north-northeast account for almost all observations at these sites; winds from the west or east are rarely observed.

- For TOOK, the 2010 wind patterns are very similar to the historical wind patterns, as are the sample day wind patterns. This indicates that conditions on sample days were representative of those experienced over the entire year and historically.

- For TMOK, the 2010 wind patterns resemble the historical wind patterns, although there is a slightly higher percentage of south-southeasterly and northwesterly to north-northwesterly winds observed in 2010.

- For PROK, the 2010 wind rose shows a significantly higher percentage of southeasterly to south-southeasterly wind observations and fewer northeasterly and south-southwesterly winds than the historical wind rose. The sample day wind patterns are similar to the full-year wind patterns, indicating that conditions on sample days were representative of conditions experienced throughout the year.

- For MWOK, the historical wind rose includes only four years worth of data. The 2010 wind patterns resemble the historical wind patterns, although there were slightly fewer south-southwesterly wind observations and more southeasterly to south-southeasterly winds observations. The sample day wind rose wind patterns resemble the historical and the full-year wind patterns rose.

- For OCOK, the wind patterns shown on the 2010 wind rose are similar to the historical wind patterns. The sample day wind rose for OCOK is similar to historical and full-year wind roses, indicating 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

19-28

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 19-4 presents the pollutants of interest 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 VOC, carbonyl compounds, and metals (TSP).

Table 19-4. Risk 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	61	61	100.00	12.22	12.22
Carbon Tetrachloride	0.17	61	61	100.00	12.22	24.45
Acetaldehyde	0.45	60	60	100.00	12.02	36.47
Formaldehyde	0.077	60	60	100.00	12.02	48.50
Manganese (TSP)	0.005	60	61	98.36	12.02	60.52
Arsenic (TSP)	0.00023	58	61	95.08	11.62	72.14
1,3-Butadiene	0.03	50	56	89.29	10.02	82.16
p-Dichlorobenzene	0.091	33	55	60.00	6.61	88.78
Ethylbenzene	0.4	31	61	50.82	6.21	94.99
Propionaldehyde	0.8	8	58	13.79	1.60	96.59
Cadmium (TSP)	0.00056	5	61	8.20	1.00	97.60
1,2-Dichloroethane	0.038	5	5	100.00	1.00	98.60
Acrylonitrile	0.015	2	2	100.00	0.40	99.00
Nickel (TSP)	0.0021	2	61	3.28	0.40	99.40
Chloromethylbenzene	0.02	1	1	100.00	0.20	99.60
1,2-Dibromoethane	0.0017	1	1	100.00	0.20	99.80
Trichloroethylene	0.2	1	11	9.09	0.20	100.00
Total		499	736	67.80		

Table 19-4. Risk Screening Results for the Oklahoma Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Tulsa, Oklahoma - TMOK						
Benzene	0.13	61	61	100.00	12.13	12.13
Carbon Tetrachloride	0.17	61	61	100.00	12.13	24.25
Acetaldehyde	0.45	60	60	100.00	11.93	36.18
Formaldehyde	0.077	60	60	100.00	11.93	48.11
Arsenic (TSP)	0.00023	58	60	96.67	11.53	59.64
Manganese (TSP)	0.005	56	60	93.33	11.13	70.78
1,3-Butadiene	0.03	55	57	96.49	10.93	81.71
Ethylbenzene	0.4	35	61	57.38	6.96	88.67
p-Dichlorobenzene	0.091	31	57	54.39	6.16	94.83
1,2-Dichloroethane	0.038	10	10	100.00	1.99	96.82
Acrylonitrile	0.015	8	8	100.00	1.59	98.41
Propionaldehyde	0.8	3	59	5.08	0.60	99.01
Cadmium (TSP)	0.00056	2	60	3.33	0.40	99.40
Chloroprene	0.0021	1	1	100.00	0.20	99.60
1,2-Dibromoethane	0.0017	1	1	100.00	0.20	99.80
Nickel (TSP)	0.0021	1	60	1.67	0.20	100.00
Total		503	736	68.34		
Pryor Creek, Oklahoma - PROK						
Benzene	0.13	61	61	100.00	14.06	14.06
Carbon Tetrachloride	0.17	61	61	100.00	14.06	28.11
Acetaldehyde	0.45	60	60	100.00	13.82	41.94
Formaldehyde	0.077	60	60	100.00	13.82	55.76
Arsenic (TSP)	0.00023	56	61	91.80	12.90	68.66
Manganese (TSP)	0.005	52	61	85.25	11.98	80.65
1,3-Butadiene	0.03	40	50	80.00	9.22	89.86
p-Dichlorobenzene	0.091	22	48	45.83	5.07	94.93
1,2-Dichloroethane	0.038	15	15	100.00	3.46	98.39
Nickel (TSP)	0.0021	3	61	4.92	0.69	99.08
Cadmium (TSP)	0.00056	2	61	3.28	0.46	99.54
Hexachloro-1,3-butadiene	0.045	1	1	100.00	0.23	99.77
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.23	100.00
Total		434	601	72.21		

Table 19-4. Risk Screening Results for the Oklahoma Monitoring Sites (Continued)

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Midwest City, Oklahoma - MWOK						
Benzene	0.13	61	61	100.00	13.09	13.09
Carbon Tetrachloride	0.17	60	61	98.36	12.88	25.97
Formaldehyde	0.077	60	60	100.00	12.88	38.84
Acetaldehyde	0.45	59	60	98.33	12.66	51.50
Arsenic (TSP)	0.00023	58	61	95.08	12.45	63.95
Manganese (TSP)	0.005	47	61	77.05	10.09	74.03
1,3-Butadiene	0.03	45	52	86.54	9.66	83.69
p-Dichlorobenzene	0.091	42	61	68.85	9.01	92.70
1,2-Dichloroethane	0.038	13	13	100.00	2.79	95.49
Ethylbenzene	0.4	8	61	13.11	1.72	97.21
Nickel (TSP)	0.0021	5	61	8.20	1.07	98.28
Acrylonitrile	0.015	2	2	100.00	0.43	98.71
Chloromethylbenzene	0.02	1	1	100.00	0.21	98.93
1,2-Dibromoethane	0.0017	1	1	100.00	0.21	99.14
Hexachloro-1,3-butadiene	0.045	1	2	50.00	0.21	99.36
Lead (TSP)	0.015	1	61	1.64	0.21	99.57
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.21	99.79
Vinyl chloride	0.11	1	3	33.33	0.21	100.00
Total		466	683	68.23		
Oklahoma City, Oklahoma - OCOK						
Benzene	0.13	61	61	100.00	13.06	13.06
Acetaldehyde	0.45	60	60	100.00	12.85	25.91
Carbon Tetrachloride	0.17	60	61	98.36	12.85	38.76
Formaldehyde	0.077	60	60	100.00	12.85	51.61
Arsenic (TSP)	0.00023	54	61	88.52	11.56	63.17
Manganese (TSP)	0.005	51	61	83.61	10.92	74.09
p-Dichlorobenzene	0.091	42	54	77.78	8.99	83.08
1,3-Butadiene	0.03	41	48	85.42	8.78	91.86
1,2-Dichloroethane	0.038	11	11	100.00	2.36	94.22
Acrylonitrile	0.015	10	10	100.00	2.14	96.36
Ethylbenzene	0.4	6	61	9.84	1.28	97.64
Chloromethylbenzene	0.02	2	2	100.00	0.43	98.07
Hexachloro-1,3-butadiene	0.045	2	2	100.00	0.43	98.50
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.43	98.93
Bromomethane	0.5	1	52	1.92	0.21	99.14
Chloroprene	0.0021	1	1	100.00	0.21	99.36
1,2-Dibromoethane	0.0017	1	1	100.00	0.21	99.57
1,1,2-Trichloroethane	0.0625	1	3	33.33	0.21	99.79
Trichloroethylene	0.2	1	4	25.00	0.21	100.00
Total		467	615	75.93		

Observations from Table 19-4 include the following:

- Seventeen pollutants failed at least one screen for TOOK; 16 pollutants failed screens for TMOK; 13 pollutants failed screens for PROK; 18 pollutants failed screens for MWOK; and 19 pollutants failed screens for OCOK.

- The risk screening process identified 10 pollutants of interest for TOOK, of which seven are NATTS MQO Core Analytes. Cadmium, nickel, and trichloroethylene were added to TOOK'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. Five additional pollutants (beryllium, chloroform, lead, tetrachloroethylene, and vinyl chloride) were added to TOOK's pollutants of interest 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.

- The risk screening process identified 10 pollutants of interest for TMOK, of which seven are NATTS MQO Core Analytes. Cadmium and nickel were added to TMOK'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 (beryllium, chloroform, lead, tetrachloroethylene, trichloroethylene, and vinyl chloride) were added to TOOK's pollutants of interest 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.

- The risk screening process identified nine pollutants of interest for PROK, of which seven are NATTS MQO Core Analytes. Nickel and cadmium were added to PROK'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. An additional six pollutants (beryllium, chloroform, lead, tetrachloroethylene, trichloroethylene, and vinyl chloride) were added to PROK's pollutants of interest 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.

- The risk screening process identified nine pollutants of interest for MWOK, of which seven are NATTS MQO Core Analytes. Nickel, lead, and vinyl chloride were added to MWOK'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. This was the only site for which there was a failed screen of vinyl chloride among all NMP sites sampling VOC. An additional five pollutants (beryllium, cadmium, chloroform, tetrachloroethylene, and trichloroethylene) were added to MWOK's pollutants of interest 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.

- The risk screening process identified 10 pollutants of interest for OCOK, of which seven are NATTS MQO Core Analytes. Trichloroethylene was added to OCOK's pollutants of interest 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

(four metals and three VOC) were added to OCOK's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not fail any screens. These pollutants do not appear in Table 19-4.

- Benzene and formaldehyde each failed 100 percent of screens for each site.

- The percentage of measured detections failing screens (of the pollutants that failed at least one screen) ranged from 68 percent (TOOK) to 76 percent (OCOK). TMOK and TOOK failed the third and fourth highest number of screens among all NMP sites, although the other Oklahoma sites ranked seventh (OCOK), ninth (MWOK), and eleventh (PROK).

19.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Oklahoma monitoring sites. Concentration averages are provided for the pollutants of interest for each Oklahoma site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at each site, where applicable. Additional site-specific statistical summaries are provided in Appendices J, L, and N.

19.4.1 2010 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 ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Tulsa, Oklahoma - TOOK						
Acetaldehyde	60/60	1.19 ± 0.25	2.19 ± 0.47	3.15 ± 0.56	2.12 ± 0.54	2.20 ± 0.29
Benzene	61/61	1.45 ± 0.46	1.93 ± 0.49	2.72 ± 0.47	3.23 ± 1.09	2.34 ± 0.36
1,3-Butadiene	56/61	0.07 ± 0.04	0.06 ± 0.02	0.06 ± 0.02	0.11 ± 0.04	0.07 ± 0.01
Carbon Tetrachloride	61/61	0.67 ± 0.07	0.63 ± 0.07	0.64 ± 0.05	0.56 ± 0.06	0.62 ± 0.03
Chloroform	38/61	0.05 ± 0.03	0.10 ± 0.03	0.12 ± 0.03	0.02 ± 0.02	0.07 ± 0.02
p-Dichlorobenzene	55/61	0.04 ± 0.02	0.12 ± 0.08	0.27 ± 0.05	0.16 ± 0.04	0.15 ± 0.03
Ethylbenzene	61/61	0.30 ± 0.12	0.50 ± 0.17	0.49 ± 0.13	0.60 ± 0.20	0.47 ± 0.08
Formaldehyde	60/60	1.48 ± 0.25	3.46 ± 0.95	4.86 ± 0.82	2.52 ± 0.36	3.14 ± 0.45
Propionaldehyde	58/60	0.22 ± 0.05	0.43 ± 0.13	0.60 ± 0.14	0.44 ± 0.14	0.43 ± 0.07
Tetrachloroethylene	57/61	0.09 ± 0.04	0.12 ± 0.05	0.17 ± 0.06	0.12 ± 0.04	0.13 ± 0.02
Trichloroethylene	11/61	0.02 ± 0.03	0.02 ± 0.02	0.02 ± 0.02	0.01 ± 0.02	0.02 ± 0.01
Vinyl Chloride	3/61	<0.01 ± <0.01	<0.01 ± <0.01	0	0	<0.01 ± <0.01
Arsenic (TSP) [a]	61/61	0.46 ± 0.09	0.70 ± 0.16	0.77 ± 0.14	0.71 ± 0.24	0.66 ± 0.08
Beryllium (TSP) [a]	61/61	0.010 ± 0.01	0.02 ± <0.01	0.03 ± <0.01	0.02 ± 0.01	0.02 ± <0.01
Cadmium (TSP) [a]	61/61	0.30 ± 0.16	0.26 ± 0.07	0.22 ± 0.06	0.36 ± 0.20	0.28 ± 0.06
Lead (TSP) [a]	61/61	3.85 ± 1.14	4.28 ± 1.12	4.84 ± 0.87	4.83 ± 1.13	4.46 ± 0.51
Manganese (TSP) [a]	61/61	16.06 ± 5.60	21.66 ± 5.51	28.75 ± 5.93	27.62 ± 7.26	23.61 ± 3.15
Nickel (TSP)[a]	61/61	0.88 ± 0.20	1.04 ± 0.19	1.24 ± 0.28	1.23 ± 0.25	1.10 ± 0.12

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

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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Tulsa, Oklahoma - TMOK						
Acetaldehyde	60/60	1.45 ± 0.22	2.17 ± 0.33	2.66 ± 0.41	1.73 ± 0.38	2.00 ± 0.20
Benzene	61/61	1.27 ± 0.28	1.32 ± 0.31	1.73 ± 0.34	1.93 ± 0.55	1.57 ± 0.20
1,3-Butadiene	57/61	0.09 ± 0.03	0.08 ± 0.02	0.10 ± 0.03	0.14 ± 0.05	0.10 ± 0.02
Carbon Tetrachloride	61/61	0.58 ± 0.09	0.65 ± 0.08	0.62 ± 0.06	0.58 ± 0.05	0.61 ± 0.03
Chloroform	39/61	0.04 ± 0.02	0.08 ± 0.03	0.11 ± 0.04	0.06 ± 0.04	0.07 ± 0.02
p-Dichlorobenzene	57/61	0.06 ± 0.02	0.12 ± 0.07	0.26 ± 0.04	0.12 ± 0.05	0.14 ± 0.03
1,2-Dichloroethane	10/61	0.03 ± 0.02	0.03 ± 0.03	0	0	0.01 ± 0.01
Ethylbenzene	61/61	0.59 ± 0.46	0.43 ± 0.11	0.59 ± 0.15	0.59 ± 0.20	0.55 ± 0.13
Formaldehyde	60/60	2.63 ± 0.30	4.20 ± 0.85	4.42 ± 0.88	2.16 ± 0.39	3.35 ± 0.40
Tetrachloroethylene	49/61	0.06 ± 0.03	0.09 ± 0.03	0.10 ± 0.03	0.09 ± 0.05	0.09 ± 0.02
Trichloroethylene	10/61	0.01 ± 0.01	0.01 ± 0.02	0.02 ± 0.02	0	0.01 ± 0.01
Vinyl Chloride	2/61	<0.01 ± <0.01	0	0	0	<0.01 ± <0.01
Arsenic (TSP) [a]	60/60	0.42 ± 0.09	0.60 ± 0.16	0.80 ± 0.16	0.66 ± 0.27	0.62 ± 0.09
Beryllium (TSP) [a]	59/60	0.01 ± <0.01	0.01 ± <0.01	0.02 ± <0.01	0.01 ± <0.01	0.01 ± <0.01
Cadmium (TSP) [a]	60/60	0.19 ± 0.05	0.23 ± 0.06	0.27 ± 0.15	0.22 ± 0.06	0.23 ± 0.04
Lead (TSP) [a]	60/60	3.04 ± 0.54	3.59 ± 0.88	4.03 ± 0.69	4.23 ± 1.11	3.72 ± 0.40
Manganese (TSP) [a]	60/60	11.57 ± 3.36	15.29 ± 3.90	18.53 ± 3.77	18.11 ± 4.41	15.88 ± 1.95
Nickel (TSP) [a]	60/60	0.75 ± 0.20	0.81 ± 0.12	1.02 ± 0.22	1.00 ± 0.30	0.89 ± 0.11

[a] Average concentrations provided for the pollutants below the black line are presented in ng/m³ for ease of viewing.

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 ($\mu g/m^3$)
Pryor Creek, Oklahoma - PROK						
Acetaldehyde	60/60	0.91 ± 0.18	1.31 ± 0.21	1.77 ± 0.29	1.45 ± 0.25	1.37 ± 0.14
Benzene	61/61	0.68 ± 0.11	0.84 ± 0.20	0.61 ± 0.06	0.72 ± 0.12	0.71 ± 0.06
1,3-Butadiene	50/61	0.04 ± 0.01	0.05 ± 0.01	0.03 ± 0.01	0.03 ± 0.02	0.04 ± 0.01
Carbon Tetrachloride	61/61	0.60 ± 0.07	0.68 ± 0.08	0.68 ± 0.06	0.64 ± 0.03	0.65 ± 0.03
Chloroform	44/61	0.04 ± 0.03	0.10 ± 0.02	0.31 ± 0.41	0.09 ± 0.07	0.14 ± 0.11
p-Dichlorobenzene	48/61	0.02 ± 0.01	0.12 ± 0.11	0.19 ± 0.02	0.06 ± 0.02	0.10 ± 0.03
1,2-Dichloroethane	15/61	0.04 ± 0.02	0.04 ± 0.03	0	0	0.02 ± 0.01
Formaldehyde	60/60	1.14 ± 0.21	2.89 ± 0.97	4.10 ± 0.72	2.30 ± 0.37	2.64 ± 0.41
Tetrachloroethylene	29/61	0.02 ± 0.02	0.04 ± 0.02	0.03 ± 0.02	0.03 ± 0.02	0.03 ± 0.01
Trichloroethylene	3/61	<0.01 ± <0.01	<0.01 ± 0.01	0.01 ± 0.01	0	<0.01 ± <0.01
Vinyl Chloride	1/61	<0.01 ± <0.01	0	0	0	<0.01 ± <0.01
Arsenic (TSP) [a]	61/61	0.43 ± 0.13	0.56 ± 0.14	0.68 ± 0.16	0.53 ± 0.15	0.55 ± 0.07
Beryllium (TSP) [a]	61/61	0.01 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.02 ± 0.01
Cadmium (TSP) [a]	61/61	0.24 ± 0.16	0.15 ± 0.04	0.14 ± 0.03	0.14 ± 0.04	0.17 ± 0.04
Lead (TSP) [a]	61/61	2.59 ± 1.58	2.80 ± 1.07	4.06 ± 1.26	2.72 ± 0.65	3.06 ± 0.58
Manganese (TSP) [a]	61/61	8.63 ± 4.36	11.46 ± 2.98	17.98 ± 4.43	12.94 ± 3.23	12.84 ± 2.00
Nickel (TSP) [a]	61/61	1.06 ± 1.01	0.66 ± 0.11	0.99 ± 0.41	0.56 ± 0.06	0.82 ± 0.26

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

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	60/60	0.90 ± 0.19	1.25 ± 0.22	1.89 ± 0.22	1.55 ± 0.26	1.41 ± 0.14
Benzene	61/61	0.87 ± 0.18	0.83 ± 0.18	0.83 ± 0.13	1.00 ± 0.29	0.88 ± 0.10
1,3-Butadiene	52/61	0.06 ± 0.03	0.07 ± 0.02	0.06 ± 0.03	0.07 ± 0.04	0.06 ± 0.01
Carbon Tetrachloride	61/61	0.62 ± 0.10	0.69 ± 0.07	0.66 ± 0.05	0.60 ± 0.07	0.64 ± 0.04
Chloroform	45/61	0.05 ± 0.02	0.07 ± 0.02	0.08 ± 0.02	0.06 ± 0.03	0.07 ± 0.01
p-Dichlorobenzene	61/61	0.09 ± 0.02	0.21 ± 0.11	0.28 ± 0.08	0.14 ± 0.04	0.18 ± 0.04
1,2-Dichloroethane	13/61	0.04 ± 0.02	0.03 ± 0.03	0.01 ± 0.01	0	0.02 ± 0.01
Formaldehyde	60/60	1.09 ± 0.25	2.47 ± 0.84	4.17 ± 0.55	2.40 ± 0.40	2.56 ± 0.38
Tetrachloroethylene	53/61	0.17 ± 0.06	0.29 ± 0.17	0.27 ± 0.18	0.13 ± 0.08	0.22 ± 0.06
Trichloroethylene	4/61	0	0.01 ± 0.01	0.01 ± 0.02	0	<0.01 ± <0.01
Vinyl Chloride	3/61	<0.01 ± <0.01	<0.01 ± <0.01	0.01 ± 0.02	0	<0.01 ± <0.01
Arsenic (TSP) [a]	61/61	0.35 ± 0.07	0.52 ± 0.17	0.48 ± 0.11	0.42 ± 0.09	0.44 ± 0.06
Beryllium (TSP) [a]	61/61	0.01 ± 0.01	0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01	0.01 ± <0.01
Cadmium (TSP) [a]	61/61	0.11 ± 0.02	0.09 ± 0.01	0.08 ± 0.02	0.11 ± 0.02	0.10 ± 0.01
Lead (TSP) [a]	61/61	2.06 ± 0.28	2.20 ± 0.46	2.23 ± 0.43	4.29 ± 3.24	2.69 ± 0.80
Manganese (TSP) [a]	61/61	7.97 ± 4.30	7.89 ± 1.82	10.97 ± 2.11	11.29 ± 2.67	9.55 ± 1.41
Nickel (TSP) [a]	61/61	1.04 ± 0.51	1.01 ± 0.41	0.84 ± 0.15	1.05 ± 0.30	0.98 ± 0.17

[a] Average concentrations provided for the pollutants below the black line are presented in ng/m³ for ease of viewing.

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 ($\mu g/m^3$)
Oklahoma City, Oklahoma - OCOK						
Acetaldehyde	60/60	1.01 ± 0.17	1.66 ± 0.30	2.21 ± 0.31	1.45 ± 0.27	1.59 ± 0.17
Acrylonitrile	10/61	0.04 ± 0.03	0.05 ± 0.10	0.02 ± 0.04	0	0.03 ± 0.03
Benzene	61/61	0.82 ± 0.16	1.05 ± 0.26	1.17 ± 0.30	1.00 ± 0.30	1.01 ± 0.13
1,3-Butadiene	48/61	0.04 ± 0.01	0.05 ± 0.02	0.04 ± 0.01	0.04 ± 0.03	0.04 ± 0.01
Carbon Tetrachloride	61/61	0.65 ± 0.08	0.71 ± 0.06	0.66 ± 0.05	0.53 ± 0.10	0.64 ± 0.04
Chloroform	40/61	0.04 ± 0.02	0.09 ± 0.02	0.09 ± 0.03	0.03 ± 0.02	0.06 ± 0.01
p-Dichlorobenzene	54/61	0.36 ± 0.22	0.22 ± 0.07	0.27 ± 0.17	0.11 ± 0.10	0.24 ± 0.07
1,2-Dichloroethane	11/61	0.03 ± 0.02	0.04 ± 0.03	0	0	0.02 ± 0.01
Formaldehyde	60/60	1.34 ± 0.19	2.83 ± 0.81	4.00 ± 0.57	1.76 ± 0.34	2.50 ± 0.36
Tetrachloroethylene	53/61	0.07 ± 0.02	0.07 ± 0.03	0.10 ± 0.05	0.12 ± 0.06	0.09 ± 0.02
Trichloroethylene	4/61	<0.01 ± <0.01	0	<0.01 ± <0.01	0.05 ± 0.08	0.01 ± 0.02
Vinyl Chloride	4/61	<0.01 ± <0.01	<0.01 ± 0.01	0	0	<0.01 ± <0.01
Arsenic (TSP) [a]	61/61	0.36 ± 0.07	0.56 ± 0.29	0.46 ± 0.07	0.39 ± 0.09	0.44 ± 0.08
Beryllium (TSP) [a]	61/61	0.01 ± 0.01	0.01 ± <0.01	0.02 ± <0.01	0.01 ± <0.01	0.01 ± <0.01
Cadmium (TSP) [a]	61/61	0.11 ± 0.04	0.09 ± 0.02	0.09 ± 0.03	0.10 ± 0.04	0.10 ± 0.01
Lead (TSP) [a]	61/61	1.85 ± 0.19	1.94 ± 0.44	2.14 ± 0.37	2.40 ± 0.71	2.08 ± 0.22
Manganese (TSP) [a]	61/61	8.67 ± 4.47	11.83 ± 2.99	14.83 ± 2.99	12.39 ± 2.81	11.98 ± 1.68

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

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 for benzene is greater than the annual average concentration of acetaldehyde for TOOK. The annual average concentrations of these three pollutants are highest for TOOK and TMOK among the Oklahoma sites.

- The annual average concentrations of manganese are the highest among the TSP metals for each site, and are also highest for TOOK and TMOK among the Oklahoma sites.

- Concentrations of the carbonyl compounds tended to be highest in the summer months and lowest in the winter months, especially for formaldehyde.

- 1,2-Dichloroethane is a pollutant of interest for four of the five Oklahoma sites. For each of these sites, the majority of the measured detections were measured during the first and second quarters of 2010. This pollutant was not detected at all at TMOK, PROK, and OCOK during the third and fourth quarters of the year. For MWOK, there was a single measured detection in July, after which there were no others.

- Concentrations of the TSP metals tended to be higher at TOOK, TMOK, and PROK than OCOK and MWOK.

Observations for the Tulsa sites from Table 19-5 include the following:

- The fourth quarter average concentration of benzene for TOOK has a fairly large confidence interval associated with it. The highest benzene concentration was measured on December 10, 2010 (6.95 $\mu g/m^3$), although two additional concentrations greater than 6 $\mu g/m^3$ were measured in October. These three concentrations are the three highest benzene measurements among NMP sites sampling this pollutant. Of the 19 concentrations of benzene that are greater than 3.5 $\mu g/m^3$ (among all NMP sites), 11 of these were measured at TOOK. Of these 11, one was measured in the first quarter of 2010, one in the second quarter, four were measured in the third quarter, and five in the fourth quarter. While benzene concentrations greater than 3.5 $\mu g/m^3$ were not measured at TMOK, this site exhibits a similar quarterly trend as six of the nine highest concentrations of benzene (those greater than 2.5 $\mu g/m^3$) were measured during the fourth quarter of 2010.

- Concentrations of p-dichlorobenzene were highest in the third quarter and lowest in the first quarter of 2010 at TOOK. A review of the data shows that the highest concentrations of this pollutant were measured in June and July while five of the six non-detects were reported for January and February. A similar trend is realized at TMOK.

- The quarterly average concentrations of manganese are higher for the third and fourth quarters than the first and second quarters of 2010 for TOOK. A review of the data shows that six of the eight concentrations greater than 40 ng/m^3 were measured

during in August, September, and October. Conversely, seven of the eight lowest concentrations of manganese were measured in January, February, and March 2010.

Observations for PROK from Table 19-5 include the following:

- The annual average concentration of chloroform for PROK is roughly twice the annual average concentrations of this pollutant for the other Oklahoma sites. The third quarter average concentration of chloroform is significantly higher than the other quarterly averages and the confidence interval associated with this average is large. A review of the data shows that the maximum concentration of chloroform was measured on August 18, 2010 (3.28 $\mu g/m^3$) and was an order of magnitude higher than the next highest concentration (0.391 $\mu g/m^3$ measured on October 17, 2010). The concentration measured on August 18, 2010 is the sixth highest concentration of this pollutant among sites sampling VOC.

- Concentrations of *p*-dichlorobenzene were highest in the third quarter and lowest in the first quarter of 2010 at PROK, similar to TOOK and TMOK. A review of the data shows that the highest concentrations of this pollutant were measured in June and July while over half of the non-detects were reported in the first quarter of 2010.

Observations for the Oklahoma City sites from Table 19-5 include the following:

- The second quarter acrylonitrile average for OCOK has a relatively large confidence interval associated with it, indicating the potential presence of outliers. The concentration of acrylonitrile on April 26, 2010 (0.744 $\mu g/m^3$) is more than twice the next highest concentration (0.311 $\mu g/m^3$ measured on August 10, 2010). Only four of the 10 measured detections of this pollutant at OCOK were greater than 0.1 $\mu g/m^3$.

- While *p*-dichlorobenzene's trend of being lowest during the first quarter and highest during the third quarter continues at MWOK, the first quarter average concentration is actually the highest among the quarterly averages for OCOK. However, this average has a relatively large confidence interval associated with it. A review of the data shows that the two highest concentrations of this pollutant were measured at OCOK on February 19, 2010 and March 2, 2010 (1.27 $\mu g/m^3$ and 1.19 $\mu g/m^3$, respectively), although another concentration greater than 1 $\mu g/m^3$ was also measured on September 29, 2010. These three concentrations are among the 10 concentrations greater than 1 $\mu g/m^3$ measured among NMP sites sampling VOC.

- The highest annual average concentration of tetrachloroethylene among the Oklahoma sites was calculated for MWOK. The second and third quarter average concentrations are greater than the other quarterly average and have relatively large confidence intervals associated with them. The only two concentrations of tetrachloroethylene greater than 1 $\mu g/m^3$ were measured at MWOK on August 30, 2010 and June 25, 2010 (1.13 and 1.09 $\mu g/m^3$, respectively). These are the seventh and tenth highest concentrations of tetrachloroethylene measured among NMP sites sampling VOC.

- The fourth quarter average concentration of lead for MWOK has a large confidence interval associated with it, indicating the likely presence of outliers. The maximum concentration of lead was measured on October 29, 2010 (26.0 ng/m^3) and is nearly five times the next highest concentration measured at MWOK (5.47 ng/m^3), also measured in October. This concentration is the highest lead concentration measured among the Oklahoma sites.

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

- TOOK has the highest annual average of concentration of benzene among all NMP sites sampling this pollutant. The annual average for TMOK ranks fifth.

- The annual average concentrations for all five Oklahoma sites ranked among the 10 highest annual average concentrations of *p*-dichlorobenzene, with OCOK ranking fourth.

- PROK and MWOK rank highest and second highest, respectively, for their annual average concentrations of 1,2-dichloroethane, with OCOK ranking fifth.

- TMOK and TOOK rank fifth and sixth highest, respectively, for their annual average concentrations of formaldehyde, among sites sampling carbonyl compounds. TOOK also ranks eighth for acetaldehyde while TMOK ranks tenth.

- The Oklahoma sites were the only NMP sites to monitor for TSP metals; thus, they are the only sites that appear in Table 4-12 under TSP metals.

- For five of the six TSP metals shown in Table 4-12, TOOK has the highest annual average concentration 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 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, arsenic, benzene, 1,3-butadiene, formaldehyde, and manganese were created for the Oklahoma sites. Figures 19-24 through 19-29 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 19-24. Program vs. Site-Specific Average Acetaldehyde Concentration
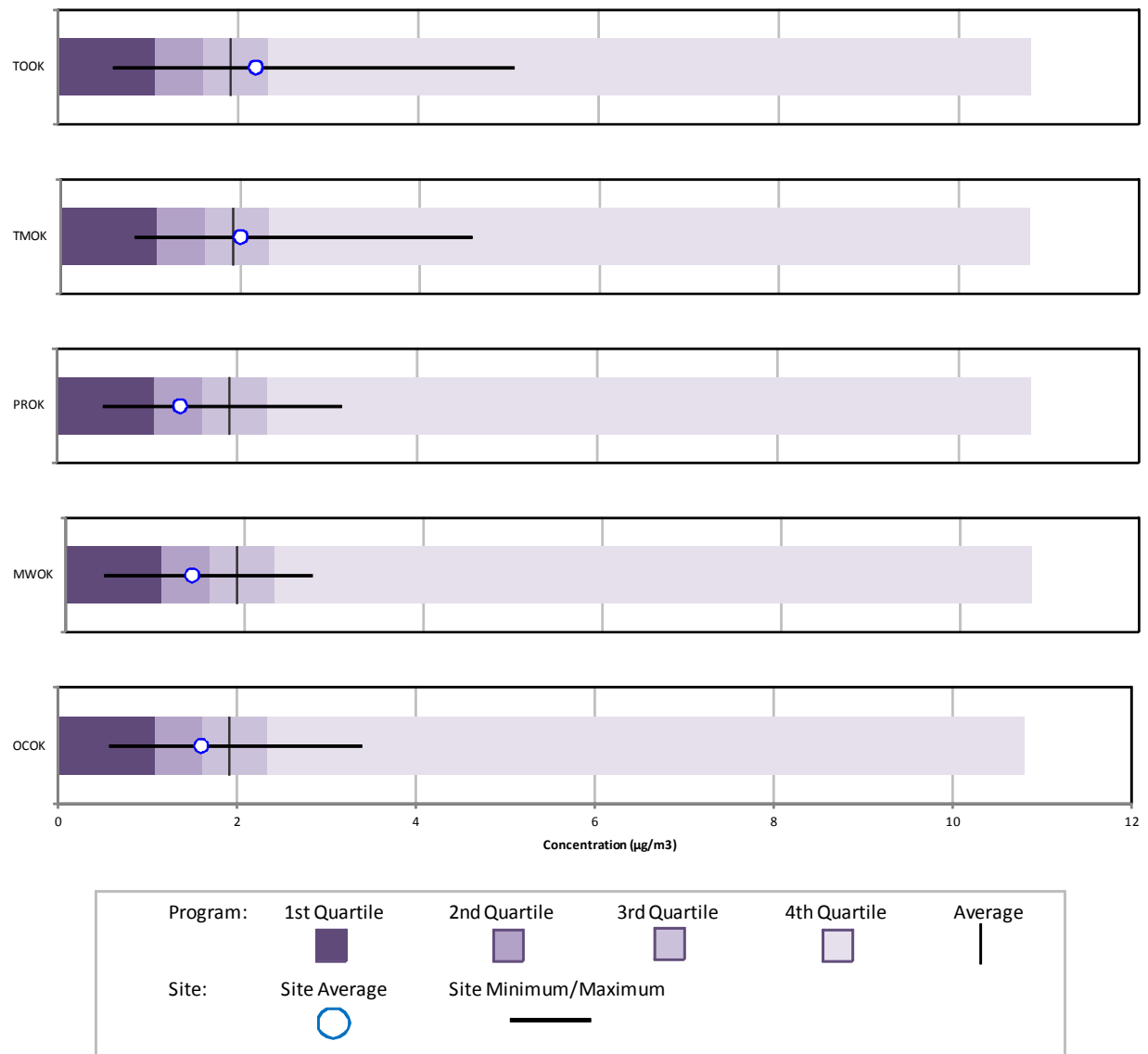
Figure 19-25. Program vs. Site-Specific Average Arsenic (TSP) Concentration
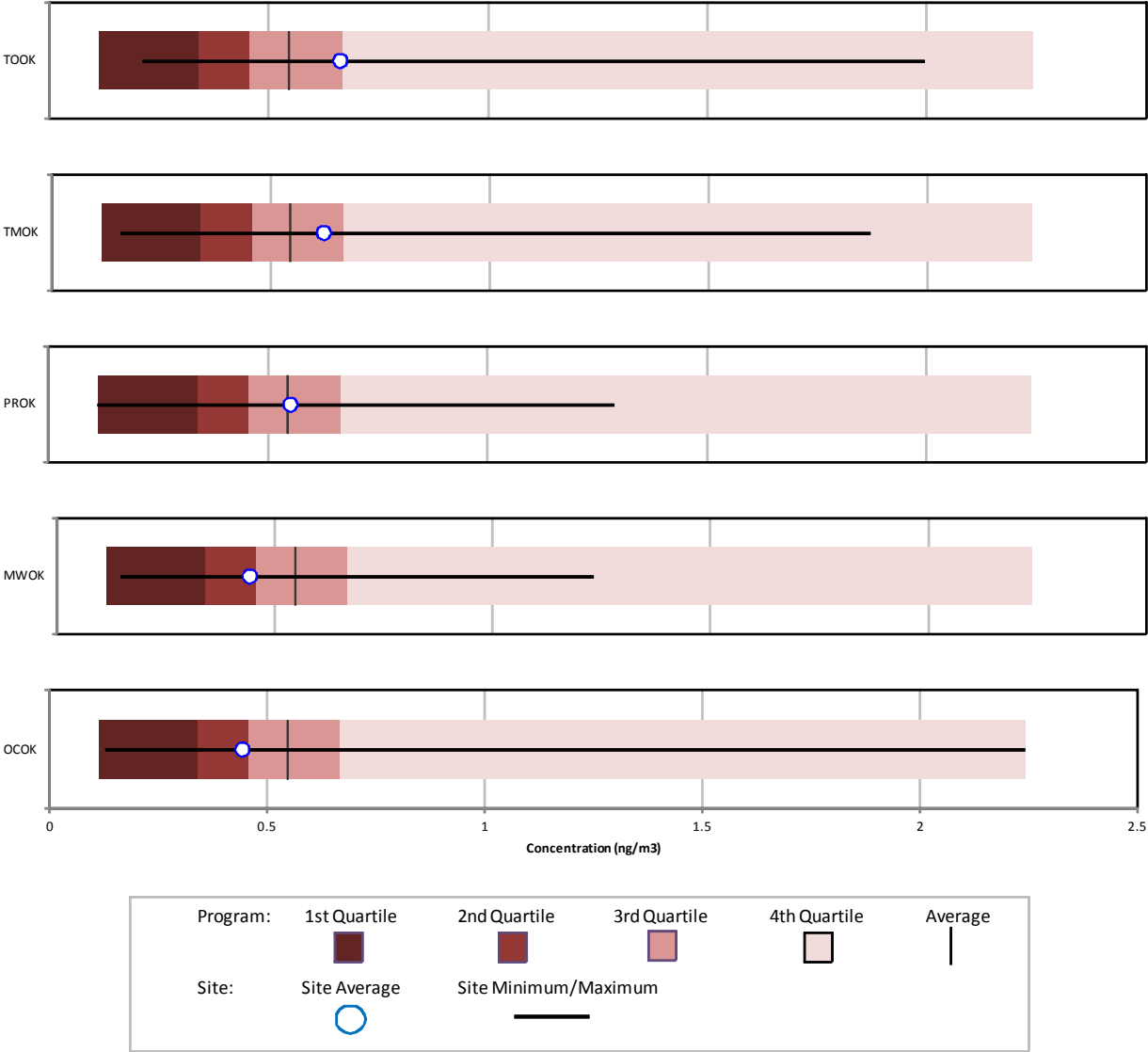
Figure 19-26. Program vs. Site-Specific Average Benzene Concentration

Concentration (μg/m3)

Program: 1st Quartile 2nd Quartile 3rd Quartile 4th Quartile Average

Site: Site Average Site Minimum/Maximum
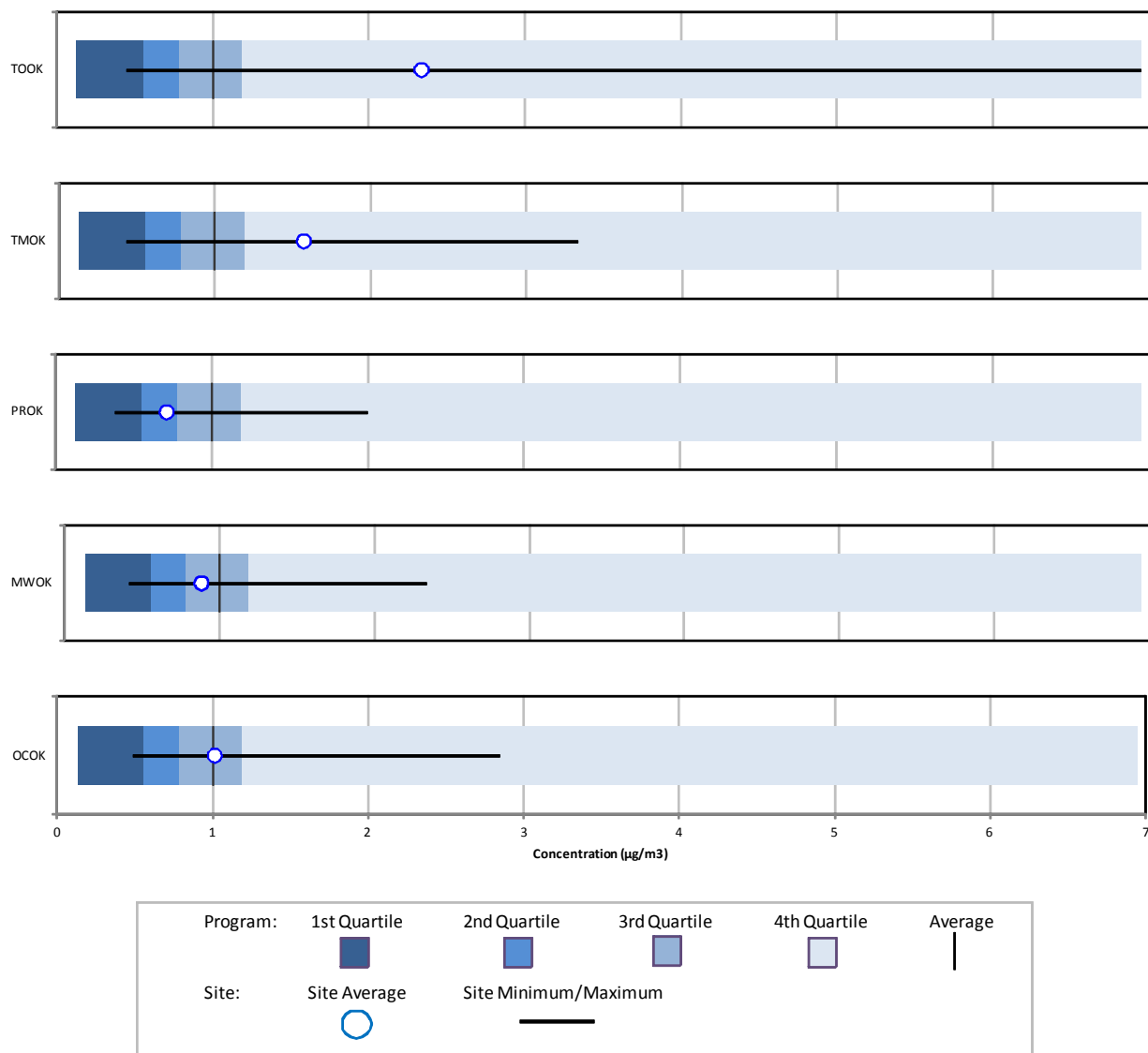
Figure 19-27. Program vs. Site-Specific Average 1,3-Butadiene Concentration
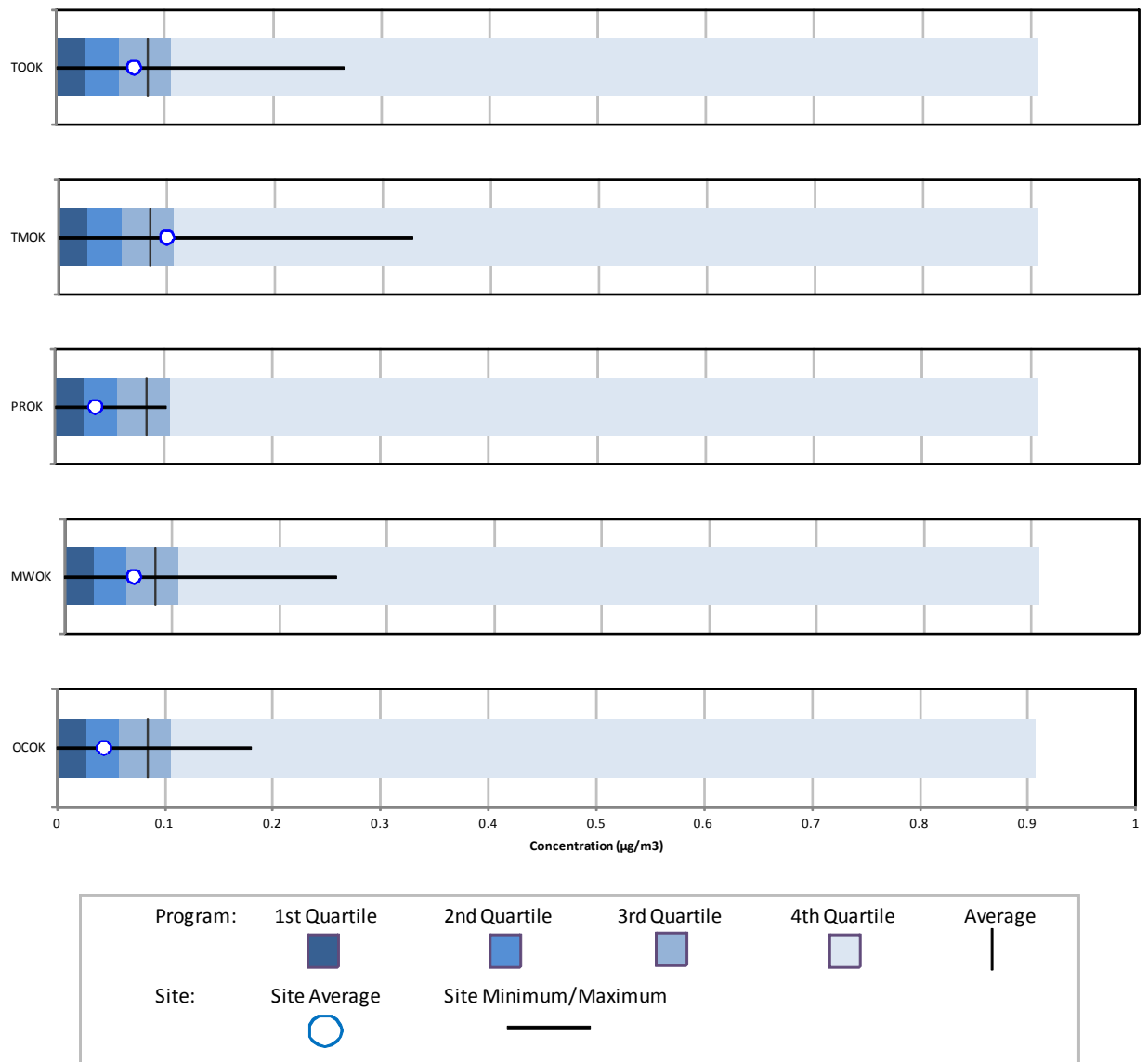
Figure 19-28. Program vs. Site-Specific Average Formaldehyde Concentration
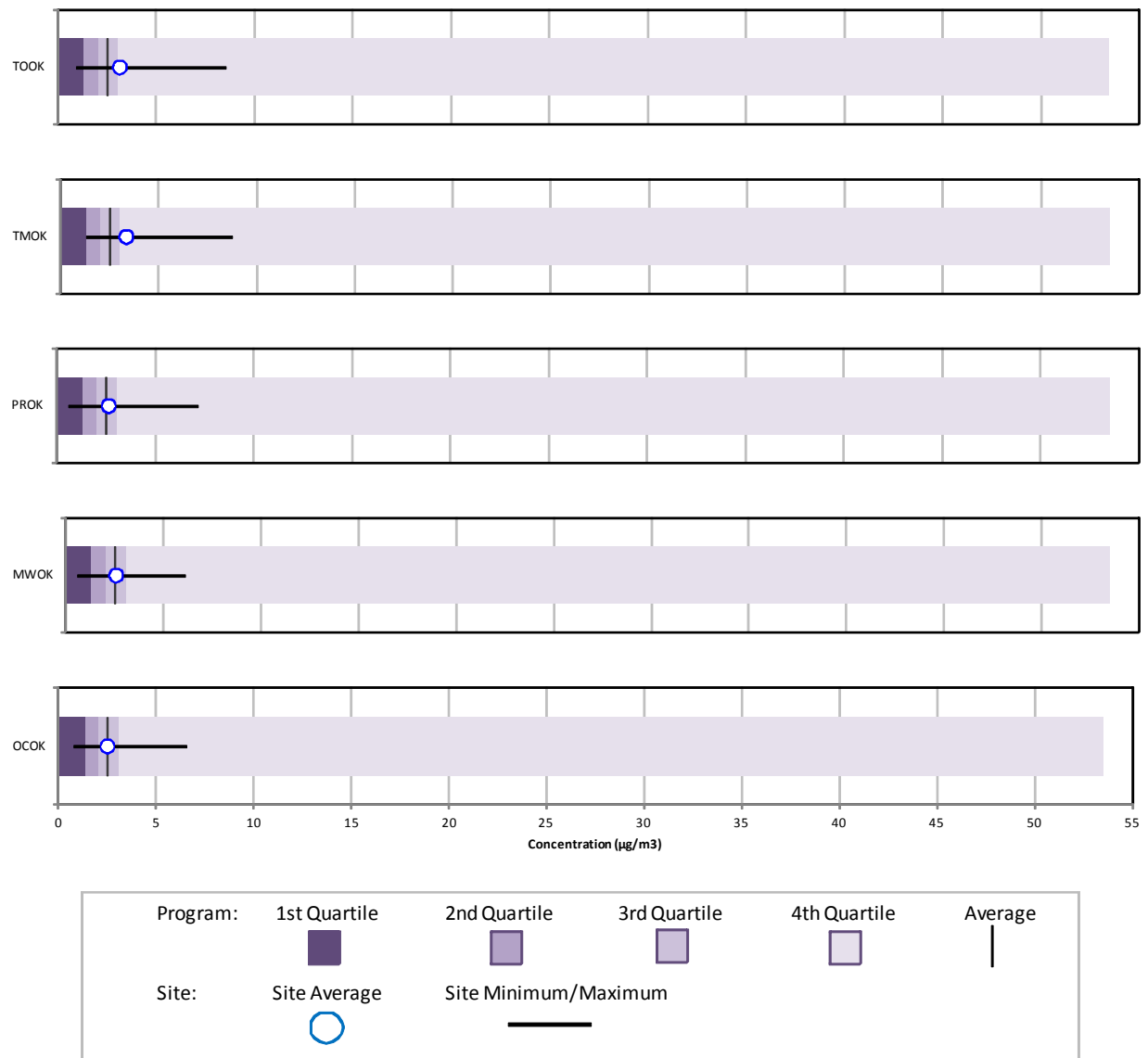
Figure 19-29. Program vs. Site-Specific Average Manganese (TSP) Concentration
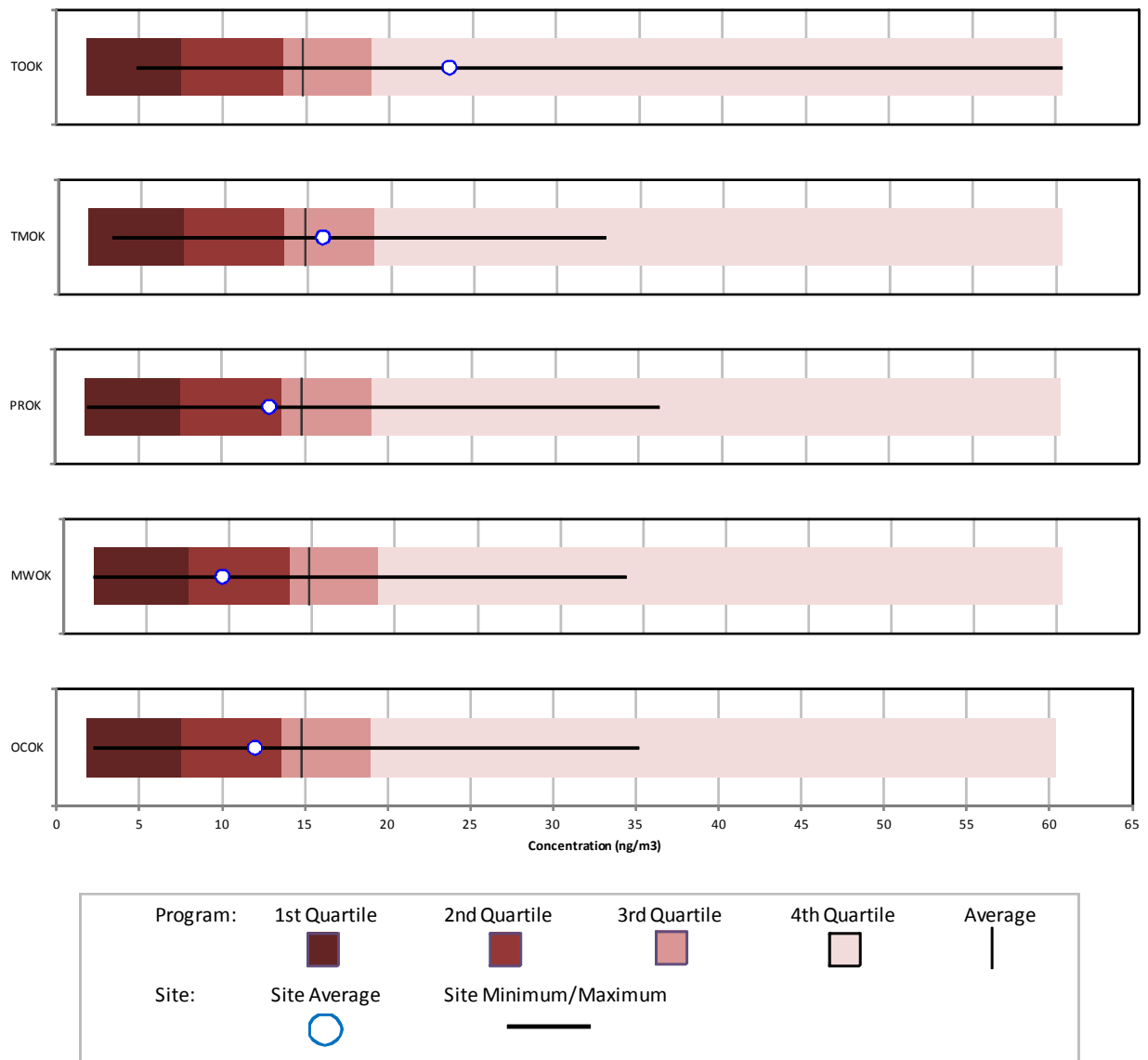
Observations from Figures 19-24 through 19-29 include the following:

- Figure 19-24 shows that the annual average acetaldehyde concentrations for TOOK and TMOK are greater than the program-level average for acetaldehyde. The range of acetaldehyde concentrations is widest for TOOK and smallest for MWOK. There were no non-detects of acetaldehyde reported for the Oklahoma sites.

- 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 highest for TOOK and lowest for OCOK. This Figure also shows that the range of measurements of arsenic is widest for TOOK and TMOK. The minimum arsenic

concentration measured at PROK is the minimum concentration measured among the five sites sampling TSP metals.

- Figure 19-26 for benzene shows that the annual average concentrations are less than the program-level average for MWOK and PROK, similar to the program level average for OCOK, and greater than the program-level average for TMOK and TOOK. The maximum concentration measured at TOOK is the maximum benzene concentration measured across the program. There were no non-detects of benzene measured at any of the Oklahoma sites.

- Figure 19-27 for 1,3-butadiene shows that the annual average concentrations for the Oklahoma sites are less than the program-level average concentration of 1,3-butadiene, with the exception of TMOK. This site also has the widest range of 1,3-butadiene measurements among the sites, although the maximum concentration measured at TMOK is well below the program-level maximum concentration. Several non-detects of 1,3-butadiene were measured at the Oklahoma sites.

- Figure 19-28 shows that the maximum formaldehyde concentration measured at each Oklahoma site is well below the maximum concentration measured across the program. However, the annual average for each Oklahoma site is greater than the program-level average concentration of formaldehyde, although the annual average for OCOK is just greater than the program-level average concentration. There were no non-detects of formaldehyde measured at the Oklahoma sites.

- Because the OK sites are the only sites sampling TSP metals, Figure 19-29 compares the individual Oklahoma site data against the combined Oklahoma data. Figure 19-29 shows that the annual average manganese (TSP) concentration is highest for TOOK and lowest for MWOK. This Figure also shows that the range of manganese measurements was greatest for TOOK and smallest for TMOK. The maximum manganese concentration measured at TOOK is nearly twice the maximum concentration for the other sites.

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 carbonyl compounds and VOC since 2006; thus, Figures 19-30 through 19-33 present the 3-year rolling statistical metrics for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects. Although TOOK has also sampled TSP metals since 2006, sampling for these pollutants did not begin until October 2006. Because three months of data is not considered representative of a year, a trends analysis was not performed for the metals.

Figure 19-30. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at TOOK
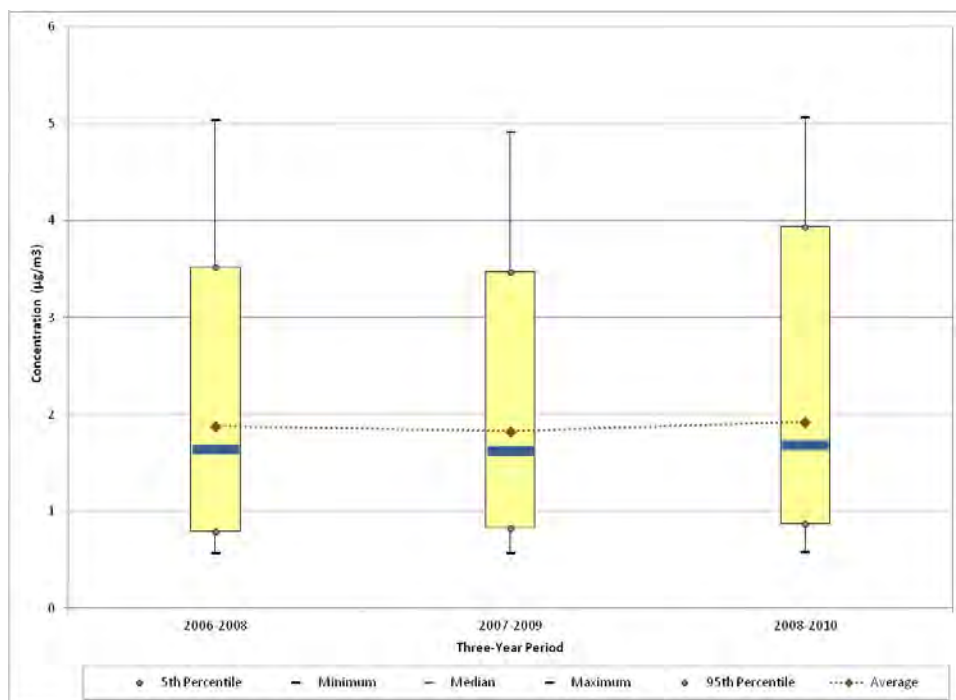
Figure 19-31. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at TOOK
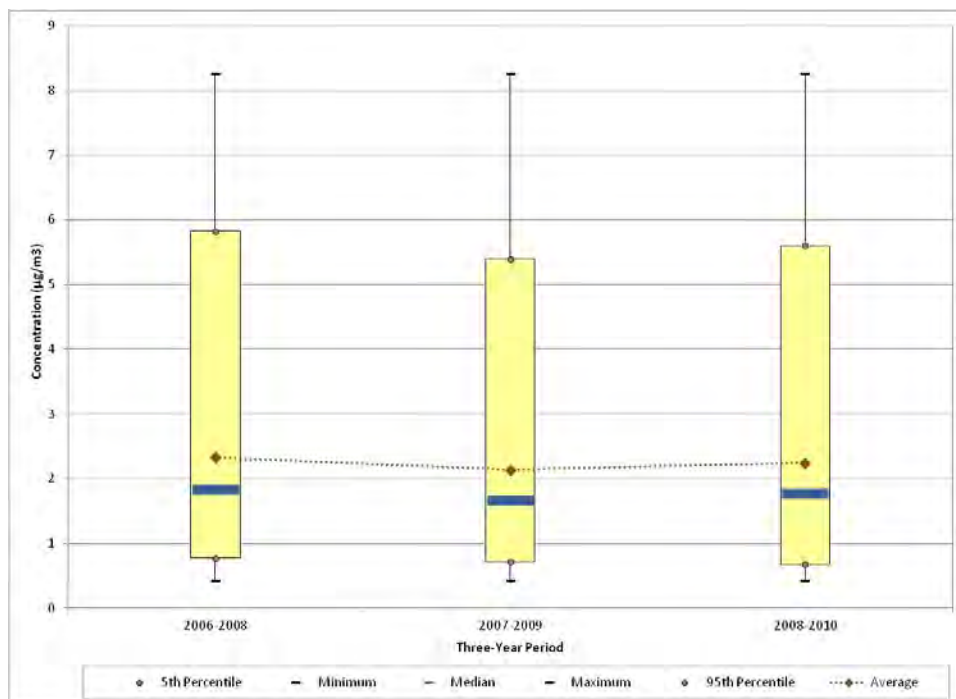
Figure 19-32. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at TOOK
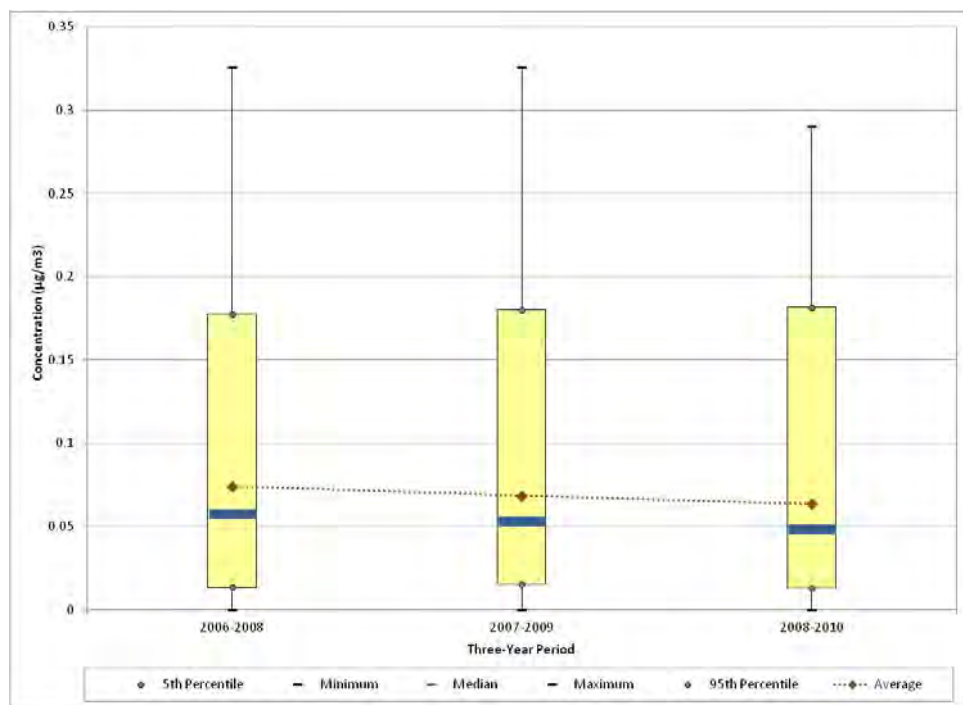
Figure 19-33. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at TOOK
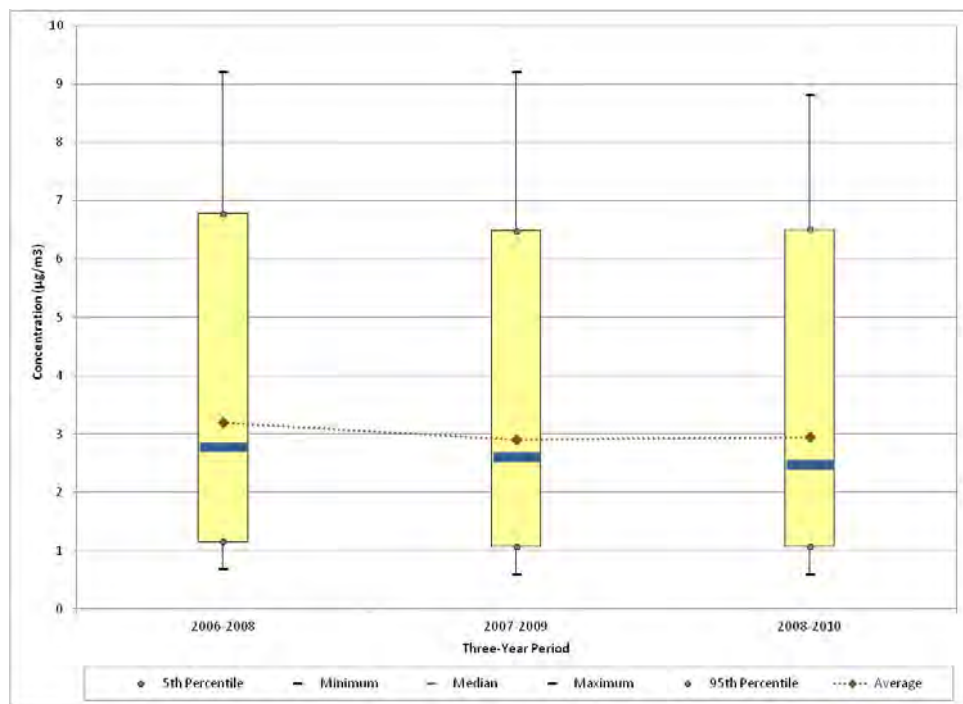
Observations from Figure 19-30 for acetaldehyde measurements at TOOK include the following:

- Although the maximum concentration of acetaldehyde was measured in 2010 (5.07 µg/m^3), similar concentrations were also measured in 2006 and 2009.

- The rolling average and median concentrations exhibit a slight decrease between 2006-2008 and 2007-2009 followed by a slight increase for 2008-2010. However, these changes are not statistically significant.

- The 95th percentile increased for the 2008-2010 period. This is not surprising given that of the 10 concentrations greater than 4 µg/m^3 measured at TOOK, five were measured in 2010 (plus one each in 2008 and 2009).

Observations from Figure 19-31 for benzene measurements at TOOK include the following:

- The maximum concentration of benzene was measured in 2008 (8.26 µg/m^3). Since this year's data is included in all three 3-year periods, this measurement is shown as the maximum concentration for all three periods. However, a similar concentration was also measured in 2007.

- The rolling average and median concentrations exhibit a slight decrease between 2006-2008 and 2007-2009 followed by a slight increase for 2008-2010. However, these changes are not statistically significant. This trend is reflected in the median and 95th percentiles as well.

Observations from Figure 19-32 for 1,3-butadiene measurements at TOOK include the following:

- Although the maximum concentration of 1,3-butadiene was measured in 2007 (0.326 µg/m^3), a similar concentration was also measured in 2008.

- While the rolling average and median concentrations exhibit a decreasing trend, the change is not statistically significant.

- The minimum concentration is zero for all three 3-year periods, indicating the presence of non-detects.

Observations from Figure 19-33 for formaldehyde measurements at TOOK include the following:

- Although the maximum concentration of formaldehyde was measured in 2007 (9.21 µg/m^3), similar concentrations were also measured in 2006 and 2008.

- The rolling average concentration exhibits a slight decrease from 2006-2008 to 2007-2009 but the change is not statistically significant. Little change is shown between 2007-2009 and 2008-2010. The median however, has a slight decreasing trend throughout the sampling period.

19.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

19.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Oklahoma monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Oklahoma monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Oklahoma monitoring sites.

19.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Oklahoma monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 19-6, where applicable.

Table 19-6. Cancer and Noncancer Surrogate Risk Approximations for the Oklahoma Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Tulsa, Oklahoma - TOOK						
Acetaldehyde	0.0000022	0.009	60/60	2.20 ± 0.29	4.83	0.24
Arsenic (TSP) [a]	0.0043	0.000015	61/61	<0.01 ± <0.01	2.85	0.04
Benzene	0.0000078	0.03	61/61	2.34 ± 0.36	18.24	0.08
Beryllium (TSP) [a]	0.0024	0.00002	61/61	<0.01 ± <0.01	0.05	<0.01
1,3-Butadiene	0.00003	0.002	56/61	0.07 ± 0.01	2.15	0.04
Cadmium (TSP) [a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.51	0.03
Carbon Tetrachloride	0.000006	0.1	61/61	0.62 ± 0.03	3.73	0.01
Chloroform	--	0.098	38/61	0.07 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	55/61	0.15 ± 0.03	1.65	<0.01
Ethylbenzene	0.0000025	1	61/61	0.47 ± 0.08	1.19	<0.01
Formaldehyde	0.000013	0.0098	60/60	3.14 ± 0.45	40.78	0.32
Lead (TSP) [a]	--	0.00015	61/61	<0.01 ± <0.01	--	0.03
Manganese (TSP) [a]	--	0.00005	61/61	0.02 ± <0.01	--	0.47
Nickel (TSP) [a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.53	0.01
Propionaldehyde	--	0.008	58/60	0.43 ± 0.07	--	0.05
Tetrachloroethylene	2.6E-07	0.04	57/61	0.13 ± 0.02	0.03	<0.01
Trichloroethylene	0.0000048	0.002	11/61	0.02 ± 0.01	0.09	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.

Table 19-6. Cancer and Noncancer Surrogate Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Tulsa, Oklahoma - TMOK						
Acetaldehyde	0.0000022	0.009	60/60	2.00 ± 0.20	4.40	0.22
Arsenic (TSP) [a]	0.0043	0.000015	60/60	<0.01 ± <0.01	2.67	0.04
Benzene	0.0000078	0.03	61/61	1.57 ± 0.20	12.25	0.05
Beryllium (TSP) [a]	0.0024	0.00002	59/60	<0.01 ± <0.01	0.03	<0.01
1,3-Butadiene	0.00003	0.002	57/61	0.10 ± 0.02	3.00	0.05
Cadmium (TSP) [a]	0.0018	0.00001	60/60	<0.01 ± <0.01	0.41	0.02
Carbon Tetrachloride	0.000006	0.1	61/61	0.61 ± 0.03	3.64	0.01
Chloroform	--	0.098	39/61	0.07 ± 0.02	--	<0.01
p-Dichlorobenzene	0.000011	0.8	57/61	0.14 ± 0.03	1.54	<0.01
1,2-Dichloroethane	0.000026	2.4	10/61	0.01 ± 0.01	0.36	<0.01
Ethylbenzene	0.0000025	1	61/61	0.55 ± 0.13	1.38	<0.01
Formaldehyde	0.000013	0.0098	60/60	3.35 ± 0.40	43.61	0.34
Lead (TSP) [a]	--	0.00015	60/60	<0.01 ± <0.01	--	0.02
Manganese (TSP) [a]	--	0.00005	60/60	0.02 ± <0.01	--	0.32
Nickel (TSP) [a]	0.00048	0.00009	60/60	<0.01 ± <0.01	0.43	0.01
Tetrachloroethylene	2.6E-07	0.04	49/61	0.09 ± 0.02	0.02	<0.01
Trichloroethylene	0.0000048	0.002	10/61	0.01 ± 0.01	0.05	<0.01
Vinyl Chloride	0.0000088	0.1	2/61	<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.

Table 19-6. Cancer and Noncancer Surrogate Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Pryor Creek, Oklahoma - PROK
Acetaldehyde	0.0000022	0.009	60/60	1.37 ± 0.14	3.01	0.15
Arsenic (TSP) [a]	0.0043	0.000015	61/61	<0.01 ± <0.01	2.37	0.04
Benzene	0.0000078	0.03	61/61	0.71 ± 0.06	5.54	0.02
Beryllium (TSP) [a]	0.0024	0.00002	61/61	<0.01 ± <0.01	0.05	<0.01
1,3-Butadiene	0.00003	0.002	50/61	0.04 ± 0.01	1.11	0.02
Cadmium (TSP) [a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.30	0.02
Carbon Tetrachloride	0.000006	0.1	61/61	0.65 ± 0.03	3.89	0.01
Chloroform	--	0.098	44/61	0.14 ± 0.11	--	<0.01
p-Dichlorobenzene	0.000011	0.8	48/61	0.10 ± 0.03	1.12	<0.01
1,2-Dichloroethane	0.000026	2.4	15/61	0.02 ± 0.01	0.54	<0.01
Formaldehyde	0.000013	0.0098	60/60	2.64 ± 0.41	34.31	0.27
Lead (TSP) [a]	--	0.00015	61/61	<0.01 ± <0.01	--	0.02
Manganese (TSP) [a]	--	0.00005	61/61	0.01 ± <0.01	--	0.26
Nickel (TSP) [a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.39	0.01
Tetrachloroethylene	2.6E-07	0.04	29/61	0.03 ± 0.01	0.01	<0.01
Trichloroethylene	0.0000048	0.002	3/61	<0.01 ± <0.01	0.01	<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 19-5.

Table 19-6. Cancer and Noncancer Surrogate Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Midwest City, Oklahoma - MWOK						
Acetaldehyde	0.0000022	0.009	60/60	1.41 ± 0.14	3.10	0.16
Arsenic (TSP) [a]	0.0043	0.000015	61/61	<0.01 ± <0.01	1.90	0.03
Benzene	0.0000078	0.03	61/61	0.88 ± 0.10	6.88	0.03
Beryllium (TSP) [a]	0.0024	0.00002	61/61	<0.01 ± <0.01	0.03	<0.01
1,3-Butadiene	0.00003	0.002	52/61	0.06 ± 0.01	1.94	0.03
Cadmium (TSP) [a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.18	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.64 ± 0.04	3.86	0.01
Chloroform	--	0.098	45/61	0.07 ± 0.01	--	<0.01
p-Dichlorobenzene	0.000011	0.8	61/61	0.18 ± 0.04	1.98	<0.01
1,2-Dichloroethane	0.000026	2.4	13/61	0.02 ± 0.01	0.50	<0.01
Formaldehyde	0.000013	0.0098	60/60	2.56 ± 0.38	33.30	0.26
Lead (TSP) [a]	--	0.00015	61/61	<0.01 ± <0.01	--	0.02
Manganese (TSP) [a]	--	0.00005	61/61	0.01 ± <0.01	--	0.19
Nickel (TSP) [a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.47	0.01
Tetrachloroethylene	2.6E-07	0.04	53/61	0.22 ± 0.06	0.06	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	0.02	<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. Cancer and Noncancer Surrogate Risk Approximations for the Oklahoma Monitoring Sites (Continued)

Pollutant	Cancer URE ($\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average ($\mu g/m^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Oklahoma City, Oklahoma - OCOK						
Acetaldehyde	0.0000022	0.009	60/60	1.59 ± 0.17	3.51	0.18
Acrylonitrile	0.000068	0.002	10/61	0.03 ± 0.03	1.90	0.01
Arsenic (TSP) [a]	0.0043	0.000015	61/61	<0.01 ± <0.01	1.90	0.03
Benzene	0.0000078	0.03	61/61	1.01 ± 0.13	7.91	0.03
Beryllium (TSP) [a]	0.0024	0.00002	61/61	<0.01 ± <0.01	0.03	<0.01
1,3-Butadiene	0.00003	0.002	48/61	0.04 ± 0.01	1.31	0.02
Cadmium (TSP) [a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.18	0.01
Carbon Tetrachloride	0.000006	0.1	61/61	0.64 ± 0.04	3.84	0.01
Chloroform	--	0.098	40/61	0.06 ± 0.01	--	<0.01
p-Dichlorobenzene	0.000011	0.8	54/61	0.24 ± 0.07	2.65	<0.01
1,2-Dichloroethane	0.000026	2.4	11/61	0.02 ± 0.01	0.45	<0.01
Formaldehyde	0.000013	0.0098	60/60	2.50 ± 0.36	32.54	0.26
Lead (TSP)[a]	--	0.00015	61/61	<0.01 ± <0.01	--	0.01
Manganese (TSP) [a]	--	0.00005	61/61	0.01 ± <0.01	--	0.24
Nickel (TSP) [a]	0.00048	0.00009	61/61	<0.01 ± <0.01	0.28	0.01
Tetrachloroethylene	2.6E-07	0.04	53/61	0.09 ± 0.02	0.02	<0.01
Trichloroethylene	0.0000048	0.002	4/61	0.01 ± 0.02	0.06	0.01
Vinyl Chloride	0.0000088	0.1	4/61	<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 concentrations of manganese are the highest for each site.

- Formaldehyde and benzene have the highest cancer risk approximations for all of the Oklahoma monitoring sites. Formaldehyde cancer risk approximations range from 32.54 in-a-million for OCOK to 43.61 in-a-million for TMOK. Benzene cancer risk approximations range from 5.54 in-a-million for PROK to 18.24 in-a-million for TOOK.

- Among the metals, arsenic has the highest cancer risk approximations for all of the Oklahoma monitoring sites, ranging from 1.90 in-a-million for MWOK and OCOK to 2.85 in-a-million for TOOK.

- None of the pollutants of interest have noncancer risk approximations greater than 1.0, the HQ level of concern for noncancer. Among the noncancer risk approximations for the Oklahoma sites, formaldehyde, manganese, and acetaldehyde have the highest noncancer risk approximations for each site.

19.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 19-7 and 19-8 present a risk-based 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. Table 19-8 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 19-7 and 19-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 VOC, carbonyl compounds, and TSP metals. In addition, the cancer and noncancer risk 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.

