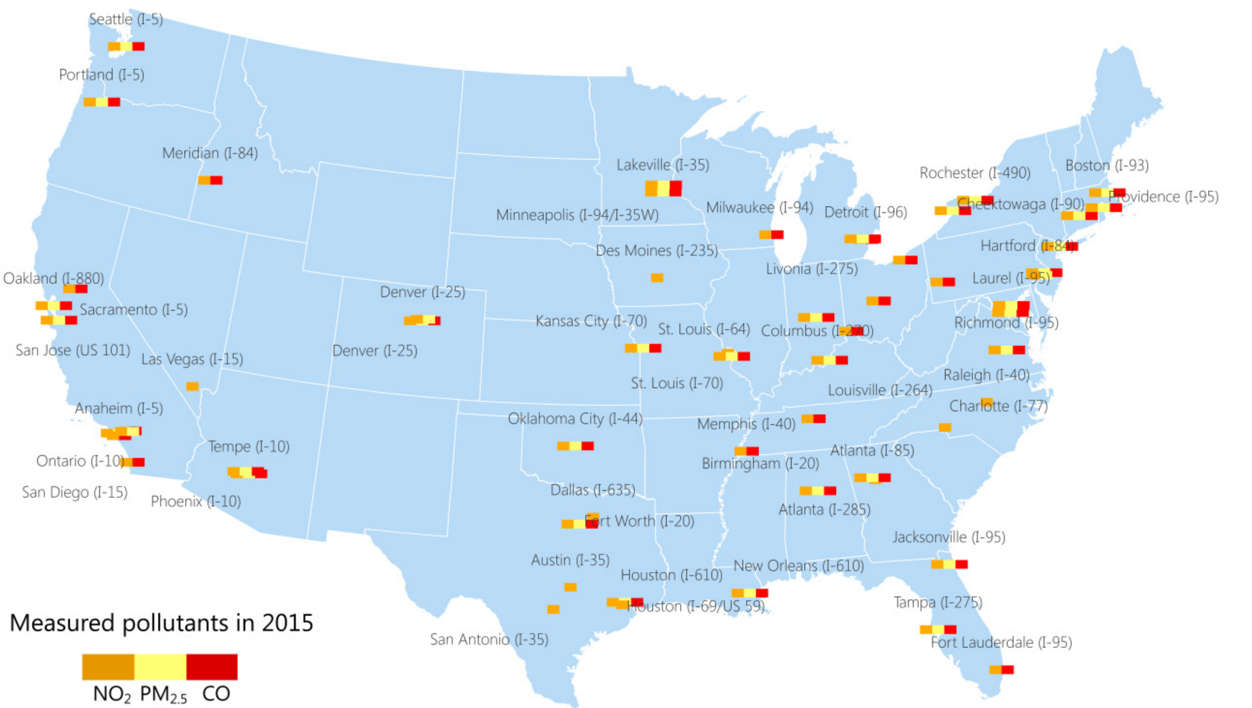
National Near-Road Data Assessment: Report No. 2 With 2015 Data



Final Report Prepared for

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Sonoma Technology, Inc.
Environmental Science and Innovative Solutions

National Near-Road Data Assessment: Report No. 2 With 2015 Data

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Cover graphic illustrates data available from the U.S. Environmental Protection Agency's (EPA's) Air Quality System (AQS) database from near-road monitoring sites at the time of this report. See Section 2.3 for details.

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Acknowledgments

The authors would like to acknowledge the assistance of Nealson Watkins of the U.S. Environmental Protection Agency (EPA) for supplying summary information on official near-road monitoring sites.

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Abstract

This work was completed as part of the Near-Road Air Quality Research Transportation Pooled Fund, TPF-5(284), under the U.S. Federal Highway Administration (FHWA) Transportation Pooled Fund Program. The lead agency for TPF-5(284) is the Washington State Department of Transportation (DOT). Other participants supporting this work include the FHWA and the Arizona, California, Texas, and Virginia DOTs. Sonoma Technology, Inc. (STI) provides technical, planning, facilitation, and website support.

National Near-Road Data Assessment: Final Report No. 2

Background: The U.S. Environmental Protection Agency (EPA) has mandated air quality monitoring next to selected major roadways throughout the United States; monitoring was phased in during 2012–2015 and included nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter (PM). The objective of this study was to obtain, summarize, and interpret data from the national near-road monitoring program. This report is the second in a series to provide a digest of findings from around the United States and highlight and examine situations where relatively high near-road pollutant concentrations have been observed. This report focuses on Year 2015 data assessments.

Methods: Routine near-road air quality data were collected by monitoring agencies in 2014–2015 and stored in the EPA's Air Quality System (AQS) database. STI gathered and processed the 2014-2015 data, and conducted a national-scale review of near-road air pollutant concentrations. The data included NO_2, CO, and $PM_{2.5}$ from official near-road monitoring sites. These data were quality-controlled by air monitoring agencies and certified by states as final in May 2016. State-reported annual average daily traffic of the major roads associated with each of the official near-road sites were provided by EPA. We evaluated where high concentrations of NO_2, $PM_{2.5}$, and CO occurred, and how concentrations varied by factors such as location, distance to roadway, and traffic volume.

Results: As of May 2016, 66 near-road monitors had reported NO_2 data to AQS, at 61 unique locations (5 monitors are collocated with another monitor). Of these, 49 reported at least three full quarters of NO_2 data. Thirty-nine near-road monitors reported 2015 $PM_{2.5}$ data to AQS, at 37 unique locations (2 monitors are collocated with another monitor). Thirty-one of these had at least three full quarters of data. There were five hourly NO_2 observations above 100 ppb, at the George Washington Bridge in New York/New Jersey (three hours in one day with concentrations greater than 100 ppb); along Interstate 880 (I-880) in Oakland, California; and along I-5 in Seattle, Washington. Sites in Denver, Colorado; Houston, Texas; Long Beach, California; Ontario, California; and Phoenix, Arizona, recorded $PM_{2.5}$ annual averages for 2015 greater than 12 $\mu g/m^3$. However, only the Long Beach and Ontario sites had a full year of data for 2015; Houston had three quarters of the year of data. There were 33 days in 2015 at 12 near-road locations with 24-hr $PM_{2.5}$ concentrations above 35 $\mu g/m^3$. Only three of the sites—Denver, Long Beach, and Ontario—had a 98th percentile of 24-hr $PM_{2.5}$ concentrations greater than 35 $\mu g/m^3$; the Denver site, however, had less than two full quarters of data, which may not be representative of a full year.

1. Introduction

1.1 Overview

The U.S. Environmental Protection Agency (EPA) has mandated air quality monitoring next to major roadways throughout the United States; monitoring was phased in during 2012–2015 (U.S. Environmental Protection Agency, 2010). Monitoring includes nitrogen dioxide (NO_2), and at some sites also includes carbon monoxide (CO), particulate matter (PM), air toxics, and ultrafine particles (UFP). These data will be used by the EPA to verify that the National Ambient Air Quality Standards (NAAQS) are being met in areas where peak pollutant concentrations are expected to occur within the near-road environment. The EPA and others will also use these data for research purposes to evaluate the relationship between near-road pollutant concentrations and traffic volumes, fleet mix, and travel speeds. In addition to the EPA-mandated near-road monitoring, several near-road research studies in various U.S. cities have been completed in recent years; during these studies, near-road air quality data have been collected that represent different geographic locations, vehicle fleets, time periods, and other variables.

The objective of this study is to obtain, summarize, and interpret data from the national near-road monitoring program and from selected special-purpose near-road studies. This report is the second in a series to provide a digest of findings from monitoring sites around the United States and to highlight and explain situations where relatively high near-road pollutant concentrations have been observed. In this report, new findings are presented for data from 2015 and results for 2014 are updated. The results generated in this work will help Transportation Pooled Fund (TPF) partners understand measured near-road concentrations, trends, and conditions that lead to high-concentration events. This report is for research purposes and should not be used for determining attainment status. Although the report includes comparisons of ambient data to the NAAQS, these comparisons are included to provide context for the data collected to date; findings are not appropriate for use as a measure of attainment status at particular sites. States are at varying stages of near-road monitoring implementation and, in many cases, sites have not collected sufficient data to support NAAQS attainment calculations by the EPA or the states.

In this study, we gathered routine near-road air quality data collected in 2014–2015 and conducted a national-scale review of near-road air pollutant concentrations. Specific steps included the following:

- Assembled air quality data from official near-road monitoring sites. These data are quality-controlled by the air monitoring agency and are certified by May 1 following each year of monitoring (i.e., data for 2015 were certified as final as of May 1, 2016).
- Collected state-reported annual average daily traffic (AADT) and fleet mix characteristics of official near-road monitoring sites from EPA (available at https://www3.epa.gov/ttnamti1/nearroad.html).

- Performed a national-scale analysis of official near-road monitoring network data to determine if/where high concentrations of NO_2, $PM_{2.5}$, and CO occurred and how concentrations varied by location, distance to roadway, weekday/weekend, and traffic volume.
- For each near-road monitoring site, investigated how much higher $PM_{2.5}$ is at the near-road site than at other urban monitoring sites.
- Performed case study analyses of pollution concentrations for the following:
  - $PM_{2.5}$ during February 2014 at the Denver, Colorado, near-road monitoring site;
  - $PM_{2.5}$ during February and April 2015 at Long Beach and Ontario, California, near-road monitoring sites;
  - NO_2 during February 2015 at the George Washington Bridge (Fort Lee, New Jersey) near-road monitoring site;
  - NO_2 during March 2015 at the Oakland, California, near-road monitoring site;
  - NO_2 during February 2015 at the Seattle, Washington, near-road monitoring site;
  - Annual average $PM_{2.5}$ at the Houston, Texas, near-road monitoring site.
- Assembled data from special near-roadway studies (EPA/Federal Highway Administration [FHWA] I-15 study in Las Vegas, Nevada, and EPA/FHWA I-96 study in Detroit, Michigan) and compared results to the data collected at the near-road monitors in Las Vegas and Detroit.
- Documented findings.

1.2 Background

The EPA promulgated near-road air quality monitoring requirements in 2010 at the same time that the agency revised the NAAQS[1] for NO_2 (U.S. Environmental Protection Agency, 2010). Monitoring requirements were revised in 2013 to extend deadlines for initiating near-road NO_2 monitoring (U.S. Environmental Protection Agency, 2013a). Monitoring near major roadways in cities across the United States initially focused on NO_2, but additional CO and $PM_{2.5}$ requirements were added during NAAQS rulemakings (U.S. Environmental Protection Agency, 2013b). The EPA adopted a phased implementation plan, with the first set of monitoring sites to be operational by January 1, 2014; subsequent sites were to be added by early 2015 and 2017. A small subset of the sites also measure air toxics, BC, and UFP; however, there are no requirements to monitor these compounds. On May 16, 2016, the EPA proposed to revise the minimum near-road monitoring requirement for NO_2 by lifting the January 1, 2017, requirement for NO_2 monitoring in Core Based Statistical Areas (CBSAs) with populations between 500,000 and 1,000,000 (81 Fed. Reg. 30224 – 30229, May 16, 2016). The proposed rule noted "current near-road NO_2 monitoring data indicate air quality levels in the near-road environment are well below the National Ambient Air Quality Standards (NAAQS) for the oxides

[1] With its 2010 NO_2 NAAQS revision, the EPA augmented the existing annual standard of 53 ppb, calculated as the annual arithmetic mean, with a 1-hr NAAQS of 100 ppb. Compliance with the 1-hr NO_2 NAAQS is determined by calculating the 98th percentile of all the daily maximum 1-hr concentrations in a year, and then averaging three consecutive years of these 98th percentile values with the averaged value not to exceed 100 ppb.

of nitrogen." This report refers to EPA-required near-road monitoring sites as "official" near-road sites to distinguish them from sites established outside the near-road monitoring requirements.

As shown in near-road monitoring studies conducted in Las Vegas, Los Angeles, and elsewhere, concentrations of air pollutants such as BC, CO, and PM are measurably greater near roadways than elsewhere in the urban environment—for example, see Roberts et al. (2010), Karner et al. (2010), and Zhu et al. (2002). Studies have shown that pollutant concentrations can be many times greater within 150 m (approximately 500 feet) of a major roadway, decreasing rapidly with increasing distance from the roadway, and that the concentrations of certain pollutants (such as black carbon) in the near-road setting are heavily influenced by truck emissions (see Figure 1). The literature also shows that at night when winds are calm, roadway-related pollutants can be detected at distances as great as 1,100 m (3,600 feet) from a major road (Hu et al., 2009).

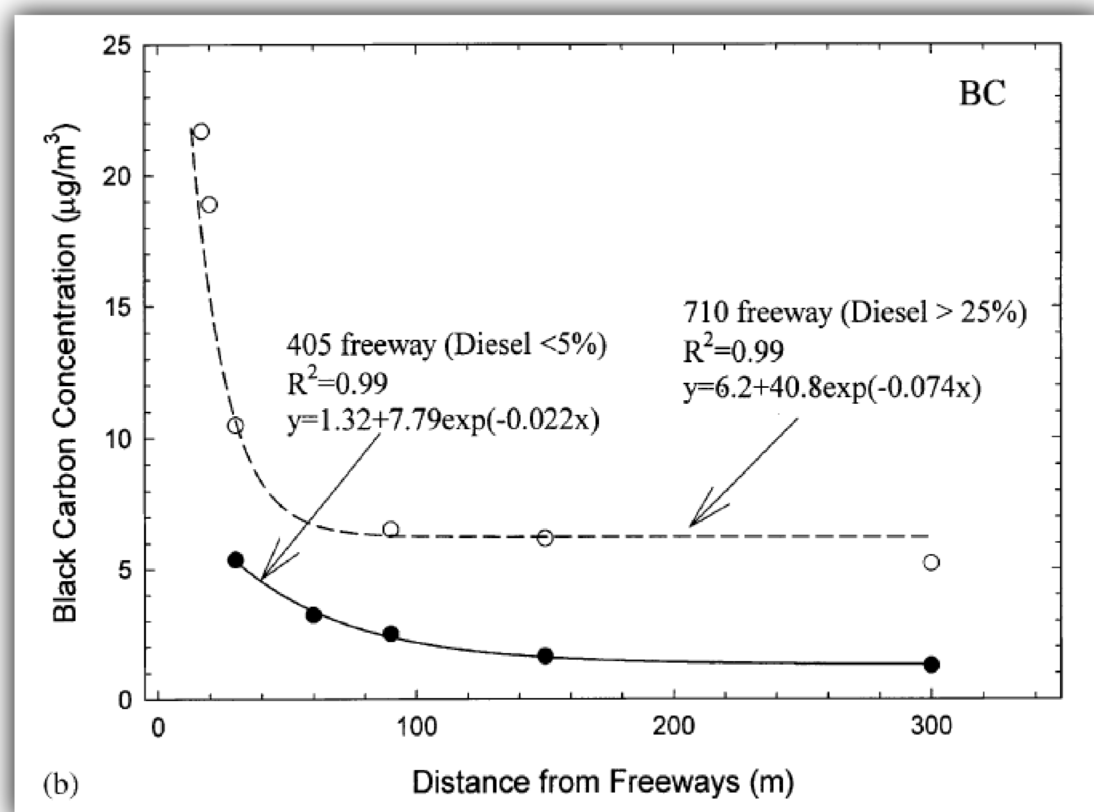


Figure 1. Decrease in BC concentrations at increasing distances from the I-405 and I-710 freeways in Los Angeles. Reproduced from Zhu et al. (2002).

State and local air monitoring agencies are required to install near-road NO_2 monitoring stations at locations where peak hourly NO_2 concentrations are expected. Agencies must consider traffic volumes, fleet mix, roadway design, traffic congestion patterns, local terrain or topography, and meteorology in deciding where to locate a required near-road NO_2 monitor. Additional factors to consider in locating a near-road monitoring station include site logistics (such as access and safety) and population exposure. The EPA provided extensive guidance on site selection and implementation (U.S. Environmental Protection Agency, 2012), including information on optional multi-pollutant monitoring. The guidance suggests that

> *…the monitor probe shall be as near as practicable to the outside nearest edge of the traffic lanes of the target road segment; but shall not be located at a distance greater than 50 meters, in the horizontal, from the outside nearest edge of the traffic lanes of the target road segment… [The EPA] recommends that the target distance for near-road NO_2 monitor probes be within 20 meters of the target road whenever possible.*

The EPA established a near-road monitoring implementation phase-in schedule based on the populations of the CBSA for each city and the AADT on-road segments. Table 1 summarizes the implementation phases for the near-road monitoring, and Figure 2 shows the proposed locations for each phase of monitoring. Most Phase 1 and 2 sites became operational sometime in 2014. Data are required to be uploaded to the EPA's Air Quality System (AQS—the national data repository for air quality monitoring) within three months of the end of each quarter.

Table 1. Summary of EPA-required implementation phases for near-road monitors (Watkins, 2015).

Phase	CBSA Population and/or AADT	Implementation Deadline
NO_2		
Phase 1	≥ 1M	Jan. 1, 2014
Phase 2	≥ 2.5M, or AADT ≥ 250K	Jan. 1, 2015
Phase 3*	500K – 1M	Jan. 1, 2017
CO and $PM_{2.5}$		
Phase 1	–	–
Phase 2	≥2.5M	Jan. 1, 2015
Phase 3*	≥1M	Jan. 1, 2017

* On May 16, 2016, the EPA proposed to revise the minimum near-road monitoring requirement for NO_2 by eliminating the January 1, 2017, requirement for NO_2 monitoring in CBSAs having populations between 500,000 and 1,000,000 persons.

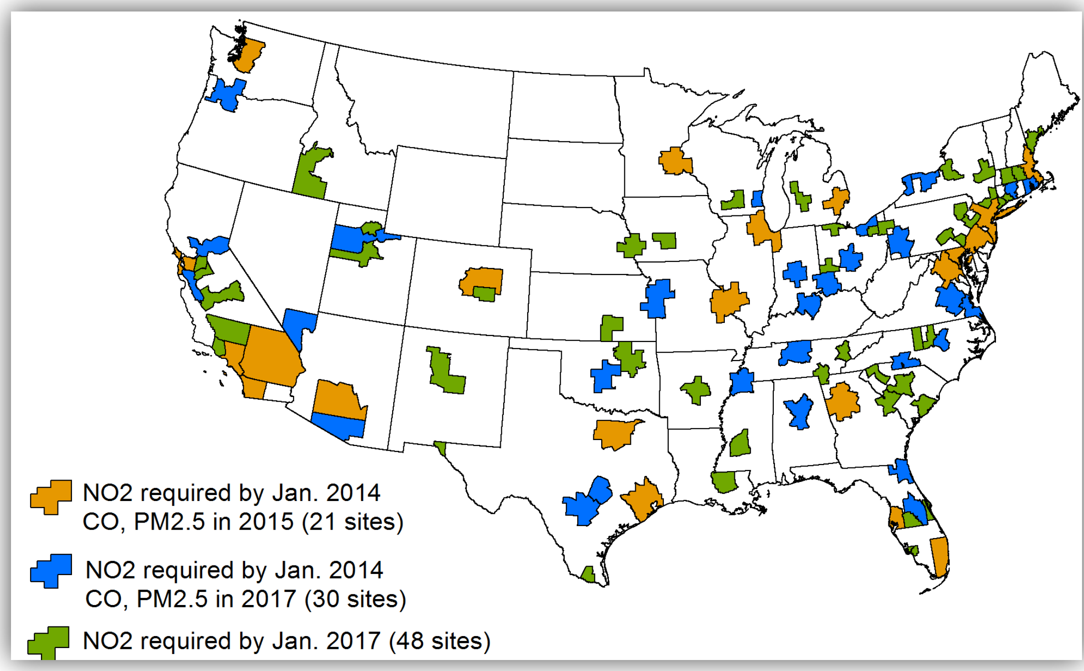


Figure 2. Expected locations (CBSA) for near-road NO_2 monitors in 2014–2017, with collocated CO and $PM_{2.5}$ monitors in 2015 (orange) and 2017 (blue). The locations are not yet finalized. Figure based on Watkins (2015).

In addition to air quality measurements collected at EPA-required near-road monitoring stations, near-road measurements have been collected during several research studies with different geographic locations, vehicle fleets, time periods, and other variables. We obtained and evaluated data from two research efforts, one in in Las Vegas and one in Detroit.

Pollutant concentrations measured at near-roadway monitors consist of background pollution plus an incremental contribution from the adjacent roadway. Analysis of near-road data alone is insufficient to estimate roadway contributions; analysis must also estimate the regional background concentration and subtract that concentration from the near-road measurements. Therefore, we examined multiple case studies to understand the roadway increment at selected sites.

1.3 Highlights

The following highlights of this study are based on final data submitted by monitoring agencies for 2015, accessed in May 2016:

- NO_2 data at sites in 66 near-road monitoring locations and $PM_{2.5}$ data for 39 near-road monitoring locations were reported in the EPA's AQS.

- Of the 66 locations with sites reporting NO_2 data, 49 reported three full quarters of data for 2015. Of the 39 locations with sites reporting $PM_{2.5}$ data, 31 reported at least three full quarters of data for 2015.
- Three 1-hr daily maximum NO_2 concentrations and five hourly NO_2 observations were above 100 ppb in 2015; these values were measured at George Washington Bridge (GWB) in New York/New Jersey (Fort Lee, New Jersey, monitoring site), along I-880 in Oakland, California, and along I-5 in Seattle, Washington.
- Sites in Denver, Colorado; Houston, Texas; Long Beach, California; Ontario, California; and Phoenix, Arizona, recorded $PM_{2.5}$ annual averages for 2015 greater than 12 $\mu g/m^3$. However, of these sites, only Long Beach and Ontario reported a full year of data for 2015.
- There were 33 days in 2015 at 12 near-road locations when 24-hr $PM_{2.5}$ concentrations were above 35 $\mu g/m^3$. Of these sites, only Denver, Long Beach, and Ontario recorded a 98th percentile of 24-hr $PM_{2.5}$ concentrations greater than 35 $\mu g/m^3$. Phoenix recorded a 98th percentile of 34.5 $\mu g/m^3$.
- CO concentrations were typically 1 ppm or less. Several high CO concentrations (greater than 4 ppm) were observed at the near-road locations in Puerto Rico; Memphis, Tennessee; and Wilkinsburg, Pennsylvania.

1.4 Guide to This Report

Section 2 of this report provides an overview of the technical approach used to identify, acquire, process, and analyze air pollutant concentration data and traffic information. Analysis results for the 2015 national assessment are described in Section 3 of this report. Results for the case study analyses are provided in Section 4, followed by conclusions in Section 5. Appendix A details data available by site, and Appendix B provides an update to the first report with new findings based on the 2014 data.

2. Technical Approach

2.1 Overview

We assembled air quality data from the near-road monitoring locations, and we put concentrations in a national context by developing high-level summary statistics of the national data set. These data were acquired from the EPA's AQS in May 2016 and have been quality-assured (QA'd) by each air monitoring and reporting agency. The 2015 data were certified in May 2016 as final. We also obtained supplemental information in order to perform case study analyses of high $PM_{2.5}$ and NO_2 concentrations at near-road sites during 2015.

2.2 Data Acquisition

We assembled the following data sets:

- **Data collected at official near-road monitoring sites since the EPA near-road measurement requirement took effect**. Air quality and meteorological data from official EPA-designated near-road monitoring sites, as documented in epa.gov/ttnamti1/nearroad.html, were acquired via the EPA's AQS and assembled into a database. We acquired data reported to AQS through December 2015.
- **Readily available special-purpose near-road measurements collected under the sponsorship of public agencies.** These data were obtained from
  - STI/NDOT US 95 study in Las Vegas, Nevada (BC, NO_2, and air toxics)
  - EPA/FHWA I-15 study in Las Vegas, Nevada (BC, PM, NO_2, and air toxics)
  - EPA/FHWA I-96 study in Detroit, Michigan (PM, BC, NO_2, air toxics, and UFP)
  - South Coast Air Quality Management District (SCAQMD) I-405 and I-710 studies (BC, PM, and NO_2)

The complete list of near-road monitoring locations that are expected to be in operation during Phases 1-3 of EPA's near-road program is shown in Table 2. The monitoring locations encompass major urban areas across the United States. The monitors are between 2 m and 50 m from a major roadway, with traffic counts (fleet equivalent annual average daily traffic, or FE-AADT)[2] that range from approximately 130,000 to 700,000 vehicles.

[2] FE-AADT is a metric that weights trucks and light-duty vehicles to come up with a single emissions-weighted traffic volume measure. EPA guidance suggests weighting heavy-duty trucks by a factor of 10 and calculates FE-AADT with the following equation: $FE\text{-}AADT=(AADT-HD_c)+(10\times HD_c)$ where HD_c is the total number of heavy-duty vehicles on a road segment. See the EPA's 2012 Near-Road NO_2 Monitoring TAD (U.S. Environmental Protection Agency, 2012).

Table 2. Locations, AADT, FE-AADT and distance to road of official near-road monitors anticipated to be in operation during 2015 (all data here are adopted directly from **https://www3.epa.gov/ ttnamti1/nearroad.html**). The list of locations was obtained in May 2016. Empty cells indicate no data reported by the monitoring agency.

Phase	AQS ID	Location	Urban Area	Road	AADT	FE-AADT	Distance to Road (m)
1	06-059-0008	Anaheim, CA	Los Angeles-Long Beach-Anaheim, CA	I-5	272,000	695,776	9
1	13-121-0056	Atlanta, GA	Atlanta-Sandy Springs-Roswell, GA	I-85	284,920	406,256	2
2	13-089-0003	Atlanta, GA	Atlanta-Sandy Springs-Roswell, GA	I-285	146,000	318,528	30
1	48-453-1068	Austin, TX	Austin-Round Rock, TX	I-35	188,150	350,712	27
3		Bakersfield, CA	Bakersfield, CA	CA 99	132,000	385,692	20
2	06-001-0013	Berkeley, CA	San Francisco-Oakland-Hayward, CA	I-80	265,000	379,246	25
1	01-073-2059	Birmingham, AL	Birmingham-Hoover, AL	I-20	141,190	215,527	23.2
1	25-025-0044	Boston, MA	Boston-Cambridge-Newton, MA-NH	I-93	198,239	251,761	10
1	37-119-0045	Charlotte, NC	Charlotte-Concord-Gastonia, NC-SC	I-77	153,000	260,830	30
1	36-029-0023	Cheektowaga, NY	Buffalo-Cheektowaga-Niagara Falls, NY	I-90	131,019	220,543	20
2		Chelmsford, MA	Boston-Cambridge-Newton, MA-NH	I-495	130,000		25
1	17-031-0216	Chicago, IL	Chicago-Naperville-Elgin, IL-IN-WI	I-90	330,000		25
1	39-061-0048	Cincinnati, OH	Cincinnati, OH-KY-IN	I-75	163,000	386,380	8
1	39-035-0073	Cleveland, OH	Cleveland-Elyria, OH	I-271	153,660	287,580	20
1	39-049-0038	Columbus, OH	Columbus, OH	I-270	142,361	286,050	32
1	48-113-1067	Dallas, TX	Dallas-Fort Worth-Arlington, TX	I-635	235,790	431,027	24
1	08-031-0027	Denver, CO	Denver-Aurora-Lakewood, CO	I-25	249,000	263,118	8.7

Phase	AQS ID	Location	Urban Area	Road	AADT	FE-AADT	Distance to Road (m)
2	08-031-0028	Denver, CO	Denver-Aurora-Lakewood, CO	I-25	192,000	210,835	6
3	19-153-6011	Des Moines, IA	Des Moines-West Des Moines, IA	I-235	110,000	150,140	13
1	26-163-0093	Detroit, MI	Detroit-Warren-Dearborn, MI	I-96	140,500	188,200	8.5
1	12-011-0035	Fort Lauderdale, FL	Miami-Fort Lauderdale-West Palm Beach, FL	I-95	306,000	622,161	30
1	34-003-0010	Fort Lee, NJ	New York-Newark-Jersey City, NY-NJ-PA	I-95/US 1	311,234	612,212	20
2	48-439-1053	Fort Worth, TX	Dallas-Fort Worth-Arlington, TX	I-20	184,680	242,856	15
3	06-019-2016	Fresno, CA	Fresno, CA	CA 99	93,000	227,505	20
1	72-061-0006	Guaynabo, PR	San Juan, Puerto Rico	De Diego Hwy	127,300		12
1	09-003-0025	Hartford, CT	Hartford-West Hartford-East Hartford, CT	I-84	159,900	231,855	17.7
1	48-201-1066	Houston, TX	Houston-The Woodlands-Sugar Land, TX	I-69/US 59	324,119	496,226	24
2	48-201-1052	Houston, TX	Houston-The Woodlands-Sugar Land, TX	I-610	202,120	334,915	15
1	18-097-0087	Indianapolis, IN	Indianapolis-Carmel-Anderson, IN	I-70	189,760	362,110	24.5
1	12-031-0108	Jacksonville, FL	Jacksonville, FL	I-95	139,000	304,062	20
1	29-095-0042	Kansas City, MO	Kansas City, MO-KS	I-70	114,495	347,582	20
2	27-037-0480	Lakeville, MN	Minneapolis-St. Paul-Bloomington, MN-WI	I-35	87,000	193,200	30
2	17-031-0116	Lansing, IL	Chicago-Naperville-Elgin, IL-IN-WI	I-80/I-94	116,400	492,600	27
1	32-003-1501	Las Vegas, NV	Las Vegas-Henderson-Paradise, NV	I-15	260,000	353,825	15
2	32-003-1502	Las Vegas, NV	Las Vegas-Henderson-Paradise, NV	US 95	177,000	224,115	15

Phase	AQS ID	Location	Urban Area	Road	AADT	FE-AADT	Distance to Road (m)
1	24-027-0006	Laurel, MD	Baltimore-Columbia-Towson, MD	I-95	186,750	452,309	16.15
2	26-163-0095	Livonia, MI	Detroit-Warren-Dearborn, MI	I-275	172,600	279,700	49
2	06-037-4008	Long Beach, CA	Los Angeles-Long Beach-Anaheim, CA	I-710	192,000	619,008	9
1	21-111-0075	Louisville, KY	Louisville/Jefferson County, KY-IN	I-264	163,000	247,600	32
1	47-157-0100	Memphis, TN	Memphis, TN-MS-AR	I-40	140,850	292,968	23.75
3	16-001-0023	Meridian, ID	Boise, ID	I-84	103,000	162,000	32
2		Miami, FL	Miami-Fort Lauderdale-West Palm Beach, FL	FL-836	197,000	248,500	
1	55-079-0056	Milwaukee, WI	Milwaukee-Waukesha-West Allis, WI	I-94	133,000	133,000	14
1	27-053-0962	Minneapolis, WI	Minneapolis-St. Paul-Bloomington, MN-WI	I-94/I-35W	277,000	387,250	32.5
1	47-037-0040	Nashville, TN	Nashville-Davidson--Murfreesboro--Franklin, TN	I-40/I-24	144,204	338,879	30
1	22-071-0021	New Orleans, LA	New Orleans-Metairie, LA	I-610	68,015	129,229	28.5
1	06-001-0012	Oakland, CA	San Francisco-Oakland-Hayward, CA	I-880	216,000	424,008	20
1	40-109-0097	Oklahoma City, OK	Oklahoma City, OK	I-44	155,300	195,554	13.56
1	06-071-0026	Ontario, CA	Riverside-San Bernardino-Ontario, CA	I-10	245,300	646,804	50
2	06-071-0027	Ontario, CA	Riverside-San Bernardino-Ontario, CA	SR-60	215,000	625,736	9
1	12-095-0009	Orlando, FL	Orlando-Kissimmee-Sanford, FL	I-4	195,773	312,062	49.5
1	42-101-0075	Philadelphia, PA	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	I-95	124,610	257,460	12

Phase	AQS ID	Location	Urban Area	Road	AADT	FE-AADT	Distance to Road (m)
2	42-101-0076	Philadelphia, PA	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	I-76	154,955	253,965	
2	04-013-4020	Phoenix, AZ	Phoenix-Mesa-Scottsdale, AZ	I-10	260,136	490,838	20
2	24-005-0009	Pikesville, MD	Baltimore-Columbia-Towson, MD	I-695/I-795	187,617	299,941	30
1	41-067-0005	Portland, OR	Portland-Vancouver-Hillsboro, OR-WA	I-5	156,000	289,052	27
1	44-007-0030	Providence, RI	Providence-Warwick, RI-MA	I-95	186,300	416,790	5
2		Queens, NY	New York-Newark-Jersey City, NY-NJ-PA	I-495 (L. I. E.)	166,340	322,030	28
1	37-183-0021	Raleigh, NC	Raleigh, NC	I-40	141,000	203,280	20
1	51-760-0025	Richmond, VA	Richmond, VA	I-95	151,000	259,720	21
1	36-055-0015	Rochester, NY	Rochester, NY	I-490	110,990	144,717	20
1	06-067-0015	Sacramento, CA	Sacramento--Roseville--Arden-Arcade, CA	I-5	186,000	475,000	20
1	48-029-1069	San Antonio, TX	San Antonio-New Braunfels, TX	I-35	201,840	405,295	20
1	06-073-1017	San Diego, CA	San Diego-Carlsbad, CA	I-15	223,000	358,000	37
1	06-085-0006	San Jose, CA	San Jose-Sunnyvale-Santa Clara, CA	US 101	191,000	294,140	32
1	53-033-0030	Seattle, WA	Seattle-Tacoma-Bellevue, WA	I-5	237,000	471,630	8
1	51-059-0031	Springfield, VA	Washington-Arlington-Alexandria, DC-VA-MD-WV	I-95	297,000	553,164	16
1	29-510-0094	St. Louis, MO	St. Louis, MO-IL	I-64	159,326	360,077	25
2	29-189-0016	St. Louis, MO	St. Louis, MO-IL	I-70	161,338	365,000	27

Phase	AQS ID	Location	Urban Area	Road	AADT	FE-AADT	Distance to Road (m)
2		St. Petersburg, FL	Tampa-St. Petersburg-Clearwater, FL	I-275	141,000	223,485	25
2	53-053-0024	Tacoma, WA	Seattle-Tacoma-Bellevue, WA	I-5	208,000	413,920	30
1	12-057-1111	Tampa, FL	Tampa-St. Petersburg-Clearwater, FL	I-275	190,500	327,660	20
1	04-013-4019	Tempe, AZ	Phoenix-Mesa-Scottsdale, AZ	I-10	320,138	624,315	12
1		Virginia Beach, VA	Virginia Beach-Norfolk-Newport News, VA-NC	I-264	199,000	239,816	10
2	11-001-0051	Washington DC, DC	Washington-Arlington-Alexandria, DC-VA-MD-WV	DC-295	115,480	172,747	15
1	42-003-1376	Wilkinsburg, PA	Pittsburgh, PA	I-376	87,534	148,248	18
1			Salt Lake City, UT				
2			San Juan, Puerto Rico				

Figure 3 shows the number of sites by distance from the roadway; most are within 30 m of the roadway's edge. Figure 4 shows the distribution of FE-AADT by site; more than half of the sites have an FE-AADT above 300,000 vehicles/day, and four sites have an FE-AADT above 600,000 vehicles/day. Most sites with high FE-AADT are close to the roadway (with the exception of Riverside, California, which is nearly 50 m from the roadway, likely due to siting constraints). Two sites, Los Angeles and Phoenix, have high FE-AADT and are very close to the roadway. The range of distances from the roadway and the range of FE-AADT on the roadways are considerable.

This report focuses on data available within AQS that were collected at official near-road sites. Not all locations described in Table 2 had data available at the time of data acquisition for this report. The locations with available data are discussed in the next section.

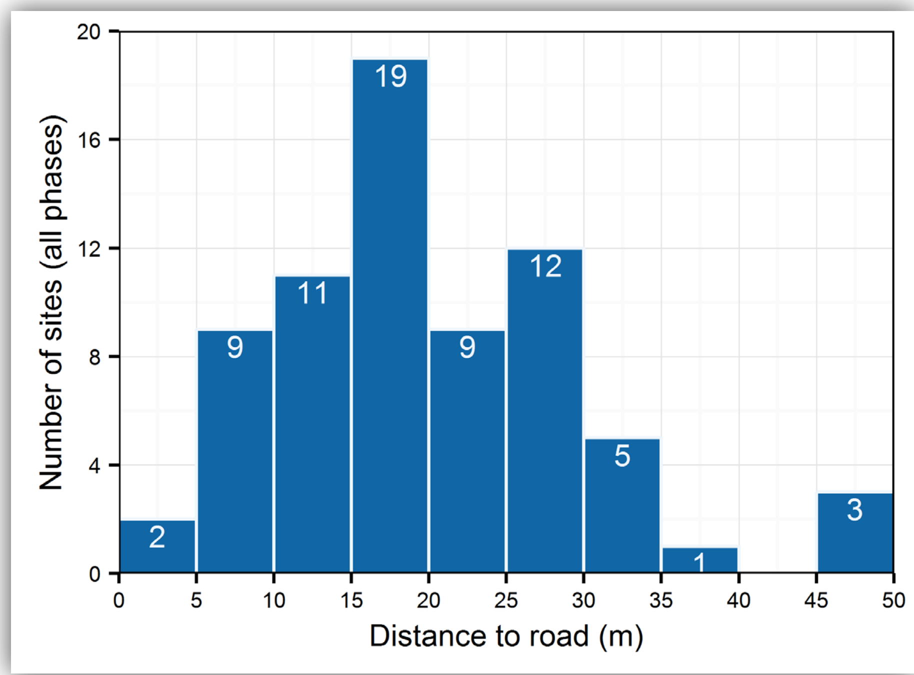


Figure 3. Number of official near-road sites by distance to roadway (as of May 2016).

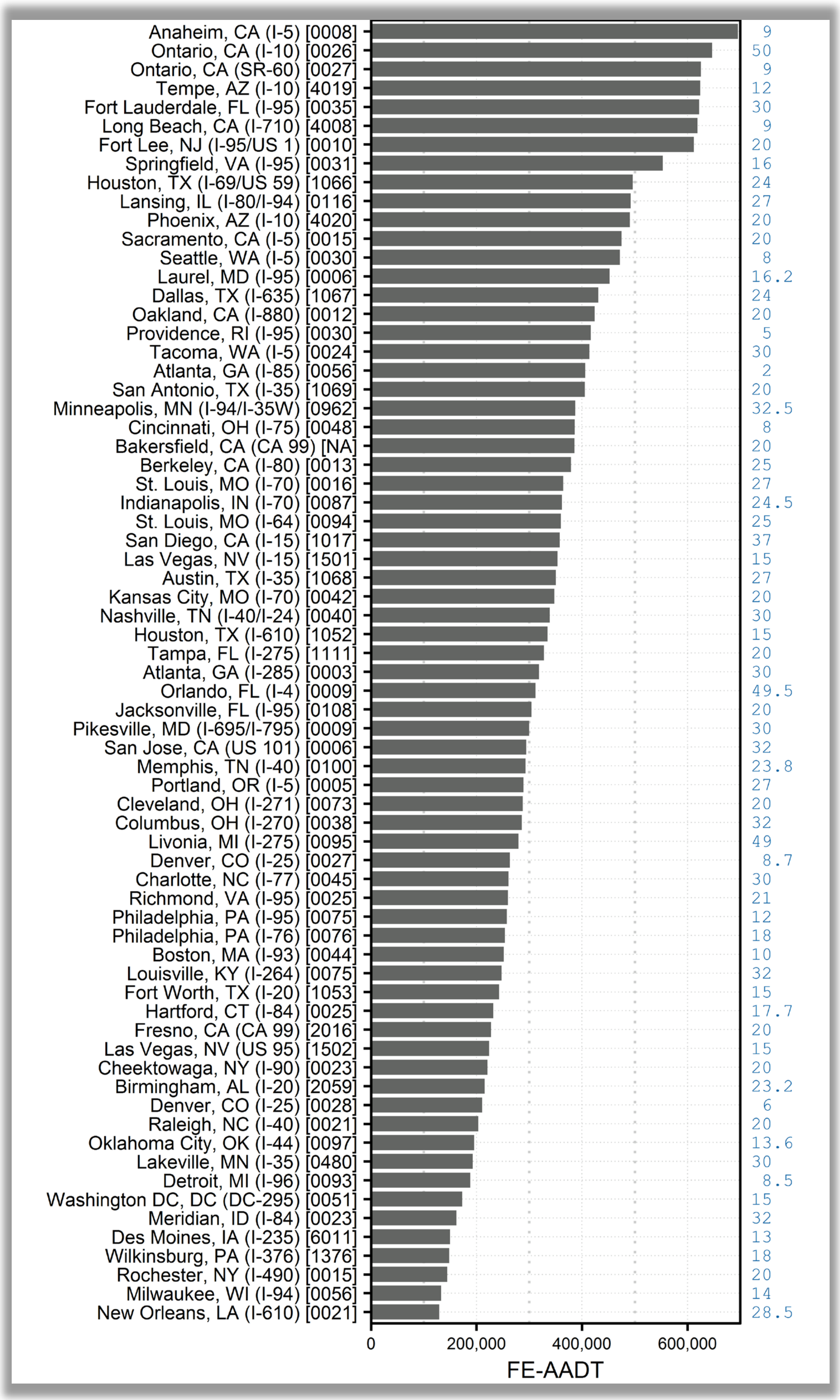


Figure 4. FE-AADT of roadways (gray bars) and distance to roadway in meters (blue numbers at right) for official near-road monitoring sites.