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 Risk Factors (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	40.78
Ethylbenzene	236.92	Formaldehyde	2.58E-03	Benzene	18.24
Formaldehyde	198.13	1,3-Butadiene	1.57E-03	Acetaldehyde	4.83
Acetaldehyde	105.13	Hexavalent Chromium, PM	1.11E-03	Carbon Tetrachloride	3.73
1,3-Butadiene	52.47	Naphthalene	8.02E-04	Arsenic	2.85
Tetrachloroethylene	41.33	Ethylbenzene	5.92E-04	1,3-Butadiene	2.15
Naphthalene	23.57	POM, Group 2b	3.16E-04	p-Dichlorobenzene	1.65
Dichloromethane	5.51	Acetaldehyde	2.31E-04	Ethylbenzene	1.19
POM, Group 2b	3.59	POM, Group 3	2.30E-04	Nickel	0.53
Nickel, PM	0.40	Nickel, PM	1.90E-04	Cadmium	0.51
Tulsa, Oklahoma (Tulsa County) - TMOK					
Benzene	398.15	Benzene	3.11E-03	Formaldehyde	43.61
Ethylbenzene	236.92	Formaldehyde	2.58E-03	Benzene	12.25
Formaldehyde	198.13	1,3-Butadiene	1.57E-03	Acetaldehyde	4.40
Acetaldehyde	105.13	Hexavalent Chromium, PM	1.11E-03	Carbon Tetrachloride	3.64
1,3-Butadiene	52.47	Naphthalene	8.02E-04	1,3-Butadiene	3.00
Tetrachloroethylene	41.33	Ethylbenzene	5.92E-04	Arsenic	2.67
Naphthalene	23.57	POM, Group 2b	3.16E-04	p-Dichlorobenzene	1.54
Dichloromethane	5.51	Acetaldehyde	2.31E-04	Ethylbenzene	1.38
POM, Group 2b	3.59	POM, Group 3	2.30E-04	Nickel	0.43
Nickel, PM	0.40	Nickel, PM	1.90E-04	Cadmium	0.41

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 Risk Factors (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	34.31
Formaldehyde	24.25	Hexavalent Chromium, PM	9.45E-04	Benzene	5.54
Ethylbenzene	17.46	Nickel, PM	5.62E-04	Carbon Tetrachloride	3.89
Acetaldehyde	12.40	Formaldehyde	3.15E-04	Acetaldehyde	3.01
1,3-Butadiene	3.72	Benzene	2.91E-04	Arsenic	2.37
Naphthalene	2.04	1,3-Butadiene	1.11E-04	p-Dichlorobenzene	1.12
Chloromethylbenzene	1.60	Beryllium, PM	8.46E-05	1,3-Butadiene	1.11
Nickel, PM	1.17	Cadmium, PM	8.35E-05	1,2-Dichloroethane	0.54
Dichloromethane	1.03	Chloromethylbenzene	7.85E-05	Nickel	0.39
Arsenic, PM	0.53	Naphthalene	6.93E-05	Cadmium	0.30
Midwest City, Oklahoma (Oklahoma County) - MWOK					
Benzene	447.79	Benzene	3.49E-03	Formaldehyde	33.30
Ethylbenzene	275.02	Formaldehyde	3.26E-03	Benzene	6.88
Formaldehyde	250.63	1,3-Butadiene	1.79E-03	Carbon Tetrachloride	3.86
Acetaldehyde	137.04	Naphthalene	9.96E-04	Acetaldehyde	3.10
1,3-Butadiene	59.70	Ethylbenzene	6.88E-04	p-Dichlorobenzene	1.98
Naphthalene	29.28	Hexavalent Chromium, PM	6.16E-04	1,3-Butadiene	1.94
Dichloromethane	15.08	POM, Group 2b	3.97E-04	Arsenic	1.90
Tetrachloroethylene	10.79	Acetaldehyde	3.01E-04	1,2-Dichloroethane	0.50
POM, Group 2b	4.51	POM, Group 3	2.64E-04	Nickel	0.47
Bis(2-ethylhexyl)phthalate (DEHP), gas	0.49	Arsenic, PM	1.85E-04	Cadmium	0.18

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 Risk Factors (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	32.54
Ethylbenzene	275.02	Formaldehyde	3.26E-03	Benzene	7.91
Formaldehyde	250.63	1,3-Butadiene	1.79E-03	Carbon Tetrachloride	3.84
Acetaldehyde	137.04	Naphthalene	9.96E-04	Acetaldehyde	3.51
1,3-Butadiene	59.70	Ethylbenzene	6.88E-04	p-Dichlorobenzene	2.65
Naphthalene	29.28	Hexavalent Chromium, PM	6.16E-04	Acrylonitrile	1.90
Dichloromethane	15.08	POM, Group 2b	3.97E-04	Arsenic	1.90
Tetrachloroethylene	10.79	Acetaldehyde	3.01E-04	1,3-Butadiene	1.31
POM, Group 2b	4.51	POM, Group 3	2.64E-04	1,2-Dichloroethane	0.45
Bis(2-ethylhexyl)phthalate (DEHP), gas	0.49	Arsenic, PM	1.85E-04	Nickel	0.28

Table 19-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Tulsa, Oklahoma (Tulsa County) - TOOK					
Toluene	1,180.06	Acrolein	577,473.50	Manganese	0.47
Xylenes	902.52	1,3-Butadiene	26,235.74	Formaldehyde	0.32
Methanol	402.45	Formaldehyde	20,217.32	Acetaldehyde	0.24
Benzene	398.15	Manganese, PM	18,832.62	Benzene	0.08
Hexane	293.67	Benzene	13,271.68	Propionaldehyde	0.05
Ethylbenzene	236.92	Lead, PM	13,200.35	Arsenic	0.04
Formaldehyde	198.13	Acetaldehyde	11,681.56	1,3-Butadiene	0.04
Acetaldehyde	105.13	Xylenes	9,025.21	Lead	0.03
1,3-Butadiene	52.47	Naphthalene	7,857.87	Cadmium	0.03
Ethylene glycol	50.77	Cobalt , PM	5,351.77	Nickel	0.01
Tulsa, Oklahoma (Tulsa County) - TMOK					
Toluene	1,180.06	Acrolein	577,473.50	Formaldehyde	0.34
Xylenes	902.52	1,3-Butadiene	26,235.74	Manganese	0.32
Methanol	402.45	Formaldehyde	20,217.32	Acetaldehyde	0.22
Benzene	398.15	Manganese, PM	18,832.62	Benzene	0.05
Hexane	293.67	Benzene	13,271.68	1,3-Butadiene	0.05
Ethylbenzene	236.92	Lead, PM	13,200.35	Arsenic	0.04
Formaldehyde	198.13	Acetaldehyde	11,681.56	Lead	0.02
Acetaldehyde	105.13	Xylenes	9,025.21	Cadmium	0.02
1,3-Butadiene	52.47	Naphthalene	7,857.87	Nickel	0.01
Ethylene glycol	50.77	Cobalt , PM	5,351.77	Carbon Tetrachloride	0.01

Table 19-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Pryor Creek, Oklahoma (Mayes County) - PROK					
Hydrochloric acid	145.18	Acrolein	91,374.65	Formaldehyde	0.27
Toluene	89.08	Chlorine	61,006.67	Manganese	0.26
Xylenes	72.70	Cyanide Compounds, gas	43,619.17	Acetaldehyde	0.15
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	0.26
Xylenes	1,058.17	1,3-Butadiene	29,851.09	Manganese	0.19
Methanol	468.16	Formaldehyde	25,574.80	Acetaldehyde	0.16
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	0.03
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 Risk Approximations for Pollutants with Noncancer RfCs for the Oklahoma Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Oklahoma City, Oklahoma (Oklahoma County) - OCOK					
Toluene	1,373.20	Acrolein	875,997.95	Formaldehyde	0.26
Xylenes	1,058.17	1,3-Butadiene	29,851.09	Manganese	0.24
Methanol	468.16	Formaldehyde	25,574.80	Acetaldehyde	0.18
Benzene	447.79	Acetaldehyde	15,226.70	Benzene	0.03
Hexane	337.57	Benzene	14,926.42	Arsenic	0.03
Ethylbenzene	275.02	Xylenes	10,581.67	1,3-Butadiene	0.02
Formaldehyde	250.63	Naphthalene	9,759.95	Acrylonitrile	0.01
Acetaldehyde	137.04	Arsenic, PM	2,874.57	Lead	0.01
Ethylene glycol	61.51	Lead, PM	2,417.07	Cadmium	0.01
1,3-Butadiene	59.70	Propionaldehyde	2,079.24	Nickel	0.01

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. Seven 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.

- Benzene and formaldehyde 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 magnitude of the emissions 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 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 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 risk approximations among the Oklahoma sites. Formaldehyde appears on both emissions-based lists for Tulsa and Oklahoma Counties but ranks 11th for toxicity-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 not Oklahoma County. There are no metals listed among the highest emitted pollutants.

- 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 2010 Monitoring Data for the Oklahoma Monitoring Sites

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

- ❖ *Seventeen pollutants failed at least one screen for TOOK; 16 pollutants failed screens for TMOK; 13 pollutants failed screens for PROK; 18 pollutants failed screens for MWOK; and 19 pollutants failed screens for OCOK.*

- ❖ *Formaldehyde had the highest annual average concentration by mass for each site. Among the TSP metals, the annual average concentrations of manganese were the highest for each site.*

- ❖ *TOOK had the highest annual average of concentration of benzene among all NMP sites sampling this pollutant.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 PRRI 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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 20-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 20-1. Providence, Rhode Island (PRRI) Monitoring Site
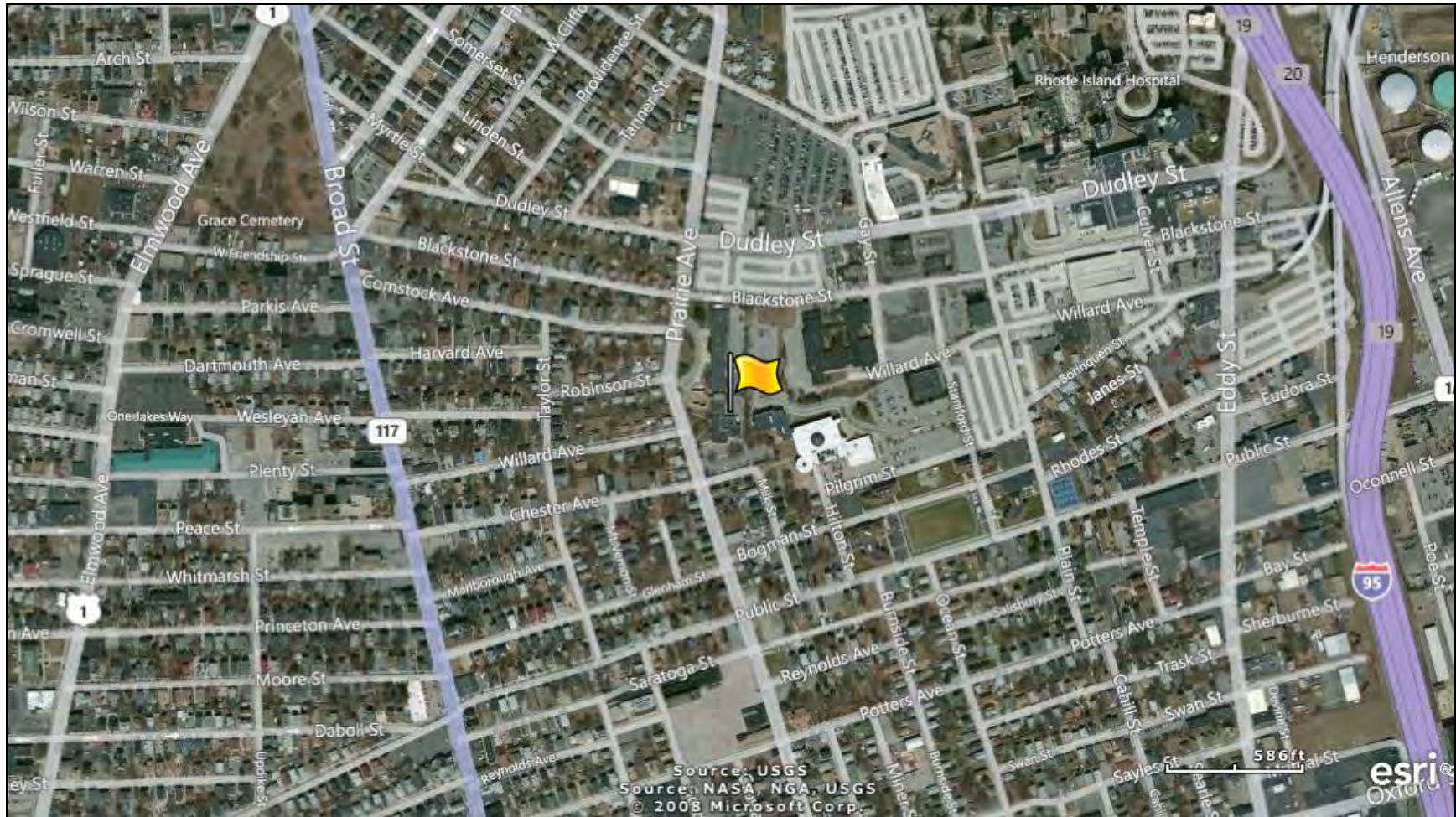
Figure 20-2. NEI Point Sources Located Within 10 Miles of PRRI

Legend

⭐ PRRI NATTS site   ◯ 10 mile radius   ☐ County boundary

Source Category Group (No. of Facilities)

✈ Aircraft Operations (13)	🐾 Flexible Polyurethane Foam Production (1)	● Oil and/or Gas Production (1)
🚐 Automobile/Truck Manufacturing (2)	F Food Processing/Agriculture (4)	⬭ Pharmaceutical Manufacturing (1)
฿ Bakery (2)	⊟ Furniture Plant (2)	1 Primary Metal Production (6)
⚓ Boat Manufacturing (1)	▮ Gasoline/Diesel Service Station (4)	P Printing/Publishing (11)
C Chemical Manufacturing (7)	▰ Glass Manufacturing (1)	⊞ Pulp and Paper Plant/Wood Products (4)
■ Concrete Batch Plant (2)	H Hospital (3)	R Rubber and Miscellaneous Plastics Products (10)
⋈ Crematory - Animal/Human (1)	☀ Hot Mix Asphalt Plant (4)	⟨ Site Remediation Activity (1)
⊕ Dry Cleaning Facility (37)	❋ Industrial Machinery and Equipment (5)	S Surface Coating (3)
e Electrical Equipment (4)	Ⓢ Institutional - school (11)	π Telecommunications (4)
⚡ Electricity Generation via Combustion (4)	▲ Landfill (1)	T Textile Mill (12)
E Electroplating, Plating, Polishing, Anodizing, & Coloring (24)	? Miscellaneous Commercial/Industrial (21)	▮ Wastewater Treatment (1)
⊙ Fabricated Metal Products (25)	M Miscellaneous Manufacturing (45)	W Woodwork, Furniture, Millwork & Wood Preserving (1)

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, VOC, Carbonyl Compounds, Meteorological parameters, PM_{10}, PM_{10} Speciation, Black Carbon, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Germanium.

[1] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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 largest number of point sources 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Rhode Island monitoring site. County-level vehicle registration data for Providence County was not available from the State of Rhode Island. Thus, state-level registration, which was obtained from the Federal Highway Administration (FHWA, 2011), was allocated to the county level using the county-level portion of the state population. State-level and county-level population information was obtained from the U.S. Census Bureau. Table 20-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 20-2 also contains annual average daily traffic information. County-level VMT was not readily available; thus, daily VMT for PRRI is not shown in Table 20-2.

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	627,070	485,837	0.77	660,225	511,525	136,800	NA

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects a ratio based on 2010 state-level vehicle registration data from the FHWA and the county-level proportion of the state population data (FHWA, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic 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 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 monitoring sites. The traffic estimate used came from 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 and 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 2010

Hourly meteorological data from the NWS weather station nearest PRRI were retrieved for 2010 (NCDC, 2010). 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 normal conditions throughout the year.

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	Sample Day	61.5 ± 4.5	53.3 ± 4.2	41.0 ± 4.5	47.6 ± 3.9	65.9 ± 3.6	1012.8 ± 2.0	7.4 ± 0.7
	173° (S)	2010	61.8 ± 1.9	53.7 ± 1.8	41.1 ± 1.9	47.8 ± 1.7	65.7 ± 1.5	1012.7 ± 0.8	7.7 ± 0.3

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

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 for 2010. Also included in Table 20-3 is the 95 percent confidence interval for each parameter. As shown in Table 20-3, average meteorological conditions on sample days were representative of average weather conditions throughout 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 2010. Included in Figure 20-3 are four back trajectories per sample day. Figure 20-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, each concentric circle around the site in Figures 20-3 and 20-4 represents 100 miles.

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 bulk of trajectories originated from the west, northwest, and north.

- The airshed domain for PRRI was among the largest in size compared to other NMP sites. The farthest away a trajectory originated was off the South Carolina coast and over the Atlantic Ocean, or nearly 800 miles away. The two longest trajectories are associated with a strong low pressure system that moved through the region January 25-26, 2010. While the average trajectory length was 306 miles long, 87 percent of back trajectories originated within 500 miles of the site.

- The cluster analysis shows that 55 percent of back trajectories originated from the west, northwest, and north, although of differing lengths, as represented by the two clusters originating over Canada (18 and 19 percent) and the short cluster originating over New York (18 percent). The short cluster originating offshore and northeast of Boston (23 percent) represents back trajectories of shorter length, generally less than 250 miles, originating to the north, east, and south over Maine, New Hampshire, Massachusetts and the offshore waters adjacent to those states, including Rhode Island. Sixteen percent of trajectories originated to the south, over New Jersey, Delaware, Maryland, and the offshore waters of those states and Virginia. Finally, six

percent of back trajectories originated over Newfoundland and New Brunswick, Canada and farther offshore.

Figure 20-3. 2010 Composite Back Trajectory Map for PRRI
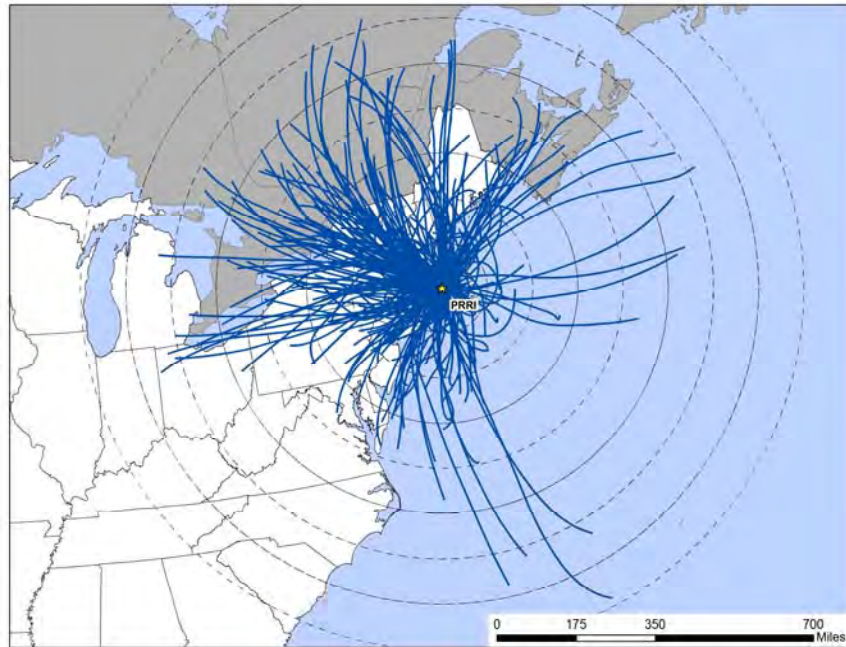
Figure 20-4. Back Trajectory Cluster Map for PRRI

20.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the PRRI monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location.

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 for PRRI shows that while westerly winds were observed the most (11 percent of observations), wind directions from the western quadrants and 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 2010 wind rose for PRRI are similar to the historical wind patterns, although there were slightly more westerly and west-northwesterly wind observations and somewhat fewer southwesterly wind observations in 2010. These similarities indicate that winds in 2010 near PRRI were similar to what is expected climatologically.

- The wind patterns shown on the sample day wind rose are similar to the full-year and historical wind patterns, although there were more north-northeasterly winds on sample days. This indicates that conditions on sample days were generally representative of conditions experienced throughout the year.

Figure 20-5. Wind Roses for the T.F. Green State Airport Weather Station near PRRI

1999-2009 Historical Wind Rose
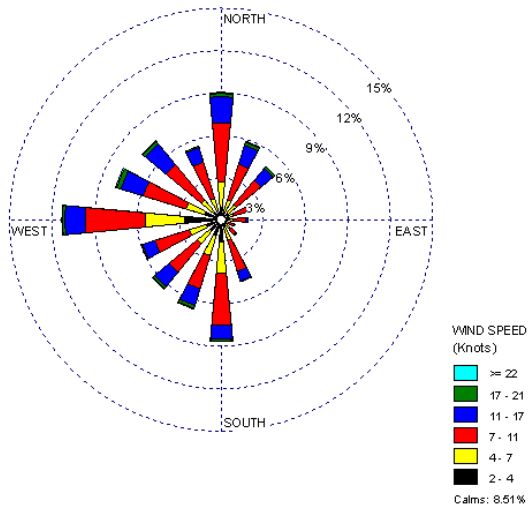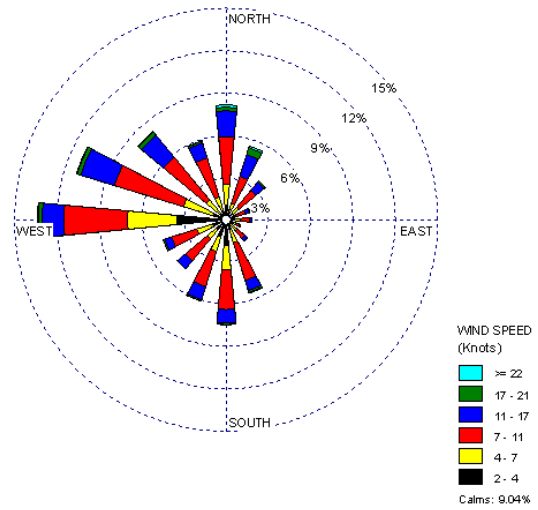
2010 Wind Rose

2010 Sample Day Wind Rose
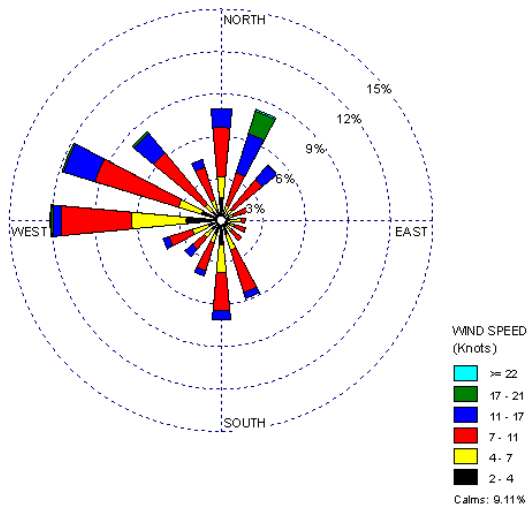
Distance between PRRI and NWS Station
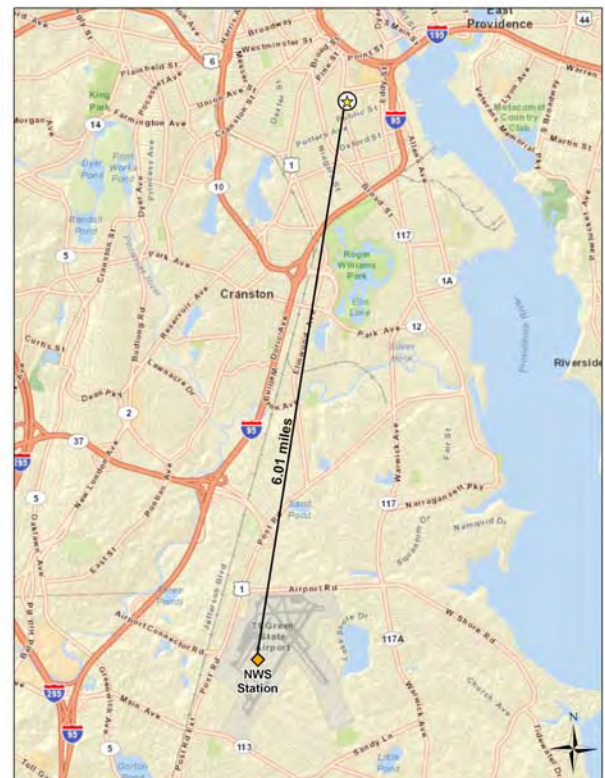
20.3   Pollutants of Interest

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 20-4 presents PRRI's pollutants of interest. 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 PAH and hexavalent chromium.

Table 20-4. Risk Screening Results for the Rhode Island Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Providence, Rhode Island - PRRI						
Naphthalene	0.029	56	58	96.55	86.15	86.15
Benzo(a)pyrene	0.00057	6	49	12.24	9.23	95.38
Fluorene	0.011	2	58	3.45	3.08	98.46
Hexavalent Chromium	0.000083	1	44	2.27	1.54	100.00
Total		65	209	31.10		

Observations from Table 20-4 include the following:

- Four pollutants (naphthalene, benzo(a)pyrene, fluorene, and hexavalent chromium) failed screens for PRRI. Naphthalene accounted for 86 percent of PRRI's failed screens (56 out of 65 total failed screens).

- Naphthalene and benzo(a)pyrene were identified as the only pollutants of interest for PRRI based on the risk screening process. Hexavalent chromium were added to PRRI's pollutants of interest because is it a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of failed screens.

20.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Rhode Island monitoring site. Concentration averages are provided for the pollutants of interest for the PRRI monitoring site, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices M and O.

20.4.1 2010 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/m³)	2nd Quarter Average (ng/m³)	3rd Quarter Average (ng/m³)	4th Quarter Average (ng/m³)	Annual Average (ng/m³)
Providence, Rhode Island - PRRI						
Benzo(a) pyrene	49/58	0.39 ± 0.14	0.19 ± 0.18	0.04 ± 0.02	0.21 ± 0.10	0.20 ± 0.07
Hexavalent Chromium	44/60	0.01 ± 0.02	0.02 ± <0.01	0.03 ± 0.01	0.01 ± 0.01	0.02 ± <0.01
Naphthalene	58/58	102.29 ± 37.14	70.36 ± 20.01	70.29 ± 15.60	115.14 ± 38.90	89.63 ± 14.87

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 two pollutants of interest.

- The first and fourth quarter averages of naphthalene are higher than the second and third quarter averages. Of the 10 concentrations of naphthalene greater than 125 ng/m³, most were measured during the first and fourth quarters of 2010 at PRRI.

- The first quarter average concentration of hexavalent chromium has a relatively high confidence interval associated with it. The maximum hexavalent chromium concentration was measured at PRRI on February 25, 2010 (0.114 ng/m³) and is the only concentration greater than 0.1 ng/m³ measured at this site.

- The quarterly average concentrations of benzo(a)pyrene have relatively high levels of variability associated with them. The first quarter average is higher than the other quarterly averages, particularly the third quarter, but both the first and second quarter average concentrations have relatively high confidence intervals associated with them. The maximum benzo(a)pyrene concentration was measured at PRRI on April 5, 2010 (1.07 ng/m³) and is the only concentration greater than 1 ng/m³ measured at this site. This measurement is also the eighth highest benzo(a)pyrene concentration measured among NMP sites sampling PAH. Of the seven concentrations of benzo(a)pyrene greater than 0.5 ng/m³, more than half were measured during the first quarter of 2010.

- Eight of the nine non-detects of benzo(a)pyrene reported for PRRI were measured between June and September 2010, the exception was one measured at the beginning of October. The median concentration is 0.081 ng/m³, which is considerably less than the annual average concentration, indicating that the higher measurements are likely driving some of the quarterly and annual averages. The annual average benzo(a)pyrene concentration for PRRI is the highest annual average benzo(a)pyrene concentration among sites sampling PAH.

20.4.2 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 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, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

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 maximum concentration (42.7 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 2 ng/m^3. Also 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 PRRI is greater than the program-level average concentration. Although the maximum concentration measured at PRRI is well below the maximum concentration measured across the program, this site measured one of the few concentrations of benzo(a)pyrene greater than 1 ng/m^3. Several non-detects of benzo(a)pyrene were measured at PRRI.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 20-7 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 20-7 shows the annual average concentration of hexavalent chromium for PRRI is less than the program-level average and roughly equivalent to the program-level median concentration. The maximum concentration measured at PRRI is well below the program-level maximum concentration. There were no non-detects of hexavalent chromium measured at PRRI.

- Figure 20-8 shows that the annual average naphthalene concentration for PRRI is similar to the program-level average concentration. The maximum naphthalene concentration measured at PRRI is well below the program-level maximum concentration. There were no non-detects of naphthalene at PRRI.

Figure 20-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Program Max Concentration = 42.7 ng/m3

Concentration (ng/m3)

Program: 1st Quartile   2nd Quartile   3rd Quartile   4th Quartile   Average

Site: Site Average   Site Minimum/Maximum

Figure 20-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

Program Max Concentration = 3.51 ng/m3

Concentration (ng/m3)

Program: 1st Quartile   2nd Quartile   3rd Quartile   4th Quartile   Average

Site: Site Average   Site Minimum/Maximum

Figure 20-8. Program vs. Site-Specific Average Naphthalene Concentration

Concentration (ng/m3)

Program: 1st Quartile   2nd Quartile   3rd Quartile   4th Quartile   Average

Site: Site Average   Site Minimum/Maximum

20-16

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 3-year rolling statistical metrics for hexavalent chromium for PRRI. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 20-9. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at PRRI
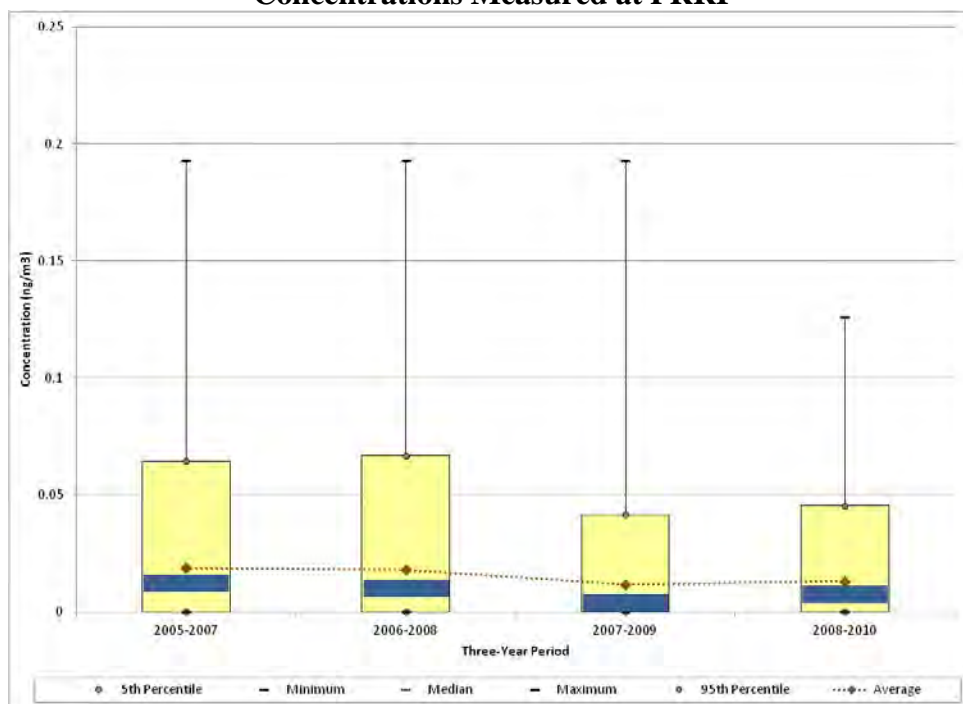
Observations from Figure 20-9 for hexavalent chromium measurements at PRRI include the following:

- Sampling for hexavalent chromium at PRRI began in January 2005.

- 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 rolling average concentrations are very similar in magnitude for 2005-2007 and 2006-2008, but exhibit a decrease for 2007-2009 and a very slight increase for 2008-2010. Confidence intervals calculated for these averages show that the changes over the period of sampling are not statistically significant. A similar trend is shown for the median concentrations.

- For each 3-year period 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 18 percent in 2006 to as high as 65 percent in 2009.

20.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

20.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Rhode Island monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for PRRI were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Rhode Island monitoring site.

20.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Rhode Island monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 20-6, where applicable.

Table 20-6. Cancer and Noncancer Surrogate Risk Approximations for the Rhode Island Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Providence, Rhode Island - PRRI						
Benzo(a)pyrene	0.00176	--	49/58	0.20 ± 0.07	0.36	--
Hexavalent Chromium	0.012	0.0001	44/60	0.02 ± <0.01	0.22	<0.01
Naphthalene	0.000034	0.003	58/58	89.63 ± 14.87	3.05	0.03

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

Observations for PRRI from Table 20-6 include the following:

- The cancer surrogate risk approximation for naphthalene (3.05 in-a-million) is the highest cancer surrogate risk approximation for PRRI's pollutants of interest. The noncancer risk approximations for benzo(a)pyrene and hexavalent chromium are considerably lower (0.36 and 0.22 in-a-million, respectively).

- None of PRRI's pollutants of interest have noncancer risk approximations greater than 1.0. The pollutant with the highest noncancer risk approximation is naphthalene (0.03).

20.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 20-7 and 20-8 present a risk-based 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 20-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 20-7 and 20-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 PAH and hexavalent chromium only. In addition, the cancer and

noncancer surrogate risk 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.

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 PAH sampled for at PRRI including acenaphthylene, fluoranthene, fluorene, and perylene. None of the PAH included in POM, Group 2b were identified as pollutants of interest for PRRI.

- POM, Group 5a ranks eighth for toxicity-weighted emissions. POM, Group 5a includes benzo(a)pyrene, one of PRRI's pollutants of interest. POM, Group 5a is not among the highest emitted "pollutants" in Providence County.

- Hexavalent chromium, which is also one of PRRI's pollutants of interest, has the seventh highest toxicity-weighted emissions for Providence County, but does not appear on the list of highest emitted pollutants.

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 Risk Factors (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	3.05
Formaldehyde	155.91	Benzene	1.60E-03	Benzo(a)pyrene	0.36
Ethylbenzene	96.49	POM, Group 3	1.18E-03	Hexavalent Chromium	0.22
Acetaldehyde	84.05	1,3-Butadiene	9.05E-04		
1,3-Butadiene	30.18	Naphthalene	5.93E-04		
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 Risk Approximations for Pollutants with Noncancer RfCs for the Rhode Island Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk 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 20-8 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 on the list of pollutants with the highest toxicity-weighted emissions, it is not one of the highest emitted pollutants (with a noncancer toxicity factor) in Providence County. Hexavalent chromium does not appear on the list of highest emitted pollutants or the list of highest toxicity-weighted emissions for Providence County.

20.6   Summary of the 2010 Monitoring Data for PRRI

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

- ❖ *Naphthalene, hexavalent chromium, fluorene, and benzo(a)pyrene failed at least one screen for PRRI.*

- ❖ *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for PRRI. However, the annual average benzo(a)pyrene concentration for PRRI is the highest annual average among NMP sites sampling this pollutant.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 21-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.
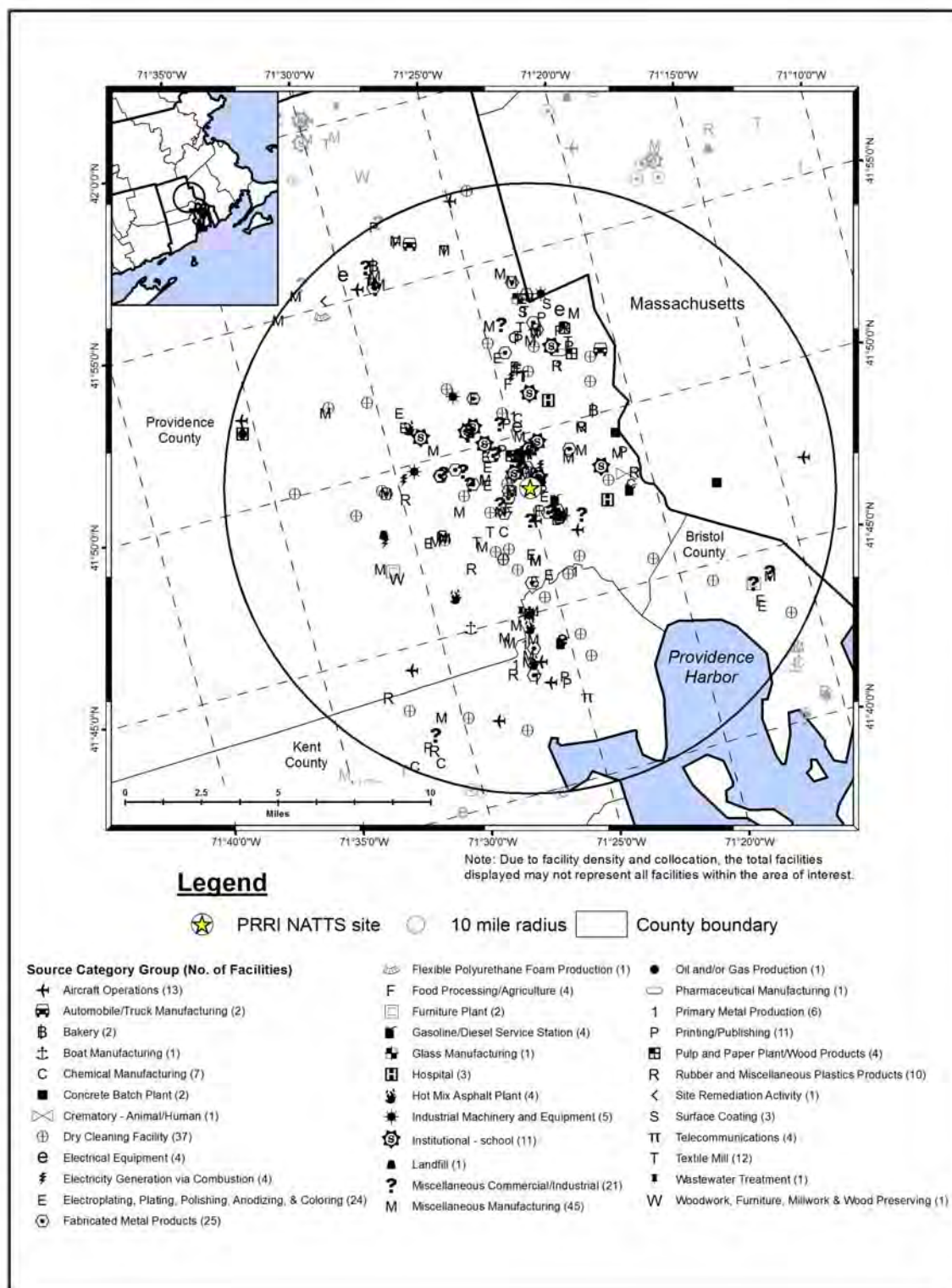
Figure 21-1. Chesterfield, South Carolina (CHSC) Monitoring Site

Figure 21-2. NEI Point Sources Located Within 10 Miles of CHSC

Legend

⭐ CHSC NATTS site   ◯ 10 mile radius   ☐ County boundary

Source Category Group (No. of Facilities)

+ Aircraft Operations (1)

✦ Industrial Machinery and Equipment (1)
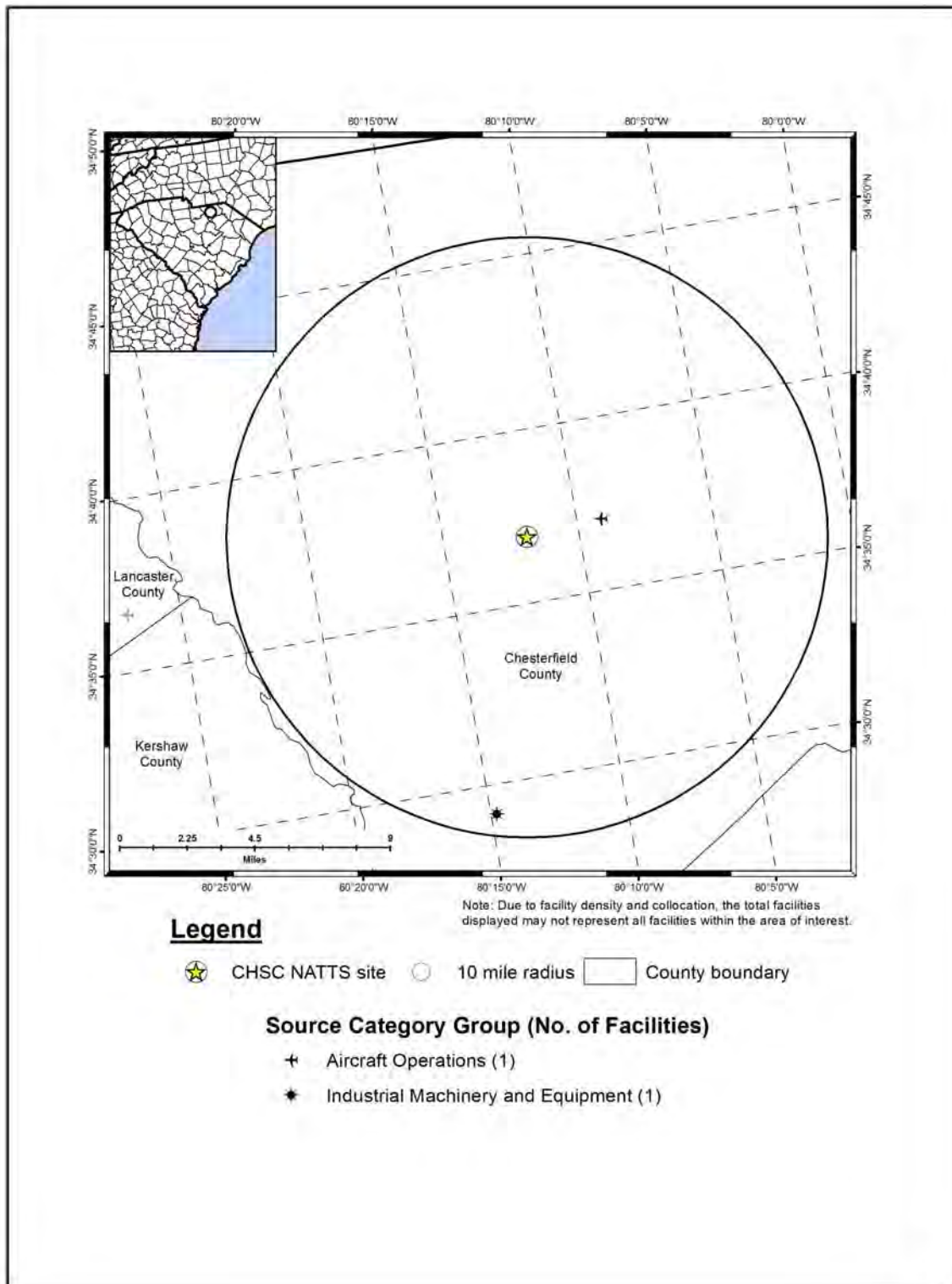
Table 21-1. Geographical Information for the South Carolina Monitoring Site

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, VOC, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation, Carbonyl Compounds, Hexachlorobutadiene.

[1] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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 and 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the South Carolina monitoring site. Table 21-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 21-2 also contains annual average daily traffic information. 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	46,665	40,431	0.87	5,605	4,856	550	1,302,685

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2009 data from the South Carolina Dept of Public Safety (SC DPS, 2009)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data from the South Carolina DOT (SC DOT, 2011)
[5] County-level VMT reflects 2010 data from the South Carolina DOT (SC DOT, 2012)
BOLD ITALICS = EPA-designated NATTS Site.

Observations from Table 21-2 include the following:

- Chesterfield County's population is among 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 used came from State Highway 145 between State Highway 109 and US-1.

- The Chesterfield County daily VMT 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, 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 average number of sleet and freezing rain events per year (Bair, 1992 and SC SCO, 2012).

21.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2010 (NCDC, 2010). 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 normal conditions throughout the year.

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 for 2010. 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.

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	Sample Day	69.4 ± 4.7	59.3 ± 4.6	46.6 ± 5.0	52.9 ± 4.3	66.2 ± 3.1	1016.8 ± 1.6	4.8 ± 0.6
	311° (NW)	2010	70.9 ± 1.9	60.3 ± 1.8	47.6 ± 2.0	53.8 ± 1.7	66.5 ± 1.4	1016.9 ± 0.6	4.5 ± 0.2

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

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 2010. Included in Figure 21-3 are four back trajectories per sample day. Figure 21-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, 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 trajectory originated was over Lake Michigan, or greater than 600 miles away. However, the average trajectory length was 194 miles and most trajectories (85 percent) originated within 300 miles of the site.

- The cluster analysis shows that nearly half of back trajectories originated from the southeast to south to southwest of CHSC over South Carolina and Georgia and less than 300 miles from the site, as represented by the cluster trajectory originating near the South Carolina-Georgia border (41 percent). Another 30 percent originated from the north to east to southeast of CHSC, over North Carolina and Virginia, and generally less than 200 miles from the site. Thus, the majority of back of trajectories originated within 300 miles of CHSC. Another 25 percent of trajectories originated from the northwest and north of CHSC, although of varying lengths. The longest trajectories originated from this direction. Another 4 percent originated from the west, generally over Tennessee and northern Alabama and Georgia.

Figure 21-3. 2010 Composite Back Trajectory Map for CHSC
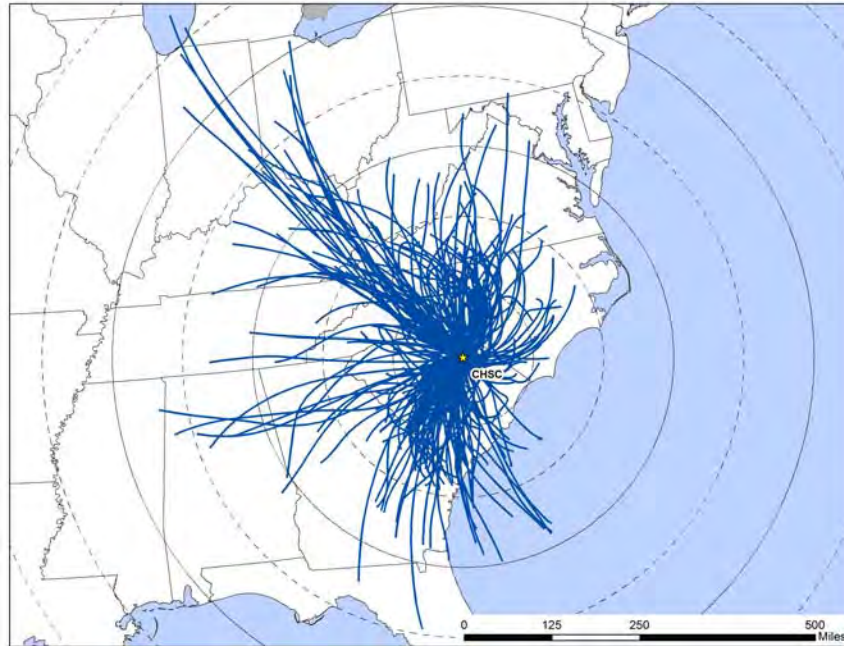
Figure 21-4. Back Trajectory Cluster Map for CHSC

21.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the CHSC monitoring site. First, a historical wind rose representing 2000 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location.

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 22 percent of the hourly measurements. Winds from the south-southwest to west-southwest account for just slightly more observations than winds from the north-northeast to east-northeast. Winds from the southeast quadrant are generally not observed.

- The wind patterns shown on the 2010 wind rose for CHSC are similar to the historical wind patterns, although there were more calm observations and fewer winds observations from the northeast quadrant. This indicates that wind conditions in 2010 were similar to what is expected climatologically near this site.

- The sample day wind patterns for 2010 also resemble the historical and full-year wind roses in the calm rate and southwest wind prevalence. However, there were fewer wind observations from the northeast quadrant, similar to the 2010 full-year wind rose, and an increased number of observations from the northwest quadrant.

Figure 21-5. Wind Roses for the Monroe Airport Weather Station near CHSC

## 2000-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between CHSC and NWS Station

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 21-4 presents CHSC's pollutants of interest. 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 PAH.

Table 21-4. Risk Screening Results for the South Carolina Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Chesterfield, South Carolina - CHSC						
Naphthalene	0.029	6	58	10.34	100.00	100.00
Total		6	58	10.34		

Observations from Table 21-4 include the following:

- Naphthalene was detected in all 58 valid samples collected at CHSC and failed six screens, or approximately 10 percent of screens.

- This site has the second lowest number of failed screens (6) 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.

21.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the South Carolina monitoring site. Concentration averages are provided for the pollutants of interest for the CHSC monitoring site, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices M and O.

21.4.1 2010 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	12/58	0.04 ± 0.04	0	0	0.02 ± 0.01	0.01 ± 0.01
Hexavalent Chromium	27/62	<0.01 ± <0.01	0.01 ± <0.01	0.01 ± 0.01	0.01 ± <0.01	0.01 ± <0.01
Naphthalene	58/58	19.27 ± 6.00	13.61 ± 2.86	14.99 ± 2.10	28.21 ± 12.80	19.16 ± 3.84

Observations for CHSC from Table 21-5 include the following:

- The annual average concentration of naphthalene is significantly higher than the annual average concentrations of hexavalent chromium and benzo(a)pyrene. Compared to other NMP sites, CHSC has some of the lowest annual average concentrations of these three pollutants.

- Benzo(a)pyrene was not detected in the second or third quarters of 2010. This pollutant was detected in less than half of the samples collected during the first and fourth quarters of 2010.

- Although hexavalent chromium was detected in all four quarters of 2010, it was detected in fewer than half of the samples collected (27 out of 62). The measurements ranged from 0.0057 ng/m^3 to 0.0407 ng/m^3, with two-thirds of the concentrations measured during the third (10) and fourth (8) quarters of 2010.

- Naphthalene was detected in every sampled collected at CHSC. The fourth quarter average concentration is higher than the other quarterly averages, although the difference is not statistically significant. This quarterly average also has a relatively large confidence interval associated with it. The maximum naphthalene concentration was measured on October 5, 2010 (106 ng/m^3) and is nearly twice the next highest measurement (54.2 ng/m^3, measured on March 9, 2010). The concentrations measured at CHSC ranged from 6.90 ng/m^3 to 106 ng/m^3, with a median concentration of 15.6 ng/m^3.
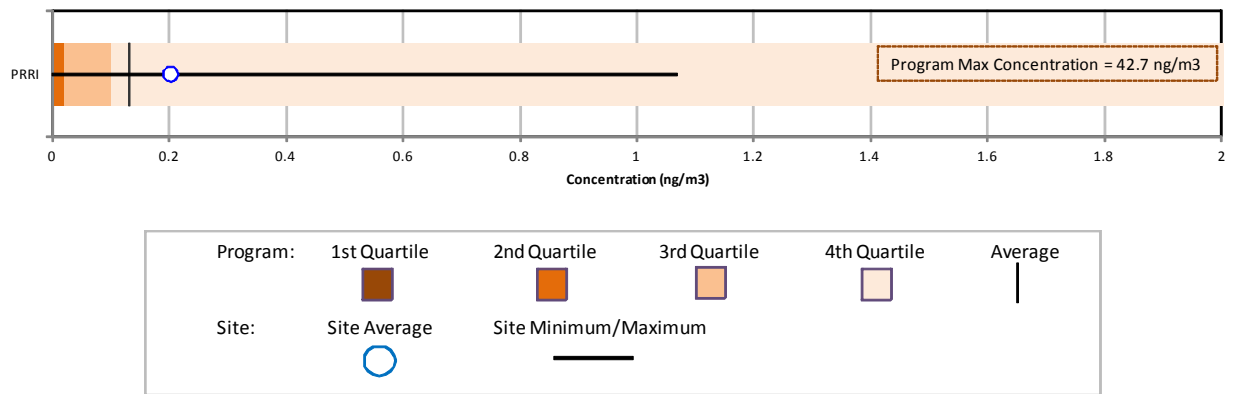
21.4.2 Concentration Comparison

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 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, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.
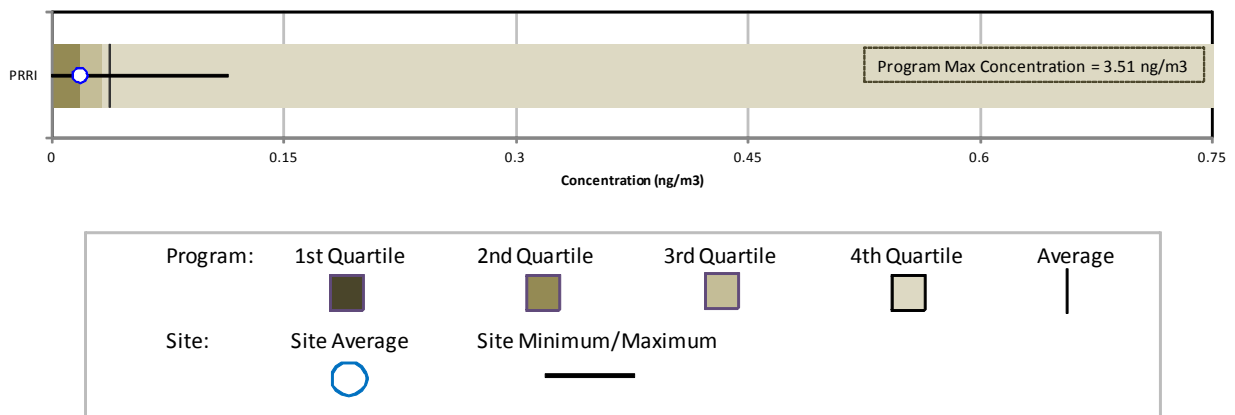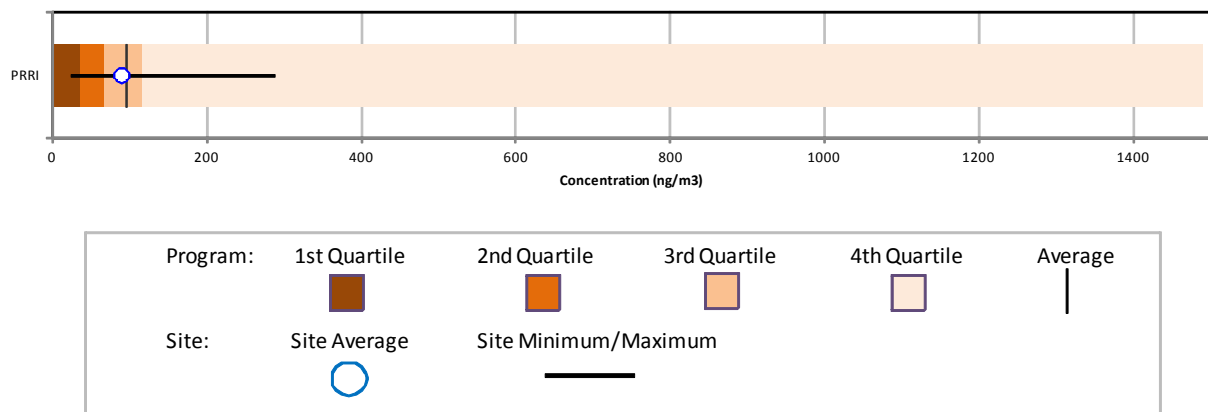
Figure 21-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration
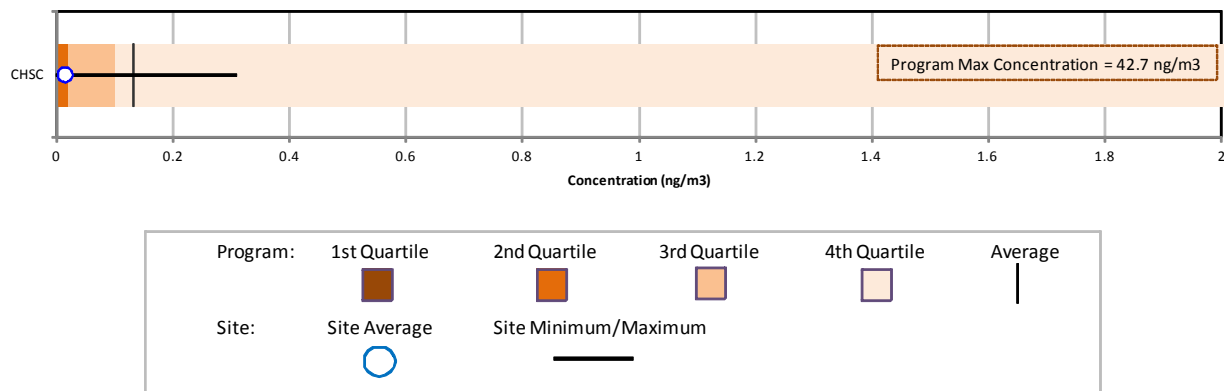
Figure 21-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration
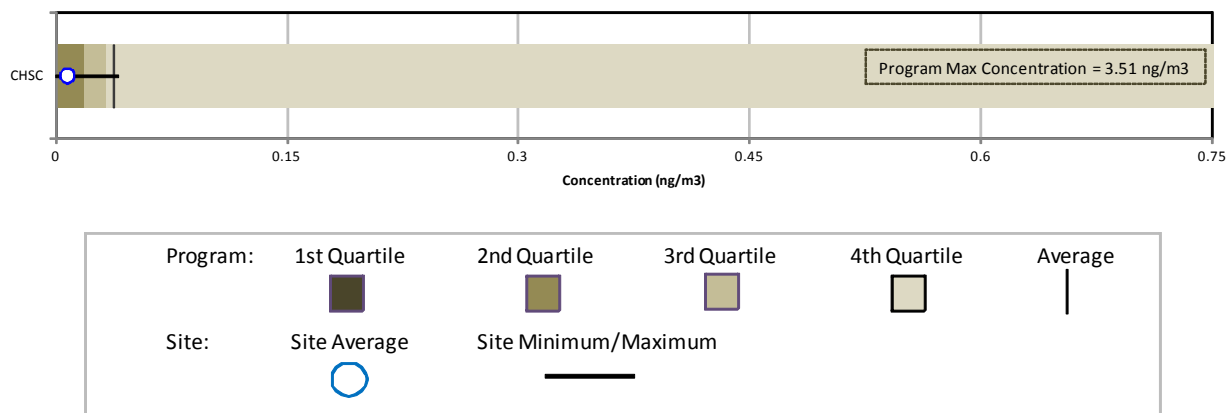
Figure 21-8. Program vs. Site-Specific Average Naphthalene Concentration
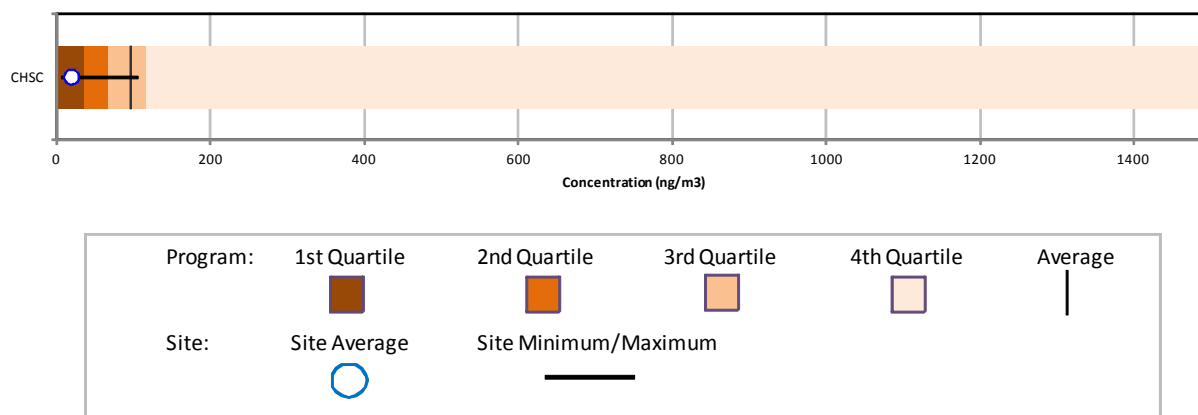
Observations from Figures 21-6 through 21-8 include the following:

- Figure 21-6 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 well below the program-level average concentration and just greater than the program median concentration. Figure 21-6 also shows that the maximum concentration measured at CHSC is well below the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at CHSC.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 21-7 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 21-7 shows the annual average concentration of hexavalent chromium for CHSC is well below the program-level average concentration and the program-level median concentration. The maximum concentration measured at CHSC is not only well below the maximum concentration measured across the program, it is just greater than the program-level average concentration of hexavalent chromium. More than half of the measurements of hexavalent chromium for CHSC were non-detects.

- Figure 21-8 shows that the annual naphthalene average for CHSC is less than the program-level average concentration as well as the program-level median concentration. The maximum naphthalene concentration measured at CHSC is less than the program-level third quartile (75th percentile).

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 3-year rolling statistical metrics for hexavalent chromium for CHSC. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 21-9. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at CHSC
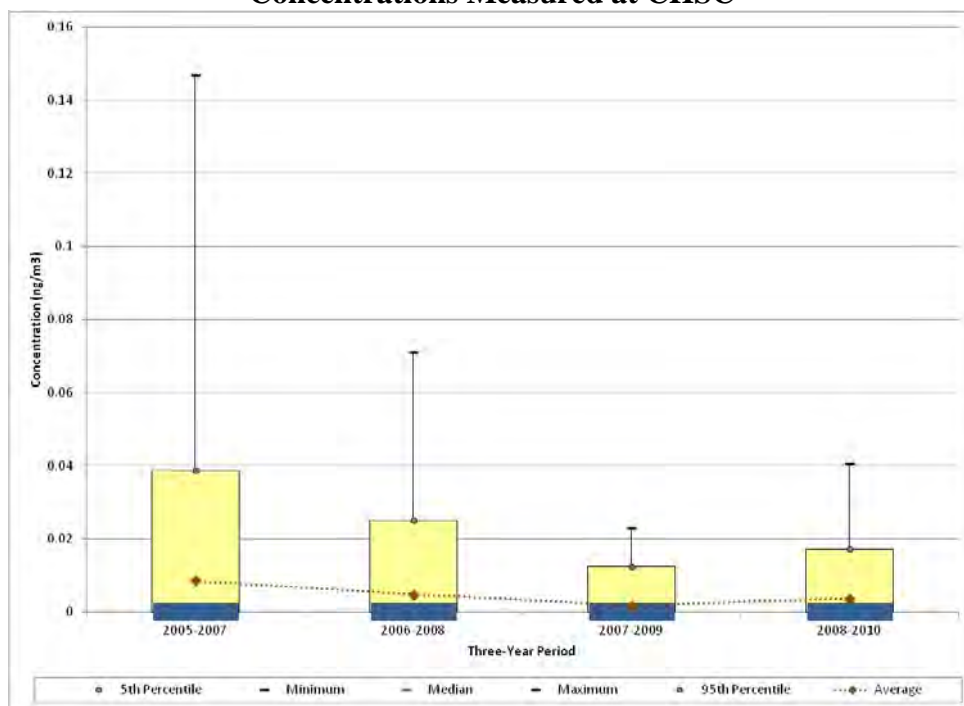
Observations from Figure 21-9 for hexavalent chromium measurements at CHSC include the following:

- Sampling for hexavalent chromium at CHSC began in January 2005.

- The maximum concentration of hexavalent chromium was measured on March 23, 2005. The maximum concentration of hexavalent chromium measured in subsequent time periods was considerably lower (by at least half).

- In addition to the maximum concentration, the 95th percentile and rolling average concentrations of hexavalent chromium exhibit a decreasing trend through the 2007-2009 time frame, with slight increases in each parameter for the final time frame.

- The minimum, 5th percentile, and median concentrations are all zero for each 3-year period shown in Figure 21-9, indicating that at least 50 are of the measurements collected at CHSC were non-detects.

21.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

21.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the South Carolina monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for CHSC were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the South Carolina monitoring site.

21.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the South Carolina monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 21-6, where applicable.

Table 21-6. Cancer and Noncancer Surrogate Risk Approximations for the South Carolina Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Chesterfield, South Carolina - CHSC						
Benzo(a)pyrene	0.00176	--	12/58	0.01 ± 0.01	0.03	--
Hexavalent Chromium	0.012	0.0001	27/62	0.01 ± <0.01	0.09	<0.01
Naphthalene	0.000034	0.003	58/58	19.16 ± 3.84	0.65	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 (0.65 in-a-million).

- The noncancer risk approximations for the three pollutants of interest are very low (0.01 or less). Because benzo(a)pyrene has no RfC, a noncancer risk approximation could not be calculated.

21.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 21-7 and 21-8 present a risk-based 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 surrogate risk approximations (in-a-million), as calculated from annual averages. Table 21-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from the annual averages.

The pollutants listed in Tables 21-7 and 21-8 are limited to those that have cancer and noncancer risk 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 and noncancer risk surrogate 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 PAH and hexavalent chromium only. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	0.65
Ethylbenzene	14.89	Formaldehyde	1.71E-04	Hexavalent Chromium	0.09
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 Risk Approximations for Pollutants with Noncancer RfCs for the South Carolina Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk 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		

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 CHSC's pollutants of interest.

- 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 PAH 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 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, but ranks eighth among the pollutants with the 10 highest toxicity-weighted emissions. Hexavalent chromium does not appear on either emissions-based list.

21.6   Summary of the 2010 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.*

❖ *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for CHSC; however, it was quite low compared to other NMP sites sampling naphthalene.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 22-2 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their rural and urban locations. Figures 22-3 and 22-4 identify 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 22-3 and 22-4. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 22-1 describes the area surrounding each monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 22-1. Sioux Falls, South Dakota (SSSD) Monitoring Site
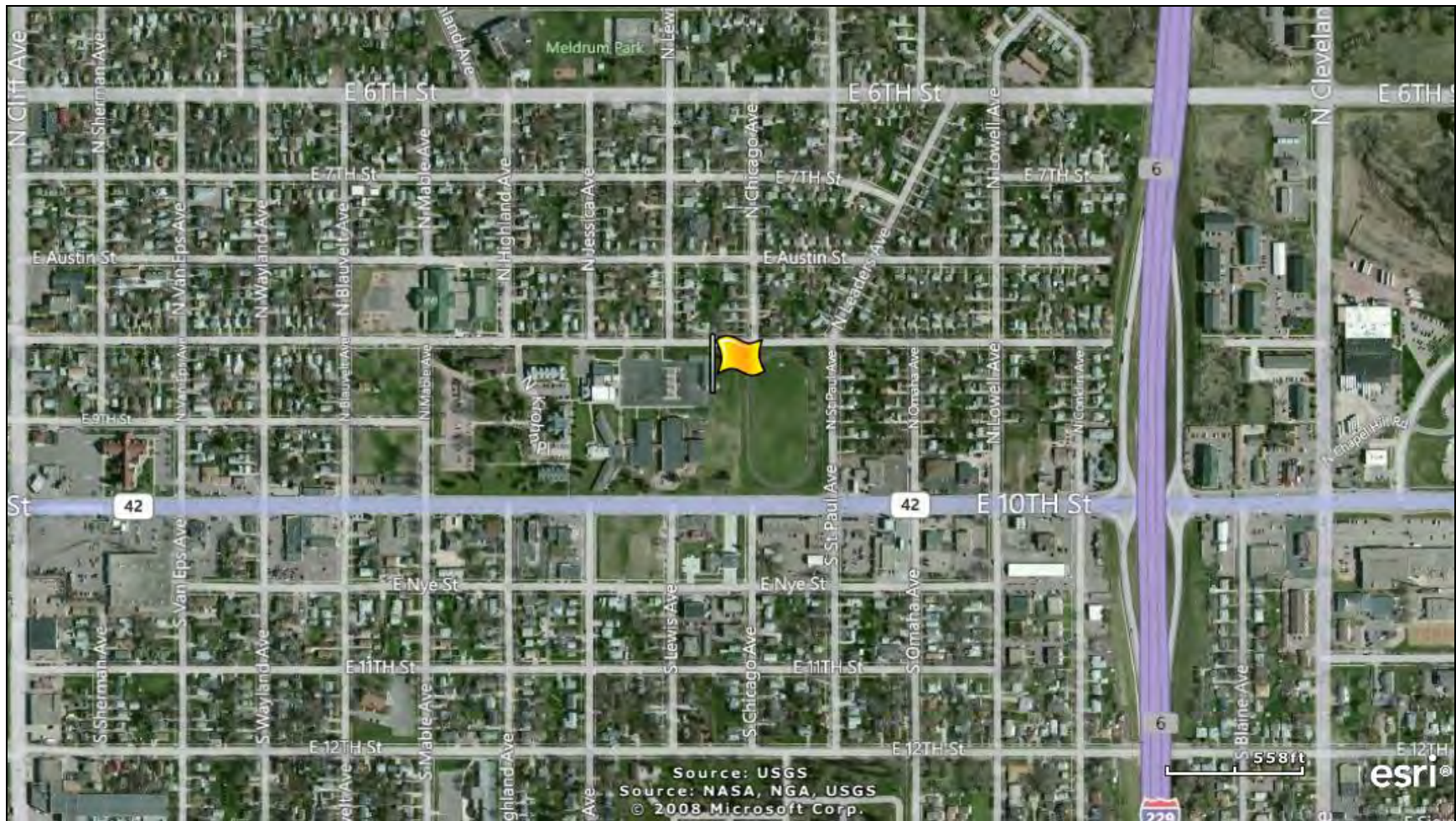
Figure 22-2. Union County, South Dakota (UCSD) Monitoring Site
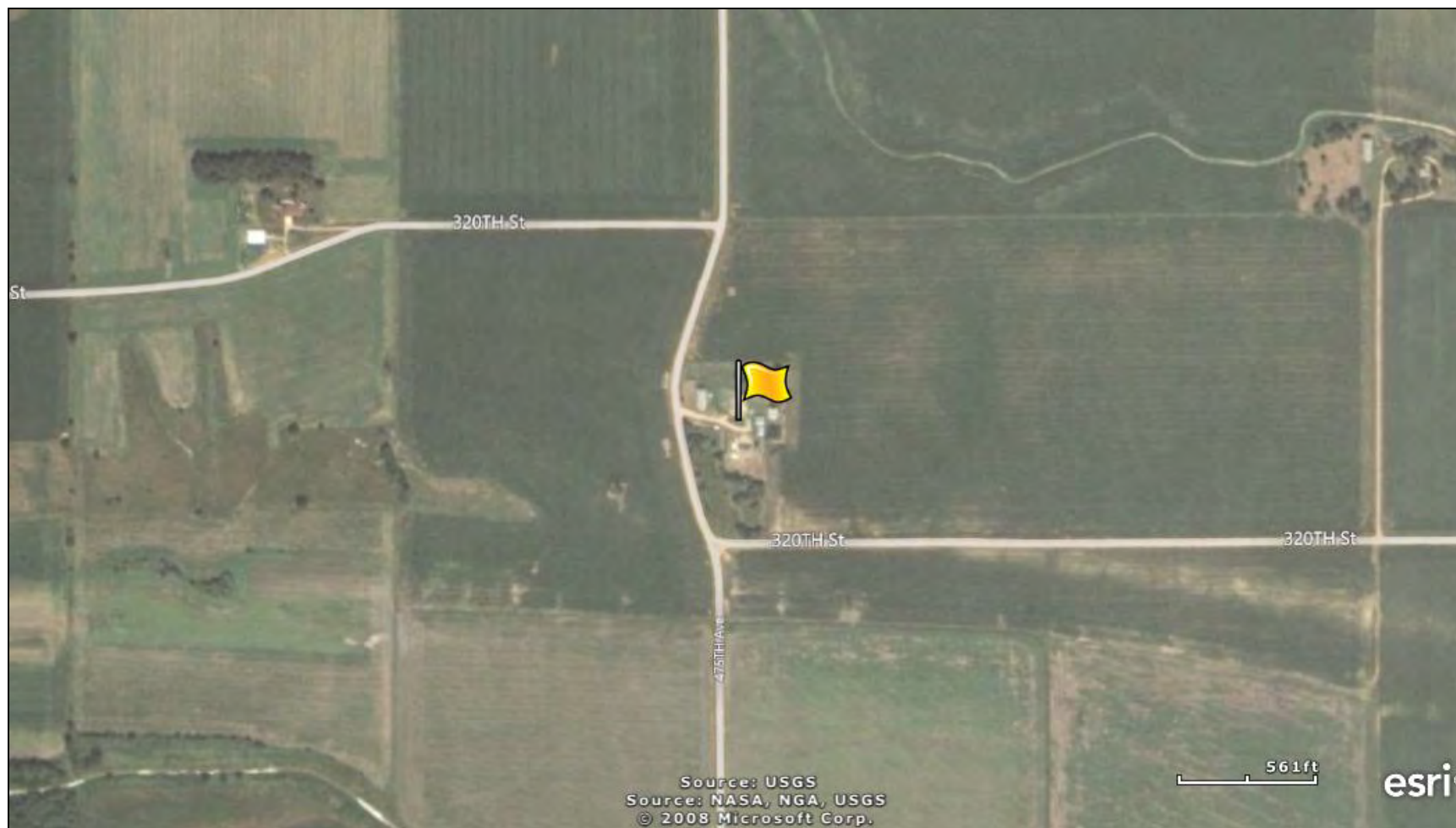
Figure 22-3. NEI Point Sources Located Within 10 Miles of SSSD
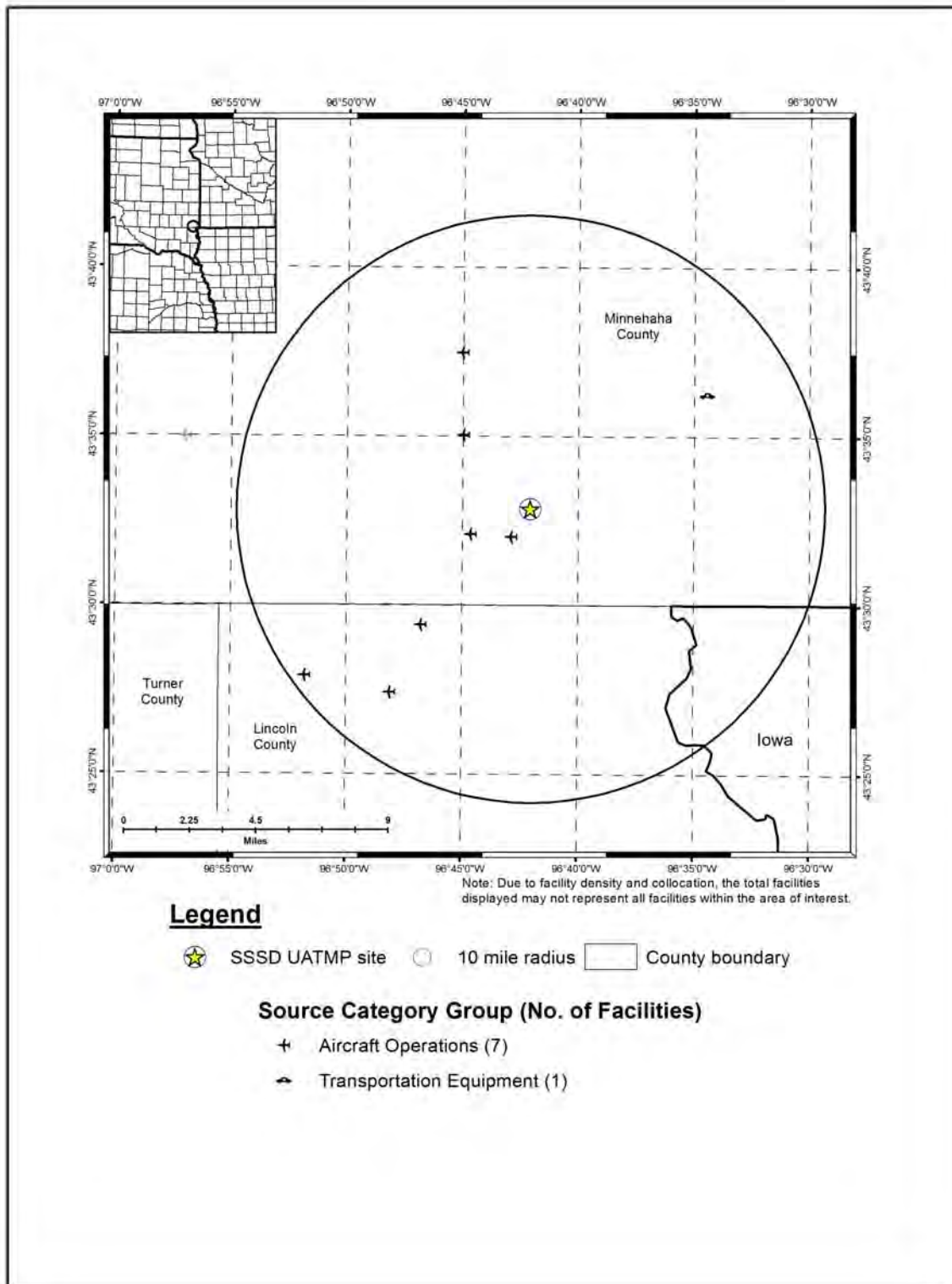
Figure 22-4. NEI Point Sources Located Within 10 Miles of UCSD
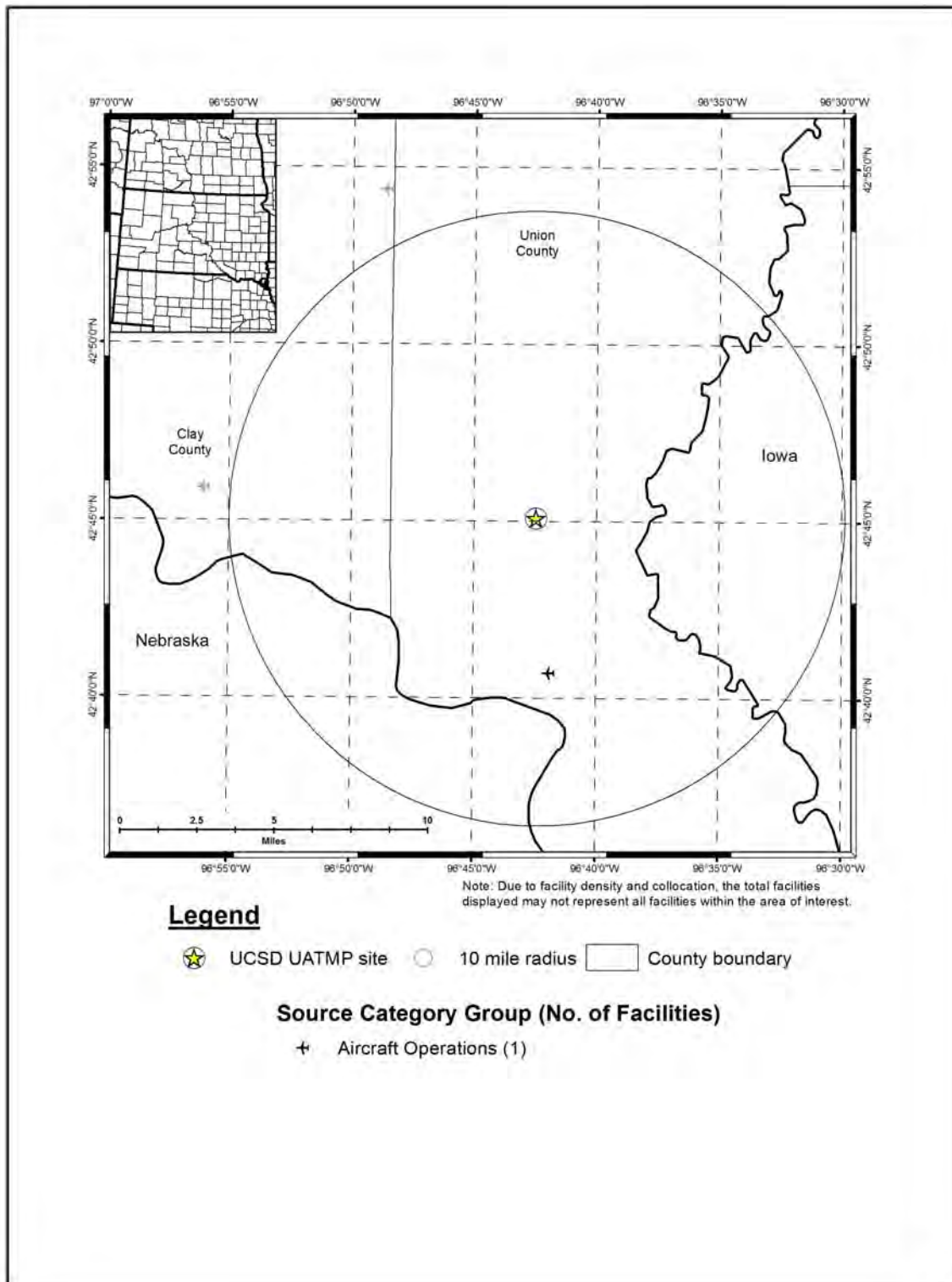
Table 22-1. Geographical Information for the South Dakota Monitoring Sites

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] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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 22-3 shows, few emissions sources are located within 10 miles of SSSD. There are only two source categories shown in Figure 22-3, the aircraft operations category 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 22-2, 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 the 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, 2010).

Table 22-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the South Dakota monitoring sites. Table 22-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 22-2 also contains annual average daily traffic information. Finally, Table 22-2 presents the 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	169,987	208,911	1.23	190,685	234,348	21,340	3,716,475
UCSD	14,501	25,051	1.73	6,153	10,630	156	790,541

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the South Dakota Department of Revenue (SD DOR, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data for SSSD and 2007 data for UCSD from the South Dakota DOT (SD DOT, 2007 and 2011)
[5] County-level VMT reflects 2010 data from the South Dakota DOT (SD DOT, 2011)

Observations from Table 22-2 include the following:

- Although SSSD's county-level population is significantly 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 populations for each site are 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 UCSD's, 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 these sites are among the highest, indicating that residents likely own multiple vehicles. The ratio for UCSD is the second highest among all NMP sites.

- 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 were obtained for East 10th Avenue between South Mable Avenue and South Highland Avenue; traffic data for UCSD were obtained for 475th Avenue near 317th Street.

- The Union County VMT is the lowest among NMP sites (where VMT was available). The Minnehaha County VMT ranks eighth 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 the spring and summer, and northwesterly winds in the autumn and winter (Bair, 1992).

22.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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	Sample Day	55.4 ± 6.4	46.3 ± 6.0	37.6 ± 5.6	42.1 ± 5.5	74.5 ± 3.0	1015.6 ± 2.1	7.7 ± 0.9
	309° (NW)	2010	55.5 ± 2.5	46.4 ± 2.4	37.2 ± 2.2	41.9 ± 2.2	73.4 ± 1.2	1015.6 ± 0.9	7.9 ± 0.4
Union County, South Dakota - UCSD								
Sioux Gateway/Col. Bud Day Field Airport 14943 (42.39, -96.38)	29.45 miles	Sample Day	60.0 ± 6.1	50.4 ± 5.6	40.2 ± 5.2	45.3 ± 5.1	71.5 ± 3.2	1015.1 ± 2.1	7.9 ± 0.9
	148° (SSE)	2010	59.3 ± 2.6	49.0 ± 2.4	38.5 ± 2.2	43.8 ± 2.2	70.5 ± 1.2	1015.7 ± 0.9	7.9 ± 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 for 2010. 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 2010. Included in Figure 22-5 are four back trajectories per sample day. Figure 22-6 is the corresponding cluster analysis for 2010. 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, 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, although primarily from the northwest and south.

- 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 trajectory originated was southern Alberta, Canada, or greater than 800 miles away. However, the average back trajectory length was nearly 280 miles and 88 percent of back trajectories originated within 500 miles of the site.

- The cluster analysis shows that back trajectories originating from the west to northwest to north accounted for 50 percent of the back trajectories for SSSD, although of varying lengths. The shorter cluster (36 percent) originating to the southeast of SSSD represents trajectories originating from a variety of directions but within 100-300 miles or so of the site. Another 14 percent of trajectories originated from the south of SSSD.

Figure 22-5. 2010 Composite Back Trajectory Map for SSSD
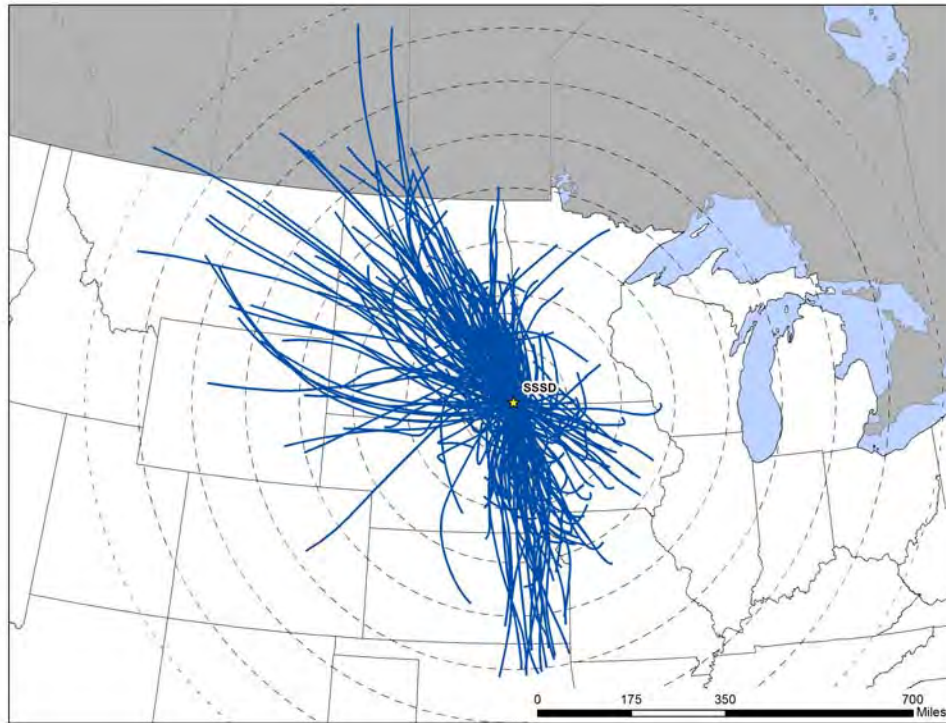
Figure 22-6. Back Trajectory Cluster Map for SSSD
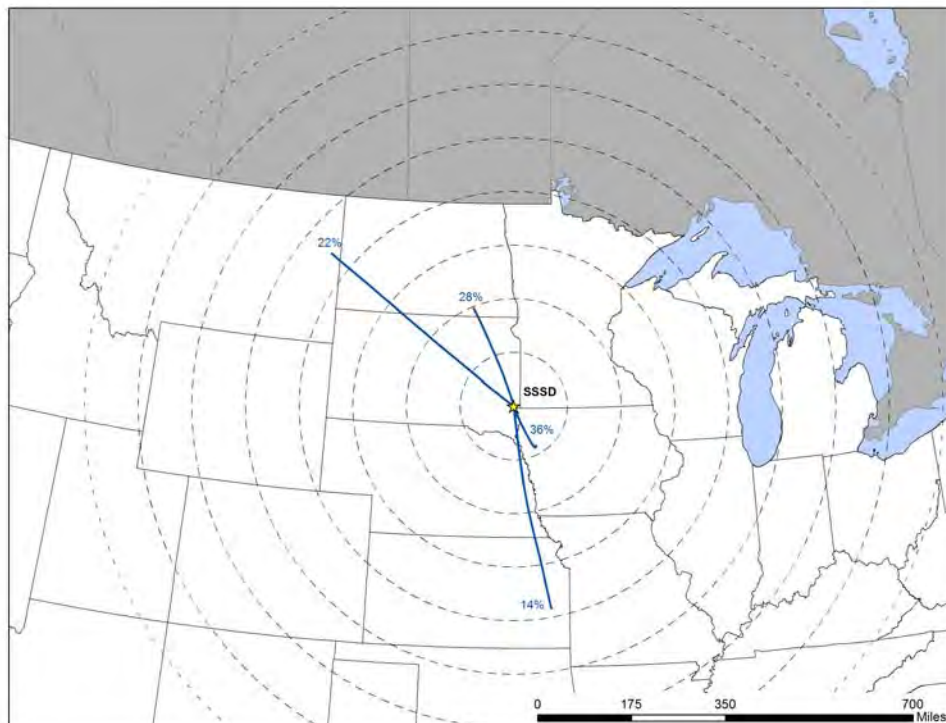
Figure 22-7. 2010 Composite Back Trajectory Map for UCSD
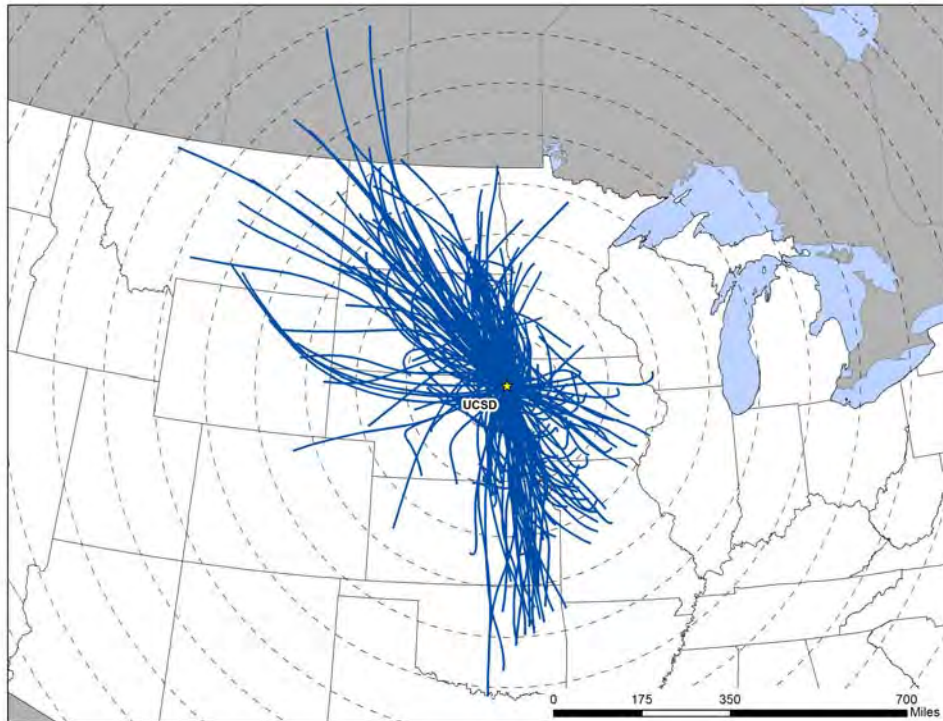
Figure 22-8. Back Trajectory Cluster Map for UCSD
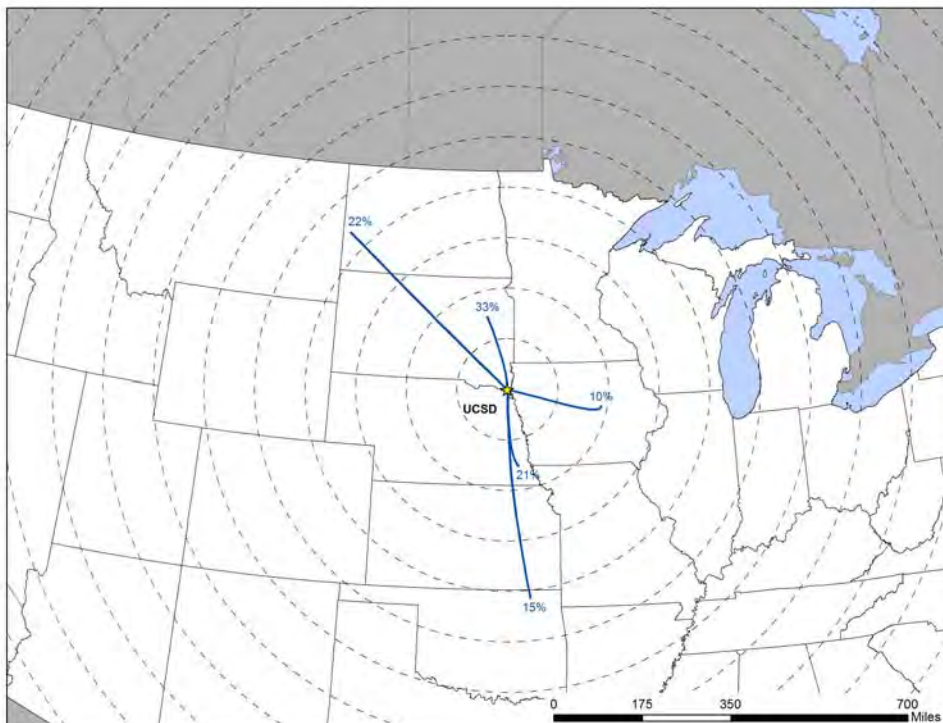
Observations from Figures 22-7 and 22-8 for UCSD include the following:

- Back trajectories originated from a variety of directions at the UCSD monitoring site. The composite map for UCSD shares similarities in the trajectory distribution for SSSD.

- The 24-hour air shed domain for UCSD was similar in size compared to SSSD. Two back trajectories originated approximately 800 miles away, one in north-central Montana and one in central Saskatchewan, Canada. However, the average trajectory length was nearly 280 miles and 90 percent of the trajectories originated within 500 miles of the site.

- The cluster analysis for UCSD shows that 22 percent of trajectories originated from the west, northwest, and north-northwest of the site. Another cluster (33 percent) represents shorter trajectories originating primarily to the north over southeast North Dakota and much of South Dakota. Back trajectories originating from the south of UCSD accounted for 36 percent of the back trajectories, although of varying lengths. Another 10 percent of trajectories originated to east over Iowa.

22.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the SSSD monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS stations and the monitoring sites is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figure 22-10 presents the three wind roses and distance map for the UCSD monitoring site.

Figure 22-9. Wind Roses for the Joe Foss Field Airport Weather Station near SSSD

1999-2009 Historical Wind Rose
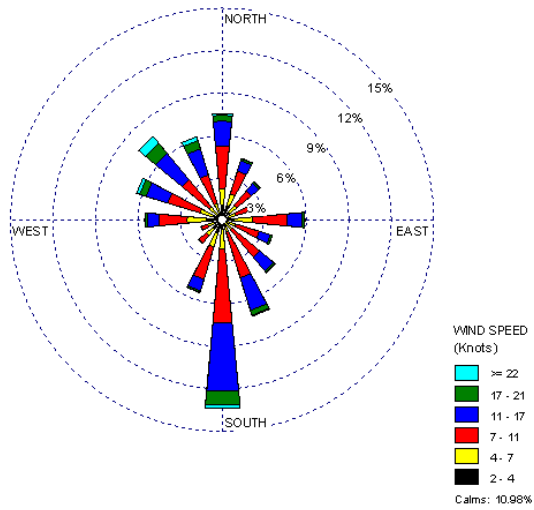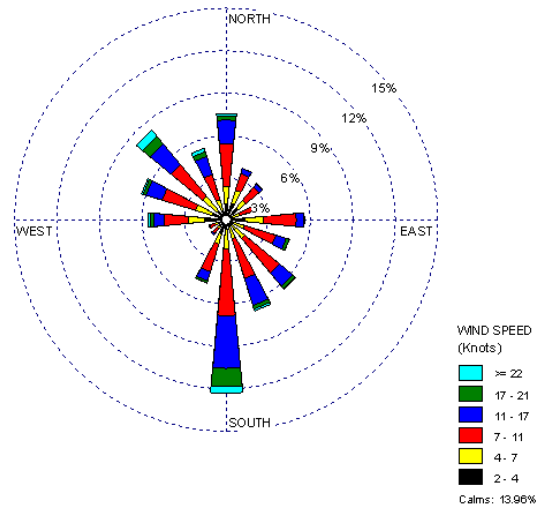
2010 Wind Rose

2010 Sample Day Wind Rose
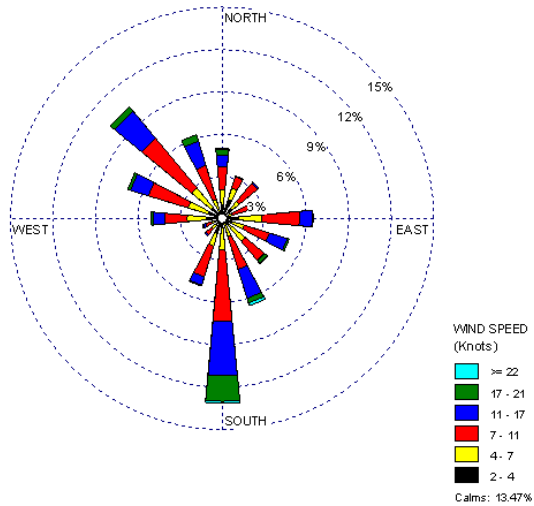
Distance between SSSD and NWS Station

Figure 22-10. Wind Roses for the Sioux Gateway Airport Weather Station near UCSD

1999-2009 Historical Wind Rose
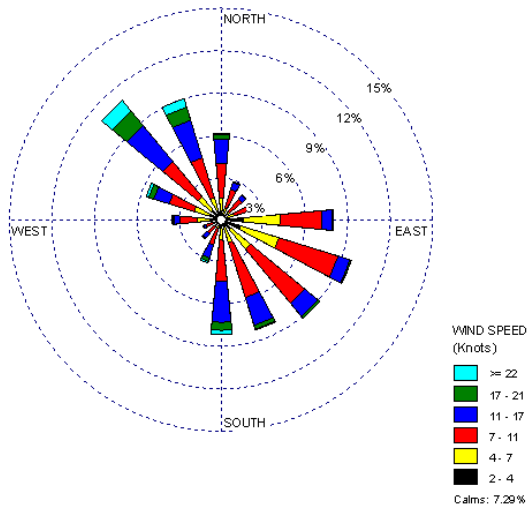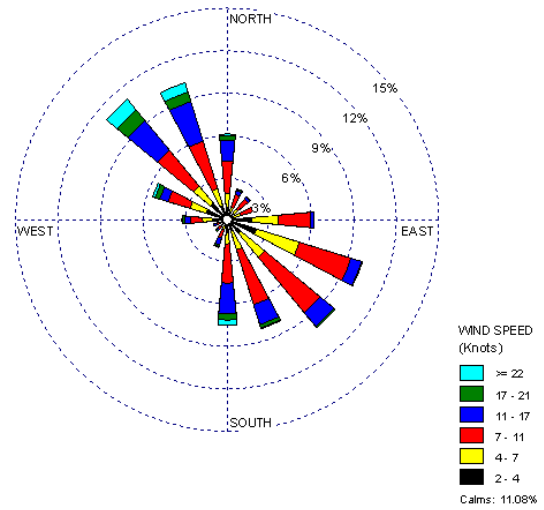
2010 Wind Rose

2010 Sample Day Wind Rose
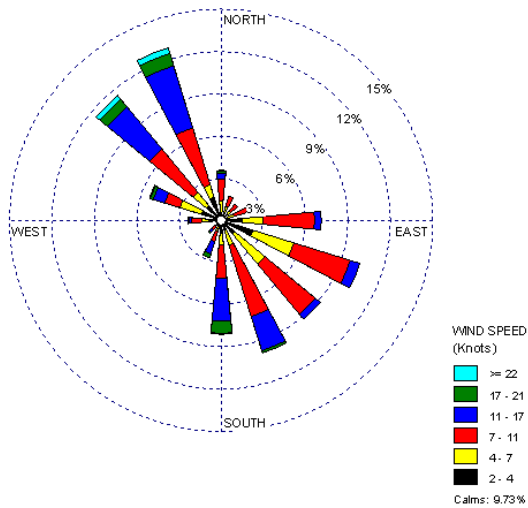
Distance between UCSD and NWS Station

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 2010 wind patterns are very similar to the historical wind patterns, although a slightly higher percentage of calm winds (14 percent) was observed during 2010.

- The sample day wind rose resembles the historical and full-year wind roses, but do exhibit some differences. The sample day wind rose has a higher percentage of northwesterly winds. In addition, the strongest winds, those greater than 22 knots, were not captured on the sample day wind rose.

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 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 2010 wind patterns are similar to the historical wind patterns, although the calm rate is higher for 2010 (11 percent).

- The sample day wind patterns resemble the full-year wind patterns, but have a higher percentage of northwesterly and north-northwesterly wind observations and less northerly wind observations.

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 22-4 presents the pollutants of interest 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 VOC, SNMOC, and carbonyl compounds.

Observations from Table 22-4 include the following:

- Thirteen pollutants failed at least one screen for SSSD; of these, six are NATTS MQO Core Analytes. Fifteen 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, six pollutants (of which five are NATTS MQO Core Analytes) were identified as pollutants of interest by the risk screening process. Trichloroethylene was added to SSSD's pollutants of interest because it's a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of the total failed screens. Chloroform, tetrachloroethylene, 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 three pollutants are not shown in Table 22-4.

- For UCSD, nine pollutants (of which six are NATTS MQO Core Analytes) were identified as pollutants of interest by the risk screening process. 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.

- Formaldehyde, benzene, and acetaldehyde were detected in every sample collected at UCSD and SSSD and failed 100 percent of screens. Other pollutants, such as acrylonitrile, 1,2-dichloroethane, and 1,2-dibromoethane also failed 100 percent screens for each site but were detected infrequently.

- 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 screening process. As the South Dakota sites sampled both VOC (TO-15) and SNMOC, the TO-15 results were used for the 12 pollutants these methods have in common.

Table 22-4. Risk Screening Results for the South Dakota Monitoring Sites

Pollutant	Screening Value (μg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Sioux Falls, South Dakota - SSSD						
Acetaldehyde	0.45	61	61	100.00	20.13	20.13
Formaldehyde	0.077	61	61	100.00	20.13	40.26
Benzene	0.13	60	60	100.00	19.80	60.07
Carbon Tetrachloride	0.17	58	60	96.67	19.14	79.21
1,3-Butadiene	0.03	42	47	89.36	13.86	93.07
1,2-Dichloroethane	0.038	9	9	100.00	2.97	96.04
1,2-Dibromoethane	0.0017	4	4	100.00	1.32	97.36
p-Dichlorobenzene	0.091	2	17	11.76	0.66	98.02
Ethylbenzene	0.4	2	60	3.33	0.66	98.68
Acrylonitrile	0.015	1	1	100.00	0.33	99.01
Chloromethylbenzene	0.02	1	1	100.00	0.33	99.34
Hexachloro-1,3-butadiene	0.045	1	2	50.00	0.33	99.67
Trichloroethylene	0.2	1	5	20.00	0.33	100.00
Total		303	388	78.09		
Union County, South Dakota - UCSD						
Benzene	0.13	59	59	100.00	20.85	20.85
Acetaldehyde	0.45	58	58	100.00	20.49	41.34
Formaldehyde	0.077	58	58	100.00	20.49	61.84
Carbon Tetrachloride	0.17	56	57	98.25	19.79	81.63
Acrylonitrile	0.015	14	14	100.00	4.95	86.57
1,2-Dichloroethane	0.038	11	11	100.00	3.89	90.46
Ethylbenzene	0.4	8	59	13.56	2.83	93.29
1,3-Butadiene	0.03	4	14	28.57	1.41	94.70
Trichloroethylene	0.2	3	15	20.00	1.06	95.76
1,2-Dibromoethane	0.0017	2	2	100.00	0.71	96.47
p-Dichlorobenzene	0.091	2	9	22.22	0.71	97.17
Hexachloro-1,3-butadiene	0.045	2	2	100.00	0.71	97.88
Propionaldehyde	0.8	2	58	3.45	0.71	98.59
1,1,2,2-Tetrachloroethane	0.017	2	2	100.00	0.71	99.29
1,1,2-Trichloroethane	0.0625	2	3	66.67	0.71	100.00
Total		283	421	67.22		

22.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the South Dakota monitoring sites. Concentration averages are provided for the pollutants of interest for each site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the

sites, where applicable. Additional site-specific statistical summaries are provided in Appendices J through L.

22.4.1 2010 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 ($\mu g/m^3$)	2nd Quarter Average ($\mu g/m^3$)	3rd Quarter Average ($\mu g/m^3$)	4th Quarter Average ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
Sioux Falls, South Dakota - SSSD						
Acetaldehyde	61/61	2.21 ± 0.43	2.14 ± 0.87	1.47 ± 0.18	1.73 ± 0.36	1.88 ± 0.26
Benzene	60/60	0.67 ± 0.08	0.74 ± 0.12	0.82 ± 0.21	0.74 ± 0.18	0.74 ± 0.07
1,3-Butadiene	47/60	0.03 ± 0.02	0.04 ± 0.01	0.04 ± 0.02	0.04 ± 0.02	0.04 ± 0.01
Carbon Tetrachloride	60/60	0.48 ± 0.12	0.60 ± 0.10	0.66 ± 0.07	0.59 ± 0.10	0.58 ± 0.05
Chloroform	43/60	0.05 ± 0.02	0.09 ± 0.01	0.09 ± 0.03	0.04 ± 0.03	0.07 ± 0.01
1,2-Dichloroethane	9/60	0.03 ± 0.02	0.01 ± 0.01	0	0	0.01 ± 0.01
Formaldehyde	61/61	2.20 ± 0.29	2.45 ± 0.54	2.02 ± 0.31	2.06 ± 0.36	2.18 ± 0.19
Tetrachloroethylene	47/60	0.06 ± 0.03	0.09 ± 0.02	0.11 ± 0.05	0.10 ± 0.06	0.09 ± 0.02

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)
Trichloroethylene	5/60	0.07 ± 0.14	0	0.01 ± 0.01	0.01 ± 0.02	0.02 ± 0.03
Vinyl Chloride	2/60	0	0	<0.01 ± <0.01	0	<0.01 ± <0.01
Union County, South Dakota - UCSD						
Acetaldehyde	58/58	2.28 ± 0.89	2.12 ± 0.80	1.65 ± 0.25	1.58 ± 0.37	1.88 ± 0.28
Acrylonitrile	14/59	0.03 ± 0.03	0.01 ± 0.01	0.10 ± 0.09	0.06 ± 0.06	0.05 ± 0.03
Benzene	59/59	0.49 ± 0.06	0.53 ± 0.19	0.57 ± 0.17	0.44 ± 0.05	0.51 ± 0.07
1,3-Butadiene	14/59	<0.01 ± <0.01	0.01 ± 0.01	0.01 ± 0.01	<0.01 ± 0.01	0.01 ± <0.01
Carbon Tetrachloride	57/59	0.49 ± 0.14	0.53 ± 0.12	0.65 ± 0.07	0.53 ± 0.12	0.56 ± 0.05
Chloroform	36/59	0.04 ± 0.02	0.08 ± 0.01	0.06 ± 0.02	0.02 ± 0.02	0.05 ± 0.01
1,2-Dichloroethane	11/59	0.04 ± 0.02	0.02 ± 0.02	0	0	0.01 ± 0.01
Ethylbenzene	59/59	0.11 ± 0.04	0.11 ± 0.02	2.15 ± 3.76	0.31 ± 0.29	0.75 ± 1.05
Formaldehyde	58/58	2.61 ± 1.29	3.64 ± 1.01	2.01 ± 0.43	1.45 ± 0.33	2.38 ± 0.42
Tetrachloroethylene	39/59	0.03 ± 0.02	0.04 ± 0.01	0.08 ± 0.04	0.03 ± 0.02	0.05 ± 0.01
Trichloroethylene	15/59	0.01 ± 0.02	<0.01 ± 0.01	0.21 ± 0.35	0.04 ± 0.06	0.08 ± 0.10
Vinyl Chloride	2/59	0	0	<0.01 ± <0.01	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 (2.18 ± 0.19 µg/m³), acetaldehyde (1.88 ± 0.26 µg/m³), and benzene (0.74 ± 0.07 µg/m³).

- Acetaldehyde concentrations appear highest during the first half of the year. The maximum acetaldehyde concentration was measured on May 26, 2009 (7.13 µg/m³). This concentration is nearly twice the next highest concentration (4.03 µg/m³ measured on April 20, 2010), although similar concentrations were also measured in February, March, and October. Note that of the 17 acetaldehyde concentrations greater than 2 µg/m³ measured at SSSD, eight were measured during the first quarter of the year, four in the second quarter, one in the third quarter, and four in the fourth quarter (all in October).

- For 1,2-dichloroethane, all of the measured detections were measured during the first and second quarters of 2010. In fact, five of the nine measured detections were measured in February, and no measured detections were measured after May 8, 2010.

- The first quarter average concentration of trichloroethylene is significantly higher than the other quarterly averages and the confidence interval is high, indicating that this average is influenced by outliers. The highest concentration of trichloroethylene was measured on January 8, 2010 (1.02 µg/m^3) and is an order of magnitude higher than the next highest concentration (0.118 µg/m^3 measured on November 22, 2010). The January 8th concentration is the only measured detection of trichloroethylene measured during the first quarter of 2010. There were only five measured detections of this pollutant for SSSD, with the other four being measured in the third and fourth quarters (three in the third and one in the fourth).

Observations for UCSD from Table 22-5 include the following:

- The pollutants with the highest annual average concentrations by mass are formaldehyde (2.38 ± 0.42 µg/m^3), acetaldehyde (1.88 ± 0.28 µg/m^3), and ethylbenzene (0.75 ± 1.05 µg/m^3).

- For formaldehyde, the second quarter 2010 average is relatively high compared to other quarterly averages and has a relatively high large confidence interval associated with it, as does the first quarter average concentration. A review of the data shows that the highest concentration of formaldehyde was measured on May 8, 2010 (9.14 µg/m^3). A similar concentration was also measured on March 15, 2010 (8.76 µg/m^3). The five highest concentrations of formaldehyde (those greater than 4 µg/m^3) were all measured between March and May 2010. Of the 12 formaldehyde concentrations greater than 3 µg/m^3, two were measured during the first quarter of 2010, seven were measured during the second quarter, and three during the third quarter (and none in the fourth quarter).

- A similar quarterly trend is shown for acetaldehyde measurements in Table 22-5, although the trend is less pronounced. The two highest concentrations of acetaldehyde were also measured on May 8th and March 15th.

- The third quarter ethylbenzene concentration is significantly higher than the other quarterly averages and has a high confidence interval associated with it, indicating the presence of outliers. The maximum concentration of ethylbenzene was measured at UCSD on July 7, 2010 (31.5 µg/m^3) and was 15 times higher than the next highest concentration (2.08 µg/m^3 measured on October 5, 2010). The July 7, 2010 concentration is the maximum ethylbenzene concentration measured among NMP sites sampling this pollutant (SNMOC or TO-15). Only three ethylbenzene concentrations were greater than 1 µg/m^3 at UCSD, with the third being measured in December.

- The three highest concentrations of trichloroethylene were measured on the same dates as the three highest concentrations of ethylbenzene, which explains the third

quarter average concentration of this pollutant for UCSD, although this pollutant was detected less frequently than ethylbenzene.

- Concentrations of tetrachloroethylene also appear higher during the third quarter of 2010. The maximum concentration of tetrachloroethylene was measured at UCSD on July 2, 2010 (0.353 µg/m^3) and was twice the next highest concentration (0.143 µg/m^3 measured on September 5, 2010). Eight of the 10 highest tetrachloroethylene concentrations were measured at UCSD in July, August, and September.

- Concentrations of chloroform appear higher during the warmer months of 2010. The three highest concentrations of chloroform (those greater than 0.1 µg/m^3) were measured in June, July, and August. The bulk of the measured detections (36) were measured during the second (13) and third (11) quarters of 2010.

- Concentrations of acrylonitrile appear higher during the third and fourth quarters of 2010 and these quarterly averages have relatively high confidence intervals associated with them. The four highest concentrations of acrylonitrile (those greater than 0.3 µg/m^3) were measured in August and September. Of the 14 measured detections of acrylonitrile, four were measured during the first quarter of 2010, one was measured during the second quarter, five during the third quarter, and four during the fourth quarter.

- Similar to SSSD, all of the measured detections of 1,2-dichloroethane were measured during the first and second quarters of 2010. Over half of the 11 measured detections were measured in the period between January 26, 2010 through February 25, 2010, and no measured detections were measured after June 19, 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 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 third highest concentration of trichloroethylene among NMP sites sampling VOC, as shown in Table 4-9. UCSD has the fourth highest concentrations of acrylonitrile and ethylbenzene among NMP sites sampling these pollutants.

22.4.2 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, 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, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 22-11. Program vs. Site-Specific Average Acetaldehyde Concentration
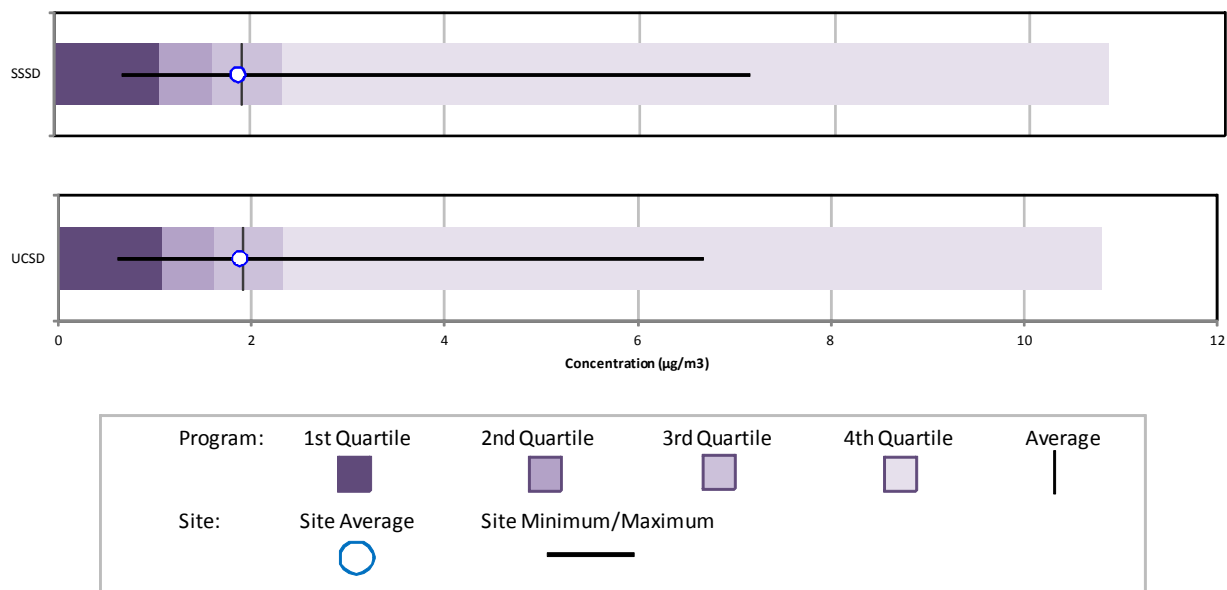
Figure 22-12. Program vs. Site-Specific Average Benzene Concentration
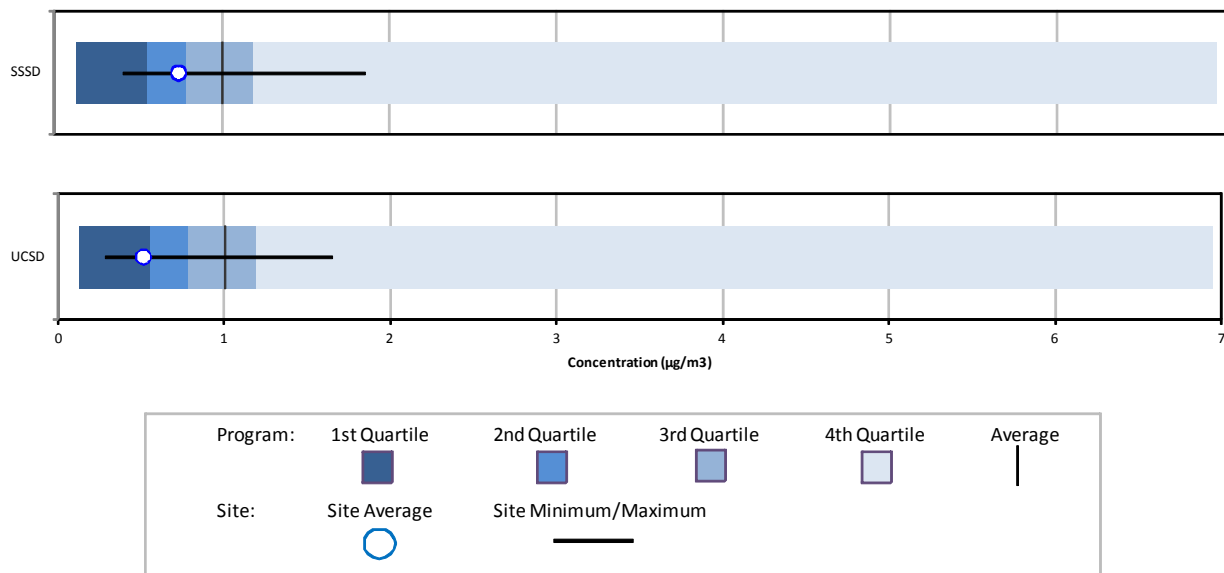
Figure 22-13. Program vs. Site-Specific Average 1,3-Butadiene Concentration
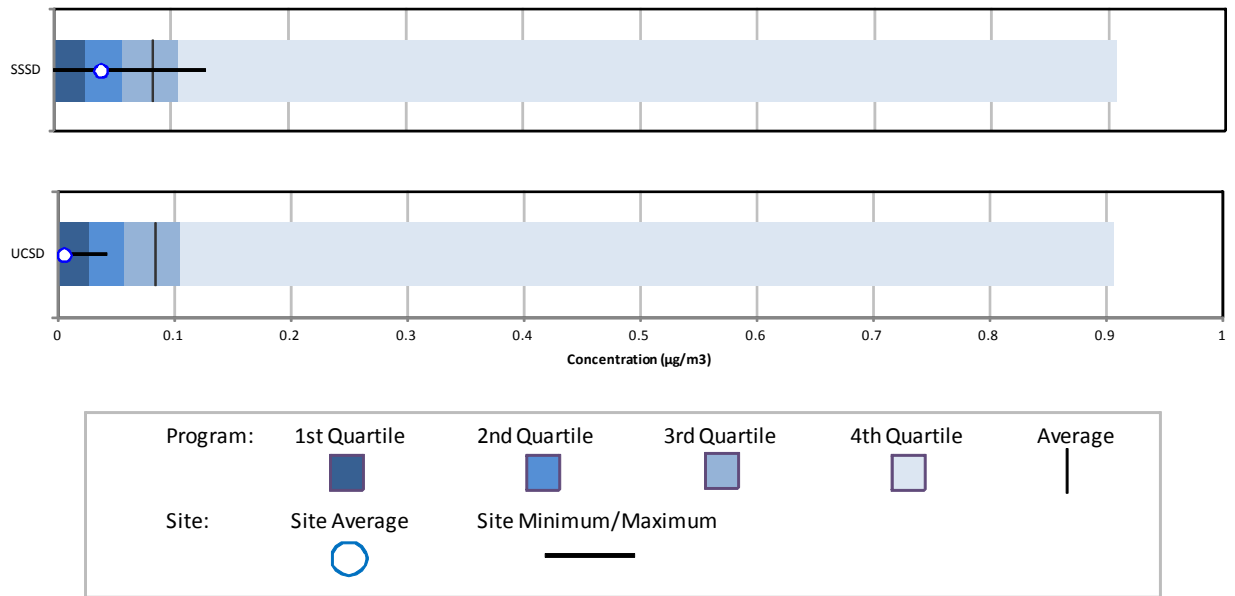
Figure 22-14. Program vs. Site-Specific Average Formaldehyde Concentration
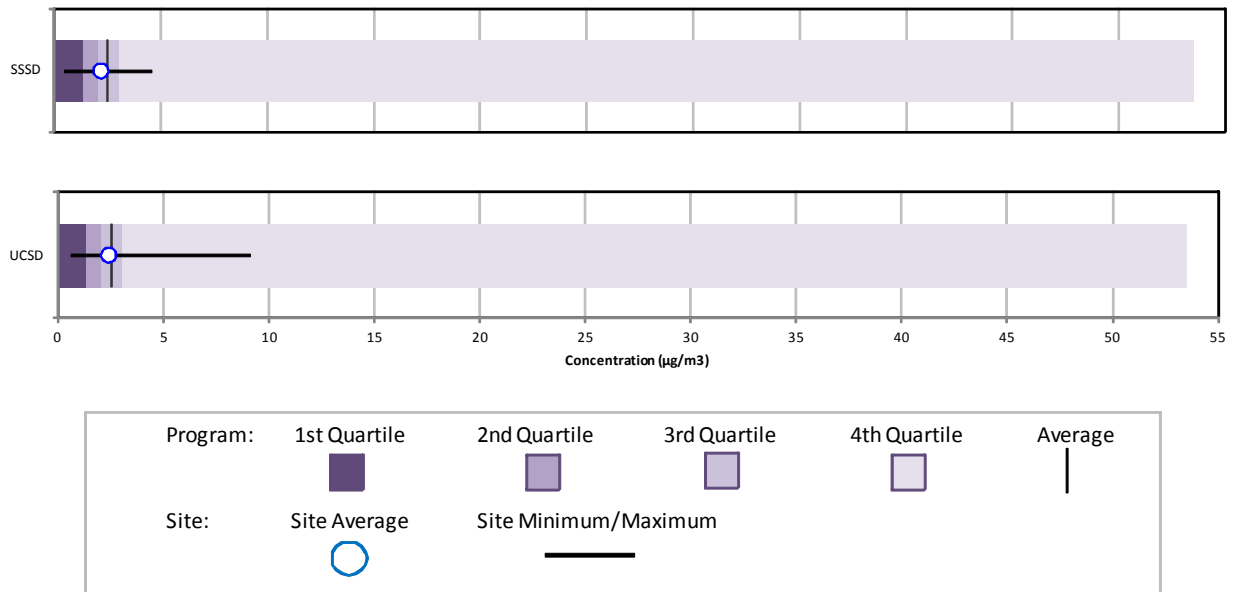
Observations from Figures 22-11 through 22-14 include the following:

- Figure 22-11 shows that the annual average acetaldehyde concentrations for SSSD and UCSD are nearly identical to each other and both are just slightly less than the program-level average concentration. The range of concentrations measured is slightly higher at SSSD than at UCSD, although the maximum concentration measured at both sites is below the maximum concentration measured across the program. There were no non-detects of acetaldehyde measured at either site.

- Figure 22-12 shows that the annual average benzene concentrations for both sites are below both 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). UCSD has the third lowest benzene concentration among sites sampling this pollutant. There were no non-detects of benzene measured at either site.

- Figure 22-13 shows that the annual average 1,3-butadiene concentrations for both sites are below both the program-level average and median concentrations of 1,3-butadiene. Further, the annual average for UCSD is less than the program-level first quartile (25th percentile). UCSD had the second lowest 1,3-butadiene concentration among sites sampling this pollutant. More than 75 percent of the measurements of 1,3-butadiene at UCSD were non-detects.

- Figure 22-14 shows that the annual average formaldehyde concentrations are both just slightly less than the program-level average concentration of formaldehyde. The range of concentrations measured at UCSD is twice than at SSSD, although the maximum concentration measured at both sites is well below 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 and UCSD in 2009; thus, a trends analysis was not conducted for these sites.

22.5 Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

22.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the South Dakota monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for each site were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the South Dakota monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the South Dakota monitoring sites.

22.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the South Dakota monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 22-6, where applicable.

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.

- These same pollutants also 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 surrogate risk approximations were greater than an HQ of 1.0.

Table 22-6. Cancer and Noncancer Surrogate Risk Approximations for the South Dakota Monitoring Sites

Pollutant	Cancer URE (µg/m³)⁻¹	Noncancer RfC (mg/m³)	# of Measured Detections vs. # of Samples	Annual Average (µg/m³)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Sioux Falls, South Dakota - SSSD					
Acetaldehyde	0.0000022	0.009	61/61	1.88 ± 0.26	4.13	0.21
Benzene	0.0000078	0.03	60/60	0.74 ± 0.07	5.78	0.02
1,3-Butadiene	0.00003	0.002	47/60	0.04 ± 0.01	1.19	0.02
Carbon Tetrachloride	0.000006	0.1	60/60	0.58 ± 0.05	3.50	0.01
Chloroform	--	0.098	43/60	0.07 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	9/60	0.01 ± 0.01	0.27	<0.01
Formaldehyde	0.000013	0.0098	61/61	2.18 ± 0.19	28.38	0.22
Tetrachloroethylene	2.6E-07	0.04	47/60	0.09 ± 0.02	0.02	<0.01
Trichloroethylene	0.0000048	0.002	5/60	0.02 ± 0.03	0.10	0.01
Vinyl Chloride	0.0000088	0.1	2/60	<0.01 ± <0.01	0.01	<0.01
Union County, South Dakota - UCSD					
Acetaldehyde	0.0000022	0.009	58/58	1.88 ± 0.28	4.13	0.21
Acrylonitrile	0.000068	0.002	14/59	0.05 ± 0.03	3.62	0.03
Benzene	0.0000078	0.03	59/59	0.51 ± 0.07	4.00	0.02
1,3-Butadiene	0.00003	0.002	14/59	0.01 ± <0.01	0.16	<0.01
Carbon Tetrachloride	0.000006	0.1	57/59	0.56 ± 0.05	3.34	0.01
Chloroform	--	0.098	36/59	0.05 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	11/59	0.01 ± 0.01	0.35	<0.01
Ethylbenzene	0.0000025	1	59/59	0.75 ± 1.05	1.87	<0.01
Formaldehyde	0.000013	0.0098	58/58	2.38 ± 0.42	30.97	0.24
Tetrachloroethylene	2.6E-07	0.04	39/59	0.05 ± 0.01	0.01	<0.01
Trichloroethylene	0.0000048	0.002	15/59	0.08 ± 0.10	0.36	0.04
Vinyl Chloride	0.0000088	0.1	2/59	<0.01 ± <0.01	0.01	<0.01

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

Observations from Table 22-6 for UCSD include the following:

- The pollutants with the highest annual average concentrations for UCSD are formaldehyde, acetaldehyde, and ethylbenzene.

- Formaldehyde has the highest cancer risk approximation for UCSD, followed by acetaldehyde and benzene. The fourth highest cancer risk approximation was calculated for acrylonitrile, which has a much lower annual average concentration than the other aforementioned pollutants, indicating the relative toxicity of this pollutant.

- None of the noncancer surrogate risk approximations for UCSD's pollutants of interest were greater than an HQ of 1.0.

22.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 22-7 and 22-8 present a risk-based 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. Table 22-8 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 22-7 and 22-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 VOC, SNMOC, and carbonyl compounds. In addition, the cancer and noncancer risk 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.

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 Risk Factors (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	28.38
Formaldehyde	56.95	Benzene	6.60E-04	Benzene	5.78
Ethylbenzene	54.47	1,3-Butadiene	3.72E-04	Acetaldehyde	4.13
Acetaldehyde	36.84	Naphthalene	2.11E-04	Carbon Tetrachloride	3.50
1,3-Butadiene	12.38	POM, Group 3	1.94E-04	1,3-Butadiene	1.19
Naphthalene	6.21	Hexavalent Chromium, PM	1.48E-04	1,2-Dichloroethane	0.27
Dichloromethane	1.65	Ethylbenzene	1.36E-04	Trichloroethylene	0.10
POM, Group 2b	1.34	POM, Group 2b	1.18E-04	Tetrachloroethylene	0.02
POM, Group 6	0.12	Acetaldehyde	8.10E-05	Vinyl Chloride	0.01
POM, Group 1a	0.12	POM, Group 5a	5.09E-05		
Union County, South Dakota (Union County) - UCSD					
Benzene	15.98	Formaldehyde	1.67E-04	Formaldehyde	30.97
Formaldehyde	12.81	Benzene	1.25E-04	Acetaldehyde	4.13
Ethylbenzene	10.98	1,3-Butadiene	6.36E-05	Benzene	4.00
Acetaldehyde	8.37	Naphthalene	3.90E-05	Acrylonitrile	3.62
1,3-Butadiene	2.12	Ethylbenzene	2.74E-05	Carbon Tetrachloride	3.34
Naphthalene	1.15	POM, Group 2b	2.04E-05	Ethylbenzene	1.87
POM, Group 2b	0.23	Acetaldehyde	1.84E-05	Trichloroethylene	0.36
Dichloromethane	0.13	POM, Group 3	1.71E-05	1,2-Dichloroethane	0.35
POM, Group 6	0.02	Hexavalent Chromium, PM	1.56E-05	1,3-Butadiene	0.16
POM, Group 1a	0.01	Arsenic, PM	1.05E-05	Tetrachloroethylene	0.01

Table 22-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the South Dakota Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Sioux Falls, South Dakota (Minnehaha County) - SSSD					
Toluene	247.74	Acrolein	148,988.96	Formaldehyde	0.22
Xylenes	232.25	1,3-Butadiene	6,191.87	Acetaldehyde	0.21
Methanol	104.42	Formaldehyde	5,811.72	Benzene	0.02
Benzene	84.66	Acetaldehyde	4,093.12	1,3-Butadiene	0.02
Formaldehyde	56.95	Benzene	2,821.95	Trichloroethylene	0.01
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	Chloroform	<0.01
Ethylene glycol	13.66	Arsenic, PM	550.67	Vinyl Chloride	<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	Formaldehyde	0.24
Xylenes	48.01	Formaldehyde	1,307.04	Acetaldehyde	0.21
Benzene	15.98	1,3-Butadiene	1,060.53	Trichloroethylene	0.04
Formaldehyde	12.81	Acetaldehyde	930.04	Acrylonitrile	0.03
Ethylbenzene	10.98	Cyanide Compounds, gas	603.39	Benzene	0.02
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	Ethylbenzene	<0.01
1,1,1-Trichloroethane	1.31	Propionaldehyde	119.46	Chloroform	<0.01

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. UCSD 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 surrogate risk approximation for SSSD; this pollutant also appeared on both emissions-based lists. This is also true for acetaldehyde, benzene, and 1,3-butadiene. Conversely, carbon tetrachloride appears on neither emissions-based list but is among the pollutants with the highest cancer risk approximations for SSSD.

- Formaldehyde, acetaldehyde, benzene, and ethylbenzene are among the pollutants with the highest cancer surrogate risk approximations for UCSD and appear on both emissions-based lists. Conversely, acrylonitrile and carbon tetrachloride appear on neither emissions-based list but were among the pollutants with the highest cancer risk approximations for UCSD.

Observations from Table 22-8 include the following:

- Toluene and xylenes are the highest emitted pollutants with noncancer RfCs in 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 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 risk 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.

22.6   Summary of the 2010 Monitoring Data for SSSD and UCSD

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

- ❖ *Thirteen pollutants failed at least one screen for SSSD and 15 pollutants failed at least one screen for UCSD.*

- ❖ *Formaldehyde and acetaldehyde had the highest annual average concentrations for both SSSD and UCSD.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 23-2 are composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 23-3 and 23-4 identify 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 23-3 and 23-4. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 23-1 describes the area surrounding each monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 23-1. Deer Park, Texas (CAMS 35) Monitoring Site
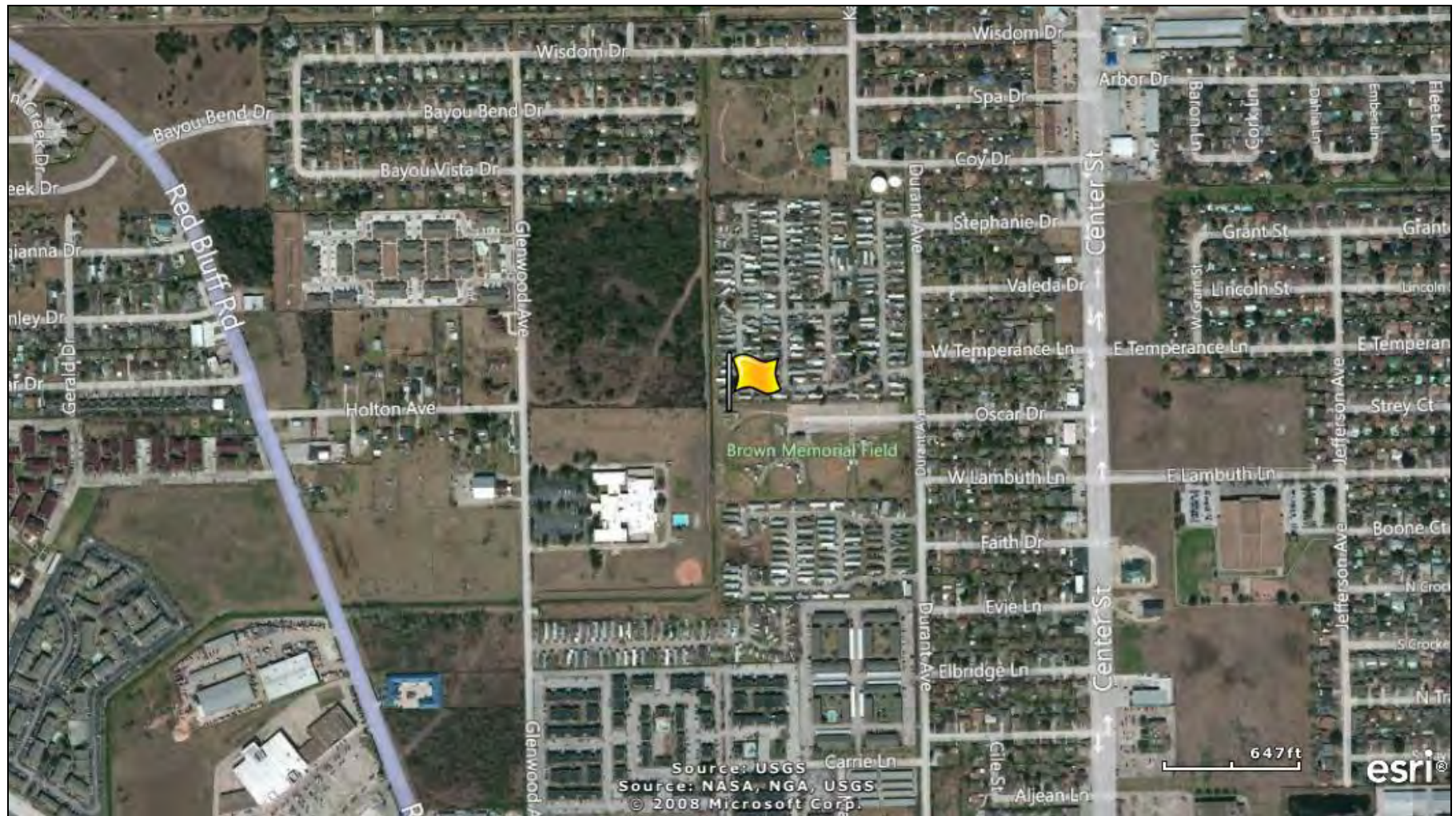
Figure 23-2. Karnack, Texas (CAMS 85) Monitoring Site
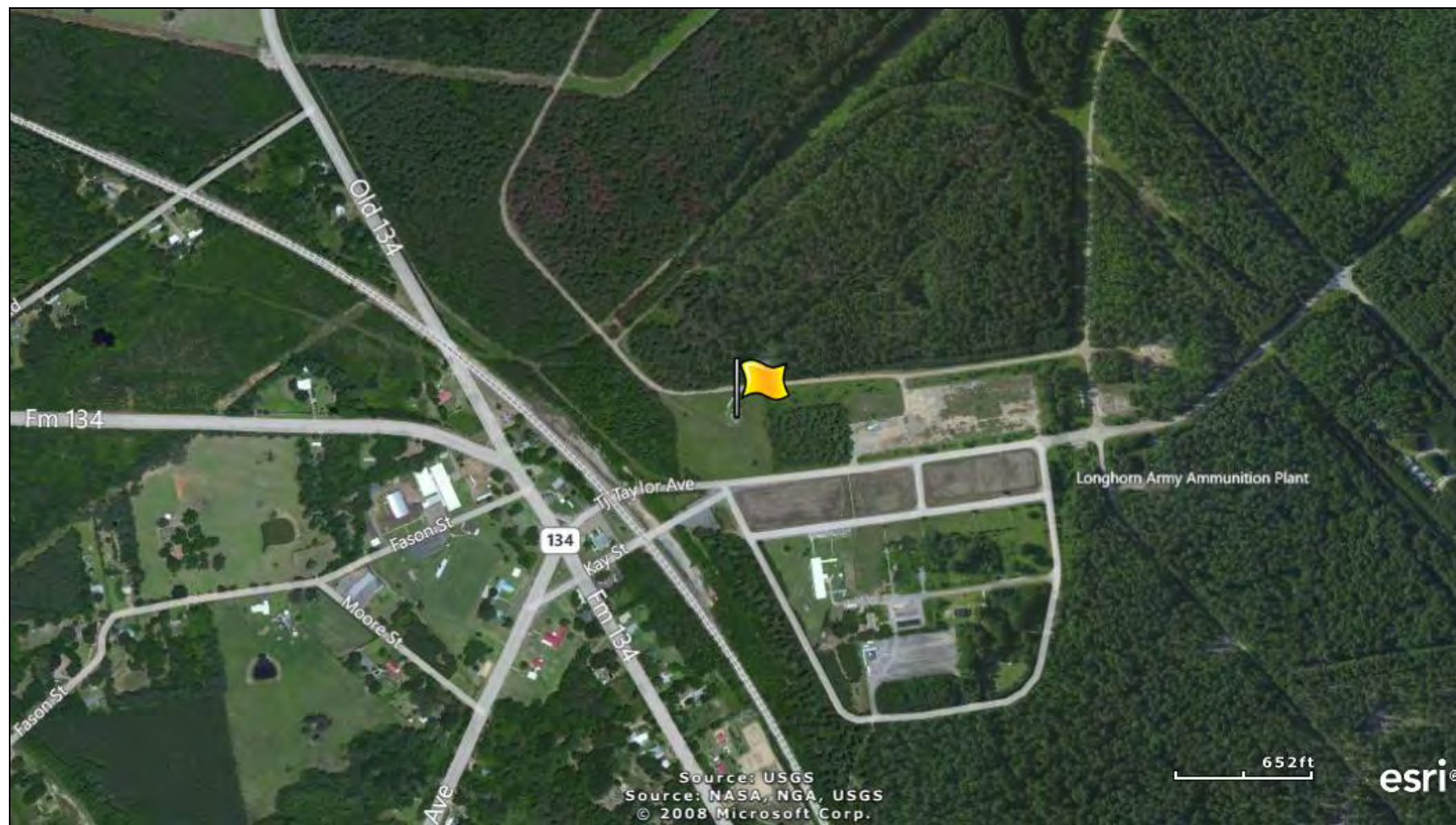
Figure 23-3. NEI Point Sources Located Within 10 Miles of CAMS 35

Legend

⭐ CAMS 35 NATTS site   ◯ 10 mile radius   ▢ County boundaries

Source Category Group (No. of Facilities)

✈	Aircraft Operations (24)	⚓	Marine Port (4)
▮	Asphalt Processing/Roofing Manufacturing (1)	?	Miscellaneous Commercial/Industrial (22)
B	Bulk Terminals/Bulk Plants (6)	M	Miscellaneous Manufacturing (2)
C	Chemical Manufacturing (59)	●	Oil and/or Gas Production (11)
⌁	Electricity Generation via Combustion (8)	◪	Petroleum Refinery (5)
E	Electroplating, Plating, Polishing, Anodizing, & Coloring (2)	⊞	Pulp and Paper Plant/Wood Products (3)
⊙	Fabricated Metal Products (8)	R	Rubber and Miscellaneous Plastics Products (19)
▰	Glass Manufacturing (1)	⚓	Ship Building and Repairing (4)
⫽	Heating Equipment Manufacturing (1)	◙	Stationary Combustion Turbines (1)
▲	Landfill (2)	✳	Transportation and Marketing of Petroleum Products (6)
		⌇	Wastewater Treatment (2)

Figure 23-4. NEI Point Sources Located Within 10 Miles of CAMS 85

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

Legend

⭐ CAMS 85 NATTS site   ○ 10 mile radius   ☐ County boundaries

Source Category Group (No. of Facilities)

+ Aircraft Operations (3)

• Oil and/or Gas Production (2)
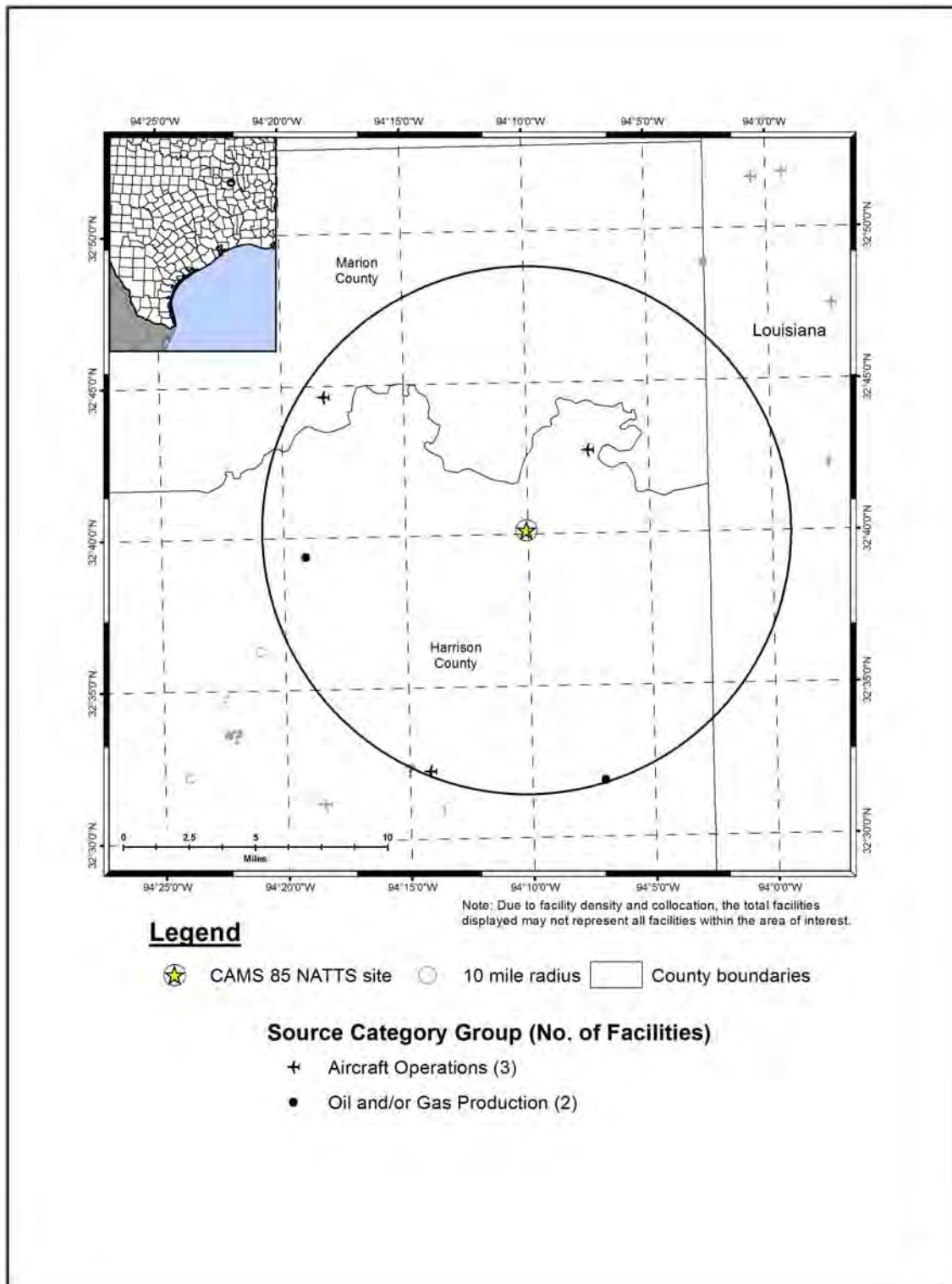
Table 23-1. Geographical Information for the Texas Monitoring Sites

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, NMOC, VOC, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM Coarse, PM_{10} Speciation, $PM_{2.5}$, and $PM_{2.5}$ Speciation, SO_2, SVOC.
CAMS 85	48-203-0002	Karnack	Harrison	Marshall, TX MSA	32.669004, -94.167449	Agricultural	Rural	SVOC, NO_2, NO, NO_x, PAMS, NMOC, Carbonyl Compounds, VOC, O_3, Meteorological parameters, PM_{10}, PM_{10} Speciation, $PM_{2.5}$, $PM_{2.5}$ Speciation.

[1] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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 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 23-3 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 largest 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 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 23-2. 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 Shreveport Regional Airport.

Table 23-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the areas surrounding the Texas monitoring sites. Table 23-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring sites. Table 23-2 also contains annual average daily traffic information. County-level VMT was not readily available for these sites; thus, daily VMT for CAMS 35 and CAMS 85 is not provided in Table 23-2.

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	4,110,771	3,115,974	0.76	715,640	542,457	31,043	NA
CAMS 85	65,766	69,883	1.06	3,034	3,224	1,400	NA

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Texas Department of Motor Vehicles (TX DMV, 2011)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data for CAMS 85 from the Texas DOT and 2004 data for CAMS 35 from Harris County Public Infrastructure Department (TX DOT, 2010 and HCPID, 2010)
[5] County-level VMT was not readily available for these sites
BOLD ITALICS = EPA-designated NATTS Site

Observations from Table 23-2 include the following:

- The population and vehicle ownership counts are significantly higher at CAMS 35 than CAMS 85. Compared to other counties with NMP monitoring sites, Harris County is the 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 county-level 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 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 were obtained for Spencer Highway between Red Bluff Road and Underwood Road; the traffic data for CAMS 85 were obtained 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, 2012).

23.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather stations nearest these sites were retrieved for 2010 (NCDC, 2010). 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 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 normal conditions 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	Sample Day	77.6 ± 3.6	69.3 ± 3.5	57.7 ± 4.2	62.7 ± 3.4	69.9 ± 3.6	1016.3 ± 1.3	6.3 ± 0.7
	258° (WSW)	2010	77.9 ± 1.4	69.3 ± 1.4	57.9 ± 1.6	62.8 ± 1.4	70.2 ± 1.3	1016.3 ± 0.6	6.4 ± 0.3
Karnack, Texas - CAMS 85									
Shreveport Regional Airport 13957 (32.45, -93.82)	24.46 miles	Sample Day	79.3 ± 4.4	68.3 ± 4.3	54.7 ± 4.4	60.5 ± 3.9	65.9 ± 3.1	1015.0 ± 1.4	6.0 ± 0.8
	127° (SE)	2010	77.1 ± 1.8	66.0 ± 1.7	52.8 ± 1.8	58.6 ± 1.6	66.2 ± 1.2	1015.9 ± 0.6	5.9 ± 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 for 2010. Also included in Table 23-3 is the 95 percent confidence interval for each parameter. As shown in Table 23-3, average meteorological conditions on sample days at CAMS 35 were fairly representative of average weather conditions throughout the year. Sample days at CAMS 85 appear slightly warmer and more humid. Sampling at CAMS 85 did not begin until February 2010, thereby missing the coldest month of the year, which may account for these slight differences.

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 2010. Included in Figure 23-5 are four back trajectories per sample day. Figure 23-6 is the corresponding cluster analysis for 2010. Similarly, 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, 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.

- The 24-hour air shed domain for CAMS 35 is the largest in size compared to other NMP monitoring sites. Two trajectories originated nearly 1,000 miles away, one over northwest Nebraska and one over south-central South Dakota. These two trajectories are for December 12, 2010, a day during which a strong cold front pushed across the state. Nearly 80 percent of trajectories originated within 400 miles of the site. The average trajectory length was 284 miles, which is among the longest average trajectory lengths for NMP sites.

- The cluster analysis for CAMS 35 shows that that the majority (67 percent) of trajectories originated over the Gulf of Mexico, although the position over the Gulf and the trajectory length varies. Recall that both direction and distance from the

23-11

monitoring site factor into the cluster analysis. Another common trajectory origin is from the northwest to north (10 percent). The short cluster trajectory originating to the north of CAMS 35 (23 percent) represents relatively short back trajectories originating to the northwest, north, and northeast, and generally within 300 miles of CAMS 35, over East Texas and Louisiana.

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 24-hour air shed domain for CAMS 35 is comparable in size to other NMP monitoring sites. The farthest away a trajectory originated was nearly 800 miles away, over southeast South Dakota. However, the average trajectory length is 237 miles and most trajectories (85 percent) originated less than 350 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 (33 percent) representing trajectories originating over East Texas and the longer cluster (11 percent) originating over the Gulf of Mexico. Another common trajectory origin is from the southeast over Louisiana (22 percent). Another 21 percent of back trajectories originated to the northwest to north of the site, as indicated by the short cluster (13 percent) representing trajectories originating over Oklahoma and the longer cluster (8 percent) originating over the central Plains. Lastly, the cluster trajectory originating from the northeast represents relatively short back trajectories originating over Arkansas.

Figure 23-5. 2010 Composite Back Trajectory Map for CAMS 35
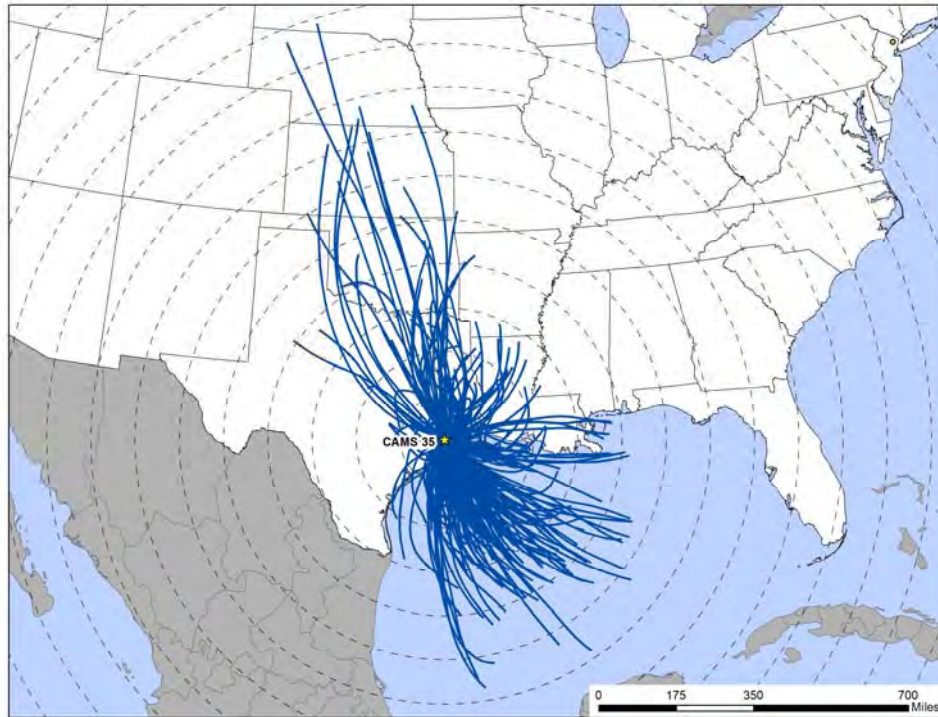
Figure 23-6. Back Trajectory Cluster Map for CAMS 35
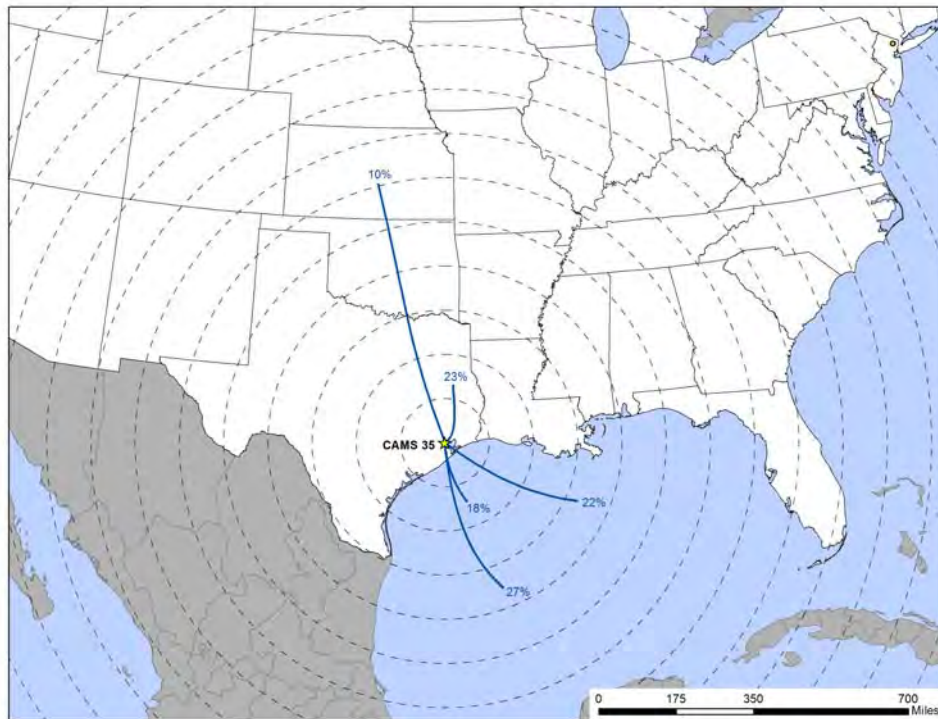
Figure 23-7. 2010 Composite Back Trajectory Map for CAMS 85
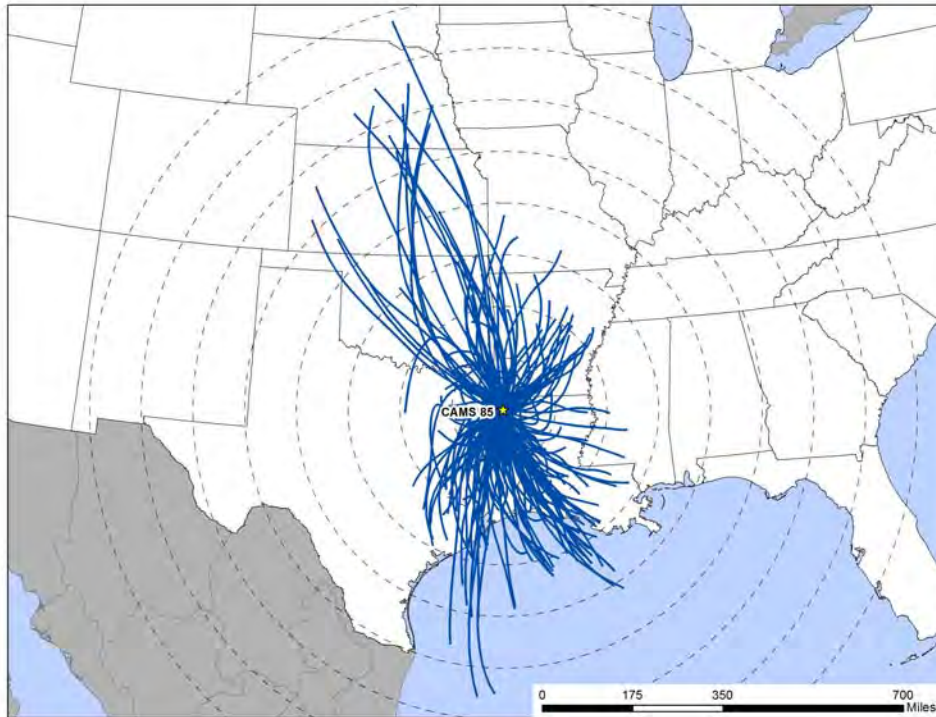
Figure 23-8. Back Trajectory Cluster Map for CAMS 85
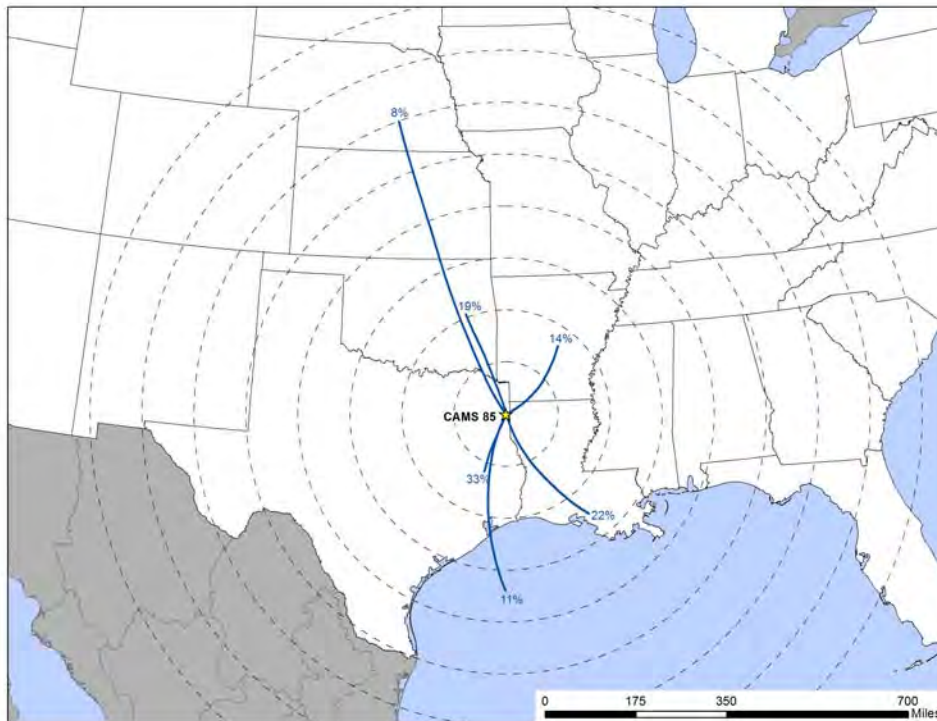
23.2.4 Wind Rose Comparison

Hourly wind data from the NWS weather stations at Hobby Airport near CAMS 35 and Shreveport Regional 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 three different wind roses for the CAMS 35 monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figure 23-10 presents the three wind roses and distance map for the CAMS 85 monitoring site.

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 13 percent of the wind measurements.

- The wind patterns shown on the 2010 wind rose are very similar to the historical wind patterns, indicating that conditions during 2010 were similar to conditions observed in past years.

- The 2010 sample day wind patterns generally resemble the full-year and historical wind patterns with a few exceptions. The sample day wind rose has fewer northerly and southerly wind observations and more easterly wind observations.

Figure 23-9. Wind Roses for the William P. Hobby Airport Weather Station near CAMS 35

1999-2009 Historical Wind Rose
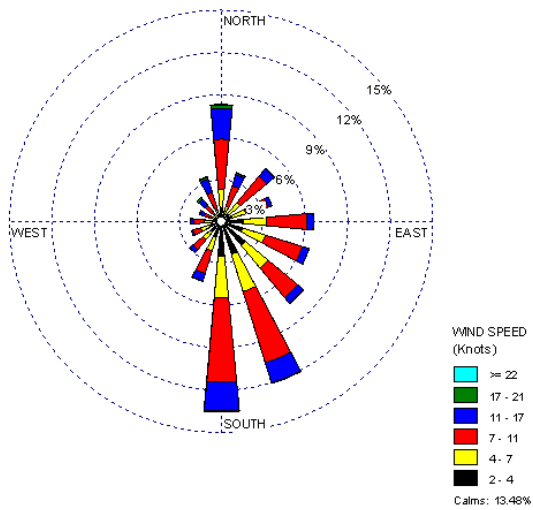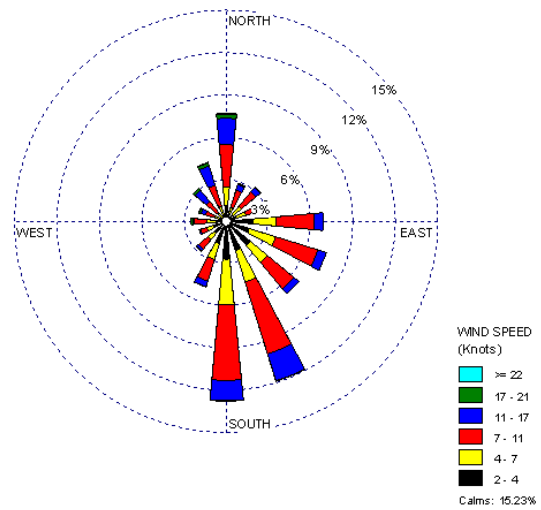
2010 Wind Rose

2010 Sample Day Wind Rose
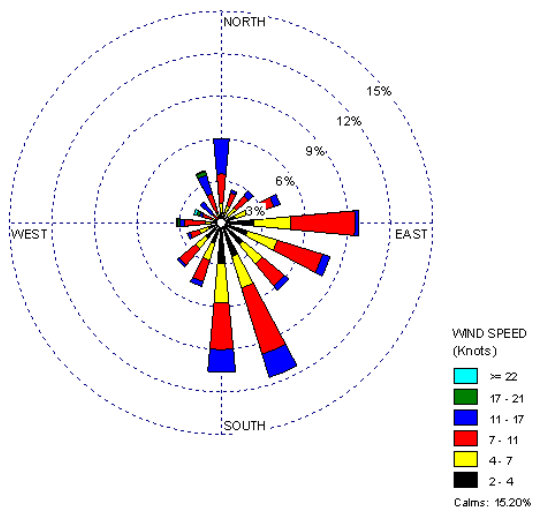
Distance between CAMS 35 and NWS Station
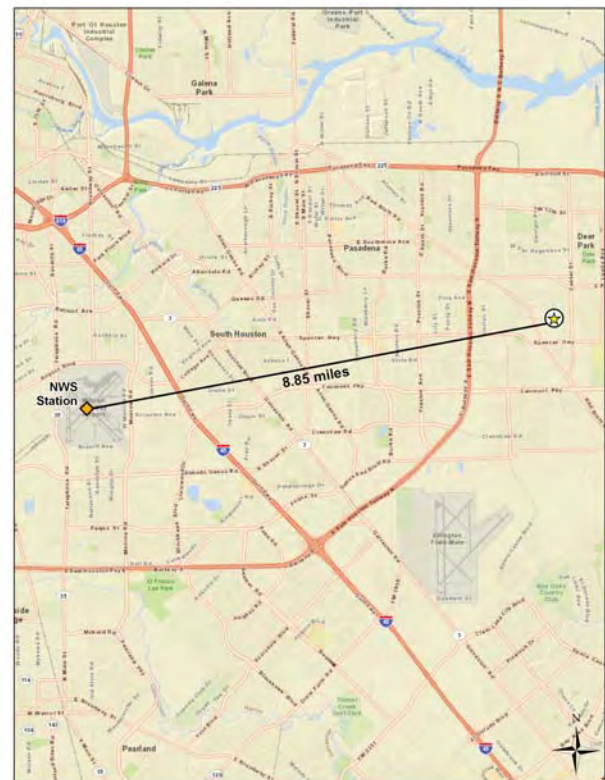
Figure 23-10. Wind Roses for the Shreveport Regional Airport Weather Station near CAMS 85

1999-2009 Historical Wind Rose
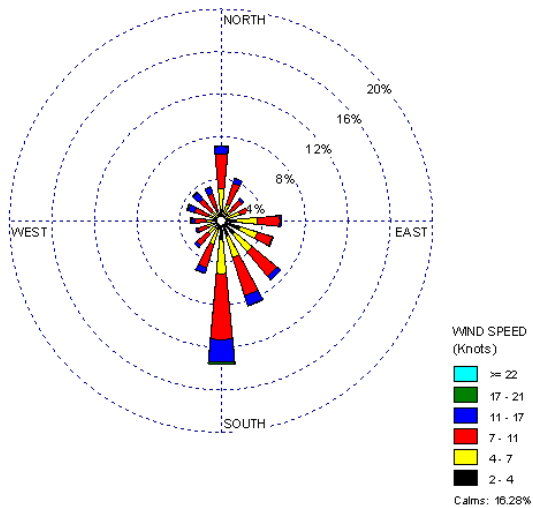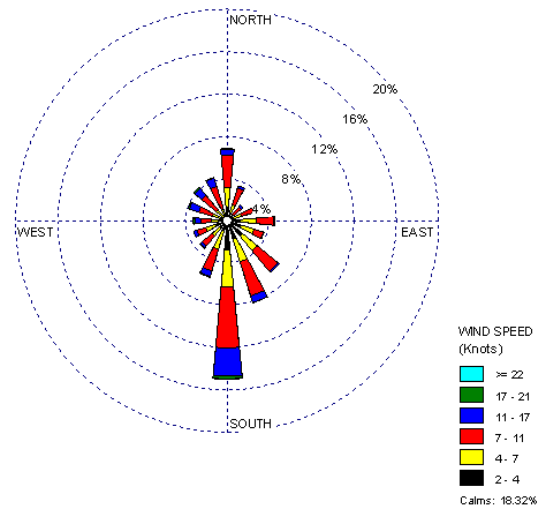
2010 Wind Rose

2010 Sample Day Wind Rose
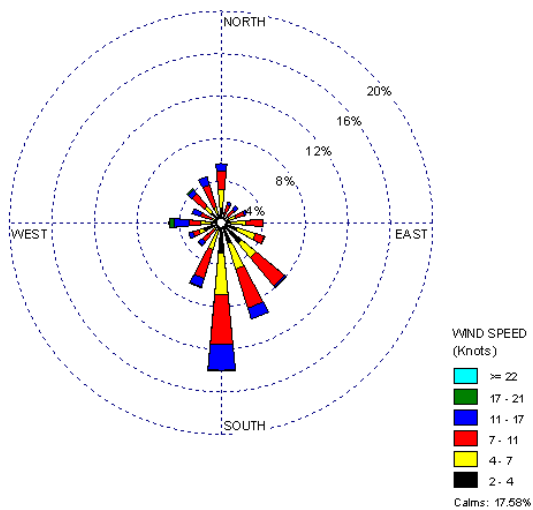
Distance between CAMS 85 and NWS Station

23-17
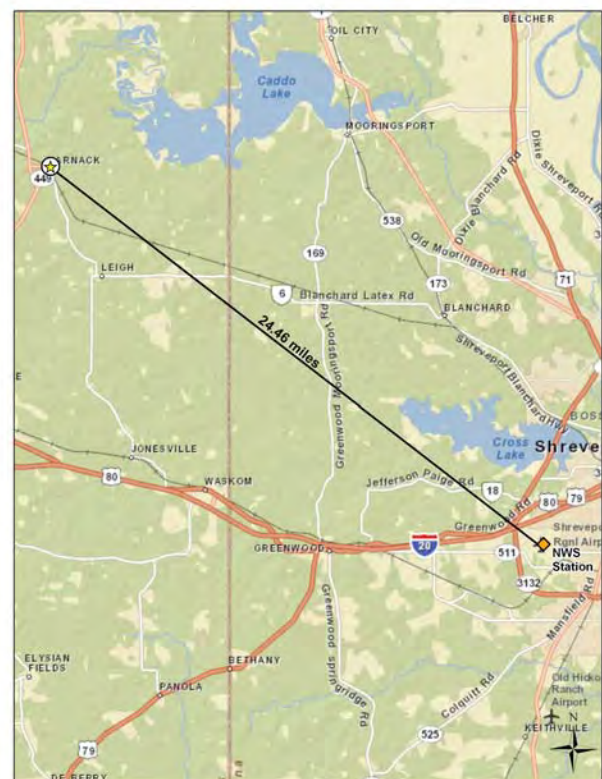
Observations from Figure 23-10 for CAMS 85 include the following:

- 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 wind roses for CAMS 85 resemble those on the wind roses for CAMS 35.