2.3 Official Near-Road Site Data Availability

As shown in Figure 5, data from official near-road sites in 66 near-road monitoring locations were available in AQS as of May 2016 (Tables 3, 4, and 5); some sites had collocated monitors, which means that they have two measurements of a given pollutant. Of the sites with data in AQS, all are reporting NO_2 data, and many sites are already reporting $PM_{2.5}$ and/or CO. Some of the sites are also reporting additional data (BC, O_3, volatile organic compounds [VOC], PM speciation, and/or meteorology). Tables 3 and 4 show the data availability and data completeness for $PM_{2.5}$ and NO_2 data in AQS for 2015, as of May 2016. The EPA typically requires data for 75% of the time periods measured in a year, plus 75% completeness by quarter or month, for a site to meet minimum data completeness requirements. A full table of data availability is provided in Appendix A.

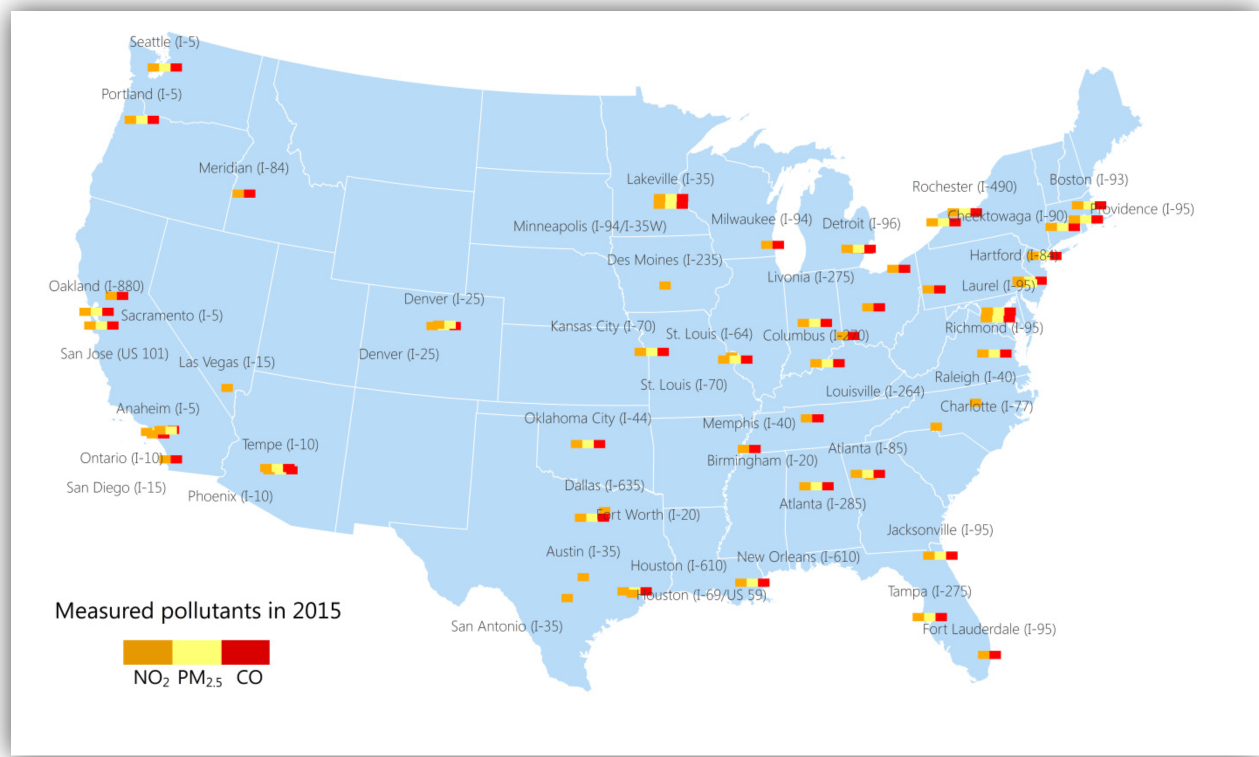


Figure 5. Official near-road monitoring stations reporting CO, NO_2, and/or $PM_{2.5}$ to the EPA's AQS database in 2015, as of May 2016. Some locations also reported BC, O_3, VOC, chemical speciation, and/or meteorological data.

Table 3. Estimated completeness (%) for $PM_{2.5}$ measurements by quarter in 2015 at the time of data acquisition (May 2016). Values over 100 indicate that more than the expected number of samples within the quarter were reported, based on the estimated sample frequency. Name labels are defined as "City, State (Target Road) [Site ID][Parameter Occurrence Code (POC)]." Quarters match the calendar year (i.e., Q.1 is January–March). Colors range from red for 0% completeness, through oranges and yellows for greater completeness, to green for 100% completeness.

AQS ID	Name Label	Sample Duration	Frequency	Q. 1	Q. 2	Q. 3	Q. 4
13-121-0056	Atlanta, GA (I-85) [0056][1]	24-hr	daily	91	86	87	97
01-073-2059	Birmingham, AL (I-20) [2059][1]	24-hr	1-in-6	93	100	100	100
25-025-0044	Boston, MA (I-93) [0044][1]	24-hr	1-in-3	100	93	100	100
25-025-0044	Boston, MA (I-93) [0044][3]	hourly	daily	0	0	33	96
36-029-0023	Cheektowaga, NY (I-90) [0023][1]	24-hr	1-in-3	87	93	100	100
08-031-0027	Denver, CO (I-25) [0027][1]	24-hr	1-in-3	100	100	100	97
08-031-0027	Denver, CO (I-25) [0027][3]	hourly	daily	100	100	100	100
08-031-0028	Denver, CO (I-25) [0028][3]	hourly	daily	0	0	0	82
34-003-0010	Fort Lee, NJ (I-95/US 1) [0010][3]	hourly	daily	91	97	99	95
48-439-1053	Fort Worth, TX (I-20) [1053][1]	24-hr	1-in-3	13	90	80	87
09-003-0025	Hartford, CT (I-84) [0025][1]	24-hr	1-in-3	83	100	100	97
48-201-1052	Houston, TX (I-610) [1052][1]	24-hr	1-in-3	0	67	97	93
18-097-0087	Indianapolis, IN (I-70) [0087][1]	24-hr	1-in-3	100	100	100	100
12-031-0108	Jacksonville, FL (I-95) [0108][3]	hourly	daily	99	32	22	99
29-095-0042	Kansas City, MO (I-70) [0042][4]	hourly	daily	100	99	97	99
27-037-0480	Lakeville, MN (I-35) [0480][3]	hourly	daily	100	100	95	100
24-027-0006	Laurel, MD (I-95) [0006][3]	hourly	daily	96	58	87	87
26-163-0095	Livonia, MI (I-275) [0095][1]	24-hr	1-in-3	93	93	100	93

AQS ID	Name Label	Sample Duration	Frequency	Q. 1	Q. 2	Q. 3	Q. 4
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	daily	74	99	95	100
21-111-0075	Louisville, KY (I-264) [0075][1]	24-hr	1-in-3	93	100	97	100
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][3]	hourly	daily	100	100	95	100
22-071-0021	New Orleans, LA (I-610) [0021][1]	24-hr	1-in-3	100	100	100	100
06-001-0012	Oakland, CA (I-880) [0012][3]	hourly	daily	100	100	100	98
40-109-0097	Oklahoma City, OK (I-44) [0097][1]	24-hr	1-in-3	0	83	83	77
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	daily	80	90	100	99
42-101-0076	Philadelphia, PA (I-76) [0076][1]	hourly	daily	0	0	9	90
42-101-0075	Philadelphia, PA (I-95) [0075][1]	hourly	daily	96	92	93	90
04-013-4020	Phoenix, AZ (I-10) [4020][3]	hourly	daily	0	0	30	100
41-067-0005	Portland, OR (I-5) [0005][1]	24-hr	1-in-3	83	97	87	100
44-007-0030	Providence, RI (I-95) [0030][1]	hourly	daily	97	81	92	93
51-760-0025	Richmond, VA (I-95) [0025][3]	hourly	daily	100	100	100	100
36-055-0015	Rochester, NY (I-490) [0015][1]	24-hr	1-in-3	73	100	100	93
06-085-0006	San Jose, CA (US 101) [0006][3]	hourly	daily	99	100	100	95
53-033-0030	Seattle, WA (I-5) [0030][3]	hourly	daily	100	96	98	99
29-510-0094	St. Louis, MO (I-64) [0094][4]	hourly	daily	94	90	99	99
12-057-1111	Tampa, FL (I-275) [1111][3]	hourly	daily	97	97	97	82
04-013-4019	Tempe, AZ (I-10) [4019][3]	hourly	daily	100	100	100	100
11-001-0051	Washington DC, DC (DC-295) [0051][1]	hourly	daily	0	33	100	100
11-001-0051	Washington DC, DC (DC-295) [0051][2]	24-hr	1-in-3	0	33	100	100

Table 4. Completeness (%) for NO_2 measurements by quarter in 2015 at the time of data acquisition (May 2016). Name labels are defined as "City, State (Target Road) [Site ID][POC]." Colors range from red for 0% completeness, through oranges and yellows, to green for 100% completeness.

AQS ID	Name Label	Q. 1	Q. 2	Q. 3	Q. 4
06-059-0008	Anaheim, CA (I-5) [0008][1]	98	98	95	98
13-089-0003	Atlanta, GA (I-285) [0003][1]	92	98	98	97
13-121-0056	Atlanta, GA (I-85) [0056][1]	97	97	97	92
48-453-1068	Austin, TX (I-35) [1068][1]	98	98	97	98
01-073-2059	Birmingham, AL (I-20) [2059][1]	94	71	88	52
25-025-0044	Boston, MA (I-93) [0044][1]	95	89	94	95
37-119-0045	Charlotte, NC (I-77) [0045][1]	97	93	46	90
36-029-0023	Cheektowaga, NY (I-90) [0023][1]	99	99	93	99
39-061-0048	Cincinnati, OH (I-75) [0048][1]	80	98	99	97
39-035-0073	Cleveland, OH (I-271) [0073][1]	93	71	83	97
39-049-0038	Columbus, OH (I-270) [0038][1]	96	95	96	95
48-113-1067	Dallas, TX (I-635) [1067][1]	98	97	97	96
08-031-0027	Denver, CO (I-25) [0027][1]	88	95	94	95
08-031-0028	Denver, CO (I-25) [0028][1]	0	0	0	95
08-031-0028	Denver, CO (I-25) [0028][2]	0	0	0	95
19-153-6011	Des Moines, IA (I-235) [6011][1]	99	97	98	99
26-163-0093	Detroit, MI (I-96) [0093][1]	99	99	100	93
12-011-0035	Fort Lauderdale, FL (I-95) [0035][1]	0	0	43	15
34-003-0010	Fort Lee, NJ (I-95/US 1) [0010][1]	97	98	98	96
48-439-1053	Fort Worth, TX (I-20) [1053][1]	22	98	96	94
72-061-0006	Guaynabo, PR (De Diego Hwy) [0006][1]	0	76	97	0
09-003-0025	Hartford, CT (I-84) [0025][1]	98	97	87	96
48-201-1052	Houston, TX (I-610) [1052][1]	0	81	93	95
48-201-1066	Houston, TX (I-69/US 59) [1066][1]	97	98	98	97
18-097-0087	Indianapolis, IN (I-70) [0087][1]	89	87	59	92
12-031-0108	Jacksonville, FL (I-95) [0108][1]	93	87	84	89
29-095-0042	Kansas City, MO (I-70) [0042][1]	99	99	90	93
27-037-0480	Lakeville, MN (I-35) [0480][1]	94	90	95	96
32-003-1501	Las Vegas, NV (I-15) [1501][1]	0	0	57	63
32-003-1501	Las Vegas, NV (I-15) [1501][2]	0	0	0	52
24-027-0006	Laurel, MD (I-95) [0006][1]	99	95	93	84
26-163-0095	Livonia, MI (I-275) [0095][1]	99	95	95	91

AQS ID	Name Label	Q. 1	Q. 2	Q. 3	Q. 4
06-037-4008	Long Beach, CA (I-710) [4008][1]	0	94	99	77
21-111-0075	Louisville, KY (I-264) [0075][1]	95	94	70	82
47-157-0100	Memphis, TN (I-40) [0100][1]	90	92	93	93
16-001-0023	Meridian, ID (I-84) [0023][1]	96	78	27	0
16-001-0023	Meridian, ID (I-84) [0023][2]	0	5	66	97
55-079-0056	Milwaukee, WI (I-94) [0056][1]	81	85	92	95
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][1]	99	93	98	98
47-037-0040	Nashville, TN (I-40/I-24) [0040][1]	78	93	97	95
22-071-0021	New Orleans, LA (I-610) [0021][1]	97	92	83	97
06-001-0012	Oakland, CA (I-880) [0012][1]	95	95	95	95
40-109-0097	Oklahoma City, OK (I-44) [0097][1]	0	99	99	94
06-071-0026	Ontario, CA (I-10) [0026][1]	97	97	92	99
06-071-0027	Ontario, CA (SR-60) [0027][1]	0	0	66	100
42-101-0076	Philadelphia, PA (I-76) [0076][1]	0	0	78	93
42-101-0075	Philadelphia, PA (I-95) [0075][1]	93	84	84	89
04-013-4020	Phoenix, AZ (I-10) [4020][1]	0	0	31	99
41-067-0005	Portland, OR (I-5) [0005][1]	97	100	91	99
44-007-0030	Providence, RI (I-95) [0030][1]	96	92	96	97
37-183-0021	Raleigh, NC (I-40) [0021][1]	94	94	94	91
51-760-0025	Richmond, VA (I-95) [0025][1]	98	98	84	97
36-055-0015	Rochester, NY (I-490) [0015][1]	99	98	98	98
06-067-0015	Sacramento, CA (I-5) [0015][1]	0	0	0	83
48-029-1069	San Antonio, TX (I-35) [1069][1]	97	97	97	97
06-073-1017	San Diego, CA (I-15) [1017][1]	5	86	89	71
06-085-0006	San Jose, CA (US 101) [0006][1]	91	95	95	92
53-033-0030	Seattle, WA (I-5) [0030][1]	97	82	96	89
29-510-0094	St. Louis, MO (I-64) [0094][1]	96	83	99	99
29-510-0094	St. Louis, MO (I-64) [0094][2]	97	99	0	0
29-510-0094	St. Louis, MO (I-64) [0094][3]	0	99	0	0
29-189-0016	St. Louis, MO (I-70) [0016][1]	90	99	100	100
12-057-1111	Tampa, FL (I-275) [1111][1]	89	99	98	82
04-013-4019	Tempe, AZ (I-10) [4019][1]	98	98	99	99
11-001-0051	Washington DC, DC (DC-295) [0051][1]	0	33	98	94
42-003-1376	Wilkinsburg, PA (I-376) [1376][1]	95	95	95	94

Table 5. Completeness (%) for CO measurements by quarter in 2015 at the time of data acquisition (May 2016). Name labels are defined as "City, State (Target Road) [Site ID][POC]." Colors range from red for 0% completeness through green for 100% completeness.

AQS ID	Name Label	Q. 1	Q. 2	Q. 3	Q. 4
06-059-0008	Anaheim, CA (I-5) [0008][1]	98	98	98	98
13-121-0056	Atlanta, GA (I-85) [0056][1]	98	99	98	99
01-073-2059	Birmingham, AL (I-20) [2059][1]	92	88	55	93
25-025-0044	Boston, MA (I-93) [0044][1]	93	87	92	89
36-029-0023	Cheektowaga, NY (I-90) [0023][1]	98	78	97	97
39-061-0048	Cincinnati, OH (I-75) [0048][1]	99	99	99	97
39-035-0073	Cleveland, OH (I-271) [0073][1]	90	90	98	92
39-049-0038	Columbus, OH (I-270) [0038][1]	97	99	97	99
08-031-0027	Denver, CO (I-25) [0027][1]	99	99	99	99
26-163-0093	Detroit, MI (I-96) [0093][1]	95	96	96	96
12-011-0035	Fort Lauderdale, FL (I-95) [0035][1]	0	0	33	99
34-003-0010	Fort Lee, NJ (I-95/US 1) [0010][1]	98	99	99	97
48-439-1053	Fort Worth, TX (I-20) [1053][1]	21	99	99	99
72-061-0006	Guaynabo, PR (De Diego Hwy) [0006][1]	0	99	97	66
09-003-0025	Hartford, CT (I-84) [0025][1]	89	95	95	95
48-201-1052	Houston, TX (I-610) [1052][1]	0	79	99	99
18-097-0087	Indianapolis, IN (I-70) [0087][1]	98	92	65	87
12-031-0108	Jacksonville, FL (I-95) [0108][1]	95	93	93	94
29-095-0042	Kansas City, MO (I-70) [0042][1]	67	91	98	98
27-037-0480	Lakeville, MN (I-35) [0480][1]	96	99	87	98
24-027-0006	Laurel, MD (I-95) [0006][1]	97	96	97	95
26-163-0095	Livonia, MI (I-275) [0095][1]	96	95	96	92
21-111-0075	Louisville, KY (I-264) [0075][1]	99	99	92	37
47-157-0100	Memphis, TN (I-40) [0100][1]	88	92	93	93
16-001-0023	Meridian, ID (I-84) [0023][1]	98	97	98	97
55-079-0056	Milwaukee, WI (I-94) [0056][1]	100	99	97	99
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][1]	99	98	99	99
47-037-0040	Nashville, TN (I-40/I-24) [0040][1]	96	93	97	96
22-071-0021	New Orleans, LA (I-610) [0021][1]	98	81	98	99
06-001-0012	Oakland, CA (I-880) [0012][1]	95	95	95	95
40-109-0097	Oklahoma City, OK (I-44) [0097][1]	0	15	100	98
06-071-0026	Ontario, CA (I-10) [0026][1]	97	97	98	99

AQS ID	Name Label	Q. 1	Q. 2	Q. 3	Q. 4
42-101-0075	Philadelphia, PA (I-95) [0075][1]	95	88	89	95
04-013-4020	Phoenix, AZ (I-10) [4020][1]	0	0	31	99
41-067-0005	Portland, OR (I-5) [0005][1]	97	100	75	99
44-007-0030	Providence, RI (I-95) [0030][1]	96	91	96	97
51-760-0025	Richmond, VA (I-95) [0025][1]	99	98	99	85
36-055-0015	Rochester, NY (I-490) [0015][1]	99	93	99	91
06-067-0015	Sacramento, CA (I-5) [0015][1]	0	0	0	82
06-073-1017	San Diego, CA (I-15) [1017][1]	0	66	91	86
06-085-0006	San Jose, CA (US 101) [0006][1]	95	95	95	92
53-033-0030	Seattle, WA (I-5) [0030][1]	97	95	95	95
29-510-0094	St. Louis, MO (I-64) [0094][1]	98	97	98	97
12-057-1111	Tampa, FL (I-275) [1111][1]	77	94	54	66
04-013-4019	Tempe, AZ (I-10) [4019][1]	99	99	99	99
11-001-0051	Washington DC, DC (DC-295) [0051][1]	0	33	99	93
42-003-1376	Wilkinsburg, PA (I-376) [1376][1]	96	95	95	95

3. Analysis

3.1 Overview of Concentrations at Near-Road Sites

For research purposes, this discussion includes comparisons of measured data to NAAQS levels; the NAAQS are shown in Table 6. These comparisons are provided for context and are not meant to assess attainment status; attainment and nonattainment areas are designated by the EPA. Most near-road sites do not have sufficient data to determine whether the site recorded a NAAQS violation for hourly NO_2, 24-hr $PM_{2.5}$, or annual $PM_{2.5}$, because these calculations require at least three years of valid monitoring data. The CO NAAQS requirement is based on a single year of data; however, only a portion of 2015 data was available for analysis at the time of the data retrieval. The following results are based on the data available in May 2016. Summary statistics for CO, NO_2, and PM at each site are provided in Appendix A. Updated results, based on 2014 data that were not available when the first near-road data assessment report was published, are provided in Appendix B. We are reporting values directly from AQS, as verified by the states and made available by EPA.

Table 6. Primary NAAQS levels for CO, NO_2, and $PM_{2.5}$. (Source: **epa.gov/criteria-air-pollutants**.)

Pollutant	Averaging Time	Level	Form
CO	8-hr	9 ppm	Not to be exceeded more than once per year
	1-hr	35 ppm	Not to be exceeded
NO_2	1-hr	100 ppb	98th percentile of 1-hr daily maximum concentrations, averaged over 3 years
	Annual	53 ppb	Annual mean
$PM_{2.5}$	24-hr	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	Annual	12 $\mu g/m^3$	Annual mean, averaged over 3 years

Concentration changes throughout the day at the near-road monitoring sites are linked to typical travel activity patterns. The diurnal patterns of CO and NO_2 concentrations are typical for urban monitoring locations. The diurnal concentration profiles include morning and evening peaks that are consistent with commute hours (Figure 6). Peak travel periods can be characterized by higher traffic volumes, lower vehicle speeds, higher per-vehicle emission rates, and (especially in the morning) low wind speeds and/or limited atmospheric mixing. Typical daily traffic patterns overlap more closely with NO_2 concentrations than with $PM_{2.5}$ concentrations. $PM_{2.5}$ concentrations are heavily influenced by regional emissions and atmospheric $PM_{2.5}$ formation that occurs throughout the day. Weekday-weekend patterns vary by pollutant, as shown in Figure 7: NO_2 concentrations are higher on weekdays than on weekends across all sites, but $PM_{2.5}$ concentrations are have no significant weekday/weekend difference. In general, there was no correlation of concentrations with either FE-AADT or distance of monitor from roadway (Figure 8).

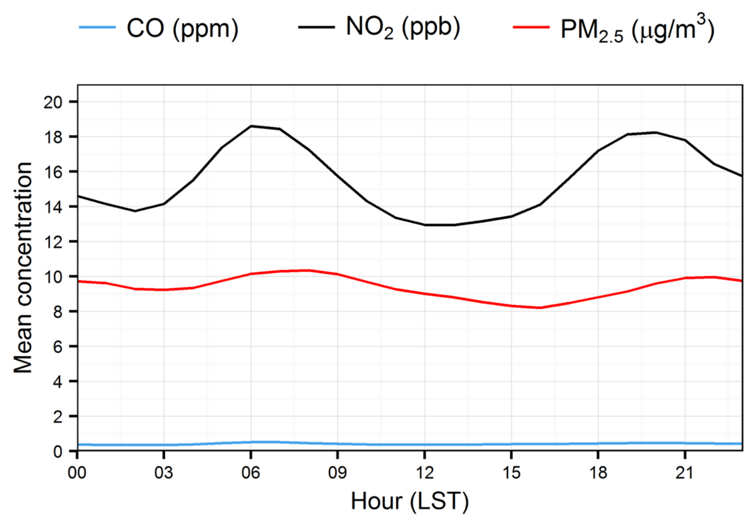


Figure 6. Diurnal patterns in hourly median NO_2 (ppb), CO (ppm), and $PM_{2.5}$ (µg/m^3) on weekdays in 2015 at all official near-road sites, where available.

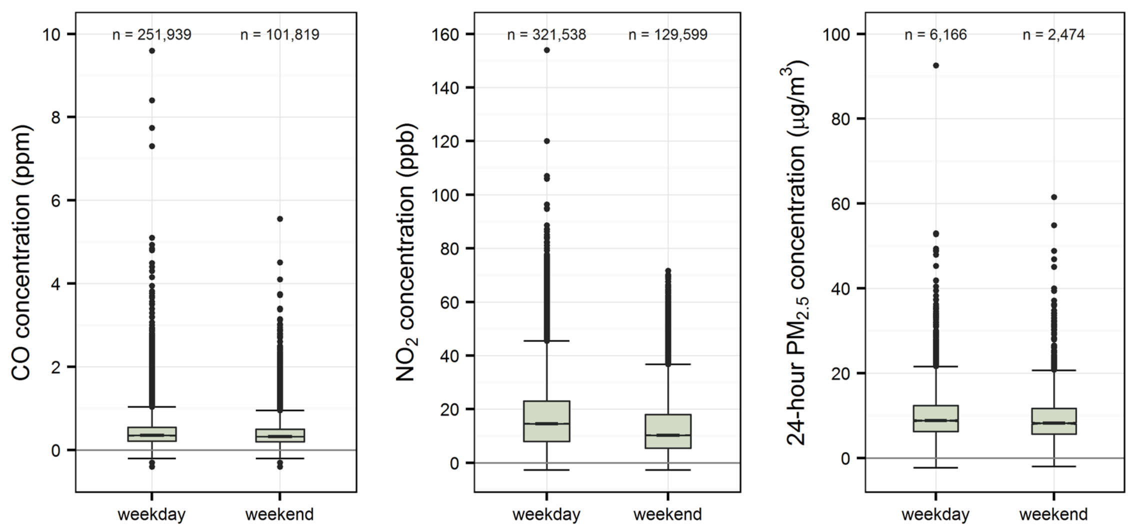


Figure 7. Box plots of hourly CO, hourly NO_2 and 24-hour averaged $PM_{2.5}$ concentrations on weekdays and weekends. The horizontal line indicates the median, the box indicates the interquartile range (IQR), the whiskers indicate 1.5*IQR, and individual points are beyond 1.5*IQR.

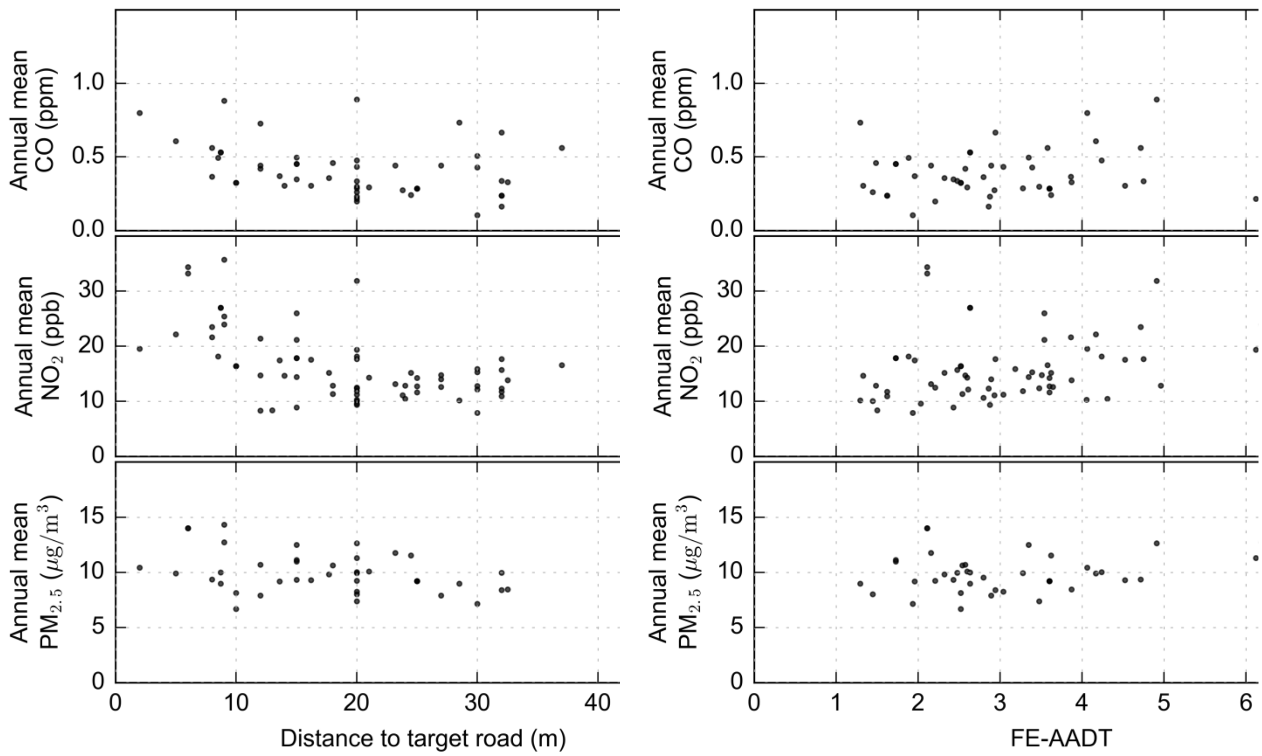


Figure 8. Comparison of annual mean CO, NO_2 and $PM_{2.5}$ concentrations at each near-road site with distance of monitor from roadway and roadway FE-AADT.

3.1.1 CO Concentrations

The hourly CO concentrations measured at the official near-road monitors ranged from a minimum value of slightly less than zero to a maximum value of 9.6 ppm, but most hourly CO concentrations were in the 0-1 ppm range (Figure 9). The highest hourly concentration, 9.6 ppm, was measured at the near-road monitor in Puerto Rico at 9:00 a.m. on September 25, 2015; however, the level of the primary NAAQS was not exceeded because the other measurements within the 8-hr time period were low (1 ppm or less). There was little variation in CO concentrations with either distance of monitor or with FE-AADT (see Figure 8).

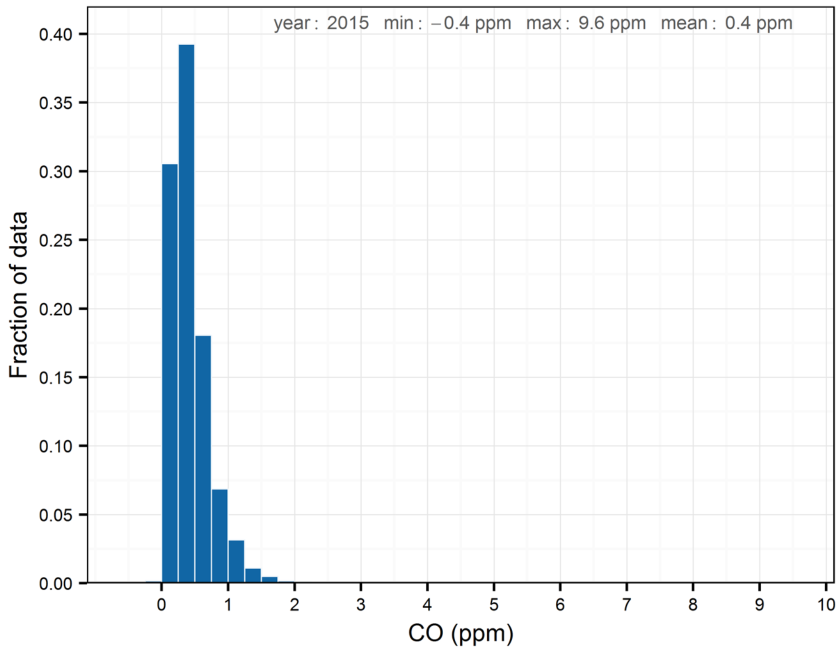


Figure 9. Distribution of all hourly CO concentrations at the official near-road monitors in 2015.

3.1.2 NO_2 Concentrations

Table 7 summarizes NO_2 concentrations by site for 2015. Hourly NO_2 concentrations were above 100 ppb at three different near-road monitors in 2015: George Washington Bridge (GWB) in New York/New Jersey (Fort Lee, New Jersey, monitoring site), along I-880 in Oakland, California, and along I-5 in Seattle, Washington. At the George Washington Bridge monitoring site, three hourly NO_2 concentrations measured between 7:00 and 9:00 a.m. on February 25, 2015, were above 100 ppb, including a maximum value of 154 ppb. The NO_2 concentration measured at the near-road monitor along I-5 in Seattle, Washington, at 3:00 p.m. on February 13, 2015, was 106.1 ppb. The NO_2 concentration measured at the near-road monitor along I-880 in Oakland, California, at 8:00 p.m. on March 26, 2015, was 105.9 ppb.

Table 7. NO_2 1-hr maximum, 1-hr average, and 98th percentile of daily 1-hr maximum (ppb) by site during 2015, and the number and date range of 2015 1-hr samples reported. One complete year of hourly data is 8,760 observations. Name labels are defined as "City, State (Target Road) [Site ID][POC]."

AQS ID	Name Label	Start Date	End Date	No. of Reported Samples	1-hr Max. (ppb)	1-hr Mean (ppb)	98th Percentile of Daily 1-hr Max. (ppb)
06-059-0008	Anaheim, CA (I-5) [0008][1]	1-Jan	31-Dec	8507	70.3	25.4	60.5
13-089-0003	Atlanta, GA (I-285) [0003][1]	1-Jan	31-Dec	8426	65.2	15.9	54.3
13-121-0056	Atlanta, GA (I-85) [0056][1]	1-Jan	31-Dec	8396	62.4	19.5	49.5
48-453-1068	Austin, TX (I-35) [1068][1]	1-Jan	31-Dec	8566	55.3	14.8	51.8
01-073-2059	Birmingham, AL (I-20) [2059][1]	1-Jan	31-Dec	6686	61.7	13.1	49.9
25-025-0044	Boston, MA (I-93) [0044][1]	1-Jan	31-Dec	8162	61.0	16.4	50.2
37-119-0045	Charlotte, NC (I-77) [0045][1]	1-Jan	31-Dec	7133	42.0	12.1	36.1
36-029-0023	Cheektowaga, NY (I-90) [0023][1]	1-Jan	31-Dec	8523	68.0	12.5	53.1
39-061-0048	Cincinnati, OH (I-75) [0048][1]	13-Jan	31-Dec	8187	85.0	21.6	57.3
39-035-0073	Cleveland, OH (I-271) [0073][1]	1-Jan	31-Dec	7539	59.0	9.4	46.6
39-049-0038	Columbus, OH (I-270) [0038][1]	1-Jan	31-Dec	8352	58.0	12.3	48.0
48-113-1067	Dallas, TX (I-635) [1067][1]	1-Jan	31-Dec	8507	54.8	10.5	45.2
08-031-0027	Denver, CO (I-25) [0027][1]	7-Jan	31-Dec	8129	81.1	27.0	64.2
08-031-0028	Denver, CO (I-25) [0028][1]	1-Oct	31-Dec	2094	77.8	34.3	74.4
08-031-0028	Denver, CO (I-25) [0028][2]	1-Oct	31-Dec	2090	72.7	33.2	71.9
19-153-6011	Des Moines, IA (I-235) [6011][1]	1-Jan	31-Dec	8594	41.2	8.4	34.3
26-163-0093	Detroit, MI (I-96) [0093][1]	1-Jan	31-Dec	8564	59.0	18.1	50.8

AQS ID	Name Label	Start Date	End Date	No. of Reported Samples	1-hr Max. (ppb)	1-hr Mean (ppb)	98th Percentile of Daily 1-hr Max. (ppb)
12-011-0035	Fort Lauderdale, FL (I-95) [0035][1]	21-Aug	15-Oct	1284	95.0	12.8	91.7
34-003-0010	Fort Lee, NJ (I-95/US 1) [0010][1]	1-Jan	31-Dec	8538	154.0	19.3	70.9
48-439-1053	Fort Worth, TX (I-20) [1053][1]	12-Mar	31-Dec	6814	58.6	8.9	39.7
72-061-0006	Guaynabo, PR (De Diego Hwy) [0006][1]	21-Apr	30-Sep	3817	42.9	8.3	34.9
09-003-0025	Hartford, CT (I-84) [0025][1]	1-Jan	31-Dec	8261	76.9	15.2	51.2
48-201-1052	Houston, TX (I-610) [1052][1]	15-Apr	31-Dec	5924	67.9	14.4	59.8
48-201-1066	Houston, TX (I-69/US 59) [1066][1]	1-Jan	31-Dec	8551	60.8	12.9	53.0
18-097-0087	Indianapolis, IN (I-70) [0087][1]	1-Jan	31-Dec	7154	53.7	15.2	44.4
12-031-0108	Jacksonville, FL (I-95) [0108][1]	1-Jan	31-Dec	7710	58.0	11.2	41.5
29-095-0042	Kansas City, MO (I-70) [0042][1]	1-Jan	31-Dec	8362	54.9	12.4	44.7
27-037-0480	Lakeville, MN (I-35) [0480][1]	1-Jan	31-Dec	8194	54.1	7.9	41.8
32-003-1501	Las Vegas, NV (I-15) [1501][1]	1-Aug	30-Nov	2644	56.4	21.2	50.0
32-003-1501	Las Vegas, NV (I-15) [1501][2]	12-Nov	31-Dec	1153	71.1	26.0	71.1
24-027-0006	Laurel, MD (I-95) [0006][1]	1-Jan	31-Dec	8109	55.4	17.6	51.0
26-163-0095	Livonia, MI (I-275) [0095][1]	1-Jan	31-Dec	8315	54.0	10.7	48.0
06-037-4008	Long Beach, CA (I-710) [4008][1]	1-Apr	31-Dec	5912	94.7	23.9	75.0
21-111-0075	Louisville, KY (I-264) [0075][1]	1-Jan	31-Dec	7468	55.2	15.7	50.4
47-157-0100	Memphis, TN (I-40) [0100][1]	1-Jan	31-Dec	8066	49.5	11.1	41.0
16-001-0023	Meridian, ID (I-84) [0023][1]	1-Jan	25-Sep	4380	56.8	10.9	46.0
16-001-0023	Meridian, ID (I-84) [0023][2]	26-Jun	31-Dec	3683	53.1	11.7	48.4

AQS ID	Name Label	Start Date	End Date	No. of Reported Samples	1-hr Max. (ppb)	1-hr Mean (ppb)	98th Percentile of Daily 1-hr Max. (ppb)
55-079-0056	Milwaukee, WI (I-94) [0056][1]	1-Jan	31-Dec	7736	49.0	14.7	46.1
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][1]	1-Jan	31-Dec	8501	55.0	13.8	49.7
47-037-0040	Nashville, TN (I-40/I-24) [0040][1]	1-Jan	31-Dec	7989	61.0	15.3	55.0
22-071-0021	New Orleans, LA (I-610) [0021][1]	1-Jan	31-Dec	8067	82.0	10.2	49.3
06-001-0012	Oakland, CA (I-880) [0012][1]	1-Jan	31-Dec	8310	105.9	18.1	50.4
40-109-0097	Oklahoma City, OK (I-44) [0097][1]	1-Apr	31-Dec	6428	57.0	17.4	52.0
06-071-0026	Ontario, CA (I-10) [0026][1]	1-Jan	31-Dec	8424	87.2	29.9	73.3
06-071-0027	Ontario, CA (SR-60) [0027][1]	1-Aug	31-Dec	3663	79.3	35.7	77.7
42-101-0076	Philadelphia, PA (I-76) [0076][1]	20-Jul	31-Dec	3757	46.1	11.3	41.6
42-101-0075	Philadelphia, PA (I-95) [0075][1]	1-Jan	31-Dec	7680	65.9	14.7	48.9
04-013-4020	Phoenix, AZ (I-10) [4020][1]	2-Sep	31-Dec	2856	69.0	31.9	64.0
41-067-0005	Portland, OR (I-5) [0005][1]	1-Jan	31-Dec	8471	40.9	14.0	36.2
44-007-0030	Providence, RI (I-95) [0030][1]	1-Jan	31-Dec	8354	86.2	22.1	67.1
37-183-0021	Raleigh, NC (I-40) [0021][1]	1-Jan	31-Dec	8162	96.4	9.6	34.5
51-760-0025	Richmond, VA (I-95) [0025][1]	1-Jan	31-Dec	8263	56.5	14.3	46.7
36-055-0015	Rochester, NY (I-490) [0015][1]	1-Jan	31-Dec	8604	54.8	10.1	45.8
06-067-0015	Sacramento, CA (I-5) [0015][1]	13-Oct	31-Dec	1834	53.0	17.7	50.1
48-029-1069	San Antonio, TX (I-35) [1069][1]	1-Jan	31-Dec	8491	51.8	10.3	47.6
06-073-1017	San Diego, CA (I-15) [1017][1]	26-Mar	31-Dec	5519	55.0	16.6	52.0
06-085-0006	San Jose, CA (US 101) [0006][1]	1-Jan	31-Dec	8183	61.1	17.7	47.8

AQS ID	Name Label	Start Date	End Date	No. of Reported Samples	1-hr Max. (ppb)	1-hr Mean (ppb)	98th Percentile of Daily 1-hr Max. (ppb)
53-033-0030	Seattle, WA (I-5) [0030][1]	1-Jan	31-Dec	7938	106.1	23.5	65.4
29-510-0094	St. Louis, MO (I-64) [0094][1]	1-Jan	31-Dec	8246	55.5	12.7	46.1
29-510-0094	St. Louis, MO (I-64) [0094][2]	1-Jan	30-Jun	4257	88.6	14.2	54.5
29-510-0094	St. Louis, MO (I-64) [0094][3]	1-Apr	30-Jun	2164	53.1	11.6	50.5
29-189-0016	St. Louis, MO (I-70) [0016][1]	9-Jan	31-Dec	8508	48.7	12.6	43.7
12-057-1111	Tampa, FL (I-275) [1111][1]	1-Jan	16-Dec	8066	84.0	11.8	47.3
04-013-4019	Tempe, AZ (I-10) [4019][1]	1-Jan	31-Dec	8631	59.0	21.4	53.0
11-001-0051	Washington DC, DC (DC-295) [0051][1]	1-Jun	31-Dec	4955	48.9	17.8	47.2
42-003-1376	Wilkinsburg, PA (I-376) [1376][1]	1-Jan	31-Dec	8286	51.6	12.8	44.9

Figure 10 shows the distribution of all hourly NO_2 concentrations across all sites for 2015. Figure 11 shows box plots of daily 1-hr maximum NO_2 concentrations by site for 2015, plus annual averages and the 98th percentile concentration. Figure 12 shows how the 98th percentile concentrations vary with distance from roadway and FE-AADT combined. There was no consistent trend in either annual average or 98th percentile concentration with either distance from roadway and FE-AADT. Concentrations approached 100 ppb at the near-road monitor in Fort Lauderdale, Florida (95 ppb, August 2015), Long Beach, California (94.7 ppb, September 2015), and in Raleigh, North Carolina (96.4 ppb, January 2015). The 98th percentile at all sites was below 100 ppb. At Fort Lauderdale, the 98th percentile of the daily 1-hr maximum concentration was 92 ppb, but only about half of a year of data were reported (late August-December). The highest annual averages from the data available in 2015 were in the Los Angeles area at Ontario, California (35.7 and 29.9 ppb at two sites).