- The historical wind rose shows that winds from the southeast to south account for just less than one-third of the wind observations near the CAMS 85. Northerly winds were also observed often. Calm winds were observed for approximately 16 percent of the wind measurements.

- The wind patterns shown on the 2010 wind rose are very similar to the historical wind patterns, indicating that conditions during 2010 were similar to conditions observed in past years.

- The 2010 sample day wind patterns resemble the full-year and historical wind patterns, indicating that wind conditions on sample days were representative of those experienced throughout 2010 and historically near CAMS 85.

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 23-4 presents the pollutants of interest 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 PAH while CAMS 85 sampled for hexavalent chromium only. Note that hexavalent chromium sampling at these sites through the NMP did not begin until February 2010.

Table 23-4. Risk Screening Results for the Texas Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Deer Park, Texas - CAMS 35						
Naphthalene	0.029	55	57	96.49	93.22	93.22
Hexavalent Chromium	0.000083	2	52	3.85	3.39	96.61
Acenaphthene	0.011	1	57	1.75	1.69	98.31
Fluorene	0.011	1	57	1.75	1.69	100.00
Total		59	223	26.46		
Karnack, Texas - CAMS 85						
Hexavalent Chromium	0.000083	33	51	64.71	100.00	100.00
Total		33	51	64.71		

Observations from Table 23-4 include the following:

- Four pollutants (three PAH and hexavalent chromium) failed at least one screen for CAMS 35.

- Naphthalene contributed to 93 percent of the total number of failed screens for CAMS 35. Hexavalent chromium, acenaphthene, and fluorene contribute to the other seven percent of failed screens.

- Naphthalene and hexavalent chromium were initially identified as pollutants of interest for CAMS 35. Benzo(a)pyrene was added to CAMS 35'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 23-4.

- Hexavalent chromium is the only pollutant of interest for CAMS 85.

- Hexavalent chromium failed nearly 65 percent of screens for CAMS 85. This is a much higher percentage than for CAMS 35, even though the number of samples collected at each site is similar.

23.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Texas monitoring sites. Concentration averages are provided for the pollutants of interest for each Texas site, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the sites, where applicable. Additional site-specific statistical summaries are provided in Appendices M and O.

23.4.1 2010 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						
Benzo(a)pyrene	16/57	0.03 ± 0.03	<0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.03	0.02 ± 0.01
Hexavalent Chromium	52/52	NA	0.06 ± 0.01	0.06 ± 0.01	0.04 ± 0.01	0.05 ± 0.01
Naphthalene	57/57	71.27 ± 22.97	84.59 ± 19.97	111.18 ± 46.77	108.14 ± 27.83	92.93 ± 14.64
Karnack, Texas - CAMS 85						
Hexavalent Chromium	51/51	NA	0.19 ± 0.06	0.72 ± 0.44	0.06 ± 0.04	0.31 ± 0.16

Observations from Table 23-5 include the following:

- Naphthalene's annual average concentration is significantly higher than the annual averages for benzo(a)pyrene and hexavalent chromium 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 lot of variability associated with them. Although the highest concentration of naphthalene was measured at CAMS 35 on August 24, 2010 (302 ng/m^3), a review of

the data shows that concentrations greater than 100 ng/m^3 were measured several times in each quarter of 2010.

- Benzo(a)pyrene was detected in less than half the PAH samples collected at CAMS 35. The confidence intervals for each of the quarterly averages are equal to or greater than their associated average concentrations, indicating that outliers may be affecting these averages. Three concentrations greater than 0.1 ng/m^3 were measured at CAMS 35 (one in February and two in November), while the magnitude of the measured detections ranged from 0.00959 ng/m^3 to 0.211 ng/m^3. Although the number of measured detections ranged from as few as two for the second quarter to seven for the first quarter of 2010, the number of zeros substituted into the quarterly averages may be a bigger factor in variability of the quarterly averages, as opposed to potential outliers.

- Because hexavalent chromium sampling through the NMP did not begin until February 2010, first quarter average concentrations could not be calculated for either Texas site.

- The second, third, and fourth quarter average concentrations for CAMS 85 are greater than the same quarterly concentrations for CAMS 35, particularly for the third quarter. The maximum concentration of hexavalent chromium for CAMS 85 (3.51 ng/m^3) is significantly higher than the maximum concentration of hexavalent chromium for CAMS 35 (0.108 ng/m^3). This measurement is the highest hexavalent chromium concentration among NMP sites sampling this pollutant in 2010 and the highest hexavalent chromium concentration measured among NMP sites since this method was added to the program in 2005. The seven July measurements of hexavalent chromium for CAMS 85 are the seven highest measurements among all NMP sites sampling this pollutant in 2010. Of the 25 measurements of hexavalent chromium greater than 0.25 ng/m^3 across the program in 2010, 17 were measured at CAMS 85 (and eight were measured at PXSS).

- As shown in Table 4-12, the annual average hexavalent chromium concentration for CAMS 85 is more than twice the next highest annual average hexavalent chromium concentration (PXSS). Although six times lower, the annual average hexavalent chromium concentration for CAMS 35 ranks third highest among NMP sites.

23.4.2 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 benzo(a)pyrene, hexavalent chromium, and naphthalene for created for CAMS 35. A box plot for hexavalent chromium for CAMS 85 was also created. Figures 23-11 through 23-13 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first

quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 23-11. Program vs. Site-Specific Average Benzo(a)pyrene Concentration
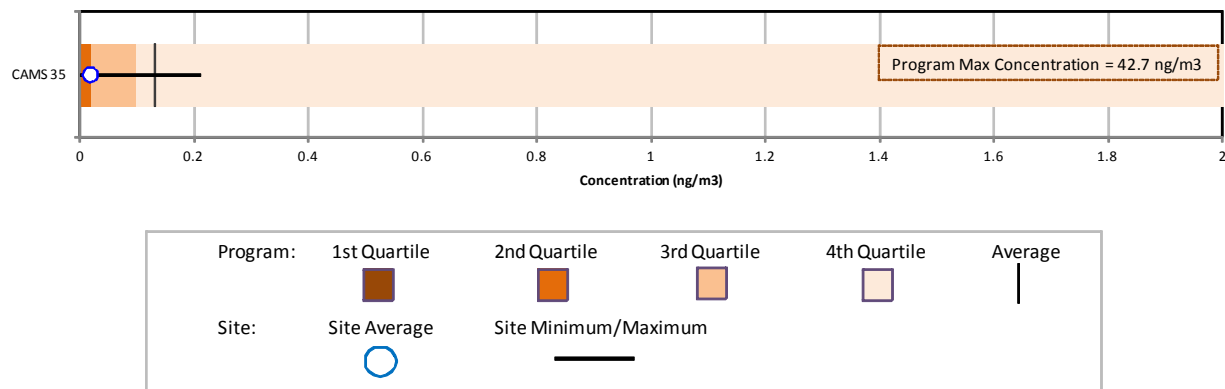
Figure 23-12. Program vs. Site-Specific Average Hexavalent Chromium Concentration
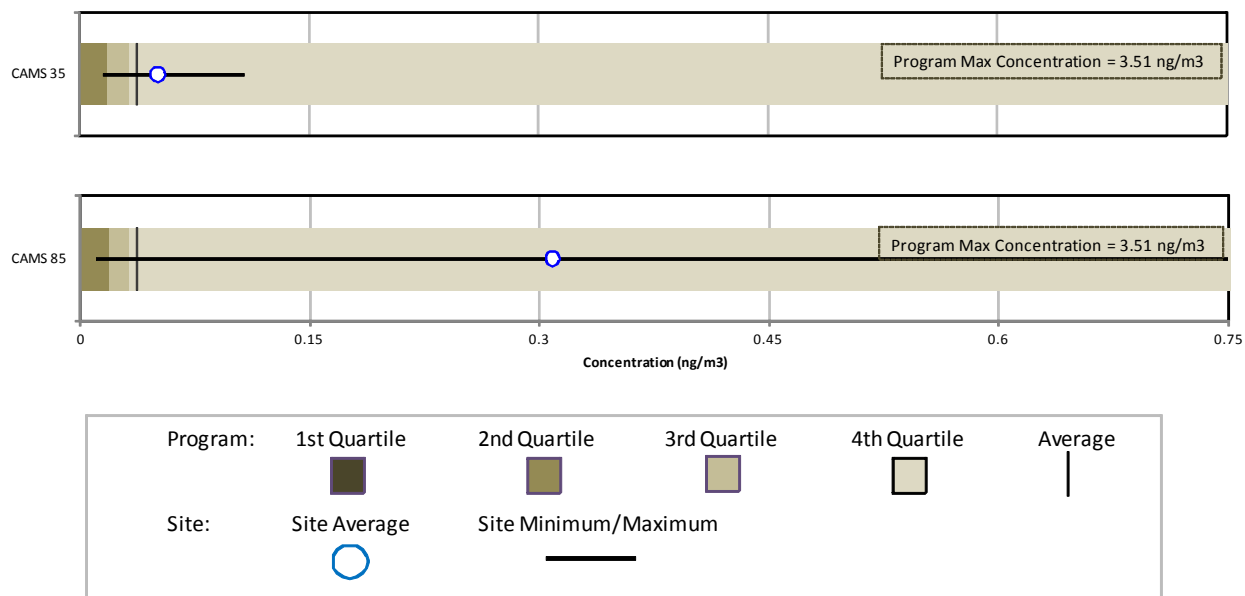
Figure 23-13. Program vs. Site-Specific Average Naphthalene Concentration
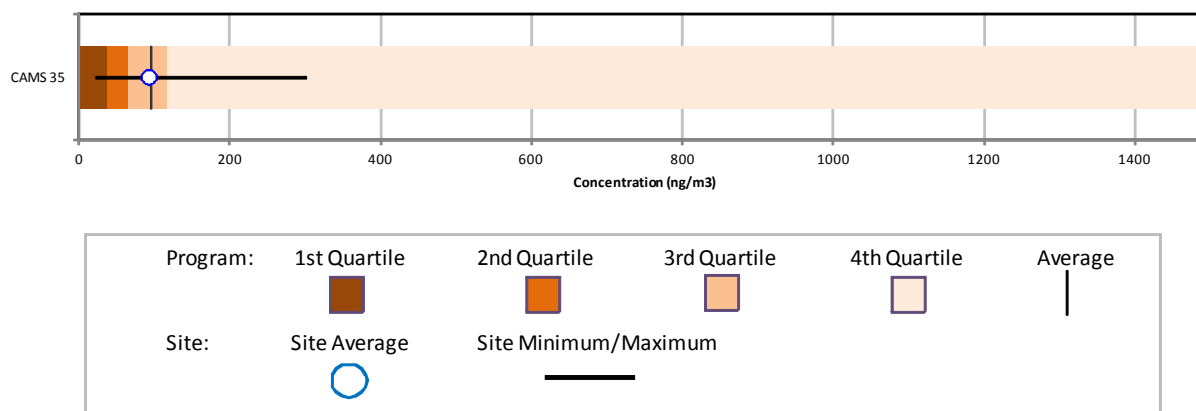
Observations from Figures 23-11 through 23-13 include the following:

- Figure 23-11 is the box plot for benzo(a)pyrene for CAMS 35. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 well below the program-level average concentration and just less than the program-level median. Figure 23-11 also shows that the maximum concentration measured at CAMS 35 is well below the maximum concentration measured across the program. Many non-detects of benzo(a)pyrene were measured at CAMS 35, as discussed in the previous section.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 23-12 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 23-12 shows the annual average concentrations of hexavalent chromium for both sites are greater than the program-level average, although the annual average concentration for CAMS 85 is six times higher than the annual average concentration for CAMS 35. While the maximum concentration measured at CAMS 35 is well below the maximum concentration measured across the program, CAMS 85 has the highest concentration among NMP sites sampling hexavalent chromium, as discussed in the previous section. The minimum concentration of hexavalent chromium measured at both CAMS 35 and CAMS 85 is greater than the first quartile (25th percentile) across the program.

- Figure 23-13 shows that the annual average naphthalene concentration for CAMS 35 is similar to the program-level average concentration. The maximum

naphthalene concentration measured at CAMS 35 is well below the program-level maximum concentration. There were no non-detects of naphthalene measured at CAMS 35.

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 PAH 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 Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

23.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Texas monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Texas monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Texas monitoring sites.

23.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Texas monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for

annual averages and how cancer and noncancer surrogate risk approximations are calculated).
Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk
approximations are presented in Table 23-6, where applicable.

Table 23-6. Cancer and Noncancer Surrogate Risk Approximations for the Texas Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Deer Park, Texas - CAMS 35						
Benzo(a)pyrene	0.00176	--	16/57	0.02 ± 0.01	0.03	--
Hexavalent Chromium	0.012	0.0001	52/52	0.05 ± 0.01	0.61	<0.01
Naphthalene	0.000034	0.003	57/57	92.93 ± 14.64	3.16	0.03
Karnack, Texas - CAMS 85						
Hexavalent Chromium	0.012	0.0001	51/51	0.31 ± 0.16	3.70	<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 3.16 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 is 3.70 in-a-million, based on the annual average. This cancer risk approximation is more than five times the cancer risk approximation for hexavalent chromium for CAMS 35.

- The noncancer risk approximations for CAMS 35 and CAMS 85, where they could be calculated, are well below the level of concern, an HQ of 1.0.

23.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 23-7 and 23-8 present a risk-based 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. Table 23-8 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

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 Risk Factors (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	3.16
Formaldehyde	1,260.11	1,3-Butadiene	1.34E-02	Hexavalent Chromium	0.61
Ethylbenzene	827.79	Benzene	1.11E-02	Benzo(a)pyrene	0.03
Acetaldehyde	699.55	Hexavalent Chromium, PM	1.04E-02		
1,3-Butadiene	446.24	Naphthalene	4.83E-03		
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	3.70
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 Risk Approximations for Pollutants with Noncancer RfCs for the Texas Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk 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 risk 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 and noncancer surrogate risk 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; in addition, CAMS 35 also sampled for PAH. In addition, the cancer and noncancer surrogate risk 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.

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 in 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 that appears on both emissions-based lists for CAMS 35. Although hexavalent chromium, which has the second highest cancer risk approximation for CAMS 35, appears among the pollutants with the highest 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 PAH sampled for at CAMS 35 including acenaphthylene, benzo(e)pyrene, fluoranthene, and perylene. 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 highest emitted.

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 in 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.

- Naphthalene ranks ninth for toxicity-weighted emissions in Harris County but is not one of the highest emitted. Hexavalent chromium does not appear on either emissions-based list for Harris County.

- Hexavalent chromium ranks tenth for toxicity-weighted emissions in Harrison County but is not one of the highest emitted.

23.6   Summary of the 2010 Monitoring Data for CAMS 35 and CAMS 85

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

- ❖ *Four pollutants failed at least one screen for CAMS 35, with naphthalene accounting for 93 percent of the total failed screens. Hexavalent chromium failed screens for CAMS 85, although it was the only pollutant sampled for at this site.*

- ❖ *Of the site-specific pollutants of the interest, naphthalene had the highest annual average concentration for CAMS 35.*

- ❖ *The maximum concentration of hexavalent chromium for CAMS 85 was the highest hexavalent chromium concentration among all NMP sites sampling this pollutant in 2010 and the highest hexavalent chromium concentration measured among NMP sites since this method was added to the program in 2005.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 24-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 24-1. Bountiful, Utah (BTUT) Monitoring Site
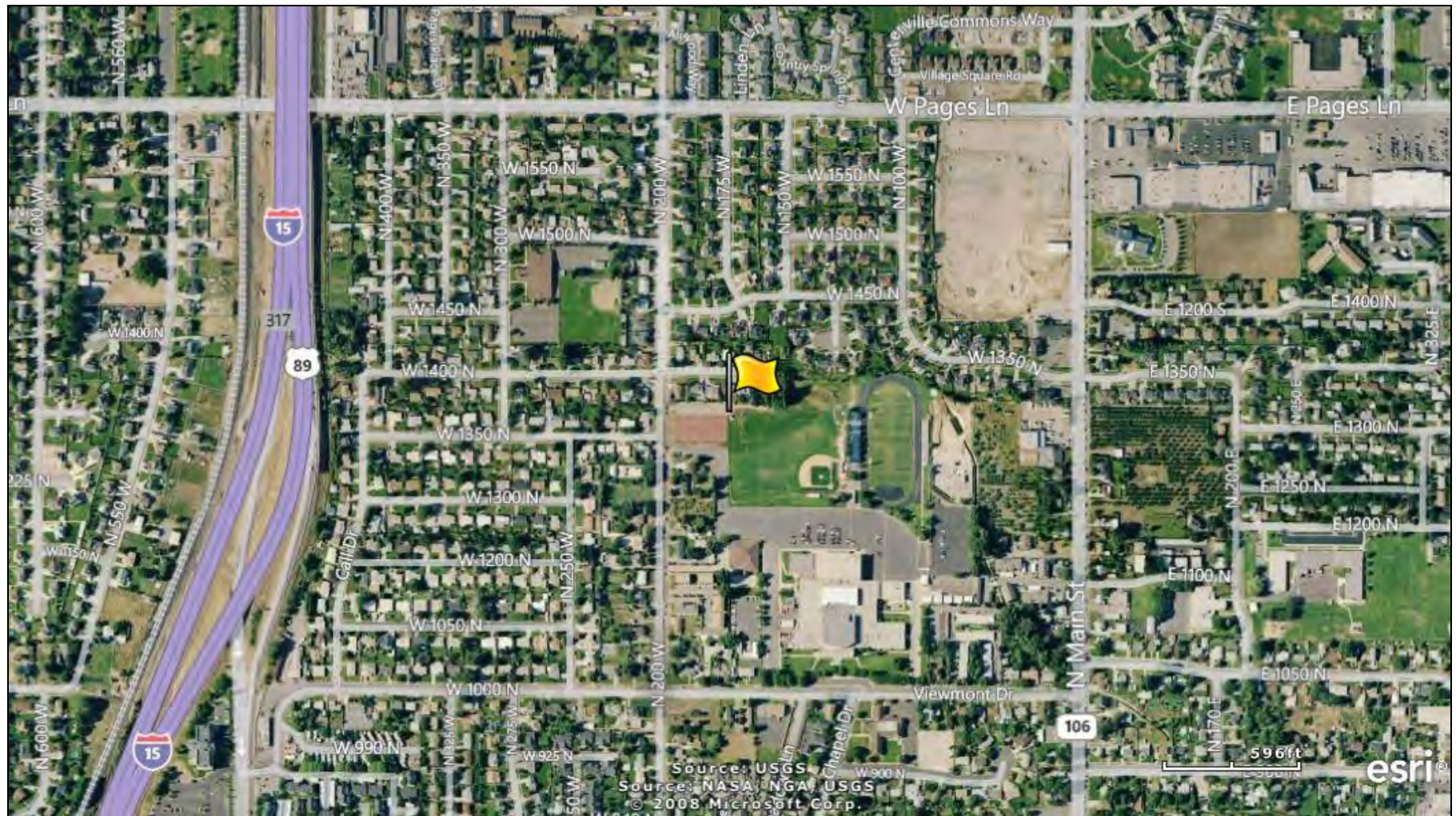
Figure 24-2. NEI Point Sources Located Within 10 Miles of BTUT

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

Legend

⭐ BTUT NATTS site ◯ 10 mile radius ☐ County boundary

Source Category Group (No. of Facilities)

- Air-conditioning/Refrigeration (1)
- ✈ Aircraft Operations (8)
- ⚡ Electricity Generation via Combustion (2)
- ⚙ Institutional - school (1)
- ? Miscellaneous Commercial/Industrial (2)
- M Miscellaneous Manufacturing (1)
- ◢ Petroleum Refinery (5)

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] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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 highest number of point sources surrounding BTUT include 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Utah monitoring site. Table 24-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 24-2 also contains annual average daily traffic information. Finally, Table 24-2 presents the 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	307,856	239,754	0.78	259,066	201,757	113,955	7,360,752

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Utah Tax Commission (UT TC, 2010)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data from the Utah DOT (UT DOT, 2010)
[5] County-level VMT reflects 2010 data from the Utah DOT (UT DOT, 2011)
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 used came from the intersection of I-15 with US-89, just west of the site.

- The Davis County VMT is on the 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 classified as semi-arid and continental in nature, and experiences large 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, 2012).

24.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather station nearest BTUT were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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 for 2010. Also included in Table 24-3 is the 95 percent confidence interval for each parameter. As shown in Table 24-3, average meteorological conditions on sample days were representative of average weather conditions throughout the year.

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 2010. Included in Figure 24-3 are four back trajectories per sample day. Figure 24-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, each concentric circle around the site in Figures 24-3 and 24-4 represents 100 miles.

Observations from Figures 24-3 and 24-4 include the following:

- Back trajectories originated from a variety of directions at BTUT.

- Similar to other sites located in the inter-mountain west, the 24-hour air shed domain for BTUT is smaller in size compared to other NMP monitoring sites. The farthest away a trajectory originated was over northeast Oregon, less than 450 miles away. A trajectory of similar length also originated over west-central Arizona. However, the average trajectory length was 177 miles and nearly 90 percent of back trajectories originated within 300 miles of the site.

- The cluster analysis shows that one-third of back trajectories originated from the south of BTUT, although of varying distances, as represented by the shorter trajectory (13 percent) and the longer trajectory (21 percent). Trajectories also originated from the west of BTUT, generally over northwest Utah and northeast Nevada, and from the northwest, over Idaho. The short cluster trajectory originating from the east of BTUT represents short trajectories originating to the northeast, east, and southeast of the site.

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	Sample Day	62.1 ± 5.2	52.6 ± 4.5	33.7 ± 2.2	43.0 ± 2.8	56.9 ± 5.6	1014.2 ± 1.8	6.7 ± 0.7
	217° (SW)	2010	62.6 ± 2.1	52.6 ± 1.9	33.2 ± 1.0	42.8 ± 1.2	55.9 ± 2.2	1014.2 ± 0.8	6.8 ± 0.4

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

Figure 24-3. 2010 Composite Back Trajectory Map for BTUT
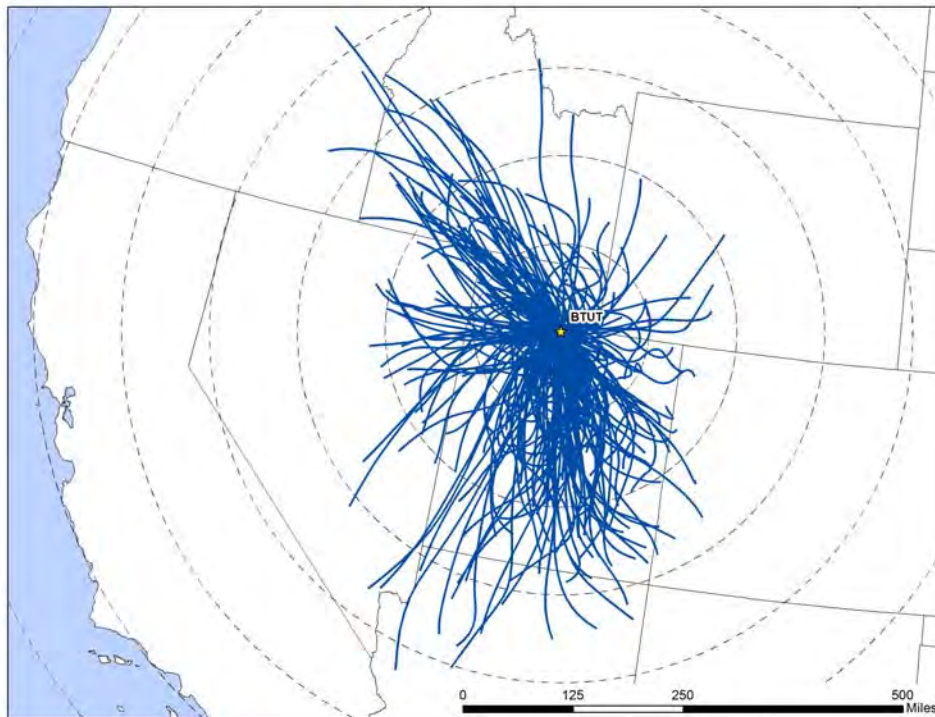
Figure 24-4. Back Trajectory Cluster Map for BTUT
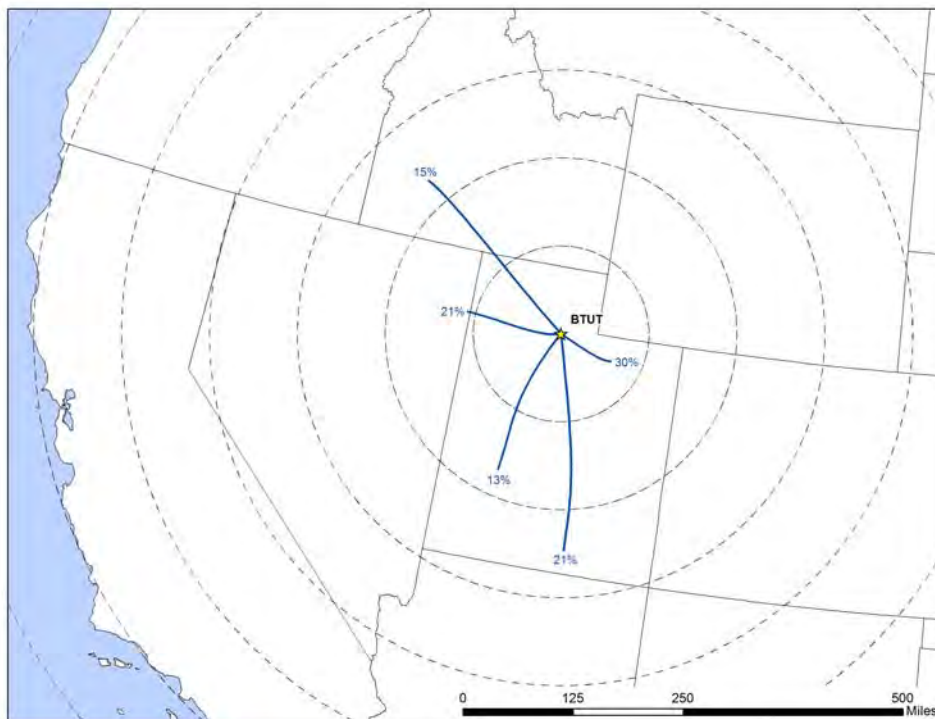
24.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the BTUT monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at this location.

Observations from Figure 24-5 for BTUT include the following:

- The Salt Lake City International 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. Winds from the north-northwest to north were also common. Calm winds (≤2 knots) were observed for approximately 11 percent of the hourly measurements from 1999-2009. The strongest wind speeds were observed with south-southeasterly and southerly winds.

- The wind patterns shown on the 2010 wind rose are similar to the historical wind patterns, although there were slightly more calm winds and fewer southeasterly to south-southeasterly winds. This indicates that wind conditions in 2010 were similar to conditions experienced historically near BTUT.

- The wind patterns shown on the sample day wind rose resemble the 2010 wind patterns, indicating that conditions on sample days were representative of those experienced over the entire year (and historically).

Figure 24-5. Wind Roses for the Salt Lake City International Airport Weather Station near BTUT

1999-2009 Historical Wind Rose
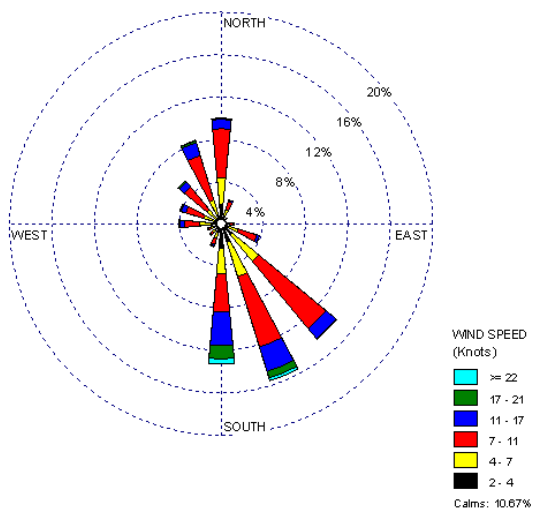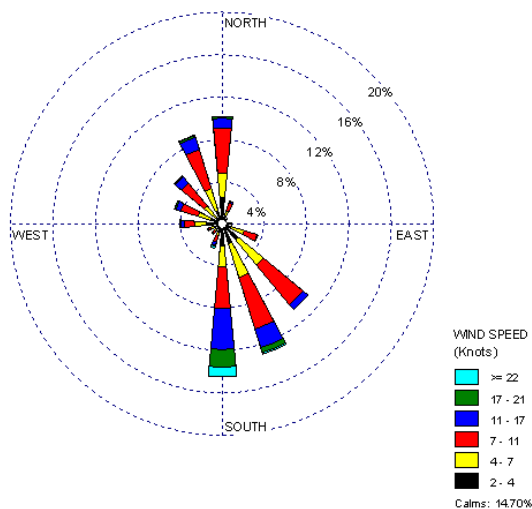
2010 Wind Rose

2010 Sample Day Wind Rose
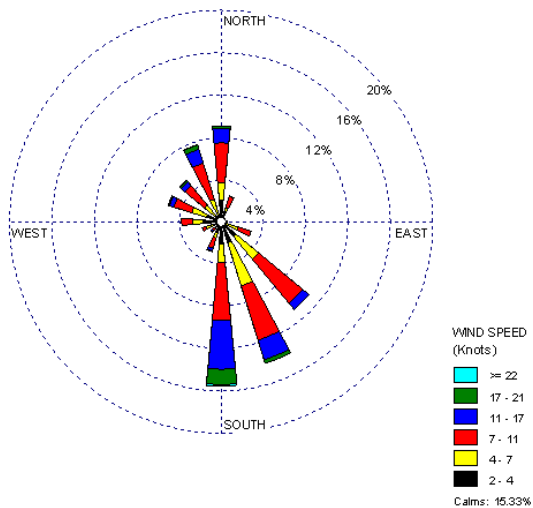
Distance between BTUT and NWS Station

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 24-4 presents BTUT's pollutants of interest. 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 VOC, carbonyl compounds, SNMOC, PAH, 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).

Observations from Table 24-4 include the following:

- Twenty-six pollutants, of which 14 are NATTS MQO Core Analytes, failed at least one screen for BTUT.

- The risk screening process identified 14 pollutants of interest for BTUT, of which eight are NATTS MQO Core Analytes. Six additional pollutants (benzo(a)pyrene, cadmium, chloroform, hexavalent chromium, nickel, and trichloroethylene) 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. Four more 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, lead, tetrachloroethylene, and vinyl chloride. These four pollutants are not shown in Table 24-4.

- The pollutants not identified as pollutants of interest via the risk screening process failed two or less screens for BTUT.

- Nearly 50 percent of measured detections failed screens (of the pollutants that failed at least one screen) for BTUT.

24-12

- 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 screening process. As BTUT sampled both VOC (TO-15) and SNMOC, the TO-15 results were used for the 12 pollutants these methods have in common.

Table 24-4. Risk Screening Results for the Utah Monitoring Site

Pollutant	Screening Value ($\mu g/m^3$)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Bountiful, Utah - BTUT						
Benzene	0.13	57	57	100.00	11.80	11.80
Carbon Tetrachloride	0.17	56	57	98.25	11.59	23.40
Acetaldehyde	0.45	53	53	100.00	10.97	34.37
Formaldehyde	0.077	53	53	100.00	10.97	45.34
1,3-Butadiene	0.03	51	53	96.23	10.56	55.90
Arsenic (PM$_{10}$)	0.00023	49	59	83.05	10.14	66.05
Naphthalene	0.029	43	57	75.44	8.90	74.95
Manganese (PM$_{10}$)	0.005	31	59	52.54	6.42	81.37
Dichloromethane	7.7	20	57	35.09	4.14	85.51
Ethylbenzene	0.4	20	57	35.09	4.14	89.65
p-Dichlorobenzene	0.091	15	42	35.71	3.11	92.75
Propionaldehyde	0.8	8	53	15.09	1.66	94.41
Acrylonitrile	0.015	7	7	100.00	1.45	95.86
1,2-Dichloroethane	0.038	7	7	100.00	1.45	97.31
Trichloroethylene	0.2	2	16	12.50	0.41	97.72
Acenaphthylene	0.011	1	30	3.33	0.21	97.93
Benzo(a)pyrene	0.00057	1	10	10.00	0.21	98.14
Cadmium (PM$_{10}$)	0.00056	1	59	1.69	0.21	98.34
Chloroform	9.8	1	43	2.33	0.21	98.55
Chloromethylbenzene	0.02	1	1	100.00	0.21	98.76
1,2-Dibromoethane	0.0017	1	1	100.00	0.21	98.96
Hexachloro-1,3-butadiene	0.045	1	1	100.00	0.21	99.17
Hexavalent Chromium	0.000083	1	53	1.89	0.21	99.38
Nickel (PM$_{10}$)	0.0021	1	59	1.69	0.21	99.59
1,1,2,2-Tetrachloroethane	0.017	1	1	100.00	0.21	99.79
Xylenes	10	1	57	1.75	0.21	100.00
Total		483	1,002	48.20		

24.4 Concentrations

This section presents various concentration averages used to characterize pollution levels at the Utah monitoring site. Concentration averages are provided for the pollutants of interest for BTUT, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are

presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendix J through Appendix O.

24.4.1 2010 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 PAH, 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	53/53	NA	2.13 ± 0.27	3.11 ± 0.67	1.50 ± 0.43	2.25 ± 0.27
Acrylonitrile	7/57	0.04 ± 0.04	0	0.03 ± 0.04	0.01 ± 0.02	0.02 ± 0.02
Benzene	57/57	1.46 ± 0.38	0.94 ± 0.15	1.08 ± 0.29	1.43 ± 0.40	1.22 ± 0.16
1,3-Butadiene	53/57	0.17 ± 0.07	0.06 ± 0.02	0.05 ± 0.02	0.13 ± 0.04	0.10 ± 0.02
Carbon Tetrachloride	57/57	0.55 ± 0.06	0.60 ± 0.06	0.57 ± 0.08	0.59 ± 0.09	0.58 ± 0.03

[a] Average concentrations provided for the pollutants below the black 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)
Chloroform	43/57	0.08 ± 0.02	0.09 ± 0.02	0.86 ± 1.57	0.05 ± 0.04	0.28 ± 0.40
p-Dichlorobenzene	42/57	0.27 ± 0.32	0.24 ± 0.42	1.48 ± 2.90	0.12 ± 0.13	0.54 ± 0.74
1,2-Dichloroethane	7/57	0.07 ± 0.05	0.01 ± 0.01	0	0	0.02 ± 0.01
Dichloromethane	57/57	105.67 ± 157.03	121.14 ± 245.91	6.53 ± 5.65	274.95 ± 354.08	125.23 ± 109.76
Ethylbenzene	57/57	0.48 ± 0.15	0.30 ± 0.06	0.60 ± 0.57	0.54 ± 0.17	0.48 ± 0.15
Formaldehyde	53/53	NA	3.50 ± 0.56	6.10 ± 1.53	1.79 ± 0.23	3.66 ± 0.63
Propionaldehyde	53/53	NA	0.55 ± 0.07	0.80 ± 0.19	0.31 ± 0.09	0.55 ± 0.08
Tetrachloroethylene	53/57	0.16 ± 0.05	0.10 ± 0.02	0.18 ± 0.12	0.18 ± 0.07	0.15 ± 0.04
Trichloroethylene	16/57	0.03 ± 0.03	0.07 ± 0.13	0.22 ± 0.41	0.03 ± 0.03	0.09 ± 0.11
Vinyl Chloride	4/57	0.01 ± 0.01	0	0	0	<0.01 ± <0.01
Arsenic (PM$_{10}$)[a]	59/59	0.93 ± 0.51	0.33 ± 0.10	0.44 ± 0.10	0.74 ± 0.28	0.61 ± 0.15
Benzo(a)pyrene [a]	10/57	0.11 ± 0.11	<0.01 ± <0.01	0	0.02 ± 0.03	0.03 ± 0.03
Beryllium (PM$_{10}$) [a]	30/59	0	<0.01 ± <0.01	0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Cadmium (PM$_{10}$) [a]	59/59	0.17 ± 0.08	0.05 ± 0.01	0.07 ± 0.02	0.12 ± 0.04	0.10 ± 0.03
Hexavalent Chromium [a]	53/59	0.03 ± 0.01	0.01 ± 0.01	0.03 ± 0.03	0.02 ± 0.01	0.03 ± 0.01
Lead (PM$_{10}$) [a]	59/59	3.28 ± 1.62	1.81 ± 0.52	2.25 ± 0.71	3.45 ± 1.40	2.68 ± 0.57
Manganese (PM$_{10}$) [a]	59/59	4.15 ± 1.29	5.50 ± 1.71	7.69 ± 1.53	5.06 ± 1.51	5.61 ± 0.79
Naphthalene [a]	57/57	76.42 ± 29.05	36.98 ± 7.60	47.66 ± 12.32	73.79 ± 27.42	57.83 ± 10.49
Nickel (PM$_{10}$) [a]	59/59	0.92 ± 0.17	0.96 ± 0.29	0.88 ± 0.19	1.01 ± 0.36	0.94 ± 0.12

[a] Average concentrations provided for the pollutants below the black 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 0.251 to 2,430 μg/m^3. Three measurements of this pollutant are greater than 1,000 μg/m^3, nine are greater than 100 μg/m^3, and a total of 20 are greater than 10.0 μg/m^3. Although the maximum concentration of dichloromethane measured across the program was not measured at BTUT, this site has the highest number of dichloromethane measurements greater than 10.0 μg/m^3 (20 out of a program total of 29). Only one other NMP site has a dichloromethane measurement greater than 100 μg/m^3 (GPCO, which also has the maximum measurement program-wide).

- Although some pollutants of interest exhibit quarterly trends, such as 1,3-butadiene, which was highest during the colder months (first and fourth quarters), most of the pollutants exhibit high variability overall and/or may be affected by potential outliers (such as *p*-dichlorobenzene), as illustrated by the quarterly averages and their associated confidence intervals.

- Several pollutants appear higher in one quarter or another, but have very large confidence intervals associated them. For example, chloroform is highest during the third quarter of 2010, but the confidence interval for this quarterly average is twice the average itself, indicating the presence of outliers. A review of the data shows that the highest concentration of chloroform was measured on August 12, 2010 (11.5 μg/m^3) and is the second highest chloroform concentration measured across the program. The August 12, 2010 concentration is two orders of magnitude higher than the next highest concentration (0.28 μg/m^3 confirm measured at BTUT on July 25, 2010).

- The maximum concentration of several of the VOC was measured on July 25, 2010, including *p*-dichlorobenzene, ethylbenzene, tetrachloroethylene, and trichloroethylene.

- The confidence intervals for each of the quarterly average concentrations of *p*-dichlorobenzene are higher than the averages themselves, indicating a high level of variability within each quarterly average and/or the presence of outliers. A review of the data shows that the highest concentration of *p*-dichlorobenzene was measured on July 25, 2010 (21.2 μg/m^3) and is nearly seven times higher than the next highest concentration (3.11 μg/m^3 measured on June 13, 2010). These are the two highest *p*-dichlorobenzene concentrations measured across the program. BTUT also has the highest *p*-dichlorobenzene concentration in 2009 and the second highest in 2008. Of the 57 valid samples collected at BTUT in 2010, three measurements were greater than 1 μg/m^3 and 15 were greater than 0.1 μg/m^3. The median *p*-dichlorobenzene concentration is 0.06 μg/m^3.

- For 1,2-dichloroethane, all seven of the measured detections were measured during the first and second quarters of 2010. Six of the seven measured detections were measured in January and February and one was measured in April, with no measured detections after April 2, 2010.

- First quarter 2010 average concentrations could not be calculated for the carbonyl compounds because they did not meet the completeness criteria for calculating a quarterly average.

- Formaldehyde concentrations appear highest during the warmer months of the year, although without a first quarter average concentration, this is a difficult assessment to make. However, 11 of the 12 concentrations of formaldehyde greater than 5 $\mu g/m^3$, ranging from 5.02 $\mu g/m^3$ to 12.7 $\mu g/m^3$, were measured in July, August, and September, while eight of the nine concentrations less than 2 $\mu g/m^3$ were measured in October, November, and December.

- Concentrations of naphthalene appear highest in the colder months, although the confidence intervals indicate that the difference is not statistically significant. Seven of the eight concentrations greater than 100 ng/m^3 were measured in the first and fourth quarters of 2010.

- Concentrations of benzo(a)pyrene also appear highest in the colder months. Although this pollutant was detected in only 10 samples, six of these were measured during the first quarter of 2010, two in the second quarter and two in the fourth quarter.

- Of the PM_{10} metals, manganese has the highest annual average concentration and the highest quarterly averages.

- Arsenic, cadmium, and lead appear to be higher during the colder months of the year (first and fourth quarters). For each of these pollutants, the highest concentrations were measured during the first and second quarters 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 BTUT from those tables include the following:

- BTUT has highest annual average concentration of *p*-dichlorobenzene, as shown in Table 4-9. BTUT also has the second highest annual average concentration of trichloroethylene, the third highest annual average of vinyl chloride, and the fourth highest annual average concentrations of chloroform and 1,2-dichloroethane.

- BTUT has the second highest annual average concentration of formaldehyde (behind only ELNJ) and seventh highest annual average concentration of acetaldehyde, as shown in Table 4-10.

- BTUT does not appear in Table 4-11 for PAH.

- BTUT has the third highest annual average concentration of arsenic (behind only S4MO and NBIL). With the exception of arsenic, annual average concentrations for the metals for BTUT are in the middle of the range compared to other NMP sites sampling PM_{10} metals, as shown in Table 4-12.

24.4.2 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, arsenic, benzene, benzo(a)pyrene, 1,3-butadiene, formaldehyde, hexavalent chromium, manganese, and naphthalene were created for BTUT. Figures 24-6 through 24-14 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 24-6. Program vs. Site-Specific Average Acetaldehyde Concentration
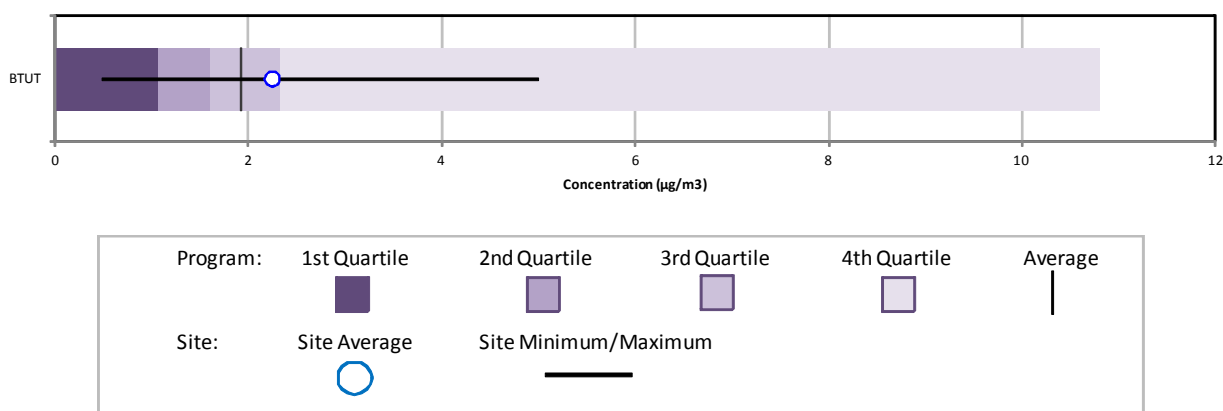
Figure 24-7. Program vs. Site-Specific Average Arsenic (PM$_{10}$) Concentration

24-18
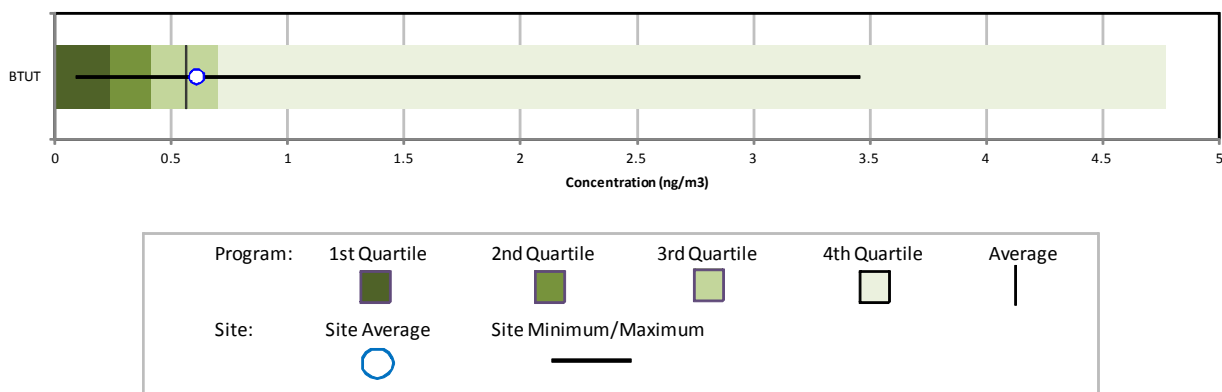
Figure 24-8. Program vs. Site-Specific Average Benzene Concentration
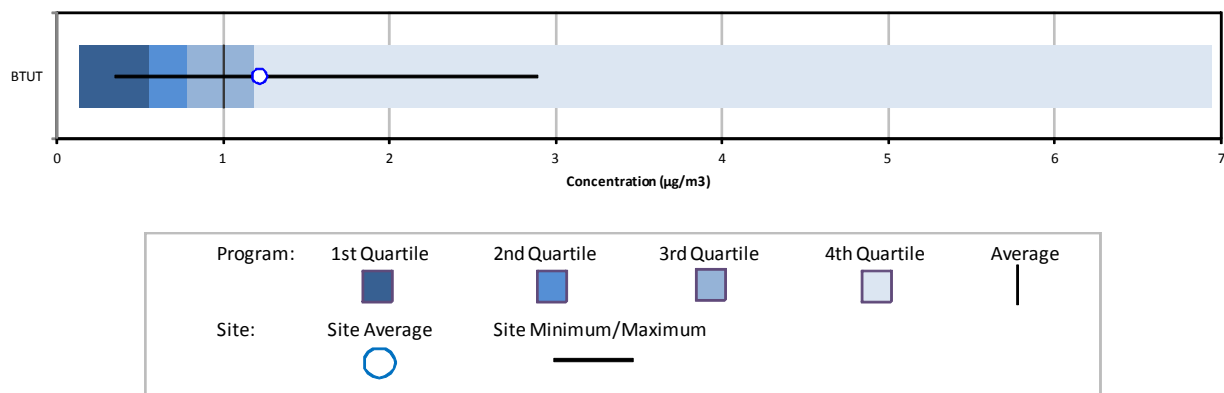
Figure 24-9. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Program Max Concentration = 42.7 ng/m3
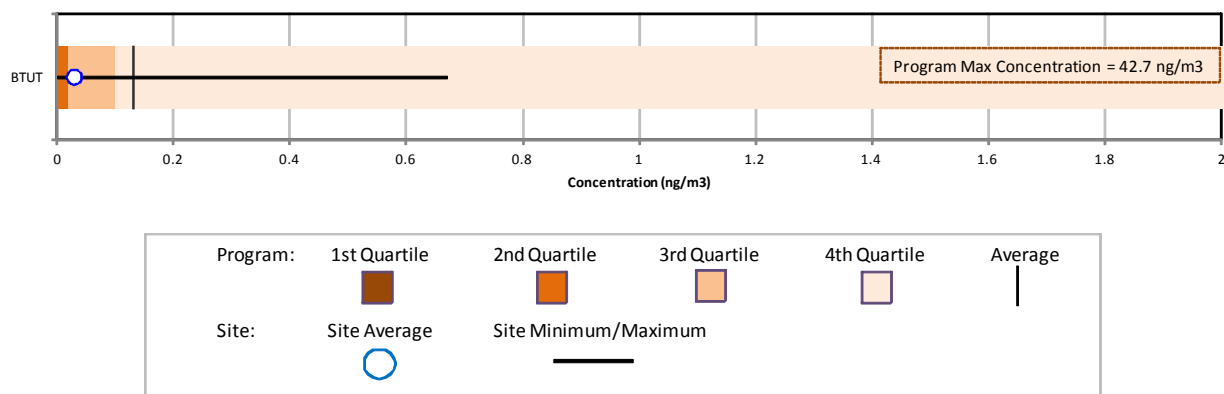
Figure 24-10. Program vs. Site-Specific Average 1,3-Butadiene Concentration

24-19
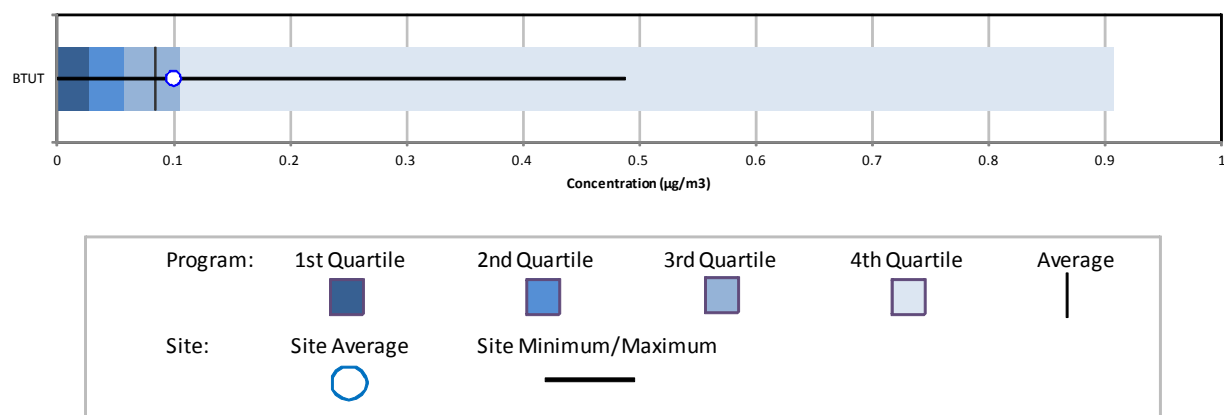
Figure 24-11. Program vs. Site-Specific Average Formaldehyde Concentration
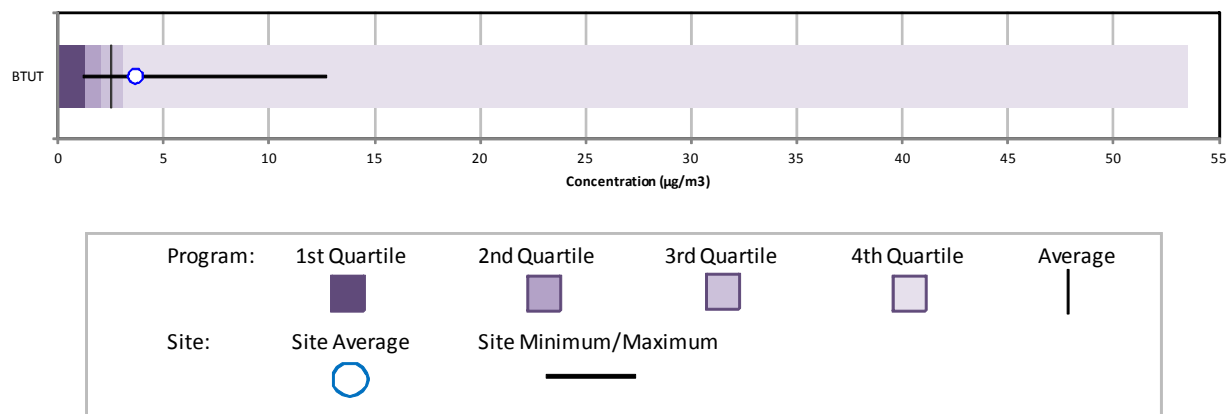
Figure 24-12. Program vs. Site-Specific Average Hexavalent Chromium Concentration
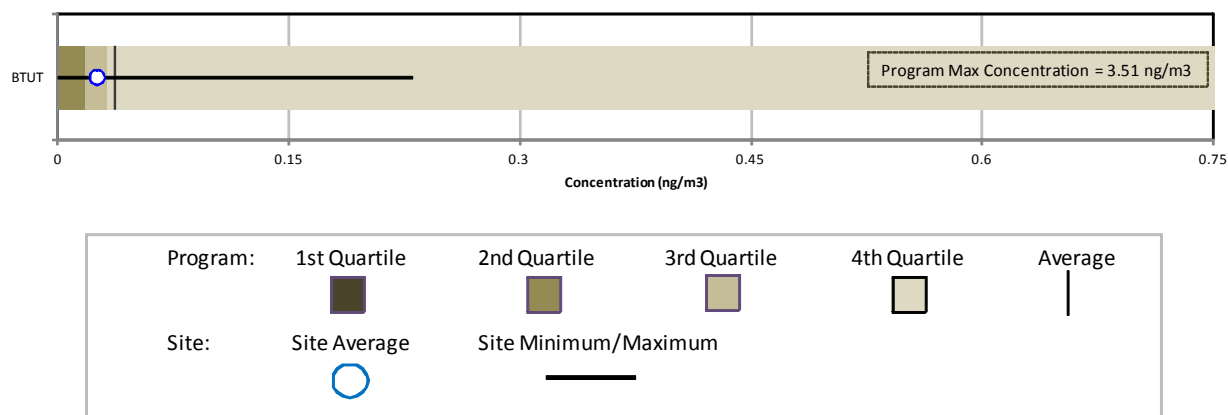
Figure 24-13. Program vs. Site-Specific Average Manganese (PM$_{10}$) Concentration
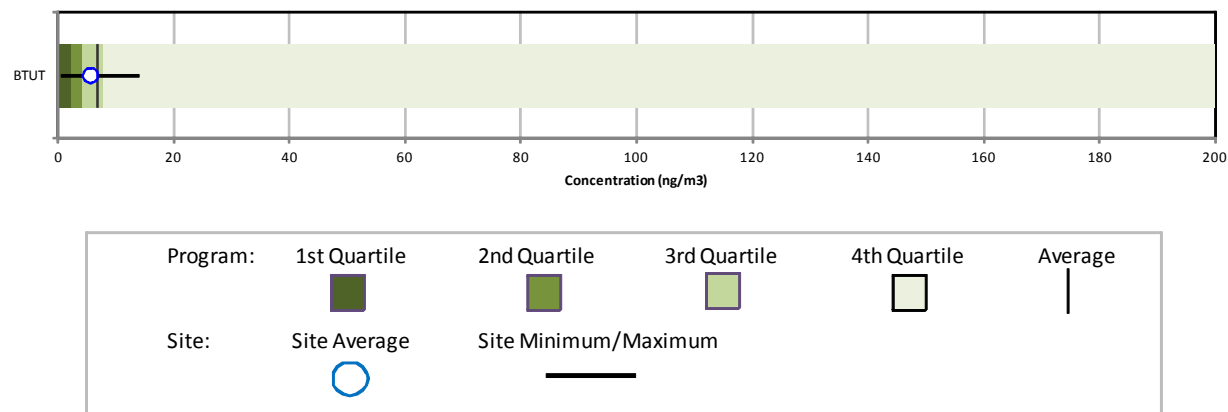
Figure 24-14. Program vs. Site-Specific Average Naphthalene Concentration
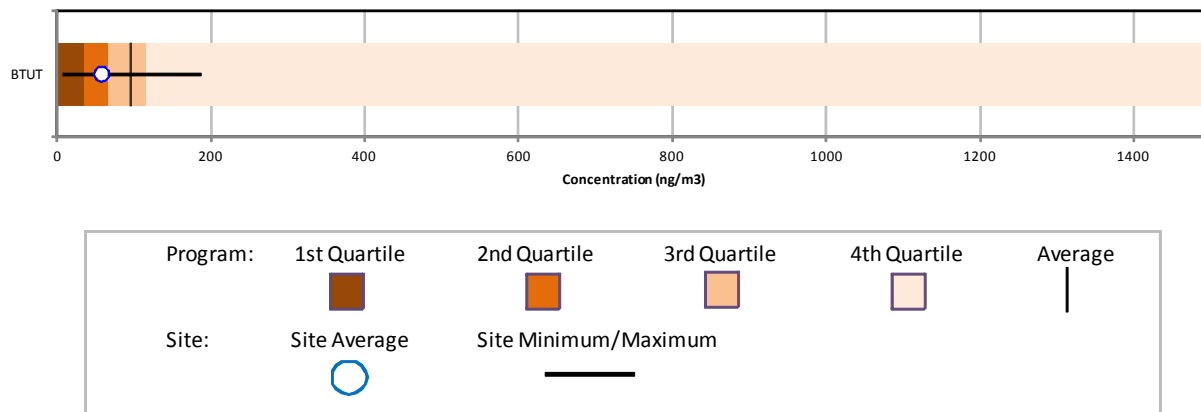
Observations from Figures 24-6 through 24-14 include the following:

- Figure 24-6 shows that BTUT's annual average acetaldehyde concentration is greater than the program-level average and just less than the program-level third quartile (75th percentile). There were no non-detects of acetaldehyde measured at BTUT.

- Figure 24-7 shows that BTUT's annual average arsenic (PM_{10}) concentration is just greater than the program-level average for arsenic (PM_{10}). Although the maximum concentration of arsenic at the program level was not measured at BTUT, the maximum concentration of arsenic for BTUT is the third highest among sites sampling PM_{10} metals. There were no non-detects of arsenic measured at BTUT.

- Figure 24-8 for benzene shows the annual average concentration for BTUT is greater than the program-level average and just greater than the program-level third quartile (75th percentile). The maximum concentration of benzene measured at BTUT is well below the maximum concentration measured across the program. There were no non-detects of benzene measured at BTUT.

- Figure 24-9 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 ng/m³) is not shown directly on the box plot because the scale of the box plot would be too large to readily observe data points at the lower end of the concentration range. Thus, the scale has been reduced to 2 ng/m³. Also 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 BTUT is well below the program-level average concentration. Figure 24-9 also shows that the maximum concentration measured at BTUT is well below the maximum concentration measured across the program. A number of non-detects of benzo(a)pyrene were measured at BTUT.

- Figure 24-10 for 1,3-butadiene shows the annual average concentration for BTUT is greater than the program-level average and just less than the program-level third quartile (75th percentile). The maximum concentration of 1,3-butadiene

24-21

measured at BTUT is below the maximum concentration measured across the program. A few 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 (75th percentile). The minimum concentration of formaldehyde measured at BTUT is just less than the program-level first quartile (25th percentile).

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 24-12 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 24-12 shows the annual average concentration of hexavalent chromium for BTUT is less than the program-level average. The maximum concentration measured at BTUT is well below the program-level maximum concentration. There were a few non-detects of hexavalent chromium at BTUT.

- Figure 24-13 shows that the annual average concentration of manganese (PM$_{10}$) for BTUT is less than the program-level average. The maximum concentration measured at BTUT is well below the program-level maximum concentration. There were no non-detects of manganese measured at BTUT.

- Figure 24-14 shows that the annual average naphthalene concentration for BTUT is less than both the program-level average and median concentrations. The maximum naphthalene concentration measured at BTUT is well below the program-level maximum concentration. There were no non-detects of naphthalene measured at BTUT.

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, VOC, metals, and SNMOC as part of the NMP since July 2003. BTUT has also sampled hexavalent chromium since 2005. Thus, Figures 24-15 through 24-21 present the 3-year rolling statistical metrics for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, and manganese for BTUT, respectively. The statistical metrics presented for assessing trends include the substitution of zeros for non-detects.

Figure 24-15. Three-Year Rolling Statistical Metrics for Acetaldehyde Concentrations Measured at BTUT
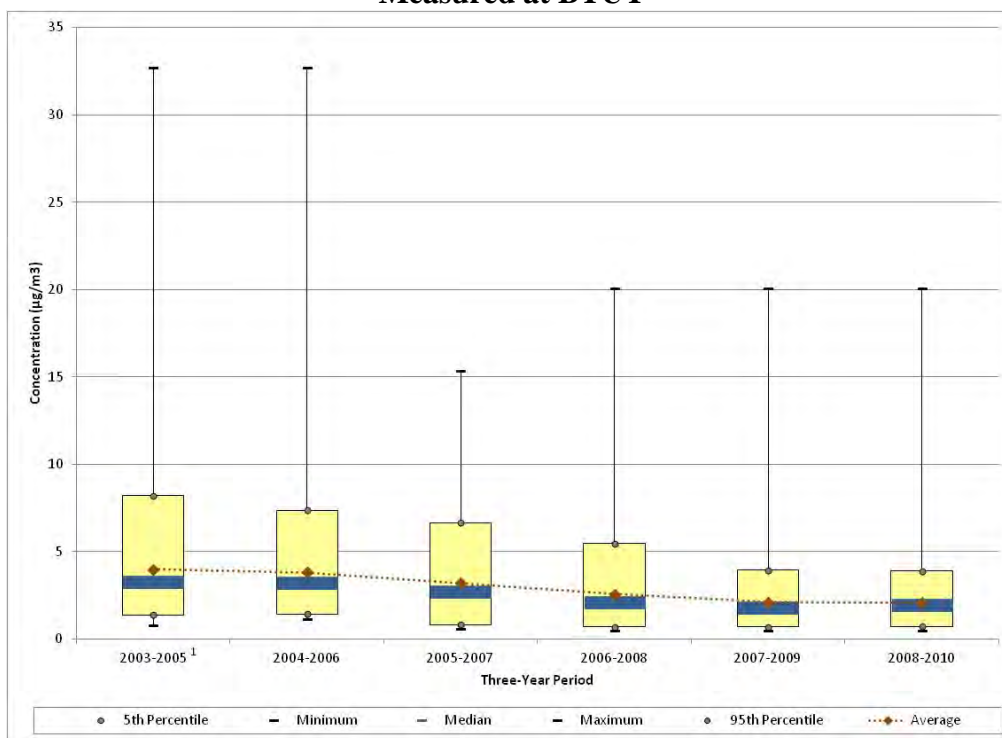
[1]Sampling for carbonyl compounds began in July 2003.

Figure 24-16. Three-Year Rolling Statistical Metrics for Arsenic (PM$_{10}$) Concentrations Measured at BTUT
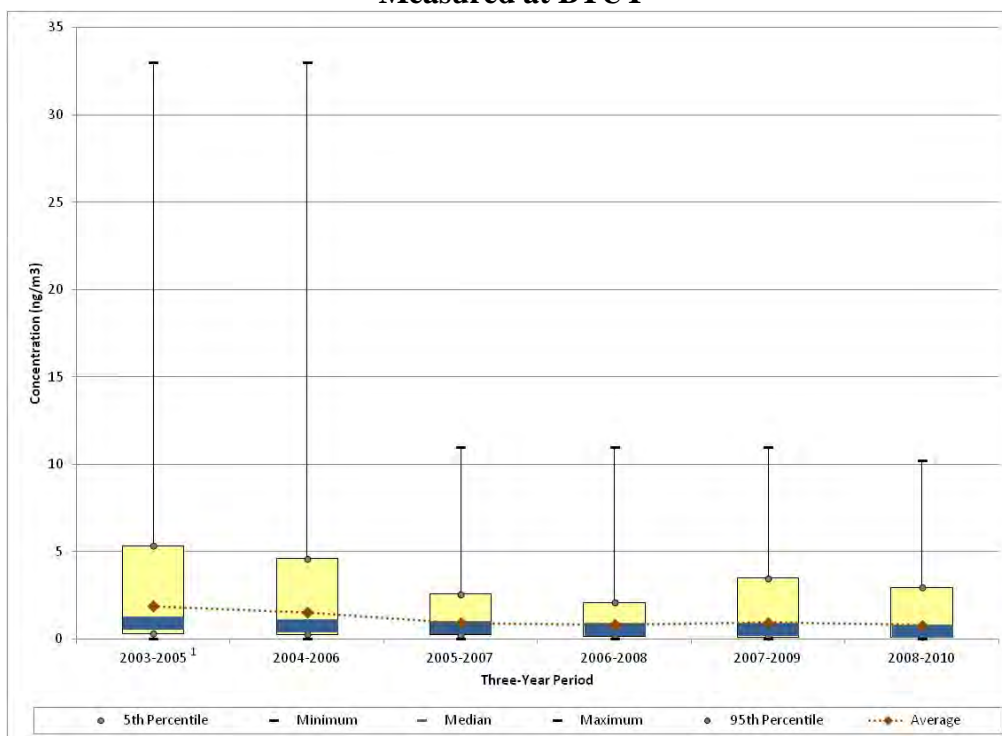
[1]Sampling for PM$_{10}$ metals began in July 2003.

Figure 24-17. Three-Year Rolling Statistical Metrics for Benzene Concentrations Measured at BTUT
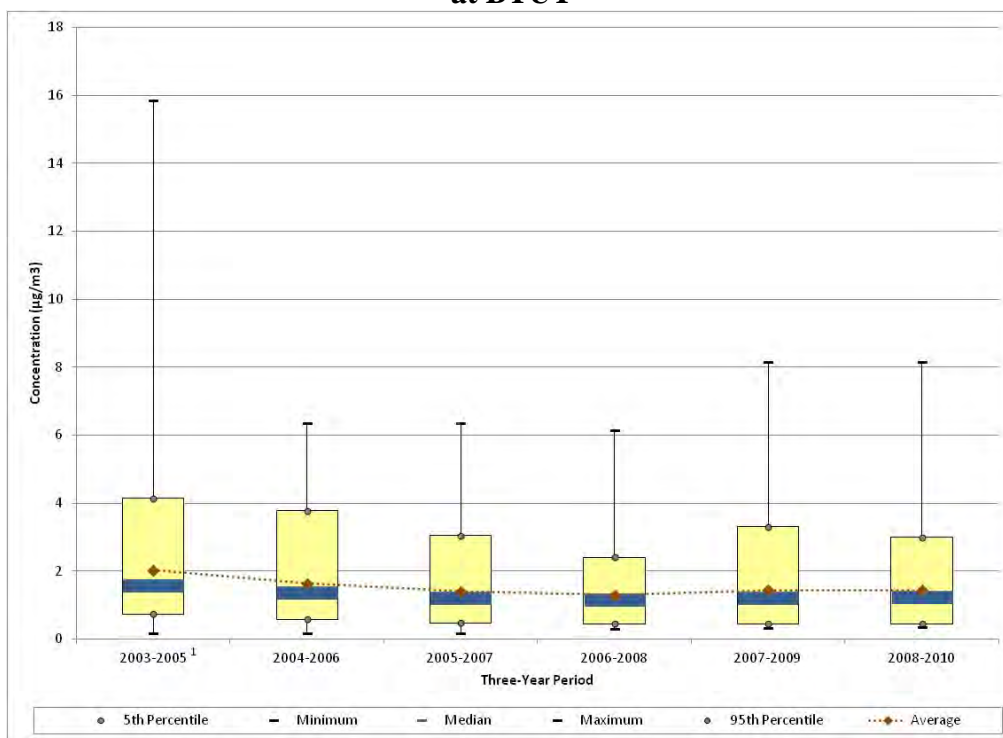
[1]Sampling for VOC began in July 2003.

Figure 24-18. Three-Year Rolling Statistical Metrics for 1,3-Butadiene Concentrations Measured at BTUT
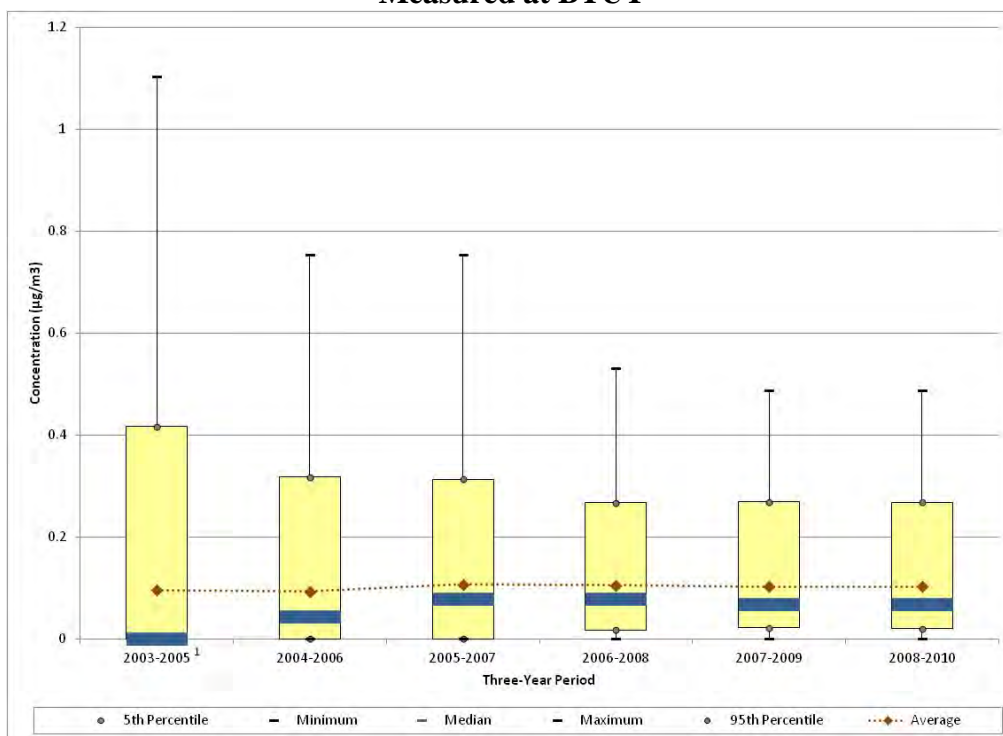
[1]Sampling for VOC began in July 2003.

Figure 24-19. Three-Year Rolling Statistical Metrics for Formaldehyde Concentrations Measured at BTUT
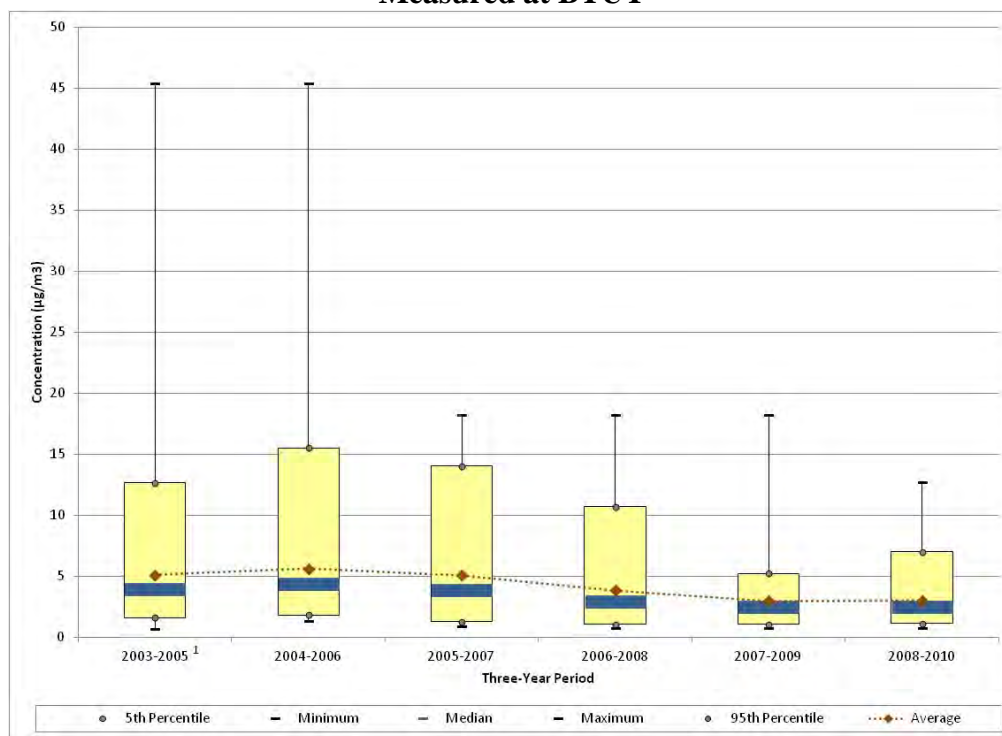
[1]Sampling for carbonyl compounds began in July 2003.

Figure 24-20. Three-Year Rolling Statistical Metrics for Hexavalent Chromium Concentrations Measured at BTUT
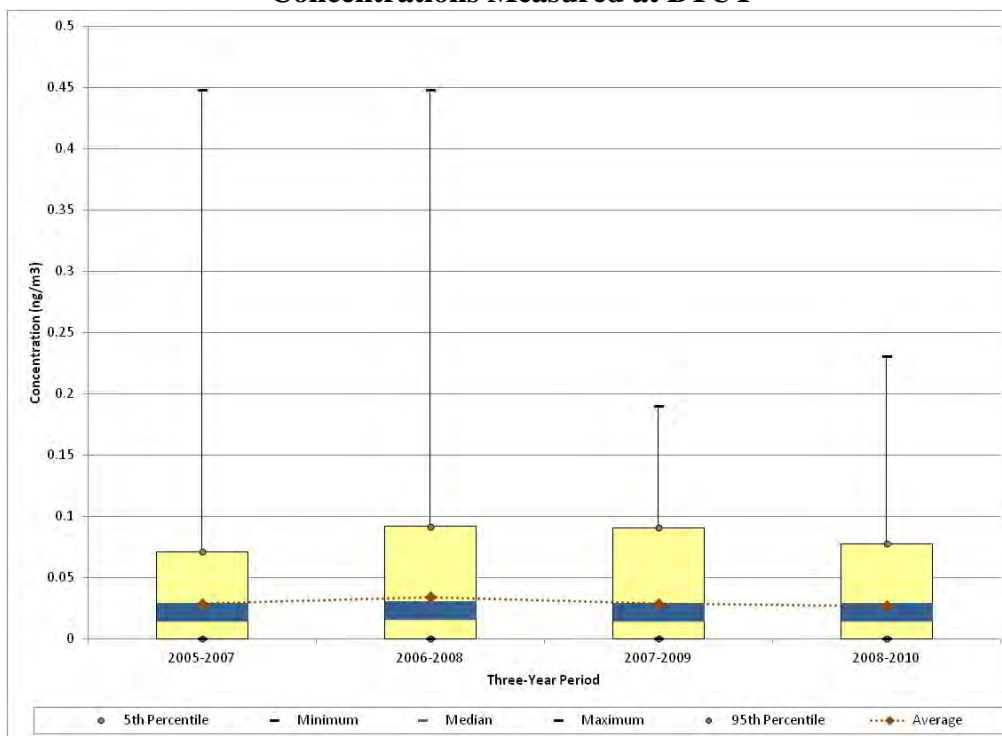
Figure 24-21. Three-Year Rolling Statistical Metrics for Manganese (PM$_{10}$) Concentrations Measured at BTUT
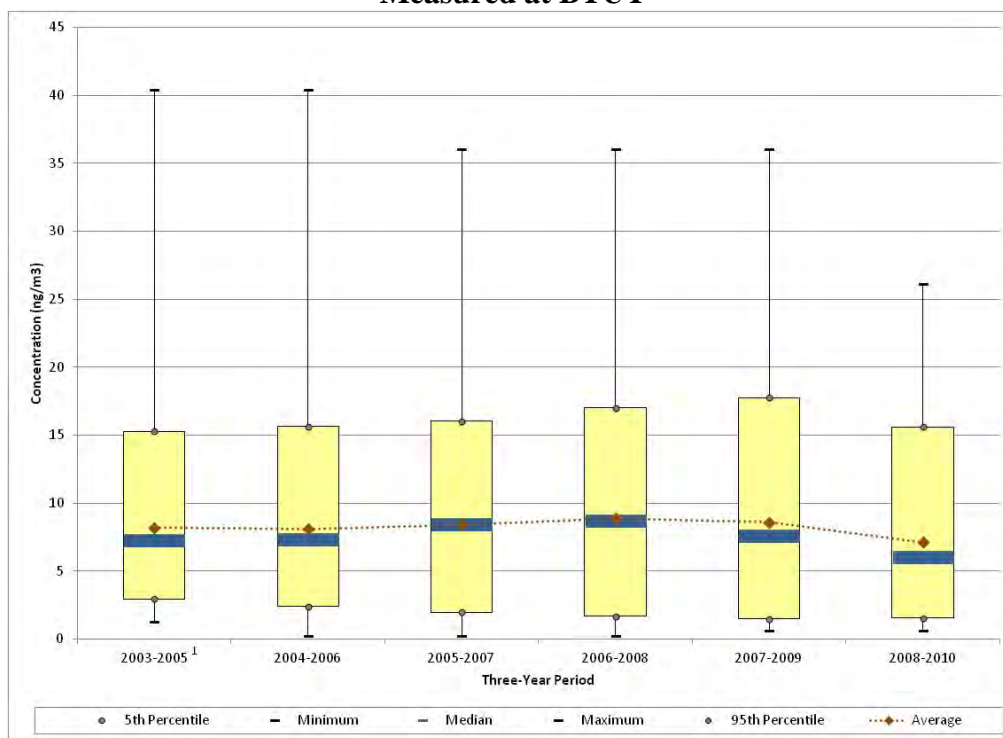
[1]Sampling for PM$_{10}$ metals began in July 2003.