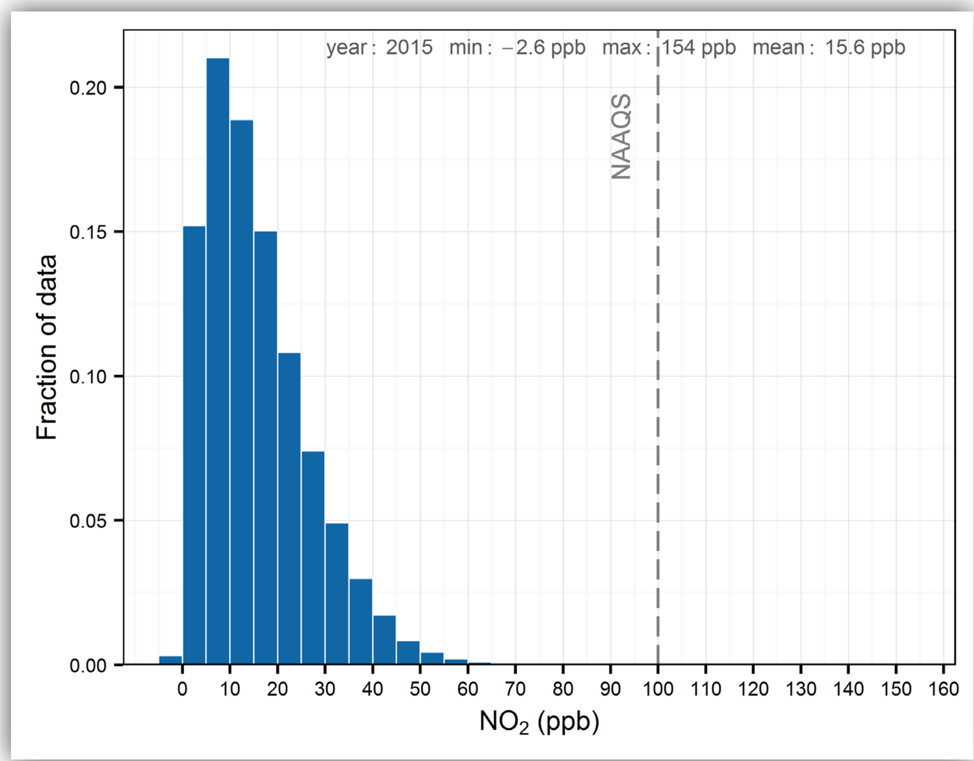


Figure 10. Distribution of all hourly NO_2 concentrations at the official near-road monitors in 2015. The dashed line indicates the NO_2 NAAQS threshold.

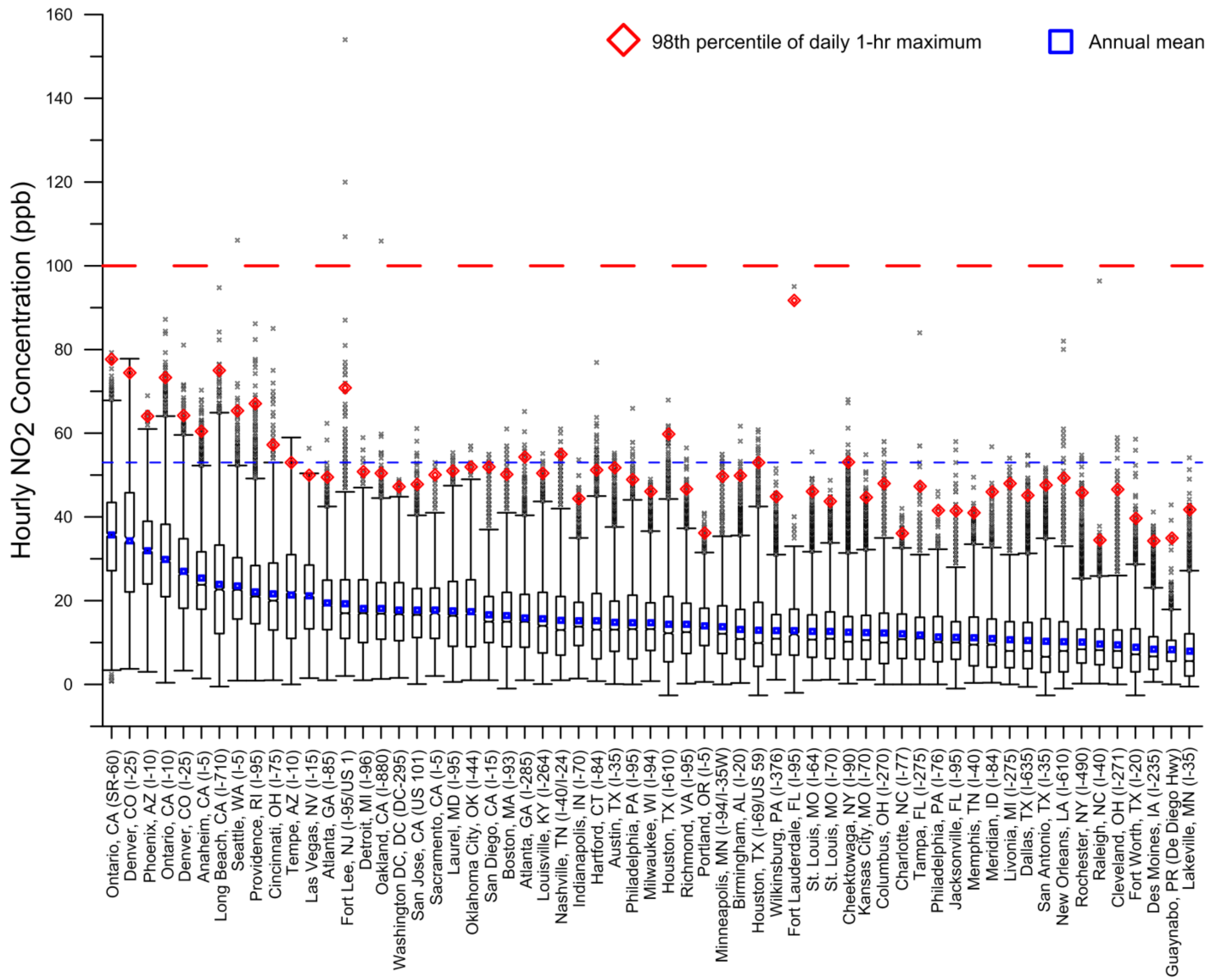


Figure 11. Box plot of all hourly NO_2 concentrations at the official near-road monitors in 2015. Sites are labeled as "City, State (Target Road) [Site ID][POC]." The notch indicates the median; the square indicates the mean; the red diamond indicates the 98th percentile; the box indicates the interquartile range (IQR); the whiskers indicate 1.5*IQR; and individual points are beyond 1.5*IQR. The red dashed line shows 100 ppb (threshold for the 1-hr NAAQS), and the blue dashed line shows 53 ppb (threshold for the annual NAAQS).

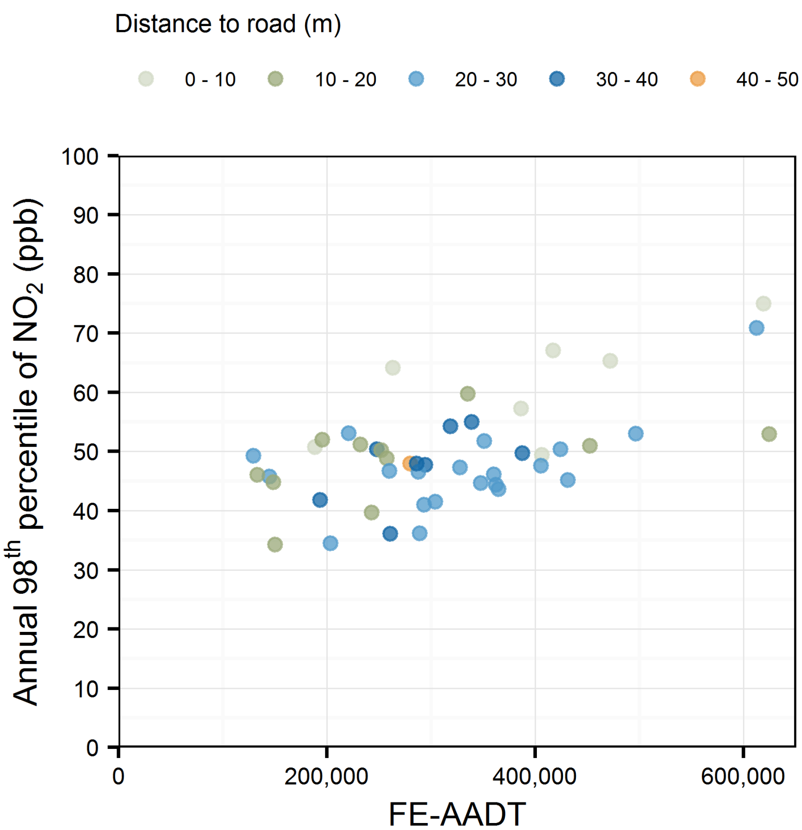


Figure 12. Annual 98th percentile concentrations of NO_2 compared to FE-AADT, colored by distance of monitor to roadway.

3.1.3 $PM_{2.5}$ Concentrations

As of May 2016, 39 locations had reported $PM_{2.5}$ data to AQS. Thirty-one locations had at least three full quarters of 2015 data; eight locations had less than three full quarters of data. Twenty-one locations reported hourly $PM_{2.5}$ data for their near-road sites, and eighteen locations reported 24-hr data (sampling on daily, 1-in-3 or 1-in-6 day cycles). Included in the 39 locations are collocated monitors at one location each in Denver and Boston; both had hourly and 24-hr data.

Figure 13 shows the 98th percentile of 24-hr $PM_{2.5}$ and annual average $PM_{2.5}$ for 2015 at official near-road monitoring sites, along with the associated nonattainment and maintenance areas designated by the EPA.[3] Several near-road monitoring sites are located in $PM_{2.5}$ nonattainment or maintenance areas. Figure 14 shows the distribution of the 24-hr and annual average concentrations.

Table 8 lists the dates and locations for which daily $PM_{2.5}$ was greater than 35 µg/m^3. Table 9 lists the locations with annual averages greater than 12 µg/m^3. Table A-3 in the Appendix provides the 98th percentile and annual average for every site with $PM_{2.5}$ data. Sites with annual averages greater than 12 µg/m^3 were:

- Ontario (14.3 µg/m^3)
- Long Beach (12.7 µg/m^3)
- Houston (12.5 µg/m^3), (data available only for April-December 2015, and
- Denver (14 µg/m^3) and Phoenix (12.6 µg/m^3), although these two sites had less than two quarters of data

Also, as shown in Figure 15, 24-hr $PM_{2.5}$ concentrations exceeded 35 µg/m^3 on 33 days at 12 near-road locations in 2015:

- The three highest 24-hr $PM_{2.5}$ concentrations occurred in Providence, Rhode Island (92.5 µg/m^3), Portland, Oregon (61.5 µg/m^3) and Indianapolis, Indiana (54.9 µg/m^3).
- A near-road monitor in the Los Angeles area measured 24-hr concentrations above 35 µg/m^3 on 18 days (11 days at Ontario and 7 days at Long Beach).
- Concentrations in Denver exceeded 35 µg/m^3 on four days.

The 98th percentile of 24-hr $PM_{2.5}$ concentrations was above 35 µg/m^3 at the Ontario (45.3 µg/m^3) and Long Beach (39.6 µg/m^3) sites. Phoenix was close to 35 µg/m^3, with a 98th percentile of 34.5 µg/m^3.

The highest two annual average concentrations, in Ontario and Long Beach, California, also had the highest FE-AADT values (see Figure 16, which shows only sites with at least two full quarters of data); however, other sites with high FE-AADT (Tempe, Arizona, and Fort Lee, New Jersey) have a range of annual average concentrations, from 7.9 µg/m^3 at Tempe to 14.3 µg/m^3 at Fort Lee. Aside from the two sites with the highest concentrations, there is no trend between annual average $PM_{2.5}$ and either

[3] See epa.gov/pmdesignations/.

FE-AADT or distance to roadway. The lack of relationship between annual average $PM_{2.5}$ concentration and either FE-AADT or distance from roadway indicates the importance of other factors at each site, such as urban-scale $PM_{2.5}$ levels and prevailing meteorology.

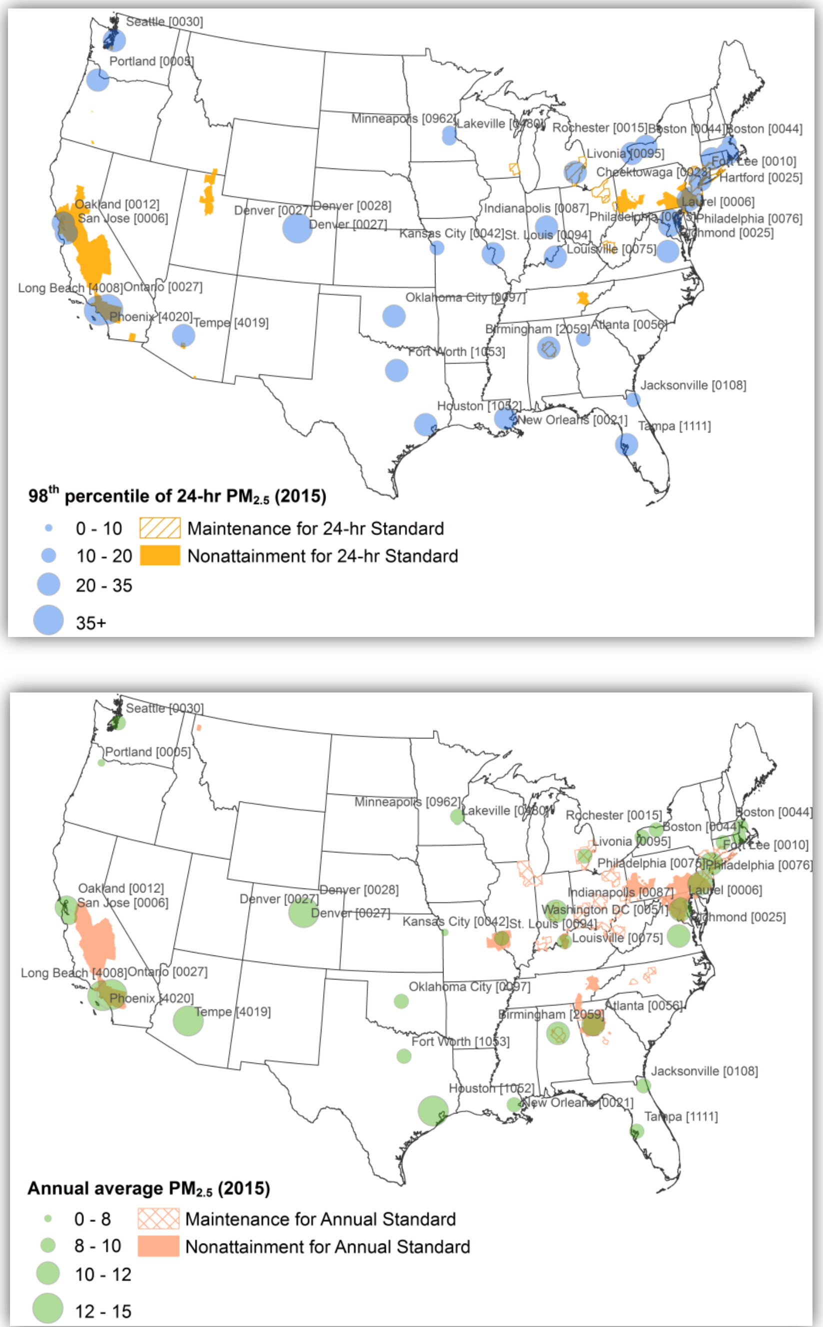
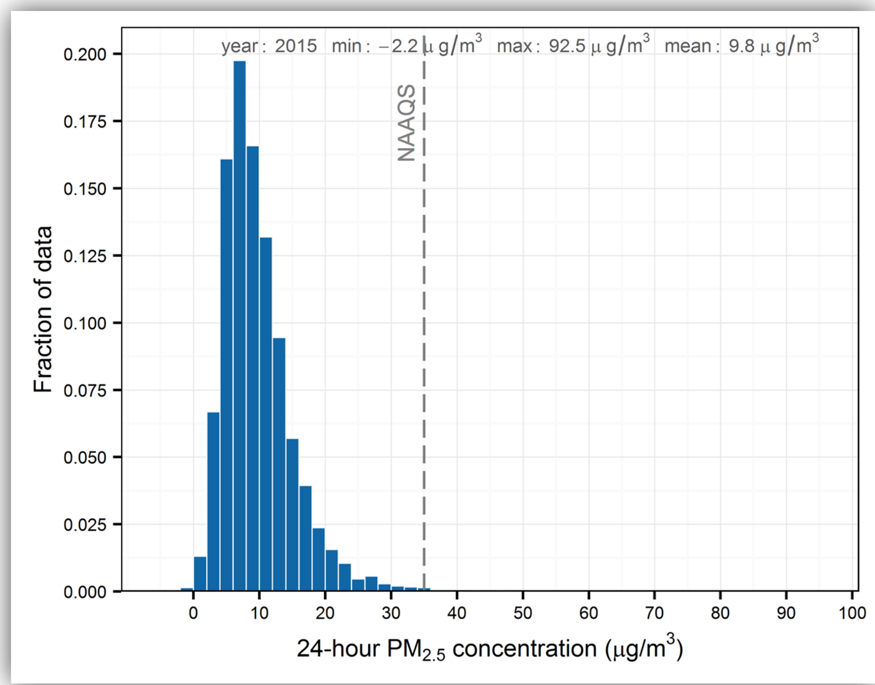


Figure 13. The 98th percentile of 24-hr $PM_{2.5}$ concentrations for 2015 (top) and the annual average $PM_{2.5}$ concentrations for 2015 (bottom) at official near-road monitoring sites. Gold and orange shading shows maintenance and nonattainment areas; concentrations are in µg/m^3.



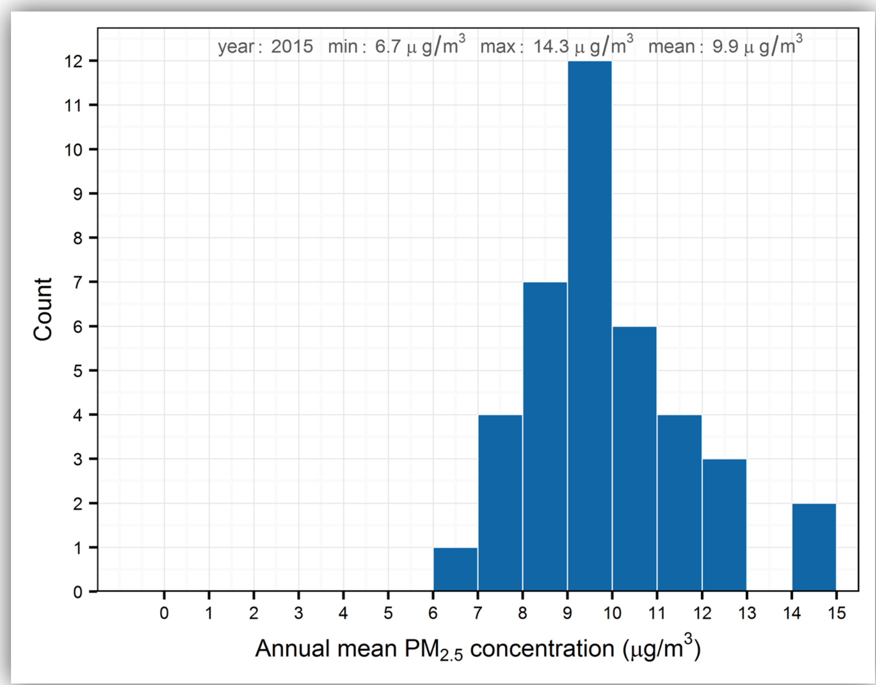


Figure 14. Distribution of 24-hr (top) and annual average (bottom) $PM_{2.5}$ concentrations at the official near-road monitors in 2015. NAAQS criteria is also shown on the top plot. Sites in Denver, Colorado; Houston, Texas; Long Beach, California; Ontario, California, and Phoenix, Arizona, recorded $PM_{2.5}$ annual averages for 2015 greater than 12 µg/m^3.

Table 8. Official near-road sites with 24-hr $PM_{2.5}$ concentrations at or above 35 μg/m^3. Name labels are defined as "City, State (Target Road) [Site ID][POC]." See Table 3 for data completeness details.

AQS ID	Name Label	Sample Duration	Date (2015)	Concentration (μg/m^3)
44-007-0030	Providence, RI (I-95) [0030][1]	hourly	10-Mar	92.5
41-067-0005	Portland, OR (I-5) [0005][1]	24-hr	22-Aug	61.5
18-097-0087	Indianapolis, IN (I-70) [0087][1]	24-hr	5-Jul	54.9
08-031-0027	Denver, CO (I-25) [0027][3]	hourly	7-Jul	53.0
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	4-Feb	52.8
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	20-Feb	49.4
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	19-Feb	49.0
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	4-Apr	48.8
08-031-0027	Denver, CO (I-25) [0027][3]	hourly	2-Mar	48.8
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	5-Feb	48.0
06-085-0006	San Jose, CA (US 101) [0006][3]	hourly	16-Aug	46.9
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	19-Mar	45.3
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	30-Apr	45.3
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	10-Jan	45.1
29-095-0042	Kansas City, MO (I-70) [0042][4]	hourly	7-Jul	41.9
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	18-Feb	41.8
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	1-Jan	40.5
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	3-Jan	40.0
08-031-0028	Denver, CO (I-25) [0028][3]	hourly	31-Dec	39.5
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	19-Feb	39.5
29-510-0094	St. Louis, MO (I-64) [0094][4]	hourly	5-Jul	39.4
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	17-Feb	38.3
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	2-Apr	37.4
06-001-0012	Oakland, CA (I-880) [0012][3]	hourly	8-Jan	37.3
42-101-0075	Philadelphia, PA (I-95) [0075][1]	hourly	6-Dec	37.1
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	3-Feb	36.3
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	11-Jan	36.3
08-031-0027	Denver, CO (I-25) [0027][3]	hourly	23-Aug	35.9
08-031-0027	Denver, CO (I-25) [0027][3]	hourly	8-Jul	35.8
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	18-Feb	35.8
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	29-Jun	35.4
04-013-4020	Phoenix, AZ (I-10) [4020][3]	hourly	18-Dec	35.3
06-001-0012	Oakland, CA (I-880) [0012][3]	hourly	15-Jan	35.0

Table 9. Locations and dates with 2015 average annual PM concentrations at or above 12 μg/m^3 at the official near-road sites. Name labels are defined as "City, State (Target Road) [Site ID][POC]." The Houston, Denver and Phoenix sites had limited data for calculating the annual average; see Table 3 for data completeness details.

AQS ID	Name Label	Sample Duration	Start Date (2015)	End Date (2015)	Concentration (μg/m^3)
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	1-Jan	31-Dec	14.3
08-031-0028	Denver, CO (I-25) [0028][3]	hourly	7-Oct	31-Dec	14.0
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	1-Jan	31-Dec	12.7
04-013-4020	Phoenix, AZ (I-10) [4020][3]	hourly	3-Sep	31-Dec	12.6
48-201-1052	Houston, TX (I-610) [1052][1]	24-hour	15-Apr	30-Dec	12.5

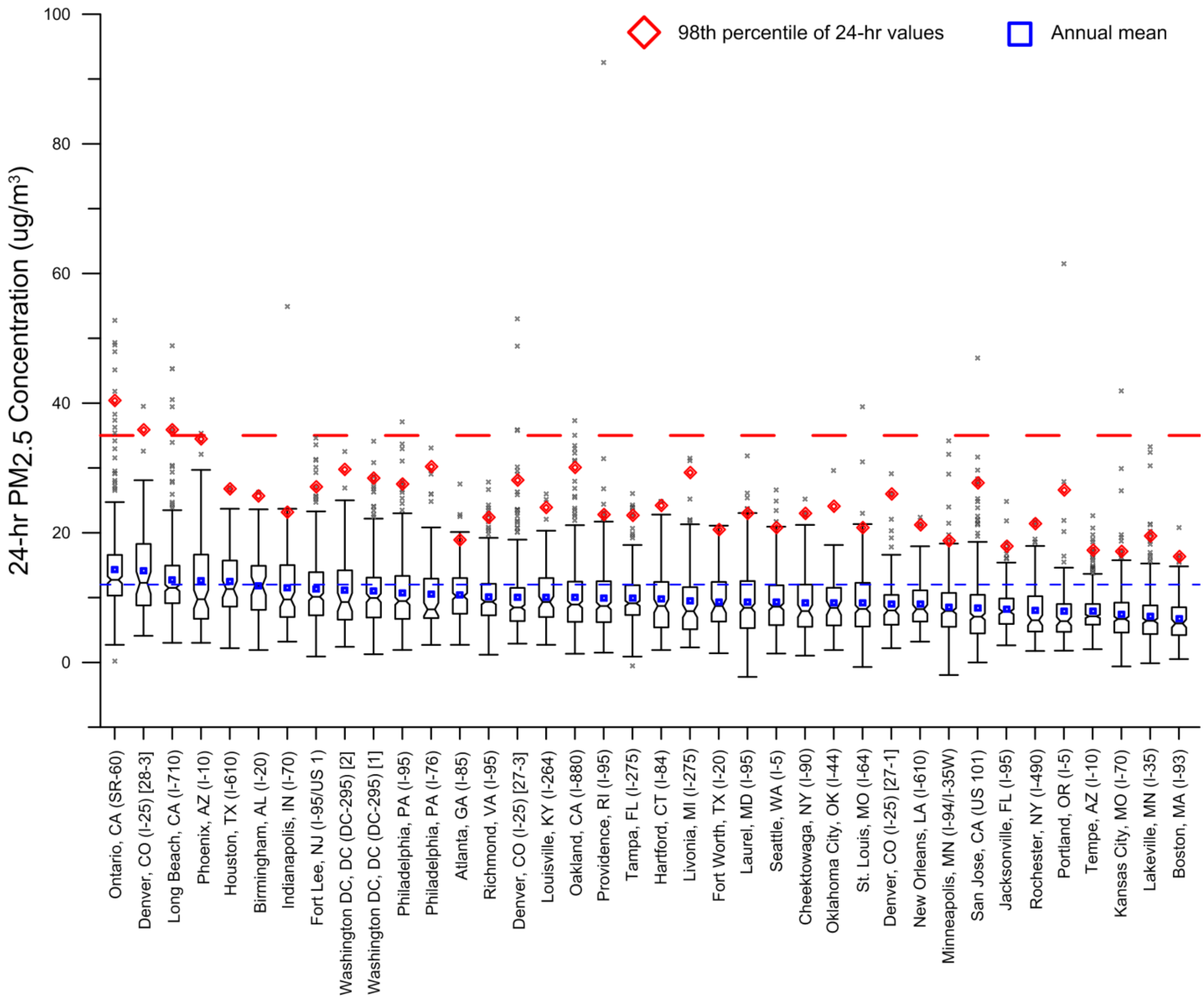


Figure 15. $PM_{2.5}$ 24-hr concentrations at the official near-road monitoring locations in 2015. Sites are labeled as "City, State (Target Road) [Site ID][POC]." The notch indicates the median; the blue square indicates the mean; the red diamond indicates the 98^{th} percentile; the box indicates the interquartile range (IQR); the whiskers indicate 1.5*IQR; and individual points are beyond 1.5*IQR. The horizontal red dashed line indicates 35 $\mu g/m^3$, and the horizontal blue dashed line indicates 12 $\mu g/m^3$. The NAAQS is exceeded when the 98^{th} percentile, averaged over three years, is greater than 35 $\mu g/m^3$, or the annual average, averaged over three years, is greater than 12 $\mu g/m^3$.

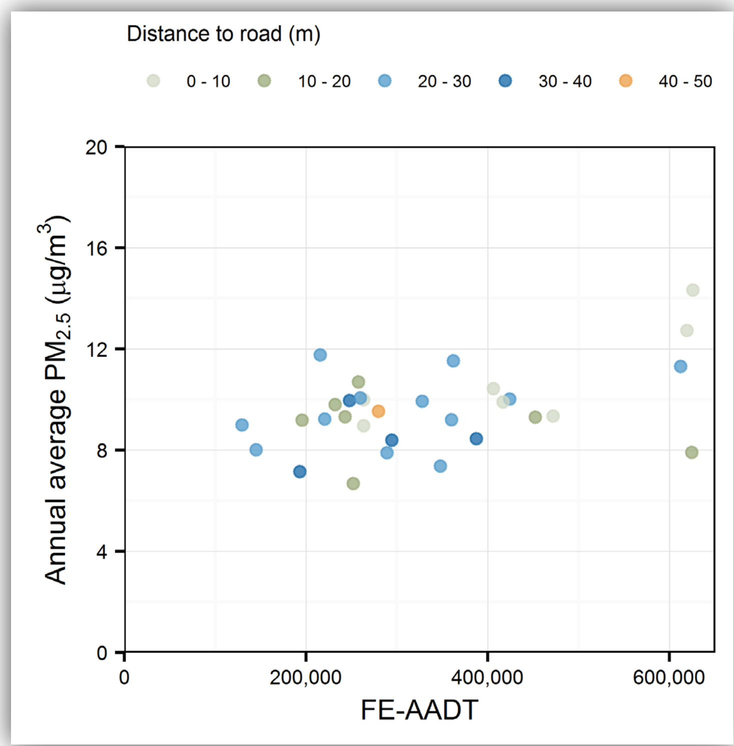


Figure 16. FE-AADT versus annual average $PM_{2.5}$ concentrations in 2015 by monitoring site, binned by the distance of the monitoring site to the roadway. Only sites with at least 2 full quarters of $PM_{2.5}$ measurements are shown. Data are shown for 31 sites.

3.2 Comparison of Recent Data to Special Study Data

Before the near-road ambient air monitoring network was deployed, FHWA and EPA coordinated on multiple special studies to characterize air pollution next to roadways. Here, we examine how concentrations reported in those studies compare to current observations. One study occurred in December 2008–December 2009 next to I-15 in Las Vegas, Nevada (Kimbrough et al., 2013a; 2013b). Measurements of NO_2 and other pollutants were taken at four sites: 100 m from the western side of I-15, and at 20 m, 100 m, and 300 m from the eastern side of I-15. Kimbrough et al. (2013a, b) found that the 98th percentile of daily 1-hr maximum NO_2 concentrations was highest (71 ppb) at the western site. Another study in October 2010–June 2011 measured NO_2 and other pollutants at four sites next to I-96 in Detroit, Michigan: 100 m from the south side of I-96, and 10 m, 100 m, and 300 m from the north side of I-96 (Kimbrough et al., 2013c). They report that the highest 1-hr NO_2 concentration was 80.7 ppb at the 100 m northern site. In both studies, PM, air toxics, and other pollutants were also measured; however, only NO_2 and CO data are available from the routine monitoring done as part of the near-road monitoring network. Since CO is well below the NAAQS throughout the network, we focus only on NO_2 here. When PM measurements are available at these sites in the future, we will compare the PM concentrations from the special study and from the routine monitoring. Lastly, in future work, we anticipate processing the data from a special study in Raleigh, North Carolina, for comparison to the routine monitoring data.

Figures 17 and 18 show box plots of NO_2 concentrations during the special studies and during routine monitoring in Detroit and Las Vegas. In Detroit, routine monitoring began soon after the completion of the special study, so data are available for multiple years. NO_2 concentrations after the special study time period appear to be slightly declining year by year, except for 2015, when concentrations were slightly higher than in 2014. Regardless, there were no 1-hr daily maximum concentrations in 2014 or 2015 above the high of 80.7 ppb found in the Detroit special study.

In Las Vegas, routine near-road monitoring began in 2015, so only data for August–November 2015 are available. The monitoring locations during the Las Vegas special study are not the same as the location for the routine near-road monitoring. Both locations are along I-15, but they are approximately 7.4 km apart. Figure 19 shows both locations. Regardless, concentrations at the official near-road site in 2015 are similar to those found in 2009 during the special study. In both the routine monitoring and special study data, there are a few days when 1-hr maximum NO_2 is above 70 ppb, but no concentrations were close to the 100 ppb NAAQS.

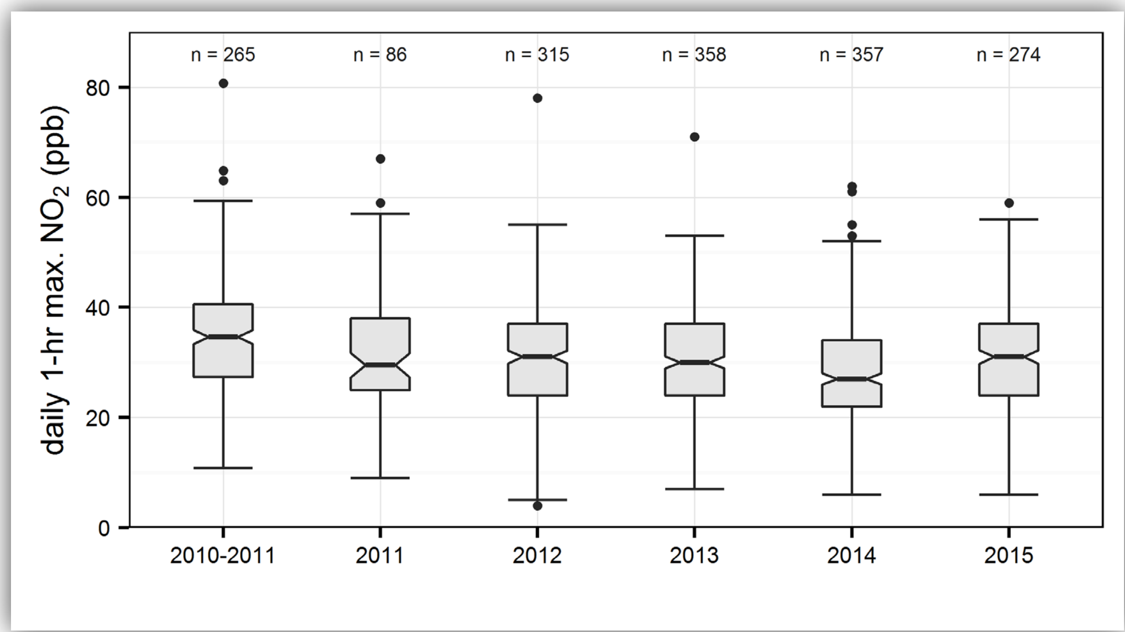


Figure 17. Daily 1-hr maximum NO_2 concentrations (ppb) at near-road monitoring sites 10 m from I-96 in Detroit, Michigan, during the EPA/FHWA special study (2010–2011) and official monitoring (2011-2015).

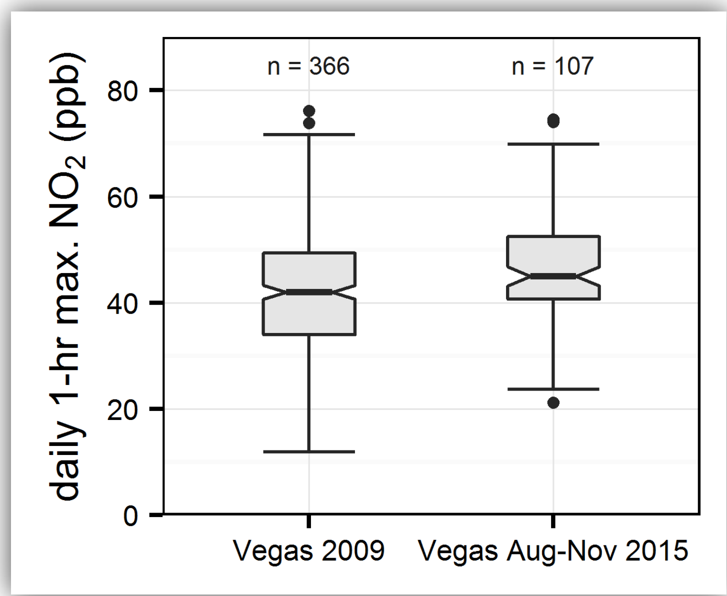


Figure 18. Daily 1-hr maximum NO_2 concentrations (ppb) at the near-road monitoring site 20 m from I-15 in Las Vegas, Nevada, during the EPA/FHWA special study (2009), and at the official monitoring site 15 m from I-15 in August–November 2015.

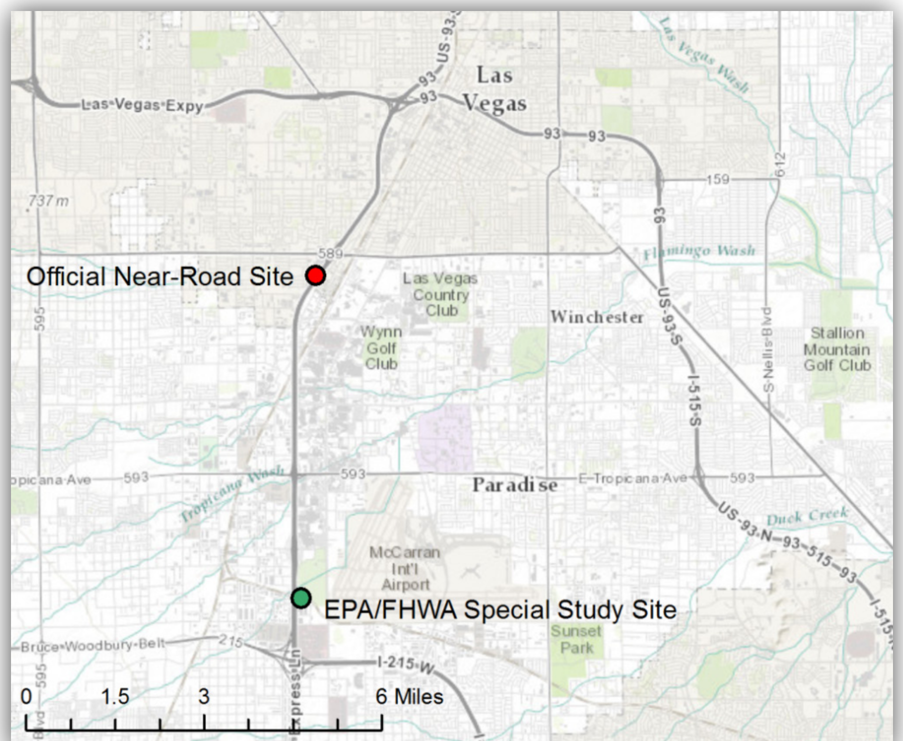


Figure 19. Map showing general location of EPA/FHWA special study site (2009) and the official near-road site (starting in 2015) in Las Vegas, Nevada.

3.3 Comparison of Near-Road and Urban $PM_{2.5}$

3.3.1 Overview

This discussion contrasts $PM_{2.5}$ air quality measurements made near major roads with measurements made at nearby sites in the same urban area but at more regionally based or centrally located monitors ("central sites"). Regional, central site monitors are used to characterize population-level exposures and are not typically located near major emissions sources such as roads. The purpose of this assessment is to gain an improved understanding of the incremental difference between pollutant concentrations observed adjacent to major roads and pollutant concentrations measured in surrounding areas. The findings shown here are not appropriate for use with conformity hot-spot demonstrations. Analyses done to complete EPA-mandated conformity hot-spot analyses must calculate incremental roadway-related concentrations and background concentrations using detailed procedures established by EPA.

Typically, as observed during short-term field monitoring studies, near-road $PM_{2.5}$ concentrations are typically slightly higher than urban/regional concentrations. The $PM_{2.5}$ data collected in the near-road network provides an opportunity to understand how near-road PM compares to urban-scale PM on a national scale and over a longer time period. Using the 2015 measurements, we compared $PM_{2.5}$ concentrations at the 39 official near-road monitors to concentrations at other nearby sites within the same urban region. In this report, we refer to the calculated difference as the "near-road increment." We then evaluated the relationship between the near-road increment and the distance between the near-road monitor and the target roadway, and also to traffic (AADT and FE-AADT) on the target road.

3.3.2 Methodology

Air quality and meteorological measurements for 2015 were obtained from EPA's AQS for all monitoring locations in the country reporting $PM_{2.5}$. Data from these monitoring locations were quality-assured by excluding any null data values or data values flagged as an EPA-approved exceptional event (such as high values due to smoke impacts from fire). The EPA typically requires data for 75% of the time periods measured in a year, plus 75% completeness by quarter or month, for a site to meet minimum data completeness requirements. In order to ensure that each monitoring site had a complete and consistent data record for use in calculating annual statistics and daily urban scale statistics, the following data completeness checks were performed so that monitoring locations that did not meet 75% data completeness requirements (daily, quarterly, and annually) were excluded from the analyses.

1. Hourly data were aggregated to daily averages for any sites measuring continuous hourly $PM_{2.5}$; 18 out of 24 hourly values were required for daily aggregates (75%).
2. The number of daily values (measurements or aggregates) was counted by quarter (e.g., the

first quarter included January-March); quarters that did not have at least 75% of the expected measurements were removed from further analysis.

3. Sites with fewer than three complete quarters of data were excluded from further analysis.

Annual statistics were calculated for each of the monitoring locations that had complete annual data records by aggregating the daily values for 2015. Next, the annual statistics were averaged for all monitoring locations within 100 km, 50 km, and 25 km of the official near-road site.

Finally, using the monitoring locations that had complete annual data records, two different approaches, resulting in six total methods, were developed to quantify the daily increment at the official near-road monitor above or below the daily urban scale concentrations of $PM_{2.5}$.

1. **A distance-based approach**, which limited the representation of regional concentrations to those measured at monitoring locations within a set distance of the official near-road monitoring site. Three different distances were evaluated (100 km, 50 km, and 25 km). The average daily increment of the official near-road site above or below regional concentrations was calculated for each day by:
   a. Calculating the difference ("increment") between the concentration at the near-road monitor and each nearby site within the specified distance (100 km, 50 km, or 25 km).
   b. Calculating the average daily increment as the mean of the differences using the nearby sites within the specified distance.

   Annual average daily increment statistics were then calculated using all the daily increment results.

2. **A correlation-based approach**, which limited spatially and statistically the data to be assessed. The premise behind this method is that if a near-road site and a regional site are influenced by the same regional conditions, total concentrations at the two sites should be highly correlated, and differentiated primarily by the incremental difference resulting from the road. In this method, we used concentrations measured at monitoring locations within 100 km of the official near-road monitoring site to represent regional conditions; we also employed a Pearson correlation,[4] calculated by comparing daily concentrations against a set analysis threshold. For this method, the Pearson correlation coefficient was calculated using all coincident pairs of daily values in 2015 between the official near-road monitor and each nearby site. The analysis was then limited to the nearby monitors that were well correlated to the official monitoring site; three different correlation thresholds were evaluated (0.5, 0.75, and 0.9). The average daily increment of the official near-road site above or below regional concentrations was calculated for each day by:
   a. Calculating the difference ("increment") between the concentration at the near-road monitor and each nearby site located within 100 km, and having a correlation coefficient greater than or equal to the specified threshold (0.5, 0.75, or 0.9).

[4] A Pearson correlation is the dependence between two variables, typically displayed as an "r" or "r^2" value. If two variables are well correlated, they typically vary together, such that when one is high the other one is also high, etc.

b. Calculating the average daily increment as the mean of the differences using the nearby sites.

Annual average daily increment statistics were then calculated using all the daily increment results.

Each methodology (distance- and correlation-based) was used separately to calculate average annual increments. In all, a total of six methods were used to calculate increments:

1. Distance-based approach using all nearby sites within 100 km
2. Distance-based approach using all nearby sites within 50 km
3. Distance-based approach using all nearby sites within 25 km
4. Correlation-based approach using all nearby sites within 100 km, with a correlation coefficient of 0.5
5. Correlation-based approach using all nearby sites within 100 km, with a correlation coefficient of 0.75
6. Correlation-based approach using all nearby sites within 100 km, with a correlation coefficient of 0.9

Finally, we calculated the average annual increment across all six methods.

3.3.3 Results

A total of 387 monitors were included in the analysis, out of 440 originally obtained, after data completeness checks were performed. Three of the 39 official near-road locations, Houston, Jacksonville, and Oklahoma City, were not included in the increment analysis because there were no nearby monitors that met the annual data completeness requirements. At the three locations that were collocated—Denver (I-25), Boston, and Washington, D.C.—only the primary locations were used. In addition, several of the near-road locations lacked three complete (75% or more data) quarters of data in 2015: one of the Boston monitors (Boston, MA (I-93) [0044][3]), one of the Denver monitors (Denver, CO (I-25) [0028][3]), Houston, Jacksonville, one of the Philadelphia locations (Philadelphia, PA (I-76) [0076][1]), Phoenix, and both Washington, DC, monitors. Most of these locations, except Houston, Jacksonville, Denver (0028), and Oklahoma City, were included in the increment analysis because there were enough data at the nearby monitors to conduct the analysis; however, we note the lack of complete annual data records.

Annual Average $PM_{2.5}$ Concentrations

Table 10 (at the end of this section) summarizes the annual mean $PM_{2.5}$ concentration at the official near-road monitor, and across all nearby sites within 100 km, 50 km, and 25 km, of the official near-road monitor. The annual mean at approximately one-half of the near-road monitors is greater than the annual mean at any of the nearby sites within 100 km. For 30 locations, the annual mean of the nearby sites within 25 km is greater than the annual mean calculated across the sites within 50 km and 100 km. This implies that the sites closer to the official near-road monitor are generally more representative of the urban-scale PM in the vicinity of the near-road monitors. The Pearson correlation values were consistent with this finding and were higher for the central sites closest to the near-road sites. Sites farther away may be outside the urban core and in rural or suburban locations that are not as comparable to the urbanized areas containing the near-road monitor. At six locations, the annual mean of the nearby sites within 25 km is less than the annual mean calculated across the sites within 100 km; however, the differences were small (0.2-0.5 μg/m^3).

Annual Average Daily Increment in $PM_{2.5}$ Concentrations

Table 11 (at the end of this section) summarizes the annual average daily increment calculated using each of the methods described above. On average, across all near-road sites, the calculated increment is lower when limited to sites within 25 km of the official near-road site as compared to sites within 100 km. The result could indicate an increase in primary and/or secondary $PM_{2.5}$ at sites in closer proximity to the urban area represented by the official near-road monitor, which would reduce the additional relative contribution from the road near the official monitor. Similarly, the average increment across all near-road monitors decreases when limited to nearby sites with a stronger correlation (≥0.9) to the official near-road monitor than sites with a weaker correlation (≥0.5). The correlation was generally higher when the central site was closer to the near-road monitor, meaning that the near-road site varied in the same way as the site close by; the average distance between the near-road monitor and the nearby sites with a stronger correlation (≥0.9) was 25 km. The sites with a weaker correlation may be outside the urban core and have lower concentrations than those within the urban core, leading to a higher increment when compared to the official near-road monitor. Note that, typically, there are fewer nearby sites within 25 km than within 100 km; therefore, the representativeness of the results from sites within 25 km may be affected by the smaller sample size of the monitors included in the analysis.

Figure 20 displays the average increment, using the mean of all six methods, for each official near-road monitoring location. The average increment across all sites is 1.2 μg/m^3, ranging from -1.2 μg/m^3 to 3.2 μg/m^3. Daily concentrations at many official near-road monitors are greater than the mean of the nearby monitors, indicating an increment due to primary traffic emissions. However, concentrations at six of the 32 near-road monitors—Louisville, KY; San Jose, CA; Livonia, MI; Laurel, MD; Kansas City, MO; and St. Louis, MO—were not greater than at the nearby sites. On average, the increment is 12% of the annual mean concentrations across the near-road sites; for the sites within 20 m of the roadway, the increment is 15% of the mean.

The annual average daily increment is weakly related to the distance between the official near-road monitor and the target road (r^2 of 0.2) (**Figure 21**), and to FE-AADT (r^2 of 0.05) (**Figure 22**). There is a slightly stronger relationship between the near-road increment and distance to target road, than for the annual average near-road $PM_{2.5}$ versus distance to road (r^2 of 0.11), shown previously in Figure 16. This result is expected, because the relationship between $PM_{2.5}$ concentrations and either FE-AADT or distance from roadway is also influenced by other site-specific factors such as meteorology; also, near-road $PM_{2.5}$ is dominated by secondarily formed $PM_{2.5}$, which is difficult to accurately quantify.

Figures 23 through 25 display the increment results, using the correlation-based approach with a Pearson coefficient of 0.9 or greater. The findings are consistent with the results using the mean of all six methodologies. The average increment across all sites is 1.1 µg/m^3, ranging from -0.9 µg/m^3 to 3.2 µg/m^3. Figure 26 compares the annual average daily $PM_{2.5}$ increment for 2015, calculated as the mean of all six methodologies, to the annual mean at each official near-road monitor. The calculated increment is positively related to the annual mean; in other words, official near-road monitors with a higher annual mean $PM_{2.5}$ concentration also have a higher calculated increment. On average, the calculated annual increment is approximately 11% of the annual mean, when using only sites with a Pearson coefficient of 0.9 or greater.

3.3.4 Conclusion

In this analysis, we compared daily $PM_{2.5}$ concentrations between official near-road monitors and nearby central sites for 32 urban areas to estimate the near-road increment in 2015. As expected, concentrations at most near-road sites were typically higher than at other nearby central sites, similar to the findings from other short-term near-road field monitoring studies. Only six of the 32 near-road sites had a negative increment, which indicates that, on average, a contribution from the adjacent road to the near-road environment is measured at the official near-road site. However, this analysis does not account for meteorology; wind speed and direction can affect concentrations at near-road and nearby central site monitors (e.g., concentrations are lower as wind speeds become higher).

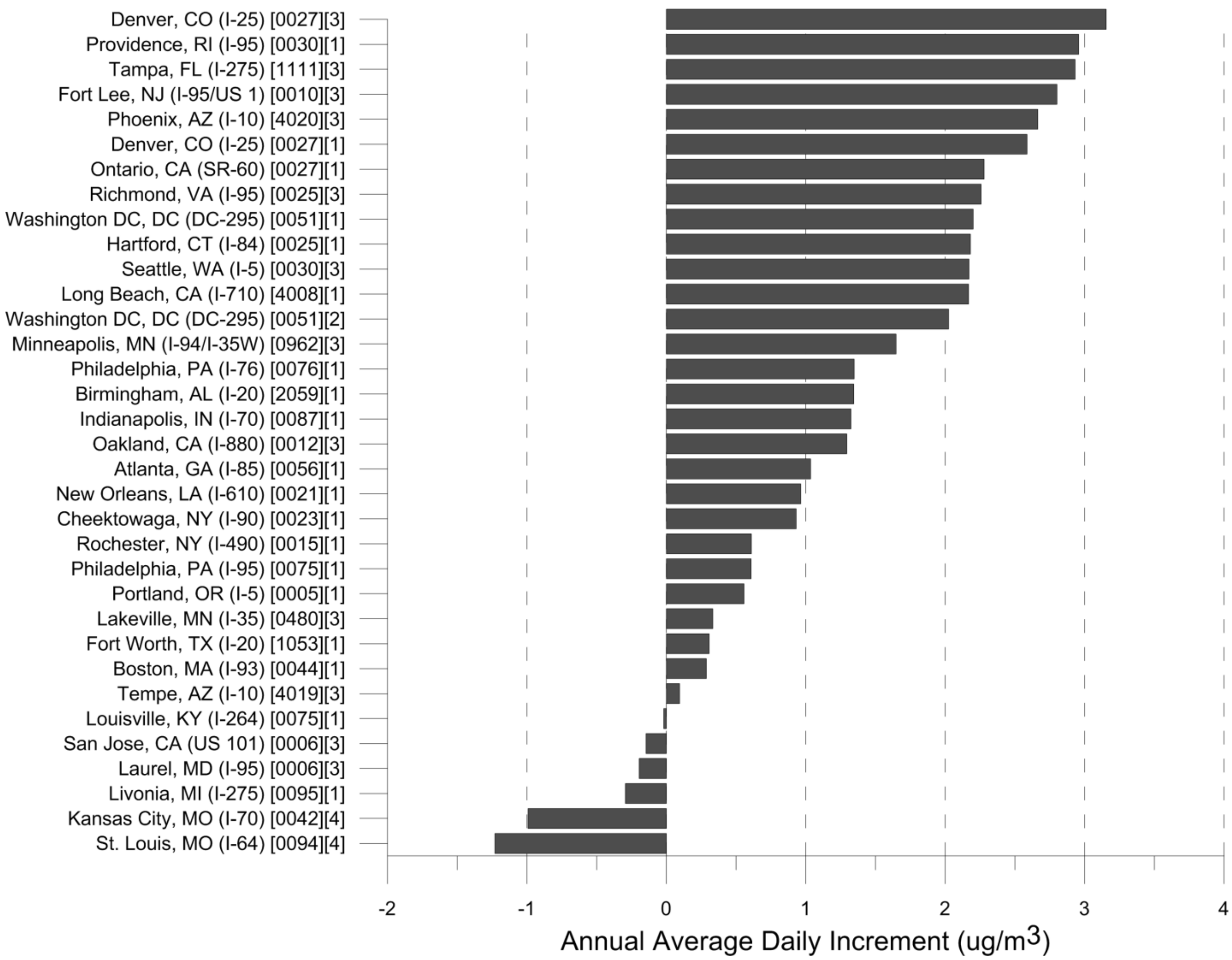


Figure 20. Annual average daily $PM_{2.5}$ increment for 2015, calculated as the mean of all six methodologies.

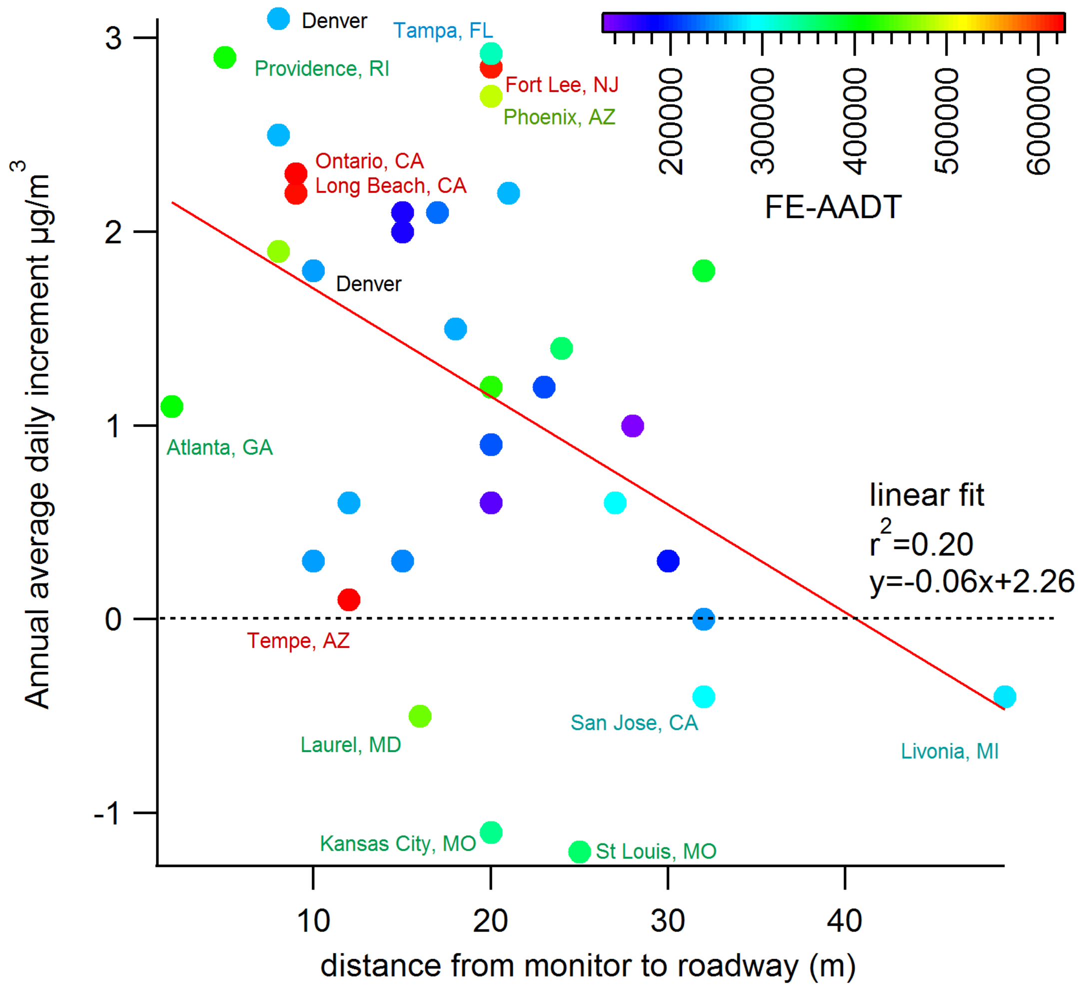


Figure 21. Annual average daily $PM_{2.5}$ increment for 2015, calculated as the mean of all six methodologies, versus the distance from the official near-road monitor to the target road; points are colored by FE-AADT.

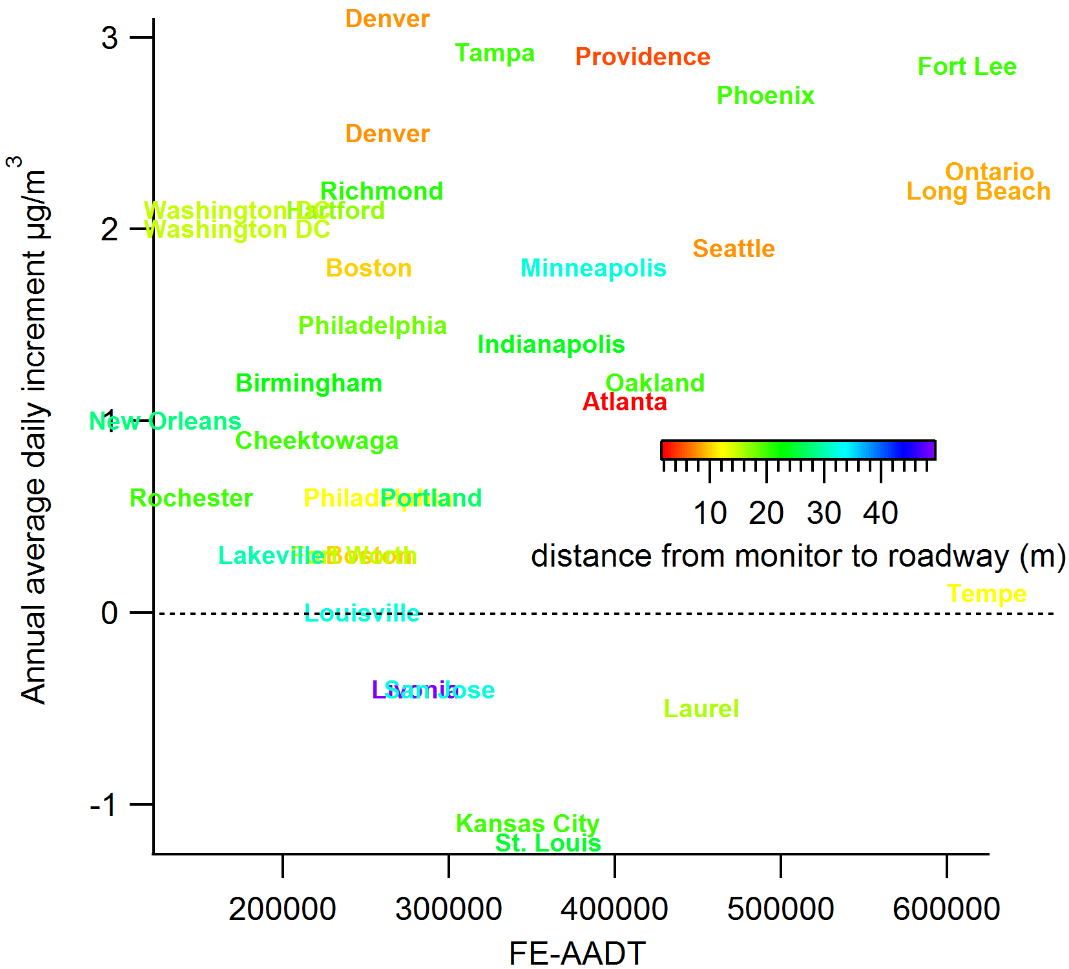


Figure 22. Annual average daily $PM_{2.5}$ increment for 2015, calculated as the mean of all six methodologies, versus the FE-AADT at the official near-road monitor; points are colored by distance to target road.

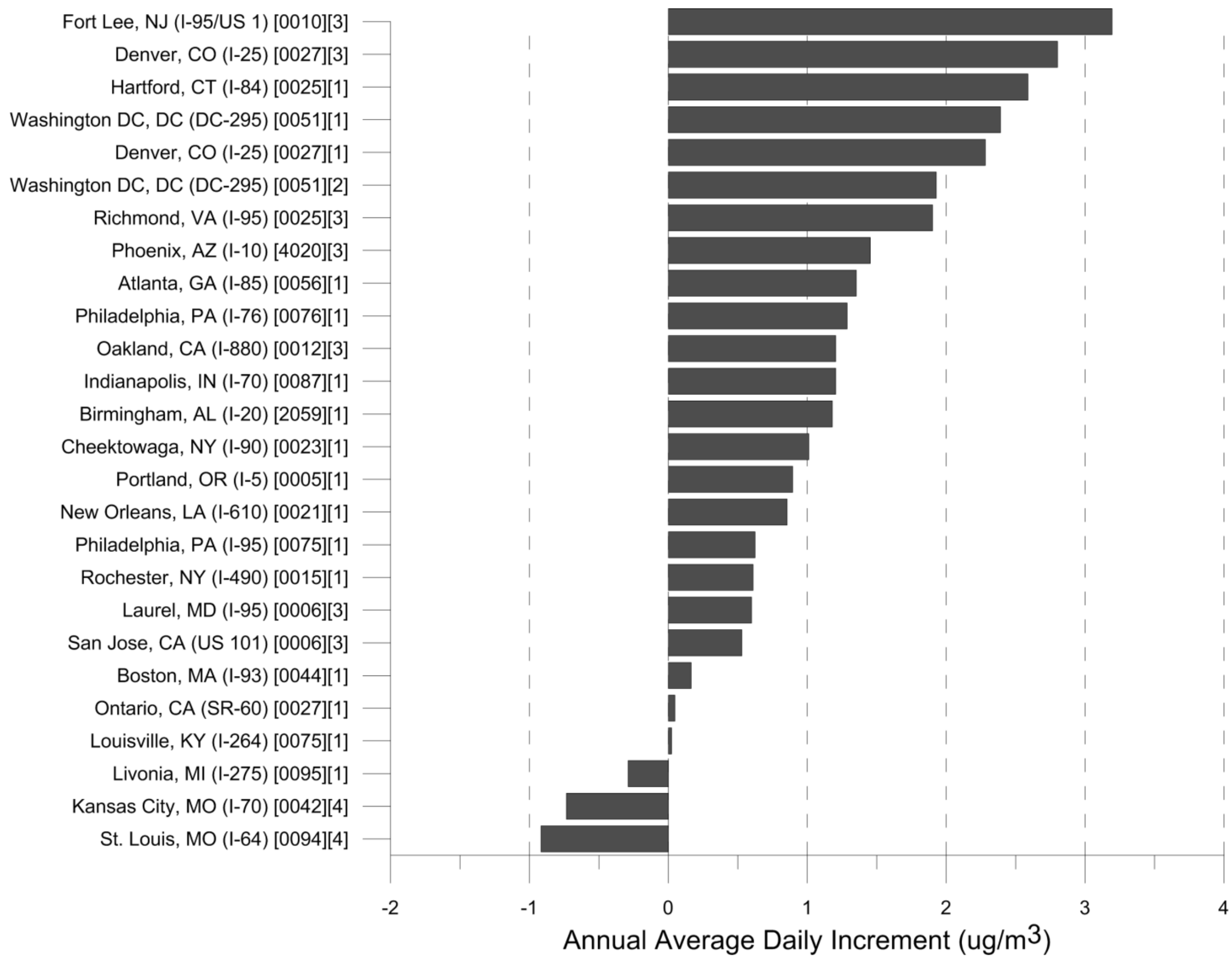


Figure 23. Annual average daily $PM_{2.5}$ increment for 2015, calculated using the correlation based approach with a Pearson coefficient of 0.9 or greater.

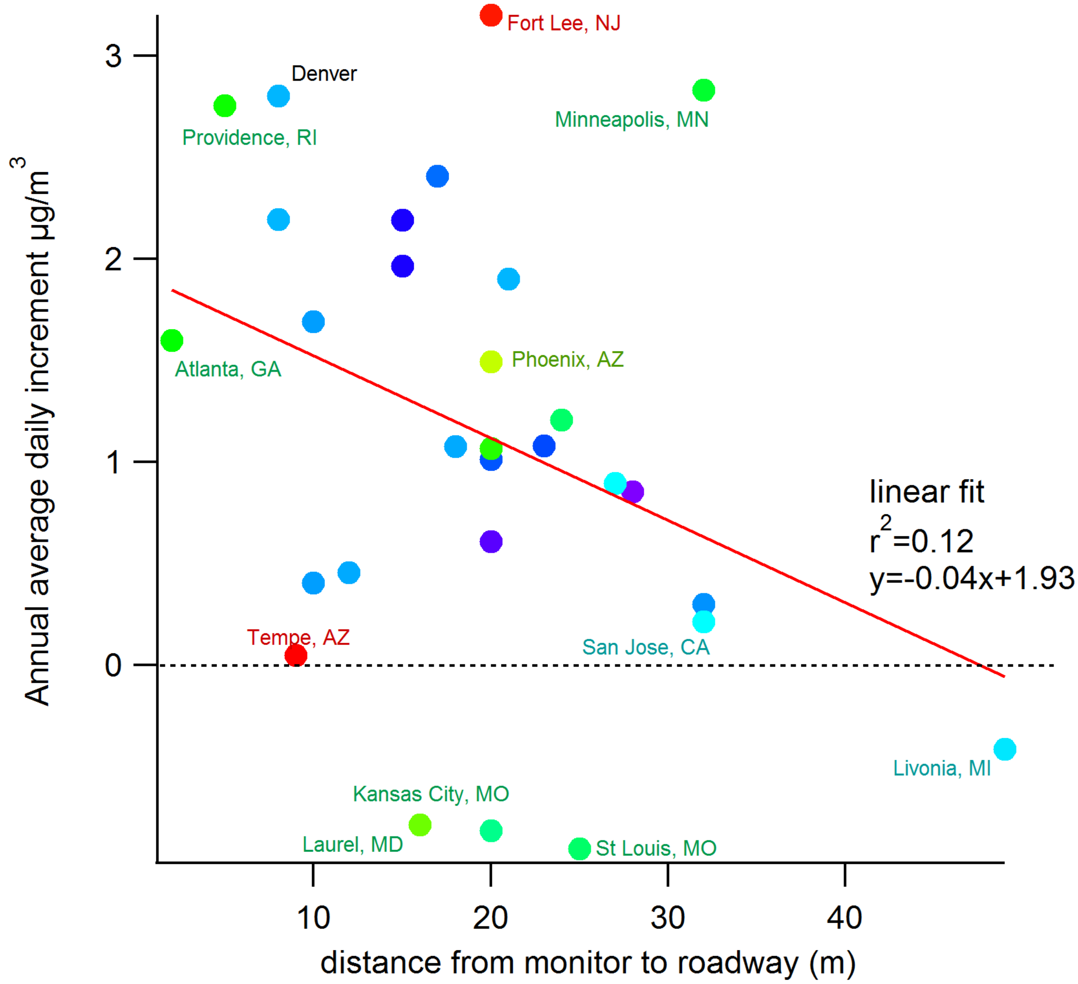


Figure 24. Annual average daily $PM_{2.5}$ increment for 2015, calculated using the correlation-based approach with a Pearson coefficient of 0.9 or greater, versus the distance from the official near-road monitor to the target road; points are colored by FE-AADT.

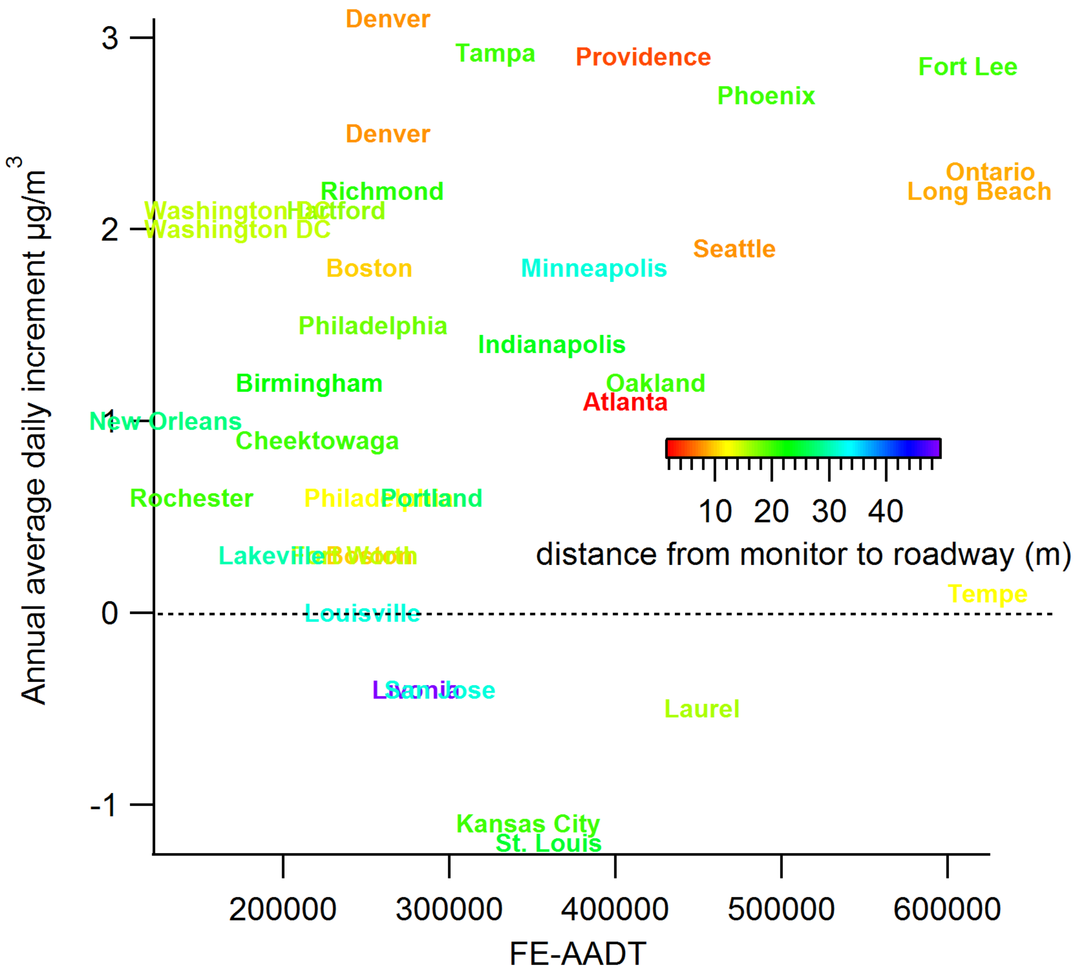


Figure 25. Annual average daily $PM_{2.5}$ increment for 2015, calculated using the correlation-based approach with a Pearson coefficient of 0.9 or greater, versus the FE-AADT at the official near-road monitor; points are colored by distance to target road.

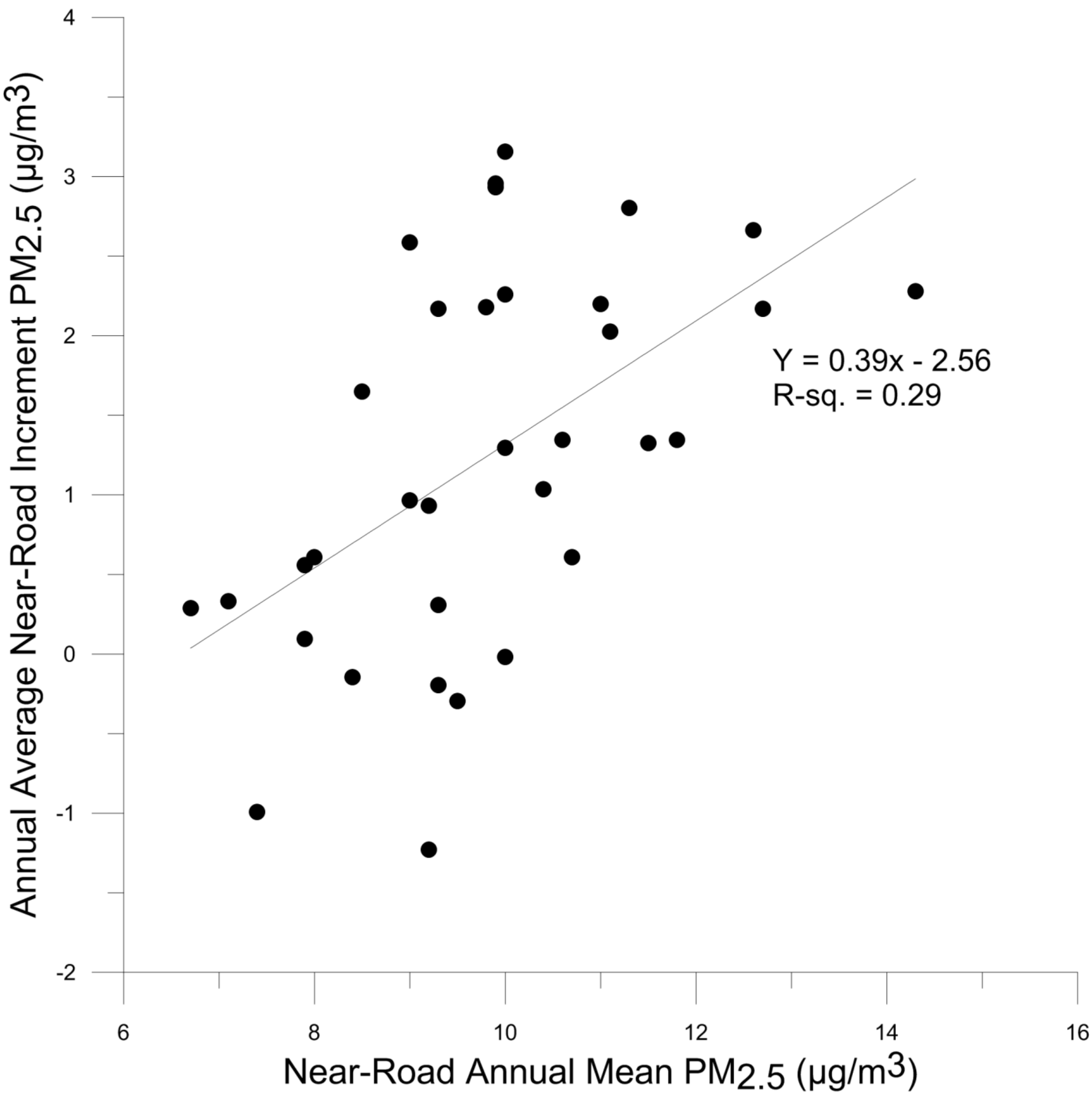


Figure 26. Comparison of the annual average daily $PM_{2.5}$ increment for 2015, calculated as the mean of all six methodologies versus the annual mean at each official near-road monitor

Table 10. Summary of the annual mean $PM_{2.5}$ concentration at the official near-road monitors, and across all nearby sites within 100 km, 50 km, and 25 km, for 2015. All values are provided in micrograms/cubic meter. Sample size n refers to the number of central site monitors included in the analysis.