Observations from Figure 24-15 for acetaldehyde measurements include the following:

- 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).

- Both the rolling average and median concentrations exhibit a steady decrease through 2007-2009, after which the average concentration held steady and the median increased slightly.

- The range of the majority of concentrations measured has also decreased, as indicated by the decreasing spread between the 5th and 95th percentiles.

Observations from Figure 24-16 for arsenic measurements include the following:

- 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 since sampling began in 2003 were all measured 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.

- Although difficult to discern in Figure 24-16, the rolling average concentrations of arsenic decreased through the 2006-2008 time period, increased slightly for the 2007-2009 time frame, then decreased slightly for 2008-2010. The median decreased as well, but was static from 2006-2008 to 2007-2009, then decreased again for 2008-2010.

Observations from Figures 24-17 for benzene include the following:

- The maximum concentration of benzene was measured in 2003 (15.8 µg/m^3). The next highest concentration (9.44 µg/m^3) was also measured in 2003.

- The rolling average and median concentrations have a decreasing trend through the 2006-2008 time frame, after which a slight increase is shown for 2007-2009. These metrics hold steady for the 2008-2010 time frame.

- Non-detects of benzene have not been measured at BTUT since the onset of VOC sampling.

Observations from Figures 24-18 for 1,3-butadiene include the following:

- The maximum concentration of 1,3-butadiene was measured in October 2003. This is the only concentration of 1,3-butaidene greater than 1 µg/m^3.

- The minimum, 5th percentile, and median concentrations are all zero for the 2003-2005 time frame, indicating that at least 50 percent of the measurements were non-detects. The detection rate of 1,3-butadiene has increased over the period sampling, up to a 100 percent detection rate for 2008 and 2009, although a few non-detects were reported in 2010.

- Figure 24-18 shows that the rolling average concentration has changed little over the years of sampling.

Observations from Figure 24-19 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 (18.2 µg/m^3), measured in 2007. Concentrations of similar magnitude were also measured on additional days in 2004 and 2007.

- The rolling average concentrations increased slightly from 2003-2005 to 2004-2006, then decreased each period through 2007-2009, and then held steady for 2008-2010. This is also true of the median concentrations.

- The difference between the median and the average concentrations decreased over most of the periods shown, indicating decreasing variability in the central tendency of formaldehyde measurements.

Observations from Figure 24-20 for hexavalent chromium measurements include the following:

- The maximum hexavalent chromium concentration was measured on July 4, 2006. The next highest concentration was measured on July 25, 2010 and is roughly half as high.

- Both the rolling average and median concentrations increased slightly during the second 3-year period then returned to 2005-2007 levels for the third and fourth 3-year periods. These changes, however, are not statistically significant.

- The minimum and 5th percentile are both zero for each time frame, 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).

Observations from Figure 24-21 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). The second, third, and fourth highest concentrations were measured in 2007.

- The rolling average concentrations exhibit an increasing trend through the 2006-2008 time frame, but decrease for the last two 3-year periods, particularly for the 2008-2010 time frame. However, the calculation of confidence intervals shows that these changes are not statistically significant. The median follows a similar trend, with a more significant decrease for the final time frame.

- The difference between the 5th and 95th percentiles increased over each period except for the final time frame, indicating an increasing spread in the measurements of manganese since the onset of sampling.

24.5 Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

24.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Utah monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the

acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL. The results of this risk screening are summarized in Table 24-6. Where a quarterly or annual average exceeds the applicable MRL, the concentration is bolded.

Observations from Table 24-6 include the following:

- Dichloromethane is the only pollutant for BTUT where a preprocessed daily measurement and/or time-period average was greater than one or more of the MRL noncancer health risk benchmarks.

- One out of 59 measured detections of dichloromethane is greater than the ATSDR acute MRL for this pollutant (2,000 µg/m^3). This concentration was measured on October 11, 2010 (2,430 µg/m^3) and is the second highest concentration of dichloromethane measured among NMP sites sampling this pollutant (behind only GPCO) and is one of two dichloromethane concentrations to exceed the acute MRL, as discussed in Section 4.2.2.

- Although none of the quarterly average concentrations of dichloromethane are greater than the ATSDR intermediate MRL of 1,000 µg/m^3, each of the quarterly averages reflects the inclusion of outliers, based on the confidence intervals, which are all greater than the associated averages, with the exception of the third quarter average concentration. These four quarterly averages are the second, third, fourth, and fifth highest quarterly averages calculated for dichloromethane among NMP sites (the highest ranking quarterly average of dichloromethane was calculated for the fourth quarter average for GPCO).

- Although the annual average concentration of dichloromethane for BTUT (125.23 ± 109.76 µg/m^3) is less than the ATSDR chronic MRL for this pollutant (1,000 µg/m^3), this is the highest annual average concentration calculated among any site-specific pollutants of interest.

For the pollutants whose concentrations are greater than their respective ATSDR acute MRL noncancer health risk benchmark(s), the concentrations were further examined by developing pollution roses for these pollutants. A pollution rose is a plot of concentration vs. wind speed and wind direction, as described in Section 3.5.5.1. Figure 24-22 is the dichloromethane pollution rose for BTUT.

Table 24-6. Noncancer Risk Screening Summary for the Utah Monitoring Site

Pollutant	Acute			Intermediate					Chronic	
	ATSDR Acute MRL[1] (µg/m³)	# of Concentrations > MRL	# of Measured Detections	ATSDR Intermediate MRL[1] (µg/m³)	1st Quarter Average (µg/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	ATSDR Chronic MRL[1] (µg/m³)	Annual Average (µg/m³)
Bountiful, Utah - BTUT										
Dichloromethane	2,000	1	59	1,000	105.67 ± 157.03	121.14 ± 245.91	6.53 ± 5.65	274.95 ± 354.08	1,000	125.23 ± 109.76

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

Figure 24-22. Dichloromethane Pollution Rose for BTUT

ATSDR MRL = 2,000 μg/m³, which corresponds to the upper end of the 100-2,000 μg/m³ (or yellow) concentration range

- 0-100 μg/m3
- 100-2,000 μg/m3
- >2,000 μg/m3

24-31
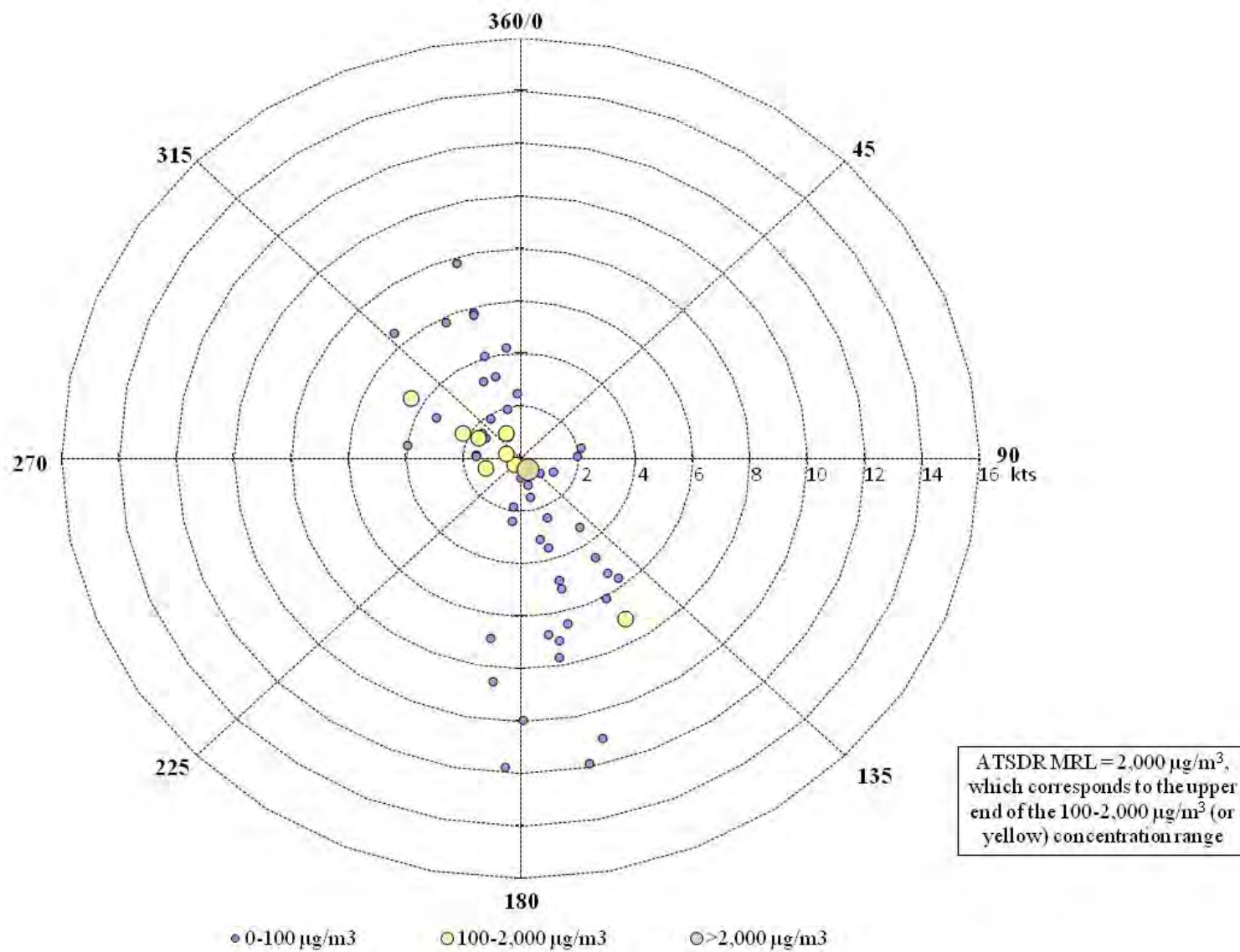
Observations from the Figure 24-22 include the following:

- There is only one measured detection that is greater than the ATSDR acute MRL (2,000 µg/m^3) for dichloromethane (shown in orange).

- The concentration greater than the ATSDR acute MRL was measured on a day with winds blowing from the southeast (on average). A review of the hourly wind data shows that southeasterly winds in the morning shifted northwesterly in the afternoon, reflecting the valley breeze effect often experienced in the area.

- The bulk of the dichloromethane concentrations greater than 100 µg/m^3 were measured on days with a northwesterly average wind direction. The average wind speed for these days is fairly light. Of the nine concentrations greater than 100 µg/m^3, eight of them were measured in the first and fourth quarters of 2010, although the one in June is the second highest dichloromethane concentration measured at BTUT (1,793 µg/m^3).

- Note that nearly all of the concentrations were measured on days with northwesterly or southeasterly winds, reflecting the same wind direction distribution on the wind roses shown in Section 24.2.4.

- Figure 24-2 shows that there are no point sources located to the northwest and southeast of BTUT, as reported in the 2008 NEI.

24.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Utah monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 24-7, where applicable.

Observations for BTUT from Table 24-7 include the following:

- The pollutants with the highest annual average concentrations are dichloromethane, formaldehyde, acetaldehyde, and benzene.

- The pollutants with the highest cancer risk approximations are formaldehyde, dichloromethane, benzene, and *p*-dichlorobenzene.

- There were no pollutants of interest with a noncancer risk approximation greater than 1.0. The highest noncancer risk approximation was calculated for formaldehyde (0.37).

Table 24-7. Cancer and Noncancer Surrogate Risk Approximations for the Utah Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Bountiful, Utah - BTUT						
Acetaldehyde	0.0000022	0.009	53/53	2.25 ± 0.27	4.94	0.25
Acrylonitrile	0.000068	0.002	7/57	0.02 ± 0.02	1.29	0.01
Arsenic (PM$_{10}$)[a]	0.0043	0.000015	59/59	<0.01 ± <0.01	2.61	0.04
Benzene	0.0000078	0.03	57/57	1.22 ± 0.16	9.50	0.04
Benzo(a)pyrene [a]	0.00176	--	10/57	<0.01 ± <0.01	0.05	--
Beryllium (PM$_{10}$) [a]	0.0024	0.00002	30/59	<0.01 ± <0.01	0.01	<0.01
1,3-Butadiene	0.00003	0.002	53/57	0.10 ± 0.02	3.00	0.05
Cadmium (PM$_{10}$) [a]	0.0018	0.00001	59/59	<0.01 ± <0.01	0.18	0.01
Carbon Tetrachloride	0.000006	0.1	57/57	0.58 ± 0.03	3.45	0.01
Chloroform	--	0.098	43/57	0.28 ± 0.40	--	<0.01
p-Dichlorobenzene	0.000011	0.8	42/57	0.54 ± 0.74	5.97	<0.01
1,2-Dichloroethane	0.000026	2.4	7/57	0.02 ± 0.01	0.46	<0.01
Dichloromethane	1.3E-07	0.6	57/57	125.23 ± 109.76	16.28	0.21
Ethylbenzene	0.0000025	1	57/57	0.48 ± 0.15	1.20	<0.01
Formaldehyde	0.000013	0.0098	53/53	3.66 ± 0.63	47.55	0.37
Hexavalent Chromium [a]	0.012	0.0001	53/59	<0.01 ± <0.01	0.31	<0.01
Lead (PM$_{10}$) [a]	--	0.00015	59/59	<0.01 ± <0.01	--	0.02
Manganese (PM$_{10}$) [a]	--	0.00005	59/59	0.01 ± <0.01	--	0.11
Naphthalene [a]	0.000034	0.003	57/57	0.06 ± 0.01	1.97	0.02
Nickel (PM$_{10}$) [a]	0.00048	0.00009	59/59	<0.01 ± <0.01	0.45	0.01
Propionaldehyde	--	0.008	53/53	0.55 ± 0.08	--	0.07
Tetrachloroethylene	2.6E-07	0.04	53/57	0.15 ± 0.04	0.04	<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 24-7. Cancer and Noncancer Surrogate Risk Approximations for the Utah 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 Risk Approximation (HQ)
Trichloroethylene	0.0000048	0.002	16/57	0.09 ± 0.11	0.42	0.04
Vinyl Chloride	0.0000088	0.1	4/57	<0.01 ± <0.01	0.02	<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.

24.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 24-8 and 24-9 present a risk-based evaluation of county-level emissions based on cancer and noncancer toxicity, respectively. Table 24-8 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. Table 24-9 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 24-8 and 24-9 are limited to those that have cancer and noncancer risk 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 tables. The cancer and noncancer surrogate risk 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 VOC, carbonyl compounds, SNMOC, metals (PM_{10}), PAH, and hexavalent chromium. In addition, the cancer and noncancer surrogate risk 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.

Table 24-8. 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 Risk Factors (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	47.55
Ethylbenzene	80.37	Formaldehyde	9.97E-04	Dichloromethane	16.28
Formaldehyde	76.71	1,3-Butadiene	6.17E-04	Benzene	9.50
Acetaldehyde	44.32	Naphthalene	3.46E-04	p-Dichlorobenzene	5.97
1,3-Butadiene	20.55	Ethylbenzene	2.01E-04	Acetaldehyde	4.94
Naphthalene	10.19	POM, Group 3	1.87E-04	Carbon Tetrachloride	3.45
Dichloromethane	2.66	POM, Group 2b	1.40E-04	1,3-Butadiene	3.00
POM, Group 2b	1.59	Hexavalent Chromium, PM	1.31E-04	Arsenic	2.61
POM, Group 1a	0.20	Acetaldehyde	9.75E-05	Naphthalene	1.97
POM, Group 6	0.14	POM, Group 5a	7.17E-05	Acrylonitrile	1.29

Table 24-9. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Utah Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Bountiful, Utah (Davis County) - BTUT					
Toluene	403.75	Acrolein	215,538.97	Formaldehyde	0.37
Xylenes	329.01	1,3-Butadiene	10,275.13	Acetaldehyde	0.25
Benzene	174.72	Formaldehyde	7,827.57	Dichloromethane	0.21
Methanol	171.92	Benzene	5,823.93	Manganese	0.11
Hexane	100.56	Acetaldehyde	4,924.23	Propionaldehyde	0.07
Ethylbenzene	80.37	Naphthalene	3,395.03	1,3-Butadiene	0.05
Formaldehyde	76.71	Xylenes	3,290.06	Trichloroethylene	0.04
Acetaldehyde	44.32	Lead, PM	1,295.06	Benzene	0.04
Ethylene glycol	22.52	Arsenic, PM	736.79	Arsenic	0.04
1,3-Butadiene	20.55	Propionaldehyde	619.63	Naphthalene	0.02

Observations from Table 24-8 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 third highest cancer risk approximations for BTUT, appear near the top of both emissions-based lists. Dichloromethane, which has the second 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 21st). p-Dichlorobenzene, which has the fourth 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 PAH sampled for at BTUT including acenaphthylene, fluoranthene, and perylene. None of the PAH included in POM, Group 2b were identified as pollutants of interest 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 emissions pollutants and is not among the pollutants with the highest cancer risk approximations for BTUT.

Observations from Table 24-9 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 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 the level of concern, formaldehyde, acetaldehyde, and dichloromethane have the highest noncancer risk approximations for BTUT. Formaldehyde and acetaldehyde rank third and fifth (respectively) for toxicity-weighted emissions and seventh and eighth (respectively) for total emissions. Dichloromethane appears on neither emissions-based list.

24.6   Summary of the 2010 Monitoring Data for BTUT

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

❖ *Twenty-six pollutants failed at least one screen for BTUT; of these, 14 were NATTS MQO Core Analytes.*

❖ *Dichloromethane had the highest annual average concentration among the pollutants of interest for BTUT, followed by formaldehyde and acetaldehyde.*

❖ *One preprocessed daily measurement of dichloromethane from BTUT was greater than its associated acute MRL noncancer health risk benchmark. None of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated intermediate or chronic MRL noncancer health risk benchmarks.*

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 through 25-3 are the composite satellite images retrieved from ArcGIS Explorer showing the monitoring sites in their urban and rural locations. Figures 25-4 and 25-5 identify 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 25-4 and 25-5. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the maps to show emissions sources outside the 10-mile boundary. 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. Table 25-1 describes the area surrounding the monitoring sites by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 25-1. Burlington, Vermont (BURVT) Monitoring Site
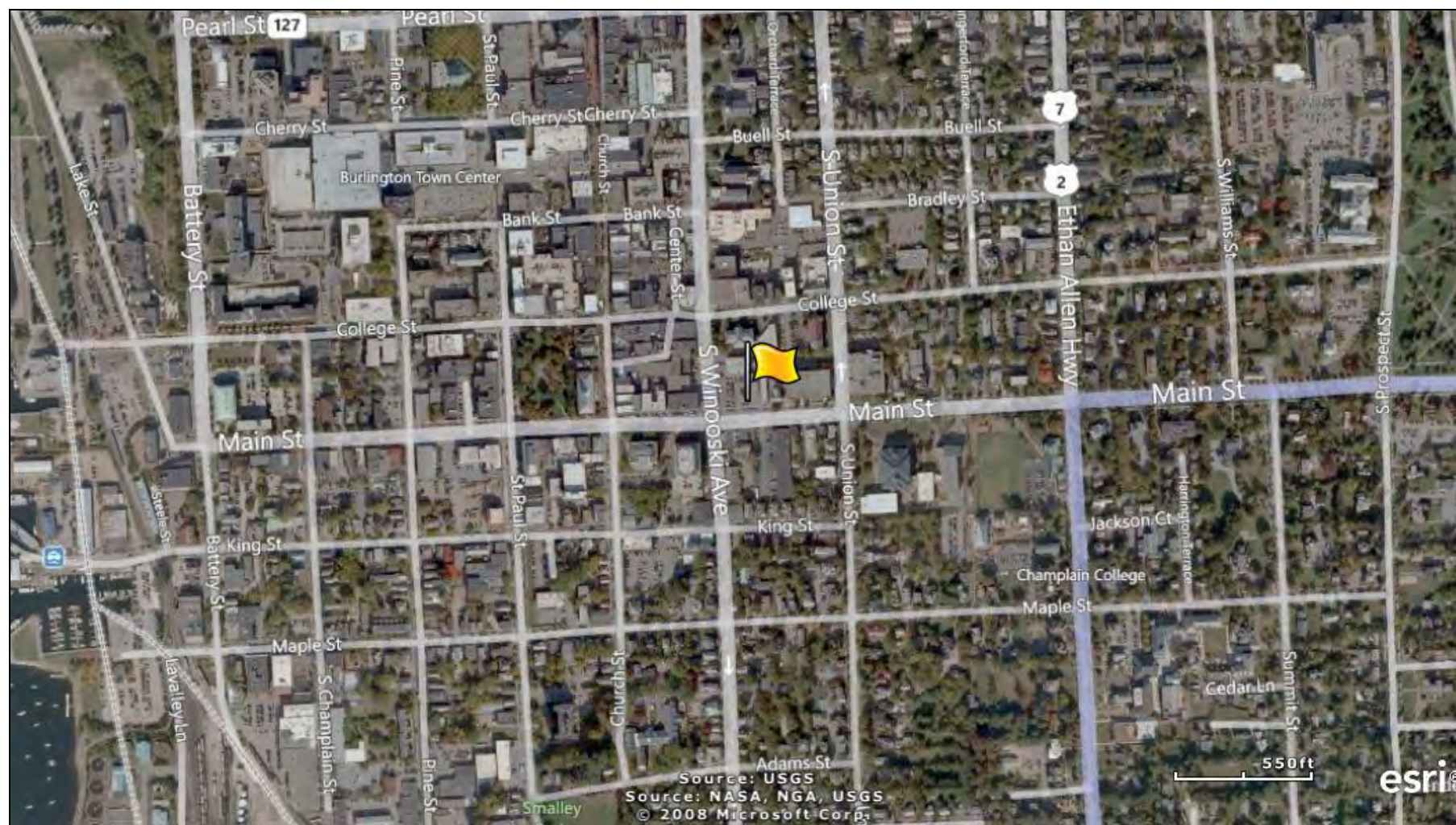
Figure 25-2. Underhill, Vermont (UNVT) Monitoring Site

Figure 25-3. Rutland, Vermont (RUVT) Monitoring Site
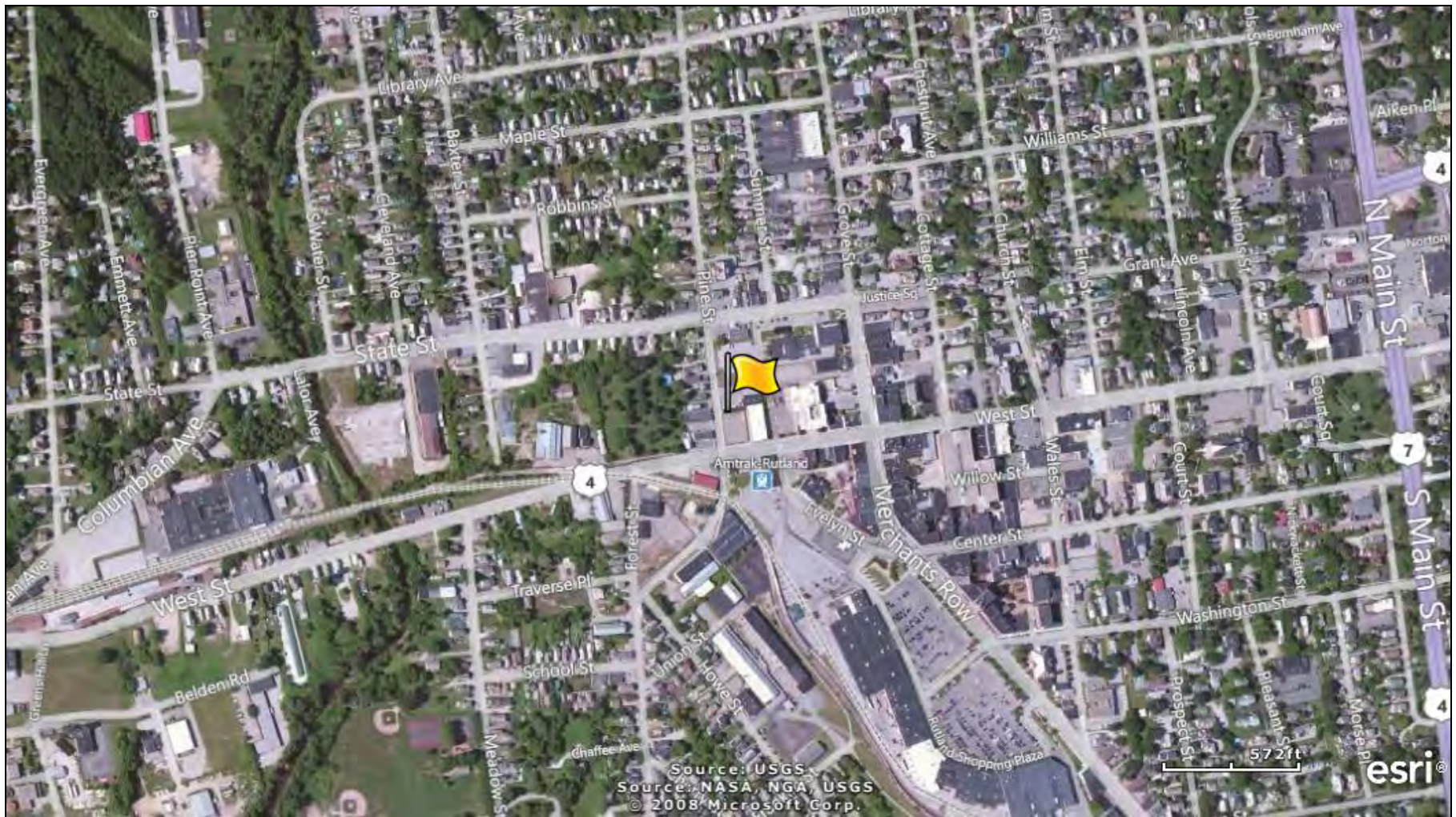
Figure 25-4. NEI Point Sources Located Within 10 Miles of BURVT and UNVT

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

Legend

⬠ BURVT UATMP site   ★ UNVT NATTS site   ◯ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

+ Aircraft Operations (13)	⌂ Institutional - school (1)
e Electrical Equipment (2)	◕ Laboratory (1)
⚡ Electricity Generation via Combustion (2)	Λ Military Base/National Security Facility (1)
▮ Gasoline/Diesel Service Station (1)	M Miscellaneous Manufacturing (1)
⚒ Hot Mix Asphalt Plant (1)	1 Primary Metal Production (1)
✳ Industrial Machinery and Equipment (2)	P Printing/Publishing (2)
	π Telecommunications (1)

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.

Legend

⊛ RUVT UATMP site   ◯ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

✙   Aerospace/Aircraft Manufacturing (2)

✛   Aircraft Operations (4)

○   Clay Ceramics Manufacturing (1)

❦   Hot Mix Asphalt Plant (1)

5   Miscellaneous Coating Manufacturing (1)

•   Plywood, Particleboard, OSB (1)

⊞   Pulp and Paper Plant/Wood Products (1)

W   Woodwork, Furniture, Millwork & Wood Preserving (1)

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] These monitoring sites report additional pollutants to AQS (EPA, 2012h); 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, 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 25-4 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 highest 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 25-3. 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 2 miles 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 highest number of sources include aircraft operations and aerospace/aircraft manufacturing. The source closest to RUVT is an aerospace/aircraft manufacturer.

Table 25-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Vermont monitoring sites. Table 25-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for each site. In addition, the population within 10 miles of each site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding each monitoring site. Table 25-2 also contains annual average daily traffic information. Finally, Table 25-2 presents the 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	156,705	223,316	1.43	116,261	165,680	4,000	4,027,945
RUVT	61,566	118,002	1.92	34,336	65,811	7,200	1,766,027
UNVT	156,705	223,316	1.43	35,228	50,202	1,200	4,027,945

[1] County-level population estimates reflect data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registrations reflect 2010 data from the Vermont DMV Commissioner's Office (VT DMV, 2010)
[3] 10-mile population estimates reflect 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 and 2005 data for BURVT and UNVT, respectively, from the Chittenden County Regional Planning Commission (CCRPC, 2005 and 2010) 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. RUVT's 10-mile population is the lowest among the three Vermont sites, although it is similar to the 10-mile population surrounding UNVT.

- Although similar patterns are shown in the vehicle ownership data, the number of vehicles registered in each county is significantly higher than the population counts, leading to rather large vehicle-per-person ratios, including the largest among all NMP sites (1.92 for RUVT). This indicates that many people own more than one vehicle.

- The traffic volume experienced near RUVT is highest and lowest near UNVT among the Vermont sites. The traffic estimates near these sites are among the lower traffic counts for NMP sites. The traffic estimate for BURVT was obtained for South Winooski Avenue between Main Street and Maple Street; Pleasant Valley Road, north of Harvey Road for UNVT; and US-4 Business between Merchants Row and Grove Street for RUVT.

- VMT for the Vermont counties rank among the lowest compared to other counties with NMP monitoring sites, with Rutland County fourth lowest and Chittenden County ninth lowest (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, 2012; NOAA, 2012f).

25.2.2 Meteorological Conditions in 2010

Hourly meteorological data from the NWS weather stations nearest the Vermont monitoring sites were retrieved for 2010 (NCDC, 2010). 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 normal conditions throughout the year.

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	Sample Day	57.0 ± 7.4	48.6 ± 6.9	37.7 ± 6.3	43.4 ± 6.1	69.1 ± 3.5	1013.2 ± 2.7	6.5 ± 1.0
	87° (E)	2010	56.2 ± 2.2	48.3 ± 2.0	38.2 ± 1.9	43.5 ± 1.8	71.1 ± 1.2	1013.0 ± 0.8	6.0 ± 0.3
Rutland, Vermont - RUVT									
Rutland State Airport 94737 (43.53, -72.95)	5.60 miles	Sample Day	55.0 ± 7.7	46.5 ± 6.9	36.7 ± 6.5	41.9 ± 6.2	71.0 ± 3.1	NA	5.4 ± 0.8
	150° (SSE)	2010	55.6 ± 2.1	47.3 ± 1.9	36.8 ± 1.9	42.5 ± 1.8	69.6 ± 1.2	NA	5.7 ± 0.3
Underhill, Vermont - UNVT									
Morrisville-Stowe State Airport 54771 (44.53, -72.61)	11.84 miles	Sample Day	54.8 ± 5.4	45.7 ± 4.7	36.4 ± 4.6	41.4 ± 4.3	73.0 ± 2.5	1013.5 ± 1.8	3.1 ± 0.5
	78° (E)	2010	55.3 ± 2.1	46.1 ± 1.9	36.8 ± 1.9	41.9 ± 1.8	73.0 ± 1.1	1013.6 ± 0.8	3.3 ± 0.2

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

Table 25-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for the entire year for 2010. 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 the Vermont monitoring sites were fairly representative of average weather conditions throughout the year.

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 2010. Included in Figure 25-6 are four back trajectories per sample day. Figure 25-7 is the corresponding cluster analysis for 2010. Similarly, Figure 25-8 and 25-10 are the composite back trajectory maps for days on which samples were collected at UNVT and RUVT and Figures 25-9 and 25-11 are the corresponding cluster analyses for these two 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. For the cluster analyses, each line corresponds to a back trajectory representative of a given cluster of trajectories. For all maps, each concentric circle around the sites in Figures 25-6 through 25-11 represents 100 miles.

Figure 25-6. 2010 Composite Back Trajectory Map for BURVT
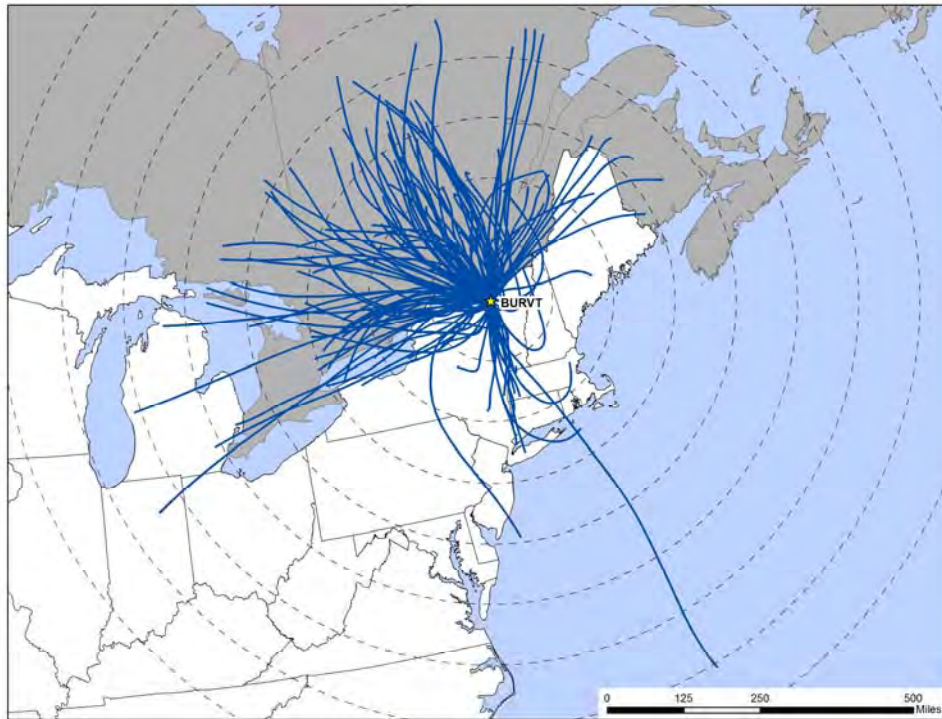
Figure 25-7. Back Trajectory Cluster Map for BURVT

Figure 25-8. 2010 Composite Back Trajectory Map for RUVT
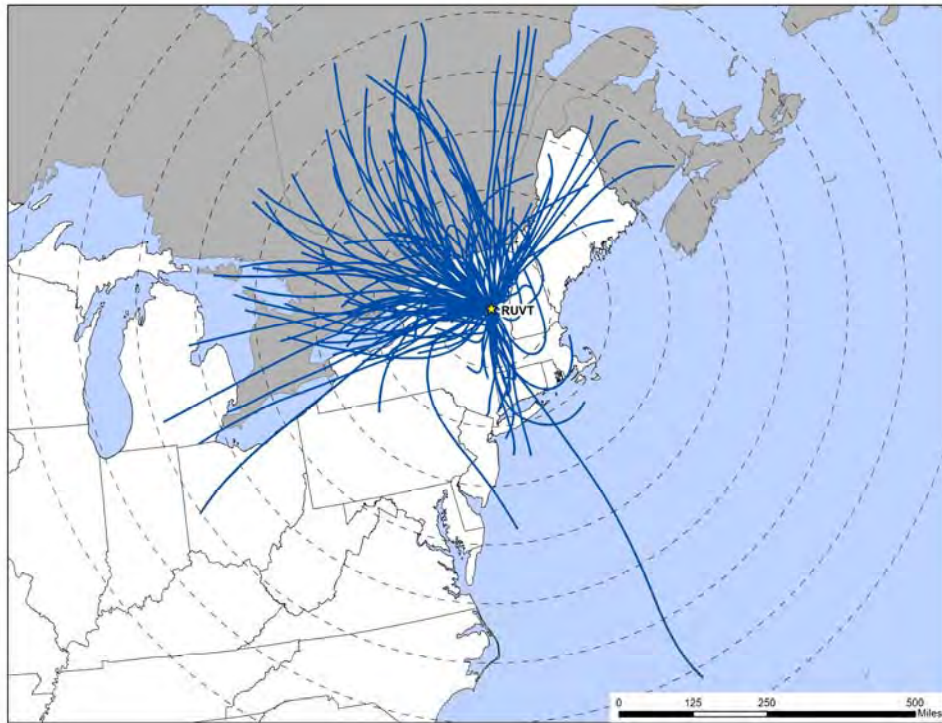
Figure 25-9. Back Trajectory Cluster Map for RUVT

Figure 25-10. 2010 Composite Back Trajectory Map for UNVT
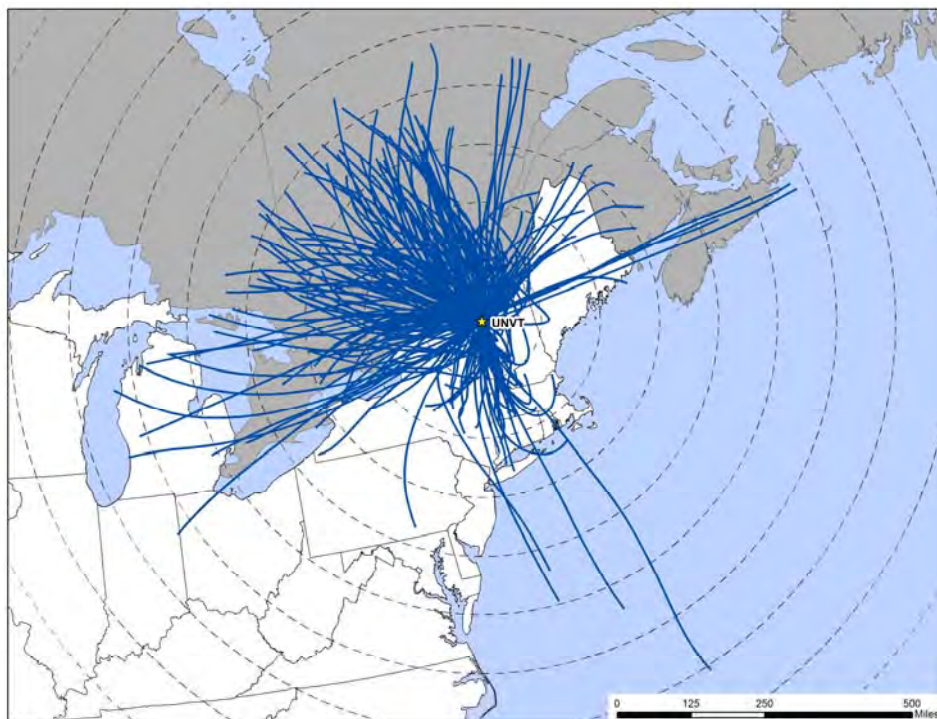
Figure 25-11. Back Trajectory Cluster Map for UNVT

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 fairly similar to each other, which is not unexpected given their relatively close proximity to each other.

- The composite back trajectory maps show that the majority of back trajectories originated from the southwest, west, northwest, and north of the Vermont monitoring sites. Note that the BURVT and RUVT monitoring sites sampled on a 1-in-12 schedule, yielding roughly half as many sample days for these sites as UNVT.

- For each of the Vermont sites, the farthest away a trajectory originated was off the North Carolina coast, greater than 700 miles away. However, this is the only trajectory of similar origin for BURVT and RUVT, while a few originate off the Virginia coast for UNVT. This trajectory is for the evening of January 25, 2010, when a strong frontal system was pushing through New England. The average trajectory length varied from 266 miles for UNVT, 282 miles for BURVT, and 289 miles for RUVT and most trajectories (roughly 80 percent) originated within 400 miles of each site.

- The cluster analyses for the Vermont sites are fairly similar to each other directionally, although percentage-wise there are some differences. For example, the cluster analyses for BURVT and RUVT show that roughly one quarter of back trajectories originated north to northeastward over Maine and eastern Quebec, Canada. For UNVT, this is also true, but the cluster trajectory is divided into two, with longer trajectories accounting for 5 percent of the trajectories and shorter trajectories accounting for 16 percent. The cluster analyses for BURVT and UNVT show that 28 percent of back trajectories originated northwest to northward over western Quebec, Canada. For RUVT, several of the back trajectories originating from the west-northwest and northwest are included with the westward originating cluster trajectory (44 percent) instead. Thus, trajectories originating from the southwest, west, northwest, north, and northeast account for 78-79 percent of back trajectories for UNVT and BURVT and 85 percent of back trajectories for RUVT. Each cluster analysis also has one southward originating trajectory. For each site, this trajectory represents southward originating trajectories as well as a sampling of trajectories originating from other directions and within 100-200 miles of the sites.

25.2.4 Wind Rose Comparison

Hourly wind data from the NWS weather stations at Burlington International Airport (for BURVT), Morrisville-Stowe State Airport (for UNVT), and Rutland State Airport (for RUVT) 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 three different wind roses for the BURVT monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location. Figures 25-13 and 25-14 present the three wind roses and distance maps for the UNVT and RUVT 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 25 percent of the hourly measurements. Calm winds (≤ 2 knots) account for another 18 percent of measurements. Winds from the northwest quadrant, including north, account for another 25 percent of the wind observations. Winds from the eastern quadrants are rarely measured.

- The wind patterns shown on the 2010 wind roses are similar to the historical wind patterns, although slightly fewer southerly winds and slightly more northwesterly to northerly winds were measured in 2010 and slightly more calm winds (21 percent) were observed.

- The sample day wind rose shows that wind conditions on sample days were similar to those experienced throughout 2010, although northwesterly winds accounted for an even higher percentage of the hourly wind measurements.

Figure 25-12. Wind Roses for the Burlington International Airport Weather Station near BURVT

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose

Distance between BURVT and NWS Station
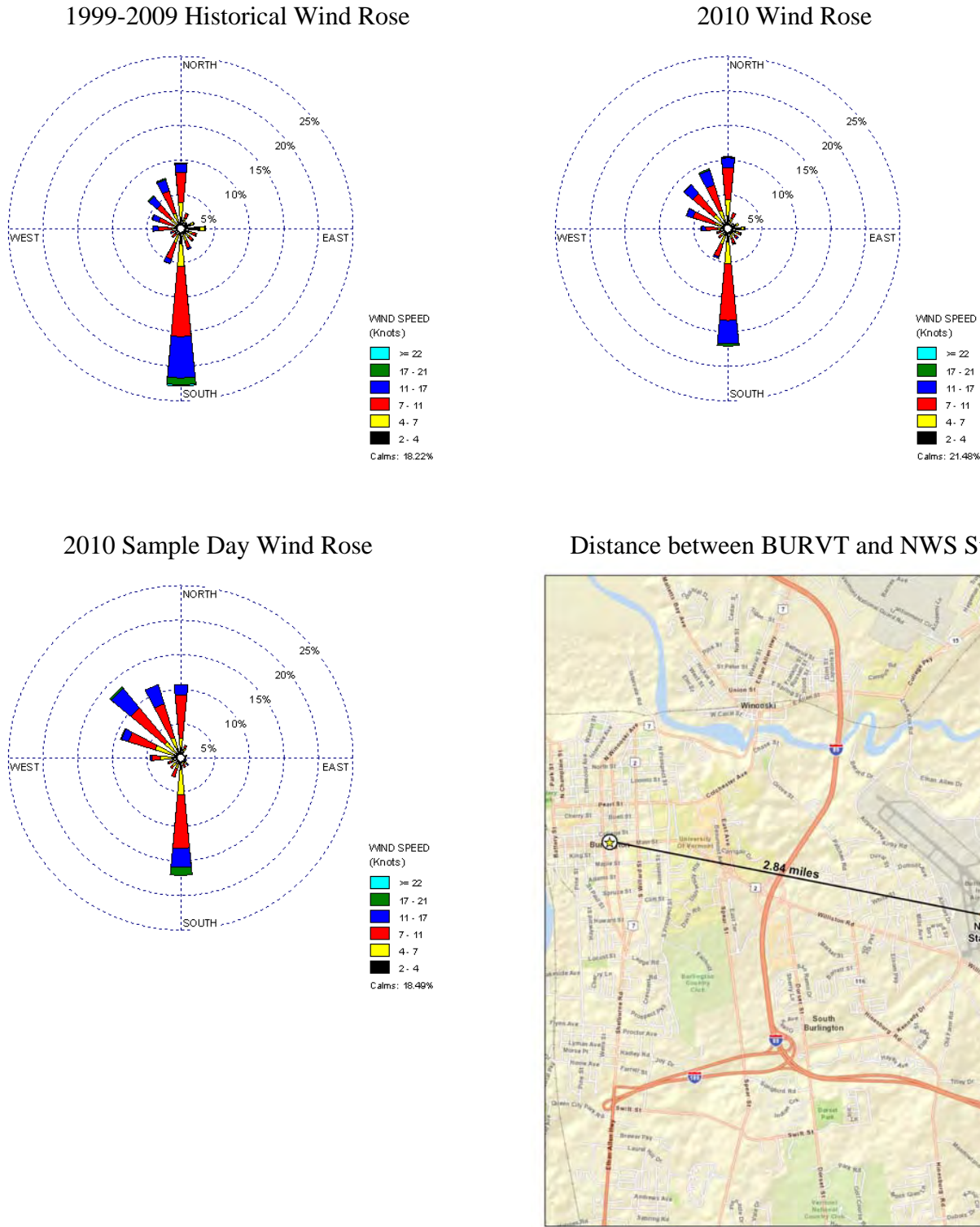
Figure 25-13. Wind Roses for the Rutland State Airport Weather Station near RUVT

2003-2009 Historical Wind Rose
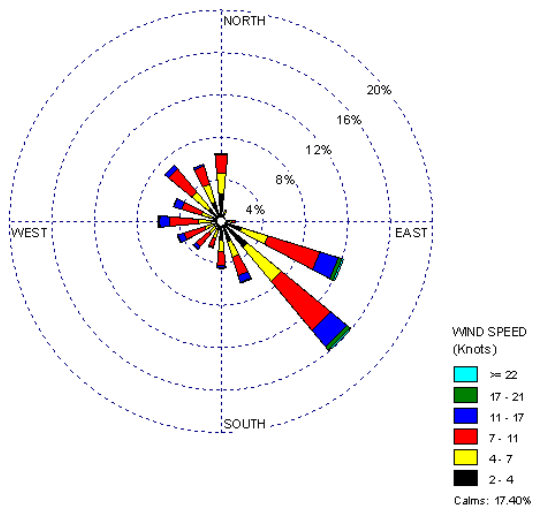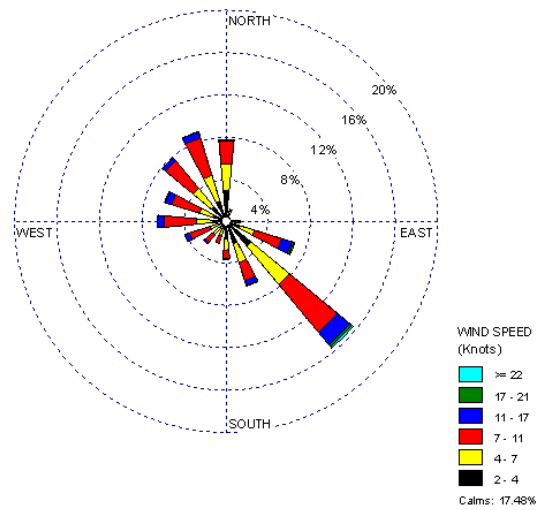
2010 Wind Rose

2010 Sample Day Wind Rose
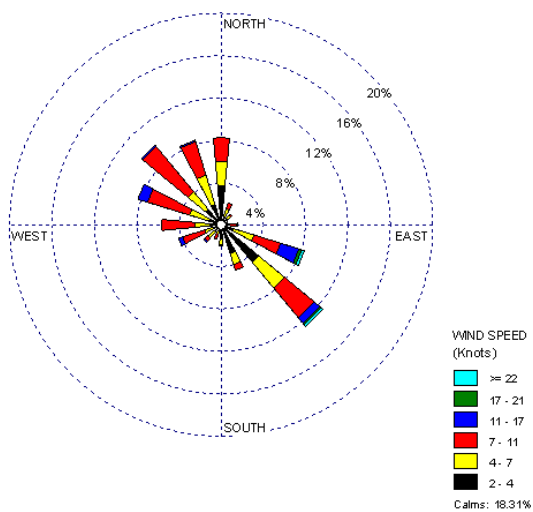
Distance between RUVT and NWS Station

Figure 25-14. Wind Roses for the Morrisville-Stowe State Airport Weather Station near UNVT

1999-2009 Historical Wind Rose
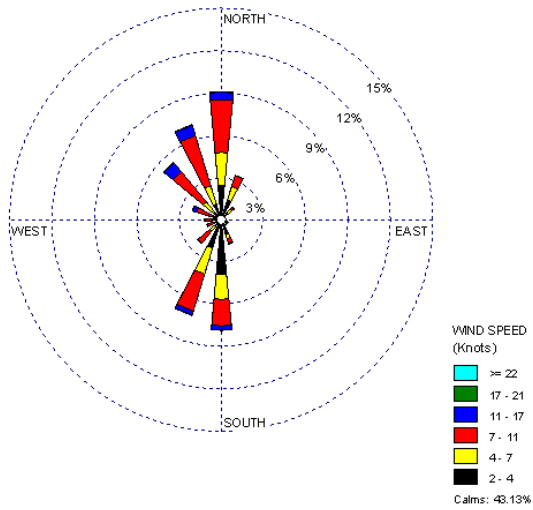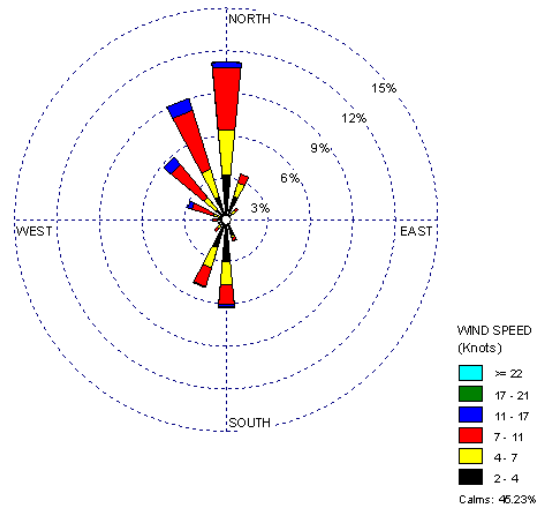
2010 Wind Rose

2010 Sample Day Wind Rose
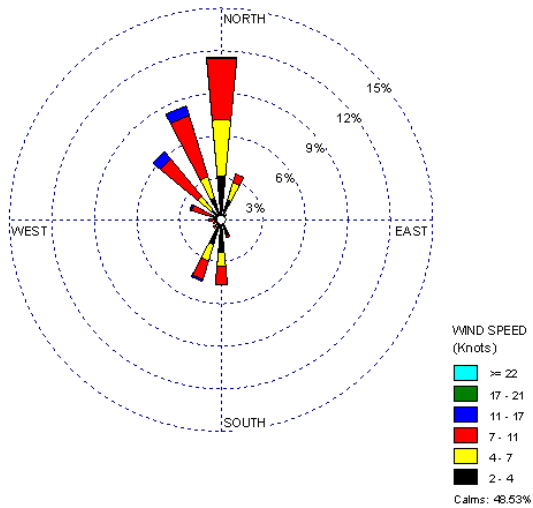
Distance between UNVT and NWS Station

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 observed frequently while winds from the northeast quadrant were almost never observed. Calm winds were observed for over 17 percent of the hourly measurements.

- The wind patterns shown on the 2010 wind rose are similar to the historical wind patterns, although a higher percentage of winds from the northwest quadrant and fewer east-southeasterly winds were observed in 2010. The 2010 calm rate is nearly identical to the historical calm rate.

- The sample day wind rose shows that wind conditions on sample days were similar to those experienced throughout 2010.

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 over 40 percent of the hourly measurements. Winds from the northwest to north account for another 20 percent of the wind observations greater than two knots and winds from the south to south-southwest account for another 15 percent of observations.

- The wind patterns shown on the 2010 wind rose are similar to the historical wind patterns, although a higher percentage of northwesterly to northerly winds and fewer southerly to south-southwesterly winds were observed in 2010. The calm rate is slightly higher in 2010.

- The sample day wind rose shows that wind conditions on sample days were similar to those experienced throughout 2010, although calm winds account for nearly 49 percent of wind measurements.

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 25-4 presents the pollutants of interest 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 VOC only while UNVT sampled for VOC, carbonyl compounds, hexavalent chromium, PAH, and metals (PM$_{10}$). Note, however, that carbonyl compounds sampling at UNVT was discontinued in June 2010.

Observations from Table 25-4 include the following:

- A total of eight pollutants, including three NATTS MQO Core Analytes, failed screens for BURVT. Six pollutants, including the same three NATTS MQO Core Analytes, failed screens for RUVT. Five pollutants failing screens were the same for BURVT and RUVT.

- Thirteen pollutants, of which nine are NATTS MQO Core Analytes, failed screens for UNVT.

- The preliminary risk screening process identified five pollutants of interest for BURVT (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. Although vinyl chloride is also a NATTS MQO Core Analyte, this pollutant was not added because it was not detected at this site. These pollutants are not shown in Table 25-4.

- The preliminary risk screening process identified four pollutants of interest for RUVT (benzene, carbon tetrachloride, 1,3-butadiene, and ethylbenzene). Four additional pollutants (chloroform, tetrachloroethylene, trichloroethylene, and vinyl chloride) 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.

- The preliminary risk screening process identified eight pollutants of interest for UNVT (three VOC, two carbonyl compounds, two metals, and one PAH). Benzo(a)pyrene and 1,3-butadiene were added to UNVT's pollutants of interest because they are NATTS MQO Core Analytes, even though they did not contribute to

95 percent of UNVT's total failed screens. Nine additional pollutants (four metals, four VOC, 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.

- Benzene, carbon tetrachloride, and 1,3-butadiene were identified as pollutants of interest for each of the Vermont monitoring sites.

Table 25-4. Risk Screening Results for the Vermont Monitoring Sites

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Burlington, Vermont - BURVT						
Benzene	0.13	31	31	100.00	29.52	29.52
Carbon Tetrachloride	0.17	30	30	100.00	28.57	58.10
1,3-Butadiene	0.03	29	29	100.00	27.62	85.71
1,2-Dichloroethane	0.038	6	6	100.00	5.71	91.43
Ethylbenzene	0.4	4	31	12.90	3.81	95.24
Acrylonitrile	0.015	2	2	100.00	1.90	97.14
Hexachloro-1,3-butadiene	0.045	2	2	100.00	1.90	99.05
Chloroprene	0.0021	1	1	100.00	0.95	100.00
Total		105	132	79.55		
Rutland, Vermont - RUVT						
Benzene	0.13	28	28	100.00	29.47	29.47
Carbon Tetrachloride	0.17	28	28	100.00	29.47	58.95
1,3-Butadiene	0.03	27	27	100.00	28.42	87.37
Ethylbenzene	0.4	8	28	28.57	8.42	95.79
1,2-Dichloroethane	0.038	3	3	100.00	3.16	98.95
p-Dichlorobenzene	0.091	1	12	8.33	1.05	100.00
Total		95	126	75.40		
Underhill, Vermont - UNVT						
Benzene	0.13	60	60	100.00	26.91	26.91
Carbon Tetrachloride	0.17	57	59	96.61	25.56	52.47
Formaldehyde	0.077	30	30	100.00	13.45	65.92
Acetaldehyde	0.45	28	30	93.33	12.56	78.48
Arsenic (PM$_{10}$)	0.00023	23	58	39.66	10.31	88.79
1,2-Dichloroethane	0.038	10	10	100.00	4.48	93.27
Manganese (PM$_{10}$)	0.005	5	61	8.20	2.24	95.52
Naphthalene	0.029	5	60	8.33	2.24	97.76
Acrylonitrile	0.015	1	1	100.00	0.45	98.21
Benzo(a)pyrene	0.00057	1	10	10.00	0.45	98.65
1,3-Butadiene	0.03	1	12	8.33	0.45	99.10
1,2-Dibromoethane	0.0017	1	1	100.00	0.45	99.55
Dichloromethane	7.7	1	59	1.69	0.45	100.00
Total		223	451	49.45		

25.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Vermont monitoring sites. Concentration averages are provided for the pollutants of interest, where applicable. Concentration averages for select pollutants are also presented graphically for each site, where applicable, to illustrate how each site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices J, L, M, N, and O.

25.4.1 2010 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 PAH, 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
Burlington, Vermont - BURVT						
Benzene	31/31	0.79 ± 0.13	0.94 ± 0.19	0.78 ± 0.22	0.89 ± 0.34	0.85 ± 0.11
1,3-Butadiene	29/31	0.07 ± 0.03	0.11 ± 0.03	0.08 ± 0.03	0.09 ± 0.02	0.09 ± 0.01
Carbon Tetrachloride	30/31	0.47 ± 0.18	0.59 ± 0.16	0.60 ± 0.10	0.52 ± 0.10	0.54 ± 0.06
Chloroform	21/31	0.06 ± 0.04	0.09 ± 0.04	0.12 ± 0.04	0.04 ± 0.04	0.08 ± 0.02
1,2-Dichloroethane	6/31	0.02 ± 0.03	0.03 ± 0.03	0	0	0.01 ± 0.01
Ethylbenzene	31/31	0.18 ± 0.04	0.33 ± 0.11	0.33 ± 0.11	0.22 ± 0.06	0.26 ± 0.04
Tetrachloroethylene	27/31	0.07 ± 0.05	0.12 ± 0.03	0.10 ± 0.05	0.10 ± 0.08	0.09 ± 0.03
Trichloroethylene	1/31	0	0	0.01 ± 0.03	0	<0.01 ± 0.01
Rutland, Vermont - RUVT						
Benzene	28/28	0.96 ± 0.45	0.86 ± 0.24	0.83 ± 0.19	1.27 ± 0.71	0.98 ± 0.20
1,3-Butadiene	27/28	0.12 ± 0.13	0.09 ± 0.04	0.08 ± 0.02	0.18 ± 0.15	0.12 ± 0.05
Carbon Tetrachloride	28/28	0.66 ± 0.16	0.63 ± 0.09	0.62 ± 0.10	0.58 ± 0.13	0.62 ± 0.05
Chloroform	18/28	0.05 ± 0.03	0.09 ± 0.06	0.10 ± 0.06	0.05 ± 0.05	0.07 ± 0.02
Ethylbenzene	28/28	0.20 ± 0.11	0.35 ± 0.13	0.39 ± 0.10	0.28 ± 0.15	0.31 ± 0.06
Tetrachloroethylene	26/28	0.20 ± 0.15	0.19 ± 0.05	0.17 ± 0.04	0.15 ± 0.09	0.18 ± 0.04
Trichloroethylene	2/28	0	0.01 ± 0.01	0.01 ± 0.02	0	<0.01 ± 0.01
Vinyl Chloride	1/28	0.01 ± 0.02	0	0	0	<0.01 ± <0.01
Underhill, Vermont - UNVT						
Acetaldehyde	30/30	0.66 ± 0.09	0.98 ± 0.22	NA	NA	NA
Benzene	60/60	0.51 ± 0.08	0.35 ± 0.06	0.38 ± 0.15	0.44 ± 0.10	0.42 ± 0.05
1,3-Butadiene	12/60	0.01 ± 0.01	<0.01 ± <0.01	0	<0.01 ± <0.01	<0.01 ± <0.01
Carbon Tetrachloride	59/60	0.60 ± 0.13	0.58 ± 0.10	0.64 ± 0.05	0.54 ± 0.09	0.59 ± 0.05
Chloroform	35/60	0.05 ± 0.02	0.07 ± 0.02	0.06 ± 0.02	0.01 ± 0.01	0.05 ± 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 black line are presented in ng/m³ 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/m³)	2nd Quarter Average (µg/m³)	3rd Quarter Average (µg/m³)	4th Quarter Average (µg/m³)	Annual Average (µg/m³)
1,2-Dichloroethane	10/60	0.02 ± 0.02	0.03 ± 0.02	0	0	0.01 ± 0.01
Formaldehyde	30/30	1.35 ± 0.15	2.23 ± 0.51	NA	NA	NA
Tetrachloroethylene	25/60	0.02 ± 0.01	0.04 ± 0.02	0.02 ± 0.01	0.02 ± 0.02	0.02 ± 0.01
Trichloroethylene	1/60	0	<0.01 ± <0.01	0	0	<0.01 ± <0.01
Vinyl Chloride	4/60	<0.01 ± <0.01	<0.01 ± <0.01	0	0	<0.01 ± <0.01
Arsenic (PM$_{10}$)[a]	58/61	0.18 ± 0.07	0.28 ± 0.10	0.20 ± 0.10	0.19 ± 0.07	0.21 ± 0.04
Benzo(a)pyrene [a]	10/60	0.14 ± 0.18	0	0	<0.01 ± <0.01	0.04 ± 0.04
Beryllium (PM$_{10}$) [a]	23/61	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Cadmium (PM$_{10}$) [a]	61/61	0.07 ± 0.02	0.06 ± 0.01	0.05 ± 0.02	0.05 ± 0.01	0.06 ± 0.01
Hexavalent Chromium [a]	12/58	<0.01 ± <0.01	<0.01 ± <0.01	0.01 ± 0.01	<0.01 ± <0.01	<0.01 ± <0.01
Lead (PM$_{10}$) [a]	61/61	1.47 ± 0.36	1.46 ± 0.37	1.28 ± 0.53	1.59 ± 1.17	1.45 ± 0.32
Manganese (PM$_{10}$) [a]	61/61	1.55 ± 0.71	3.12 ± 0.95	1.96 ± 0.59	1.11 ± 0.48	1.94 ± 0.38
Naphthalene [a]	60/60	22.38 ± 7.37	7.10 ± 1.98	7.64 ± 1.75	15.03 ± 3.56	13.17 ± 2.59
Nickel (PM$_{10}$) [a]	61/61	0.26 ± 0.10	0.26 ± 0.06	0.24 ± 0.05	0.29 ± 0.10	0.26 ± 0.04

NA = Not available due to the criteria for calculating a quarterly and/or annual average.
[a] Average concentrations provided for the pollutants below the black line are presented in ng/m³ for ease of viewing.

Observations for BURVT and RUVT from Table 25-5 include the following:

- BURVT and RUVT sampled VOC 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/m³.

- The fourth quarter benzene average for RUVT is higher than the other quarterly averages and has a relatively large confidence interval associated with it. Concentrations of benzene measured at RUVT ranged from 0.455 µg/m³ to 2.91 µg/m³, with the maximum benzene concentration measured on December 28, 2010. The next highest concentration was measured on January 14, 2010 (2.18 µg/m³). These were the only two concentrations greater than

2 µg/m^3 measured at this site. The third highest concentration (1.83 µg/m^3) was measured on November 22, 2010, also in the fourth quarter of 2010. The three highest 1,3-butadiene concentrations were also measured on these three days.

- Chloroform concentrations measured at BURVT and RUVT appear higher during the warmer months of the year, although the confidence intervals indicate that the differences are not statistically significant.

- All of the measured detections of 1,2-dichloroethane for BURVT were measured during the first and second quarters of 2010 with no measured detections after May 14, 2010. This is similar to other NMP sites sampling VOC (including RUVT, for which this pollutant is not a pollutant of interest).

- Trichloroethylene was detected only once at BURVT and twice at RUVT. Vinyl chloride was detected once at RUVT.

Observations for UNVT from Table 25-5 include the following:

- UNVT sampled VOC, carbonyl compounds, PAH, PM$_{10}$ metals, and hexavalent chromium on a 1-in-6 day schedule.

- Carbonyl compound sampling was discontinued at UNVT at the end of the June 2010; thus, annual average concentrations were not calculated for these pollutants. However, Appendix L provides the pollutant-specific average concentration for all valid samples collected at UNVT over the entire sample period.

- For the pollutants of interest for which annual average concentrations could be calculated, carbon tetrachloride, benzene, and chloroform are the pollutants with the 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 has the highest annual average concentration, followed by lead and nickel.

- The first quarter benzene average for UNVT is higher than the other quarterly averages, although the differences are not statistically significant. While the maximum concentration of benzene was measured on July 7, 2010 (1.46 µg/m^3) and is the only benzene measurement greater than 1 µg/m^3, most of the higher benzene measurements were collected during the first and fourth quarters of 2010. Of the 13 measurements greater than 0.5 µg/m^3, six were measured during the first quarter, one each in the second and third quarters, and five were measured during the fourth quarter.

- Chloroform exhibits the same tendency at UNVT as it did at BURVT and UNVT, with the higher quarterly averages calculated for the second and third quarters of the year.

- Similar to BURVT and RUVT, as well as other NMP sites sampling VOC, there were no measured detections of 1,2-dichloroethane measured at UNVT after May 14, 2010.

- Trichloroethylene was detected only once and vinyl chloride was detected only four times at UNVT (three times in the first quarter and once in the second).

- 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 (1.26 ng/m^3) was measured on January 14, 2010 and is nearly three times higher than the next highest concentration (0.451 ng/m^3, measured on March 27, 2010). Of the 10 measured detections of benzo(a)pyrene, nine were measured during the first quarter and one was measured during the fourth quarter, with no measured detections in the second and third quarters of 2010.

- The fourth quarter lead average for UNVT has a relatively large confidence interval associated with it, compared to the other quarterly averages. The maximum concentration of this pollutant (9.20 ng/m^3) was measured on October 11, 2010 and is nearly three times higher than the next highest concentration (3.36 ng/m^3, measured on August 30, 2010). These were the only two measurements greater than 3 ng/m^3 among the 61 measured detections for UNVT. The second highest lead concentration measured during the fourth quarter was measured on December 10, 2010 (2.41 ng/m^3).

- The second quarter manganese average for UNVT is higher than the other quarterly averages (although not statistically so). All five concentrations of manganese greater than 5 ng/m^3 were measured during the second quarter of 2010.

- Concentrations of naphthalene at UNVT tended to be higher during the colder months of the year. The three highest concentrations were all measured in January 2010 and of the 17 highest concentrations (those greater than 15 ng/m^3), eight were measured during the first quarter of the year, one each during the second and third quarter, and seven were measured during the fourth quarter 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 the Vermont monitoring sites from those tables include the following:

- RUVT appears three times in Table 4-9. RUVT has the fourth, eighth, and tenth highest annual average concentrations of vinyl chloride, 1,3-butaidene, and tetrachloroethylene (respectively) among NMP sites sampling VOC.

- UNVT has the eighth highest annual average concentration of vinyl chloride. However, the annual average concentrations of this pollutant for both RUVT and UNVT, as well as all NMP sites sampling this pollutant, are less than 0.01 µg/m^3.

- Because only nine NMP sites sampled PM_{10} metals, all nine sites appear in Table 4-12. UNVT ranks ninth for all six program-wide metal pollutants of interest and last for hexavalent chromium.

- Compared to other NMP sites, UNVT has some of the lowest annual average concentrations for each of the program-wide pollutants of interest.

25.4.2 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 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, and naphthalene for UNVT. Figures 25-15 through 25-21 overlay the sites' minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 25-15. Program vs. Site-Specific Average Arsenic (PM_{10}) Concentration
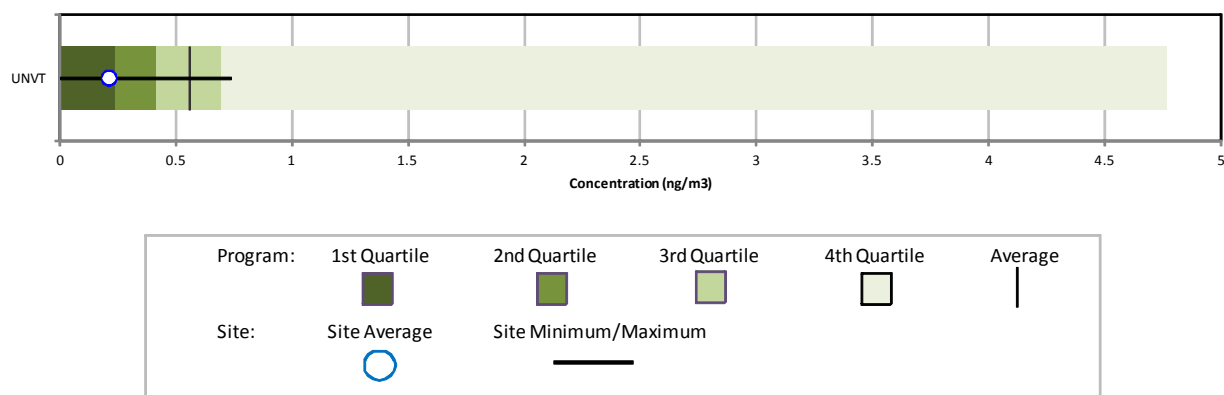
Figure 25-16. Program vs. Site-Specific Average Benzene Concentration
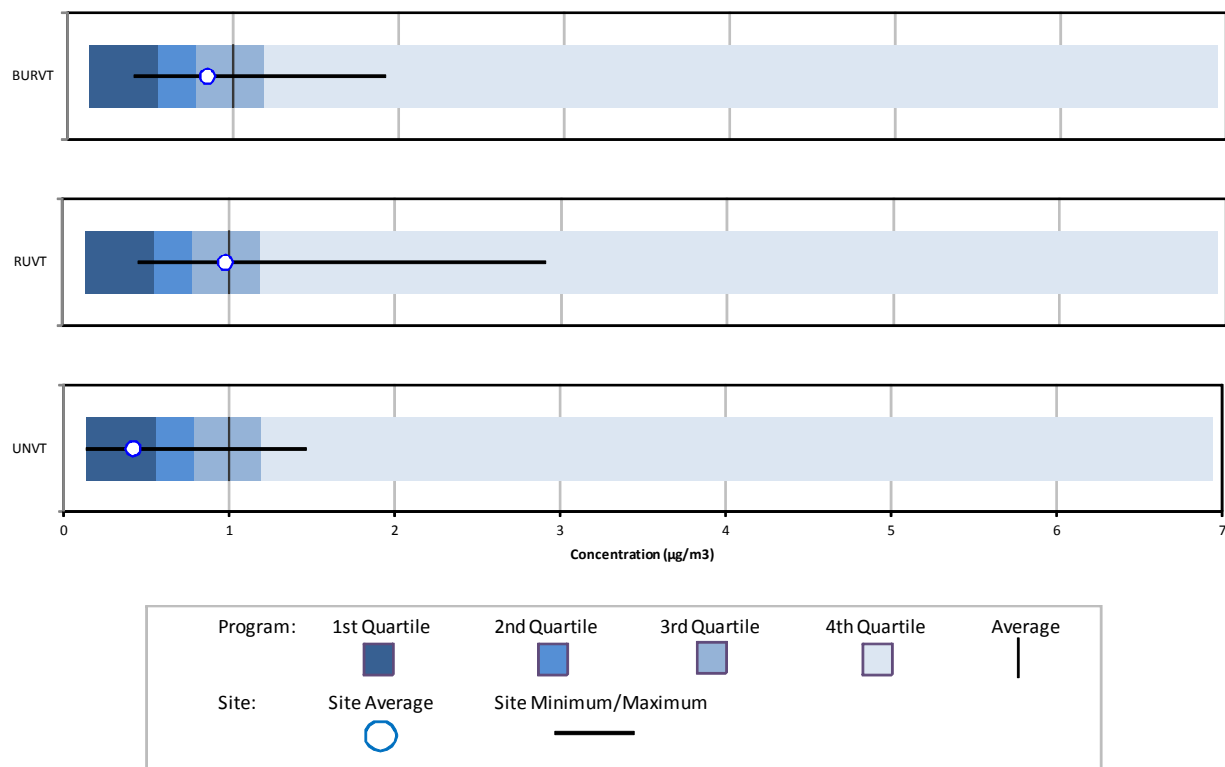
Figure 25-17. Program vs. Site-Specific Average Benzo(a)pyrene Concentration
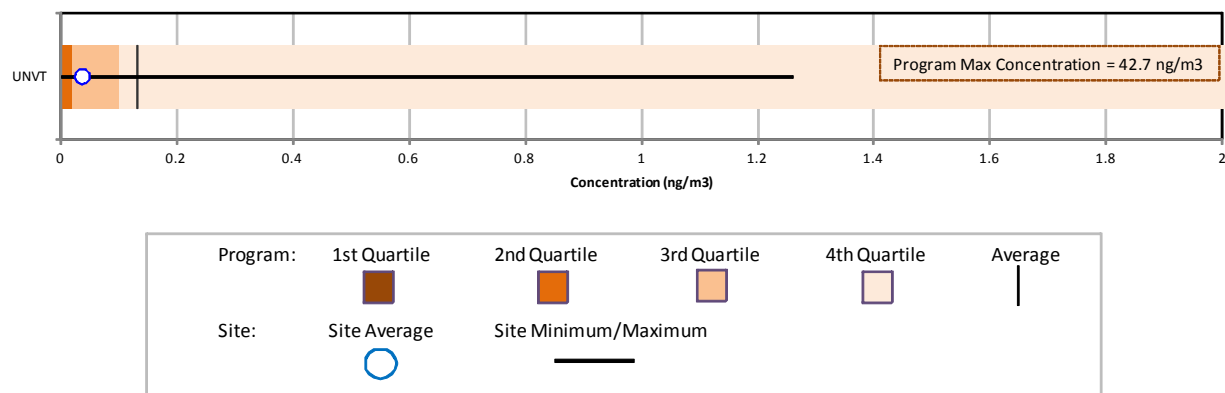
Figure 25-18. Program vs. Site-Specific Average 1,3-Butadiene Concentration
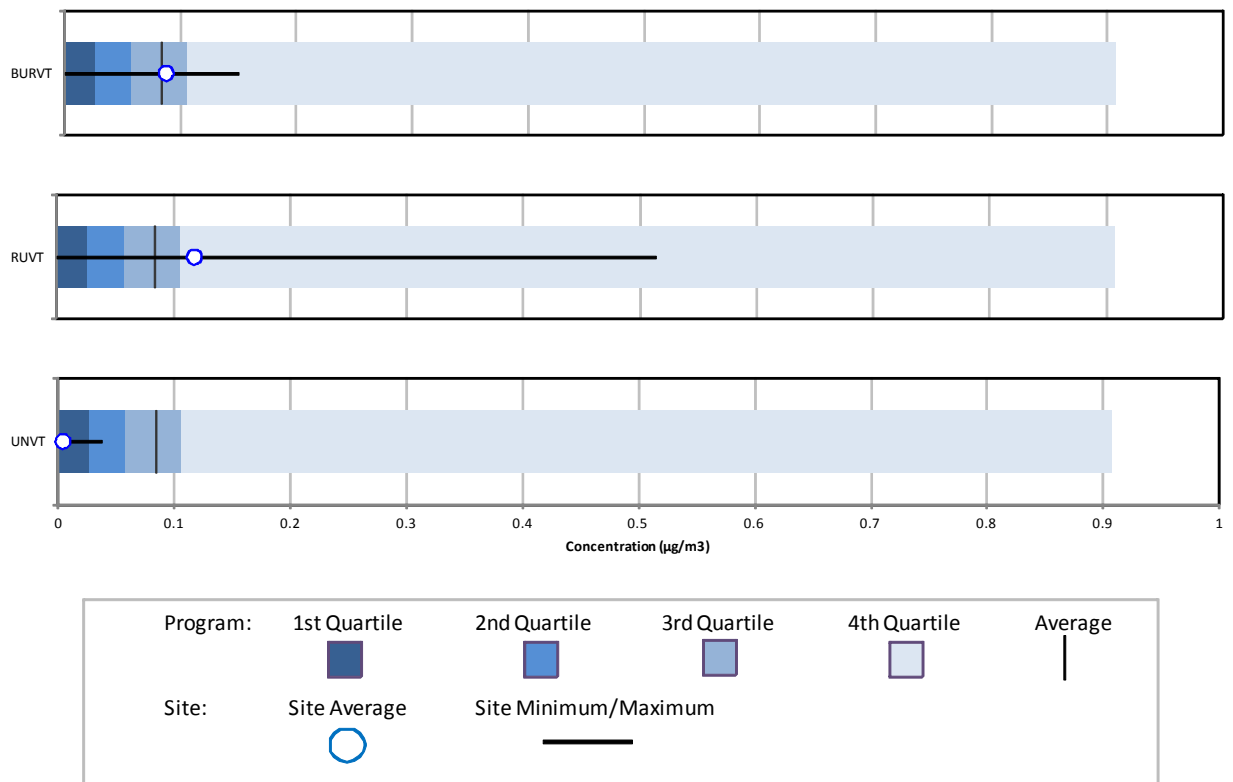
Figure 25-19. Program vs. Site-Specific Average Hexavalent Chromium Concentration
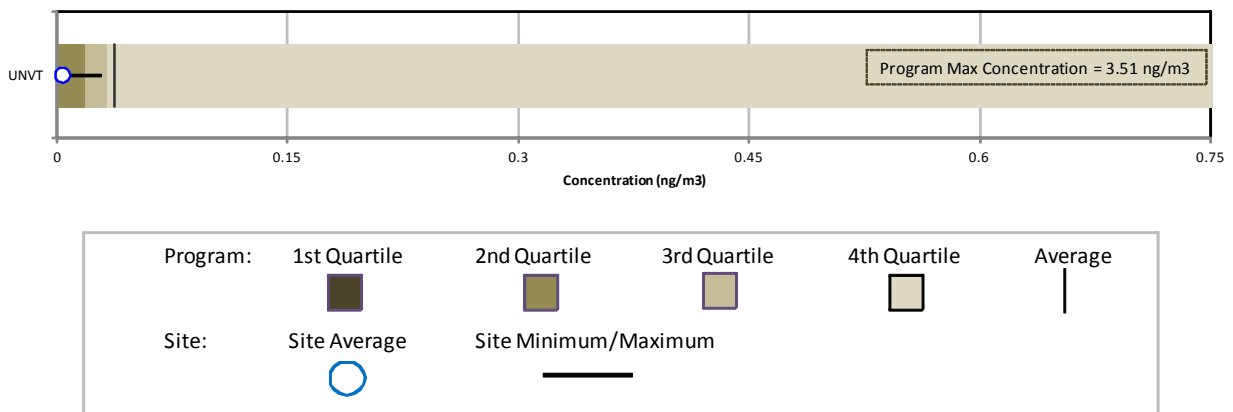
Figure 25-20. Program vs. Site-Specific Average Manganese (PM$_{10}$) Concentration
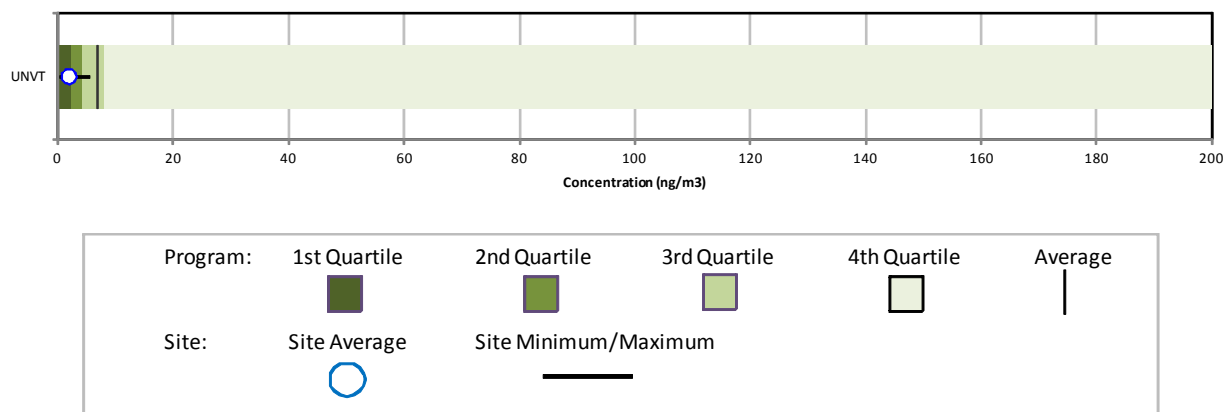
Figure 25-21. Program vs. Site-Specific Average Naphthalene Concentration
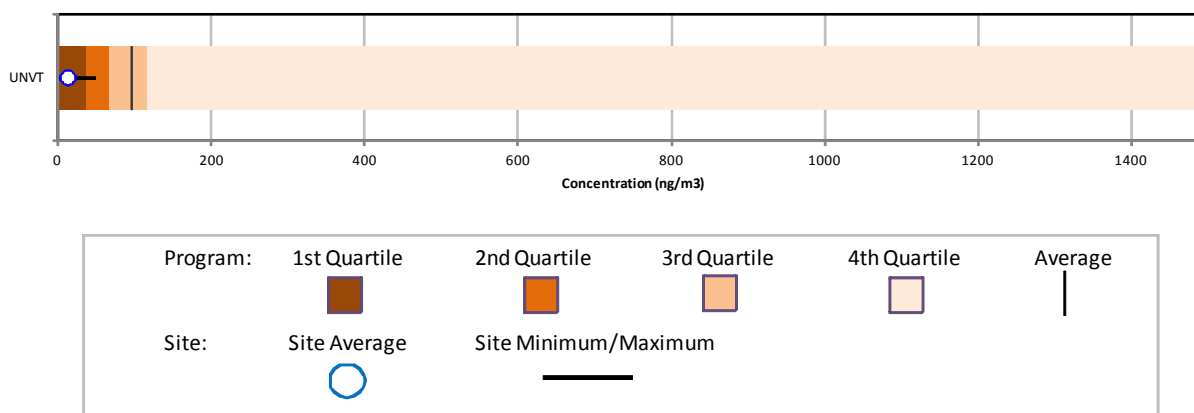
Observations from Figures 25-15 through 25-21 include the following:

- Figure 25-15 shows that UNVT's annual average arsenic (PM$_{10}$) concentration is well below the program-level average and median concentrations for arsenic (PM$_{10}$) as well as 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. A few non-detects of arsenic were measured at UNVT.