Location	FE-AADT	Distance (m)	Mean (100 km)	Annual Mean (Daily Range)	100 km Avg. Annual Mean (Range) n	50 km Avg. Annual Mean (Range) n	25 km Avg. Annual Mean (Range) n
Atlanta, GA (I-85) [0056][1]	406,256	2	10.4	10.4 (2.7 - 27.5)	8.7 (7.3 - 10.1) n= 8	9.3 (8.5 - 10.1) n= 5	9.8 (9.5 - 10.1) n= 3
Birmingham, AL (I-20) [2059][1]	215,527	23	11.8	11.8 (1.9 - 26.2)	10.1 (8.8 - 11.7) n= 6	10.6 (9.9 - 11.7) n= 4	11.1 (10.5 - 11.7) n= 2
Boston, MA (I-93) [0044][1]	251,761	10	6.7	6.7 (0.5 - 20.8)	6.4 (5 - 7.8) n= 19	6.1 (5 - 7.5) n= 8	6.4 (5 - 7.5) n= 5
Boston, MA (I-93) [0044][3]	251,761	10	8.1	8.1 (2.6 - 21.3)	6.1 (4.6 - 8.3) n= 19	5.8 (4.6 - 8.3) n= 8	6.3 (4.6 - 8.3) n= 5
Cheektowaga, NY (I-90) [0023][1]	220,543	20	9.2	9.2 (1 - 25.2)	8.2 (7.9 - 8.8) n= 3	8.3 (7.9 - 8.8) n= 2	8.3 (7.9 - 8.8) n= 2
Denver, CO (I-25) [0027][1]	263,118	8	9	9 (2.2 - 29.1)	6.1 (3.4 - 7.9) n= 11	6.3 (5.5 - 7.1) n= 6	6.4 (5.5 - 7.1) n= 4
Denver, CO (I-25) [0027][3]	263,118	8	10	10 (2.9 - 53)	6.1 (3.3 - 8) n= 11	6.3 (5.3 - 7.2) n= 6	6.4 (5.3 - 7.2) n= 4
Denver, CO (I-25) [0028][3]	210,835	6	14	14 (4.1 - 39.5)	6.7 (4.1 - 9) n= 9	6.4 (4.1 - 8.1) n= 7	6.5 (5.8 - 7.1) n= 3
Fort Lee, NJ (I-95/US 1) [0010][3]	612,212	20	11.3	11.3 (0.9 - 34.6)	8.7 (7.2 - 10.9) n= 26	9 (7.3 - 10.9) n= 16	9.2 (7.8 - 10.9) n= 12
Fort Worth, TX (I-20) [1053][1]	242,856	15	9.3	9.3 (1.4 - 21.1)	9.1 (9.1 - 9.2) n= 2	9.1 (9.1 - 9.2) n= 2	9.1 (9.1 - 9.1) n= 1

Location	FE-AADT	Distance (m)	Mean (100 km)	Annual Mean (Daily Range)	100 km Avg. Annual Mean (Range) n	50 km Avg. Annual Mean (Range) n	25 km Avg. Annual Mean (Range) n
Hartford, CT (I-84) [0025][1]	231,855	17	9.8	9.8 (1.9 - 24.8)	7.4 (5.4 - 9.8) n= 15	7.8 (6.3 - 9) n= 4	8.3 (8.3 - 8.3) n= 1
Indianapolis, IN (I-70) [0087][1]	362,110	24	11.5	11.5 (3.2 - 54.9)	9.8 (7.9 - 11.4) n= 13	10.5 (8.8 - 11.4) n= 6	10.9 (9.9 - 11.4) n= 5
Kansas City, MO (I-70) [0042][4]	347,582	20	7.4	7.4 (-0.6 - 41.9)	8.1 (6.6 - 9.4) n= 6	7.9 (6.6 - 8.7) n= 5	8.2 (7.3 - 8.7) n= 3
Lakeville, MN (I-35) [0480][3]	193,200	30	7.1	7.1 (-0.1 - 33.3)	7 (5.9 - 8.4) n= 10	6.8 (5.9 - 7.8) n= 7	6.6 (6.5 - 6.6) n= 2
Laurel, MD (I-95) [0006][3]	452,309	16	9.3	9.3 (-2.3 - 31.9)	9.4 (7.6 - 11) n= 19	9.4 (7.6 - 10.6) n= 12	10 (9.6 - 10.5) n= 3
Livonia, MI (I-275) [0095][1]	279,700	49	9.5	9.5 (2.3 - 31.5)	9.7 (8.1 - 11.5) n= 18	10.2 (9 - 11.5) n= 9	9.2 (9 - 9.3) n= 3
Long Beach, CA (I-710) [4008][1]	619,008	9	12.7	12.7 (3 - 48.8)	9.9 (5.2 - 14.1) n= 20	10 (8.7 - 11.7) n= 9	10.4 (9.2 - 11.7) n= 6
Louisville, KY (I-264) [0075][1]	247,600	32	10	10 (2.7 - 26)	9.8 (8.9 - 10.6) n= 6	10 (9.2 - 10.6) n= 5	10 (9.2 - 10.6) n= 5
Minneapolis, MN (I-94/I-35W) [0962][3]	387,250	32	8.5	8.5 (-2 - 34.2)	6.9 (5.9 - 8.4) n= 11	7 (5.9 - 8.4) n= 10	6.9 (5.9 - 7.8) n= 5
New Orleans, LA (I-610) [0021][1]	129,229	28	9	9 (3.2 - 22.4)	8 (6.9 - 9.1) n= 6	8.4 (7.8 - 9.1) n= 2	8.4 (7.8 - 9.1) n= 2
Oakland, CA (I-880) [0012][3]	424,008	20	10	10 (1.3 - 37.3)	8.8 (4.9 - 12.7) n= 16	8.6 (5.7 - 10.2) n= 9	8.8 (7.6 - 10.2) n= 4
Ontario, CA (SR-60) [0027][1]	625,736	9	14.3	14.3 (0.2 - 52.8)	9.8 (5.2 - 14.3) n= 21	10.6 (6.7 - 14.3) n= 10	12.4 (10.6 - 14.3) n= 4

Location	FE-AADT	Distance (m)	Mean (100 km)	Annual Mean (Daily Range)	100 km Avg. Annual Mean (Range) n	50 km Avg. Annual Mean (Range) n	25 km Avg. Annual Mean (Range) n
Philadelphia, PA (I-76) [0076][1]	253,965	18	10.6	10.6 (2.7 - 33.1)	8.3 (5.2 - 11.9) n= 30	8.9 (5.2 - 11.9) n= 15	9.1 (5.2 - 11.9) n= 9
Philadelphia, PA (I-95) [0075][1]	257,460	12	10.7	10.7 (1.9 - 37.1)	9.5 (7.1 - 12.6) n= 33	9.8 (7.6 - 11.3) n= 13	10.4 (9 - 11.3) n= 7
Phoenix, AZ (I-10) [4020][3]	490,838	20	12.6	12.6 (3 - 35.3)	8.7 (4.3 - 11.4) n= 11	9.2 (5.1 - 11.4) n= 8	10.1 (7.7 - 11.4) n= 6
Portland, OR (I-5) [0005][1]	289,052	27	7.9	7.9 (1.8 - 61.5)	7.4 (7 - 7.8) n= 2	7.4 (7 - 7.8) n= 2	7.4 (7 - 7.8) n= 2
Providence, RI (I-95) [0030][1]	416,790	5	9.9	9.9 (1.5 - 92.5)	6.6 (5.2 - 8.3) n= 16	6.5 (5.2 - 7.7) n= 8	7.4 (7.2 - 7.7) n= 3
Richmond, VA (I-95) [0025][3]	259,720	21	10	10 (1.2 - 26.7)	7.8 (7.6 - 8.3) n= 4	7.8 (7.6 - 8.3) n= 4	7.9 (7.7 - 8.3) n= 3
Rochester, NY (I-490) [0015][1]	144,717	20	8	8 (1.8 - 21.8)	7.4 (7.4 - 7.4) n= 1	7.4 (7.4 - 7.4) n= 1	7.4 (7.4 - 7.4) n= 1
San Jose, CA (US 101) [0006][3]	294,140	32	8.4	8.4 (0 - 46.9)	8.5 (4.3 - 14.3) n= 20	7.2 (4.9 - 10.1) n= 6	10.1 (10.1 - 10.1) n= 1
Seattle, WA (I-5) [0030][3]	471,630	8	9.3	9.3 (1.4 - 26.6)	7 (5 - 9.8) n= 8	6.9 (5 - 9.8) n= 6	6.8 (5 - 9.8) n= 5
St. Louis, MO (I-64) [0094][4]	360,077	25	9.2	9.2 (-0.7 - 39.4)	10 (7.9 - 11.6) n= 12	10.4 (9 - 11.6) n= 10	10.8 (10.1 - 11.6) n= 8
Tampa, FL (I-275) [1111][3]	327,660	20	9.9	9.9 (-0.5 - 26)	6.6 (5.7 - 7.4) n= 5	6.8 (6.2 - 7.4) n= 4	7.4 (7.4 - 7.4) n= 1
Tempe, AZ (I-10) [4019][3]	624,315	12	7.9	7.9 (2 - 22.6)	7.5 (4.8 - 10.1) n= 11	7.5 (4.8 - 10.1) n= 10	7.5 (4.8 - 9) n= 7

Location	FE-AADT	Distance (m)	Mean (100 km)	Annual Mean (Daily Range)	100 km Avg. Annual Mean (Range) n	50 km Avg. Annual Mean (Range) n	25 km Avg. Annual Mean (Range) n
Washington DC, DC (DC-295) [0051][1]	172,747	15	11	11 (1.3 - 34.1)	8.8 (7.1 - 10.5) n= 16	8.8 (7.5 - 9.6) n= 9	8.6 (7.5 - 9.6) n= 6
Washington DC, DC (DC-295) [0051][2]	172,747	15	11.1	11.1 (2.4 - 32.5)	9 (7.5 - 10.5) n= 16	9 (8 - 10) n= 9	8.8 (8 - 9.7) n= 6

Table 11. Annual average daily $PM_{2.5}$ increment calculated for 2015 using six different methods; the average of all six methods is also provided. All values are provided in micrograms/cubic meter.

Location	FE-AADT	Distance (m)	Increment (100 km)	Increment (50 km)	Increment (25 km)	Increment ($R2 \geq 0.5$)	Increment ($R2 \geq 0.75$)	Increment ($R2 \geq 0.9$)	AVERAGE
Atlanta, GA (I-85) [0056][1]	406,256	2	1.2	0.9	0.4	1.2	1.2	1.4	1.0
Birmingham, AL (I-20) [2059][1]	215,527	23	1.7	1.2	0.7	1.7	1.7	1.2	1.3
Boston, MA (I-93) [0044][1]	251,761	10	0.3	0.5	0.3	0.2	0.3	0.2	0.3
Boston, MA (I-93) [0044][3]	251,761	10	1.8	2.0	1.8	1.8	1.6	1.3	1.7
Cheektowaga, NY (I-90) [0023][1]	220,543	20	1.0	0.8	0.8	1.0	1.0	1.0	0.9
Denver, CO (I-25) [0027][1]	263,118	8	2.8	2.7	2.6	2.6	2.6	2.3	2.6
Denver, CO (I-25) [0027][3]	263,118	8	3.9	3.1	3.0	3.0	3.1	2.8	3.2
Denver, CO (I-25) [0028][3]	210,835	6	6.9	7.1	7.1	7.2	7.3		7.1
Fort Lee, NJ (I-95/US 1) [0010][3]	612,212	20	2.8	2.6	2.8	2.8	2.6	3.2	2.8

Location	FE-AADT	Distance (m)	Increment (100 km)	Increment (50 km)	Increment (25 km)	Increment (R2 ≥ 0.5)	Increment (R2 ≥ 0.75)	Increment (R2 ≥ 0.9)	AVERAGE
Fort Worth, TX (I-20) [1053][1]	242,856	15	0.3	0.3	0.3	0.3	0.3		0.3
Hartford, CT (I-84) [0025][1]	231,855	17	2.4	2.0	1.5	2.4	2.2	2.6	2.2
Indianapolis, IN (I-70) [0087][1]	362,110	24	1.7	1.0	0.7	1.7	1.6	1.2	1.3
Kansas City, MO (I-70) [0042][4]	347,582	20	-1.1	-0.8	-0.9	-1.1	-1.1	-0.7	-1.0
Lakeville, MN (I-35) [0480][3]	193,200	30	0.2	0.6	0.5	0.2	0.2		0.3
Laurel, MD (I-95) [0006][3]	452,309	16	-0.2	-0.2	-0.9	-0.2	-0.2	0.6	-0.2
Livonia, MI (I-275) [0095][1]	279,700	49	-0.3	-0.7	0.2	-0.3	-0.3	-0.3	-0.3
Long Beach, CA (I-710) [4008][1]	619,008	9	2.4	2.5	2.3	1.3	2.3		2.2
Louisville, KY (I-264) [0075][1]	247,600	32	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0
Minneapolis, MN (I-94/I-35W) [0962][3]	387,250	32	1.6	1.5	1.9	1.6	1.7		1.6
New Orleans, LA (I-610) [0021][1]	129,229	28	1.1	0.9	0.9	1.1	1.0	0.9	1.0
Oakland, CA (I-880) [0012][3]	424,008	20	1.3	1.5	1.3	1.3	1.2	1.2	1.3
Ontario, CA (SR-60) [0027][1]	625,736	9	3.7	2.6	1.6	3.1	2.6	0.0	2.3
Philadelphia, PA (I-76) [0076][1]	253,965	18	1.5	1.2	1.0	1.5	1.5	1.3	1.3
Philadelphia, PA (I-95) [0075][1]	257,460	12	0.8	0.8	0.1	0.8	0.6	0.6	0.6
Phoenix, AZ (I-10) [4020][3]	490,838	20	3.3	3.0	2.6	3.1	2.6	1.5	2.7
Portland, OR (I-5) [0005][1]	289,052	27	0.5	0.5	0.5	0.5	0.5	0.9	0.6

Location	FE-AADT	Distance (m)	Increment (100 km)	Increment (50 km)	Increment (25 km)	Increment (R2 ≥ 0.5)	Increment (R2 ≥ 0.75)	Increment (R2 ≥ 0.9)	AVERAGE
Providence, RI (I-95) [0030][1]	416,790	5	3.2	3.4	2.7	2.8	2.7		3.0
Richmond, VA (I-95) [0025][3]	259,720	21	2.3	2.3	2.3	2.3	2.3	1.9	2.3
Rochester, NY (I-490) [0015][1]	144,717	20	0.6	0.6	0.6	0.6	0.6	0.6	0.6
San Jose, CA (US 101) [0006][3]	294,140	32	-0.1	1.2	-1.7	-0.2	-0.6	0.5	-0.1
Seattle, WA (I-5) [0030][3]	471,630	8	2.3	2.5	2.6	2.3	1.3		2.2
St. Louis, MO (I-64) [0094][4]	360,077	25	-1.3	-1.4	-1.5	-1.3	-0.9	-0.9	-1.2
Tampa, FL (I-275) [1111][3]	327,660	20	3.0	2.9	2.7	3.0	3.0		2.9
Tempe, AZ (I-10) [4019][3]	624,315	12	0.1	0.1	0.0	0.1	0.1		0.1
Washington DC, DC (DC-295) [0051][1]	172,747	15	2.2	2.0	2.2	2.2	2.3	2.4	2.2
Washington DC, DC (DC-295) [0051][2]	172,747	15	2.0	1.9	2.2	2.0	2.1	1.9	2.0

4. Case Study Analyses

This section provides case study analyses based on national near-road network measurements. For the case studies, we selected the sites with the highest NO_2 values that occurred in 2015 (in Oakland, CA; Seattle, WA; and George Washington Bridge, NJ), the site with the highest 24-hour $PM_{2.5}$ values in 2014 (Denver, CO), and the sites with at least three quarters of complete year of data in 2015 and the annual average $PM_{2.5}$ greater than 12 µg/m^3 (Ontario, CA; Long Beach, CA Houston, TX). In addition, we compared $PM_{2.5}$ at each near-road monitoring site to concentrations in the nearby urban area; using an interpolation analysis of $PM_{2.5}$ data from hundreds of monitoring sites, we investigated how the incremental increase in $PM_{2.5}$ varies with monitor distance to roadway and with roadway FE-AADT. With these case studies, we investigated:

1. What conditions (traffic, meteorological, and/or regional-scale) contributed to high NO_2 and/or $PM_{2.5}$ values observed in 2014 or 2015?
2. In areas with multiple near-road sites, are concentration differences between sites driven by differences in traffic or by other urban-scale influences?
3. How often and where are near-road site annual average PM concentrations higher than the PM concentrations at other nearby sites?
4. What are near-road PM concentrations at locations with the highest FE-AADT?

4.1 Denver Near-Road Case Study: High $PM_{2.5}$ in February 2014

This case study consists of a detailed analysis of traffic, meteorological, and air pollution data during February 2014 when the Denver, Colorado, near-road monitoring site adjacent to I-25 registered the highest $PM_{2.5}$ concentration found at all near-road sites in 2014 (**Figure 27**). During a 10-day period in February 2014, $PM_{2.5}$ concentrations at the site were above the NAAQS threshold of 35 µg/m^3 on three days.

In the following sections, we first describe the site location and give an overview of $PM_{2.5}$ at the Denver near-road site in February 2014. Then, we step through a detailed look at hourly traffic, meteorological, and air pollution data during the high-$PM_{2.5}$ days. Finally, we compare observations at the near-road site to observations at other sites in the Denver urban area during February and during all of 2014, to understand how often, and by how much, $PM_{2.5}$ concentrations at the near-road site are higher than at other sites in the urban area. Hourly traffic data (volume, speed) were provided by the Colorado Department of Transportation for the I-25/6th Avenue location on I-25, approximately 700 m south of the near-road monitoring site. Hourly meteorology, $PM_{2.5}$, and $NO/NO_2/NO_x$ data were all available at the near-road monitoring site.

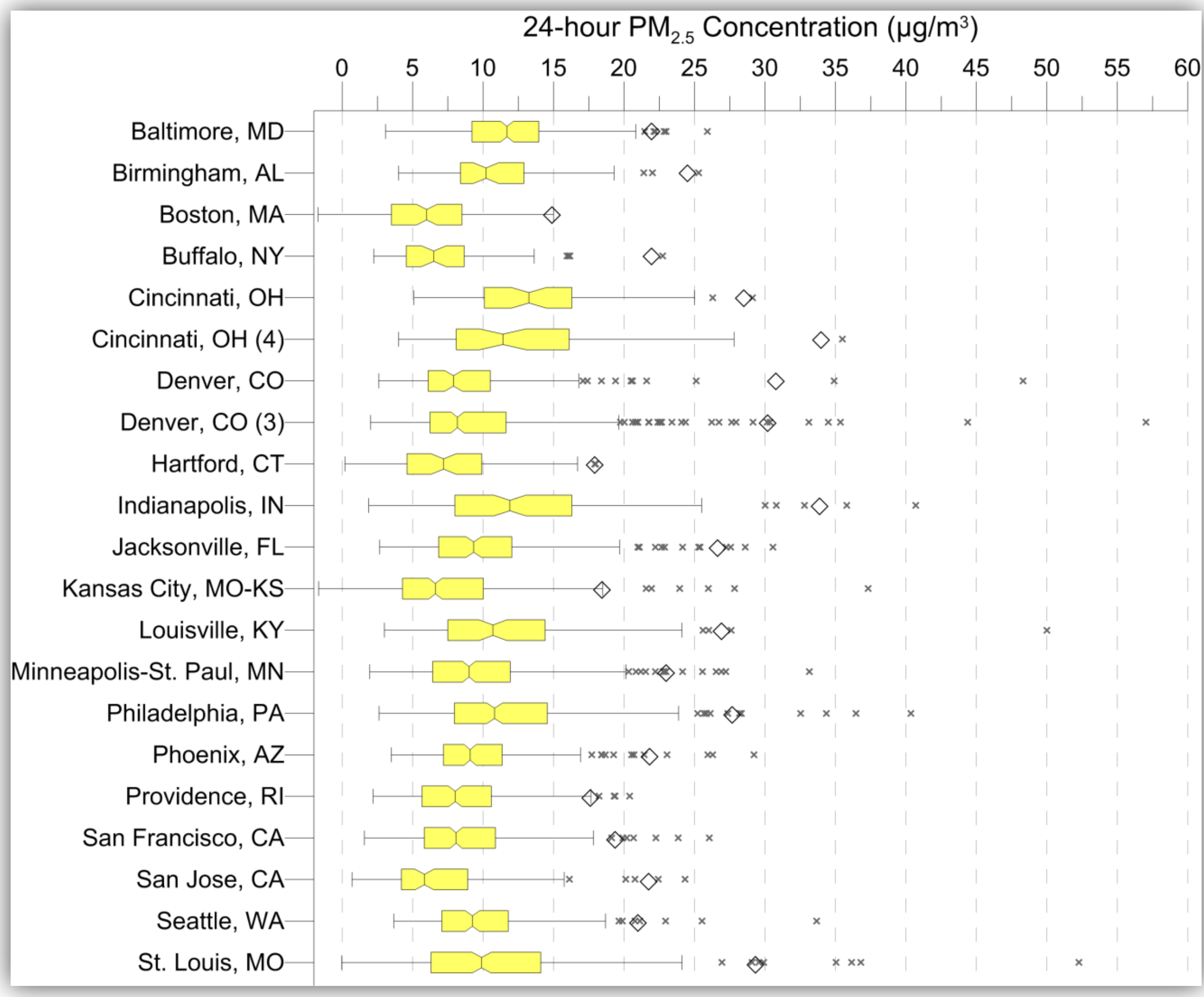


Figure 27. 24-hr $PM_{2.5}$ concentrations at the official near-road monitoring locations in 2014. The vertical line at the notch indicates the median; the notch around the vertical line indicates the 95th percentile confidence interval in the median; the box indicates the interquartile range (IQR); the whiskers indicate 1.5*IQR; and individual points are beyond 1.5*IQR. The 98th percentile value, based on the available data as of May 2015, is also shown (diamond). Numbers in parentheses indicate collocated monitors that may have different sampling durations. The NAAQS is exceeded when the 98th percentile, averaged over three years, is greater than 35 µg/m^3. Six of the sites (Buffalo, Hartford, Jacksonville, Phoenix, San Jose, and Seattle) have fewer than three quarters of data available for 2014.

The official near-road monitoring site in Denver, Colorado, is just east of I-25, approximately two miles southwest of downtown Denver. Four $PM_{2.5}$ monitoring sites close to the near-road site were identified; Figure 28 shows a map of the Denver area and nearby monitoring sites, and Figure 29 shows an aerial and street view of the near-road site. At the monitoring site location, I-25 has an AADT of 249,000 and an FE-AADT of 263,118; the monitoring site is 9 m east of the edge of the freeway. In addition, I-25 is slightly curved around the site, so that the monitoring site is generally downwind of I-25 under winds from 180 to 360 degrees. Directly east of the monitoring site are one-story buildings, which may have a mild effect forcing the local winds in a north-south direction.

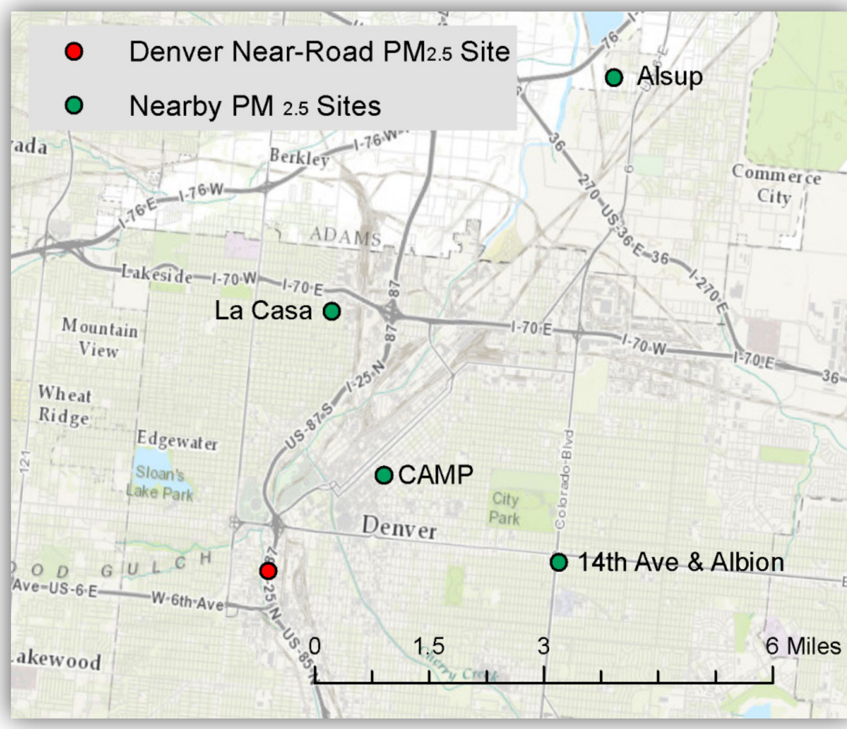


Figure 28. The locations of the four monitoring sites where $PM_{2.5}$ was measured (green dots) within several miles of Denver I-25 and the near-road site (red dot).

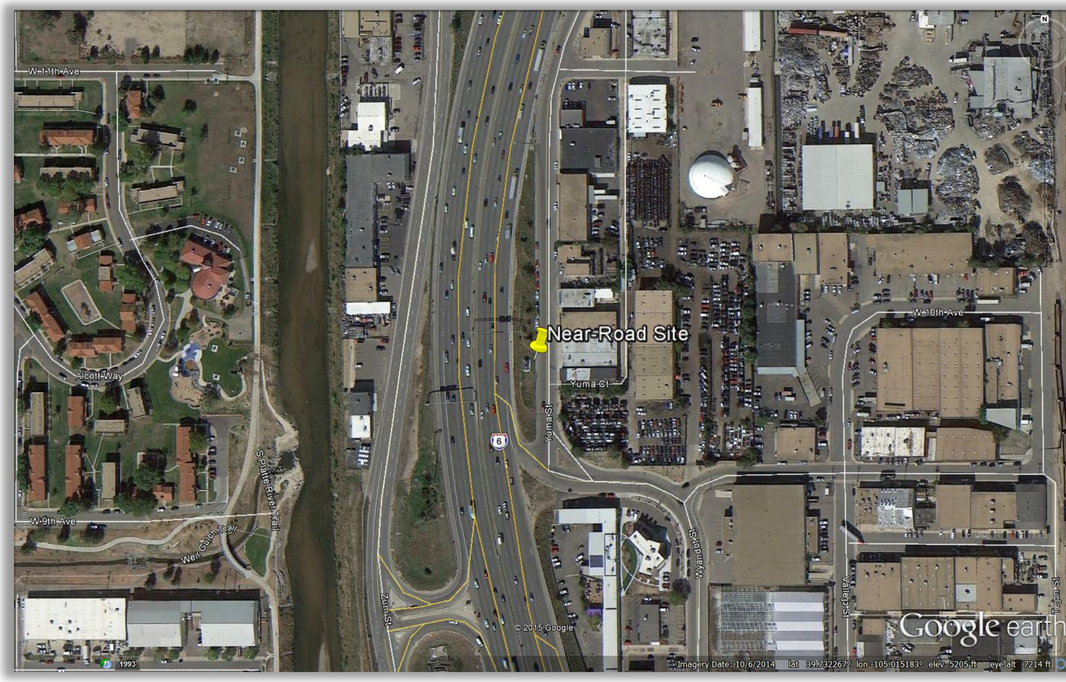


Figure 29. Top: Google Earth view of Denver near-road monitoring site next to I-25. Bottom: Google Earth street view of monitor (blue box) area looking south, with I-25 to the right of the monitor. Note how I-25 curves around the near-road monitoring site.

Figure 30 shows the diurnal pattern of $PM_{2.5}$ and of traffic, and Figure 31 shows the pollution rose of $PM_{2.5}$, at the Denver near-road site during February 2014. The $PM_{2.5}$ concentrations do not have the typical pattern of mobile-source dominated areas with morning and evening peaks, but instead follow the diurnal pattern of traffic at the site, which has a modest morning peak but is high throughout the daytime. In the pollution rose (Figure 31), the highest concentrations (dark green and blue) occur when winds are from the north, and to a lesser degree when they're from the south. When winds are from the west, directly from the adjacent freeway, concentrations are typically lower than they are when winds come from other directions.

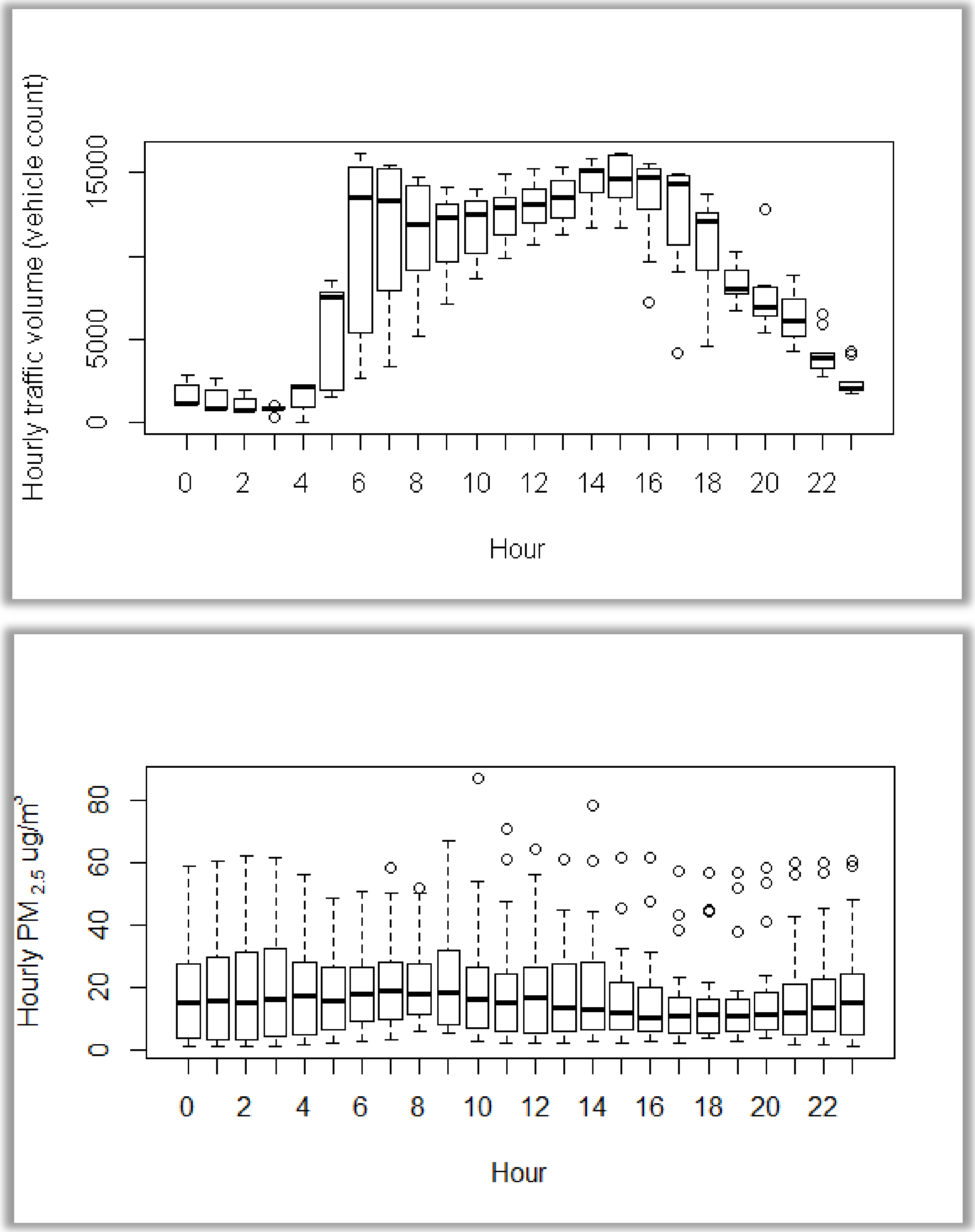


Figure 30. Box plots of (top) traffic count on I-25 and (bottom) $PM_{2.5}$ (µg/m^3) at the Denver near-road site by hour during February 2014.

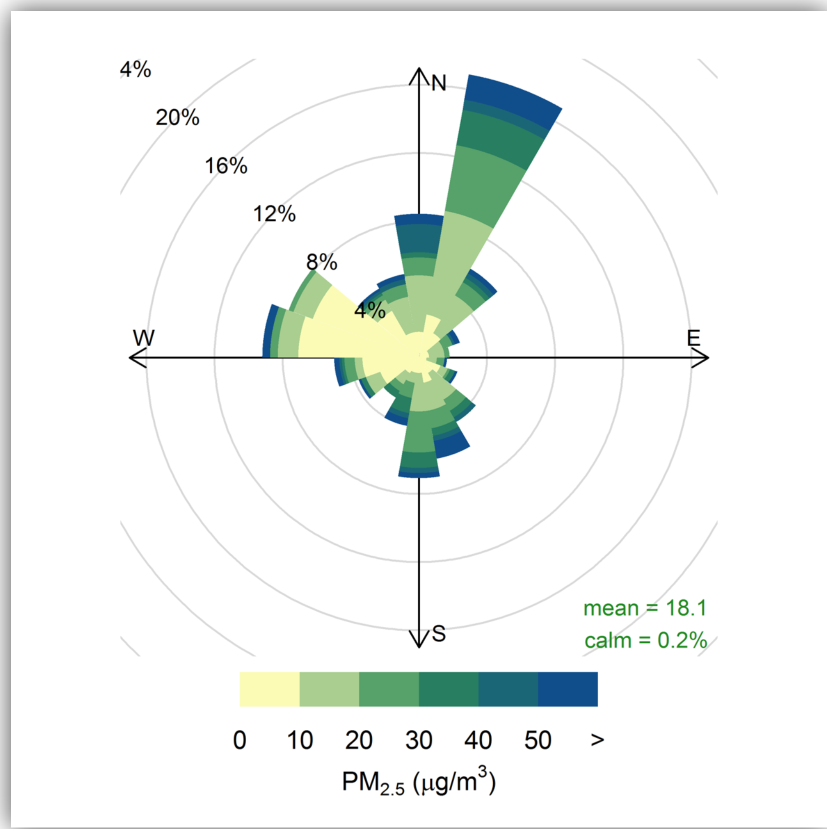


Figure 31. Pollution rose for hourly $PM_{2.5}$ concentrations (µg/m^3) at the Denver near-road site in February 2014. The size of each wedge indicates the frequency of wind direction. (For example, winds were out of the northeast nearly 25% of the time.) Color bands indicate the relative fraction of the time that concentrations occurred for each wind direction. (For example, when winds were from the northeast, concentrations of 10-20 µg/m^3 were most frequent, followed by concentrations of 20-30 µg/m^3.)

Figure 32 shows hourly and 24-hr average $PM_{2.5}$ concentrations at the near-road site in Denver for February 2014. Between February 2 and 12, four periods of relatively high $PM_{2.5}$ concentrations were measured. Hourly concentrations were high overnight on February 3-4, during the morning and afternoon of February 4, at midday on February 7, and throughout February 9 and 10. The 24-hr $PM_{2.5}$ concentrations exceeded 35 µg/m^3 on three days: February 7 (35.4 µg/m^3), February 9 (44.4 µg/m^3), and February 10 (57.0 µg/m^3). The February 10 $PM_{2.5}$ concentration was the highest 24-hr $PM_{2.5}$ value measured in 2014 across all of the EPA-mandated near-road monitoring sites. Section 4.1.1 focuses on the period of high observed $PM_{2.5}$ on February 2–12.

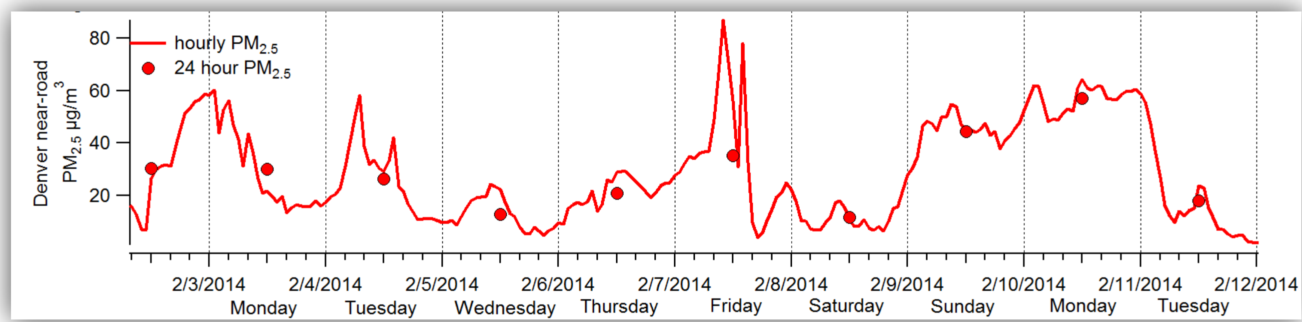


Figure 32. Hourly (red line) and 24-hr (red dots) $PM_{2.5}$ concentrations ($\mu g/m^3$) at the near-road site in Denver during February 2–12, 2014.

4.1.1 Analysis of February 2-12, 2014

Hourly $PM_{2.5}$ concentrations do not exhibit a consistent diurnal cycle during February 2–12, 2014. In some instances, hourly $PM_{2.5}$ concentrations peaked during the middle of the day (e.g., February 2 and 7), while in other cases, $PM_{2.5}$ concentrations were highest during the overnight hours (e.g., February 3). $PM_{2.5}$ concentrations were consistently elevated for multiple consecutive days between February 9 and 11. Figure 33 shows hourly and 24-hr $PM_{2.5}$ concentrations plus wind speed at the Denver near-road monitoring site during this time period. In general, $PM_{2.5}$ was higher when wind speeds were lower. Although wind speeds vary from day to day, they are generally higher during midday and afternoon.

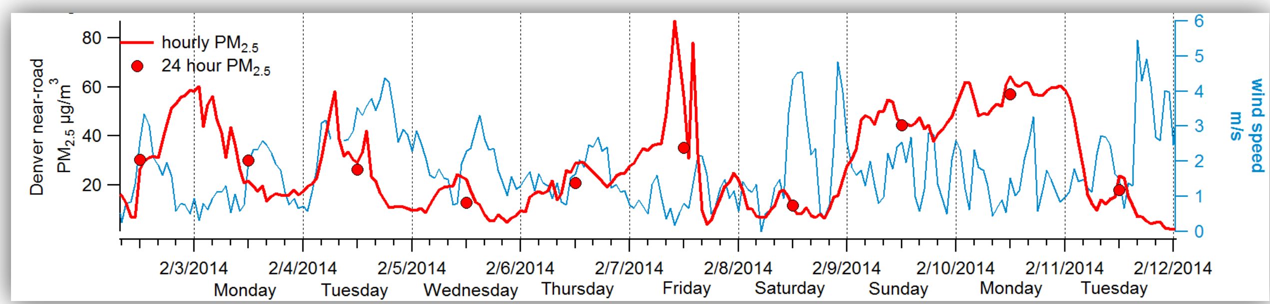


Figure 33. Hourly (red line) and 24-hr (red dots) $PM_{2.5}$ concentrations ($\mu g/m^3$), plus wind speed (m/s, blue line), at the near-road site in Denver during February 2–12, 2014.

Figure 34 shows the hourly and 24-hr $PM_{2.5}$ concentrations shown in Figure 33, alongside a chart showing whether the monitoring site was downwind or upwind of the freeway for each hour. Downwind is defined as winds originating from 180 to 360 degrees, and upwind is defined as winds originating from 0 to 180 degrees. As seen in the site map in Figure 29, the road's curvature means that when winds are from the north, the monitoring site is still downwind of the freeway. When hourly $PM_{2.5}$ concentrations were elevated, wind speeds were typically low and winds were often from the north (i.e., roughly parallel to the freeway), varying between upwind and downwind conditions.

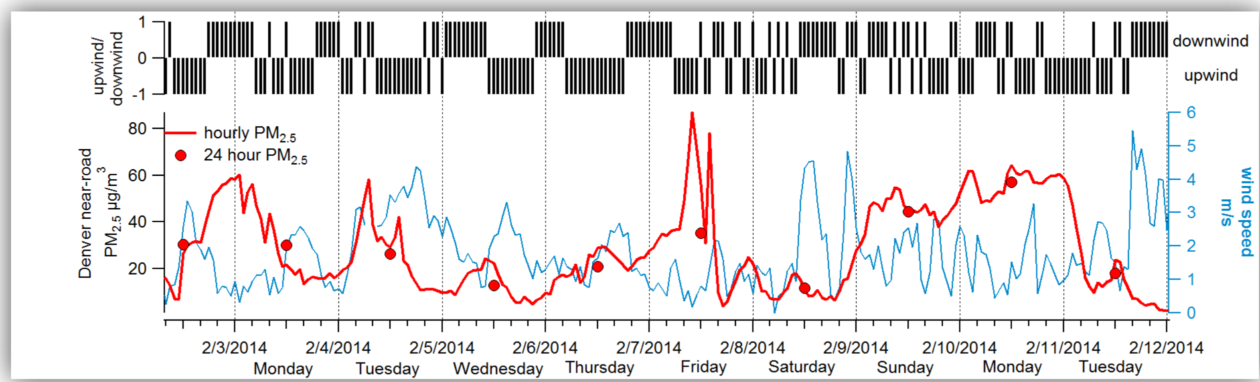


Figure 34. Hourly $PM_{2.5}$ concentrations (µg/m^3, red line), 24-hr $PM_{2.5}$ concentrations (µg/m^3, red dots), and wind speed (m/s, blue line) at the near-road site in Denver, and whether the monitoring site was upwind (0 to 180 degrees) or downwind (180 to 360 degrees) of the freeway (top, black bars) during February 2–12, 2014.

Figure 35 shows the data from Figure 32, overlaid with hourly NO, NO_2, and NO_x concentrations and temperature measured at the near-road site. In some cases, high hourly $PM_{2.5}$ concentrations coincided with high hourly NO_x concentrations (e.g., February 7). During other periods of high $PM_{2.5}$ concentrations, NO_x concentrations were not elevated (e.g., February 4). NO_2 concentrations were consistently low at the near-road site between February 2 and 12. There is no consistent relationship between NO/NO_2/NO_x or temperature and high $PM_{2.5}$; when the temperature was less than 20°F on February 5-6, $PM_{2.5}$ was relatively low.

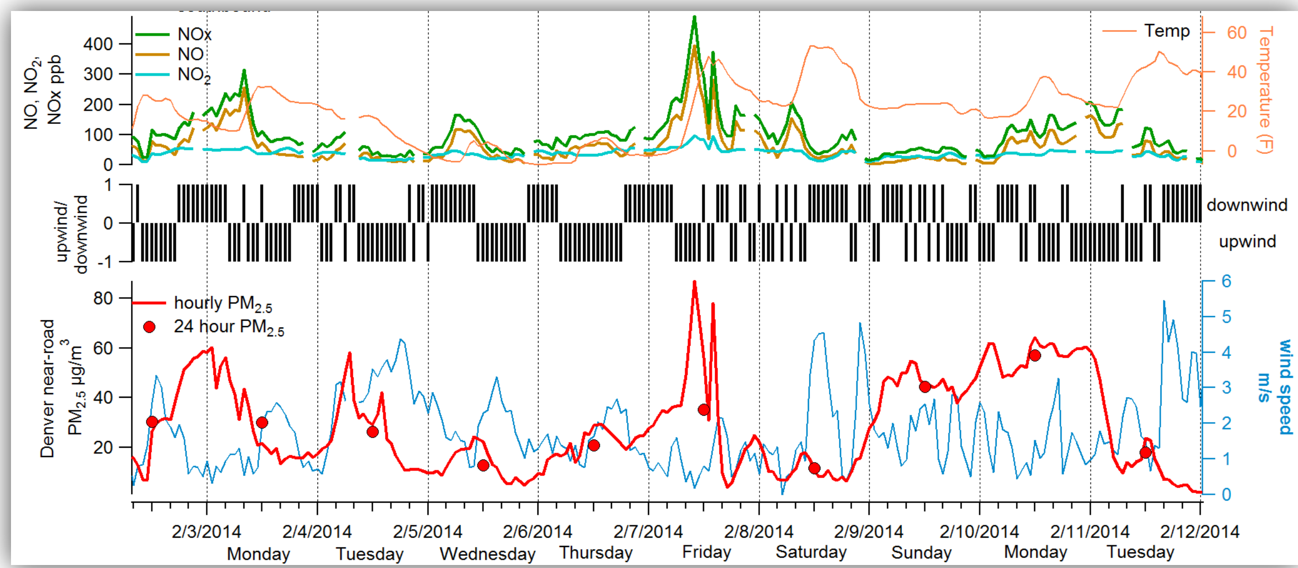


Figure 35. Hourly $PM_{2.5}$ concentrations (µg/m^3, red line), 24-hr $PM_{2.5}$ concentrations (µg/m^3, red dots), whether the monitoring site was upwind (0 to 180 degrees) or downwind (180 to 360 degrees) of the freeway (middle, black bars), NO_x concentrations (ppb, green line), NO concentrations (ppb, gold line), NO_2 concentrations (ppb, teal line), and temperature (°F, orange line) at the near-road site in Denver during February 2–12, 2014.

Figure 36 shows the air quality and meteorological data from Figure 35, overlaid with traffic volume and vehicle speed data from I-25, provided by Colorado DOT. Traffic volumes exhibit a typical diurnal activity pattern, with morning and afternoon peaks consistent with the morning and evening commute times. Traffic speeds are somewhat variable and do not track the diurnal signature of traffic volumes. Neither NO_x nor $PM_{2.5}$ concentrations are correlated with vehicle speeds or traffic volumes during February 2–12, 2014.

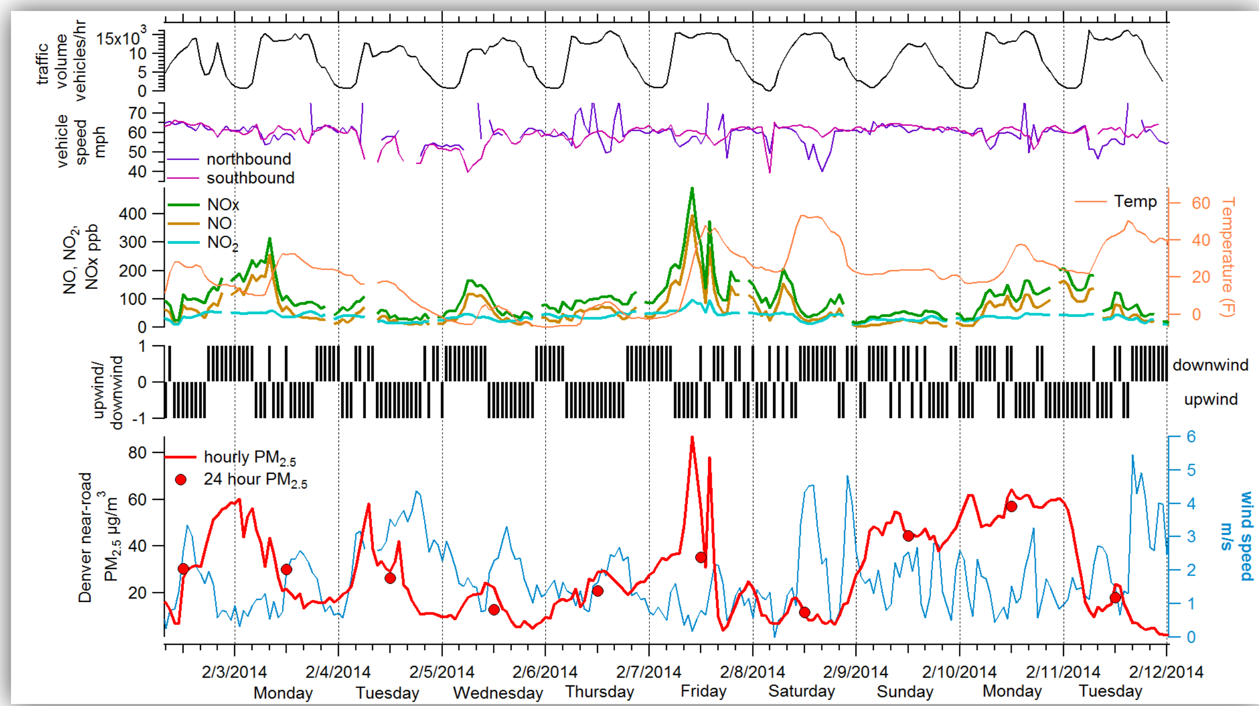


Figure 36. Hourly and 24-hr $PM_{2.5}$ concentrations ($\mu g/m^3$, red line), 24-hr $PM_{2.5}$ concentrations ($\mu g/m^3$, red dots), wind speed (m/s, blue line), whether the monitoring site was upwind (0 to 180 degrees) or downwind (180 to 360 degrees) of the freeway (black bars), NO_x concentrations (ppb, green line), NO concentrations (ppb, gold line), NO_2 concentrations (ppb, teal line), and temperature (°F, orange line) at the near-road site in Denver during February 2–12, 2014. Also shown are vehicle speeds on I-25 (northbound, purple line; southbound, dark pink line) and traffic volume on I-25 (black line). Traffic data are for I-25 at 6th Ave, approximately 700 m south of the monitoring site.

4.1.2 Comparison of Near-Road to Urban Concentrations

Next, we examined $PM_{2.5}$ data from nearby sites, to assess whether all sites varied together, indicating an urban-scale $PM_{2.5}$ signature. Figure 37 shows the hourly and 24-hr $PM_{2.5}$ concentrations at the near-road site and at three nearby regional $PM_{2.5}$ monitoring sites, and the difference between the concentrations at the near-road site and the maximum of the concentrations across the other nearby sites. Hourly $PM_{2.5}$ concentrations at the near-road site are closely correlated with concentrations at nearby sites. $PM_{2.5}$ concentrations are typically higher at the near-road site than at the regional sites. Hourly $PM_{2.5}$ concentrations are higher at the near-road site than at the nearby regional CAMP, 14th and Albion, and La Casa $PM_{2.5}$ monitoring sites during 71% of the hours in February 2014; 24-hr concentrations are higher at the near-road site than at the nearby regional sites 79% of the days in 2014. Furthermore, concentrations at the near-road site are typically higher than concentrations at other sites when $PM_{2.5}$ concentrations are high. For example, on February 9 and 10, hourly $PM_{2.5}$ concentrations at the near-road site were 7–12 µg/m^3 higher than at other nearby sites for multiple hours. Figure 38 shows a plot similar to Figure 37, but for 24-hr average $PM_{2.5}$ concentrations at all sites during February 2014. For 24-hr concentrations during February 2014, the near-road site had the highest concentrations of any of the sites in Denver on all but one day, regardless of wind speed or other factors.

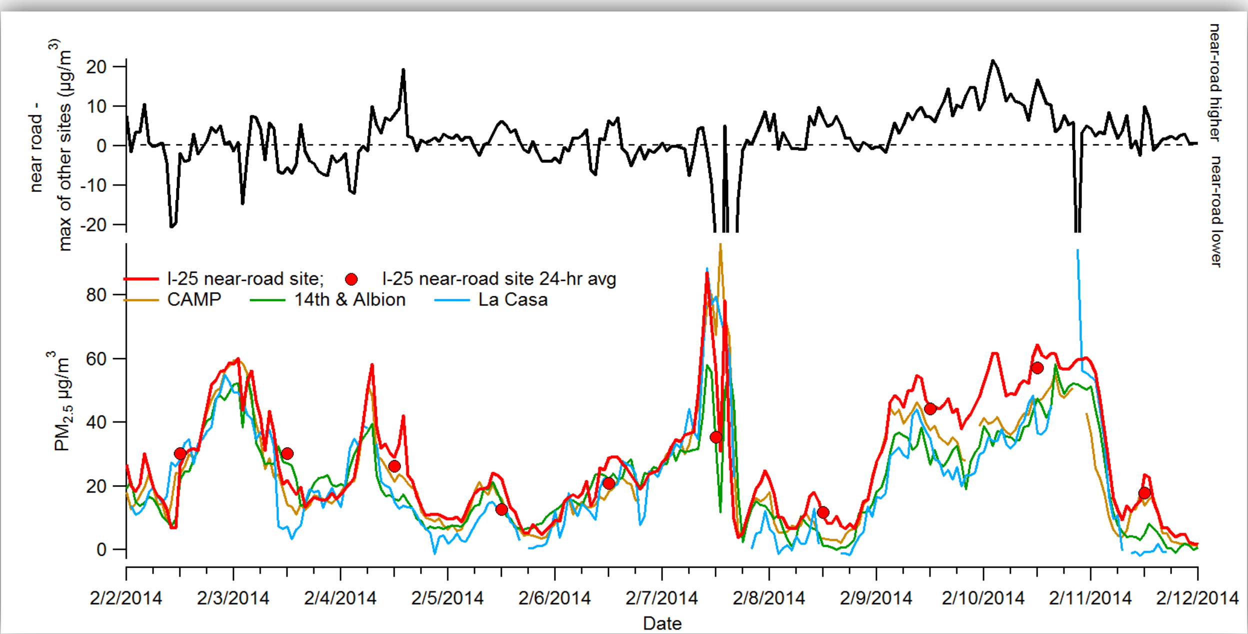


Figure 37. Daily (red dots) and hourly (red line) $PM_{2.5}$ concentrations (µg/m^3) at the near-road site and the nearby CAMP (gold line), 14th and Albion (green line), and La Casa (blue line) monitoring sites in Denver during February 2–12, 2014, and the difference between hourly $PM_{2.5}$ concentrations (µg/m^3) at the near-road site and the maximum hourly $PM_{2.5}$ concentration (µg/m^3) at the nearby sites (black line).

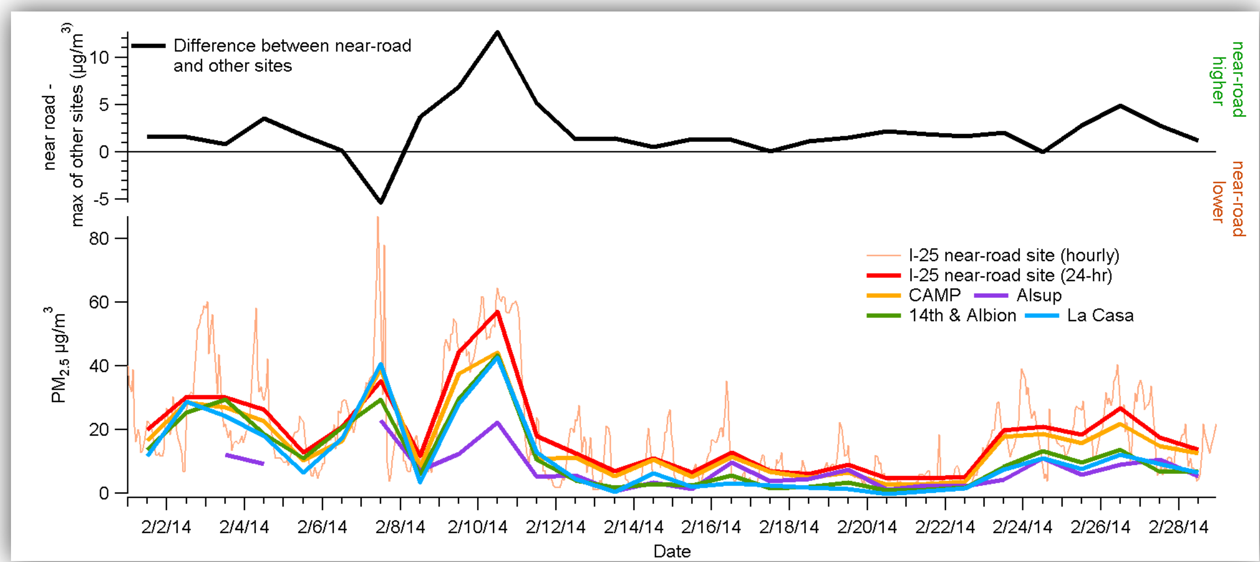


Figure 38. Hourly (thin orange line) and 24-hr $PM_{2.5}$ concentrations ($\mu g/m^3$, thick colored lines) at the near-road and nearby sites during February 2014, and the difference between 24-hr $PM_{2.5}$ concentrations ($\mu g/m^3$) at the near-road site and the maximum 24-hr $PM_{2.5}$ concentration ($\mu g/m^3$) at the nearby sites (black line).

Next, we examined whether the excess concentrations typically found at the near-road site occurred only when the near-road site was downwind of the freeway, or if the near-road site recorded higher concentrations than other sites regardless of wind direction. To better depict the variation of $PM_{2.5}$ with wind direction for data collected during February 2014, Figure 39 shows wind direction versus the difference between hourly $PM_{2.5}$ concentrations at the near-road site and the maximum of hourly $PM_{2.5}$ concentrations at nearby regional sites. Observations are sized by wind speed and colored by PM concentration, since wind direction measurements are highly uncertain under low-wind-speed conditions. The near-road site typically recorded the highest hourly concentrations of any site in Denver during February 2014, regardless of wind direction and wind speed.

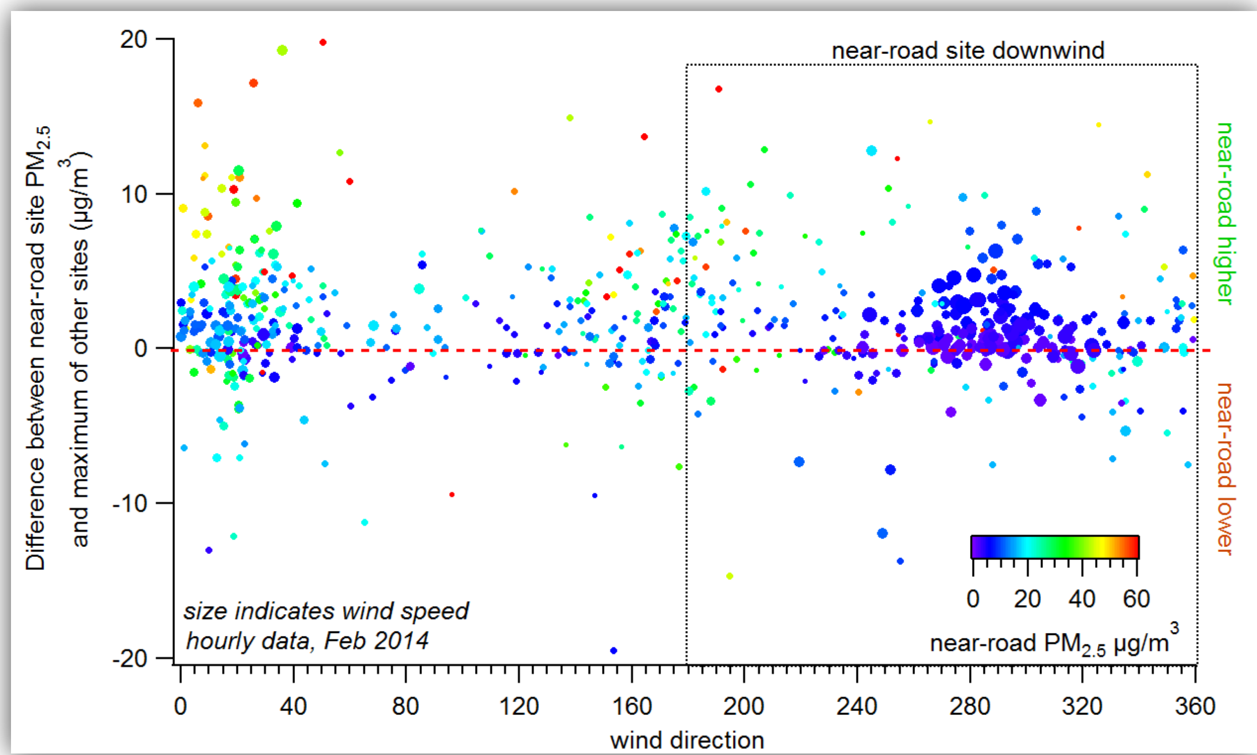


Figure 39. Wind direction versus the difference between hourly $PM_{2.5}$ concentrations at the near-road site and the maximum of hourly $PM_{2.5}$ concentrations at nearby sites for data collected during February 2014. Observations are sized by wind speed, so that larger points indicate higher wind speed, and are colored by near-road $PM_{2.5}$ concentration. Points above the horizontal dotted line indicate that hourly $PM_{2.5}$ concentrations at the near-road site were higher than concentrations at the nearby sites (CAMP, 14th and Alsup, and La Casa), whereas points below the line indicate that hourly $PM_{2.5}$ concentrations at the near-road site were lower than at the regional sites. The black box shows data collected when the near-road site was downwind of I-25 (i.e., winds were from 180 to 360 degrees).

Since the near-road site consistently had the highest $PM_{2.5}$ concentrations during February, we examined whether this is true throughout the year. Figure 40 shows the daily $PM_{2.5}$ concentrations during 2014 for the Denver near-road site, the maximum concentration observed at other nearby sites, and the difference in concentration between the near-road site and the maximum concentration among other nearby sites. On 79% of the days in 2014, the near-road site measured the highest concentration of sites in Denver; on 10 out of 365 days, the near-road site concentration was lower than the other sites' concentrations by at least 5 µg/m^3. The scatter plot in Figure 41 provides additional context, showing the difference between the near-road site's 24-hr near-road $PM_{2.5}$ concentrations and the maximum concentrations at other nearby sites. The near-road site's PM concentration is consistently higher than concentrations at other nearby sites, except on some days with high $PM_{2.5}$.

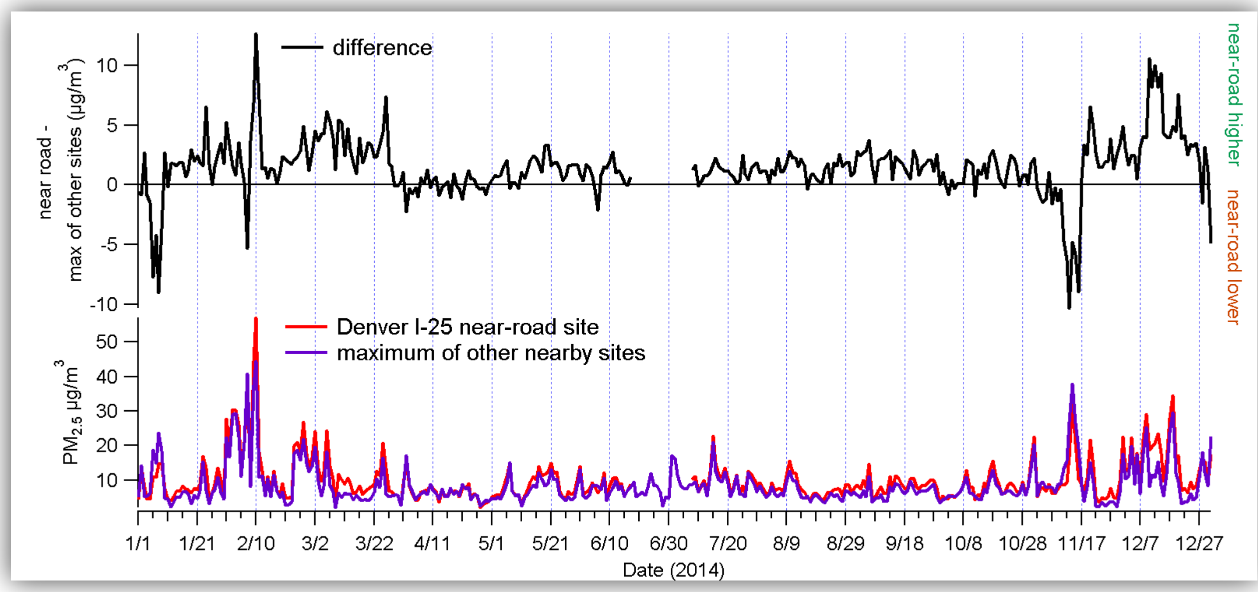


Figure 40. Daily $PM_{2.5}$ concentration at the official Denver near-road site, the maximum concentration of all other nearby sites, and the difference between the two concentrations during 2014.

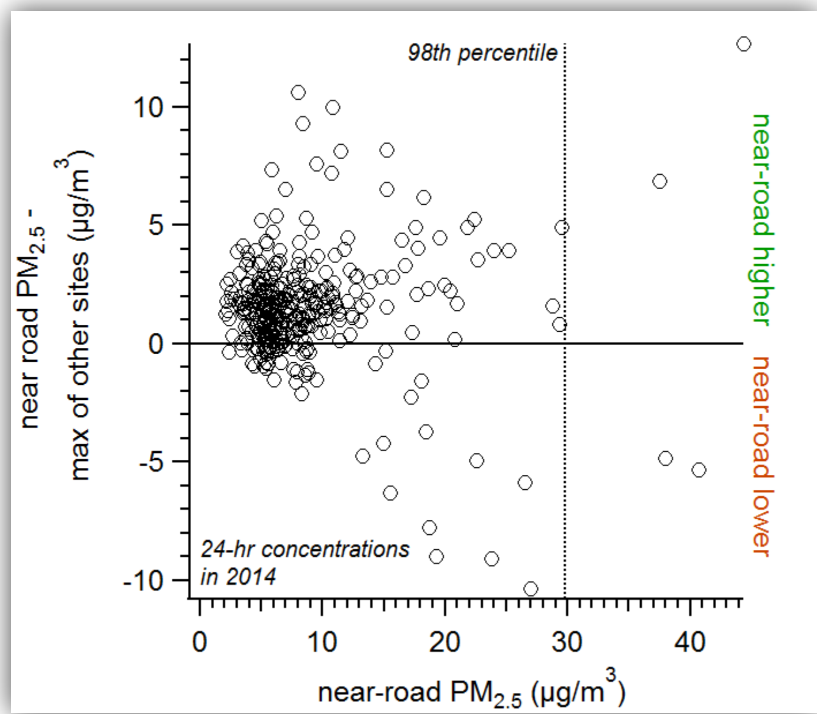


Figure 41. Comparison of 24-hr $PM_{2.5}$ concentrations at the near-road site and the maximum of 24-hr $PM_{2.5}$ concentrations at nearby sites during 2014.

In summary, the Denver near-road site consistently has the highest $PM_{2.5}$ in the Denver area. As seen in specific high-$PM_{2.5}$ events during February 2014 and year-round in 2014, the near-road site is typically highest regardless of meteorology and season, except for some days when Denver experiences high $PM_{2.5}$ and the near-road site is not the location of highest concentrations. The high near-road concentration events during February 2014 do not appear to be caused by unusual traffic conditions next to the monitoring site; the high concentrations are largely driven by regional $PM_{2.5}$ conditions. Typically, including during the February 2014 $PM_{2.5}$ events, the near-road site has higher $PM_{2.5}$ concentrations than the other urban sites, indicating that emissions from the roadway contributed to the $PM_{2.5}$ at the near-road site.

As seen in this case study, near-road $PM_{2.5}$ concentrations result from a complex mix of factors. Here, concentrations were typically higher when winds were closer to parallel to the freeway, rather than perpendicular; with the alignment of the freeway, even under these near-parallel winds, the monitoring site is still downwind of the freeway. However, there was no clear link between unusual or increased traffic and high near-road $PM_{2.5}$ concentrations. Despite the lack of correlation between concentrations and traffic activity upwind of the monitor, regardless of time of year and meteorology, the near-road site was typically the highest $PM_{2.5}$ site in the Denver urban area.

4.2 Los Angeles Area Near-Road Case Study: High $PM_{2.5}$ Events in 2015

Of the 33 instances in 2015 when a 24-hr average $PM_{2.5}$ concentration measured at an official near-road monitor was at or above 35 µg/m^3, 20 occurred in the greater Los Angeles area. In this case study, we examined high $PM_{2.5}$ events during 2015 when Los Angeles-area near-road monitoring sites in Long Beach (adjacent to I-710) and Ontario (adjacent to State Route [SR] 60) measured 24-hr average $PM_{2.5}$ concentrations above the NAAQS threshold of 35 µg/m^3. A majority of the high concentration events occurred on different days; however, concentrations were high at both near-road sites and at other neighboring sites on February 18–19, 2015. In this section, we provide an overview of the site location and $PM_{2.5}$ concentrations during 2015 at each of the Long Beach and Ontario sites, followed by a more detailed look at individual high-$PM_{2.5}$ days and how concentrations compare with traffic volumes, meteorological conditions, NO_x concentrations, and $PM_{2.5}$ concentrations at nearby monitors.

4.2.1 Overview of the Long Beach and Ontario Near-Road Sites

Figure 42 shows the locations of the Long Beach and Ontario near-road monitoring sites, other $PM_{2.5}$ monitoring sites within 15 miles of the near-road sites, and the Long Beach and Ontario airports. Both the Long Beach and Ontario near-road sites measure daily 24-hr average $PM_{2.5}$ concentrations; hourly $PM_{2.5}$ concentrations and meteorological data are not available at either monitor. Daily Quality Controlled Local Climatological Data (QCLCD) for Long Beach and Ontario airports for 2015 were obtained for comparison from the NOAA National Centers for Environmental Information website (http://www.ncdc.noaa.gov/qclcd/QCLCD?prior=N). Airport meteorological data likely do not capture local-scale meteorological conditions at the near-road monitors but are included to illustrate the general weather patterns in the area.

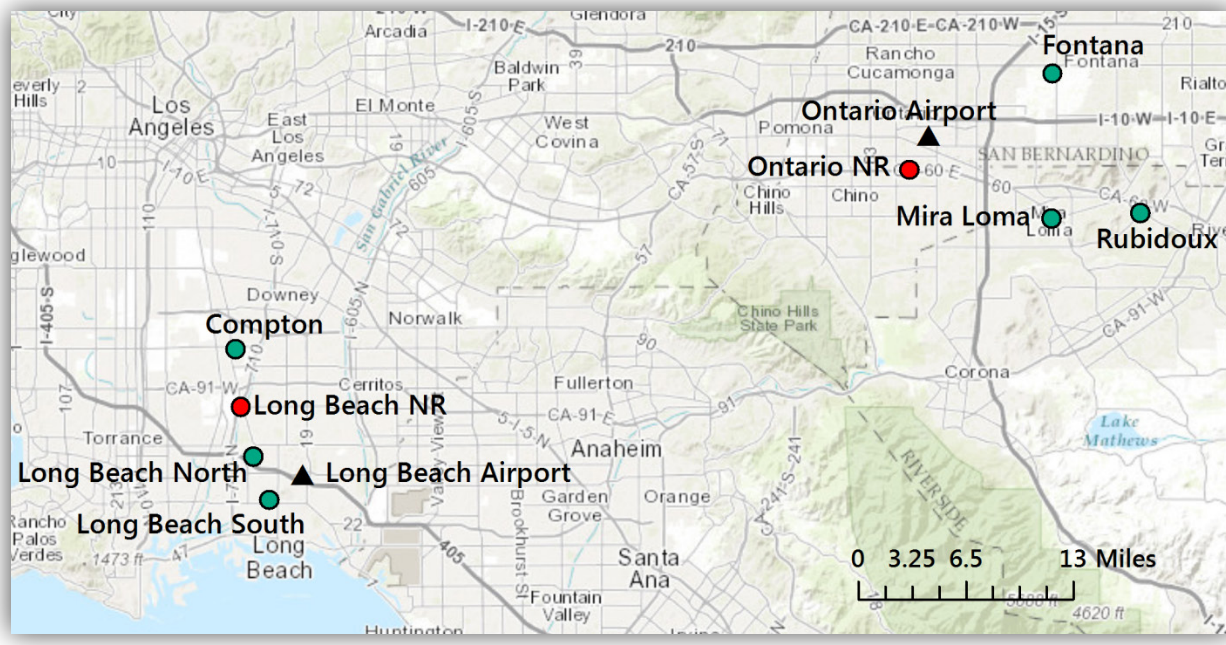


Figure 42. The locations of $PM_{2.5}$ monitoring sites (green dots) within 15 miles of the Long Beach and Ontario $PM_{2.5}$ near-road monitoring sites (red dots), and the locations of the Long Beach and Ontario airports (black triangles).

4.2.2 Analysis of 2015 Long Beach Near-Road Site Data

The near-road monitoring site in Long Beach, California, is southeast of I-710, approximately 16 miles south of downtown Los Angeles. Three $PM_{2.5}$ monitoring sites within approximately 15 miles of the near-road site were identified. Figure 43 shows an aerial view of the Long Beach near-road monitoring site. At the site location, I-710 has an AADT of 192,000 and an FE-AADT of 619,008; the site is approximately 9 m southeast of the edge of the freeway.

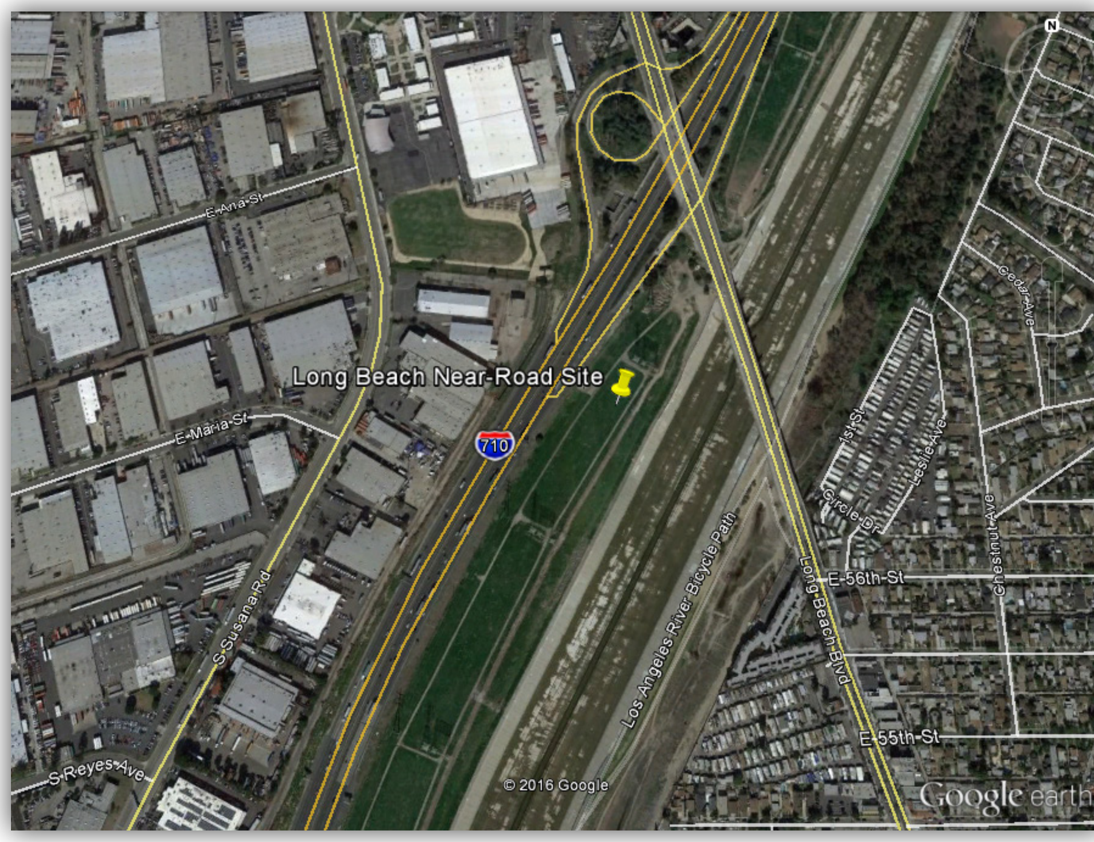


Figure 43. Google Earth view of the Long Beach near-road monitoring site next to I-710.

Figure 44 shows a pollution rose of $PM_{2.5}$ at the Long Beach near-road site during 2015. The highest concentrations occur when winds are from the west, and to a lesser degree, when winds are from the south.

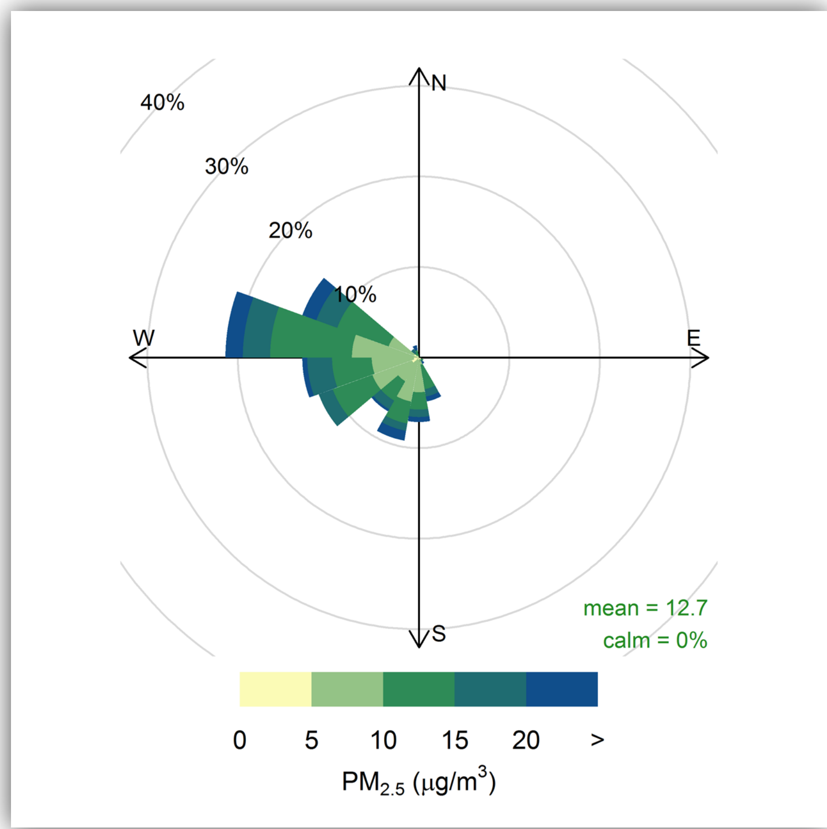


Figure 44. Pollution rose showing 24-hour averaged $PM_{2.5}$ and wind direction at the Long Beach near-road site during 2015. Wind data are from the nearby Long Beach Airport meteorological monitoring site.