- Figure 25-16 for benzene shows all three Vermont sites. 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 below the program-level average, median, and first quartile (25th percentile) concentrations (and the lowest among all NMP sites sampling benzene). The range of benzene measurements is smallest for UNVT and largest for RUVT, although there were no non-detects of benzene measured at the Vermont sites.

- Figure 25-17 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 UNVT is less than the program-level average concentration. Although the maximum concentration measured at UNVT is well below the maximum concentration measured across the program, the January 14, 2010 measurement (1.26 ng/m^3) is the fifth highest concentration of this pollutant measured among NMP sites sampling PAH. However, more than 80 percent of the measurements at UNVT were non-detects.

- Figure 25-18 for 1,3-butadiene also shows all three sites. The annual average concentration is highest for RUVT and lowest for UNVT, among the Vermont sites. The annual averages for BURVT and RUVT are greater than the program-level average concentration while the annual average for UNVT is the lowest of all NMP sites sampling this pollutant. Although the maximum concentration measured at RUVT is well below the maximum concentration across the program, the December 28, 2010 measurement (0.514 µg/m^3) is the eleventh highest 1,3-butadiene concentration across the program (for Method TO-15). A single non-detects of 1,3-butadiene was measured at RUVT, two were measured at BURVT, and 80 percent of the measurements were non-detects for UNVT.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 25-19 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/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 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 25-19 shows the annual average concentration of hexavalent chromium for UNVT is less than both the program-level average and median concentrations. Similar to 1,3-butadiene, the annual average concentration for UNVT is the lowest annual average hexavalent chromium concentration among NMP sites sampling this pollutant. Nearly 80 percent of the measurements of hexavalent chromium were non-detects for UNVT.

- Figure 25-20 shows the annual average concentration of manganese (PM$_{10}$) for UNVT is less than the program-level average, median, and first quartile (25th percentile) concentrations for this pollutant. The annual average concentration of manganese for UNVT is the lowest annual average concentration among NMP sites sampling this pollutant, even though there were no non-detects of manganese measured at UNVT.

- Figure 25-21 shows that the annual naphthalene average for UNVT is also less than the program-level average, median, and first quartile (25th percentile) concentrations. The maximum naphthalene concentration measured at UNVT is less than the program-level median concentration. UNVT's annual average

naphthalene concentration is the lowest annual average concentration of this pollutant among NMP sites sampling PAH (even though there were no non-detects of naphthalene measured at UNVT).

- Recall that annual averages could not be calculated for formaldehyde and acetaldehyde, as discussed in Section 25.4.1.

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 25-22 presents the 3-year rolling statistical metrics for hexavalent chromium for UNVT. The statistical metrics presented for calculating trends include the substitution of zeros for non-detects.

Observations from Figure 25-22 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.

- The rolling average concentration has decreased since the onset of sampling. However, the confidence intervals calculated for the first two 3-year periods are very large due to the presence of outliers. The 95th percentile exhibits a similar decreasing trend as the rolling average.

- 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 number 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.

**Figure 25-22. Three-Year Rolling Statistical Metrics for Hexavalent Chromium
Concentrations Measured at UNVT**
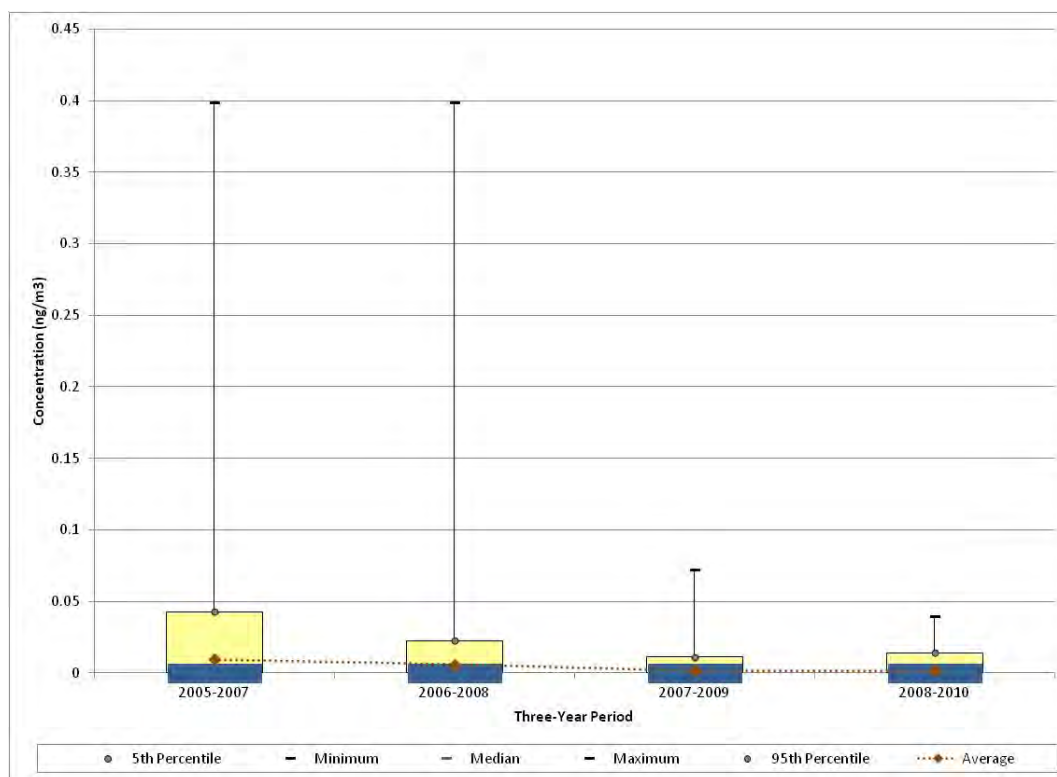
25.5 Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

25.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Vermont monitoring sites to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for each site were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Vermont monitoring sites were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for the Vermont monitoring sites.

25.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Vermont monitoring sites and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 25-6, where applicable.

Table 25-6. Cancer and Noncancer Surrogate Risk Approximations for the Vermont Monitoring Sites

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Burlington, Vermont - BURVT						
Benzene	0.0000078	0.03	31/31	0.85 ± 0.11	6.60	0.03
1,3-Butadiene	0.00003	0.002	29/31	0.09 ± 0.01	2.64	0.04
Carbon Tetrachloride	0.000006	0.1	30/31	0.54 ± 0.06	3.26	0.01
Chloroform	--	0.098	21/31	0.08 ± 0.02	--	<0.01
1,2-Dichloroethane	0.000026	2.4	6/31	0.01 ± 0.01	0.36	<0.01
Ethylbenzene	0.0000025	1	31/31	0.26 ± 0.04	0.66	<0.01
Tetrachloroethylene	2.6E-07	0.04	27/31	0.09 ± 0.03	0.02	<0.01
Trichloroethylene	0.0000048	0.002	1/31	<0.01 ± 0.01	0.02	<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 25-5.

Table 25-6. Cancer and Noncancer Surrogate Risk Approximations for the Vermont Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Rutland, Vermont - RUVT						
Benzene	0.0000078	0.03	28/28	0.98 ± 0.20	7.63	0.03
1,3-Butadiene	0.00003	0.002	27/28	0.12 ± 0.05	3.54	0.06
Carbon Tetrachloride	0.000006	0.1	28/28	0.62 ± 0.05	3.73	0.01
Chloroform	--	0.098	18/28	0.07 ± 0.02	--	<0.01
Ethylbenzene	0.0000025	1	28/28	0.31 ± 0.06	0.76	<0.01
Tetrachloroethylene	2.6E-07	0.04	26/28	0.18 ± 0.04	0.05	<0.01
Trichloroethylene	0.0000048	0.002	2/28	<0.01 ± 0.01	0.02	<0.01
Vinyl Chloride	0.0000088	0.1	1/28	<0.01 ± <0.01	0.02	<0.01
Underhill, Vermont - UNVT						
Acetaldehyde	0.0000022	0.009	30/30	NA	NA	NA
Arsenic (PM_{10}) [a]	0.0043	0.000015	58/61	<0.01 ± <0.01	0.91	0.01
Benzene	0.0000078	0.03	60/60	0.42 ± 0.05	3.25	0.01
Benzo(a)pyrene [a]	0.00176	--	10/60	<0.01 ± <0.01	0.06	--
Beryllium (PM_{10}) [a]	0.0024	0.00002	23/61	<0.01 ± <0.01	<0.01	<0.01
1,3-Butadiene	0.00003	0.002	12/60	<0.01 ± <0.01	0.12	<0.01
Cadmium (PM_{10}) [a]	0.0018	0.00001	61/61	<0.01 ± <0.01	0.10	0.01
Carbon Tetrachloride	0.000006	0.1	59/60	0.59 ± 0.05	3.55	0.01
Chloroform	--	0.098	35/60	0.05 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	10/60	0.01 ± 0.01	0.31	<0.01
Formaldehyde	0.000013	0.0098	30/30	NA	NA	NA
Hexavalent Chromium [a]	0.012	0.0001	12/58	<0.01 ± <0.01	0.04	<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 25-5.

Table 25-6. Cancer and Noncancer Surrogate Risk Approximations for the Vermont Monitoring Sites (Continued)

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average $(\mu g/m^3)$	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Lead (PM$_{10}$) [a]	--	0.00015	61/61	<0.01 ± <0.01	--	0.01
Manganese (PM$_{10}$) [a]	--	0.00005	61/61	<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	61/61	<0.01 ± <0.01	0.13	<0.01
Tetrachloroethylene	2.6E-07	0.04	25/60	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	4/60	<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 25-5.

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 (6.60 in-a-million and 3.26 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 (7.63 in-a-million and 3.73 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 (3.55 in-a-million and 3.25 in-a-million, respectively).

- The noncancer risk approximations for the pollutants of interest for all three Vermont sites are well below the level of concern, indicating virtually no noncancer health risks attributable to these pollutants.

25.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 25-7 and 25-8 present a risk-based 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. Table 25-8 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 25-7 and 25-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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. As discussed in Section 25.3, UNVT sampled for VOC, carbonyl compounds, PAH, metals (PM_{10}), and hexavalent chromium; BURVT and RUVT sampled for VOC only. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	6.60
Formaldehyde	57.01	Formaldehyde	7.41E-04	Carbon Tetrachloride	3.26
Ethylbenzene	42.71	1,3-Butadiene	3.90E-04	1,3-Butadiene	2.64
Acetaldehyde	30.61	Hexavalent Chromium, PM	2.57E-04	Ethylbenzene	0.66
1,3-Butadiene	12.99	POM, Group 3	2.46E-04	1,2-Dichloroethane	0.36
Dichloromethane	7.10	Arsenic, PM	2.44E-04	Tetrachloroethylene	0.02
Naphthalene	6.54	Naphthalene	2.22E-04	Trichloroethylene	0.02
POM, Group 2b	1.69	POM, Group 2b	1.49E-04		
POM, Group 6	0.20	POM, Group 5a	1.24E-04		
POM, Group 1a	0.12	Ethylbenzene	1.07E-04		
Underhill, Vermont (Chittenden County) - UNVT					
Benzene	117.39	Benzene	9.16E-04	Carbon Tetrachloride	3.55
Formaldehyde	57.01	Formaldehyde	7.41E-04	Benzene	3.25
Ethylbenzene	42.71	1,3-Butadiene	3.90E-04	Arsenic	0.91
Acetaldehyde	30.61	Hexavalent Chromium, PM	2.57E-04	Naphthalene	0.45
1,3-Butadiene	12.99	POM, Group 3	2.46E-04	1,2-Dichloroethane	0.31
Dichloromethane	7.10	Arsenic, PM	2.44E-04	Nickel	0.13
Naphthalene	6.54	Naphthalene	2.22E-04	1,3-Butadiene	0.12
POM, Group 2b	1.69	POM, Group 2b	1.49E-04	Cadmium	0.10
POM, Group 6	0.20	POM, Group 5a	1.24E-04	Benzo(a)pyrene	0.06
POM, Group 1a	0.12	Ethylbenzene	1.07E-04	Hexavalent Chromium	0.04

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 Risk Factors (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	7.63
Formaldehyde	24.42	Formaldehyde	3.17E-04	Carbon Tetrachloride	3.73
Ethylbenzene	20.01	1,3-Butadiene	1.94E-04	1,3-Butadiene	3.54
Acetaldehyde	14.97	POM, Group 3	1.38E-04	Ethylbenzene	0.76
1,3-Butadiene	6.47	Hexavalent Chromium, PM	1.24E-04	Tetrachloroethylene	0.05
Naphthalene	3.14	Naphthalene	1.07E-04	Trichloroethylene	0.02
POM, Group 2b	0.93	POM, Group 2b	8.17E-05	Vinyl Chloride	0.02
Dichloromethane	0.47	POM, Group 5a	6.57E-05		
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 Risk Approximations for Pollutants with Noncancer RfCs for the Vermont Monitoring Sites

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Burlington, Vermont (Chittenden County) - BURVT					
Toluene	221.14	Acrolein	552,694.88	1,3-Butadiene	0.04
Xylenes	170.08	Manganese, PM	67,632.70	Benzene	0.03
Benzene	117.39	Chlorine	13,450.30	Carbon Tetrachloride	0.01
Methanol	88.67	1,3-Butadiene	6,493.30	Tetrachloroethylene	<0.01
Formaldehyde	57.01	Formaldehyde	5,817.27	Trichloroethylene	<0.01
Ethylbenzene	42.71	Benzene	3,912.93	Chloroform	<0.01
Hexane	41.71	Arsenic, PM	3,782.88	Ethylbenzene	<0.01
Hydrochloric acid	41.61	Acetaldehyde	3,400.90	1,2-Dichloroethane	<0.01
Acetaldehyde	30.61	Cyanide Compounds, gas	2,550.52		
1,3-Butadiene	12.99	Naphthalene	2,180.85		
Underhill, Vermont (Chittenden County) - UNVT					
Toluene	221.14	Acrolein	552,694.88	Manganese	0.04
Xylenes	170.08	Manganese, PM	67,632.70	Arsenic	0.01
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	Carbon Tetrachloride	0.01
Ethylbenzene	42.71	Benzene	3,912.93	Cadmium	0.01
Hexane	41.71	Arsenic, PM	3,782.88	Naphthalene	<0.01
Hydrochloric acid	41.61	Acetaldehyde	3,400.90	Nickel	<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	Tetrachloroethylene	<0.01

Table 25-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Vermont Monitoring Sites (Continued)

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Rutland, Vermont (Rutland County) - RUVT					
Toluene	121.10	Acrolein	74,401.74	1,3-Butadiene	0.06
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	Vinyl Chloride	<0.01
1,3-Butadiene	6.47	Arsenic, PM	462.98		
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 were nearly twice as high in Chittenden County than in Rutland County.

- Benzene and formaldehyde are also the pollutants with the highest toxicity-weighted emissions (of the pollutants with cancer UREs) for both counties, followed by 1,3-butadiene.

- 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. Ethylbenzene and 1,3-butadiene also appear on all three lists for BURVT and RUVT. While 1,3-butadiene appears on all three lists for UNVT, ethylbenzene is not a pollutant of interest for this site.

- Among UNVT's non-VOC pollutants of interest, naphthalene appears on all three lists. Three additional pollutants, hexavalent chromium, arsenic, and benzo(a)pyrene, are among the pollutants with the highest cancer risk approximations for UNVT and are among the pollutants with the highest toxicity-weighted emissions. Note that benzo(a)pyrene is part of POM, Group 5a. None of these three pollutants are among the highest emitted in Chittenden County.

- POM, Group 2b is the eighth highest emitted "pollutant" in Chittenden County and ranks eighth for toxicity-weighted emissions. POM, Group 2b includes several PAH sampled for at UNVT including acenaphthylene, fluoranthene, and perylene. None of the PAH 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 PAH 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.

- Acrolein is the pollutant with the highest toxicity-weighted emissions (of the pollutants with noncancer RfCs) for 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 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 four of the highest emitted pollutants for Rutland County also have the highest toxicity-weighted emissions.

- Although very low, 1,3-butadiene, benzene, and carbon tetrachloride have the highest noncancer risk approximations for BURVT and RUVT. While benzene and 1,3-butadiene appear on both emissions-based lists, carbon tetrachloride appears on neither emissions-based list.

- Although very low, manganese and arsenic have the highest noncancer risk 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 2010 Monitoring Data for the Vermont Monitoring Sites

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

- ❖ *A total of eight pollutants failed screens for BURVT; six pollutants failed screens for RUVT; and 13 pollutants failed screens for UNVT.*

- ❖ *Benzene and carbon tetrachloride have the highest annual average concentrations among the pollutants of interest for BURVT and RUVT while carbon tetrachloride's annual average concentration for UNVT was greater than benzene's annual average concentration. None of the annual average concentrations for the pollutants of interest for the Vermont 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.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest, where they could be calculated, were greater than their associated MRL noncancer health risk benchmarks.*

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 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 26-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 26-1. Richmond, Virginia (RIVA) Monitoring Site
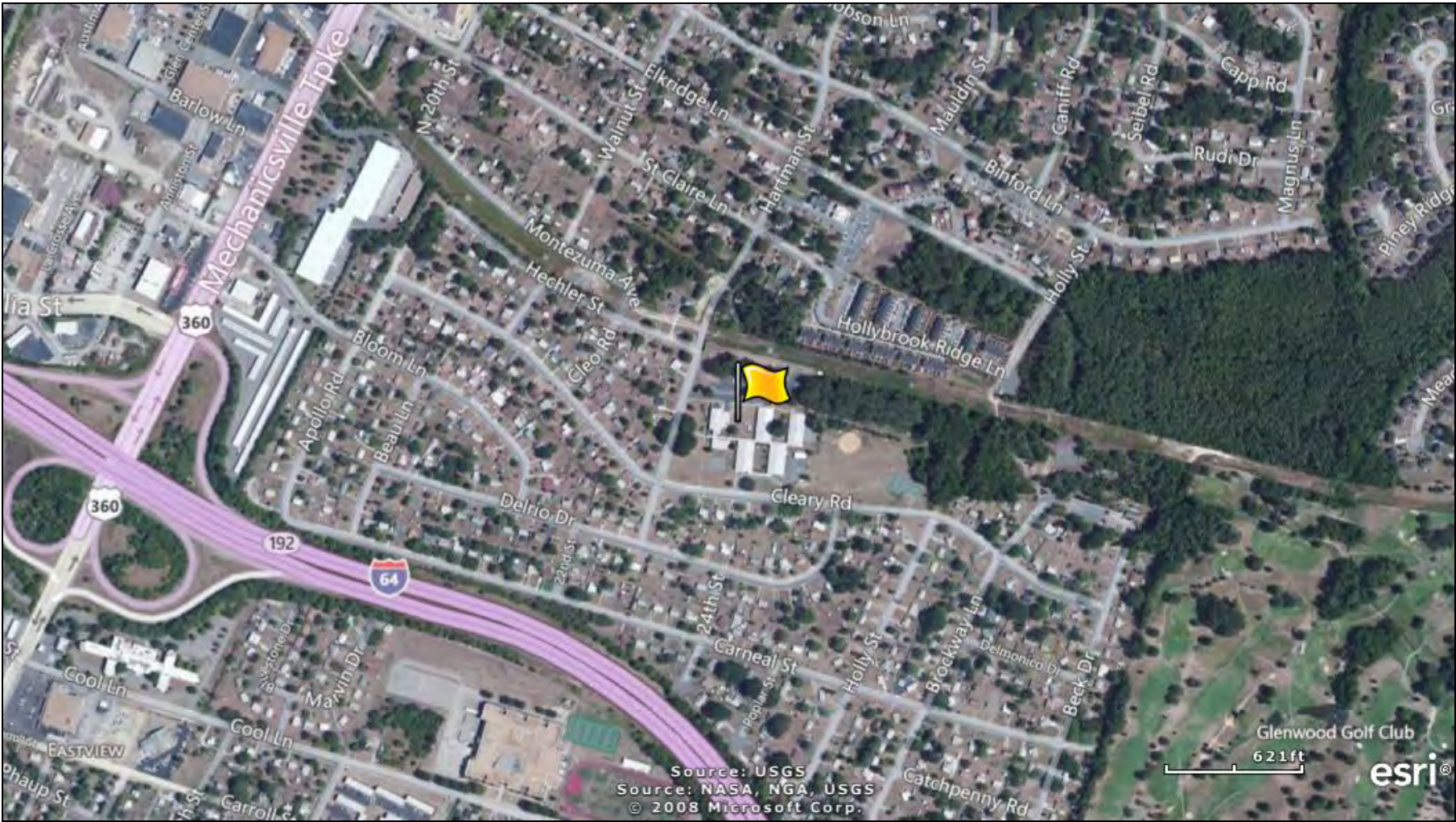
Figure 26-2. NEI Point Sources Located Within 10 Miles of RIVA
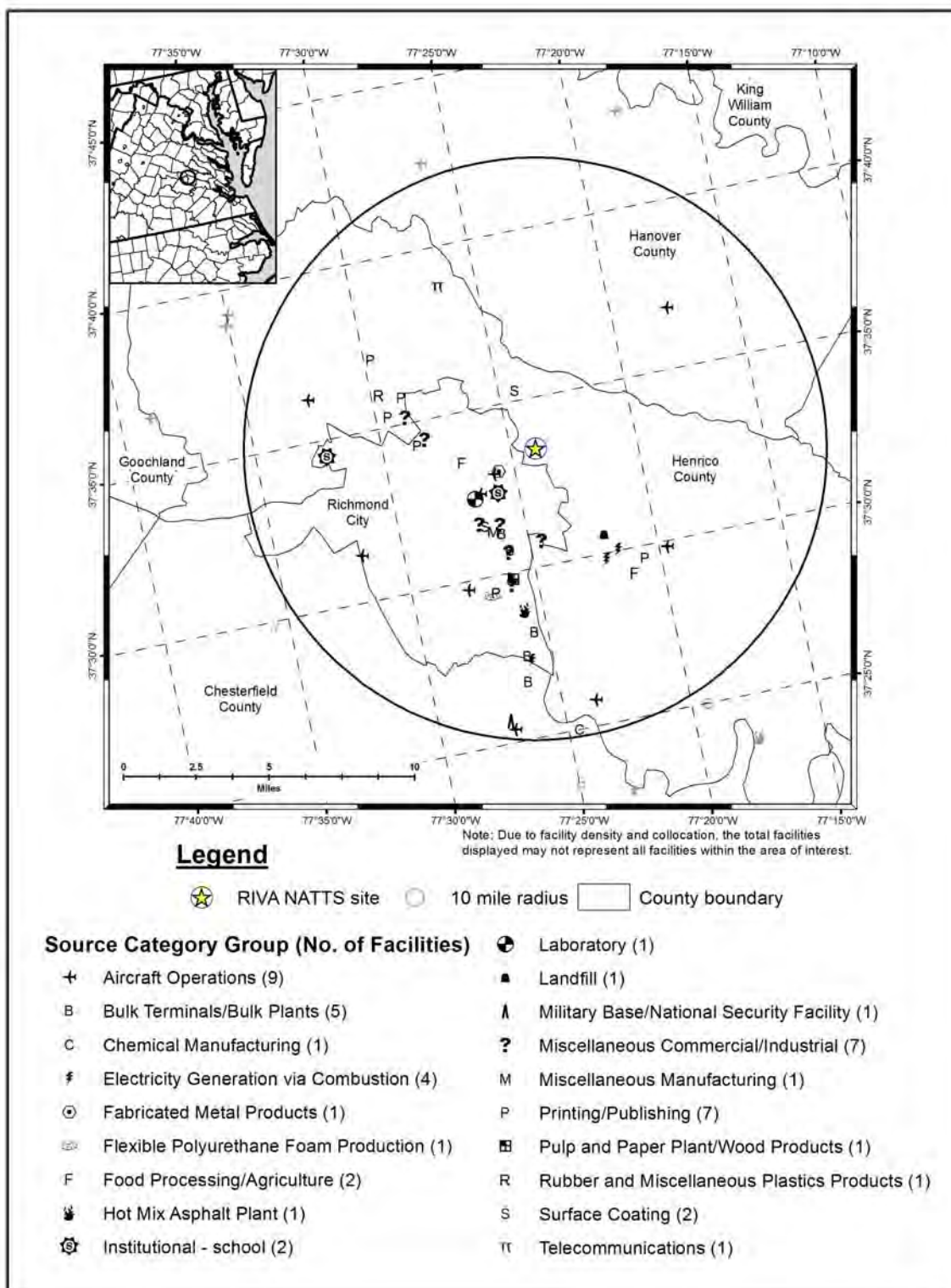
Table 26-1. Geographical Information for the Virginia Monitoring Site

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, NMOC, VOC, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Metals, PM Coarse, $PM_{2.5}$, and $PM_{2.5}$ Speciation, CO, Tetrahydrofuran.

[1] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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 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 highest 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Virginia monitoring site. Table 26-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 26-2 also contains annual average daily traffic information. Finally, Table 26-2 presents the 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	307,435	347,790	1.13	460,195	520,602	74,000	8,260,273

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Revenue Division of the County of Henrico (Henrico County, 2011)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2009 data from the Virginia DOT (VA DOT, 2009)
[5] County-level VMT reflects 2010 data from the Virginia DOT (VA DOT, 2011)
BOLD ITALICS = EPA-designated NATTS Site.

Observations from Table 26-2 include the following:

- RIVA's county-level population is in the lower third compared to other counties with NMP sites. The 10-mile population is in the middle of the range among NMP sites.

- The county-level vehicle ownership and 10-mile vehicle ownership are in the middle of the ranged 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 estimate used came from the interchange of US-360 (Mechanicsville Turnpike) and I-64.

- The VMT for Henrico County is in the middle of the range compared to other county with NMP sites.

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 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for 2010 (NCDC, 2010). 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 normal conditions 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	Sample Day	69.5 ± 5.3	59.3 ± 4.9	44.8 ± 4.9	51.9 ± 4.4	62.5 ± 3.3	1015.5 ± 1.8	6.3 ± 0.8
	118° (ESE)	2010	70.0 ± 2.1	59.8 ± 1.9	45.1 ± 2.0	52.3 ± 1.7	62.2 ± 1.4	1015.6 ± 0.7	6.3 ± 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 for 2010. 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 2010. Included in Figure 26-3 are four back trajectories per sample day. Figure 26-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, each concentric circle around the site in Figures 26-3 and 26-4 represents 100 miles.

Figure 26-3. 2010 Composite Back Trajectory Map for RIVA
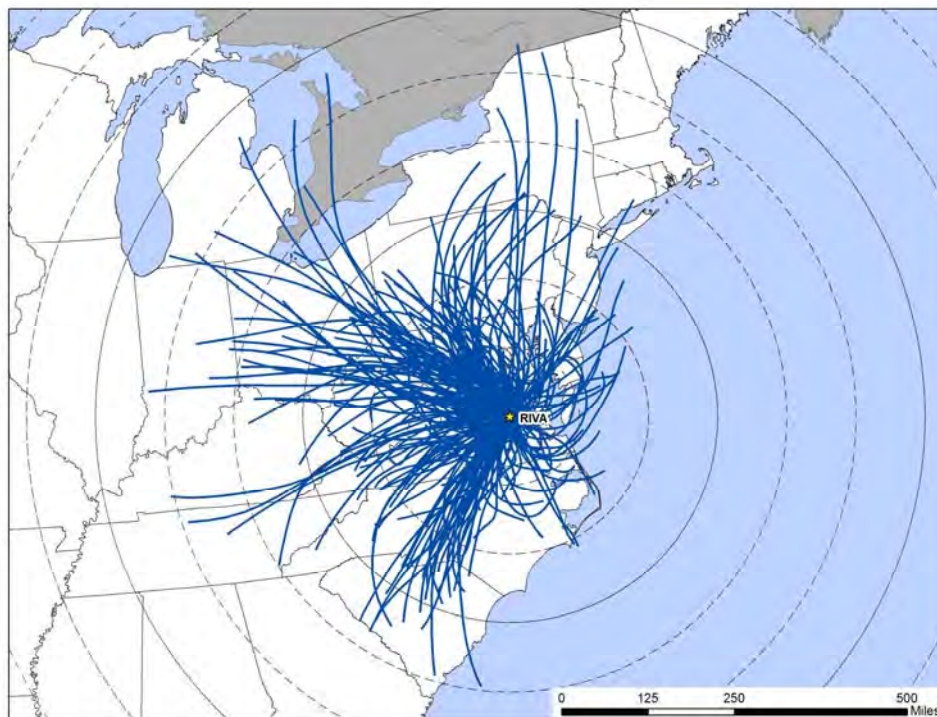
Figure 26-4. Back Trajectory Cluster Map for RIVA

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 primarily to the southwest, west, and northwest of the site.

- 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 Georgian Bay, northwest of Toronto, Canada, or over 550 miles away. However, the average trajectory distance is 230 miles and most (91 percent) trajectories originated within 400 miles of the site.

- The cluster analysis shows that the majority of trajectories originated from the southwest, west, and northwest. Twenty-four percent originated from the southwest to west over Virginia, North Carolina, and South Carolina. Thirty-five percent of trajectories originated from the west and northwest, but of different lengths, which is why they are represented by two different cluster trajectories (12 and 23 percent). The short trajectory originating due south of RIVA (20 percent) represents trajectories originating from the southeast and east, but also several trajectories originating within approximately 100 miles of the site over central Virginia. Another 21 percent of trajectories originated from the north to northeast of the site.

26.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the RIVA monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location.

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 14 percent of the hourly wind measurements.

- The 2010 wind rose resembles the historical wind rose in some ways but exhibits deviations as well. While the northerly prominence is the same for both, the 2010 wind rose exhibits a shift from southerly to southwesterly winds to a more even distribution of winds from the southwest to west to northwest.

- The sample day wind patterns are similar to the full-year wind patterns, indicating that winds conditions on sample days were representative of those experienced throughout 2010.

Figure 26-5. Wind Roses for the Richmond International Airport Weather Station near RIVA

1999-2009 Historical Wind Rose

2010 Wind Rose

2010 Sample Day Wind Rose
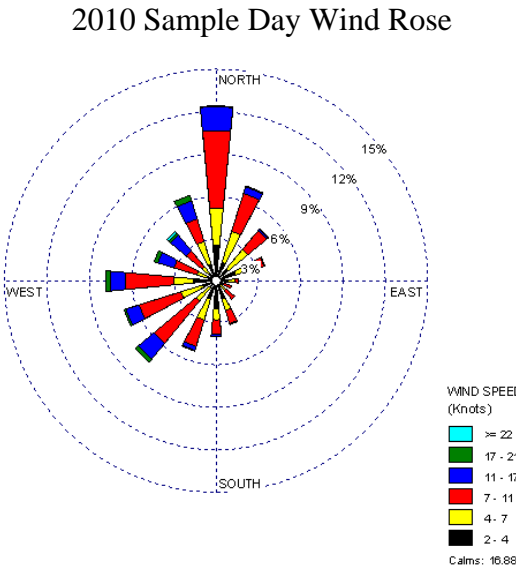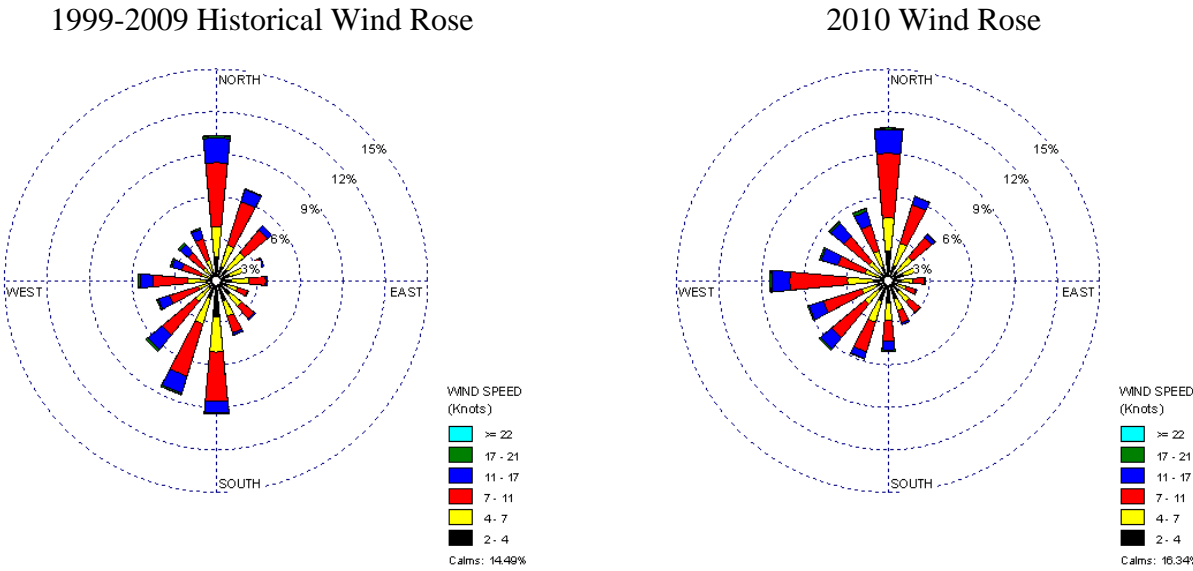
Distance between RIVA and NWS Station

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 26-4 presents the pollutants of interest 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 PAH and hexavalent chromium.

Table 26-4. Risk Screening Results for the Virginia Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Richmond, Virginia - RIVA						
Naphthalene	0.029	58	60	96.67	95.08	95.08
Acenaphthene	0.011	1	60	1.67	1.64	96.72
Benzo(a)pyrene	0.00057	1	23	4.35	1.64	98.36
Fluorene	0.011	1	60	1.67	1.64	100.00
Total		61	203	30.05		

Observations from Table 26-4 include the following:

- Although four PAH failed screens for RIVA, naphthalene contributed to more than 95 percent of the total failed screens, while the other pollutants accounted for one failed screen each.

- The maximum concentrations of naphthalene, acenaphthene, and fluorene were all measured on August 30, 2010 for RIVA. For acenaphthene and fluorene, the August 30th concentrations were the only ones to fail screens.

- The risk screening process identified naphthalene as RIVA's only pollutant of interest. Benzo(a)pyrene was added to this site's pollutants of interest because it is a NATTS MQO Core Analyte, although it did not contribute to 95 percent of the failed screens. Hexavalent chromium was also added to the pollutants of interest for RIVA because it too is a NATTS MQO Core Analyte, even though it did not fail any screens. This pollutant is not shown in Table 26-4.

26.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Virginia monitoring site. Concentration averages are provided for the pollutants of interest for the RIVA monitoring site, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices M and O.

26.4.1 2010 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						
Benzo(a)pyrene	23/60	0.16 ± 0.09	0.01 ± 0.01	0	0.13 ± 0.09	0.08 ± 0.04
Hexavalent Chromium	34/61	<0.01 ± <0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± <0.01	0.01 ± <0.01
Naphthalene	60/60	108.51 ± 44.85	95.05 ± 29.50	93.64 ± 32.17	127.48 ± 32.29	106.17 ± 16.89

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 hexavalent chromium and benzo(a)pyrene.

- The quarterly averages of benzo(a)pyrene are higher in the colder months of the year and lower in the warmer months of the year. In fact, this pollutant was not detected in the third quarter of 2010, and was only detected twice during the second quarter of 2010. Thus, 21 of the 23 measured detections were measured during the first and fourth quarters of the year.

- The quarterly averages of hexavalent chromium did not vary significantly from quarter to quarter.

- Naphthalene appears to exhibit a similar quarterly trend as benzo(a)pyrene, but the confidence intervals indicate that the difference is not statistically significant.

26.4.2 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 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, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 26-6. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Program Max Concentration = 42.7 ng/m3

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
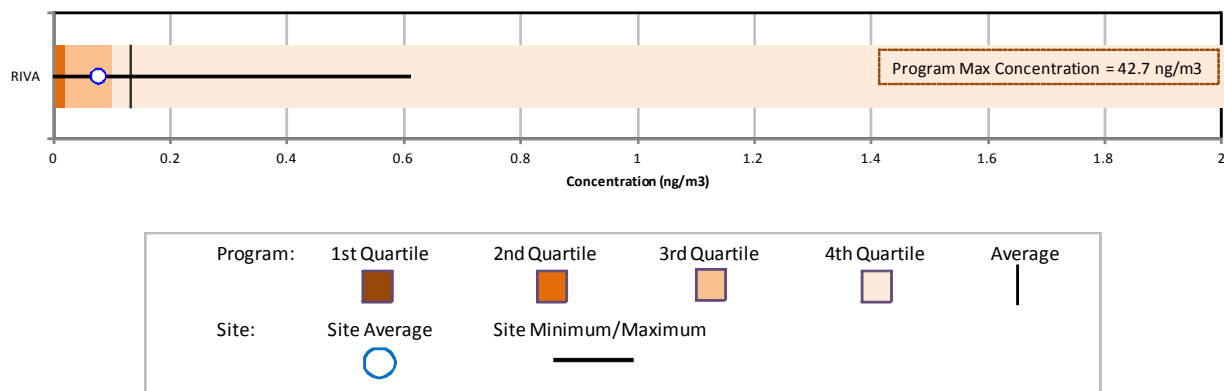
Figure 26-7. Program vs. Site-Specific Average Hexavalent Chromium Concentration

Program Max Concentration = 3.51 ng/m3

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
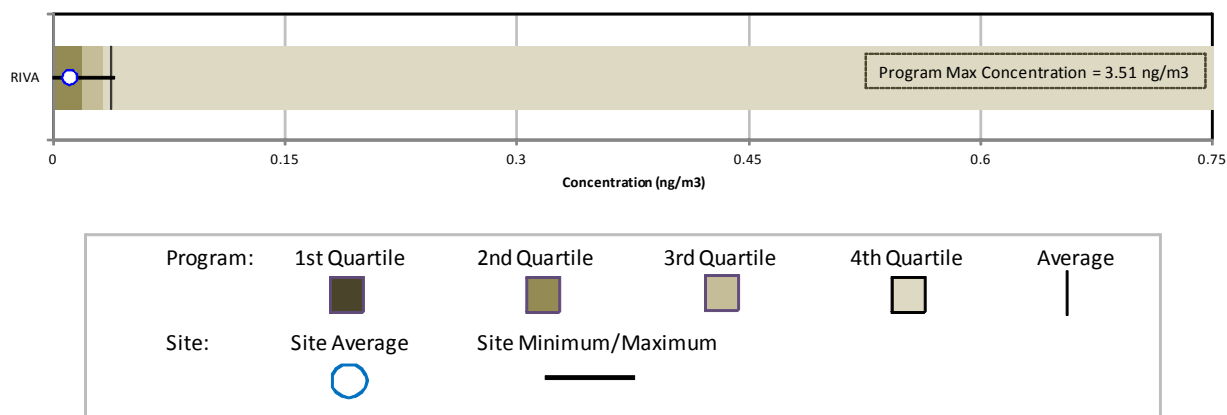
Figure 26-8. Program vs. Site-Specific Average Naphthalene Concentration

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |

26-15
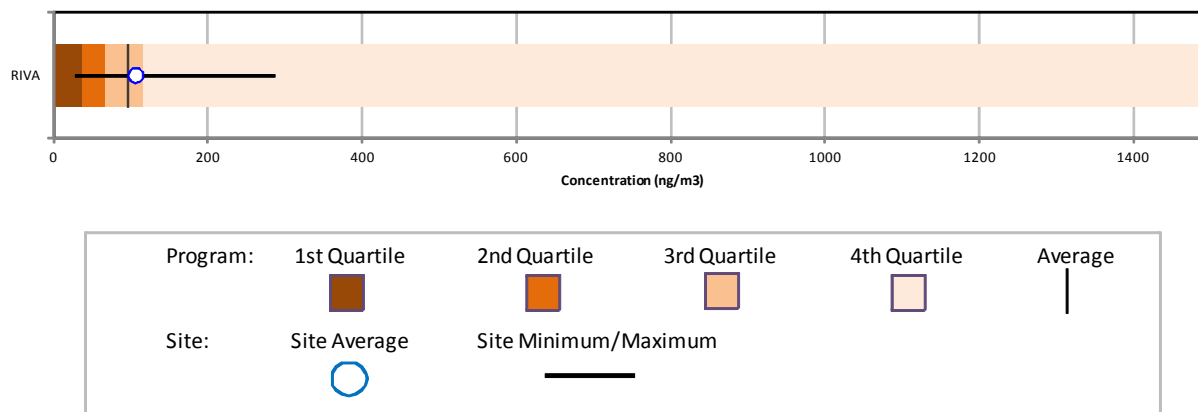
Observations from Figures 26-6 through 26-8 include the following:

- Figure 26-6 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 less than the program-level average concentration. Figure 26-6 also shows that the maximum concentration measured at RIVA is well below the maximum concentration measured across the program. Several non-detects of benzo(a)pyrene were measured at RIVA.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 26-7 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 26-7 shows the annual average concentration of hexavalent chromium for RIVA is less than the program-level average concentration as well as the program-level median concentration. The maximum concentration measured at RIVA is just greater than the program-level average concentration. Several non-detects of hexavalent chromium were measured at RIVA.

- Figure 26-8 shows that the annual naphthalene average for RIVA is greater than the program-level average concentration. The maximum naphthalene concentration measured at RIVA is well below the program-level maximum concentration. There were no non-detects of naphthalene measured at RIVA.

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 3.5.3. RIVA did not begin sampling PAH or hexavalent chromium under the NMP until October 2008; therefore, the trends analysis was not conducted.

26.5 Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

26.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Virginia monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Virginia monitoring site were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for RIVA.

26.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Virginia monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 26-6, where applicable.

Table 26-6. Cancer and Noncancer Surrogate Risk Approximations for the Virginia Monitoring Site

Pollutant	Cancer URE $(\mu g/m^3)^{-1}$	Noncancer RfC (mg/m^3)	# of Measured Detections vs. # of Samples	Annual Average (ng/m^3)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Richmond, Virginia - RIVA						
Benzo(a)pyrene	0.00176	--	23/60	0.08 ± 0.04	0.13	--
Hexavalent Chromium	0.012	0.0001	34/61	0.01 ± <0.01	0.13	<0.01
Naphthalene	0.000034	0.003	60/60	106.17 ± 16.89	3.61	0.04

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

Observations for RIVA from Table 26-6 include the following:

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

- The cancer surrogate risk approximation for naphthalene is 3.61 in-a-million. The cancer risk approximations for benzo(a)pyrene and hexavalent chromium are well below 1.0 in-a-million.

- The noncancer risk approximations for hexavalent chromium and naphthalene are well below than the level of concern for noncancer, which is an HQ of 1.0. There is not a noncancer RfC for benzo(a)pyrene.

26.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 26-7 and 26-8 present a risk-based 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 26-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Tables 26-7 and 26-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 PAH and hexavalent chromium. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	3.61
Formaldehyde	90.51	Benzene	8.99E-04	Benzo(a)pyrene	0.13
Ethylbenzene	64.92	1,3-Butadiene	5.90E-04	Hexavalent Chromium	0.13
Acetaldehyde	60.31	Naphthalene	3.32E-04		
1,3-Butadiene	19.67	POM, Group 3	2.60E-04		
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 Risk Approximations for Pollutants with Noncancer RfCs for the Virginia Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Richmond, Virginia (Henrico County) - RIVA					
Toluene	752.59	Acrolein	216,262.42	Naphthalene	0.04
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		

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.

- Hexavalent chromium does not appear among the highest emitted pollutants, but ranks sixth for the toxicity-weighted emissions.

- POM, Group 2b is the eighth highest emitted "pollutant" in Henrico County and ranks seventh for toxicity-weighted emissions. POM, Group 2b includes several PAH sampled for at RIVA including acenaphthylene, fluoranthene, and perylene. None of the PAH included in POM, Group 2b were identified as pollutants of interest for RIVA.

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.

- Hexvalent chromium appears on neither emissions-based list.

26.6   Summary of the 2010 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.*

26-21

❖ *The annual average concentration of naphthalene was significantly higher than the annual average concentrations of the other two pollutants of interest.*

❖ *Benzo(a)pyrene concentrations appear to be higher during the colder months of the year.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 images retrieved from ArcGIS Explorer showing the monitoring site in its urban location. Figure 27-2 identifies 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 27-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 27-1. Seattle, Washington (SEWA) Monitoring Site

Figure 27-2. NEI Point Sources Located Within 10 Miles of SEWA

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

Legend

⭐ SEWA NATTS site ◯ 10 mile radius ▭ County boundary

Source Category Group (No. of Facilities)

✖	Aerospace/Aircraft Manufacturing (2)	⚙	Glass Manufacturing (1)
☼	Air-conditioning/Refrigeration (1)	Ⓢ	Institutional - school (1)
+	Aircraft Operations (25)	?	Miscellaneous Commercial/Industrial (2)
🚗	Automobile/Truck Manufacturing (1)	7	Portland Cement Manufacturing (2)
฿	Bakery (2)	⚓	Ship Building and Repairing (1)
⊏	Brick Manufacturing & Structural Clay (1)	▼	Steel Mill (1)
		⌐	Wastewater Treatment (1)

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] This monitoring site reports additional pollutants to AQS (EPA, 2012h); 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. To the south of the site a middle school and a hospital can be seen 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 farther north. Interstate-90 runs east-west across Seattle, 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.

Table 27-2 presents information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Washington monitoring site. Table 27-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person) for the site. In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 27-2 also contains annual average daily traffic information. Finally, Table 27-2 presents the 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	1,937,961	1,763,504	0.91	952,319	866,590	234,000	23,454,115

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Washington Department of Licensing (WA DOL, 2010)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2010 data from the Washington DOT (WA DOT, 2010a)
[5] County-level VMT reflects 2010 data from the Washington DOT (WA DOT, 2010b)
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 in the top third among NMP sites.

- The county-level and 10-mile vehicle registration counts for SEWA mimicked the rankings of the county-level and 10-mile populations.

- The vehicle-per-person ratio for SEWA was in the middle of the range compared to other NMP sites.

- The traffic volume experienced near SEWA was the third highest compared to other NMP monitoring sites. The traffic estimate used came from I-5 near Spokane Street.

- The King County VMT was 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 2010

Hourly meteorological data from the NWS weather station nearest SEWA were retrieved for 2010 (NCDC, 2010). 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 normal conditions throughout the year.

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	60.4 ± 2.6	53.9 ± 2.2	43.6 ± 1.8	48.7 ± 1.7	70.5 ± 2.6	1015.7 ± 1.7	4.3 ± 0.6
		2010	60.6 ± 1.1	53.8 ± 0.9	43.8 ± 0.8	48.8 ± 0.8	71.1 ± 1.1	1015.2 ± 0.7	4.3 ± 0.2

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

Table 27-3 presents average temperature (average maximum and average daily), moisture (average dew point temperature, average wet bulb temperature, and average relative humidity), pressure (average sea level pressure), and wind (average scalar wind speed) information for days samples were collected and for the entire year for 2010. 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 near SEWA were representative of average weather conditions throughout the year.

27.2.3 Back Trajectory Analysis

Figure 27-3 is the composite back trajectory map for days on which samples were collected at the SEWA monitoring site in 2010. Included in Figure 27-3 are four back trajectories per sample day. Figure 27-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, each concentric circle around the site in Figures 27-3 and 27-4 represents 100 miles.

Observations from Figures 27-3 and 27-4 for SEWA include the following:

- Back trajectories originated from a variety of directions from SEWA.

- The 24-hour air shed domain for SEWA is somewhat smaller than for other NMP sites. Although the longest trajectory originated greater than 800 miles away over the Pacific Ocean, the average trajectory length was less than 200 miles long and 80 percent of trajectories originated within 300 miles of the site.

- The cluster analysis shows that 35 percent of back trajectories originated to the southeast or southwest of SEWA, over the southwestern portion of Washington, and generally less than 200 miles from the site. Another 24 percent of back trajectories originated to the northeast or northwest of SEWA, over northwestern Washington and southern British Columbia, Canada, and also less than 200 miles from the site. Thus, nearly 70 percent of trajectories originated with 200 miles of the site. Another 17 percent of trajectories originated to the northwest of SEWA, over the Pacific Ocean, with the bulk of these originating within 300 miles of the site. Fifteen percent of back trajectories originated from the southeast over central Oregon, while another 10 percent originated off the coast of Oregon and northern California.

Figure 27-3. 2010 Composite Back Trajectory Map for SEWA
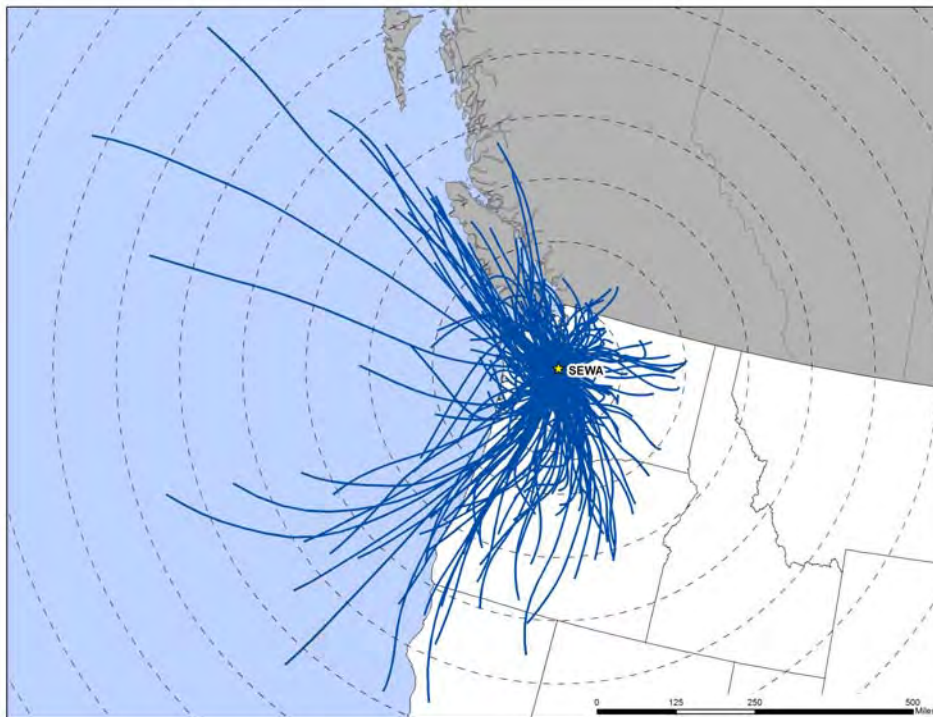
Figure 27-4. Back Trajectory Cluster Map for SEWA

27.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the SEWA monitoring site. First, a historical wind rose representing 1999 to 2009 is presented, which shows the predominant surface wind speed and direction over an extended period of time. Second, a wind rose for 2010 representing wind observations for the entire year is presented. Next, a wind rose representing days on which samples were collected in 2010 is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location.

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 more than one-third of observations. Calm winds (≤ 2 knots) accounted for 23 percent of wind observations near SEWA.

- The wind patterns shown on the 2010 wind rose are similar to the historical wind patterns, although the percentage of calms winds is higher (nearly 28 percent) in 2010.

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

27-10

Figure 27-5. Wind Roses for the Boeing Field/King County International Airport Weather Station near SEWA

1999-2009 Historical Wind Rose
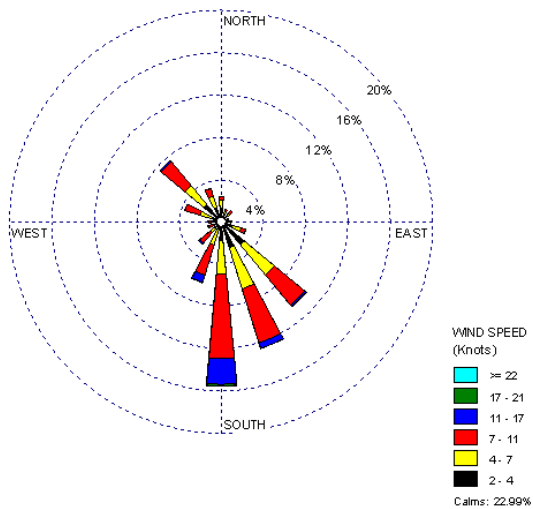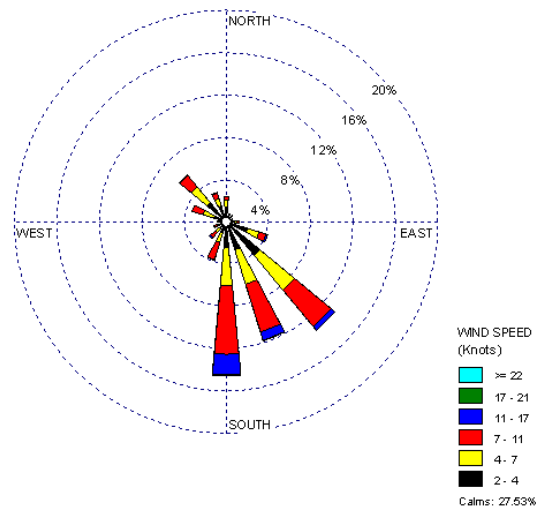
2010 Wind Rose

2010 Sample Day Wind Rose
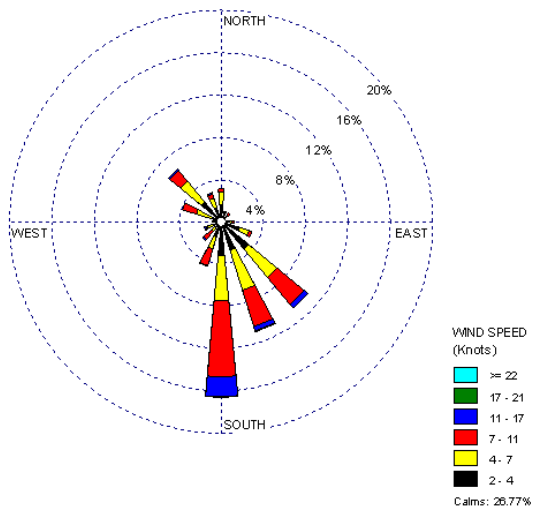
Distance between SEWA and NWS Station

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 27-4 presents the pollutants of interest 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, VOC, PAH, carbonyl compounds, and hexavalent chromium.

Table 27-4. Risk Screening Results for the Washington Monitoring Site

Pollutant	Screening Value (µg/m³)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Seattle, Washington - SEWA						
Benzene	0.13	59	59	100.00	13.29	13.29
Carbon Tetrachloride	0.17	59	59	100.00	13.29	26.58
Formaldehyde	0.077	59	59	100.00	13.29	39.86
Arsenic (PM₁₀)	0.00023	53	58	91.38	11.94	51.80
1,3-Butadiene	0.03	50	53	94.34	11.26	63.06
Naphthalene	0.029	50	58	86.21	11.26	74.32
Acetaldehyde	0.45	49	59	83.05	11.04	85.36
Manganese (PM₁₀)	0.005	20	58	34.48	4.50	89.86
Nickel (PM₁₀)	0.0021	20	58	34.48	4.50	94.37
1,2-Dichloroethane	0.038	12	12	100.00	2.70	97.07
Ethylbenzene	0.4	5	59	8.47	1.13	98.20
Dichloromethane	7.7	4	59	6.78	0.90	99.10
Acenaphthene	0.011	1	57	1.75	0.23	99.32
Acrylonitrile	0.015	1	1	100.00	0.23	99.55
Fluorene	0.011	1	57	1.75	0.23	99.77
Hexavalent Chromium	0.000083	1	50	2.00	0.23	100.00
Total		444	816	54.41		

Observations from Table 27-4 for SEWA include the following:

- Sixteen pollutants failed at least one screen for SEWA, of which 10 are NATTS MQO Core Analytes.

- The risk screening process identified 10 pollutants of interest, of which all but one (1,2-dichloroethane) are NATTS MQO Core Analytes. Hexavalent chromium was added to SEWA's pollutants of interest because it is a NATTS MQO Core Analyte, even though it did not contribute to 95 percent of SEWA's total failed screens. Seven 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 (benzo(a)pyrene, beryllium, cadmium, chloroform, lead, tetrachloroethylene, and trichloroethylene). These seven pollutants are not shown in Table 27-4 but are shown in subsequent tables in the following sections. While vinyl chloride is also a NATTS MQO Core Analyte, it was not detected at SEWA, and therefore not added to the list of pollutants of interest.

- The percentage of measured detections failing screens (of the pollutants with at least one failed screen) for SEWA is greater than 50 percent.

- Benzene, carbon tetrachloride, and formaldehyde failed 100 percent of screens for SEWA. Acrylonitrile and 1,2-dichloroethane also failed 100 percent of screens for SEWA, but these two pollutants were detected in only a few of the total sampled collected, while benzene, carbon tetrachloride, and formaldehyde were detected in all 59 samples collected.

27.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Washington monitoring site. Concentration averages are provided for the pollutants of interest for the site, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices J, L, M, N, and O.

27.4.1 2010 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 PAH, 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 Washington 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	59/59	0.74 ± 0.20	0.62 ± 0.11	1.09 ± 0.20	0.75 ± 0.20	0.81 ± 0.10
Benzene	59/59	0.82 ± 0.14	0.58 ± 0.11	0.57 ± 0.11	0.81 ± 0.11	0.69 ± 0.06
1,3-Butadiene	53/59	0.08 ± 0.03	0.05 ± 0.01	0.05 ± 0.02	0.09 ± 0.02	0.07 ± 0.01
Carbon Tetrachloride	59/59	0.78 ± 0.07	0.71 ± 0.10	0.69 ± 0.06	0.71 ± 0.06	0.72 ± 0.04
Chloroform	59/59	0.12 ± 0.01	0.16 ± 0.04	0.16 ± 0.01	0.12 ± 0.01	0.14 ± 0.01
1,2-Dichloroethane	12/59	0.03 ± 0.02	0.03 ± 0.02	0	0	0.02 ± 0.01
Formaldehyde	59/59	0.59 ± 0.17	0.41 ± 0.09	0.90 ± 0.16	0.63 ± 0.17	0.64 ± 0.08
Tetrachloroethylene	52/59	0.11 ± 0.05	0.10 ± 0.02	0.12 ± 0.04	0.16 ± 0.05	0.12 ± 0.02
Trichloroethylene	5/59	0	0.01 ± 0.01	0.01 ± 0.01	0	<0.01 ± <0.01
Arsenic (PM$_{10}$)[a]	58/58	0.64 ± 0.22	0.52 ± 0.13	0.55 ± 0.09	0.63 ± 0.28	0.58 ± 0.09
Benzo(a)pyrene [a]	20/58	0.05 ± 0.03	<0.01 ± <0.01	<0.01 ± 0.01	0.05 ± 0.03	0.03 ± 0.01
Beryllium (PM$_{10}$) [a]	41/58	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01
Cadmium (PM$_{10}$) [a]	57/58	0.09 ± 0.03	0.08 ± 0.02	0.07 ± 0.05	0.11 ± 0.05	0.09 ± 0.02

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

Table 27-5. Quarterly and Annual Average Concentrations of the Pollutants of Interest for the Washington 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 ($\mu g/m^3$)
Hexavalent Chromium [a]	50/59	0.03 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.03 ± 0.01
Lead (PM_{10}) [a]	58/58	2.88 ± 0.92	2.13 ± 0.47	2.73 ± 0.55	2.75 ± 0.65	2.63 ± 0.32
Manganese (PM_{10}) [a]	58/58	5.95 ± 3.57	5.59 ± 2.89	8.04 ± 5.10	2.86 ± 0.84	5.75 ± 1.79
Naphthalene [a]	58/58	68.87 ± 17.00	38.64 ± 12.03	78.34 ± 26.48	59.67 ± 12.29	61.44 ± 9.43
Nickel (PM_{10}) [a]	58/58	1.59 ± 0.89	1.95 ± 0.78	2.76 ± 1.30	1.17 ± 0.53	1.91 ± 0.48

[a] Average concentrations provided for the pollutants below the black 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 $\mu g/m^3$. The pollutants with the highest annual average concentrations by mass are acetaldehyde (0.81 ± 0.10 $\mu g/m^3$), carbon tetrachloride (0.72 ± 0.04 $\mu g/m^3$), benzene (0.69 ± 0.06 $\mu g/m^3$), and formaldehyde (0.64 ± 0.08 $\mu g/m^3$).

- Acetaldehyde and formaldehyde's third quarter concentration averages are higher than the other quarterly averages. While the confidence intervals indicate that these differences are not statistically significant, a review of the data shows that seven of the 13 acetaldehyde concentrations greater than 1 $\mu g/m^3$ and five of the eight formaldehyde concentrations greater than 1 $\mu g/m^3$ were measured during the third quarter of 2010 at SEWA.

- Benzene, 1,3-butadiene, arsenic, and benzo(a)pyrene appear to be higher during the colder months of year. However, the confidence intervals indicate that the differences are statistically significant for benzo(a)pyrene only. All six of the benzo(a)pyrene concentrations greater than 0.1 ng/m^3 were measured during the first (3) or fourth (3) quarters. This pollutant was detected in about one-third of PAH samples collected at SEWA (20/58), with eight measured during the first quarter, two each during the second and third quarters, and eight during the fourth quarter.

- All of the measured detections of 1,2-dichloroethane were measured during the first and second quarters of 2010 with no measured detections after May 14, 2010. This is similar to other NMP sites sampling VOC.

- The third quarter average concentration of manganese is greater than the other quarterly averages and has a relatively high confidence interval associated with it. A review of the data shows that the maximum manganese concentration was measured on August 30, 2010 (44.0 ng/m^3) and is four times higher than the next highest

concentration measured during the third quarter (9.60 ng/m^3 measured on August 12, 2010). The concentration measured on August 30 is the fifth highest manganese concentration measured among sites sampling PM$_{10}$ metals. Note that the first and second quarter average concentrations of manganese also have relatively high confidence intervals, indicating a considerable amount of variability associated with manganese concentrations measured at SEWA.

- The third quarter average concentration of nickel is also higher than the other quarterly averages and has a relatively high confidence interval associated with it. A review of the data shows that the maximum nickel concentration was measured on July 25, 2010 (10.6 ng/m^3) and is roughly 50 percent higher than the next highest concentration measured during the third quarter (6.65 ng/m^3 measured on August 24, 2010). The concentration measured on July 25 is the highest nickel concentration measured among sites sampling metals and the August 24 concentration ranks third. Of the 22 nickel concentrations greater than 3 ng/m^3 measured among all NMP sites sampling nickel, 13 were measured at SEWA.

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 4-9, SEWA has the highest annual average concentration of carbon tetrachloride among NMP sites sampling VOC. However, the annual average concentrations of this pollutant do not vary significantly among the sites.

- As shown in Table 4-12, SEWA has the highest annual average concentration of nickel among all sites sampling metals (PM$_{10}$ and TSP).

- SEWA does not appear in Table 4-10 for carbonyl compounds or Table 4-11 for PAH.

27.4.2 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, arsenic, benzene, benzo(a)pyrene, 1,3-butadiene, formaldehyde, hexavalent chromium, manganese, and naphthalene were created for SEWA. Figures 27-6 through 27-14 overlay the site's minimum, annual average, and maximum concentrations onto the program-level minimum, first quartile, average, median, 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
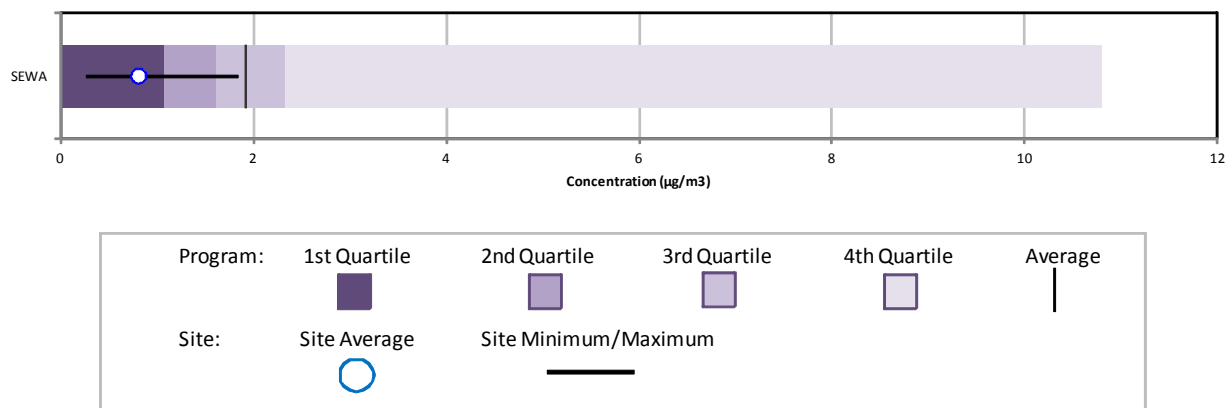
Figure 27-7. Program vs. Site-Specific Average Arsenic (PM$_{10}$) Concentration
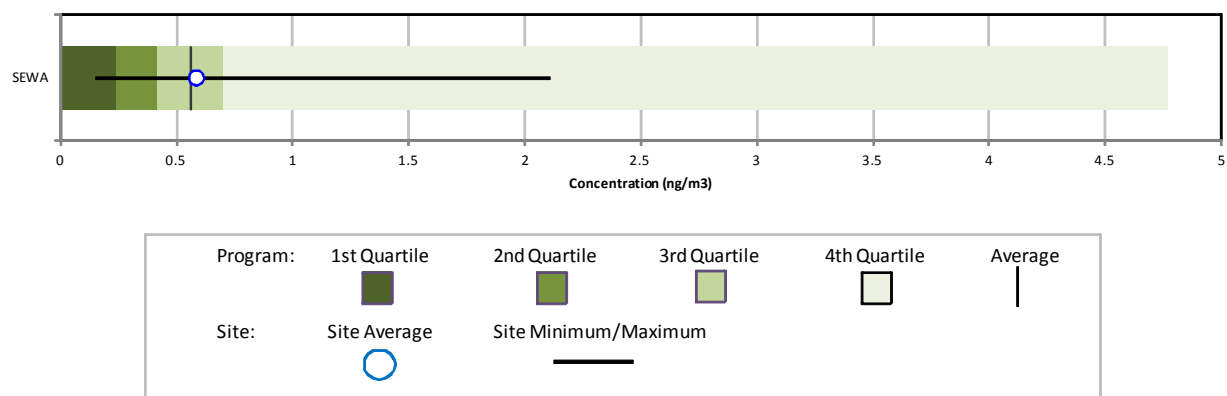
Figure 27-8. Program vs. Site-Specific Average Benzene Concentration
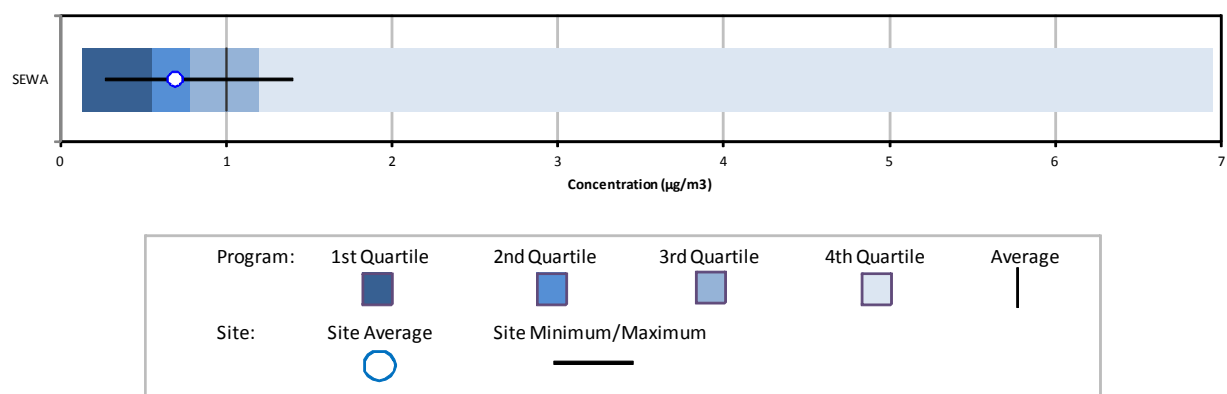
Figure 27-9. Program vs. Site-Specific Average Benzo(a)pyrene Concentration

Program Max Concentration = 42.7 ng/m3

Program:	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Average

Site:	Site Average	Site Minimum/Maximum
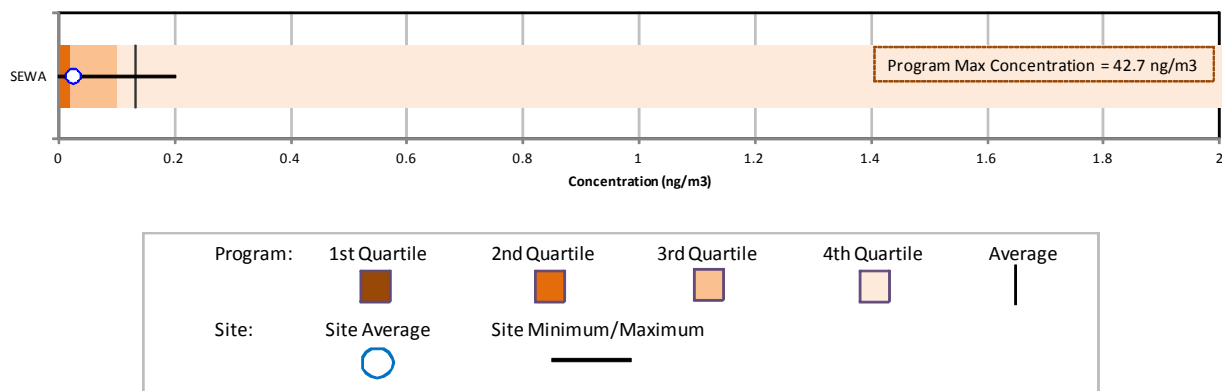
Figure 27-10. Program vs. Site-Specific Average 1,3-Butadiene Concentration

Program:	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Average

Site:	Site Average	Site Minimum/Maximum
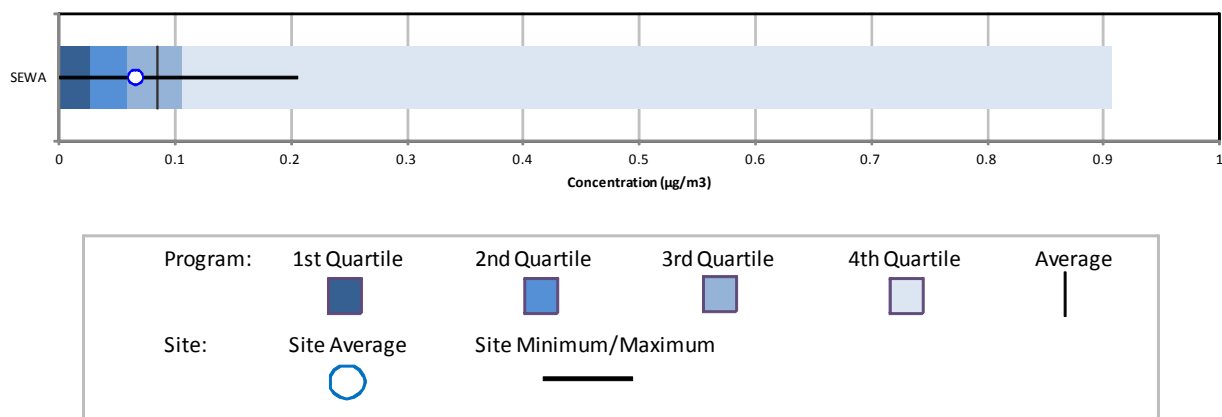
Figure 27-11. Program vs. Site-Specific Average Formaldehyde Concentration

Program:	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Average

Site:	Site Average	Site Minimum/Maximum
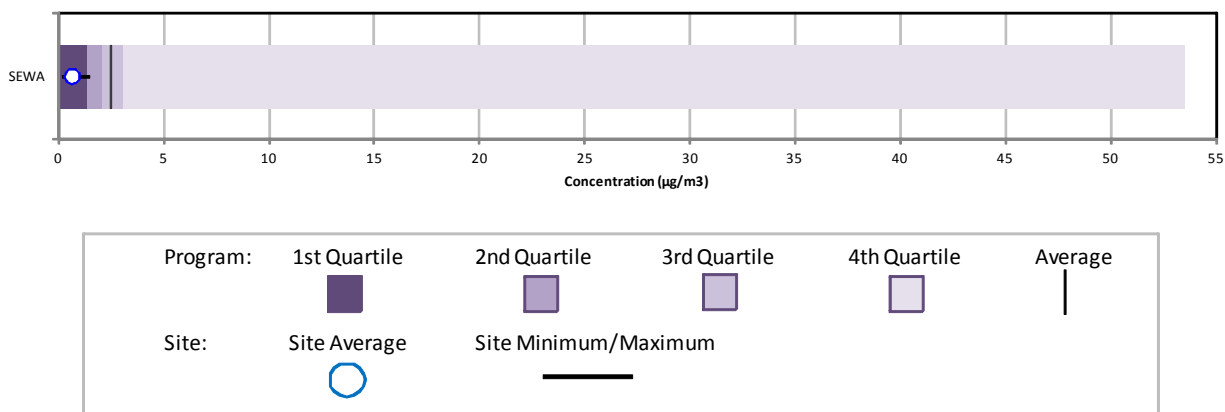
Figure 27-12. Program vs. Site-Specific Average Hexavalent Chromium Concentration

Program Max Concentration = 3.51 ng/m3

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
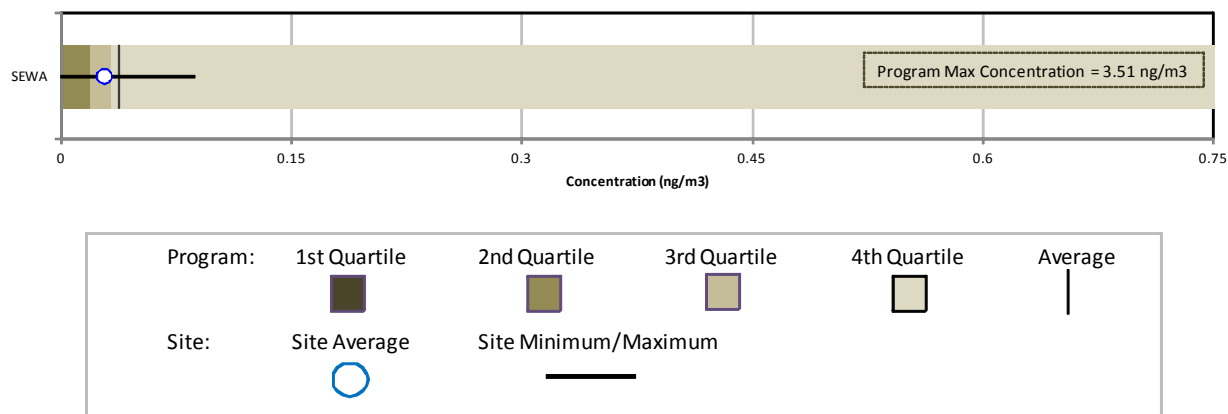
Figure 27-13. Program vs. Site-Specific Average Manganese (PM$_{10}$) Concentration

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
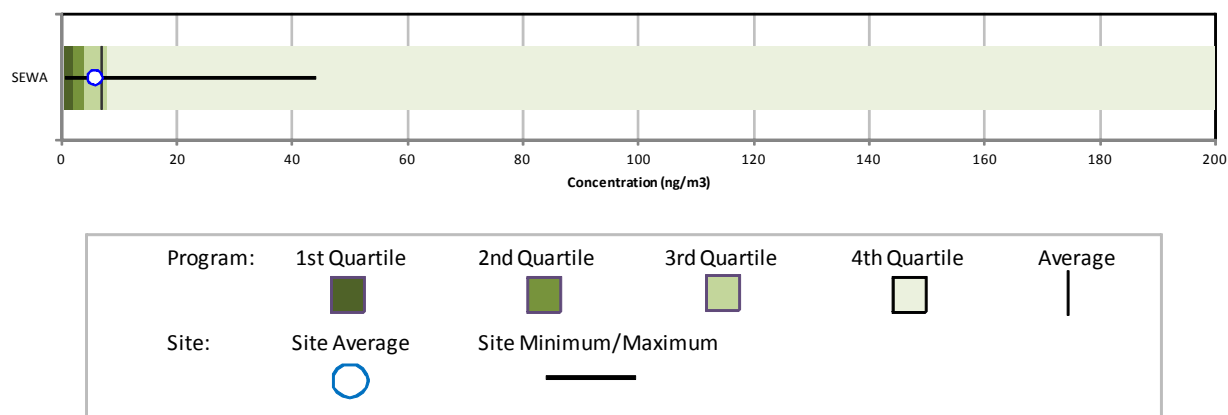
Figure 27-14. Program vs. Site-Specific Average Naphthalene Concentration

Concentration (ng/m3)

| Program: | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | Average |
| Site: | Site Average | Site Minimum/Maximum | | | |
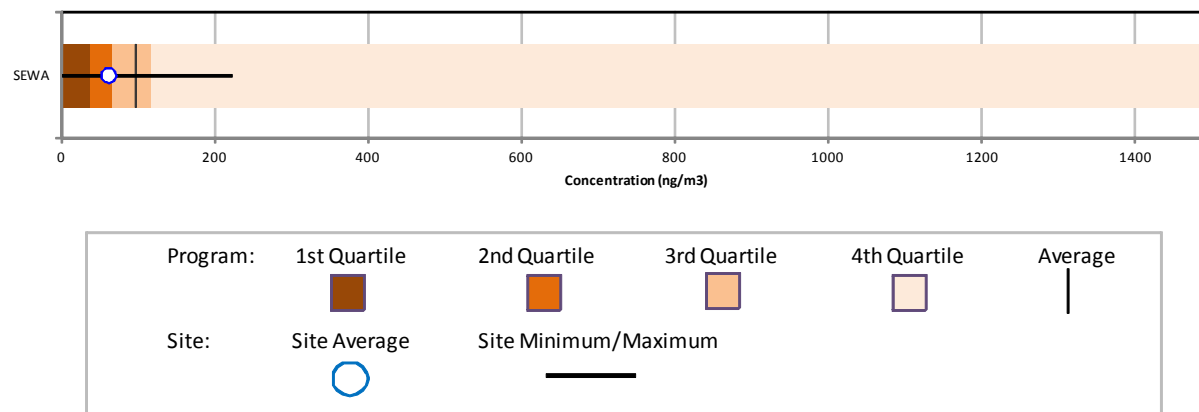
Observations from Figures 27-6 through 27-14 include the following:

- Figure 27-6 shows that SEWA's annual average acetaldehyde concentration is well below the program-level average for acetaldehyde. SEWA's annual average acetaldehyde concentration is also below the program-level median and first quartile. Even the maximum acetaldehyde concentration measured at SEWA is below 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 just greater than the program-level average for arsenic (PM_{10}). There were no non-detects of arsenic measured at SEWA.

- Figure 27-8 for benzene shows that the annual average concentration for SEWA is less than both the program-level average and median concentration. The maximum benzene concentration measured at SEWA is well below the maximum benzene concentration measured across the program. There were no non-detects of benzene measured at SEWA.

- Figure 27-9 is the box plot for benzo(a)pyrene. Note that the program-level maximum concentration (42.7 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 2 ng/m^3. Also 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 well below the program-level average concentration and just greater than the program-level median. Figure 27-9 also shows that the maximum concentration measured at SEWA is well below the maximum concentration measured across the program. Sixty-six percent of the benzo(a)pyrene measurements at SEWA were non-detects.

- Figure 27-10 for 1,3-butadiene shows that the annual average concentration for SEWA is below 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 well below 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 below not only the program-level average but also the median and first quartile concentrations at the program level. The maximum formaldehyde concentration measured at SEWA is less than both the program-level average and median concentrations. Similar to its acetaldehyde concentration, this site has the lowest annual average concentration of formaldehyde among NMP sites sampling carbonyl compounds.