At the Long Beach near-road site, 24-hr average $PM_{2.5}$ concentrations were above 35 µg/m^3 on seven days in 2015 (Figure 45). All seven high-$PM_{2.5}$ days occurred in the first half of 2015, between January 1, 2015, and April 30, 2015.

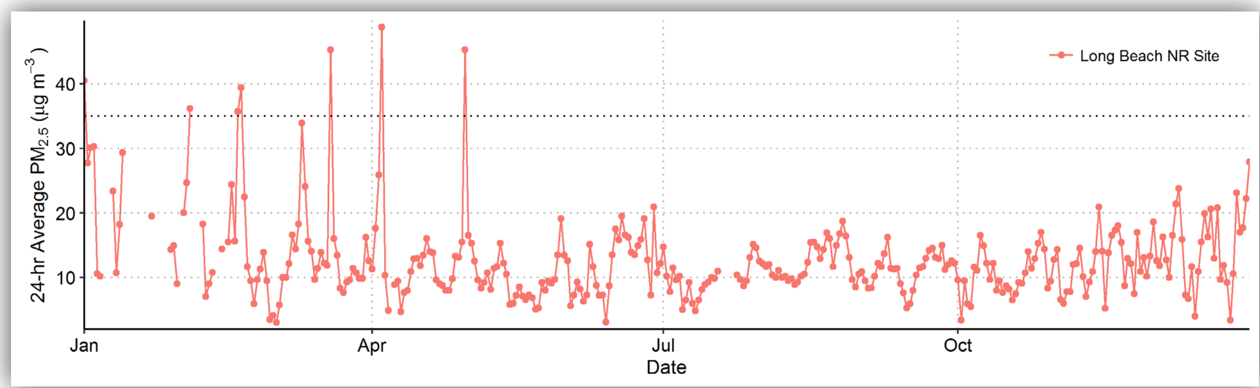


Figure 45. 24-hr average $PM_{2.5}$ concentrations (µg/m^3) at the near-road site in Long Beach during 2015. Points above the dotted horizontal line show $PM_{2.5}$ concentrations above 35 µg/m^3.

Figure 46 shows daily 24-hr average $PM_{2.5}$ concentrations for 2015 at the near-road site and at three nearby $PM_{2.5}$ monitoring sites. Daily $PM_{2.5}$ concentrations at the Long Beach near-road site typically are modestly correlated with concentrations at nearby sites (r^2 values of 0.52-0.62 between Long Beach near-road site and Long Beach North, Long Beach South, and Compton sites). During three days in March-April, concentrations at the near-road site were substantially higher than at nearby sites.

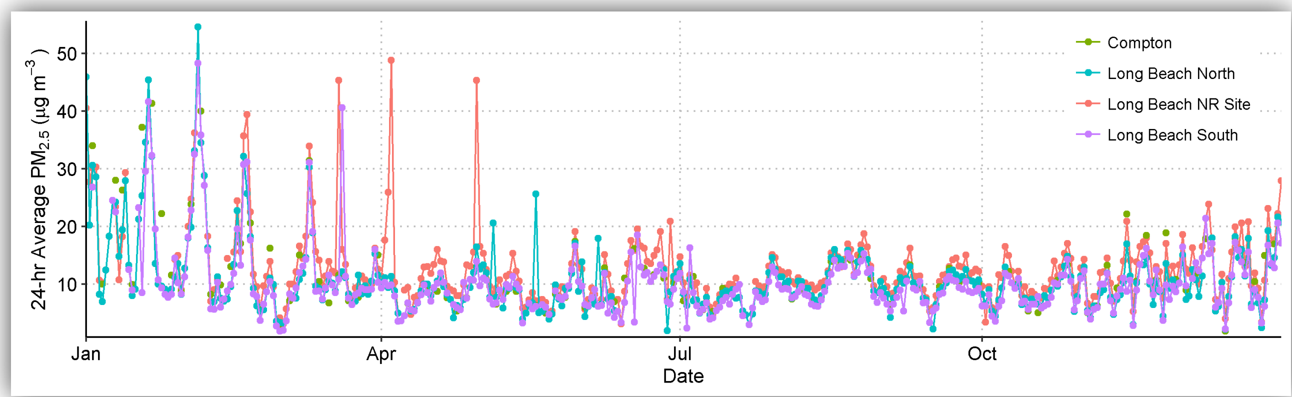


Figure 46. 24-hr average $PM_{2.5}$ concentrations (µg/m^3) at the near-road site in Long Beach and at nearby monitoring sites in 2015.

Figure 47 shows the difference between $PM_{2.5}$ concentrations at the near-road site and the maximum of the concentrations across the other nearby sites. Daily average $PM_{2.5}$ concentrations were higher at the near-road site than at nearby sites on approximately 82% of days in 2015; $PM_{2.5}$ concentrations were more than 5 µg/m^3 higher at the near-road site than at nearby sites on 15 days. On three days in March and April, concentrations at the near-road site were more than 25 µg/m^3 higher than at nearby sites. The average near-road increment on all days in 2015 is 1.6 µg/m^3 (median: 1.5 µg/m^3).

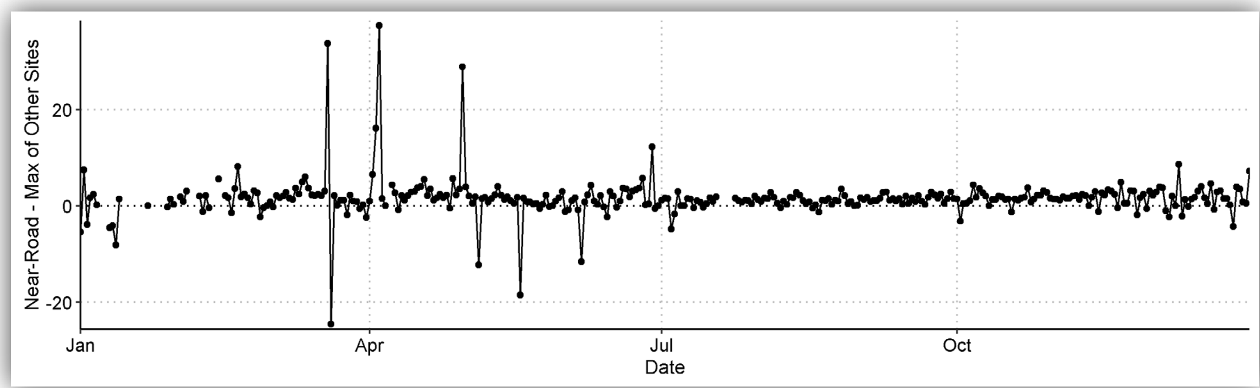


Figure 47. The difference between 24-hr $PM_{2.5}$ concentrations at the Long Beach near-road site and the maximum of the 24-hr $PM_{2.5}$ concentration at the nearby sites in 2015.

Figure 48 shows daily $PM_{2.5}$ concentrations at the Long Beach near-road site versus the difference between the concentrations at the near-road site and the maximum among nearby sites. Points above the horizontal dotted line show values where the near-road site was higher than the maximum among nearby sites. Points right of the vertical dotted line show values greater than 35 µg/m^3 reported by the near-road site. On six of the seven high-$PM_{2.5}$ days (i.e., greater than 35 µg/m^3), concentrations at the near-road site were higher than the maximum concentration among nearby sites.

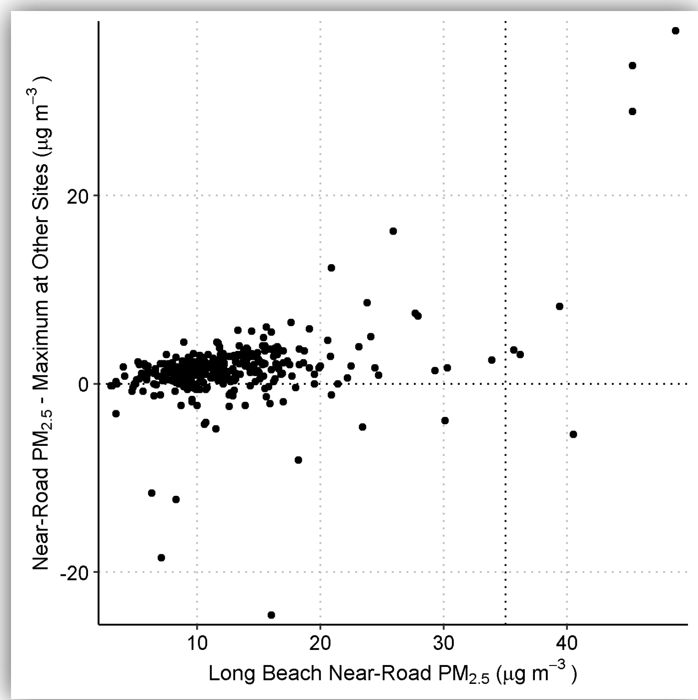


Figure 48. Daily 2015 $PM_{2.5}$ concentrations at the Long Beach near-road site versus the difference between the concentration at the near-road site and maximum among nearby sites.

Table 12 summarizes $PM_{2.5}$ concentration, meteorological, and traffic data on the seven days in 2015 when $PM_{2.5}$ concentrations were greater than 35 µg/m^3 at the near-road site. On three of the high-$PM_{2.5}$ days, the concentration was 3.1 to 8.2 µg/m^3 higher than at nearby sites; and on three days, concentrations were much higher (28.9 to 37.5 µg/m^3) than concentrations at nearby monitors. All three days when concentrations were substantially higher at the near-road site occurred in March or April. To show whether meteorological or traffic conditions were unusual on the high-concentration days and may have contributed to the high concentration episodes at the near-road site, Table 12 also provides the average $PM_{2.5}$, meteorological, and traffic data for spring 2015. On March 19 and April 30, truck volumes and total traffic volumes were higher than the springtime average; however, on April 4, volumes were much lower than the springtime average because it was a Saturday. In addition, we did not find any reports of unusual traffic accidents or stoppages on the three days where the near-road site was much higher than nearby sites. Average wind speed tended to be lower on high-$PM_{2.5}$ days; temperature, wind direction, and vehicle speed were not substantially different on the high-$PM_{2.5}$ days than the springtime average.

Table 12. $PM_{2.5}$ concentration at Long Beach near-road site, meteorological, and traffic data on days during 2015 when $PM_{2.5}$ concentrations were greater than 35 µg/m^3 at the Long Beach near-road site and the average values during spring 2015 (italicized row). Bold rows show dates when concentrations were substantially higher at the near-road site than at nearby sites. The monitoring site is downwind of the freeway when winds are from roughly 220 to 360 degrees.

Date	Near-Road $PM_{2.5}$ (µg/m^3)	Maximum Nearby $PM_{2.5}$ (µg/m^3)	Near-Road – Maximum Nearby $PM_{2.5}$ (µg/m^3)	Daily Max Temperature (°F)	Daily Average Wind Speed (mph)	Daily Average Wind Direction (degrees)	Daily Average Speed (mph)	Daily Average Truck Volume	Daily Average Total Traffic Volume
1/1/2015	40.5	45.9	-5.4	58	0.4	150	68	1,870	104,376
2/3/2015	36.2	33.1	3.1	69	1	260	53	15,026	180,908
2/18/2015	35.7	32.1	3.6	72	1.1	300	61	21,098	219,270
2/19/2015	39.4	31.2	8.2	69	0.9	210	60	20,709	219,957
3/19/2015	**45.3**	**11.5**	**33.8**	**74**	**1.7**	**260**	**56**	**26,486**	**233,187**
4/4/2015	**48.8**	**11.3**	**37.5**	**84**	**2.2**	**280**	**64**	**8,060**	**173,688**
4/30/2015	**45.3**	**16.4**	**28.9**	**89**	**3.9**	**290**	**59**	**26,150**	**236,212**
Average in Mar-May 2015	*11.3*	*10.0*	*1.3*	*75*	*3.3*	*246*	*59*	*18,799*	*206,161*

NO_x measurements began at the Long Beach near-road site on April 1, 2015. Figure 49 shows $PM_{2.5}$, NO, NO_2, and NO_x concentrations at the near-road site in April through May 2015. NO_x concentrations were not especially high on April 4 or April 30, when $PM_{2.5}$ concentrations were much higher there than at nearby sites.

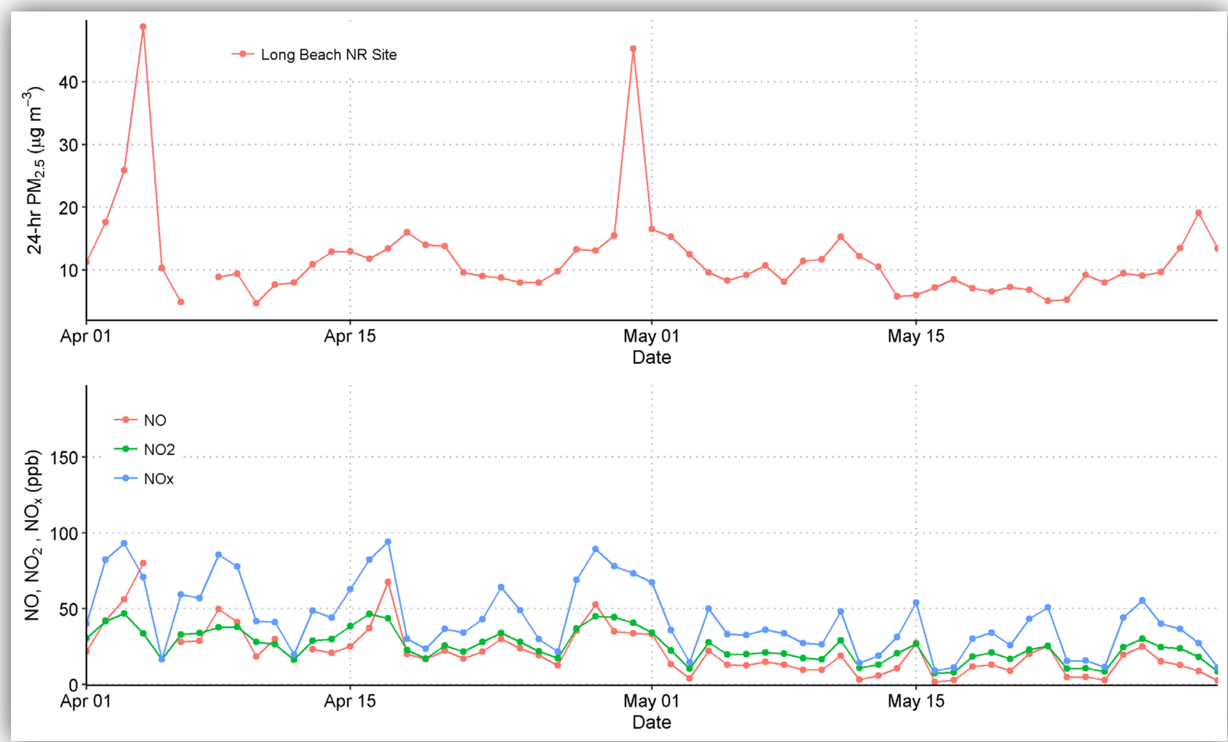


Figure 49. Daily $PM_{2.5}$ concentrations (top) and NO, NO_2, and NO_x concentrations (bottom) at the Long Beach near-road site during April–May 2015.

4.2.3 Analysis of 2015 Ontario Near-Road Site Data

There are two official near-road monitoring sites in Ontario, California, but only one of the two sites measures $PM_{2.5}$ concentrations. The Ontario $PM_{2.5}$ near-road site is north of SR-60, approximately 43 miles east of Los Angeles. Three $PM_{2.5}$ monitoring sites within approximately 15 miles of the SR-60 near-road site were identified. Figure 50 shows an aerial view of the SR-60 Ontario near-road site. At the monitoring site location, SR-60 has an AADT of 215,000 and an FE-AADT of 625,736; the monitoring site is approximately 9 m north of the edge of the freeway.

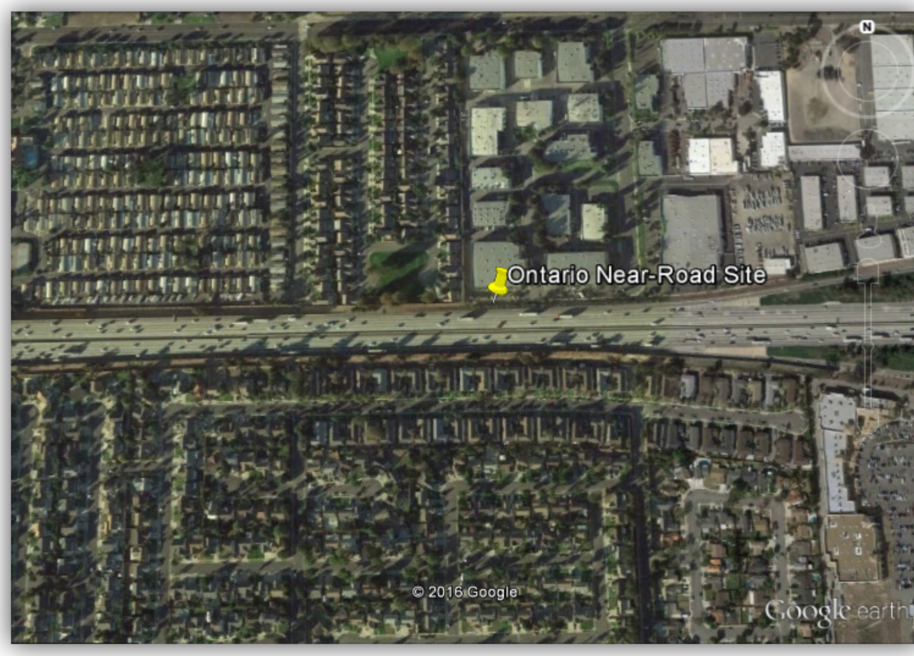


Figure 50. Google Earth view of the Ontario near-road monitoring site next to and north of SR-60.

Figure 51 shows a pollution rose of $PM_{2.5}$ at the Ontario SR-60 near-road site during 2015. Winds are predominately from the west and southwest; high $PM_{2.5}$ concentrations occurred when winds were from the west/southwest and, to a much lesser extent, when winds were from the north.

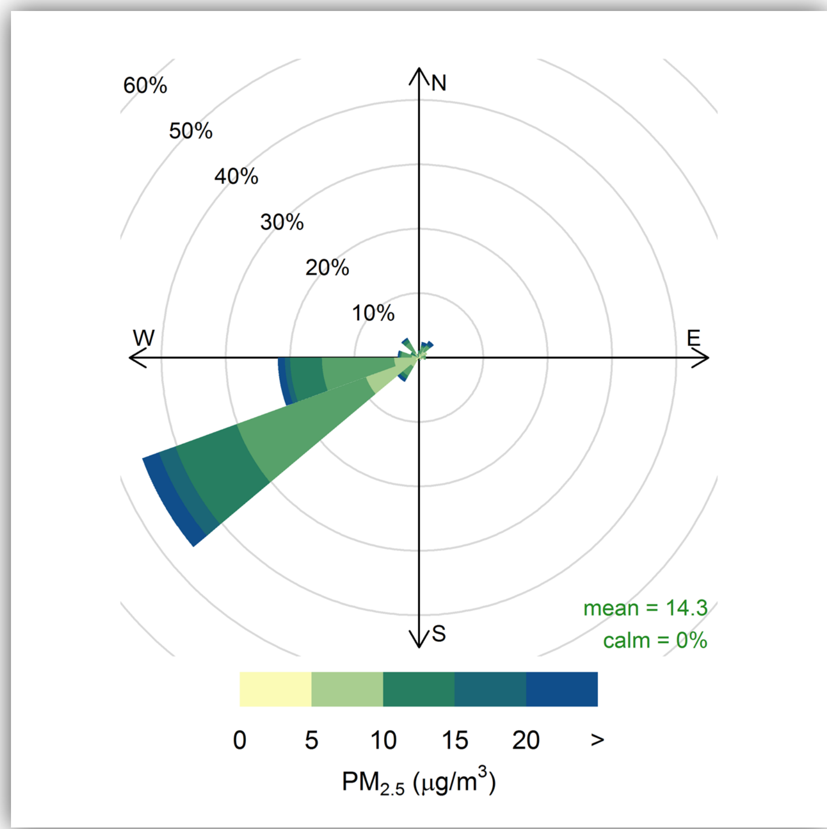


Figure 51. Pollution rose showing 24-hour average $PM_{2.5}$ and wind direction at the Ontario, California, near-road site for 2015.

On 11 days in 2015, 24-hr average $PM_{2.5}$ concentrations were above 35 µg/m^3 at the Ontario near-road $PM_{2.5}$ monitoring site (Figure 52). All 11 high-$PM_{2.5}$ days occurred in the first half of 2015, spanning January 3 to June 29.

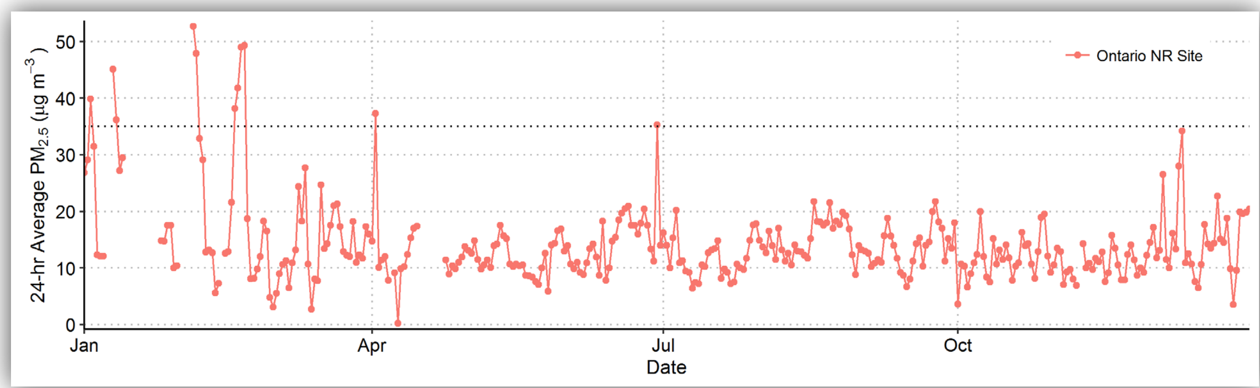


Figure 52. 24-hr average $PM_{2.5}$ concentrations (µg/m^3) at the near-road site in Ontario during 2015. Points above the dotted horizontal line show when $PM_{2.5}$ concentrations were above 35 µg/m^3.

Figure 53 shows daily 24-hr average $PM_{2.5}$ concentrations for 2015 at the near-road site and at three nearby $PM_{2.5}$ monitoring sites. On a majority of days, daily $PM_{2.5}$ concentrations at the Ontario near-road site were modestly correlated with concentrations at nearby sites (r^2 values of 0.64-0.69).

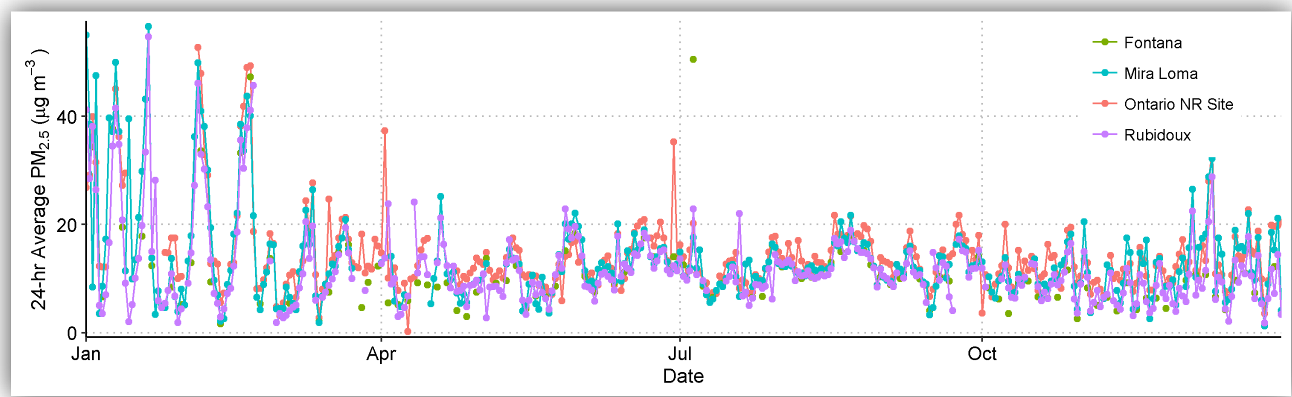


Figure 53. 24-hr average $PM_{2.5}$ concentrations (µg/m^3) at the near-road site in Ontario and at nearby monitoring sites during 2015.

Figure 54 shows the difference between $PM_{2.5}$ concentrations at the Ontario near-road site and the maximum of the concentrations across the other nearby sites. Daily average $PM_{2.5}$ concentrations at the near-road site were higher than $PM_{2.5}$ concentrations at nearby sites on 73% of days in 2015; $PM_{2.5}$ concentrations were more than 5 µg/m^3 higher at the near-road site than nearby sites on 24 days. The average near-road increment on all days in 2015 was 1.0 µg/m^3 (median: 1.4 µg/m^3).

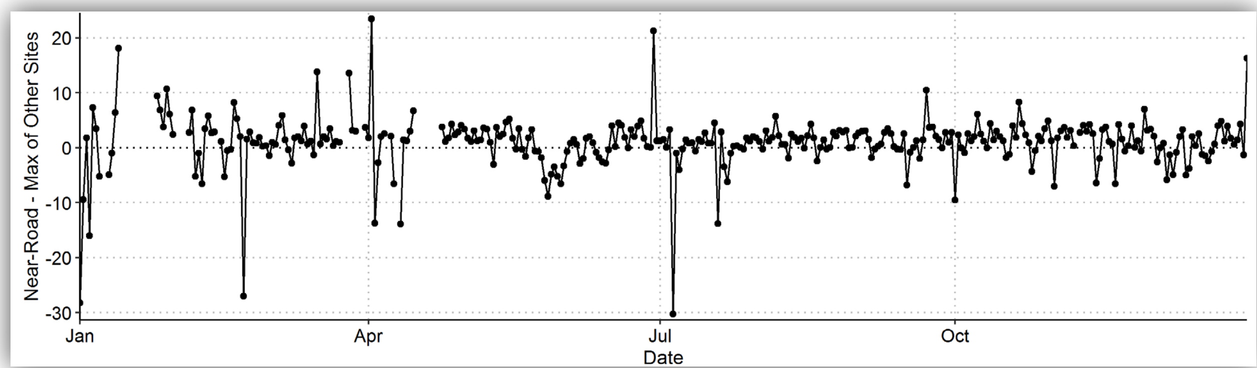


Figure 54. The difference between 24-hr $PM_{2.5}$ concentrations at the Ontario near-road site and the maximum 24-hr $PM_{2.5}$ concentration at the nearby sites.

Figure 55 shows daily $PM_{2.5}$ concentrations at the Ontario near-road site versus the difference between the concentration at the near-road site and the maximum among nearby sites. Points above the horizontal dotted line show values where the near-road site was higher than the maximum among nearby sites. Points right of the vertical dotted line show values reported at the near-road site greater than 35 µg/m^3. On eight of the 11 high-$PM_{2.5}$ days, $PM_{2.5}$ concentrations at the near-road site were higher than the maximum concentration among nearby sites.

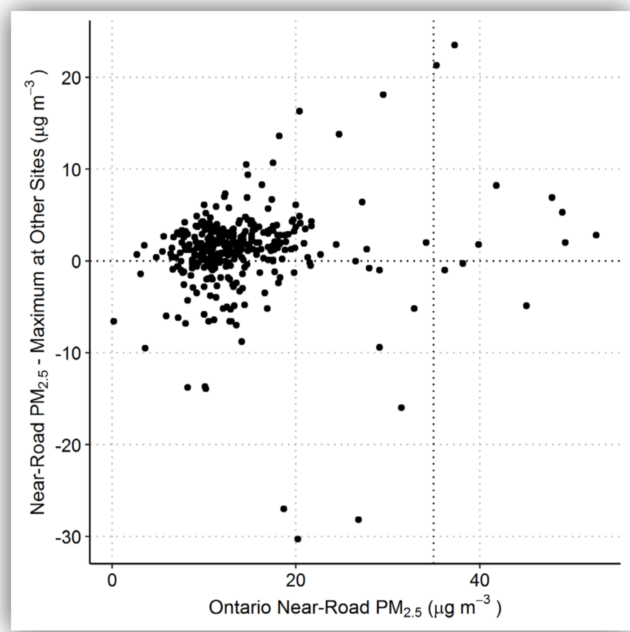


Figure 55. Daily $PM_{2.5}$ concentrations at the Ontario near-road site versus the difference between the concentration at the near-road site and the maximum among nearby sites.

Table 13 summarizes $PM_{2.5}$ concentration, meteorological, and traffic data on the 11 days in 2015 when $PM_{2.5}$ concentrations were greater than 35 µg/m^3 at the Ontario site. On six of the high-$PM_{2.5}$ days, the concentration was somewhat higher there than at nearby sites, ranging from 1.8 to 8.2 µg/m^3 higher; and on two days (April 2 and June 29), concentrations were 21.3 and 23.5 µg/m^3 higher than concentrations at nearby monitors. To show whether meteorological or traffic conditions were unusual on the high-concentration days and may have contributed to the high concentration episodes at the near-road site, Table 13 also provides the average $PM_{2.5}$, meteorological, and traffic data for spring and summer 2015. Truck volumes and total traffic volumes were higher and wind speeds were lower than seasonal averages on several of the days when $PM_{2.5}$ concentrations were higher at the near-road site than nearby sites. An internet search found no large traffic disturbances on the two days where the near-road site was much higher than nearby sites. Average temperature, wind direction, and vehicle speed on the high-$PM_{2.5}$ days were not substantially different from the spring and summer averages. Winds were typically from the west on high-concentration days. NO_x measurements began on August 1, 2015, and thus were not available on the high-$PM_{2.5}$ days.

Table 13. $PM_{2.5}$ concentration at Ontario near-road site, meteorological, and traffic data on days during 2015 when $PM_{2.5}$ concentrations were greater than 35 µg/m^3 at the Long Beach near-road site and the average values during spring 2015 (italicized row). Bold rows show dates when concentrations were substantially higher at the near-road site than at nearby sites. The monitoring site is downwind of the freeway when winds are from roughly 135 to 225 degrees.

Date	Near-Road $PM_{2.5}$ (µg/m^3)	Maximum Nearby $PM_{2.5}$ (µg/m^3)	Near-Road - Maximum Nearby $PM_{2.5}$ (µg/m^3)	Daily Max Temperature (°F)	Resultant Wind Speed (mph)	Resultant Wind Direction (degrees)	Speed (mph)	Truck Volume	Total Traffic Volume
1/3/2015	39.9	38.1	1.8	60	0.3	20	65	3,923	173,100
1/10/2015	45.1	50.0	-4.9	62	0.4	250	64	4,117	178,523
1/11/2015	36.2	37.2	-1.0	58	0.8	230	64	2,936	133,986
2/4/2015	52.7	49.9	2.8	78	0.5	220	58	7,426	213,575
2/5/2015	47.9	41.0	6.9	84	1.5	250	59	7,087	218,810
2/17/2015	38.2	38.5	-0.3	75	3.0	240	61	6,044	213,358
2/18/2015	41.8	33.6	8.2	78	2.8	260	61	7,589	219,376
2/19/2015	49.0	43.7	5.3	77	3.4	250	59	7,348	218,674
2/20/2015	49.3	47.3	2.0	72	3.1	260	60	7,137	229,847
4/2/2015	**37.3**	**13.8**	**23.5**	**77**	**3.7**	**270**	**60**	**7,628**	**226,236**
6/29/2015	**35.3**	**14.0**	**21.3**	**97**	**5.6**	**250**	**58**	**6,844**	**216,487**
Mar-May 2015	*12.4*	*11.4*	*1.0*	*78*	*5.0*	*242*	*59*	*6,102*	*206,692*
Jun-Aug 2015	*13.7*	*13.3*	*0.4*	*92*	*5.9*	*250*	*59*	*6,329*	*206,816*

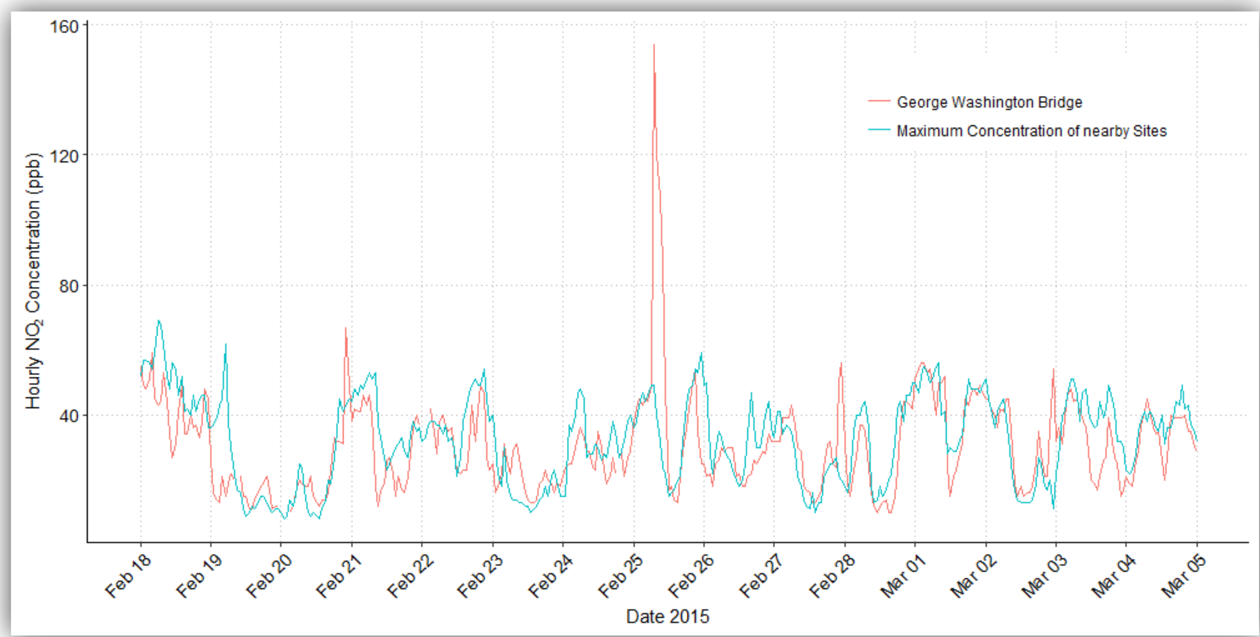
4.2.4 Ontario and Long Beach Summary

In summary, 24-hr average $PM_{2.5}$ concentrations at the Los Angeles-area near-road sites during 2015 were modestly correlated (r^2 of 0.52-0.69) with concentrations at nearby monitoring sites. Neither the Long Beach nor the Ontario near-road site consistently recorded concentrations higher than those at the nearby sites in the Los Angeles area. Higher traffic volumes and lower wind speeds relative to seasonal averages suggest that these factors may have contributed to some of the high near-road concentration events during 2015; however, on other days with high traffic volumes and low wind speeds, concentrations were not elevated compared with nearby sites. Therefore, it appears unlikely that these factors were the sole cause of the enhanced concentrations. In general, there is no obvious explanation of why the highest $PM_{2.5}$ increments were substantially higher than concentrations at nearby sites. More extensive investigation may be needed to understand the causal factors for these high-$PM_{2.5}$ days. Unlike in Denver, where hourly air pollution data were available to help describe the causal factors leading to high concentrations, Long Beach and Ontario only provide daily averaged $PM_{2.5}$ data, making interpretation of high-concentration days more difficult.

4.3 High NO_2 Concentrations: George Washington Bridge, NY/NJ

The near-road air quality monitoring site for the New York-New Jersey CBSA is next to the George Washington Bridge (GWB) toll booth on I-95 in New Jersey. Hourly NO_2 concentrations were greater than 100 ppb on February 25, 2015. The location of the site is shown in **Figure 56**. The peak hourly NO_2 concentration at the near-road site was 153 ppb at 7:00 a.m. on February 25 (**Figure 57**). The hourly NO_2 data and the daily maximum of hourly data at the near-road GWB site were compared to data from regional NO_2 monitors within 200 km of the GWB site. The NO_2 concentrations measured at the GWB site were significantly higher than the concentrations at the sites in the surrounding region on February 25.

Figure 56. The location of the New York-New Jersey CBSA near-road air quality monitoring site on the New Jersey side of the George Washington Bridge toll booth on Interstate 95.



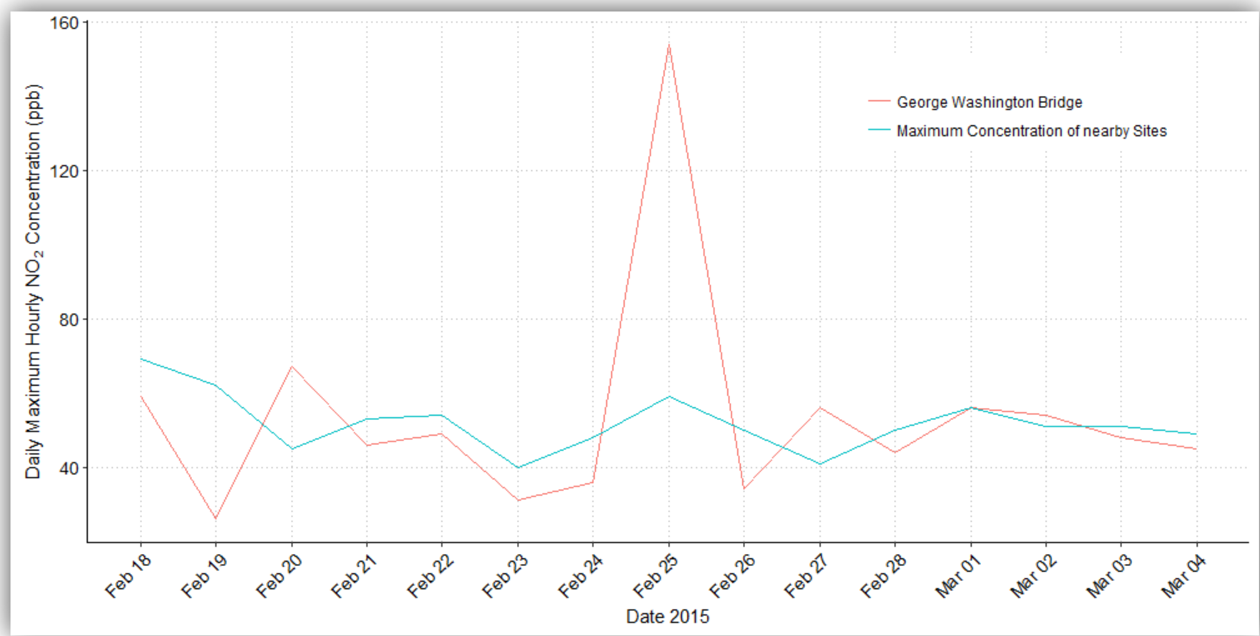


Figure 57. Hourly NO_2 concentrations (top) and daily maximum 1-hr NO_2 concentrations (bottom) at the near-road site (red line) versus peak values among 11 nearby NO_2 monitoring sites (blue lines).

Wind data were available at the near-road site. Wind speeds were fairly low (3–5 mph), indicating that emissions from the roadway could potentially accumulate at the GWB monitoring site. Morning wind flow from the west (approximately 270 degrees) could exacerbate near road pollution, since wind flow was nearly parallel to the road. The hourly data from 6:00 to 11:00 a.m. on February 25 were submitted to AQS with a qualifier code ("RR") indicating a "unique traffic disturbance" near the monitor. Hourly NO, NO_2 and $PM_{2.5}$ concentrations on February 25 are shown in **Figure 58**; all three pollutants show a significant enhancement on the morning of February 25. The peak hourly values of NO_2, NO, and $PM_{2.5}$ occurred at 7:00, 8:00 and 9:00 a.m. respectively.