- Similar to benzo(a)pyrene, the scale for hexavalent chromium has been adjusted in Figure 27-12 as a result of a relatively large maximum concentration. The

27-20

program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 27-12 shows the annual average concentration of hexavalent chromium for SEWA is less than the program-level average but greater than the program-level median concentration. A few non-detects of hexavalent chromium were measured at SEWA.

- Figure 27-13 shows the annual average concentration of manganese (PM$_{10}$) for SEWA is less than the program-level average. While the maximum concentration measured at SEWA is well below the program maximum concentration, the maximum concentration measured at SEWA is among one of the highest concentrations among the NMP sites sampling manganese (PM$_{10}$), as discussed in the previous section. Although difficult to discern in Figure 27-13, there were no non-detects of manganese measured at SEWA.

- Figure 27-14 shows that the annual naphthalene average for SEWA is less than the program-level average concentration and just less than the program-level median concentration. The maximum naphthalene concentration measured at SEWA is well below the program-level maximum concentration. There were no non-detects of naphthalene measured at SEWA.

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. Although SEWA has sampled hexavalent chromium since 2005, sampling was discontinued for an eight-month period in 2006 from March through October. Because four months is not considered enough to be representative of an entire year, and this year would factor into two of the three 3-year periods, the trends analysis was not conducted. In addition, sampling for PM$_{10}$ metals, VOC, and carbonyl compounds did not begin until January 2007 and PAH sampling did not begin until March 2008.

27.5 Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

27.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data for the Washington monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest for SEWA were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual and/or study averages were compared to the chronic MRL.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Washington monitoring site were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for SEWA.

27.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Washington monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 27-6, where applicable.

Observations from Table 27-6 for SEWA include the following:

- The pollutants with the highest annual averages for SEWA are acetaldehyde, carbon tetrachloride, benzene, and formaldehyde.

- The pollutants with the highest cancer surrogate risk approximations are formaldehyde, benzene, carbon tetrachloride, and arsenic. Although the cancer risk approximation for formaldehyde is the highest for SEWA, it is the lowest cancer risk approximation for this pollutant among NMP sites sampling carbonyl compounds.

- The noncancer surrogate risk approximations for SEWA are all less than 1.0, with the highest calculated for manganese (0.11).

Table 27-6. Cancer and Noncancer Surrogate Risk Approximations for the Washington Monitoring Site

Pollutant	Cancer URE ($\mu g/m^3)^{-1}$	Noncancer RfC (mg/m³)	# of Measured Detections vs. # of Samples	Annual Average ($\mu g/m^3$)	Cancer Risk Approximation (in-a-million)	Noncancer Risk Approximation (HQ)
Seattle, Washington - SEWA						
Acetaldehyde	0.0000022	0.009	59/59	0.81 ± 0.10	1.77	0.09
Arsenic (PM$_{10}$)[a]	0.0043	0.000015	58/58	<0.01 ± <0.01	2.51	0.04
Benzene	0.0000078	0.03	59/59	0.69 ± 0.06	5.38	0.02
Benzo (a) pyrene [a]	0.00176	--	20/58	<0.01 ± <0.01	0.04	--
Beryllium (PM$_{10}$) [a]	0.0024	0.00002	41/58	<0.01 ± <0.01	<0.01	<0.01
1,3-Butadiene	0.00003	0.002	53/59	0.07 ± 0.01	1.98	0.03
Cadmium (PM$_{10}$) [a]	0.0018	0.00001	57/58	<0.01 ± <0.01	0.16	0.01
Carbon Tetrachloride	0.000006	0.1	59/59	0.72 ± 0.04	4.35	0.01
Chloroform	--	0.098	59/59	0.14 ± 0.01	--	<0.01
1,2-Dichloroethane	0.000026	2.4	12/59	0.02 ± 0.01	0.42	<0.01
Formaldehyde	0.000013	0.0098	59/59	0.64 ± 0.08	8.26	0.06
Hexavalent Chromium [a]	0.012	0.0001	50/59	<0.01 ± <0.01	0.34	<0.01
Lead (PM$_{10}$) [a]	--	0.00015	58/58	<0.01 ± <0.01	--	0.02
Manganese (PM$_{10}$) [a]	--	0.00005	58/58	0.01 ± <0.01	--	0.11
Naphthalene [a]	0.000034	0.003	58/58	0.06 ± 0.01	2.09	0.02
Nickel (PM$_{10}$) [a]	0.00048	0.00009	58/58	<0.01 ± <0.01	0.91	0.02
Tetrachloroethylene	2.6E-07	0.04	52/59	0.12 ± 0.02	0.03	<0.01
Trichloroethylene	0.0000048	0.002	5/59	<0.01 ± <0.01	0.02	<0.01

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

[a] For the annual average concentration of this pollutant in ng/m³, refer to Table 27-5.

27.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 27-7 and 27-8 present a risk-based 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 surrogate risk approximations (in-a-million), as calculated from the annual averages. Table 27-8 presents similar information, but identifies the 10 pollutants with the highest noncancer surrogate risk approximations (HQ), also calculated from annual averages.

The pollutants listed in Table 27-7 and 27-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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, SEWA sampled for VOC, carbonyl compounds, PAH, metals (PM_{10}), and hexavalent chromium. In addition, the cancer and noncancer surrogate risk 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.

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 Risk Factors (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	8.26
Formaldehyde	849.03	Formaldehyde	1.10E-02	Benzene	5.38
Ethylbenzene	654.82	POM, Group 3	8.19E-03	Carbon Tetrachloride	4.35
Acetaldehyde	430.54	1,3-Butadiene	5.70E-03	Arsenic	2.51
1,3-Butadiene	190.09	Naphthalene	3.37E-03	Naphthalene	2.09
Naphthalene	99.14	POM, Group 2b	2.49E-03	1,3-Butadiene	1.98
POM, Group 2b	28.31	Ethylbenzene	1.64E-03	Acetaldehyde	1.77
Dichloromethane	17.29	Nickel, PM	1.36E-03	Nickel	0.91
POM, Group 6	2.99	Hexavalent Chromium, PM	1.34E-03	1,2-Dichloroethane	0.42
Nickel, PM	2.83	POM, Group 5a	1.11E-03	Hexavalent Chromium	0.34

Table 27-8. Top 10 Emissions, Toxicity-Weighted Emissions, and Noncancer Risk Approximations for Pollutants with Noncancer RfCs for the Washington Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk Approximation (HQ)
Seattle, Washington (King County) - SEWA					
Toluene	3,282.31	Acrolein	2,237,728.52	Manganese	0.11
Xylenes	2,629.14	1,3-Butadiene	95,046.24	Acetaldehyde	0.09
Benzene	1,542.30	Formaldehyde	86,635.26	Formaldehyde	0.06
Methanol	1,092.81	Benzene	51,409.86	Arsenic	0.04
Formaldehyde	849.03	Acetaldehyde	47,837.23	1,3-Butadiene	0.03
Ethylbenzene	654.82	Naphthalene	33,047.76	Benzene	0.02
Hexane	642.62	Nickel, PM	31,499.47	Nickel	0.02
Acetaldehyde	430.54	Xylenes	26,291.40	Naphthalene	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.

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

- Formaldehyde and benzene topped SEWA's highest cancer risk approximations list. These two pollutants top both emissions-based lists as well. Naphthalene, 1,3-butadiene, and nickel also appear on all three lists.

- Carbon tetrachloride, which is the third-ranked pollutant for SEWA's cancer risk approximations, does 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. Hexavalent chromium has the tenth highest cancer risk approximation and ranks ninth for toxicity-weighted emissions, but ranks 19th for total 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 PAH sampled for at SEWA including acenaphthene, fluorene, and perylene. Although none of the PAH included in POM, Group 2b were identified as pollutants of interest for SEWA, acenaphthene and fluorene did fail screens for SEWA.

- POM, Group 3 ranks third for toxicity-weighted emissions for King County. POM, Group 3 does not include any pollutants sampled for at SEWA.

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 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 risk 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 risk approximations for SEWA are also among the pollutants with the highest toxicity-weighted emissions (arsenic, nickel, and lead). However, none of these metals are among the highest emitted pollutants in King County.

27.6   Summary of the 2010 Monitoring Data for SEWA

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

- *Sixteen pollutants failed at least one screen for SEWA, of which 10 are NATTS MQO Core Analytes.*

- ❖ *Acetaldehyde had the highest annual average concentration for SEWA. The annual average concentrations of carbon tetrachloride and nickel for SEWA were the highest among NMP sites sampling these pollutants.*

- ❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations of the pollutants of interest were greater than their associated MRL noncancer health risk benchmarks.*

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 NATTS site located in Mayville, Wisconsin (MVWI) was moved to a new location in Horicon, Wisconsin (HOWI) in mid-December 2009 and promptly began sampling. In order to capture all of the data generated by the new site, the data results in this section include the two sample days in December 2009 (December 21 and December 27) as well as all of 2010. Figure 28-1 is a composite satellite image retrieved from ArcGIS Explorer showing the monitoring site in its rural location. Figure 28-2 identifies 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. Thus, sources outside the 10-mile radius have been grayed out, but are visible on the map to show emissions sources outside the 10-mile boundary. 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. Table 28-1 describes the area surrounding the monitoring site by providing supplemental geographical information such as land use, location setting, and locational coordinates.

Figure 28-1. Horicon, Wisconsin (HOWI) Monitoring Site
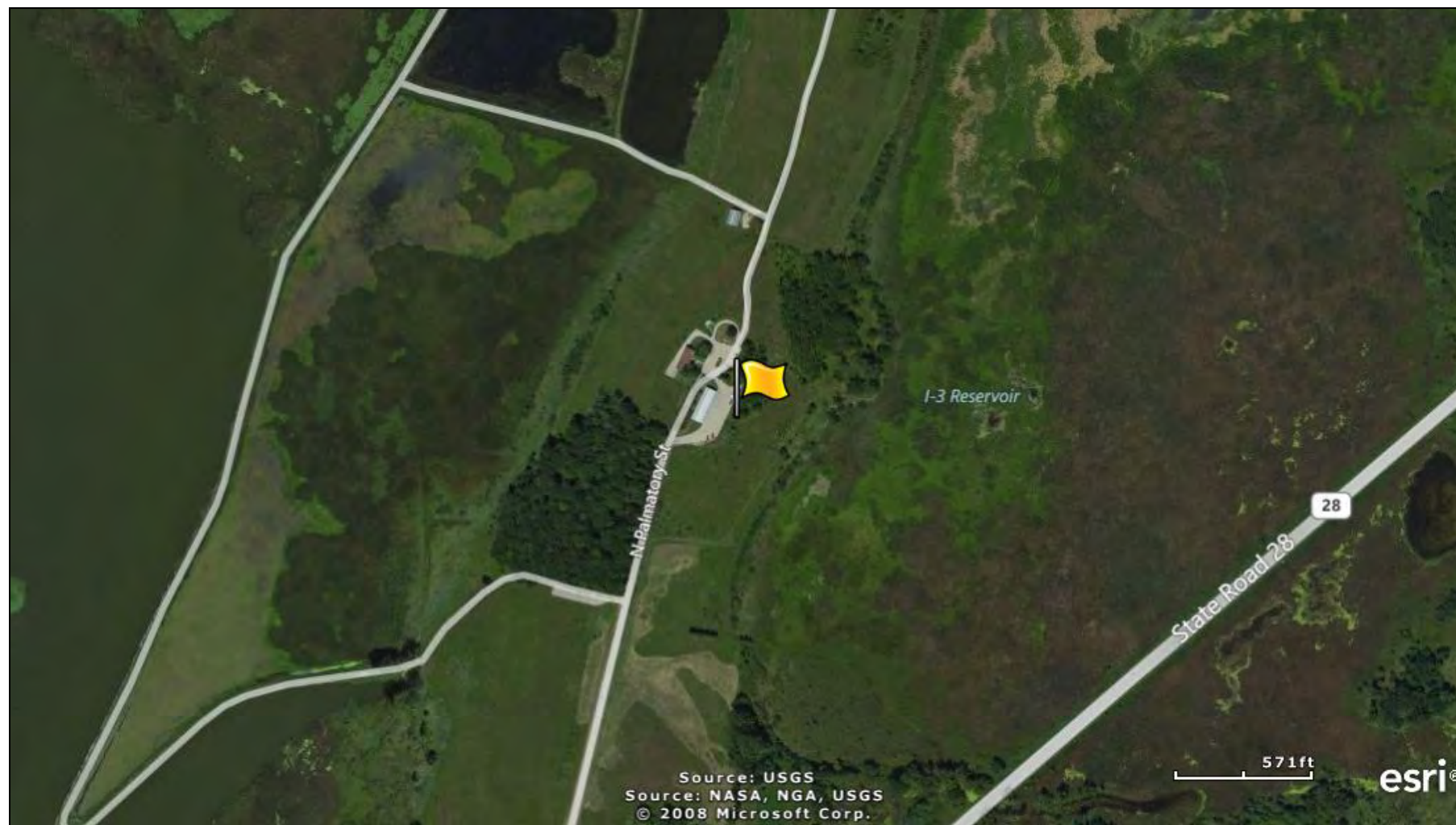
Figure 28-2. NEI Point Sources Located Within 10 Miles of HOWI

Legend

⭐ HOWI NATTS site   ◯ 10 mile radius   ▢ County boundary

Source Category Group (No. of Facilities)

✛ Aircraft Operations (3)	Ⓗ Hospital (1)
🚐 Automobile/Truck Manufacturing (1)	Hot Mix Asphalt Plant (1)
E Electroplating, Plating, Polishing, Anodizing, & Coloring (1)	▲ Landfill (1)
⊙ Fabricated Metal Products (5)	➤ Lime Manufacturing (1)
F Food Processing/Agriculture (2)	5 Miscellaneous Coating Manufacturing (1)
≫ Heating Equipment Manufacturing (1)	M Miscellaneous Manufacturing (1)
	P Printing/Publishing (1)

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, VOC, Carbonyl compounds, O_3, Meteorological parameters, PM_{10}, PM_{10} Metals, $PM_{2.5}$, and $PM_{2.5}$ Speciation, SVOC, PM Coarse.

[1] This monitoring site reports additional pollutants to AQS (EPA, 2012h); however, these data are not generated by ERG and are therefore not included in this report.
BOLD ITALICS = EPA-designated NATTS Site.

The new NATTS site is located just north of the town of Horicon, in southwest Wisconsin, within the boundaries of the Horicon Marsh Wildlife Area. The new location is approximately 5 miles northwest of the old location. 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 impacted by nearby urban areas, and thus, could show the impacts 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 the point sources is located just south and west of HOWI, in the town of Horicon. The closest point source near HOWI is an automobile and truck manufacturing facility. The source categories with the most emissions sources 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 information related to mobile source activity, such as population, traffic, VMT, and estimated vehicle ownership information for the area surrounding the Wisconsin monitoring site. Table 28-2 also includes a vehicle registration-to-county population ratio (vehicles-per-person). In addition, the population within 10 miles of the site is presented. An estimate of 10-mile vehicle ownership was calculated by applying the county-level vehicle registration-to-population ratio to the 10-mile population surrounding the monitoring site. Table 28-2 also contains annual average daily traffic information. Finally, Table 28-2 presents the 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	88,748	98,211	1.11	21,539	23,836	5,000	2,659,643

[1] County-level population estimate reflects data from the U.S. Census Bureau (Census Bureau, 2011)
[2] County-level vehicle registration reflects 2010 data from the Wisconsin DOT (WI DOT, 2010)
[3] 10-mile population estimate reflects 2011 data from Xionetic (Xionetic, 2011)
[4] Annual Average Daily Traffic reflects 2008 data from the Wisconsin DOT (WI DOT, 2008)
[5] County-level VMT reflects 2010 data from the Wisconsin DOT (WI DOT, 2011)
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 experienced near HOWI is also on the low end compared to other NMP monitoring sites. The traffic estimate used was for State Road 28 near State Road 33 on the east side of Horicon.

- The Dodge County daily VMT 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 2010

Hourly meteorological data from the NWS weather station nearest this site were retrieved for December 2009 and all of 2010 (NCDC, 2009 and 2010) to correspond with the sampling period covered in this report. The closest weather station is located at Dodge County Airport (WBAN 04898). Additional information about the Dodge County 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 normal conditions throughout the sample period.

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 sample period. Also included in Table 28-3 is the 95 percent confidence interval for each parameter. As shown in Table 28-3, average meteorological conditions on sample days were representative of average weather conditions throughout the sample period.

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. Included in Figure 28-3 are four back trajectories per sample day. Figure 28-4 is the corresponding cluster analysis for 2010. 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. For the cluster analysis, each line corresponds to a back trajectory representative of a given cluster of trajectories. For both maps, 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	Sample Day	56.2 ± 5.5	47.3 ± 5.1	36.6 ± 4.7	42.2 ± 4.6	69.7 ± 2.9	NA	6.1 ± 0.7
	229° (SW)	Sample Period	55.5 ± 2.2	47.2 ± 2.1	36.7 ± 1.9	42.3 ± 1.9	70.6 ± 1.3	NA	6.7 ± 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 Dodge County Airport.

Figure 28-3. Composite Back Trajectory Map for HOWI
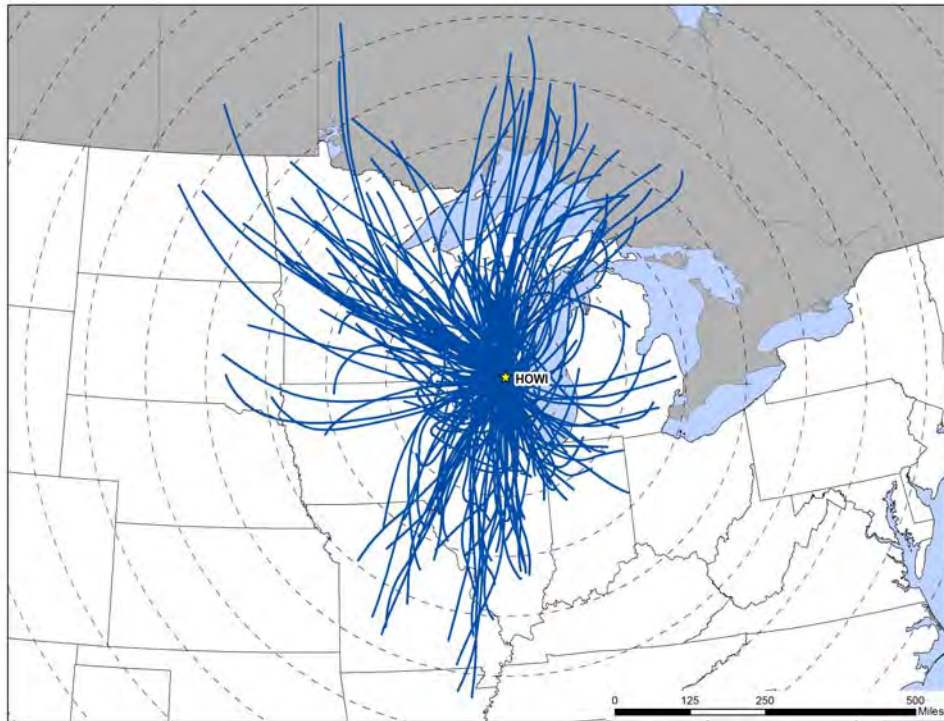
Figure 28-4. Back Trajectory Cluster Map for HOWI

Observations from Figures 28-3 and 28-4 for HOWI include the following:

- Back trajectories originated from a variety of directions at HOWI, although less frequently from the east.

- The 24-hour air shed domain for HOWI is similar in size to many other NMP monitoring sites. The farthest away a trajectory originated was Manitoba, Canada, or approximately 650 miles away. However, the average trajectory length was 256 miles and most trajectories (81 percent) originated within 400 miles of the site.

- The cluster analysis shows that 32 percent of the back trajectories originated from the north of HOWI, although of varying distances. Another 28 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 within 200 miles of the site and originated from the northwest, west, and southwest. Longer back trajectories originating from the west to northwest of the site account for 13 percent of trajectories; back trajectories originating from the south to southwest account for 15 percent; and back trajectories originating from the southeast of the site account for another 13 percent of the back trajectories.

28.2.4 Wind Rose Comparison

Hourly 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 three different wind roses for the HOWI monitoring site. First, a historical wind rose representing 2003 to 2009 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 the entire sampling period is presented. Next, a wind rose representing days on which samples were collected during the sample period is presented. These can be used to determine if wind observations on sample days were representative of conditions experienced over the entire year and historically. Finally, a map showing the distance between the NWS station and the monitoring site is presented, which may be useful for identifying topographical influences that may affect the meteorological patterns experienced at each location.

Figure 28-5. Wind Roses for the Dodge County Airport Weather Station near HOWI

2003-2009 Historical Wind Rose

Sample Period Wind Rose

Sample Day Wind Rose

Distance between HOWI and NWS Station
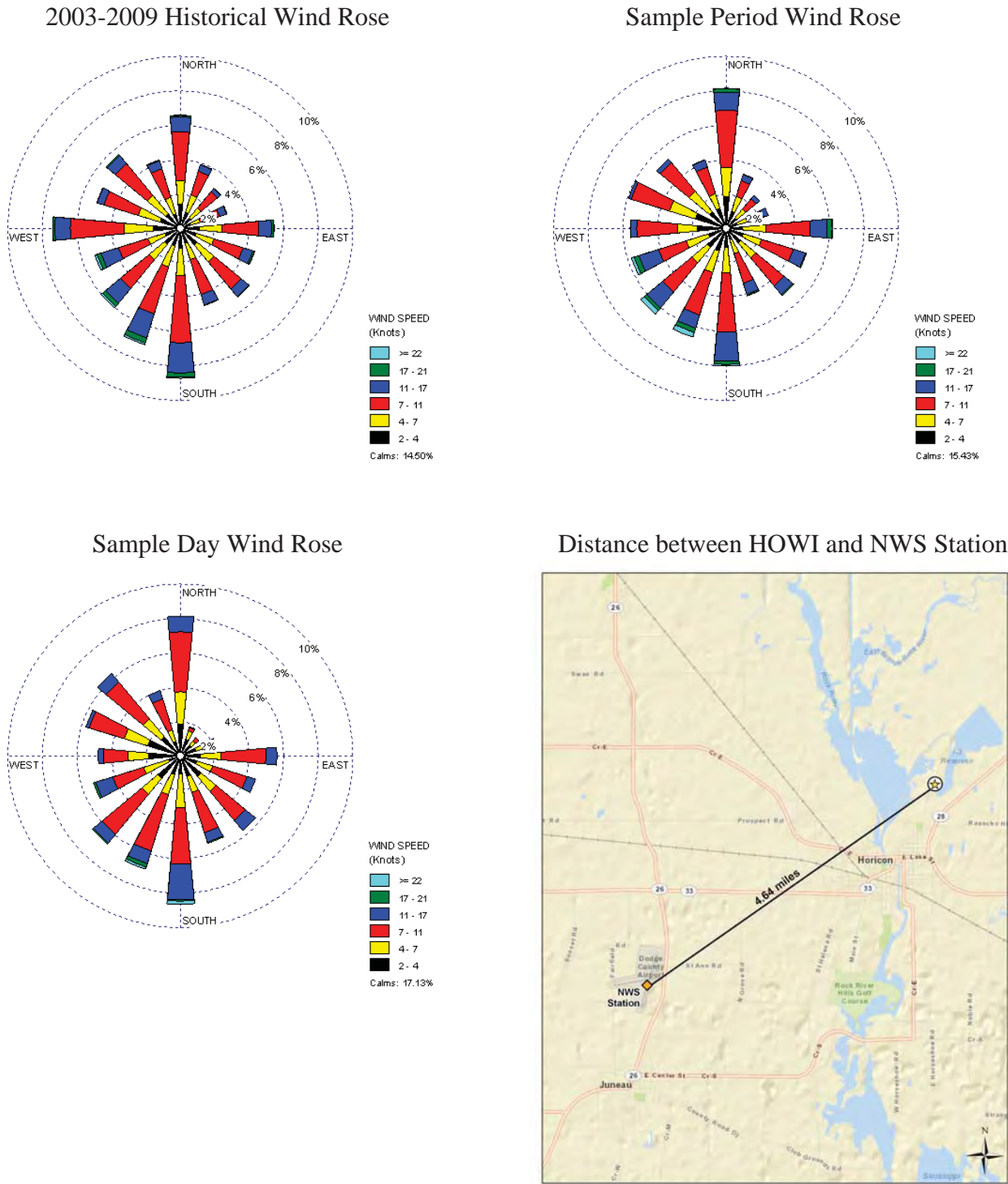
Observations from Figure 28-5 for MVWI include the following:

- 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 the most 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 2010 wind rose resemble the historical wind patterns, although winds from the north were observed more frequently.

- The sample day wind rose resembles both the historical and sample period wind roses, although winds from the northeast quadrant were observed even less frequently and the calm rate was slightly higher.

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 screening, that pollutant was added to the list of site-specific pollutants of interest. A more in-depth description of the risk screening process is presented in Section 3.2.

Table 28-4 presents HOWI's pollutants of interest. 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. HOWI sampled for PAH and hexavalent chromium beginning in December 2009, but stopped sampling PAH in June 2010.

Table 28-4. Risk Screening Results for the Wisconsin Monitoring Site

Pollutant	Screening Value (µg/m^3)	# of Failed Screens	# of Measured Detections	% of Screens Failed	% of Total Failures	Cumulative % Contribution
Horicon, Wisconsin - HOWI						
Naphthalene	0.029	10	31	32.26	100.00	100.00
Total		10	31	32.26		

Observations from Table 28-4 include the following:

- Naphthalene was the only pollutant to fail screens for HOWI.

- Naphthalene was detected in all 31 valid samples collected at HOWI and failed roughly one-third of screens.

- Naphthalene was identified as a pollutant of interest for HOWI, based on the risk screening process. However, hexavalent chromium and benzo(a)pyrene were added to HOWI's pollutants of interest because they are also NATTS MQO Core Analytes, even though they did not fail any screens. These two pollutants are not shown in Table 28-4.

28.4   Concentrations

This section presents various concentration averages used to characterize pollution levels at the Wisconsin monitoring site. Concentration averages are provided for the pollutants of interest for the HOWI monitoring site, where applicable. Concentration averages for select pollutants are also presented graphically for the site, where applicable, to illustrate how the site's concentrations compare to the program-level averages. In addition, concentration averages for select pollutants are presented from previous years of sampling in order to characterize concentration trends at the site, where applicable. Additional site-specific statistical summaries are provided in Appendices M and O.

28.4.1 2010 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						
Benzo(a)pyrene	19/31	0.14 ± 0.05	0.01 ± 0.01	NA	NA	NA
Hexavalent Chromium	40/63	0.01 ± 0.01	0.02 ± 0.01	0.02 ± <0.01	0.01 ± <0.01	0.01 ± <0.01
Naphthalene	31/31	34.54 ± 9.35	17.89 ± 5.63	NA	NA	NA

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:

- The two December 2009 samples were factored into the first quarter 2010 averages.

- Because PAH sampling was discontinued in June 2010, annual averages concentrations could not be calculated for naphthalene and benzo(a)pyrene. However, Appendix M provides the pollutant-specific average concentration for all valid PAH samples collected over the entire sample period.

- The first quarter benzo(a)pyrene average is significantly higher than the second quarter average concentration. The three highest concentrations of this pollutant were measured in February. Of the 19 measure detections of this pollutant at HOWI, 16 were measured during the first quarter of 2010 (including December 2009).

- A similar trend is shown in the quarterly averages of naphthalene. Concentrations of naphthalene ranged from 7.18 ng/m^3 to 80.2 ng/m^3, with the five highest concentrations measured in December 2009 and February 2010.

- Concentrations of hexavalent chromium ranged from 0 ng/m^3 to 0.0667 ng/m^3, with the maximum concentration measured on June 25, 2010. The three highest concentrations of this pollutant were measured during the second quarter of 2010.

28.4.2 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, 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, average, median, third quartile, and maximum concentrations, as described in Section 3.5.3.

Figure 28-6. Program vs. Site-Specific Average Hexavalent Chromium Concentration
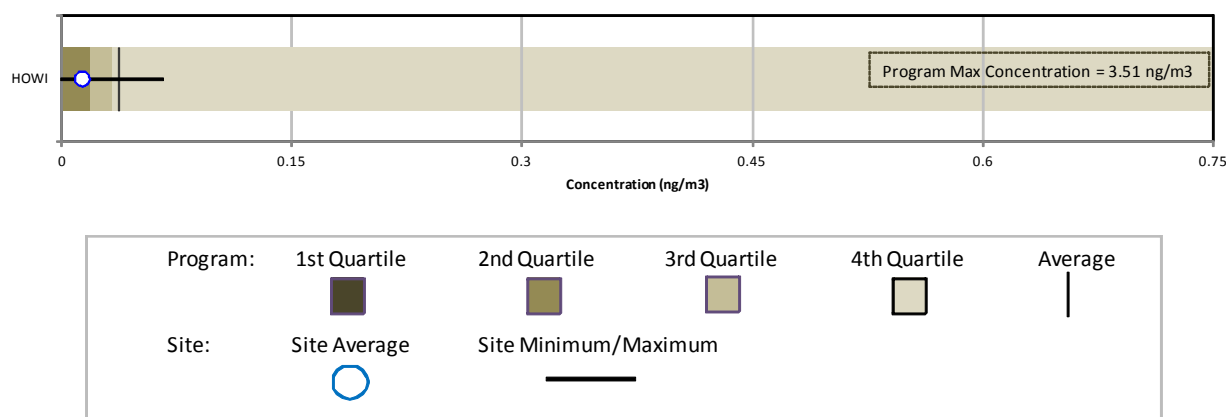
Observations from Figure 28-6 include the following:

- The scale for hexavalent chromium has been adjusted in Figure 28-6 as a result of a relatively large maximum concentration. The program-level maximum concentration (3.51 ng/m^3) is not shown directly on the box plot in order to allow for the observation of data points at the lower end of the concentration range; thus, the scale has been reduced to 0.75 ng/m^3. Also note that the first quartile for this pollutant is zero and is not visible on this box plot. Figure 28-6 shows that the annual average concentration of hexavalent chromium for HOWI is less than the program-level average and median concentrations. The maximum concentration measured at HOWI is well below the program maximum concentration. There were several 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 3.5.3. Because HOWI did not begin sampling under the NMP until December 2009, a trends analysis was not conducted for this site.

28.5   Additional Risk Screening Evaluations

The following risk 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 risk factors, time frames, and calculations associated with these risk screenings.

28.5.1 Risk Screening Assessment Using MRLs

A noncancer risk screening was conducted by comparing the concentration data from the Wisconsin monitoring site to the ATSDR acute, intermediate, and chronic MRLs, where available. As described in Section 3.3, 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. The preprocessed daily measurements of the pollutants of interest were compared to the acute MRL; the quarterly averages were compared to the intermediate MRL; and the annual averages were compared to the chronic MRL, where applicable.

None of the measured detections or time-period average concentrations of the pollutants of interest for the Wisconsin monitoring site, where they could be calculated, were greater than their respective MRL noncancer health risk benchmarks. This is also true for pollutants not identified as pollutants of interest for HOWI.

28.5.2 Cancer and Noncancer Surrogate Risk Approximations

For the pollutants of interest for the Wisconsin monitoring site and where *annual average* concentrations could be calculated, risk was further examined by calculating cancer and noncancer surrogate risk approximations (refer to Section 3.5.5.2 regarding the criteria for annual averages and how cancer and noncancer surrogate risk approximations are calculated). Annual averages, cancer UREs and/or noncancer RfCs, and cancer and noncancer surrogate risk approximations are presented in Table 28-6, where applicable.

Table 28-6. Cancer and Noncancer Surrogate 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 Risk Approximation (HQ)
			Horicon, Wisconsin - HOWI			
Benzo(a)pyrene	0.00176	--	19/31	NA	NA	NA
Hexavalent Chromium	0.012	0.0001	40/63	0.01 ± <0.01	0.16	<0.01
Naphthalene	0.000034	0.003	31/31	NA	NA	NA

NA = Not available due to the criteria for calculating an annual average.
-- = a Cancer URE or Noncancer RfC is not available.

Observations for HOWI from Table 28-6 include the following:

- The cancer risk approximation for hexavalent chromium is less than 1.0 in-a-million (0.16 in-a-million).

- The noncancer risk approximation for hexavalent chromium (<0.01) is well below the level of concern (an HQ of 1.0).

- Annual averages, and therefore cancer and noncancer risk approximations, could not be calculated for benzo(a)pyrene and naphthalene.

28.5.3 Risk-Based Emissions Assessment

In addition to the risk screenings discussed above, Tables 28-7 and 28-8 present a risk-based 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 10 pollutants with the highest cancer risk approximations (in-a-million), as calculated from the annual averages. Table 28-8 presents similar information, but identifies the 10 pollutants with the highest noncancer risk approximations (HQ), also calculated from annual averages.

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 Risk Factors (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	0.16
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 Risk Approximations for Pollutants with Noncancer RfCs for the Wisconsin Monitoring Site

Top 10 Total Emissions for Pollutants with Noncancer Risk Factors (County-Level)		Top 10 Noncancer Toxicity-Weighted Emissions (County-Level)		Top 10 Noncancer Risk Approximations Based on Annual Average Concentrations (Site-Specific)	
Pollutant	Emissions (tpy)	Pollutant	Noncancer Toxicity Weight	Pollutant	Noncancer Risk 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		

The pollutants listed in Tables 28-7 and 28-8 are limited to those that have cancer and noncancer risk 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 and noncancer surrogate risk 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 PAH and hexavalent chromium. In addition, the cancer and noncancer surrogate risk 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.

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 for which a cancer risk approximation could be calculated, has the third highest toxicity-weighted emissions for Dodge County, but is not among the highest emitted.

- Naphthalene, one of HOWI's pollutants of interest, appears on both emissions-based lists. Benzo(a)pyrene is part of POM, Group 5a, which ranks eighth for toxicity-weighted emissions but is not among the highest emitted pollutants.

- POM, Group 2b ranks seventh for both total emissions and toxicity-weighted emissions. POM, Group 2b includes several PAH sampled for at HOWI including acenaphthylene, fluoranthene, and perylene. None of the PAH included in POM, Group 2b were identified as pollutants of interest for HOWI. POM Group 3 ranks sixth for toxicity-weighted emissions. POM Group 3 does not include any pollutants sampled at HOWI.

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).

28-20

- Four of the highest emitted pollutants in Dodge County also have the highest toxicity-weighted emissions.

- None of HOWI's pollutants of interest appear among the highest emitted pollutants (with noncancer RfCs) in Dodge County. Naphthalene, however, ranks ninth for toxicity-weighted emissions.

28.6   Summary of the 2010 Monitoring Data for HOWI

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

❖ *Sampling for hexavalent chromium and PAH began in December 2009 at HOWI. However, PAH sampling was discontinued in June 2010.*

❖ *Naphthalene was the only pollutant to fail at least one screen. Benzo(a)pyrene and hexavalent chromium were added to the pollutants of interest for HOWI because they are also NATTS MQO Core Analytes.*

❖ *None of the preprocessed daily measurements and none of the quarterly or annual average concentrations for the pollutants of interest, where they could be calculated, were greater than their associated MRL noncancer health risk benchmarks.*

29.0   Data Quality

This section discusses the data quality of the ambient air measurements that constitute the 2010 NMP dataset. In accordance with the Data Quality Objectives (DQOs) presented in ERG's EPA-approved QAPP (ERG, 2009), the following data quality indicators were assessed: completeness, precision, and accuracy (also called bias).

The quality assessments presented in this section show that the 2010 monitoring data are of a known and high quality. As indicators of the reliability and representativeness of experimental measurements, both precision and accuracy are considered when interpreting ambient air monitoring data. The method precision for collocated and duplicate analyses met the precision DQO of 15 percent coefficient of variation (CV) for all methods except SNMOC, which was 15.29 percent CV. The analytical precision level for replicate analyses met the DQOs. Audit samples show that ERG is meeting the accuracy requirements of the NATTS TAD (EPA, 2009b).

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 DQO 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, 2009). Completeness statistics are presented in Section 2.4. The DQO of 85 percent completeness was met by all but five out 126 site-method combinations.

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 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 2010 sampling year, duplicate and collocated samples were collected on at least 10 percent of the scheduled sample days, as outlined in the QAPP. These samples were then analyzed in replicate. *Replicate measurements* are repeated analyses performed on a duplicate or collocated pair of samples. Collocated systems were not provided under the national contract for sites sampling PAH and were the responsibility of the participating agency. Thus, collocated samples were not collected for most PAH sites because few sites had collocated samplers. Therefore, the method precision data for PAH is based on only five sites for 2010.

Method precision was calculated by comparing the concentrations of the duplicates/collocates for each compound. 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 calculated from 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. This is a change in procedure compared to NMP reports in previous years, where ½ MDL was substituted for non-detects. To make an overall estimate of method precision, program-average CVs were calculated for each pollutant by averaging the values from the individual duplicate or collocated analyses. The expression "average variability" for a given dataset refers to the average CV.

Table 29-1 presents the 2010 NMP method precision for VOC, SNMOC, carbonyl compounds, metals, hexavalent chromium, and PAH, presented as average CV (expressed as a percentage). Each method met the program DQO for method precision, which is 15 percent CV, except SNMOC, which was slightly above the program DQO (15.29 percent and bolded in Table 29-1). The average CV for the SNMOC method may be driven largely by the individual pollutant concentration differences. Differences in very small concentrations may yield relatively large CVs (i.e., the percent difference between 0.001 ppbC and 0.002 ppbC is 100 percent).

Table 29-1. Method Precision by Analytical Method

Method/Pollutant Group	Average Coefficient of Variation (%)	Number of Pairs
VOC (TO-15)	14.11	2,935
SNMOC	**15.29**	1,191
Carbonyl Compounds (TO-11A)	6.17	1,209
Metals Analysis (Method IO-3.5)	12.97	1,178
Hexavalent Chromium (EPA-approved method)	14.89	112
PAH (TO-13)	13.18	378
DQO	15.00 percent CV	

Tables 29-2 through 29-7 present method precision for VOC, SNMOC, carbonyl compounds, metals, hexavalent chromium, and PAH, respectively, as the average CVs per pollutant per site, per site, and per method. Also included in these tables is the number of duplicated and/or collocated pairs included in the CV calculations. CVs exceeding the 15 percent

DQO are bolded in each table. The shaded rows in each table identify the NATTS MQO Core Analytes for each method.

29.2.1 VOC Method Precision

Table 29-2 presents the method precision for all duplicate and collocated VOC samples as the average CV per pollutant per site, the average CV per site, and the overall average CV for NMP sites sampling VOC. The average pollutant-specific CV ranged from 0 percent for a few pollutants for several sites to 99.69 percent (carbon disulfide for PROK). The site-specific average CV ranged from 6.66 percent for S4MO to 34.13 percent for GPCO. The overall method precision for VOC was 14.11 percent.

Table 29-2. VOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site

Pollutant	# of Pairs	*BTUT*	BURVT	CHNJ	*DEMI*	ELNJ	*GLKY*
Acetylene	131	12.39	**20.04**	10.35	2.36	4.26	4.53
Acrylonitrile	3	**28.28**	NA	NA	NA	**39.12**	NA
tert-Amyl Methyl Ether	0	NA	NA	NA	NA	NA	NA
Benzene	131	**15.46**	**17.83**	11.04	5.25	**15.21**	**66.70**
Bromochloromethane	0	NA	NA	NA	NA	NA	NA
Bromodichloromethane	4	NA	NA	NA	NA	NA	NA
Bromoform	0	NA	NA	NA	NA	NA	NA
Bromomethane	28	**59.75**	NA	14.89	5.24	4.13	**25.38**
1,3-Butadiene	105	9.14	14.41	5.12	2.01	6.28	**16.76**
Carbon Disulfide	86	**15.26**	**43.45**	10.09	**15.10**	4.51	**23.33**
Carbon Tetrachloride	126	**33.19**	**24.73**	**18.19**	6.13	11.39	**33.91**
Chlorobenzene	0	NA	NA	NA	NA	NA	NA
Chloroethane	12	NA	**16.61**	NA	10.88	4.56	NA
Chloroform	76	7.16	9.08	8.95	**45.76**	5.69	0
Chloromethane	131	5.59	7.61	9.68	8.75	5.53	8.22
Chloromethylbenzene	0	NA	NA	NA	NA	NA	NA
Chloroprene	0	NA	NA	NA	NA	NA	NA
Dibromochloromethane	2	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	0	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	2	**28.02**	NA	NA	NA	NA	NA
o-Dichlorobenzene	0	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	40	14.66	3.85	NA	NA	7.53	NA
Dichlorodifluoromethane	131	5.91	6.23	9.75	1.45	4.17	6.45
1,1-Dichloroethane	0	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	9	NA	5.04	NA	12.12	NA	NA
1,1-Dichloroethene	0	NA	NA	NA	NA	NA	NA

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-2. VOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	BTUT	BURVT	CHNJ	DEMI	ELNJ	GLKY
cis-1,2-Dichloroethylene	0	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	1	NA	NA	NA	NA	7.62	NA
Dichloromethane	131	21.46	28.95	7.99	33.85	6.45	33.36
1,2-Dichloropropane	0	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	124	2.86	7.77	12.11	1.75	7.19	4.88
Ethyl Acrylate	0	NA	NA	NA	NA	NA	NA
Ethyl tert-Butyl Ether	0	NA	NA	NA	NA	NA	NA
Ethylbenzene	129	**15.15**	12.40	**17.82**	2.77	7.02	**15.22**
Hexachloro-1,3-butadiene	0	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	131	**20.74**	**27.95**	**17.48**	10.46	**27.55**	**23.29**
Methyl Isobutyl Ketone	104	**16.53**	**33.08**	13.19	14.25	**27.70**	**41.87**
Methyl Methacrylate	0	NA	NA	NA	NA	NA	NA
Methyl tert-Butyl Ether	0	NA	NA	NA	NA	NA	NA
n-Octane	103	11.63	8.46	**18.20**	3.57	10.60	12.41
Propylene	131	8.10	11.91	9.54	4.92	5.83	14.39
Styrene	103	**19.46**	**22.38**	9.68	**17.62**	12.36	**28.59**
1,1,2,2-Tetrachloroethane	0	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	68	**15.46**	5.68	7.44	1.95	7.20	NA
Toluene	131	11.28	**18.45**	**20.45**	2.93	8.79	7.66
1,2,4-Trichlorobenzene	0	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	2	**17.07**	NA	NA	NA	NA	0
1,1,2-Trichloroethane	0	NA	NA	NA	NA	NA	NA
Trichloroethylene	7	**24.36**	NA	NA	5.48	NA	NA
Trichlorofluoromethane	131	5.46	6.14	9.07	1.26	3.86	4.40
Trichlorotrifluoroethane	131	6.66	6.45	10.78	4.77	4.58	4.63
1,2,4-Trimethylbenzene	125	**15.31**	**17.84**	**17.78**	2.61	7.13	8.96
1,3,5-Trimethylbenzene	108	**16.17**	**22.47**	11.63	2.26	10.92	11.17
Vinyl chloride	0	NA	NA	NA	NA	NA	NA
m,p-Xylene	130	**16.08**	9.95	**24.97**	3.32	6.25	9.61
o-Xylene	128	**15.37**	15.63	20.21	4.21	6.62	7.78
Average by Site	14.11	16.47	15.72	13.06	8.32	9.66	16.54

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-2. VOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	*GPCO*	MWOK	*NBIL*	NBNJ	OCOK	PANJ
Acetylene	131	**37.95**	7.04	14.64	7.76	14.59	5.30
Acrylonitrile	3	NA	NA	NA	NA	NA	NA
tert-Amyl Methyl Ether	0	NA	NA	NA	NA	NA	NA
Benzene	131	**46.73**	7.29	5.92	13.01	8.83	6.57
Bromochloromethane	0	NA	NA	NA	NA	NA	NA
Bromodichloromethane	4	NA	NA	NA	NA	NA	NA
Bromoform	0	NA	NA	NA	NA	NA	NA
Bromomethane	28	14.76	**58.74**	**79.02**	5.06	3.70	NA
1,3-Butadiene	105	**16.53**	4.31	**25.07**	5.19	13.53	6.97
Carbon Disulfide	86	**43.09**	**69.71**	**37.74**	**30.37**	**25.54**	**34.05**
Carbon Tetrachloride	126	**28.60**	12.83	3.49	**19.86**	**16.86**	3.29
Chlorobenzene	0	NA	NA	NA	NA	NA	NA
Chloroethane	12	NA	NA	NA	5.24	**66.99**	3.95
Chloroform	76	4.56	0	**71.41**	3.13	0	4.10
Chloromethane	131	7.23	3.21	6.04	8.95	8.55	5.78
Chloromethylbenzene	0	NA	NA	NA	NA	NA	NA
Chloroprene	0	NA	NA	NA	NA	NA	NA
Dibromochloromethane	2	NA	NA	**20.00**	NA	NA	NA
1,2-Dibromoethane	0	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	2	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	0	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	40	NA	**38.07**	**44.56**	14.63	**36.53**	11.47
Dichlorodifluoromethane	131	7.00	3.54	3.19	8.93	7.76	4.54
1,1-Dichloroethane	0	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	9	**34.57**	4.04	0	NA	NA	NA
1,1-Dichloroethene	0	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	0	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	1	NA	NA	NA	NA	NA	NA
Dichloromethane	131	**55.48**	8.74	**55.84**	12.42	**20.99**	10.20
1,2-Dichloropropane	0	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	124	4.95	2.27	4.40	3.91	8.31	3.82
Ethyl Acrylate	0	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	0	NA	NA	NA	NA	NA	NA
Ethylbenzene	129	**52.78**	7.27	11.92	9.97	8.48	4.23
Hexachloro-1,3-butadiene	0	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	131	**52.39**	13.55	**27.09**	**41.68**	**43.47**	10.07
Methyl Isobutyl Ketone	104	2.56	**22.39**	**49.27**	**42.29**	**37.24**	12.24
Methyl Methacrylate	0	NA	NA	NA	NA	NA	NA
Methyl *tert*-Butyl Ether	0	NA	NA	NA	NA	NA	NA
n-Octane	103	**51.89**	11.36	**16.06**	**19.31**	7.79	9.31
Propylene	131	**49.65**	14.97	**10.39**	**15.02**	34.08	6.09

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-2. VOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	GPCO	MWOK	NBIL	NBNJ	OCOK	PANJ
Styrene	103	**56.80**	5.25	13.91	8.23	12.93	10.32
1,1,2,2-Tetrachloroethane	0	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	68	**51.04**	1.47	12.30	4.67	**24.73**	5.59
Toluene	131	**57.69**	7.78	**19.71**	**45.68**	8.96	3.36
1,2,4-Trichlorobenzene	0	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	2	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	0	NA	NA	NA	NA	NA	NA
Trichloroethylene	7	NA	NA	2.02	NA	NA	NA
Trichlorofluoromethane	131	4.07	3.24	14.02	9.93	8.30	8.31
Trichlorotrifluoroethane	131	7.38	3.64	3.87	8.68	8.98	5.76
1,2,4-Trimethylbenzene	125	**58.83**	**17.62**	14.46	**20.43**	**20.05**	6.99
1,3,5-Trimethylbenzene	108	**27.41**	7.96	12.52	14.64	11.69	9.26
Vinyl chloride	0	NA	NA	NA	NA	NA	NA
m,p-Xylene	130	**57.62**	7.69	**15.34**	**19.45**	10.27	4.35
o-Xylene	128	**55.89**	6.42	13.83	13.51	11.68	4.26
Average by Site	*14.11*	*34.13*	*12.98*	*22.54*	*15.26*	*17.81*	*7.70*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-2. VOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	PROK	PXSS	S4MO	SEWA	SPIL	SSSD
Acetylene	131	11.43	**21.11**	4.70	2.75	7.51	7.26
Acrylonitrile	3	NA	NA	NA	NA	NA	NA
tert-Amyl Methyl Ether	0	NA	NA	NA	NA	NA	NA
Benzene	131	**15.31**	5.09	3.49	5.29	**16.32**	5.38
Bromochloromethane	0	NA	NA	NA	NA	NA	NA
Bromodichloromethane	4	NA	NA	NA	NA	NA	NA
Bromoform	0	NA	NA	NA	NA	NA	NA
Bromomethane	28	14.99	NA	13.69	NA	NA	12.33
1,3-Butadiene	105	**15.69**	6.57	4.86	10.02	6.70	11.28
Carbon Disulfide	86	**99.69**	**37.46**	10.43	**20.61**	**32.59**	**86.91**
Carbon Tetrachloride	126	8.46	8.65	6.12	6.91	11.49	**15.12**
Chlorobenzene	0	NA	NA	NA	NA	NA	NA
Chloroethane	12	**33.95**	NA	NA	NA	NA	NA
Chloroform	76	**20.93**	8.50	3.89	**17.69**	5.26	4.97
Chloromethane	131	8.10	4.23	5.68	3.97	3.18	5.83
Chloromethylbenzene	0	NA	NA	NA	NA	NA	NA
Chloroprene	0	NA	NA	NA	NA	NA	NA
Dibromochloromethane	2	NA	NA	NA	NA	NA	NA

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-2. VOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	PROK	PXSS	S4MO	SEWA	SPIL	SSSD
1,2-Dibromoethane	0	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	2	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	0	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	40	14.24	3.02	3.29	NA	12.20	7.07
Dichlorodifluoromethane	131	7.62	5.31	4.88	2.38	3.72	3.48
1,1-Dichloroethane	0	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	9	NA	NA	NA	7.07	NA	NA
1,1-Dichloroethene	0	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	0	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	1	NA	NA	NA	NA	NA	NA
Dichloromethane	131	**18.82**	**25.66**	12.13	**42.04**	5.94	**18.28**
1,2-Dichloropropane	0	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	124	7.30	1.62	6.31	**35.66**	3.93	2.36
Ethyl Acrylate	0	NA	NA	NA	NA	NA	NA
Ethyl tert-Butyl Ether	0	NA	NA	NA	NA	NA	NA
Ethylbenzene	129	5.69	6.72	2.21	7.49	13.32	**20.26**
Hexachloro-1,3-butadiene	0	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	131	**25.86**	**18.01**	12.97	**48.12**	15.65	7.20
Methyl Isobutyl Ketone	104	10.44	**15.61**	**18.70**	**31.08**	14.06	2.91
Methyl Methacrylate	0	NA	NA	NA	NA	NA	NA
Methyl tert-Butyl Ether	0	NA	NA	NA	NA	NA	NA
n-Octane	103	7.20	**15.29**	9.29	**26.27**	**15.21**	**15.71**
Propylene	131	7.50	11.47	6.64	**15.88**	2.38	8.43
Styrene	103	4.33	**28.05**	6.86	**31.83**	13.85	**19.17**
1,1,2,2-Tetrachloroethane	0	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	68	NA	8.40	1.10	5.91	7.56	4.99
Toluene	131	7.45	12.45	2.29	7.88	12.34	**25.24**
1,2,4-Trichlorobenzene	0	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	2	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	0	NA	NA	NA	NA	NA	NA
Trichloroethylene	7	NA	NA	NA	NA	10.74	NA
Trichlorofluoromethane	131	7.75	3.67	4.50	2.17	6.79	2.83
Trichlorotrifluoroethane	131	6.47	7.10	4.96	4.54	4.81	2.71
1,2,4-Trimethylbenzene	125	8.91	13.64	9.94	7.52	**19.48**	**28.48**
1,3,5-Trimethylbenzene	108	11.70	**16.46**	9.35	7.43	**21.73**	13.41
Vinyl chloride	0	NA	NA	NA	NA	NA	NA
m,p-Xylene	130	5.80	7.53	3.50	5.58	14.96	**21.53**
o-Xylene	128	4.26	7.00	1.35	5.63	**16.08**	23.91
Average by Site	*14.11*	*15.00*	*11.94*	*6.66*	*14.47*	*11.45*	*14.50*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-2. VOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	TMOK	TOOK	UCSD
Acetylene	131	6.08	5.70	5.83
Acrylonitrile	3	**15.71**	NA	NA
tert-Amyl Methyl Ether	0	NA	NA	NA
Benzene	131	12.75	5.97	6.61
Bromochloromethane	0	NA	NA	NA
Bromodichloromethane	4	NA	NA	NA
Bromoform	0	NA	NA	NA
Bromomethane	28	5.06	14.14	0
1,3-Butadiene	105	8.64	9.22	6.15
Carbon Disulfide	86	**49.86**	NA	4.88
Carbon Tetrachloride	126	**26.30**	14.62	**27.83**
Chlorobenzene	0	NA	NA	NA
Chloroethane	12	NA	NA	14.63
Chloroform	76	0	0	6.43
Chloromethane	131	6.09	9.78	6.33
Chloromethylbenzene	0	NA	NA	NA
Chloroprene	0	NA	NA	NA
Dibromochloromethane	2	NA	NA	NA
1,2-Dibromoethane	0	NA	NA	NA
m-Dichlorobenzene	2	4.88	NA	NA
o-Dichlorobenzene	0	NA	NA	NA
p-Dichlorobenzene	40	**56.91**	**39.80**	NA
Dichlorodifluoromethane	131	5.99	4.85	6.03
1,1-Dichloroethane	0	NA	NA	NA
1,2-Dichloroethane	9	7.86	NA	NA
1,1-Dichloroethene	0	NA	NA	NA
cis-1,2-Dichloroethylene	0	NA	NA	NA
trans-1,2-Dichloroethylene	1	NA	NA	NA
Dichloromethane	131	**20.96**	**31.60**	7.87
1,2-Dichloropropane	0	NA	NA	NA
cis-1,3-Dichloropropene	0	NA	NA	NA
trans-1,3-Dichloropropene	0	NA	NA	NA
Dichlorotetrafluoroethane	124	7.58	3.76	5.26
Ethyl Acrylate	0	NA	NA	NA
Ethyl *tert*-Butyl Ether	0	NA	NA	NA
Ethylbenzene	129	7.16	4.41	6.64
Hexachloro-1,3-butadiene	0	NA	NA	NA
Methyl Ethyl Ketone	131	13.03	6.00	**23.26**
Methyl Isobutyl Ketone	104	**52.87**	**24.36**	**27.78**
Methyl Methacrylate	0	NA	NA	NA
Methyl *tert*-Butyl Ether	0	NA	NA	NA
n-Octane	103	11.77	5.06	6.61

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-2. VOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	TMOK	TOOK	UCSD
Propylene	131	3.48	9.24	10.93
Styrene	103	4.63	2.33	14.24
1,1,2,2-Tetrachloroethane	0	NA	NA	NA
Tetrachloroethylene	68	5.34	3.70	NA
Toluene	131	9.51	3.61	10.11
1,2,4-Trichlorobenzene	0	NA	NA	NA
1,1,1-Trichloroethane	2	NA	NA	NA
1,1,2-Trichloroethane	0	NA	NA	NA
Trichloroethylene	7	NA	NA	NA
Trichlorofluoromethane	131	6.07	3.44	7.09
Trichlorotrifluoroethane	131	6.55	4.80	11.17
1,2,4-Trimethylbenzene	125	**18.43**	8.06	4.68
1,3,5-Trimethylbenzene	108	3.02	3.03	3.03
Vinyl chloride	0	NA	NA	NA
m,p-Xylene	130	10.11	3.64	4.33
o-Xylene	128	14.31	5.91	3.49
Average by Site	*14.11*	*13.83*	*9.08*	*9.25*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

29.2.2 SNMOC Method Precision

The SNMOC method precision for duplicate and collocated samples is presented in Table 29-3 as the average CV per pollutant per site, the average CV per site, and the overall CV for NMP sites sampling SNMOC. The results from duplicate and collocated samples show low- to high-level variability among pollutants per sites, ranging from an average CV of 0 percent (2-methylheptane and 2,2,3-trimethylpentane for NBIL) to 96.61 percent (ethylbenzene for BRCO). The site-specific average CV ranged from 11.14 percent for BRCO to 19.32 percent for PACO, with an overall method average of 15.29 percent.

Table 29-3. SNMOC Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site

Pollutant	# of Pairs	BRCO	*BTUT*	*NBIL*	*PACO*	*RICO*	SSSD	UCSD
Acetylene	31	8.81	8.76	14.43	5.61	3.42	5.18	5.63
Benzene	31	**20.57**	11.14	10.58	**26.59**	10.01	5.28	**27.55**
1,3-Butadiene	3	NA	6.91	NA	NA	6.46	NA	NA
n-Butane	27	1.65	12.73	11.00	**20.63**	6.12	1.21	1.38
cis-2-Butene	11	NA	12.03	NA	6.26	3.90	8.41	NA
trans-2-Butene	13	3.36	**22.67**	NA	11.56	13.25	3.03	12.86
Cyclohexane	21	2.48	12.48	**16.58**	6.96	5.89	**28.87**	5.52
Cyclopentane	28	1.85	14.00	13.27	11.68	7.44	**27.67**	11.71
Cyclopentene	0	NA	NA	NA	NA	NA	NA	NA
n-Decane	17	13.94	13.15	**44.71**	**32.48**	8.38	**68.53**	NA
1-Decene	0	NA	NA	NA	NA	NA	NA	NA
m-Diethylbenzene	2	NA	**17.44**	NA	NA	NA	NA	NA
p-Diethylbenzene	2	NA	**21.45**	NA	NA	NA	NA	NA
2,2-Dimethylbutane	28	5.80	**27.03**	**16.27**	5.82	**19.58**	**33.03**	6.36
2,3-Dimethylbutane	26	4.26	9.77	**19.46**	4.23	4.67	11.78	2.55
2,3-Dimethylpentane	27	10.37	**15.07**	**25.95**	10.71	**26.36**	**19.22**	9.50
2,4-Dimethylpentane	19	9.21	13.00	**26.29**	6.32	**20.62**	4.51	NA
n-Dodecane	6	**30.22**	8.12	NA	**73.36**	7.46	8.86	NA
1-Dodecene	6	NA	**24.15**	**29.74**	NA	NA	7.77	4.66
Ethane	31	1.91	8.83	**18.83**	6.90	6.23	1.04	1.55
2-Ethyl-1-butene	0	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	25	**96.61**	12.81	8.96	**30.70**	**77.72**	8.85	8.10
Ethylene	31	11.98	4.87	6.13	**30.31**	9.76	4.21	5.48
m-Ethyltoluene	18	0.58	13.95	13.49	**24.51**	7.08	6.06	NA
o-Ethyltoluene	11	NA	**66.74**	20.29	**21.49**	10.55	NA	NA
p-Ethyltoluene	10	0.47	13.60	6.48	**23.41**	3.21	NA	NA
n-Heptane	25	6.12	11.54	**17.44**	11.07	7.50	**32.09**	2.22
1-Heptene	8	10.60	**20.20**	NA	5.98	**19.52**	NA	NA
n-Hexane	30	3.83	**52.61**	14.99	8.47	7.41	**23.31**	**17.11**
1-Hexene	1	NA	10.80	NA	NA	NA	NA	NA
cis-2-Hexene	1	NA	13.50	NA	NA	NA	NA	NA
trans-2-Hexene	0	NA	NA	NA	NA	NA	NA	NA
Isobutane	31	0.64	11.36	**16.12**	11.37	6.21	12.41	5.10
Isobutene/1-Butene	29	**36.02**	10.66	13.06	**24.00**	63.87	6.79	4.53
Isopentane	31	2.87	11.79	**17.99**	13.52	3.37	**28.75**	13.42
Isoprene	18	10.21	**31.34**	13.42	**55.21**	13.27	14.89	**44.00**
Isopropylbenzene	1	NA	**28.34**	NA	NA	NA	NA	NA
2-Methyl-1-butene	5	NA	**16.59**	NA	NA	3.88	6.37	NA
3-Methyl-1-butene	4	NA	NA	NA	NA	NA	NA	NA
2-Methyl-1-pentene	0	NA	NA	NA	NA	NA	NA	NA
4-Methyl-1-pentene	0	NA	NA	NA	NA	NA	NA	NA
2-Methyl-2-butene	0	NA	12.71	NA	NA	10.16	NA	NA

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

**Table 29-3. SNMOC Method Precision: Average Coefficient of Variation
Based on Duplicate and Collocated Samples by Site (Continued)**

Pollutant	# of Pairs	BRCO	*BTUT*	*NBIL*	PACO	RICO	SSSD	UCSD
Methylcyclohexane	24	1.14	13.19	**16.69**	7.76	11.65	**23.04**	2.26
Methylcyclopentane	31	6.17	**39.99**	**18.18**	4.56	**15.84**	12.17	**30.33**
2-Methylheptane	14	3.56	7.40	0	5.89	7.81	NA	NA
3-Methylheptane	17	8.25	14.01	**23.36**	8.95	9.43	6.36	NA
2-Methylhexane	23	2.67	13.86	**17.15**	6.22	5.31	11.36	8.52
3-Methylhexane	27	**16.97**	12.91	**25.49**	14.60	**24.69**	**19.44**	**42.19**
2-Methylpentane	28	**15.07**	**18.70**	5.29	3.08	**19.86**	13.67	**48.17**
3-Methylpentane	31	1.48	**26.55**	14.75	7.25	2.77	6.60	5.68
n-Nonane	17	4.77	11.19	**31.16**	8.20	10.15	**62.94**	NA
1-Nonene	2	NA	11.74	NA	NA	NA	NA	NA
n-Octane	18	5.27	7.41	2.66	10.73	10.22	10.09	NA
1-Octene	1	NA	NA	NA	12.07	NA	NA	NA
n-Pentane	31	3.32	**15.84**	**21.72**	59.82	5.28	**33.07**	22.38
1-Pentene	29	13.06	10.65	**46.52**	30.18	54.34	13.26	9.92
cis-2-Pentene	7	NA	**16.37**	NA	NA	2.33	NA	NA
trans-2-Pentene	19	**19.36**	16.02	35.19	25.92	28.15	5.45	8.98
a-Pinene	8	12.00	**16.43**	13.08	NA	**15.66**	NA	NA
b-Pinene	1	NA	NA	NA	NA	NA	NA	5.15
Propane	31	1.38	10.18	10.14	7.54	7.10	2.96	1.09
n-Propylbenzene	8	0.57	**16.99**	NA	**26.86**	10.71	NA	NA
Propylene	31	13.91	7.87	8.76	**15.08**	9.47	2.59	5.71
Propyne	0	NA	NA	NA	NA	NA	NA	NA
Styrene	3	NA	**23.28**	NA	NA	NA	NA	**15.29**
Toluene	31	8.46	7.13	**17.20**	11.97	6.05	**23.50**	9.62
n-Tridecane	0	NA	NA	NA	NA	NA	NA	NA
1-Tridecene	0	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trimethylbenzene	5	**21.54**	**17.95**	NA	NA	8.32	NA	NA
1,2,4-Trimethylbenzene	21	**19.53**	8.39	9.53	**15.13**	11.04	7.63	2.14
1,3,5-Trimethylbenzene	15	3.17	13.32	13.08	9.60	10.19	NA	NA
2,2,3-Trimethylpentane	8	2.49	**18.58**	0	**37.43**	**59.82**	NA	NA
2,2,4-Trimethylpentane	21	**20.53**	13.40	**21.73**	NA	**29.53**	7.20	**15.78**
2,3,4-Trimethylpentane	15	14.71	10.89	**20.00**	NA	**22.62**	5.92	NA
n-Undecane	11	**27.88**	**35.14**	1.75	**65.58**	6.53	**39.51**	NA
1-Undecene	9	NA	**78.78**	**48.28**	**72.67**	NA	**19.50**	**24.22**
m-Xylene/*p*-Xylene	25	13.93	12.41	13.15	9.16	5.34	**15.65**	4.02
o-Xylene	21	12.81	10.65	7.89	**20.15**	5.69	**22.18**	NA
Average by Site		*15.29*	*11.14*	*17.26*	*17.11*	*19.32*	*14.20*	*15.79*	*12.18*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

29.2.3 Carbonyl Compound Method Precision

Table 29-4 presents the method precision for duplicate and collocated carbonyl compound samples as the average CV per pollutant per site, the average CV per site, 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 an average CV of 0 percent (valeraldehyde for SPIL) to 32.37 percent (tolualdehydes for ELNJ). The site-specific average CV ranged from 3.42 percent for TOOK to 11.16 percent for ELNJ. Note that the average CV for every site was less than the program DQO of 15 percent. The overall method precision was 6.17 percent for carbonyl compounds.

Table 29-4. Carbonyl Compound Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site

Pollutant	# of Pairs	AZFL	*BTUT*	CHNJ	*DEMI*	ELNJ	*GPCO*
Acetaldehyde	127	0.44	3.45	6.30	7.81	5.80	1.45
Acetone	127	6.27	1.10	9.71	3.61	**16.11**	8.97
Benzaldehyde	124	10.26	2.15	6.06	7.13	9.22	5.58
Butyraldehyde	127	8.71	3.95	7.02	**21.37**	9.18	3.81
Crotonaldehyde	126	2.94	5.06	7.71	4.84	9.33	4.56
2,5-Dimethylbenzaldehyde	0	NA	NA	NA	NA	NA	NA
Formaldehyde	127	2.20	3.22	6.10	5.76	3.89	2.09
Hexaldehyde	125	7.72	4.02	5.08	11.05	8.82	7.08
Isovaleraldehyde	2	NA	NA	NA	NA	NA	NA
Propionaldehyde	127	2.92	4.33	4.65	3.23	7.15	3.53
Tolualdehydes	74	10.31	3.80	4.41	7.92	**32.37**	11.44
Valeraldehyde	123	7.08	9.13	5.71	13.03	9.70	5.66
Average by Site	*6.17*	*5.89*	*4.02*	*6.28*	*8.58*	*11.16*	*5.42*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-4. Carbonyl Compound Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	INDEM	MWOK	*NBIL*	NBNJ	OCOK	ORFL
Acetaldehyde	127	6.32	2.01	6.95	2.86	1.08	2.54
Acetone	127	6.01	2.70	12.31	**16.20**	2.05	7.86
Benzaldehyde	124	9.29	5.41	8.27	10.29	2.96	7.17
Butyraldehyde	127	7.73	6.44	6.64	9.16	3.48	8.67
Crotonaldehyde	126	8.58	4.10	6.18	4.03	2.75	5.30
2,5-Dimethylbenzaldehyde	0	NA	NA	NA	NA	NA	NA
Formaldehyde	127	7.48	1.72	7.69	3.71	2.05	2.37
Hexaldehyde	125	7.53	5.50	8.64	7.78	6.66	6.57
Isovaleraldehyde	2	NA	NA	NA	NA	6.15	NA
Propionaldehyde	127	6.81	2.68	9.68	4.77	4.73	5.67
Tolualdehydes	74	7.94	12.47	6.79	8.33	5.25	6.98
Valeraldehyde	123	8.90	4.68	4.76	8.53	3.72	5.23
Average by Site	*6.17*	*7.66*	*4.77*	*7.79*	*7.57*	*3.72*	*5.84*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-4. Carbonyl Compound Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	PROK	*PXSS*	*S4MO*	*SEWA*	*SKFL*	SPIL
Acetaldehyde	127	0.89	2.69	2.45	2.39	3.02	9.48
Acetone	127	4.18	1.18	4.65	4.06	14.05	5.00
Benzaldehyde	124	8.56	7.56	8.81	12.28	6.78	11.57
Butyraldehyde	127	5.10	5.53	4.44	1.60	8.50	10.03
Crotonaldehyde	126	3.81	6.67	3.37	3.23	3.17	9.38
2,5-Dimethylbenzaldehyde	0	NA	NA	NA	NA	NA	NA
Formaldehyde	127	1.59	3.44	2.81	5.23	1.85	12.91
Hexaldehyde	125	6.60	9.07	4.11	9.56	6.83	13.51
Isovaleraldehyde	2	NA	NA	NA	NA	NA	NA
Propionaldehyde	127	2.61	7.83	3.32	2.84	5.05	7.51
Tolualdehydes	74	5.49	3.19	12.12	10.09	9.01	5.11
Valeraldehyde	123	8.13	12.86	6.98	5.62	5.88	0
Average by Site	*6.17*	*4.70*	*6.00*	*5.31*	*5.69*	*6.41*	*8.45*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-4. Carbonyl Compound Method Precision: Average Coefficient of Variation Based on Duplicate and Collocated Samples by Site (Continued)

Pollutant	# of Pairs	SSSD	*SYFL*	TMOK	TOOK	UCSD	WPIN
Acetaldehyde	127	2.81	3.60	1.39	1.60	5.37	4.94
Acetone	127	7.25	9.73	4.53	1.44	**15.62**	5.07
Benzaldehyde	124	3.28	6.84	4.76	6.42	8.65	4.57
Butyraldehyde	127	6.09	3.52	2.65	1.99	7.76	5.49
Crotonaldehyde	126	2.66	8.21	2.53	3.12	7.47	6.47
2,5-Dimethylbenzaldehyde	0	NA	NA	NA	NA	NA	NA
Formaldehyde	127	3.66	6.10	2.02	1.72	4.78	4.19
Hexaldehyde	125	3.22	6.37	5.20	5.82	9.69	5.76
Isovaleraldehyde	2	NA	NA	NA	NA	NA	4.99
Propionaldehyde	127	3.75	3.61	1.80	2.01	8.50	7.80
Tolualdehydes	74	6.08	12.07	7.90	7.56	8.08	7.55
Valeraldehyde	123	4.77	5.32	7.44	2.54	11.77	6.55
Average by Site	*6.17*	*4.36*	*6.54*	*4.02*	*3.42*	*8.77*	*5.76*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

29.2.4 Metals Method Precision

The method precision for all collocated metals samples are presented in Table 29-5 as the average CV per pollutant per site, the average CV per site, 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 high-level variability among sites, ranging from 0 percent (cobalt for UNVT) to 72.53 percent (mercury for NBIL). The site-specific average CV ranged from 8.27 percent for BOMA to 27.11 percent for NBIL. The overall method precision for metals was 12.97 percent.

**Table 29-5. Metals Method Precision: Average Coefficient of Variation
Based on Collocated Samples by Site**

Pollutant	# of Pairs	BOMA	BTUT	NBIL	S4MO	TOOK	UNVT
Antimony	140	3.69	**17.77**	**15.59**	3.83	**28.57**	5.87
Arsenic	139	3.04	6.52	**18.35**	2.78	6.55	9.52
Beryllium	104	**24.23**	NA	**27.55**	10.74	8.80	NA
Cadmium	128	**23.32**	11.55	**28.84**	**17.15**	**24.77**	10.99
Chromium	15	NA	NA	NA	0.84	4.68	NA
Cobalt	137	5.60	12.37	**35.33**	**15.07**	**18.21**	0
Lead	137	5.03	3.95	**25.87**	4.82	7.18	3.44
Manganese	140	2.42	6.22	**22.10**	**16.68**	8.76	4.15
Mercury	83	6.37	NA	**72.53**	14.75	**20.21**	NA
Nickel	19	3.47	**31.44**	14.26	NA	4.50	**16.72**
Selenium	136	5.55	7.73	10.72	3.92	7.34	**17.39**
Average by Site	*12.97*	*8.27*	*12.19*	*27.11*	*9.06*	*12.69*	*8.51*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

29.2.5 Hexavalent Chromium Method Precision

Table 29-6 presents the method precision results from collocated hexavalent chromium samples as the average 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 collocated NATTS sites. The site-specific average CV ranged from 2.69 percent for BOMA to 33.84 percent for CHSC, with an overall method precision of 14.89 percent.

Table 29-6. Hexavalent Chromium Method Precision: Average Coefficient of Variation Based on Collocated Samples by Site

Site	Average CV
BOMA	2.69
BTUT	14.03
BXNY	**23.36**
CAMS 35	**15.41**
CHSC	**33.84**
DEMI	11.28
GLKY	7.13
GPCO	10.86
HOWI	**21.12**
MONY	3.63
NBIL	**19.50**
PRRI	**22.44**
PXSS	9.59
RIVA	7.81
ROCH	12.94
S4MO	5.31
SDGA	**21.97**
SEWA	9.99
SKFL	**15.93**
SYFL	**17.75**
UNVT	**17.53**
WADC	**23.45**
Average by Site	*14.89*
# of Pairs	112

BOLD ITALICS = EPA-designated NATTS Site.

29.2.6 PAH Method Precision

The method precision results for the collocated PAH samples are shown in Table 29-7 as the average CV per pollutant per site, the average CV per site, and the overall average CV for NMP sites sampling PAH. The results from collocated samples show low- to high-level average variability among sites, ranging from 0.23 percent (benzo(e)pyrene for SEWA) to 62.73 percent (acenaphthylene for RUCA). The site-specific average CV ranged from 9.17 percent for DEMI to 21.08 percent for RUCA. The overall method precision was 13.18 percent.

Table 29-7. PAH Method Precision: Average Coefficient of Variation Based on Collocated Samples by Site

Pollutant	# of Pairs	DEMI	RUCA	SDGA	SEWA	SYFL
Acenaphthene	29	2.95	10.01	6.61	**15.11**	9.95
Acenaphthylene	11	6.54	**62.73**	9.80	6.60	NA
Anthracene	13	8.45	**28.21**	8.86	5.62	NA
Benzo(a)anthracene	6	**19.92**	**28.25**	7.66	4.33	NA
Benzo(a)pyrene	8	7.86	**32.79**	10.89	1.73	NA
Benzo(b)fluoranthene	13	8.06	**25.71**	11.01	**28.14**	2.29
Benzo(e)pyrene	11	7.21	**20.23**	0.52	0.23	7.30
Benzo(g,h,i)perylene	20	5.41	**17.83**	13.15	**26.54**	7.82
Benzo(k)fluoranthene	6	12.97	**28.04**	NA	1.01	NA
Chrysene	29	8.75	**16.89**	11.45	7.66	12.98
Coronene	11	5.53	**15.98**	**18.60**	1.82	**26.60**
Cyclopenta[cd]pyrene	1	NA	NA	NA	1.70	NA
Dibenz(a,h)anthracene	2	9.12	NA	NA	10.08	NA
Fluoranthene	29	4.39	14.93	6.63	9.23	7.42
Fluorene	29	4.80	10.84	4.42	**16.79**	9.37
9-Fluorenone	29	2.82	9.26	5.20	**24.37**	8.63
Indeno(1,2,3-cd)pyrene	15	8.34	**25.49**	13.09	**35.38**	9.89
Naphthalene	29	2.98	10.21	9.15	**30.90**	8.01
Perylene	8	9.28	14.72	6.64	9.92	**22.64**
Phenanthrene	29	2.48	13.95	6.27	**16.01**	5.54
Pyrene	29	9.17	12.50	23.58	11.61	**21.36**
Retene	21	**45.58**	23.06	8.99	**43.62**	20.34
Average by Site	*13.18*	*9.17*	*21.08*	*9.61*	*14.02*	*12.01*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

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, but typically originate from random "noise" inherent to analytical instruments. Laboratories can easily 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.

29-18

Table 29-8 presents the 2010 NMP analytical precision for VOC, SNMOC, carbonyl compounds, metals, hexavalent chromium, and PAH, presented as average CV (expressed as a percentage). The analytical precision averaged across all sites collecting duplicate or collocated samples met the program DQO, which is 15 percent CV. The analytical precision for all six methods was less than 8 percent.

Table 29-8. Analytical Precision by Analytical Method

Method/Pollutant Group	Average Coefficient of Variation (%)	Number of Pairs
VOC (TO-15)	5.90	6,090
SNMOC	7.11	2,417
Carbonyl Compounds (TO-11A)	2.36	2,674
Metals Analysis (Method IO-3.5)	5.44	2,409
Hexavalent Chromium (EPA-approved method)	6.30	226
PAH (TO-13)	3.67	769
DQO	15.00 percent CV	

Tables 29-9 through 29-14 present analytical precision for VOC, SNMOC, carbonyl compounds, metals, hexavalent chromium, and PAH, respectively, as the average CVs per pollutant per site, per site, and per method. Pollutants exceeding the 15 percent DQO 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 DQOs. 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 average CV per pollutant per site, the average CV per site, and the overall average CV for NMP sites sampling VOC. 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 DQO of 15 percent. The average CV ranged from 0 percent for several pollutants and several sites to 47.14 percent (*p*-dichlorobenzene for SEWA). The site-specific average CV ranged from 4.01 percent for SPIL to 7.79 percent for UCSD. The overall analytical precision was 5.90 percent.

Table 29-9. VOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	# of Pairs	*BTUT*	BURVT	CHNJ	*DEMI*	ELNJ	*GLKY*
Acetylene	267	5.56	4.00	6.81	3.62	5.92	4.85
Acrylonitrile	6	NA	NA	NA	NA	2.44	NA
tert-Amyl Methyl Ether	0	NA	NA	NA	NA	NA	NA
Benzene	267	7.99	5.07	6.56	4.41	5.28	4.19
Bromochloromethane	0	NA	NA	NA	NA	NA	NA
Bromodichloromethane	9	NA	NA	NA	NA	NA	NA
Bromoform	1	NA	NA	6.15	NA	NA	NA
Bromomethane	77	5.58	8.25	5.00	5.12	7.51	7.21
1,3-Butadiene	219	6.83	5.84	3.87	12.11	5.44	7.97
Carbon Disulfide	194	5.27	10.66	6.10	3.54	5.64	4.32
Carbon Tetrachloride	262	9.28	6.70	4.82	3.65	5.79	3.42
Chlorobenzene	0	NA	NA	NA	NA	NA	NA
Chloroethane	34	NA	7.47	NA	7.69	8.58	NA
Chloroform	168	5.04	6.53	5.79	4.67	8.51	2.56
Chloromethane	267	5.31	5.14	6.33	2.74	5.76	4.16
Chloromethylbenzene	0	NA	NA	NA	NA	NA	NA
Chloroprene	0	NA	NA	NA	NA	NA	NA
Dibromochloromethane	5	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	0	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	4	4.64	NA	NA	NA	NA	NA
o-Dichlorobenzene	0	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	95	4.42	6.30	6.73	NA	8.19	NA
Dichlorodifluoromethane	267	5.43	5.11	6.09	2.81	5.72	4.13

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-9. VOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	*BTUT*	BURVT	CHNJ	*DEMI*	ELNJ	*GLKY*
1,1-Dichloroethane	0	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	18	NA	NA	NA	NA	NA	NA
1,1-Dichloroethene	0	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	0	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	2	NA	NA	NA	NA	5.66	NA
Dichloromethane	267	4.77	5.74	5.07	4.07	5.62	3.98
1,2-Dichloropropane	0	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	255	3.99	7.87	8.19	4.41	9.42	5.81
Ethyl Acrylate	0	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	0	NA	NA	NA	NA	NA	NA
Ethylbenzene	263	7.82	5.05	7.72	3.77	7.06	6.94
Hexachloro-1,3-butadiene	0	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	267	6.38	5.71	7.45	4.28	5.57	4.16
Methyl Isobutyl Ketone	214	7.69	8.29	8.52	10.16	11.40	6.33
Methyl Methacrylate	1	NA	NA	NA	NA	NA	NA
Methyl *tert*-Butyl Ether	0	NA	NA	NA	NA	NA	NA
n-Octane	212	8.88	8.13	8.90	7.70	8.14	3.80
Propylene	267	7.05	4.58	6.91	4.23	5.65	5.05
Styrene	211	8.71	9.37	10.13	7.82	11.04	4.47
1,1,2,2-Tetrachloroethane	0	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	145	11.13	6.86	7.89	4.12	7.24	NA
Toluene	267	8.40	4.97	5.85	3.76	5.69	4.25
1,2,4-Trichlorobenzene	0	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	6	1.64	NA	0	NA	NA	5.66
1,1,2-Trichloroethane	0	NA	NA	NA	NA	NA	NA
Trichloroethylene	16	3.20	0	NA	6.54	NA	NA
Trichlorofluoromethane	267	5.34	5.13	5.38	3.22	5.32	3.42
Trichlorotrifluoroethane	267	4.84	5.08	8.13	4.28	5.66	3.71
1,2,4-Trimethylbenzene	255	7.72	6.25	10.37	4.99	6.60	7.43
1,3,5-Trimethylbenzene	225	7.61	13.81	8.74	5.09	11.27	9.88
Vinyl chloride	0	NA	NA	NA	NA	NA	NA
m,p-Xylene	264	8.07	5.01	8.23	4.30	5.58	4.52
o-Xylene	259	7.95	5.53	7.71	5.73	6.05	6.24
Average by Site	*5.90*	*6.43*	*6.53*	*6.77*	*5.26*	*6.82*	*5.14*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-9. VOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	*GPCO*	MWOK	*NBIL*	NBNJ	OCOK	PANJ
Acetylene	267	4.73	4.38	3.41	4.54	8.06	3.81
Acrylonitrile	6	NA	NA	NA	7.62	0	NA
tert-Amyl Methyl Ether	0	NA	NA	NA	NA	NA	NA
Benzene	267	5.11	5.04	3.62	4.97	6.08	7.92
Bromochloromethane	0	NA	NA	NA	NA	NA	NA
Bromodichloromethane	9	NA	NA	NA	NA	NA	NA
Bromoform	1	NA	NA	NA	NA	NA	NA
Bromomethane	77	7.65	5.82	6.00	6.05	3.87	NA
1,3-Butadiene	219	6.30	6.89	5.06	8.80	10.96	4.97
Carbon Disulfide	194	4.88	4.75	2.11	4.98	7.17	6.15
Carbon Tetrachloride	262	5.36	5.35	4.94	5.64	4.93	3.88
Chlorobenzene	0	NA	NA	NA	NA	NA	NA
Chloroethane	34	1.55	5.24	NA	3.70	2.13	2.71
Chloroform	168	5.41	5.70	6.48	3.89	4.04	6.48
Chloromethane	267	5.46	4.53	3.93	4.98	4.91	3.33
Chloromethylbenzene	0	NA	NA	NA	NA	NA	NA
Chloroprene	0	NA	NA	NA	NA	NA	NA
Dibromochloromethane	5	NA	NA	4.61	NA	NA	NA
1,2-Dibromoethane	0	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	4	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	0	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	95	0	5.19	3.65	6.83	5.69	8.11
Dichlorodifluoromethane	267	5.44	4.40	3.90	5.05	4.65	3.75
1,1-Dichloroethane	0	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	18	NA	NA	NA	NA	11.47	NA
1,1-Dichloroethene	0	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	0	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	2	NA	NA	NA	NA	NA	NA
Dichloromethane	267	5.16	4.06	3.40	4.29	5.33	4.52
1,2-Dichloropropane	0	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	255	4.93	6.78	3.62	6.35	7.60	3.31
Ethyl Acrylate	0	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	0	NA	NA	NA	NA	NA	NA
Ethylbenzene	263	7.49	3.79	4.03	5.24	6.63	6.43

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-9. VOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	*GPCO*	MWOK	*NBIL*	NBNJ	OCOK	PANJ
Hexachloro-1,3-butadiene	0	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	267	7.69	4.26	3.69	4.67	5.06	6.25
Methyl Isobutyl Ketone	214	4.65	7.14	6.25	**15.24**	13.85	7.74
Methyl Methacrylate	1	0	NA	NA	NA	NA	NA
Methyl *tert*-Butyl Ether	0	NA	NA	NA	NA	NA	NA
n-Octane	212	9.01	5.36	7.75	6.65	8.27	6.12
Propylene	267	4.74	7.09	2.80	5.02	6.68	3.62
Styrene	211	8.73	6.85	9.70	8.83	12.33	12.09
1,1,2,2-Tetrachloroethane	0	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	145	5.13	8.41	2.04	6.61	11.89	4.72
Toluene	267	6.89	3.23	2.50	4.10	6.39	6.02
1,2,4-Trichlorobenzene	0	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	6	**23.70**	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	0	NA	NA	NA	NA	NA	NA
Trichloroethylene	16	NA	NA	4.84	NA	NA	NA
Trichlorofluoromethane	267	5.22	4.09	3.39	4.84	5.00	3.51
Trichlorotrifluoroethane	267	4.88	4.13	3.30	5.59	5.38	3.31
1,2,4-Trimethylbenzene	255	9.54	4.23	3.26	6.56	10.43	8.25
1,3,5-Trimethylbenzene	225	5.24	7.81	6.14	**18.34**	**23.10**	9.01
Vinyl chloride	0	NA	NA	NA	NA	NA	NA
m,p-Xylene	264	7.56	4.30	4.50	5.80	6.27	6.65
o-Xylene	259	7.55	3.43	3.41	5.19	8.72	6.63
Average by Site	*5.90*	*6.19*	*5.08*	*4.20*	*6.44*	*7.48*	*5.74*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-9. VOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	PROK	*PXSS*	*S4MO*	*SEWA*	SPIL	SSSD
Acetylene	267	3.92	14.42	3.61	2.63	3.78	6.38
Acrylonitrile	6	NA	**16.64**	NA	NA	NA	NA
tert-Amyl Methyl Ether	0	NA	NA	NA	NA	NA	NA
Benzene	267	4.78	3.82	2.83	2.54	3.52	4.14
Bromochloromethane	0	NA	NA	NA	NA	NA	NA
Bromodichloromethane	9	NA	NA	NA	NA	NA	NA
Bromoform	1	NA	NA	NA	NA	NA	NA
Bromomethane	77	6.29	12.17	5.34	4.29	0	1.91
1,3-Butadiene	219	5.75	5.61	10.07	3.46	5.38	11.15
Carbon Disulfide	194	4.98	5.20	3.62	4.32	4.59	10.98
Carbon Tetrachloride	262	5.04	5.46	3.55	3.31	3.98	6.53
Chlorobenzene	0	NA	NA	NA	NA	NA	NA
Chloroethane	34	5.08	4.29	NA	0	4.56	NA
Chloroform	168	11.63	7.66	4.13	3.23	2.51	3.22
Chloromethane	267	3.75	4.46	3.73	3.00	3.34	7.16
Chloromethylbenzene	0	NA	NA	NA	NA	NA	NA
Chloroprene	0	NA	NA	NA	NA	NA	NA
Dibromochloromethane	5	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	0	NA	NA	NA	NA	NA	NA
m-Dichlorobenzene	4	NA	NA	NA	NA	NA	NA
o-Dichlorobenzene	0	NA	NA	NA	NA	NA	NA
p-Dichlorobenzene	95	8.18	4.36	2.22	**47.14**	4.56	4.69
Dichlorodifluoromethane	267	3.84	4.56	3.60	2.85	3.16	6.16
1,1-Dichloroethane	0	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	18	NA	NA	NA	2.44	NA	NA
1,1-Dichloroethene	0	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	0	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethylene	2	NA	NA	NA	NA	NA	NA
Dichloromethane	267	5.22	4.49	3.95	3.80	3.97	5.02
1,2-Dichloropropane	0	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
trans-1,3-Dichloropropene	0	NA	NA	NA	NA	NA	NA
Dichlorotetrafluoroethane	255	5.13	8.59	4.84	2.78	3.23	3.45
Ethyl Acrylate	0	NA	NA	NA	NA	NA	NA
Ethyl *tert*-Butyl Ether	0	NA	NA	NA	NA	NA	NA
Ethylbenzene	263	7.48	4.47	4.55	5.62	4.26	9.93

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-9. VOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	PROK	*PXSS*	*S4MO*	*SEWA*	SPIL	SSSD
Hexachloro-1,3-butadiene	0	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone	267	3.93	5.02	6.20	3.19	3.87	3.53
Methyl Isobutyl Ketone	214	9.28	5.85	8.31	5.55	2.32	5.44
Methyl Methacrylate	1	NA	NA	NA	NA	NA	NA
Methyl *tert*-Butyl Ether	0	NA	NA	NA	NA	NA	NA
n-Octane	212	7.30	4.35	4.88	8.55	6.20	9.37
Propylene	267	9.03	3.98	3.95	2.58	4.27	6.92
Styrene	211	7.24	14.55	6.17	12.04	9.54	9.74
1,1,2,2-Tetrachloroethane	0	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	145	NA	5.74	4.27	1.52	3.86	5.59
Toluene	267	3.41	3.79	3.48	3.64	3.73	3.93
1,2,4-Trichlorobenzene	0	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	6	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	0	NA	NA	NA	NA	NA	NA
Trichloroethylene	16	NA	0	NA	NA	3.72	NA
Trichlorofluoromethane	267	3.68	4.28	3.31	1.94	3.01	5.35
Trichlorotrifluoroethane	267	3.97	6.81	4.90	2.84	2.70	5.97
1,2,4-Trimethylbenzene	255	5.70	5.76	4.70	5.46	4.31	6.87
1,3,5-Trimethylbenzene	225	8.43	8.76	6.20	9.13	5.42	8.03
Vinyl chloride	0	NA	NA	NA	NA	NA	NA
m,p-Xylene	264	5.17	4.59	3.55	3.63	3.89	5.06
o-Xylene	259	4.77	4.55	3.74	4.91	4.51	4.69
Average by Site	*5.90*	*5.88*	*6.35*	*4.60*	*5.59*	*4.01*	*6.20*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-9. VOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	TMOK	TOOK	UCSD
Acetylene	267	3.44	6.10	**17.13**
Acrylonitrile	6	0	NA	NA
tert-Amyl Methyl Ether	0	NA	NA	NA
Benzene	267	4.16	5.39	5.70
Bromochloromethane	0	NA	NA	NA
Bromodichloromethane	9	NA	NA	NA
Bromoform	1	NA	NA	NA
Bromomethane	77	10.68	11.45	0
1,3-Butadiene	219	6.43	7.67	7.69
Carbon Disulfide	194	5.40	5.49	7.36
Carbon Tetrachloride	262	3.29	5.13	12.97
Chlorobenzene	0	NA	NA	NA
Chloroethane	34	4.83	NA	4.56
Chloroform	168	10.53	2.98	1.90
Chloromethane	267	3.08	4.36	5.96
Chloromethylbenzene	0	NA	NA	NA
Chloroprene	0	NA	NA	NA
Dibromochloromethane	5	NA	NA	NA
1,2-Dibromoethane	0	NA	NA	NA
m-Dichlorobenzene	4	3.23	NA	NA
o-Dichlorobenzene	0	NA	NA	NA
p-Dichlorobenzene	95	4.28	7.96	NA
Dichlorodifluoromethane	267	2.93	4.39	6.83
1,1-Dichloroethane	0	NA	NA	NA
1,2-Dichloroethane	18	5.56	NA	NA
1,1-Dichloroethene	0	NA	NA	NA
cis-1,2-Dichloroethylene	0	NA	NA	NA
trans-1,2-Dichloroethylene	2	NA	NA	NA
Dichloromethane	267	7.39	5.30	5.32
1,2-Dichloropropane	0	NA	NA	NA
cis-1,3-Dichloropropene	0	NA	NA	NA
trans-1,3-Dichloropropene	0	NA	NA	NA
Dichlorotetrafluoroethane	255	5.88	8.15	4.90
Ethyl Acrylate	0	NA	NA	NA
Ethyl *tert*-Butyl Ether	0	NA	NA	NA
Ethylbenzene	263	2.93	5.57	7.73

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-9. VOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	TMOK	TOOK	UCSD
Hexachloro-1,3-butadiene	0	NA	NA	NA
Methyl Ethyl Ketone	267	3.54	5.60	8.55
Methyl Isobutyl Ketone	214	5.47	6.92	3.92
Methyl Methacrylate	1	NA	NA	NA
Methyl *tert*-Butyl Ether	0	NA	NA	NA
n-Octane	212	5.11	11.72	10.18
Propylene	267	7.48	5.92	12.31
Styrene	211	10.98	9.60	7.08
1,1,2,2-Tetrachloroethane	0	NA	NA	NA
Tetrachloroethylene	145	3.27	7.79	NA
Toluene	267	4.38	5.45	6.05
1,2,4-Trichlorobenzene	0	NA	NA	NA
1,1,1-Trichloroethane	6	NA	NA	NA
1,1,2-Trichloroethane	0	NA	NA	NA
Trichloroethylene	16	NA	NA	NA
Trichlorofluoromethane	267	3.08	4.12	8.72
Trichlorotrifluoroethane	267	2.29	4.39	6.06
1,2,4-Trimethylbenzene	255	6.53	5.77	10.53
1,3,5-Trimethylbenzene	225	2.76	6.02	8.26
Vinyl chloride	0	NA	NA	NA
m,p-Xylene	264	5.41	5.81	13.77
o-Xylene	259	5.17	6.10	11.25
Average by Site	*5.90*	*4.98*	*6.35*	*7.79*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

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 average CV per pollutant per site, the average CV per site, and the overall average CV for NMP sites sampling SNMOC. The average CV ranged from 0.18 percent (isobutane for BRCO) to 69.73 percent (1-undecene for PACO). The site-specific average CV ranged from 4.72 percent for RICO to 9.24 percent for PACO. The overall program average CV was 7.11 percent.

Table 29-10. SNMOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	# of Pairs	BRCO	*BTUT*	*NBIL*	PACO	RICO	SSSD	UCSD
Acetylene	61	4.93	3.40	4.02	3.29	6.30	5.43	7.03
Benzene	61	5.38	8.04	6.62	7.98	3.35	9.13	13.20
1,3-Butadiene	7	NA	6.14	NA	NA	3.96	1.82	NA
n-Butane	55	1.66	1.44	2.53	0.89	0.65	1.93	3.07
cis-2-Butene	23	NA	7.42	**21.04**	7.22	4.24	14.53	4.90
trans-2-Butene	23	NA	12.66	3.49	2.03	3.24	12.33	4.45
Cyclohexane	42	0.63	3.92	5.41	1.68	1.29	6.48	4.28
Cyclopentane	54	7.24	5.48	13.51	3.05	3.22	8.37	9.11
Cyclopentene	1	NA	NA	**20.65**	NA	NA	NA	NA
n-Decane	35	7.43	6.43	5.92	6.33	2.78	3.59	NA
1-Decene	0	NA	NA	NA	NA	NA	NA	NA
m-Diethylbenzene	7	3.28	11.55	4.90	NA	NA	NA	NA
p-Diethylbenzene	5	NA	**30.45**	NA	NA	NA	9.67	NA
2,2-Dimethylbutane	55	4.84	13.78	13.93	2.56	2.62	13.19	8.24
2,3-Dimethylbutane	52	2.02	4.71	7.48	1.57	1.65	13.59	9.26
2,3-Dimethylpentane	52	8.68	4.41	9.81	3.77	5.50	**17.85**	**15.25**
2,4-Dimethylpentane	39	6.84	4.04	9.99	3.85	2.58	9.02	NA
n-Dodecane	16	12.93	6.03	NA	**39.54**	4.58	**15.48**	NA
1-Dodecene	16	5.52	**24.32**	6.60	**18.93**	NA	10.26	8.92
Ethane	61	0.43	1.09	1.02	0.91	0.28	1.04	1.83
2-Ethyl-1-butene	0	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	52	9.34	7.38	10.55	12.70	4.95	12.77	6.77
Ethylene	61	5.63	2.21	3.12	**17.64**	7.77	2.72	2.74
m-Ethyltoluene	37	6.20	12.42	7.98	7.65	4.17	10.98	NA
o-Ethyltoluene	25	NA	**50.19**	11.12	**23.08**	9.47	3.91	NA
p-Ethyltoluene	21	10.13	8.40	5.35	7.26	6.18	NA	NA
n-Heptane	49	3.61	5.90	6.70	6.82	2.57	7.97	7.30
1-Heptene	16	3.98	4.59	NA	5.17	7.42	NA	NA
n-Hexane	59	3.93	6.40	6.58	4.56	3.15	10.11	10.09
1-Hexene	4	3.45	8.90	NA	NA	0.36	NA	NA
cis-2-Hexene	2	NA	2.97	NA	NA	NA	NA	NA
trans-2-Hexene	0	NA	NA	NA	NA	NA	NA	NA
Isobutane	61	0.18	1.17	2.75	1.51	0.55	3.12	6.51
Isobutene/1-Butene	57	4.09	3.36	5.50	**26.78**	3.20	6.25	6.21
Isopentane	61	1.69	2.08	1.67	1.49	0.56	2.15	2.00
Isoprene	36	2.13	6.43	1.66	5.90	4.28	11.36	2.08

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-10. SNMOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	BRCO	*BTUT*	*NBIL*	PACO	RICO	SSSD	UCSD
Isopropylbenzene	2	NA	10.12	NA	NA	NA	NA	NA
2-Methyl-1-butene	11	NA	6.39	NA	NA	5.38	6.33	NA
3-Methyl-1-butene	0	NA	NA	NA	NA	NA	NA	NA
2-Methyl-1-pentene	2	NA	NA	NA	NA	NA	NA	NA
4-Methyl-1-pentene	0	NA	1.67	NA	NA	NA	NA	**15.53**
2-Methyl-2-butene	10	NA	7.42	6.45	NA	7.76	NA	NA
Methylcyclohexane	49	1.93	4.14	13.25	3.58	2.73	10.88	7.45
Methylcyclopentane	61	2.24	6.79	6.12	2.06	2.30	7.58	10.15
2-Methylheptane	27	3.57	7.27	7.09	8.86	1.56	7.17	NA
3-Methylheptane	36	8.15	9.77	11.48	6.11	5.85	12.05	NA
2-Methylhexane	46	4.18	5.67	7.70	4.31	3.20	9.67	12.12
3-Methylhexane	54	3.40	6.56	5.85	5.48	2.62	12.89	7.12
2-Methylpentane	57	1.78	4.87	1.19	3.87	1.46	5.48	7.83
3-Methylpentane	59	1.51	3.93	4.59	2.26	1.61	8.75	9.02
n-Nonane	35	4.13	12.92	5.83	6.62	4.23	6.36	NA
1-Nonene	9	2.07	10.01	NA	7.60	10.21	NA	NA
n-Octane	35	2.55	5.44	9.59	6.65	3.26	6.06	NA
1-Octene	2	NA	NA	NA	11.34	NA	NA	NA
n-Pentane	61	2.32	3.35	1.81	3.57	1.34	3.60	5.31
1-Pentene	55	7.50	5.42	**15.90**	**28.36**	4.00	14.84	8.90
cis-2-Pentene	15	NA	8.67	NA	NA	8.91	0.66	NA
trans-2-Pentene	34	8.97	9.87	**21.01**	14.92	5.99	14.39	14.86
a-Pinene	22	2.54	5.78	7.65	6.28	3.51	8.53	9.57
b-Pinene	4	NA	5.27	NA	NA	**30.36**	NA	14.04
Propane	61	0.37	1.02	0.77	0.75	0.33	1.01	1.45
n-Propylbenzene	16	9.10	7.61	NA	**16.03**	13.42	NA	NA
Propylene	61	5.57	2.23	2.43	6.07	1.42	1.75	3.11
Propyne	0	NA	NA	NA	NA	NA	NA	NA
Styrene	7	NA	7.68	NA	NA	NA	10.06	2.53
Toluene	61	4.33	8.02	5.45	8.36	2.93	6.06	7.72
n-Tridecane	0	NA	NA	NA	NA	NA	NA	NA
1-Tridecene	0	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trimethylbenzene	14	9.70	**15.94**	NA	7.14	6.32	0.36	NA
1,2,4-Trimethylbenzene	42	9.30	7.19	6.13	6.64	3.80	12.14	7.17
1,3,5-Trimethylbenzene	29	4.54	8.06	13.76	5.73	8.12	NA	NA
2,2,3-Trimethylpentane	14	5.67	5.76	4.20	**23.75**	7.25	NA	NA

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-10. SNMOC Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	BRCO	BTUT	NBIL	PACO	RICO	SSSD	UCSD
2,2,4-Trimethylpentane	46	**21.48**	5.93	7.40	1.35	3.39	5.29	8.83
2,3,4-Trimethylpentane	33	1.87	3.90	5.85	3.36	14.10	11.31	NA
n-Undecane	30	8.93	8.96	7.16	**17.53**	8.24	4.16	NA
1-Undecene	19	8.00	6.62	4.81	**69.73**	NA	12.04	8.41
m-Xylene/*p*-Xylene	50	6.23	8.17	7.21	6.09	3.14	8.09	4.61
o-Xylene	42	9.48	8.48	4.47	8.15	3.40	11.94	NA
Average by Site		*7.11*	*5.24*	*7.71*	*7.32*	*9.24*	*4.72*	*8.08*	*7.47*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

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 average CV per pollutant per site, the average CV per site, and the overall average CV for NMP sites sampling carbonyl compounds. The overall average variability was 2.36 percent, which is well within the program DQO of 15 percent CV. The analytical precision results replicate analyses from duplicate and collocated samples range from 0 percent (hexaldehyde for RICO) to 5.77 percent (tolualdehydes for PROK). The site-specific average CV ranged from 1.66 percent for RICO to 2.93 percent for INDEM. Note that RICO is included in Table 29-11 for analytical precision, whereas it was not included in Table 29-4 for method precision table. This is due to the site having only one valid collocate that was analyzed in replicate.

Table 29-11. Carbonyl Compound Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	# of Pairs	AZFL	*BTUT*	CHNJ	*DEMI*	ELNJ	*GPCO*
Acetaldehyde	281	0.41	0.16	0.41	0.41	0.44	0.53
Acetone	281	0.73	0.39	0.68	0.39	0.23	0.32
Benzaldehyde	275	4.38	2.90	3.91	3.80	2.64	2.08
Butyraldehyde	281	4.20	0.95	2.65	3.45	2.34	1.40
Crotonaldehyde	277	2.83	2.31	2.77	3.16	1.37	1.99
2,5-Dimethylbenzaldehyde	0	NA	NA	NA	NA	NA	NA
Formaldehyde	281	0.61	1.33	0.65	0.47	0.77	0.53
Hexaldehyde	276	4.33	3.43	4.19	3.17	3.62	3.35
Isovaleraldehyde	4	NA	NA	NA	NA	NA	NA
Propionaldehyde	281	4.12	2.11	2.84	1.61	2.14	2.33
Toluadehydes	165	3.42	5.49	2.62	5.58	4.73	4.23
Valeraldehyde	272	3.01	3.28	5.02	5.04	1.52	2.80
Average by Site	*2.36*	*2.80*	*2.23*	*2.57*	*2.71*	*1.98*	*1.95*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-11. Carbonyl Compound Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	INDEM	MWOK	*NBIL*	NBNJ	OCOK	ORFL
Acetaldehyde	281	0.85	0.34	0.71	0.20	0.33	0.50
Acetone	281	0.40	0.41	0.70	0.17	0.34	1.28
Benzaldehyde	275	5.20	4.76	3.42	4.68	2.57	4.76
Butyraldehyde	281	4.13	2.95	2.78	2.88	1.62	3.56
Crotonaldehyde	277	3.86	1.04	3.73	3.30	2.51	2.02
2,5-Dimethylbenzaldehyde	0	NA	NA	NA	NA	NA	NA
Formaldehyde	281	0.56	0.72	0.89	0.57	0.56	0.77
Hexaldehyde	276	4.02	3.42	2.99	5.60	4.42	2.22
Isovaleraldehyde	4	NA	NA	NA	NA	4.35	NA
Propionaldehyde	281	2.32	1.93	2.89	2.50	1.81	3.31
Toluadehydes	165	4.38	4.50	2.88	2.28	3.80	4.64
Valeraldehyde	272	3.61	2.24	2.81	2.31	4.54	3.41
Average by Site	*2.36*	*2.93*	*2.23*	*2.38*	*2.45*	*2.44*	*2.64*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-11. Carbonyl Compound Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	PROK	PXSS	RICO	S4MO	SEWA	SKFL
Acetaldehyde	281	0.22	1.17	0.77	0.18	0.40	0.41
Acetone	281	0.27	0.30	0.35	0.80	0.47	0.43
Benzaldehyde	275	3.59	2.92	2.32	2.94	2.84	4.34
Butyraldehyde	281	2.38	1.09	2.97	3.08	1.87	4.03
Crotonaldehyde	277	2.30	3.62	1.94	2.05	3.55	1.31
2,5-Dimethylbenzaldehyde	0	NA	NA	NA	NA	NA	NA
Formaldehyde	281	0.58	0.41	0.45	0.61	0.46	0.74
Hexaldehyde	276	4.41	1.79	0	4.39	3.40	4.62
Isovaleraldehyde	4	NA	NA	NA	NA	NA	NA
Propionaldehyde	281	1.03	3.16	2.50	2.70	2.06	2.05
Tolualdehydes	165	5.77	5.18	NA	4.21	2.92	3.82
Valeraldehyde	272	4.41	5.01	3.63	2.04	3.63	3.66
Average by Site	*2.36*	*2.49*	*2.47*	*1.66*	*2.30*	*2.16*	*2.54*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

Table 29-11. Carbonyl Compound Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site (Continued)

Pollutant	# of Pairs	SPIL	SSSD	SYFL	TMOK	TOOK	UCSD	WPIN
Acetaldehyde	281	0.65	0.30	0.63	0.37	0.43	0.47	0.63
Acetone	281	0.42	0.26	0.82	0.34	0.38	0.41	0.63
Benzaldehyde	275	2.47	2.05	3.24	3.36	3.24	3.47	3.33
Butyraldehyde	281	1.81	1.90	1.67	1.24	2.01	1.77	2.87
Crotonaldehyde	277	3.30	3.50	1.78	2.36	1.95	3.09	3.34
2,5-Dimethylbenzaldehyde	0	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	281	0.94	0.52	0.49	0.90	0.57	0.88	0.60
Hexaldehyde	276	3.81	3.89	2.37	3.37	4.28	4.11	3.41
Isovaleraldehyde	4	NA	NA	NA	NA	NA	NA	2.63
Propionaldehyde	281	2.41	1.98	2.91	1.22	1.85	2.35	3.15
Tolualdehydes	165	4.49	4.26	4.79	5.04	3.92	4.19	4.69
Valeraldehyde	272	4.43	3.70	2.78	2.84	2.31	2.54	3.48
Average by Site	*2.36*	*2.47*	*2.24*	*2.15*	*2.11*	*2.09*	*2.33*	*2.61*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

29.3.4 Metals Analytical Precision

Table 29-12 presents analytical precision results from replicate analyses of all collocated metals samples as the average CV per pollutant per site, the average CV per site, and the overall average CV for NMP sites sampling metals. The results from collocated samples show low- to high-level variability among sites, ranging from an average CV of 0 percent (cadmium for UNVT) to 20.64 percent (selenium for BTUT). The site-specific average CV ranged from 3.33 percent for TOOK to 9.06 percent for BTUT. The overall analytical precision was 5.44 percent.

Table 29-12. Metals Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	# of Pairs	BOMA	BTUT	NBIL	S4MO	TOOK	UNVT
Antimony	283	2.04	13.04	1.09	1.27	4.09	9.88
Arsenic	281	2.46	5.51	1.84	1.14	1.87	9.18
Beryllium	216	**16.83**	NA	14.89	8.51	5.94	NA
Cadmium	257	7.14	7.28	1.62	5.00	2.41	0
Chromium	33	NA	NA	NA	0.92	1.24	NA
Cobalt	275	5.26	7.56	3.83	8.05	3.46	7.86
Lead	277	1.48	2.18	4.02	1.46	2.13	3.02
Manganese	283	1.20	5.69	3.68	2.21	2.28	3.21
Mercury	178	12.71	NA	4.63	11.63	9.05	NA
Nickel	51	0.88	10.57	2.20	NA	1.05	5.75
Selenium	275	3.87	**20.64**	2.25	2.15	3.10	14.03
Average by Site	*5.44*	*5.39*	*9.06*	*4.00*	*4.23*	*3.33*	*6.62*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

29.3.5 Hexavalent Chromium Analytical Precision

Table 29-13 presents analytical precision results from replicate analyses of all collocated hexavalent chromium samples as the average 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 2.04 percent (for MONY) to 13.28 percent (for SKFL), with an overall analytical precision of 6.30 percent.

Table 29-13. Hexavalent Chromium Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site

Site	Average CV
BOMA	5.42
BTUT	4.52
BXNY	6.46
CAMS 35	5.48
CHSC	9.81
DEMI	6.09
GLKY	7.66
GPCO	4.42
HOWI	6.56
MONY	2.04
NBIL	5.97
PRRI	4.58
PXSS	5.55
RIVA	6.16
ROCH	7.58
S4MO	4.78
SDGA	8.82
SEWA	6.18
SKFL	13.28
SYFL	4.72
UNVT	2.96
WADC	9.47
Average CV	*6.30*
# of Pairs	226

BOLD ITALICS = EPA-designated NATTS Site.

29.3.6 PAH Analytical Precision

Table 29-14 presents analytical precision results from replicate analyses of all collocated PAH samples as the average CV per pollutant per site, the average CV per site, and the overall average CV for NMP sites sampling PAH. The analytical precision results from replicate analysis of collocated samples show low-level variability among sites, ranging from 0.68 percent (anthracene for SYFL) to 15.49 percent (acenaphthylene for RUCA). The site-specific average CV ranged from 2.95 percent for DEMI to 4.37 percent for SDGA. The overall average CV for all sites was 3.67 percent.

Table 29-14. PAH Analytical Precision: Average Coefficient of Variation Based on Replicate Analyses by Site

Pollutant	# of Pairs	DEMI	RUCA	SDGA	SEWA	SYFL
Acenaphthene	57	2.66	6.89	3.43	4.34	2.98
Acenaphthylene	24	7.13	**15.49**	4.27	1.93	3.12
Anthracene	31	2.31	4.79	10.97	2.01	0.68
Benzo(a)anthracene	13	1.70	5.16	5.35	3.18	NA
Benzo(a)pyrene	17	3.98	1.61	6.90	3.03	2.86
Benzo(b)fluoranthene	28	2.45	4.74	7.64	2.40	1.57
Benzo(e)pyrene	26	2.82	3.84	3.17	6.86	5.58
Benzo(g,h,i)perylene	37	1.90	2.32	4.22	4.87	2.26
Benzo(k)fluoranthene	14	7.33	3.45	NA	11.64	NA
Chrysene	55	2.11	2.65	5.95	2.41	4.49
Coronene	25	1.63	5.00	5.88	3.47	9.45
Cyclopenta[cd]pyrene	4	3.40	1.94	NA	4.68	NA
Dibenz(a,h)anthracene	4	1.23	NA	NA	6.22	NA
Fluoranthene	57	2.22	1.99	2.23	2.14	2.27
Fluorene	57	2.87	2.20	2.26	2.38	6.12
9-Fluorenone	57	2.50	2.86	2.76	2.86	2.18
Indeno(1,2,3-cd)pyrene	30	3.68	2.96	4.30	4.24	3.42
Naphthalene	57	1.29	3.87	2.55	2.21	3.72
Perylene	18	2.43	1.52	3.52	4.92	3.80
Phenanthrene	57	1.37	1.89	1.13	1.45	1.72
Pyrene	57	2.58	2.17	2.90	2.32	1.87
Retene	44	5.41	5.15	3.59	2.34	2.50
Average by Site	*3.67*	*2.95*	*3.93*	*4.37*	*3.72*	*3.37*

NA=No pairs with concentrations greater than or equal to the MDL
BOLD ITALICS = EPA-designated NATTS Site
Shading indicates NATTS MQO Core Analyte

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 VOC, carbonyl compounds, metals, hexavalent chromium, and PAH which are used to quantitatively measure analytical accuracy. Tables 29-15 through 29-19 present ERG's results from the 2010 NATTS PT audit samples for VOC, carbonyl compounds, metals,

hexavalent chromium, and PAH, respectively. The program DQO 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.

Table 29-15. VOC NATTS PT Audit Samples: Percent Difference from True Value

Pollutant	March, 2010
Acrolein	-9.5
Benzene	-13.2
1,3-Butadiene	-3.7
Carbon Tetrachloride	**31.3**
Chloroform	1.0
1,2-Dibromoethane	-9.0
1,2-Dichloroethane	-2.8
Dichloromethane	4.5
1,2-Dichloropropane	-15.2
cis-1,3-Dichloropropene	-18.2
trans-1,3-Dichloropropene	-20.2
1,1,2,2-tetrachloroethane	-14.3
Tetrachloroethylene	-16.1
Trichloroethylene	-6.4
Vinyl Chloride	-14.1

Shading indicates NATTS MQO Core Analyte

Table 29-16. Carbonyl Compound NATTS PT Audit Samples: Percent Difference from True Value

Pollutant	May, 2010
Formaldehyde	-2.8
Acetaldehyde	0.7

Shading indicates NATTS MQO Core Analyte

Table 29-17. Metals NATTS PT Audit Samples: Percent Difference from True Value

Pollutant	February, 2010
Arsenic	7.3
Beryllium	11.2
Cadmium	4.9
Lead	-3.5
Manganese	0.6
Nickel	4.7

Shading indicates NATTS MQO Core Analyte

Table 29-18. Hexavalent Chromium PT Audit Samples: Percent Difference from True Value

Pollutant	January, 2010
Hexavalent Chromium	10.5

Shading indicates NATTS MQO Core Analyte

Table 29-19. PAH NATTS PT Audit Samples: Percent Difference from True Value

Pollutant	February, 2010
Acenaphthene	-15.4
Anthracene	-9.2
Benzo(a)pyrene	-2.3
Fluoranthene	-9.3
Fluorene	-13.4
Naphthalene	-17.1
Phenanthrene	-13.5
Pyrene	-9.4

Shading indicates NATTS MQO Core Analyte

The accuracy of the 2010 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 2010 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 2010 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 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 2010 monitoring data identified the following notable results, observations, trends, and patterns in the program-level and state- and site-specific air pollution data.

30.1.1 National-level Summary

- *Number of participating NATTS sites.* Twenty-six of the 52 sites are EPA-designated NATTS sites (BOMA, BTUT, BXNY, CAMS 35, CAMS 85, CELA, CHSC, DEMI, GLKY, GPCO, HOWI, MONY, NBIL, PRRI, PXSS, RIVA, ROCH, RUCA, S4MO, SDGA, SEWA, SJJCA, SKFL, SYFL, UNVT, and WADC).

- *Total number of samples collected and analyzed.* Over 8,500 samples were collected yielding over 214,900 valid measurements of air toxics.

- *Detects.* The detection of a given pollutant is subject to the analytical methods used and the limitations of the instruments. Simply stated, a method detection limit is the lowest concentration of a substance that can be measured and reported with 99 percent confidence that the pollutant concentration is greater than zero. Approximately 55 percent of the reported measurements were above the associated MDLs. Of the 187 pollutants monitored, only three pollutants were not detected over the course of the 2010 monitoring effort: *trans*-1,3-dichloropropene, 2,5-dimethylbenzaldehyde, and propyne.

- *Program-level Pollutants of Interest.* The pollutants of interest at the program-level are based on the number of exceedances, or "failures," of the preliminary risk screening values. In addition, 18 NATTS MQO Core Analytes (excluding acrolein) are classified as pollutants of interest. Only two NATTS MQO Core Analytes (beryllium and tetrachloroethylene) did not fail any screens.

- *Noncancer Risk Screening using ATSDR MRLs*. One preprocessed daily measurement of formaldehyde (measured at NBIL) and two preprocessed daily measurements of dichloromethane (measured at BTUT and GPCO) were higher than the associated

ATSDR acute MRLs. None of the quarterly or annual average concentrations of any pollutants were higher than the associated ATSDR intermediate or chronic MRLs.

- *Cancer Surrogate Risk Approximations.* The cancer surrogate risk approximation calculated for ELNJ for formaldehyde's annual average (57.93 in-a-million) was the highest of all annual average-based cancer risk approximations. No other sites exhibited cancer risk approximations greater than 50 in-a-million.

- *Noncancer Surrogate Risk Approximations.* The noncancer surrogate risk approximation calculated for TOOK's annual average of manganese (an HQ of 0.47) was the highest of all annual average-based noncancer risk approximations. No site had noncancer risk approximations greater than 1.0.

- *Emissions and Toxicity Weighted Emissions.* Benzene, formaldehyde, and ethylbenzene often had the highest county-level emissions for the participating counties (of those with a cancer URE). Both benzene and formaldehyde tended to have the highest toxicity-weighted emissions. Toluene and xylenes were often the highest emitted pollutants with noncancer risk factors, although they rarely had top 10 toxicity-weighted emissions. Acrolein tended to have the highest toxicity-weighted emissions of pollutants with noncancer RfCs, although it was rarely emitted in high enough quantities to rank in the top 10 emissions for the participating counties.

30.1.2 State-level Summary

Arizona.

- The Arizona monitoring sites are located in Phoenix. PXSS is a NATTS site; SPAZ is a UATMP site.

- Back trajectories originated from a variety of directions at PXSS and SPAZ, though many are from the southwest and west. Their air shed domains were smaller in size compared to other NMP monitoring sites, as nearly all trajectories originated within 250 miles of the sites.

- The wind roses show that calm, easterly, westerly, and east-southeasterly winds were prevalent near PXSS and SPAZ.

- PXSS sampled for VOC, carbonyl compounds, PAH, metals (PM_{10}), and hexavalent chromium. SPAZ sampled for VOC only.

- Twenty-two pollutants, of which 14 are NATTS MQO Core Analytes, failed screens for PXSS. PXSS failed the second highest number of screens among all NMP sites.

- Nine 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. Benzene also had the highest annual average concentration for SPAZ. This was the only pollutant for either site with an annual average concentration greater than $1\mu g/m^3$.

- PXSS had the highest annual average concentration of tetrachloroethylene and the second highest annual average concentrations of 1,3-butadiene, hexavalent chromium, beryllium, lead, and manganese among all NMP sites sampling these pollutants.

- SPAZ had the highest annual average concentrations of acrylonitrile and 1,3-butadiene compared to all NMP sites sampling these pollutants.

- Annual average concentrations could not be calculated for carbonyl compounds for PXSS due to a sampler problem that led to invalidation of all 2010 carbonyl samples from mid-February to the end of the year.

- Metals and hexavalent chromium sampling for has occurred at PXSS for at least five consecutive years; thus, a trends analysis was conducted for arsenic, hexavalent chromium, and manganese. Average rolling concentrations of arsenic and hexavalent chromium exhibit little change over the years of sampling. Manganese exhibits a slightly decreasing trend in the rolling average concentrations over the sampling period.

- None of the measured detections or time-period average concentrations of the pollutants of interest, where they could be calculated, were greater than their respective ATSDR MRL noncancer health risk benchmarks for either of the Arizona monitoring sites.

- Benzene and 1,3-butadiene had the highest cancer risk approximations for PXSS while acrylonitrile and benzene had the highest cancer risk approximations for SPAZ. None of the pollutants of interest for either site had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Maricopa County, while toluene was the highest emitted pollutant with a noncancer risk 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.

- Back trajectories for CELA and RUCA primarily originated from the northwest, with a secondary cluster originating from the northeast. Their air shed domains were

smaller in size compared to other NMP monitoring sites as nearly all trajectories originated within 300 miles of the sites. The back trajectories for SJJCA primarily originated from the northwest to north to northeast directions. The air shed domain for SJJCA is larger than the other two California sites; nearly all trajectories originated within 400 miles of the site.

- CELA experienced primarily calm winds, although those greater than 2 knots were predominantly from the west. Westerly winds were prevalent near RUCA. SJJCA experienced predominantly westerly to northwesterly winds.

- CELA and RUCA sampled for PAH only. SJJCA sampled for PAH and metals (PM_{10}).

- Four pollutants failed screens for CELA, of which two (naphthalene and benzo(a)pyrene) are NATTS MQO Core Analytes. Two pollutants failed screens for RUCA, both of which are NATTS MQO Core Analytes. Four pollutants (arsenic, naphthalene, manganese, and nickel) failed screens for SJJCA, all of which are NATTS MQO Core Analytes.

- Naphthalene had the highest annual average concentration for each site. The annual average concentration of naphthalene for CELA was significantly higher than the annual average for RUCA and more than double the annual average for SJJCA, and second highest compared to all NMP sites sampling naphthalene.

- None of the measured detections or time-period average concentrations of the pollutants of interest were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Of the pollutants of interest for each site, naphthalene exhibited the highest cancer risk approximation for all three California sites. The noncancer surrogate risk approximations for each pollutant of interest were less than 1.0 for all three sites.

- Formaldehyde was the highest emitted pollutant with a cancer risk 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 risk factor in Los Angeles County, while toluene was the highest emitted pollutant with a noncancer risk 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 five CSATAM sites located northeast of Grand Junction in Garfield County. The sites are located in the towns of Battlement Mesa (BMCO), Silt (BRCO), Parachute (PACO), Rifle (RICO), and Rulison (RUCO).   The instruments at RUCO were moved to the new location at Battlement Mesa in September 2010.

- Back trajectories originated from a variety of directions at GPCO, though almost all had a westerly component. The 24-hour air shed domain GPCO was smaller in size than other NMP monitoring sites, with most back trajectories originating less than 300 miles from the site. The Garfield County sites had air shed domains of similar size to GPCO, which is expected given the close proximity of these sites to GPCO.

- The wind roses for GPCO show that easterly, east-southeasterly, and southeasterly winds were prevalent near the site. Westerly and southerly winds were prevalent for the Garfield County sites.

- GPCO sampled for VOC, carbonyl compounds, PAH, and hexavalent chromium. The Garfield County sites sampled for SNMOC and carbonyl compounds.

- Nineteen pollutants failed at least one screen for GPCO, of which seven are NATTS MQO Core Analytes. The number of pollutants that failed screens for the Garfield County sites ranged from four (BMCO) to five (BRCO, PACO, RICO, and RUCO).

- Of the pollutants of interest for GPCO, formaldehyde had the highest annual average concentration, followed by acetaldehyde and benzene.

- Benzene had the highest annual average concentration for each of the Garfield County sites (where an annual average concentration could be calculated).

- GPCO had the highest annual average concentration of naphthalene and the second highest annual average concentrations of benzo(a)pyrene and tetrachloroethylene among all NMP sites sampling these pollutants. Annual average benzene concentrations for the Colorado sites account for five of the 10 highest annual average concentrations for sites that sampled benzene. In addition, PACO and RICO have the highest and second highest annual average concentrations, respectively, of ethylbenzene.

- VOC, carbonyl compound, and hexavalent chromium sampling has occurred at GPCO for at least five consecutive years; thus, a trends analysis was conducted for acetaldehyde, benzene, 1,3-butadiene, formaldehyde, and hexavalent chromium. The rolling average concentration for acetaldehyde shows little change after the 2004-2006 timeframe. Benzene, hexavalent chromium and 1,3-butadiene exhibited a slight decreasing trend. Formaldehyde exhibited an increasing trend through the

2007-2009 timeframe, after which the rolling average concentration decreased slightly.

- Of the 59 measured detections, one dichloromethane measurement was greater than the ATSDR acute MRL for GPCO. This was also the highest measured detection among all NMP sites sampling dichloromethane.

- For sites where annual averages of formaldehyde could be calculated (GPCO and PACO), formaldehyde had the highest cancer risk approximations. The cancer risk approximations for benzene were greater than 10 in-a-million for all sites except BMCO (where an annual average could not be calculated) and BRCO. All noncancer risk approximations were less than 1.0 for all six Colorado sites.

- Benzene was the highest emitted pollutant with a cancer risk factor in Mesa County, while formaldehyde was the highest emitted pollutant with a cancer risk 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 risk factor for both counties, acrolein had the highest noncancer toxicity-emissions.

District of Columbia

- The Washington, D.C. monitoring site (WADC) is a NATTS site.

- Back trajectories originated from a variety of directions at WADC, with most of them originating from the southwest, west, and northwest.

- The wind roses show that southerly and south-southwesterly winds were prevalent near WADC.

- WADC sampled for hexavalent chromium and PAH. The only pollutants to fail screens for WADC were naphthalene and fluorene. Naphthalene accounted for nearly 97 percent of the failed screens for the site.

- The pollutant with the highest annual average concentrations for WADC was naphthalene, which ranked the sixth highest annual average concentration among NMP sites sampling PAH.

- Hexavalent chromium sampling has occurred at WADC for at least five consecutive years; thus, a trends analysis was conducted for hexavalent chromium. Hexavalent chromium exhibited a slight decreasing trend through the 2007-2009 timeframe, after which a slight increase in rolling average concentration was exhibited.

- None of the measured detections or time-period average concentrations of the pollutants of interest for WADC were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Naphthalene had the only cancer risk approximation for WADC greater than 1.0 in-a-million, while none of the pollutants of interest had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in the District of Columbia, while toluene was the highest emitted pollutant with a noncancer risk 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.

- Back trajectory maps were similar for the Tampa/St. Petersburg sites, where back trajectories originated from a variety of directions for each of the Florida sites. Back trajectories also originated from a variety of directions for ORFL and PAFL.

- Winds from a variety of directions were observed near the Tampa/St. Petersburg sites, however winds from the southwest quadrant were observed the least. Winds from a variety of directions were observed near the Orlando sites.

- AZFL and ORFL sampled for carbonyl compounds only. SKFL and SYFL sampled for hexavalent chromium and PAH in addition to carbonyl compounds. PAFL sampled only PM_{10} metals.

- Acetaldehyde and formaldehyde were the only pollutants to fail screens for AZFL and ORFL, where only carbonyl compounds were sampled. Naphthalene, in addition to acetaldehyde and formaldehyde, failed screens for SKFL and SYFL. Arsenic, lead, nickel, and manganese failed screens for PAFL, where only metals were sampled.

- Acetaldehyde had the highest annual average concentration for AZFL and SKFL, while formaldehyde had the highest annual average concentration for SYFL and ORFL. SKFL and AZFL had the second and third highest concentrations of acetaldehyde, respectively, among all NMP sites sampling carbonyl compounds. Lead and manganese had the highest annual average concentrations for PAFL.

- Carbonyl compound sampling has been conducted at AZFL, ORFL, SKFL, and SYFL for at least five consecutive years; thus a trends analysis was conducted for acetaldehyde and formaldehyde. In the later years of sampling, the rolling average acetaldehyde concentrations have increased at AZFL and SKFL and decreased at

ORFL and SYFL while the rolling average formaldehyde concentrations have decreased at AZFL, ORFL and SKFL and increased at SYFL.

- Hevavalent chromium sampling has occurred at SYFL since 2005; thus a trends analysis was conducted. Rolling average and median concentrations exhibit a decreasing trend since the onset of hexavalent chromium sampling, with a slight increase in rolling average concentration for the 2008-2010 time period.

- None of the measured detections or time-period average concentrations of the pollutants of interest for any of the Florida monitoring sites were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- For the four Florida sites sampling carbonyl compounds, formaldehyde had the highest cancer surrogate risk approximations. Arsenic had the highest cancer risk approximation for the site sampling metals (PAFL). All noncancer risk approximations for the Florida sites' pollutants of interest were less than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk 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 risk 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.

- Back trajectories originated from a variety of directions at SDGA, though trajectories from the southwest were most common.

- The wind roses show that winds from the west to north-northwest were prevalent near SDGA. Easterly winds were also common.

- SDGA sampled for PAH and hexavalent chromium. Naphthalene, acenaphthene, and benzo(a)pyrene failed screens for SDGA, with naphthalene accounting for nearly 97 percent of the total failed screens.

- Of the pollutants of interest for SDGA, naphthalene had the highest annual average concentration, ranking fifth among NMP sites sampling PAH.

- Hexavalent chromium sampling has occurred at SDGA for at least five consecutive years; thus, a trends analysis was conducted. Hexavalent chromium exhibited a decreasing trend over the period of sampling.

30-8

- None of the measured detections or time-period average concentrations of the pollutants of interest for SDGA were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Naphthalene was the only pollutant with a cancer risk approximation greater than 1.0 in-a-million. None of SDGA's pollutants of interest had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in DeKalb County, while toluene was the highest emitted pollutant with a noncancer risk factor. Benzene also had the highest cancer toxicity-weighted emissions, while acrolein had the highest noncancer toxicity-weighted emissions in 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.

- Back trajectories originated from a variety of directions at the sites, although back trajectories primarily originated from the south, north, and northwest.

- The wind roses show that winds from a variety of directions were observed near the monitoring sites, although winds from the southeast quadrant were infrequently observed.

- Both Illinois sites sampled for VOC and carbonyl compounds. NBIL also sampled for SNMOC, PAH, hexavalent chromium and metals (PM_{10}).

- Twenty pollutants failed screens for NBIL, of which 12 are NATTS MQO Core Analytes. Fourteen pollutants failed screens for SPIL, of which six are NATTS MQO Core Analytes.

- Of the pollutants of interest for NBIL and SPIL, formaldehyde had the highest annual average concentrations. NBIL had the highest annual average concentration of chloroform measured among NMP sites sampling this pollutant, and SPIL had the highest annual concentration of trichloroethylene.

- VOC and carbonyl compound sampling have been conducted at NBIL and SPIL for at least five consecutive years; thus, a trends analysis was conducted for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde for both sites. Most recently, rolling average concentrations of acetaldehyde and benzene have increased at both sites, while 1,3-butadiene exhibited little change. The rolling average concentration of formaldehyde has increased at NBIL and decreased at SPIL.

- PM_{10} metals and hexavalent chromium sampling have been conducted at NBIL for at least five consecutive years; thus, a trends analysis was conducted for arsenic,

30-9

hexavalent chromium, and manganese. Most recently, rolling average concentrations have decreased slightly for arsenic and manganese, while an increase in rolling average concentration is shown for hexavalent chromium in the final time frame.

- Of 55 measured detections of formaldehyde at NBIL, one measurement was greater than the ATSDR acute MRL for this pollutant. Yet none of the time-period average concentrations of formaldehyde were greater than their respective ATSDR MRL noncancer health risk benchmarks. None of the measured detections or time-period average concentrations of the pollutants of interest at SPIL were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Formaldehyde had the highest cancer risk approximations for both sites. All noncancer risk approximations for the Illinois sites' pollutants of interest were less than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Cook County, while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk 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.

- Back trajectories originated from a variety of directions at the Indiana sites, although less frequently from the east and southeast. Trajectories originating from the east were generally shorter than trajectories originating from other directions.

- The wind roses show that winds from the southwest and northwest quadrants, including due south and due north, were observed most frequently near WPIN. Winds from the south, south-southwest, and west were observed most frequently near INDEM.

- WPIN and INDEM sampled for carbonyl compounds only.

- Formaldehyde and acetaldehyde failed screens for both INDEM and WPIN; propionaldehyde also failed screen a single screen for INDEM.

- Of the pollutants of interest, formaldehyde had the highest annual average concentrations for both sites. WPIN had the fourth and sixth highest annual average concentrations of formaldehyde and acetaldehyde, respectively, among NMP sites sampling carbonyl compounds.

- Carbonyl compound sampling has been conducted at INDEM for at least five consecutive years; thus, a trends analysis was conducted for acetaldehyde and

formaldehyde. The average rolling concentrations of both acetaldehyde and formaldehyde have decreased at INDEM, beginning with the 2007-2009 time period.

- None of the measured detections or time-period average concentrations of the pollutants of interest for either Indiana site were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Formaldehyde had the highest cancer risk approximations for both Indiana sites. Neither site's pollutants of interest had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Marion and Lake Counties, while coke oven emissions (PM) had the highest cancer toxicity-weighted emissions for Lake County and formaldehyde had the highest cancer toxicity-weighted emissions for Marion County.

- Toluene was the highest emitted pollutant with a noncancer risk 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.

- Back trajectories originated from a variety of directions for both sites, with the majority originating to the south, west and northwest, and north of the site. .

- Although calm winds were prevalent near GLKY, winds from the southwest were the most frequently observed wind directions for winds greater than 2 knots.

- GLKY sampled for hexavalent chromium, PAH, and VOC. Six pollutants failed screens for GLKY, of which four are NATTS MQO Core Analytes.

- Annual averages could not be calculated for VOC compounds because sampling did not begin until June. Of the pollutants of interest for which annual averages could be calculated, naphthalene had the highest annual average concentration for GLKY.

- None of the measured detections or time-period average concentrations of the pollutants of interest for GLKY, where they could be calculated, were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- None of the pollutants of interest for GLKY had cancer surrogate risk approximations greater than 1 in-a-million; similarly, none of the pollutants of interest for GLKY had noncancer surrogate risk approximations greater than 1.0.

30-11

- Benzene was the highest emitted pollutant with a cancer risk factor in Carter County and had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk factor, while acrolein had the highest noncancer toxicity-weighted emissions in Carter County.

Massachusetts.

- The Massachusetts monitoring site (BOMA) is a NATTS site in Boston.

- Back trajectories originated from a variety of directions at BOMA. Although the bulk of trajectories originated from the west to northwest to north of the site.

- The wind roses show that winds from the west, west-northwest, and northwest were prevalent near BOMA.

- BOMA sampled for metals (PM_{10}), PAH, and hexavalent chromium.

- Five pollutants failed screens for BOMA, all of which are NATTS MQO Core Analytes. Naphthalene accounted for half of the site's failed screens.

- Of the pollutants of interest, naphthalene had the highest annual average concentration. BOMA's concentrations of cadmium and nickel ranked second highest among sites sampling PM_{10} metals.

- Metals and hexavalent chromium sampling has been conducted at BOMA for at least five consecutive years; thus, a trends analysis was conducted for arsenic, hexavalent chromium, and manganese. The rolling average concentrations of arsenic have changed little; hexavalent chromium concentrations have decreased slightly; and manganese concentrations have decreased over the period of sampling at BOMA.

- None of the measured detections or time-period average concentrations of the pollutants of interest for BOMA were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- The only pollutants 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 risk approximations greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Suffolk County, while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk factor in Suffolk County, while acrolein had the highest noncancer toxicity-weighted emissions.

Michigan.

- DEMI is a NATTS site located in Dearborn, Michigan, near Detroit.

- Back trajectories originated from a variety of directions at DEMI, although less frequently from the east and southeast.

- The wind roses for DEMI show that winds from a variety of directions were observed near the monitoring site, although winds from the southeast quadrant were observed the least.

- DEMI sampled for VOC, carbonyl compounds, PAH, and hexavalent chromium.

- Sixteen pollutants failed screens for DEMI, of which nine are NATTS MQO Core Analytes.

- Formaldehyde and acetaldehyde had the highest annual average concentrations for DEMI. Compared to other NMP sites, DEMI had the second highest annual average concentration of chloroform among sites sampling VOC. DEMI also had the highest annual average concentrations of acenaphthene and fluorene among sites sampling PAH, and the fourth highest annual average concentration of hexavalent chromium.

- Hexavalent chromium and VOC sampling has been conducted at DEMI for at least five consecutive years; thus, a trends analysis was conducted for benzene, 1,3-butadiene, and hexavalent chromium. A decreasing trend in concentrations is exhibited for benzene. A decrease in concentrations is also shown for 1,3-butadiene and hexavalent chromium, but neither decrease is statistically significant. A trends analysis was not performed for carbonyl compounds because a large number of 2007-2008 carbonyl samples were invalidated.

- None of the measured detections or time-period average concentrations of the pollutants of interest for DEMI were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Formaldehyde had the highest cancer surrogate risk approximation for DEMI. None of the pollutants of interest for DEMI had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk 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 risk 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.

- Back trajectories originated from a variety of directions at S4MO, with trajectories highest percentage of trajectories originating from the northwest.

- The wind roses for S4MO show that south-southeasterly, southerly, and northerly winds were the most often most frequently near this site.

- S4MO sampled for VOC, carbonyl compounds, PAH, metals (PM_{10}), and hexavalent chromium.

- Twenty-four pollutants failed at least one screen for S4MO, of which 14 are NATTS MQO Core Analytes. S4MO failed the second highest number of screens among all NMP sites.

- Of the pollutants of interest, acetaldehyde and formaldehyde had the highest annual average concentrations for S4MO. S4MO had the highest annual average concentration of acetaldehyde, arsenic, beryllium, cadmium, lead, and manganese among all NMP sites sampling those pollutants.

- Carbonyl compounds, VOC, metals, and hexavalent chromium sampling have been conducted at S4MO for at least five consecutive years; thus, a trends analysis was conducted for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, and manganese. No significant change in concentrations is shown for acetaldehyde, 1,3-butadiene, and manganese. Arsenic, formaldehyde and hexavalent chromium have shown a slight decreasing trend, as does benzene, although there is an increase shown in the most recent time frame.

- None of the measured detections or time-period average concentrations of the pollutants of interest for S4MO were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Formaldehyde had the highest cancer risk approximation for S4MO. None of the pollutants of interest for S4MO had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in St. Louis (city), while toluene was the highest emitted pollutant with a noncancer risk 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).

- Due to the close proximity of the New Jersey sites, the composite back trajectories exhibit similar patterns across the four sites. Back trajectories originated from a variety of directions, though less frequently from the east and southeast.

- Calm winds were observed for a majority of the wind observations near CHNJ, NBNJ, and PANJ. Although winds from the north are prevalent near CHNJ and

30-14

NBNJ from a historical standpoint, winds from the northwest to north-northwest were prevalent during 2010 (for winds greater than 2 knots). Winds from the northwest quadrant were most common at PANJ. Winds from a variety of directions were observed near ELNJ, although few easterly and southeasterly wind observations were observed near this site.

- CHNJ, ELNJ, and NBNJ sampled for VOC and carbonyl compounds, while PANJ sampled for VOC only.

- Twelve pollutants failed at least one screen For NBNJ and CHNJ; 14 pollutants failed screens for ELNJ; and 8 failed screens for PANJ.

- Of the pollutants of interest, formaldehyde had the highest annual average concentrations for CHNJ, and ELNJ, while acetaldehyde had the highest annual average concentration for NBNJ. Annual average concentrations could not be calculated for PANJ due to a combination of a shortened sampling duration (sampling did not begin until the end of April) and a 1-in-12 day sampling schedule.

- Compared to other NMP sites, 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 five consecutive years; thus, a trends analysis was conducted for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde. The rolling average concentrations of acetaldehyde showed a decreasing trend for all three sites in recent years. Although significant changes are shown over the years of sampling, in the most recent years, the rolling average concentrations of benzene and 1,3-butadiene exhibit little change at CHNJ, ELNJ, and NBNJ. Formaldehyde exhibited little change in rolling average concentrations in recent years at CHNJ and NBNJ, but exhibited a decreasing trend at ELNJ.

- None of the measured detections or time-period average concentrations of the pollutants of interest for the New Jersey sites were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- 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 risk approximations greater than 1.0. Cancer and noncancer risk 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 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 risk factor in all four counties, while acrolein had the highest noncancer toxicity-weighted emissions for each county.

New York.

- Two New York monitoring sites are located in the Bronx Borough of New York City (BXNY and MONY). A third site is located in Rochester (ROCH) and the fourth monitoring site is located north of Buffalo in Tonawanda (TONY). The BXNY NATTS site was relocated to the MONY location in mid-2010. The ROCH site is also a NATTS monitoring site.

- Back trajectories originated from a variety of directions at each of the New York sites, though less frequently from the east, particularly for ROCH and TONY.

- Winds from the northwest quadrant were observed most frequently near BXNY, while winds from the west and west-northwest were most frequently observed near MONY. South-southwesterly to westerly winds were most common near ROCH and TONY.

- All three New York sites sampled PAH. BXNY, MONY, and ROCH also sampled hexavalent chromium.

- Fourteen pollutants failed screens for BXNY and MONY. Only naphthalene failed screens for ROCH. Six PAH failed screens for TONY.

- Due to abbreviated sampling durations, annual average concentrations could not be calculated for the pollutants of interest for BXNY and MONY. Sampling was discontinued at TONY in mid-2010. Additionally, sampler problems at ROCH led to the invalidation of the majority of PAH samples for 2010. Therefore, annual average concentrations could only be calculated for hexavalent chromium for ROCH.

- None of the measured detections or time-period average concentrations of the pollutants of interest for the New York sites, where they could be calculated were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- The cancer surrogate risk approximation for hexavalent chromium (for ROCH) was well below 1 in-a-million; similarly, the noncancer surrogate risk approximation for hexavalent chromium (for ROCH) was well below 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor for all three New York counties. It also had the highest cancer toxicity-weighted emissions for Bronx County and Monroe County. Coke oven emissions (PM) had the highest cancer toxicity-weighted emissions for Erie County.

- Methanol was the highest emitted pollutant with a noncancer risk factor in Bronx County, while toluene was the highest emitted pollutant with a noncancer risk factor in Monroe and Erie Counties. Acrolein had the highest noncancer toxicity-weighted emissions for all three counties.

Oklahoma.

- There are five Oklahoma UATMP monitoring sites: two located in Tulsa (TOOK and TMOK), one in Pryor Creek (PROK), and in Oklahoma City (OCOK) and one in the Oklahoma City suburb of Midwest City (MWOK).

- The back trajectory maps for the Tulsa, Pryor Creek and Oklahoma City sites are similar in trajectory distribution, with a strong tendency for back trajectories to originate from the south and the northwest to north of the sites.

- The wind roses show that southerly winds prevailed near each monitoring site, accounting for one-fifth to one-quarter of the observations at each site..

- Each of Oklahoma sites sampled for VOC, carbonyls compounds, and metals (TSP).

- Seventeen pollutants failed screens for TOOK, 16 failed screens for TMOK; 13 failed screens for PROK; 18 failed screens for MWOK; and 19 failed screens for OCOK.

- Of the pollutants of interest, formaldehyde had the highest annual average concentrations for each Oklahoma site.

- TOOK had the highest annual average for benzene among NMP sites sampling this pollutant. PROK and MWOK had the highest and second highest annual average concentrations of 1,2-dichloroethane, respectively, among NMP sites sampling this pollutant.

- TOOK has sampled carbonyl and VOC compounds for at least five years, therefore a trends analysis was conducted for acetaldehyde, benzene, 1,3-butadiene, and formaldehyde. Any changes in the rolling average concentrations of these pollutants were not statistically significant.

- None of the measured detections or time-period average concentrations of the pollutants of interest for the Oklahoma sites were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Formaldehyde and benzene had the highest cancer risk approximations for all of the Oklahoma monitoring sites. Arsenic had the highest cancer risk approximations among the metals. None of the pollutants of interest for the Oklahoma sites had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Mayes, Oklahoma, and Tulsa Counties. Arsenic had the highest cancer toxicity-weighted emissions for Mayes County and benzene had the highest cancer toxicity-weighted emissions for Oklahoma and Tulsa Counties.

- Toluene was the highest emitted pollutant with a noncancer risk factor in Tulsa and Oklahoma Counties, while hydrochloric acid was the highest emitted pollutant with a noncancer risk 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.

- Back trajectories originated from a variety of directions at PRRI, although more frequently from the west, northwest, and north.

- The wind roses show that winds from the north, south, or with a westerly component were prevalent near PRRI.

- PRRI sampled for PAH and hexavalent chromium.

- Naphthalene, benzo(a)pyrene, flourene, and hexavalent chromium failed screens for PRRI, although 86 percent of failed screens are attributed to naphthalene.

- The annual average concentration of naphthalene was significantly higher than that of the other pollutants of interest. The annual average benzo(a)pyrene concentration for PRRI is the highest among all sites sampling the pollutant.

- Hexavalent chromium sampling has been conducted at PRRI for at least five consecutive years; thus, a trends analysis was conducted. The rolling average concentrations of hexavalent chromium have fluctuated over the period of sampling, though confidence intervals indicate that any changes are not statistically significant.

- None of the measured detections or time-period average concentrations of the pollutants of interest for PRRI were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Naphthalene had the highest cancer risk approximation for PRRI, and the only one greater than 1.0 in-a-million; all noncancer risk approximations for PRRI were less than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Providence County, while formaldehyde had the highest cancer toxicity-weighted emissions.

Toluene was the highest emitted pollutant with a noncancer risk 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.

- Back trajectories originated from a variety of directions at CHSC.

- The wind roses show that calm winds, south-southwesterly to west-southwesterly winds were prevalent near CHSC.

- CHSC sampled for hexavalent chromium and PAH.

- Naphthalene was the only pollutant to fail screens for CHSC. Naphthalene failed six screens out of 58 measured detections).

- The annual average concentration of naphthalene was significantly higher than the annual average concentrations of the other two pollutants of interest. Compared to other program sites sampling PAH and hexavalent chromium, CHSC had some of the lowest daily average concentrations.

- Hexavalent chromium sampling has been conducted at CHSC for at least five consecutive years; thus, a trends analysis was conducted. Initial decreases in hexavalent chromium concentrations were followed by a slight increase over the most recent three-year period.

- None of the measured detections or time-period average concentrations of the pollutants of interest for CHSC were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- The cancer surrogate risk approximations for the pollutants of interest were below 1 in-a-million; the noncancer surrogate risk approximations were well below 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Chesterfield County and had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk 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).
- Back trajectories originated from a variety of directions at the South Dakota sites, although primarily from the west to northwest to north.

- Winds from a variety of directions were observed near SSSD, although southerly winds were the most common wind direction. Winds from the southeast and northwest quadrants were the most frequently observed wind directions near UCSD.

- Both South Dakota sites sampled for VOC, SNMOC, and carbonyl compounds.

- Thirteen pollutants failed screens for SSSD, of which five are NATTS MQO Core Analytes. Fifteen pollutants failed screens for UCSD, of which six are also NATTS MQO Core Analytes.

- Formaldehyde had the highest annual average concentration for both UCSD and SSSD, with the annual average concentrations of acetaldehyde being second highest. UCSD had the highest concentration of trichloroethylene among all NMP sites sampling VOC and the fourth highest concentrations of acrylonitrile and ethylbenzene.

- None of the measured detections or time-period average concentrations of the pollutants of interest for the South Dakota sites were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Formaldehyde had the highest cancer risk approximations for both sites. None of the pollutants of interest for any of the South Dakota sites had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk 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 risk factor in Minnehaha and Union Counties, while acrolein had the highest noncancer toxicity-weighted emissions for all three counties.

Texas.

- There are two NATTS sites in Texas: one in Deer Park (CAMS 35) and one in Karnack (CAMS 85).

- Back trajectories originated from a variety of directions at CAMS 35, although most trajectories originated from the east to southeast to south over the Gulf of Mexico. Back trajectories also originated from a variety of directions at CAMS 85, although there is a north-south distribution pattern of trajectories similar to CAMS 35.

- The wind roses show that winds from the southeast quadrant (including easterly and southerly winds) were the most commonly observed wind directions near CAMS 35. A similar wind pattern is exhibited near CAMS 85.

- The CAMS 35 site sampled for PAH. Both sites began sampling for hexavalent chromium in February 2010.

- Four pollutants failed screens for CAMS 35, with naphthalene, contributing to nearly 97 percent of the total failed screens. Hexavalent chromium failed nearly 65 percent of screens for CAMS 85.

- Of the pollutants of interest, naphthalene had the highest annual average concentration for CAMS 35, and is significantly higher than the annual averages for the other pollutants of interest. The annual average concentration of hexavalent chromium for CAMS 85 was six times higher than the annual average concentration for CAMS 35 and the highest among NMP sites sampling hexavalent chromium.

- None of the measured detections or time-period average concentrations of the pollutants of interest for the Texas sites were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Naphthalene had the highest cancer risk approximation among the pollutants of interest for CAMS 35. The cancer risk approximation for hexavalent chromium for CAMS 85 is one of only two hexavalent chromium risk approximations greater than 1 in-a-million. None of the pollutants of interest for either Texas site had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Harris County, while formaldehyde had the highest cancer toxicity-weighted emissions. In Harrison County, formaldehyde was the highest emitted pollutant with a cancer risk factor, while hexavalent chromium had the highest cancer toxicity-weighted emissions.

- Toluene was the highest emitted pollutant with a noncancer risk factor in both counties, while acrolein had the highest noncancer toxicity-weighted emissions.

Utah.

- The NATTS site in Utah is located in Bountiful (BTUT), north of Salt Lake City.

- Back trajectories originated from a variety of directions at BTUT. Back trajectories originating from the northeast, east, and southeast tended to be shorter in length than trajectories from other directions.

- The wind roses show that southeasterly, south-southeasterly, and southerly winds were prevalent near BTUT.

- BTUT sampled for VOC, carbonyl compounds, SNMOC, PAH, metals (PM_{10}), and hexavalent chromium.

- Twenty-six pollutants failed screens for BTUT, of which 14 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 *p*-dichlorobenzene, and the second highest annual average concentrations of trichloroethylene and formaldehyde among NMP sites sampling these pollutants. Among sites sampling PM_{10} metals, BTUT had the third highest annual average concentration of arsenic.

- Carbonyl compounds, VOC, SNMOC, metals (PM_{10}), and hexavalent chromium sampling have been conducted at BTUT for at least five consecutive years; thus, a trends analysis was conducted for acetaldehyde, arsenic, benzene, 1,3-butadiene, formaldehyde, hexavalent chromium, and manganese. After initial decreases, concentrations of acetaldehyde, benzene, formaldehyde, and hexavalent chromium have remained steady over recent years. Concentrations of 1,3-butadiene have also changed little. Concentrations of manganese have started to decrease over the more recent time frames.

- Of 59 measured detections of dichloromethane, one was greater than the ATSDR acute MRL. This was the only pollutant with a measured detections or time-period average greater than an MRL noncancer health risk benchmark for BTUT.

- The pollutant with the highest cancer surrogate risk approximation for BTUT was formaldehyde. None of the pollutants of interest had a noncancer risk approximations greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Davis County and had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk factor, while acrolein had the highest noncancer toxicity-weighted emissions for Davis County.

Vermont.

- Two Vermont monitoring sites are located in or near Burlington (UNVT and BURVT); a third monitoring site is located in Rutland (RUVT). UNVT is a NATTS monitoring site.

- The back trajectory maps for the Vermont sites are similar to each other, with most back trajectories originating from the southwest, west, northwest, and north of the sites.

- The wind roses for the Vermont sites show that southerly winds were prevalent near BURVT, although northwesterly to northerly winds were also common; east-southeasterly and southeasterly winds were prevalent near RUVT, although winds

30-22

from the northwest quadrant were also common; and calm winds were prevalent near UNVT.

- UNVT sampled for VOC, carbonyl compounds, hexavalent chromium, PAH, and metals (PM_{10}). BURVT and RUVT sampled for VOC only.

- Eight pollutants failed screens for BURVT and six failed screens for RUVT. Thirteen pollutants failed screens for UNVT, of which nine are NATTS MQO Core Analytes.

- Benzene had the highest annual average concentration for BURVT and RUVT, while carbon tetrachloride had the highest annual average concentration for UNVT. Because carbonyl compound sampling ended in June 2010 at UNVT, annual average concentrations could not be calculated for these compounds. 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 five consecutive years; thus, a trends analysis was conducted for hexavalent chromium. A decreasing trend is shown for hexavalent chromium over the period of sampling. At least 50 percent of the measurements were non-detects for each 3-year period.

- None of the measured detections or time-period average concentrations of the pollutants of interest for the Vermont sites were higher than their respective ATSDR MRL noncancer health risk benchmarks.

- Benzene had the highest cancer risk approximation for BURVT and RUVT. Carbon tetrachloride had the highest cancer risk approximation for UNVT, followed by the cancer risk approximation for benzene. None of the noncancer risk approximations, where they could be calculated, were greater than an HQ of 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Chittenden and Rutland Counties and also had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk factor in both counties, while acrolein had the highest noncancer toxicity-weighted emissions.

Virginia.

- The NATTS site in Virginia is located near Richmond (RIVA).

- Back trajectories originated from a variety of directions at RIVA, although primarily from the southwest, west, and northwest of the site.

- The wind rose shows that northerly winds were observed the most and winds from the southeast quadrant were observed the least.

- RIVA sampled for PAH and hexavalent chromium.

- Four PAH pollutants failed screens for RIVA, though naphthalene contributed to nearly 97 percent of the total failed screens.

- Of the pollutants of interest, naphthalene had the highest annual average concentrations.

- None of the measured detections or time-period average concentrations of the pollutants of interest for the Virginia site were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Naphthalene had the highest cancer risk approximation for RIVA. None of the pollutants of interest for RIVA had a noncancer risk approximation greater than 1.0.

- Benzene was the highest emitted pollutant with a cancer risk factor in Henrico County, while formaldehyde had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk factor in Henrico County, while acrolein had the highest noncancer toxicity-weighted emissions.

Washington.

- The NATTS site in Washington is located in Seattle (SEWA).

- Back trajectories for SEWA originated from a variety of directions. Back trajectories originating to the south and northwest tended to be longer than trajectories originated to the north and east.

- The wind roses show that southeasterly to southerly winds were prevalent near the SEWA.

- SEWA sampled for VOC, carbonyl compounds, PAH, PM_{10} metals, and hexavalent chromium.

- Sixteen pollutants failed screens for SEWA, of which 10 are NATTS MQO Core Analytes.

- Of the pollutants of interest for SEWA, acetaldehyde had the highest annual average concentration. SEWA had the highest annual average concentration for carbon tetrachloride among NMP sites sampling VOC and the highest annual average concentration of nickel among NMO sites sampling metals.

- None of the measured detections or time-period average concentrations of the pollutants of interest for SEWA were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Formaldehyde had the highest cancer surrogate risk approximation for SEWA. All of the noncancer risk 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 risk factor in King County and had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk 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. Because the site started in December 2009, the two samples from that month are also included in this report.

- Back trajectories originated from a variety of directions at HOWI, although less frequently from the east.

- The wind roses show that winds from a variety of directions are observed at HOWI, though winds from the south and north were observed most frequently.

- HOWI sampled for PAH and hexavalent chromium although PAH sampling ended in June 2010.

- Naphthalene was the only pollutant to fail screens for HOWI.

- Because PAH sampling ended in June 2010, annual average concentrations could not be calculated for the PAH pollutants.

- None of the measured detections or time-period average concentrations of the pollutants of interest for the Wisconsin site were greater than their respective ATSDR MRL noncancer health risk benchmarks.

- Because annual average concentrations are not available, cancer and noncancer risk approximations could not be calculated for naphthalene and benzo(a)pyrene. Both the cancer and noncancer risk approximations for hexavalent chromium were low.

- Benzene was the highest emitted pollutant with a cancer risk factor in Dodge County and had the highest cancer toxicity-weighted emissions. Toluene was the highest emitted pollutant with a noncancer risk factor in Dodge County, while acrolein had the highest noncancer toxicity-weighted emissions.

30.1.3 Composite Site-level Summary

- Thirty-one pollutants were identified as site-specific pollutants of interest, based on the risk screening process. Acetaldehyde and formaldehyde were the two most

common pollutants of interest among the monitoring sites. All sites (30) 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 (29) had this as a pollutant of interest. Every site that sampled PAH (26) had naphthalene as a pollutant of interest.

- Among the site-specific pollutants of interest, formaldehyde frequently had the highest annual average concentration among the monitoring sites; formaldehyde had the highest annual average concentration for 17 sites. Naphthalene had the next highest at 11.

- Benzo(a)pyrene was detected most frequently during the first and fourth quarters of the calendar year. There were 269 measured detections during the first quarter of 2010, 129 during the second quarter, 87 during the third quarter, and 200 during the fourth quarter of 2010.

- Of the 214 measured detections of 1,2-dichloroethane, 117 were measured during the first quarter of 2010, 87 during the second quarter, 3 during the third quarter, and 5 during the fourth quarter of 2010. Virtually all (203 out of 214) were measured prior to May 14, 2010.

- The toxicity factor for formaldehyde used in the preliminary risk 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 and the 2010 report than in previous reports.

- Formaldehyde and naphthalene tended to have the highest cancer risk approximations. This is also true for the noncancer risk approximations, although there were no noncancer risk approximations greater than an HQ of 1.0 among any of the site-specific pollutants of interest.

- Carbon tetrachloride often had relatively high cancer risk approximations based on annual averages among the monitoring sites, but tended to have relatively low emissions and toxicity-weighted emissions according to the NEI. This suggests that this pollutant is present in "background" levels of ambient air; that is, it is consistently present at similar levels at any given location. Although production of this pollutant has declined sharply over the last 30 years due to its role as an ozone depleting substance, it has a relatively long atmospheric lifetime.

- Benzene, formaldehyde, and ethylbenzene tended to have the highest county-level emissions of the pollutants with cancer risk factors. Ethylbenzene did not appear as frequently among the highest emitted pollutants in the 2008-2009 report (based on the 2005 NEI) as it does in the 2010 report (based on the 2008 NEI). Formaldehyde,

benzene, and 1,3-butadiene tended to have the highest toxicity-weighted emissions among the pollutants with cancer risk factors.

- While toluene, xylenes, and methanol tended to have the highest county-level emissions of the pollutants with noncancer risk factors, acrolein, formaldehyde, and 1,3-butadiene tended to have the highest toxicity-weighted emissions among the pollutants with noncancer risk factors

- 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.

30.1.4 Data Quality Summary

Method precision and analytical precision was determined for the 2010 NMP monitoring efforts using CV calculations based on duplicate, collocated, and replicate samples. The overall method precision for most methods was well within data quality objective specifications and monitoring method guidelines, while one method exceeded the data quality objective specifications (SNMOC). The method precision presented in this report is based on analytical results greater than or equal to the sample- and pollutant-specific MDL, which represents a change from previous reports (where ½ MDL substitutions were performed).

Sampling and 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.

Ambient air concentration data sets generally met data quality objectives for completeness. Completeness, or the number of valid samples collected compared to the number expected from a 1-in-6 or 1-in-12 day sampling schedule, measures the reliability of the sampling and analytical equipment as well as the efficiency of the program. Typically, a completeness of 85-100 percent is desired for a complete data set. Only five out of 126 data sets failed to comply with the data quality objective of 85 percent completeness. Thirty-eight data sets achieved 100 percent completeness.

NATTS data generated under the NMP for 2010 were included in EPA's NATTS Network Assessment (EPA 2012j), which assessed the NATTS program trends DQO and determined if the data are suitable for trends analysis. The DQO is satisfied if the data generated for the NATTS program meets the MQOs for completeness, sensitivity, bias, and precision. According to the NATTS Network Assessment, the NATTS data generated under the NMP for 2010 met the MQOs and were determined to be suitable for trends analysis, with the exception of two data sets where sampling issues in the field resulted in the invalidation of a large subset of data.

30.2   Conclusions

Conclusions resulting from the data analyses of the data generated from the 2010 NMP monitoring efforts are presented below.

- There are a large number of concentrations that are greater than their respective preliminary risk screening values, particularly for many of the NATTS MQO Core Analytes. However, there are few 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 surrogate risk approximations were greater than 100-in-a-million; 34 were greater than 10-in-a-million (23 for formaldehyde, one for dichloromethane; eight for benzene, and two for acrylonitrile and naphthalene); and approximately 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 surrogate risk approximations was greater than an HQ of 1.0.

- When comparing the highest emitted pollutants for a specific county to the pollutants with the highest toxicity-weighted emissions, the listed pollutants were more similar for the pollutants with cancer UREs than for pollutants with noncancer RfCs. This indicates that pollutants with cancer UREs that are emitted in higher quantities are often more toxic than pollutants emitted in lower quantities; conversely, the highest emitted pollutants with noncancer RfCs are not necessarily the most toxic. For example, toluene is the noncancer pollutant that was emitted in the highest quantities for many NMP counties, yet was rarely one of the pollutants with highest toxicity-weighted emissions. Further, while acrolein had the highest noncancer toxicity-weighted emissions for every NMP county, it was rarely among the highest emitted pollutants.

- The number of states and sites participating in the NMP changes from year to year. Yet, many of the data analyses utilized here require data from year-round (or nearly year-round) sampling. Of the 52 sites whose data are included in the 2010 report, seven sites sampled for an abbreviated duration (due to site initialization and/or site closure/relocation). Of the 126 site-method combinations, 16 site-method combinations did not cover the entire year As a result, time-period averages and subsequent risk-based analyses could not be calculated for nearly 13 percent of participating sites (and site-method combinations), although this is an improvement from the 2008-2009 monitoring effort. While these gaps have ramifications for the results contained in this report, they also inhibit the potential determination of trends.

- Of the 52 monitoring sites participating in the 2010 NMP, only two sampled for all six available analytical methods under the national program (BTUT and NBIL). Another four sites sampled all five methods required for NATTS sites through the national program. The wide range of methods/pollutants sampled among the sites makes it difficult to draw definitive conclusions regarding air toxics in ambient air in a global manner.

- This report strives to utilize the best laboratory and data analysis techniques available (which includes the improvement of MDLs and the incorporation of updated values for various risk factors, for example). This often leads 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 the 2008-2009 NMP report and the 2010 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 for the 2010 report, allowing for the calculation of quarterly average concentrations for those pollutants detected less frequently than others.

30.3 Recommendations

Based on the conclusions from the 2010 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 participation in the NMP.

- *Participate in the National Monitoring Programs year-round.* Many of the analyses presented in the 2010 report require a full year of data to be most useful and representative of conditions experienced at each specified location. Therefore, state

and local agencies should be encouraged to implement year-long ambient air monitoring programs in addition to participating in future monitoring efforts.

- *Monitor for additional pollutant groups based on the results of data analyses in the annual report.* The risk-based analysis where county-level emissions are weighted based on toxicity identifies those pollutants whose emissions may result in adverse health effects in a specific area. If a site is not sampling for a pollutant or pollutant group identified as particularly hazardous in 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 is integral to the identification of trends and the impacts 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, the 2006 annual report included observations of high hexavalent chromium concentrations on July 4, 2006. 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 impact 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 the 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.* Several of the pollutants sampled during the 2010 program years were higher 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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