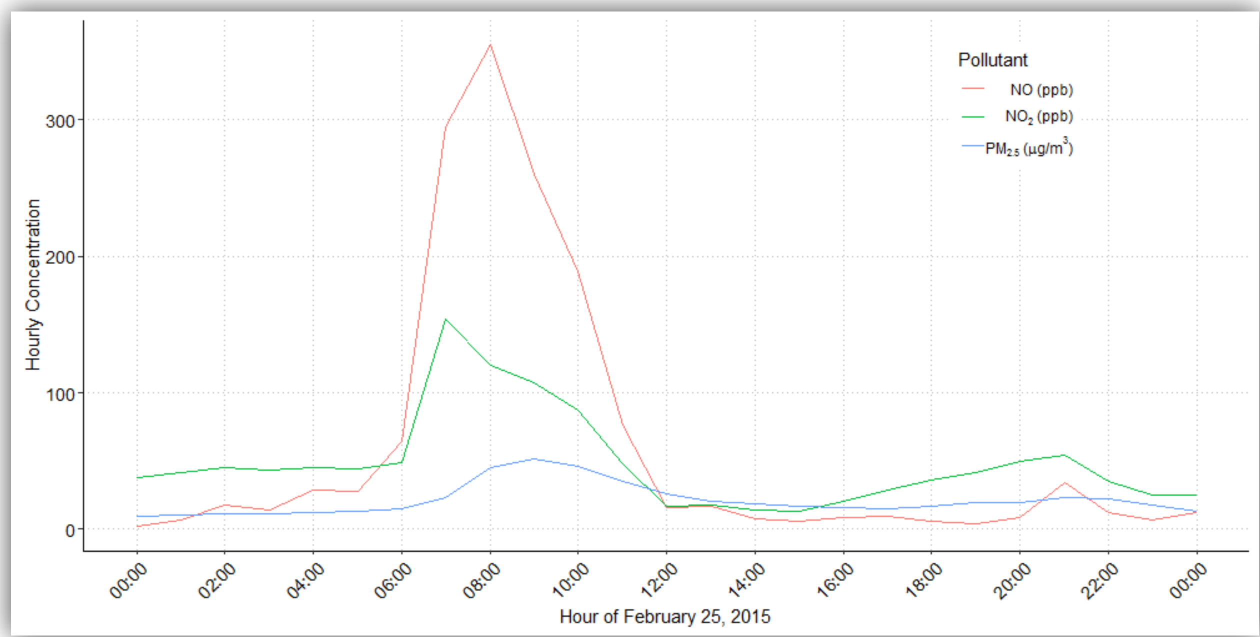


Figure 58. Hourly concentrations of NO, NO_2, and $PM_{2.5}$ on February 25, 2015.

The monitor is located near the toll booth, where many lanes pass through the booths. Linking New Jersey to New York City, the bridge has been ranked one of the worst traffic bottlenecks in the region;[5] major traffic delays during rush hour traffic are common. At 8:41 a.m. on February 25, 2015, the Port Authority of New York and New Jersey issued a traffic advisory of a 15-minute delay following a traffic incident on the Cross Bronx Expressway.[6] The combination of meteorological conditions, high traffic volumes, and a traffic incident all occurring during peak morning travel hours suggests that traffic likely played a major role in the high NO, NO_2, and $PM_{2.5}$ concentrations. This finding is consistent with the fact that the air quality monitors in the surrounding region did not detect particularly elevated NO_2 levels at this time (surrounding monitors remained below 60 ppb; see Figure 57). In summary, it is likely that the morning traffic contributed to the high NO_2 concentrations, since the high NO_2 concentrations were localized only at this monitoring site; however, without hourly traffic data this conclusion is not definitive.

[5] http://wagner.nyu.edu/blog/rudincenter/tag/george-washington-bridge/
[6] https://twitter.com/search?q=from%3APANYNJ_GWB%20since%3A2015-02-22%20until%3A2015-02-28&src=typd&lang=en

4.4 High NO_2 Concentrations: Seattle, WA

The near-road air quality monitoring site in Seattle is along I-5, just north of the I-5/I-90 interchange (Figure 59). The Seattle site is approximately 8 m east of the edge of I-5; the AADT is 237,000, and the FE-AADT is 471,630.

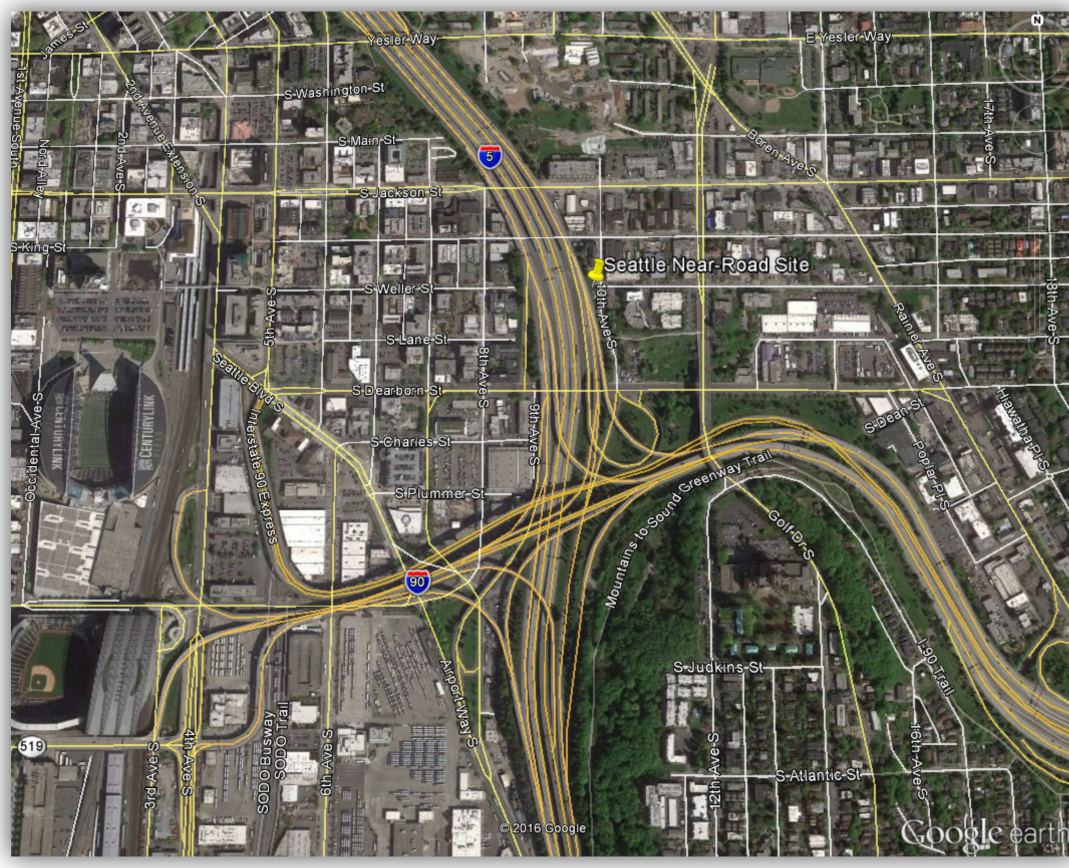
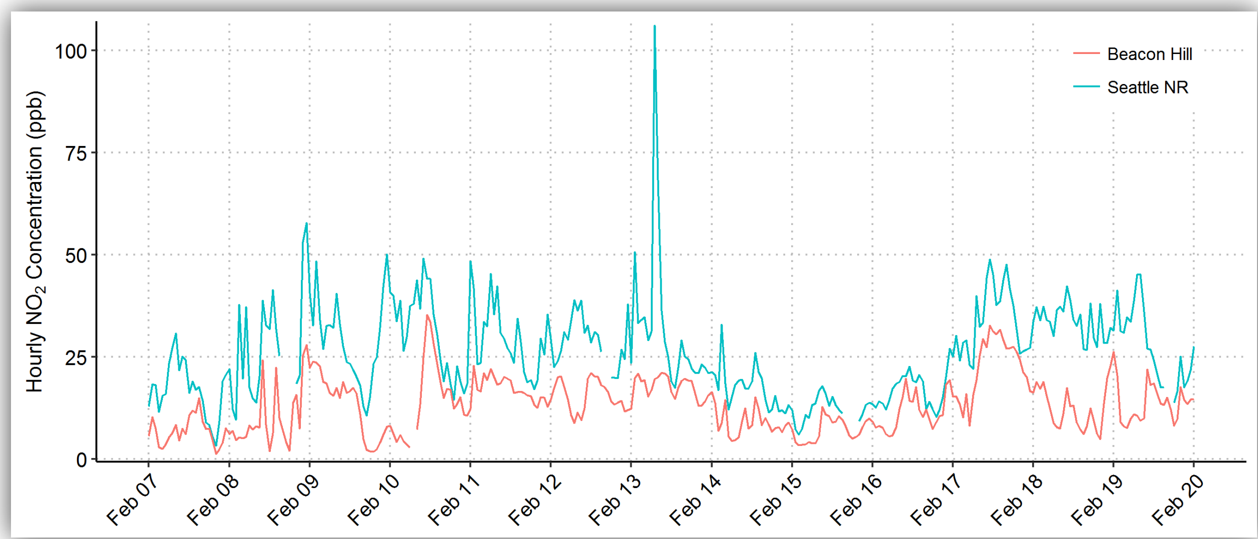


Figure 59. Google Earth view of the Seattle near-road monitoring site just east of I-5.

On February 13, 2015, hourly NO_2 at the Seattle near-road site reached 106.1 ppb at 3:00 p.m. PST, the second highest daily 1-hour maximum across all sites in 2015 The hourly NO_2 data and the daily maximum of hourly data at the near-road Seattle site were compared to data from the regional Beacon Hill NO_2 monitor, which is approximately 3.3 km south of the near-road site (Figure 60). The hourly NO_2 concentrations at the near-road site are consistently higher than concentrations at the nearby Beacon Hill site. Daily maximum 1-hr NO_2 concentrations are correlated between sites; however, concentrations were much higher at the near-road site than at the Beacon Hill site on February 13.



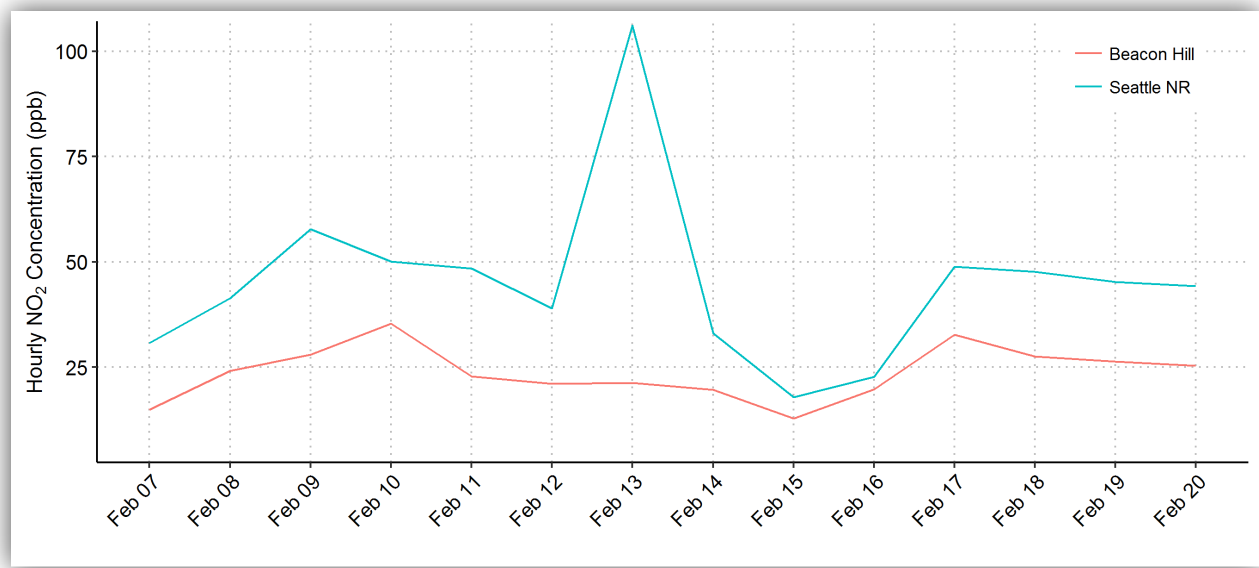


Figure 60. Hourly NO_2 concentrations (top) and daily maximum 1-hr NO_2 concentrations (bottom) at the near-road site (blue line) versus values at the nearby Beacon Hill regional monitoring site (red line).

Wind data were collected at the near-road site during 2015. Wind speeds measured at the near-road site on February 13 were low, ranging from 1.3 to 3.9 mph (not shown). The wind direction was variable in the morning hours, but a steady westerly flow set in between 9:00 a.m. and 5:00 p.m., during which time the near-road site was directly downwind of the I-5 freeway. The combination of low wind speeds and westerly flow means that emissions from the roadway may have accumulated at the Seattle near-road site.

Figures 61 and 62 show hourly NO, NO_2, CO, and $PM_{2.5}$ at the Seattle near-road monitor on February 13, 2015. NO, NO_2, and CO show an enhancement on the afternoon of February 13; peak NO occurred at 3:00 p.m., coincident with the peak NO_2 concentration. There was a large increase in CO concentrations between 2:00 p.m. and 3:00 p.m.; peak CO at the site occurred at 4:00 p.m. $PM_{2.5}$ concentrations were moderately high at 3:00 p.m. but were not as well-correlated with NO_2 concentrations; the peak $PM_{2.5}$ concentration occurred at 9:00 a.m.

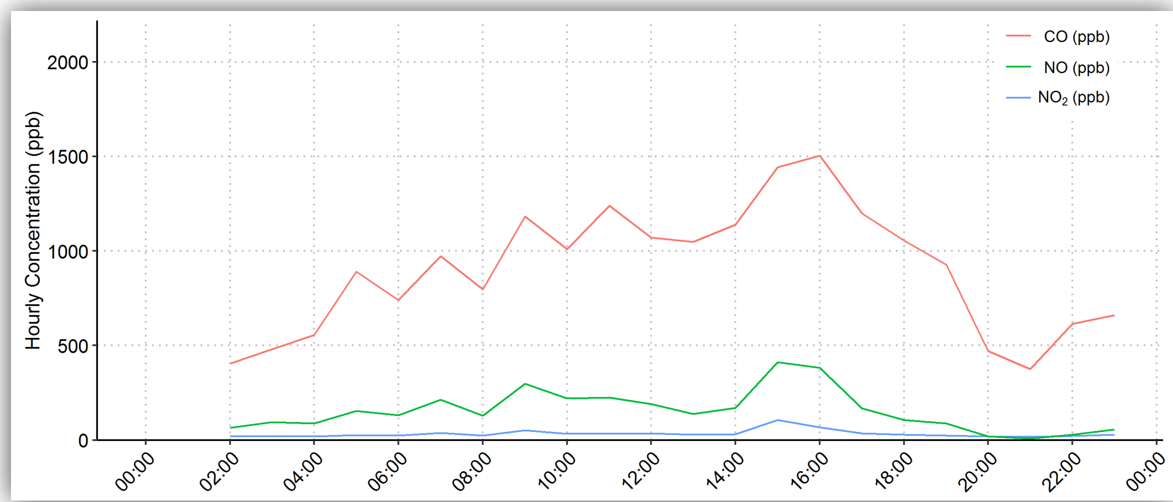


Figure 61. Hourly concentrations of NO, NO_2, and CO on February 13, 2015.

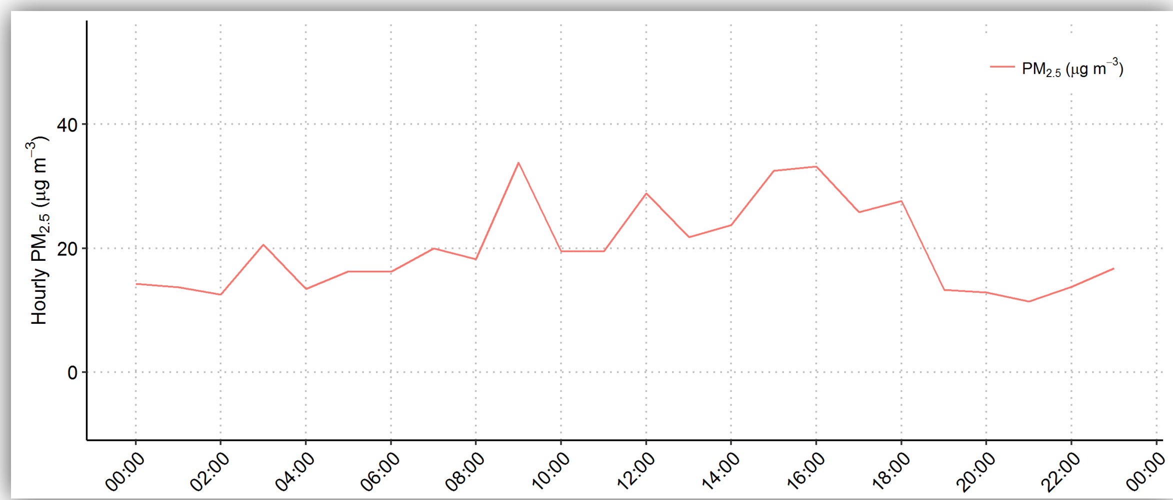


Figure 62. Hourly $PM_{2.5}$ concentrations on February 13, 2015.

Several traffic incidents, including six collisions and one disabled vehicle, were reported along I-5 in the vicinity of the near-road monitor on February 13 (not shown); however, none of these incidents occurred during the 1:00 p.m. to 5:00 p.m. window.

We spoke with staff from the Washington Department of Ecology, who noted that the near-road monitoring station experienced a power outage on the morning of February 13, which may have caused the NO_2 monitor to malfunction. However, given the consistency of the NO_2 diurnal patterns between the near-road and Beacon Hill monitors, and the enhanced CO concentrations between 3:00 p.m. and 4:00 p.m., the evidence suggests that the high NO_2 concentration may have been caused by motor vehicle traffic along I-5. In conclusion, it appears that local traffic may have led to elevated NO_2 concentrations, though this conclusion is not definitive without hourly traffic data.

4.5 High NO_2 Concentrations: Oakland, CA

On March 26, 2015, at 8:00 p.m., hourly NO_2 concentrations at the Oakland, California, near-road site peaked at 105 ppb, which was the third-highest daily 1-hr maximum concentration observed at any near-road site in 2015. We contacted the Bay Area Air Quality Management District (BAAQMD) regarding the data. A BAAQMD staff person was on site on the afternoon of March 26 and noted that a carnival was set up in the parking lot by the air monitoring trailer (see **Figure 63**). The presumption is that the carnival was using diesel powered generators. This likely caused the spike in NO_2 and black carbon (BC), seen in **Figure 64**. At the hour when the high NO_2 occurred, no other nearby site recorded high concentrations, indicating that this was a highly localized event, likely due to the carnival adjacent to the monitoring site. In summary, the high near-road NO_2 here was likely not caused by traffic emissions, but rather by highly localized emissions from the adjacent carnival.

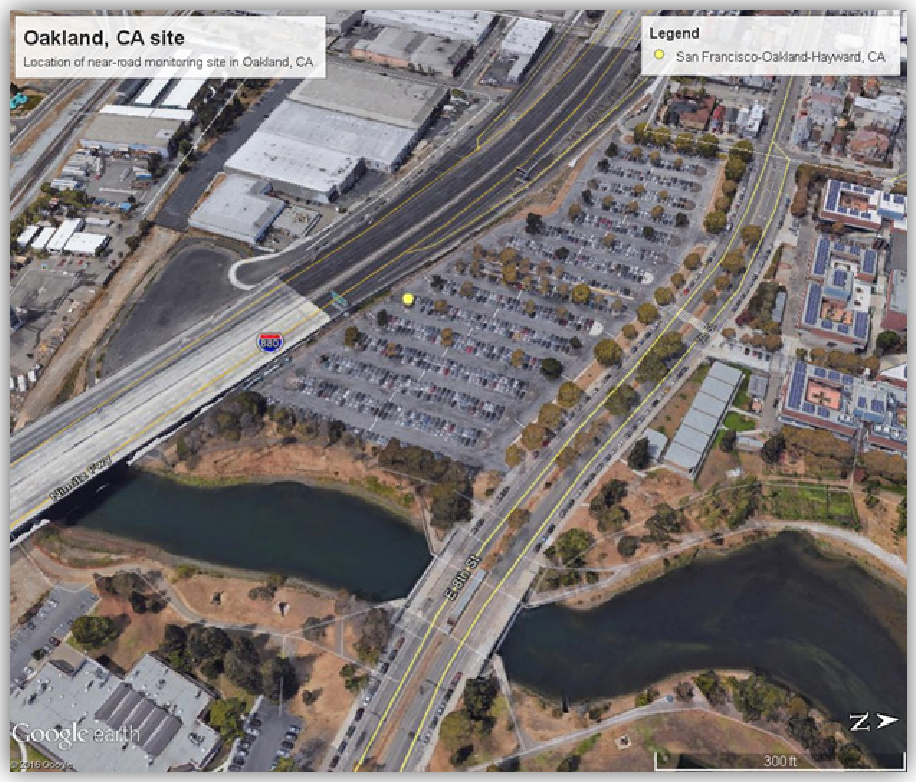


Figure 63. Map of the near-road monitor in Oakland.

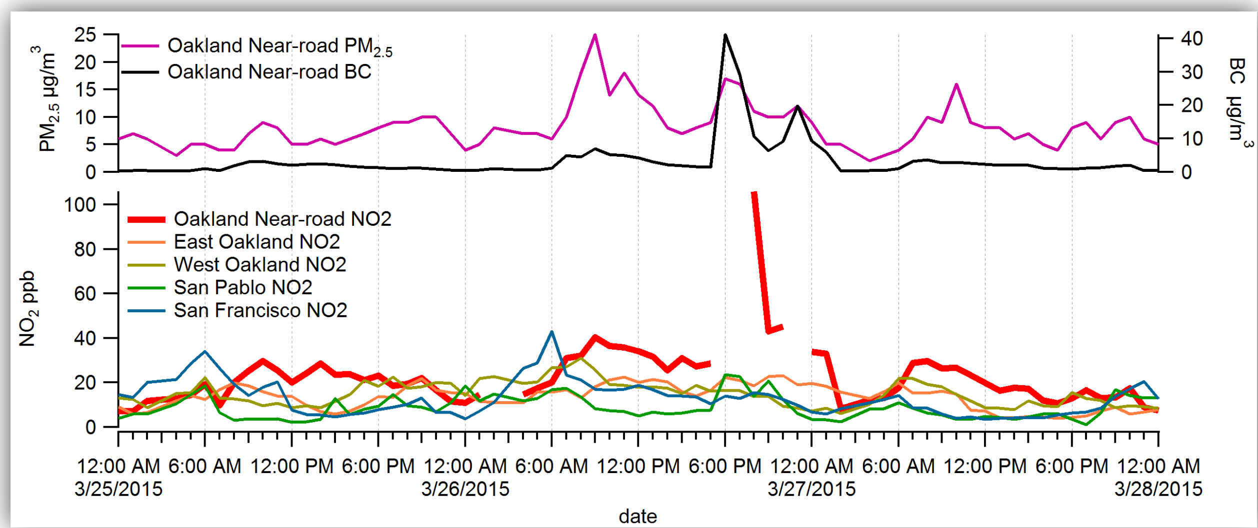


Figure 64. Time series of Oakland near-road BC (µg/m^3), $PM_{2.5}$ (µg/m^3) and NO_2 (ppb), with NO_2 concentrations (ppb) from other nearby sites, on March 25–27, 2015.

4.6 High Annual Average $PM_{2.5}$ Concentration: Houston, TX

The annual average $PM_{2.5}$ concentration of 13.6 µg/m^3 at the Houston I-610 near-road site is among the highest measured at all official near-road sites for 2015 (see Table A-3 in Appendix A). The near-road air quality monitoring site in Houston is on the north side of I-610, just west of the I-610/I-45 interchange (Figure 65). The site has reported 24-hr average $PM_{2.5}$ concentrations on a 1-in-3 day schedule since April 15, 2015.

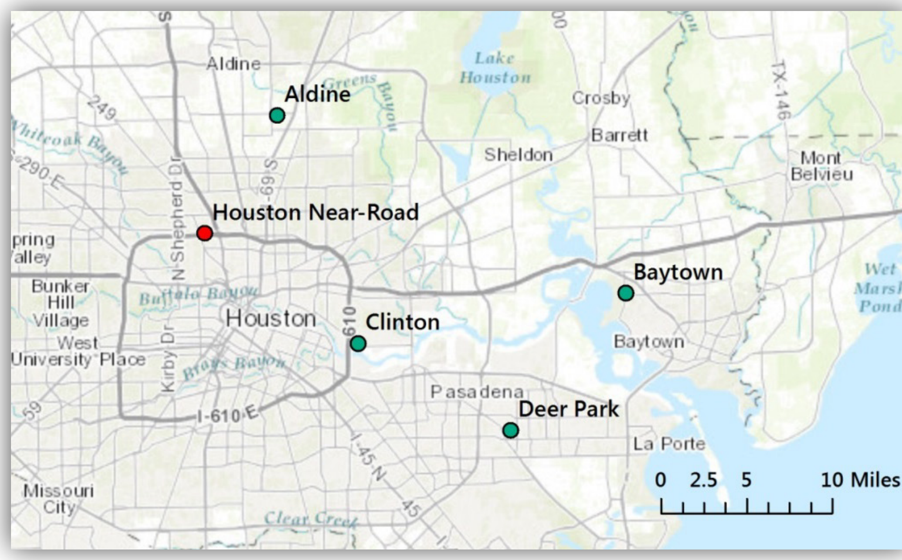


Figure 65. The locations of $PM_{2.5}$ monitoring sites (green dots) near the Houston $PM_{2.5}$ near-road monitoring site (red dot).

Daily average $PM_{2.5}$ concentrations were compared with concentrations collected at four monitors (Aldine, Baytown, Clinton, and Deer Park) within 35 km of the Houston near-road site to examine whether concentrations measured at the near-road site were typically higher than nearby sites or if high 24-hr $PM_{2.5}$ concentrations occurred regionally. Figure 66 shows a time series of 24-hr average $PM_{2.5}$ concentrations at the Houston near-road monitoring site and the maximum 24-hr $PM_{2.5}$ concentration at the nearby sites. Daily $PM_{2.5}$ concentrations collected at the near-road site are well-correlated with the maximum concentration at nearby sites (r^2=0.78).

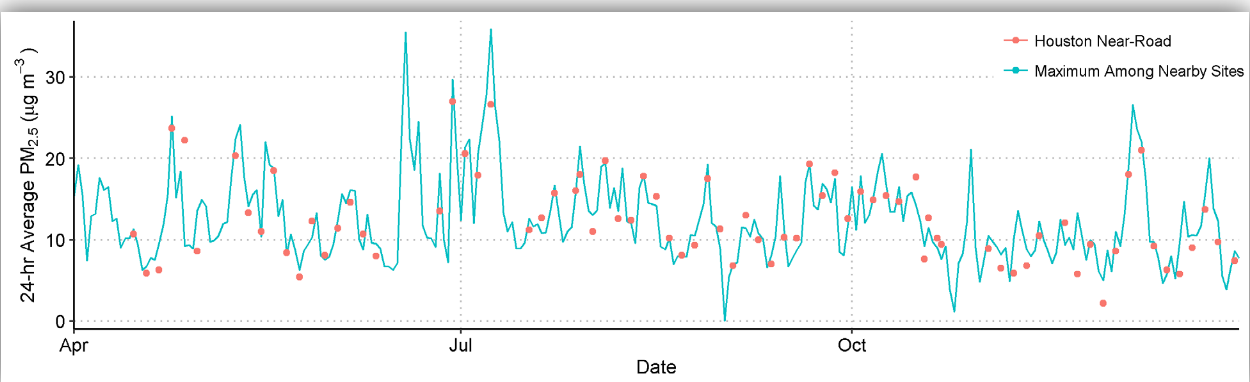


Figure 66. Daily average $PM_{2.5}$ concentrations at the Houston near-road monitoring site (pink points) and the maximum 24-hr $PM_{2.5}$ concentration at the nearby sites (blue line) for 2015.

Figure 67 shows a scatter plot of the 24-hr average $PM_{2.5}$ concentrations at the Houston near-road site versus the difference between concentrations at the near-road site and the maximum of 24-hr $PM_{2.5}$ concentrations at nearby sites during 2015. Daily $PM_{2.5}$ concentrations at the near-road site were higher than the maximum concentration among nearby sites only 30% of the time during 2015. On the 23 out of 77 days when concentrations were higher at the near-road monitor than at other sites, the average increment was 1.7 $\mu g/m^3$. On six of the seven days when the Houston near-road monitor reported 24-hr average $PM_{2.5}$ concentrations above 20 $\mu g/m^3$, concentrations were lower at the near-road site than at nearby sites. Concentrations were only more than 5 $\mu g/m^3$ higher than the maximum at other sites on one day in 2015 (April 27).

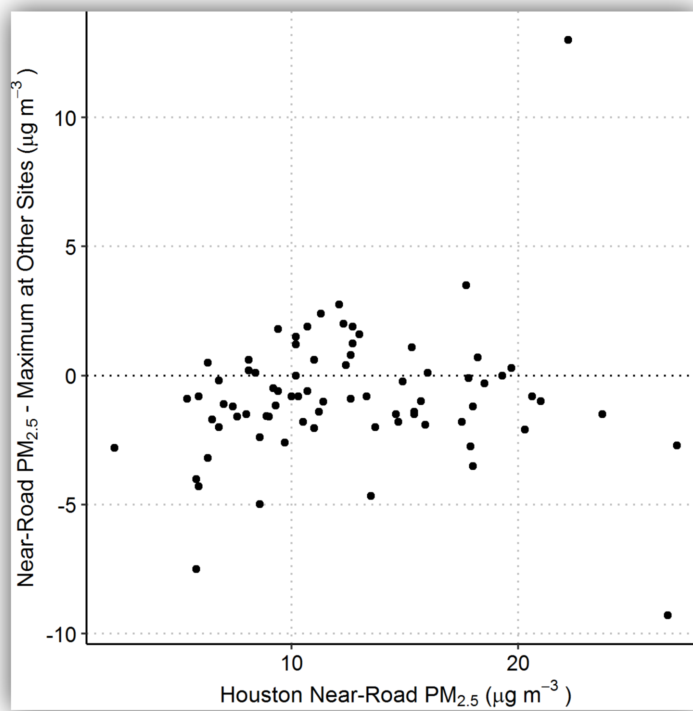


Figure 67. Daily average $PM_{2.5}$ concentrations at the Houston near-road monitoring site versus the maximum of 24-hr $PM_{2.5}$ concentrations at nearby sites during 2015.

Figure 68 shows a scatter plot of the 24-hr average $PM_{2.5}$ versus NO_x concentrations at the Houston near-road monitoring site. $PM_{2.5}$ concentrations are not well-correlated with NO_x concentrations.

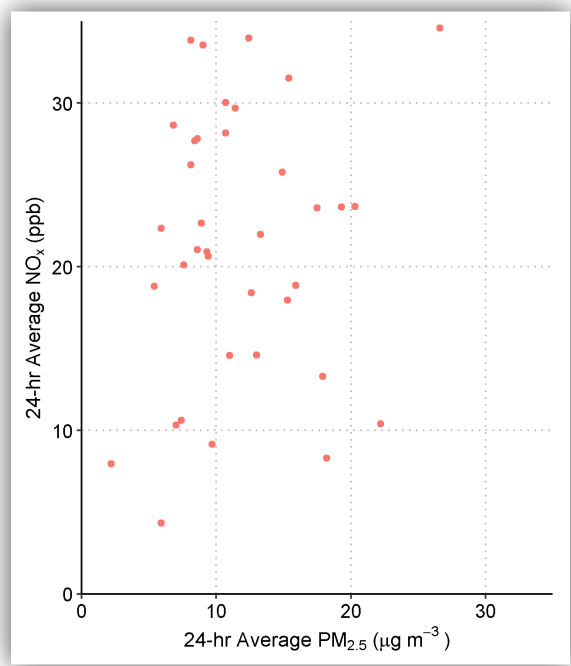


Figure 68. Daily average $PM_{2.5}$ concentrations versus NO_x concentrations at the Houston near-road monitoring site during 2015.

While not an official near-road monitoring site, the Clinton monitor in Houston is located approximately 150 feet north of the four-lane Clinton Drive, and so may be biased high compared to other urban sites not next to large roadways. To sensitivity-test the comparisons between the near-road concentrations and concentrations at nearby sites, we repeated the analyses without the Clinton site data. Daily $PM_{2.5}$ concentrations at the near-road site were higher than the maximum concentrations among the Aldine, Deer Park, and Baytown sites 57% of the time during 2015. On the 44 of 77 days that concentrations at the near-road monitor were higher than other sites, the average increment was 2.2 $\mu g/m^3$.

In summary, daily $PM_{2.5}$ concentrations at the Houston near-road monitoring site are well-correlated with nearby monitors, suggesting that the high near-road concentrations are largely driven by high regional $PM_{2.5}$ conditions. This is consistent with the observation that $PM_{2.5}$ concentrations at the near-road monitor are not well-correlated with NO_x concentrations. Excluding data from the Clinton Drive monitoring site, the average near-road $PM_{2.5}$ increment relative to the maximum among nearby sites for all days in 2015 is approximately 0.4 $\mu g/m^3$.

5. Summary

An understanding of air pollutant concentrations next to the official national near-road monitoring sites is emerging, now that many of the required near-road sites are operational and reporting complete years of both NO_2 and $PM_{2.5}$. With the finalized and certified data from 2015, accessed in May 2016, we found:

- NO_2 data at sites in 66 near-road monitoring locations and $PM_{2.5}$ data for 39 near-road monitoring locations were reported in the EPA's AQS.
- Of the 66 locations with sites reporting NO_2 data to AQS, 49 locations reported at least three full quarters of data for 2015. For $PM_{2.5}$ data, 31 of the 39 locations reported at least three full quarters of 2015 data, and eight locations had $PM_{2.5}$ data for fewer than three full quarters in 2015.
- Three 1-hr daily maximum NO_2 concentrations and five hourly observations were above 100 ppb; these values were measured at George Washington Bridge (GWB) in New York/New Jersey (Fort Lee, New Jersey, monitoring site); along I-880 in Oakland, California; and along I-5 in Seattle, Washington.
- Sites in Denver, Colorado; Houston, Texas; Long Beach, California; Ontario, California; and Phoenix, Arizona, recorded $PM_{2.5}$ annual averages for 2015 greater than 12 $\mu g/m^3$. However, of these sites, only Long Beach and Ontario reported a full year of data for 2015, while Houston had three quarters of the year of data. There were 33 days in 2015 at 12 near-road locations that had 24-hr $PM_{2.5}$ concentrations above 35 $\mu g/m^3$. Only three of the sites, Denver, Ontario, and Long Beach, had a 98^{th} percentile of 24-hr $PM_{2.5}$ concentrations greater than 35 $\mu g/m^3$. Phoenix had a 98^{th} percentile of 34.5 $\mu g/m^3$.
- CO concentrations were typically 1 ppm or less. Several comparatively high CO concentrations (greater than 4 ppm) were observed at the near-road locations in Puerto Rico; Memphis, Tennessee; and Wilkinsburg, Pennsylvania, although all of these 1-hr values were well below the CO 1-hr NAAQS of 35 ppm.

Future work, with additional years of data, can assess which sites have high concentrations; how these high near-road concentrations relate to traffic, urban-scale concentrations, and meteorology; and what the predictors of high near-road concentrations are.

6. References

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Appendix A: Details of Data Availability and Ambient $PM_{2.5}$ Concentrations

Table A-1. CO 1-hr maximum and 1-hr average (ppm) by site during 2015, plus the number and date range of 2015 1-hr samples. One complete year of hourly data has 8,760 observations. Name labels are defined as "City, State (Target Road) [Site ID][POC]."

AQS ID	Name Label	Start Date	End Date	No. of Reported Samples	1-hr Max. (ppm)	1-hr Mean (ppm)
06-059-0008	Anaheim, CA (I-5) [0008][1]	1-Jan	31-Dec	8582	3.07	0.88
13-121-0056	Atlanta, GA (I-85) [0056][1]	1-Jan	31-Dec	8622	2.50	0.80
01-073-2059	Birmingham, AL (I-20) [2059][1]	1-Jan	31-Dec	7188	3.19	0.44
25-025-0044	Boston, MA (I-93) [0044][1]	1-Jan	31-Dec	7920	1.79	0.32
36-029-0023	Cheektowaga, NY (I-90) [0023][1]	1-Jan	31-Dec	8109	1.32	0.20
39-061-0048	Cincinnati, OH (I-75) [0048][1]	1-Jan	31-Dec	8631	2.58	0.37
39-035-0073	Cleveland, OH (I-271) [0073][1]	1-Jan	31-Dec	8117	1.13	0.23
39-049-0038	Columbus, OH (I-270) [0038][1]	1-Jan	31-Dec	8587	2.20	0.16
08-031-0027	Denver, CO (I-25) [0027][1]	1-Jan	31-Dec	8700	2.91	0.53
26-163-0093	Detroit, MI (I-96) [0093][1]	1-Jan	31-Dec	8404	2.30	0.49
12-011-0035	Fort Lauderdale, FL (I-95) [0035][1]	31-Aug	31-Dec	2906	1.56	0.51
34-003-0010	Fort Lee, NJ (I-95/US 1) [0010][1]	1-Jan	31-Dec	8627	2.20	0.22
48-439-1053	Fort Worth, TX (I-20) [1053][1]	12-Mar	31-Dec	6997	1.67	0.35
72-061-0006	Guaynabo, PR (De Diego Hwy) [0006][1]	1-Apr	30-Nov	5764	9.60	0.73
09-003-0025	Hartford, CT (I-84) [0025][1]	1-Jan	31-Dec	8175	1.85	0.36
48-201-1052	Houston, TX (I-610) [1052][1]	15-Apr	31-Dec	6082	2.36	0.50
18-097-0087	Indianapolis, IN (I-70) [0087][1]	1-Jan	27-Dec	7484	1.70	0.24
12-031-0108	Jacksonville, FL (I-95) [0108][1]	1-Jan	31-Dec	8189	2.50	0.43
29-095-0042	Kansas City, MO (I-70) [0042][1]	29-Jan	31-Dec	7741	1.53	0.30
27-037-0480	Lakeville, MN (I-35) [0480][1]	1-Jan	31-Dec	8320	1.00	0.10
24-027-0006	Laurel, MD (I-95) [0006][1]	1-Jan	31-Dec	8444	1.02	0.30

AQS ID	Name Label	Start Date	End Date	No. of Reported Samples	1-hr Max. (ppm)	1-hr Mean (ppm)
26-163-0095	Livonia, MI (I-275) [0095][1]	1-Jan	31-Dec	8295	1.40	0.36
21-111-0075	Louisville, KY (I-264) [0075][1]	1-Jan	27-Dec	7145	1.77	0.34
47-157-0100	Memphis, TN (I-40) [0100][1]	1-Jan	31-Dec	8035	7.74	0.27
16-001-0023	Meridian, ID (I-84) [0023][1]	1-Jan	31-Dec	8549	1.29	0.24
55-079-0056	Milwaukee, WI (I-94) [0056][1]	1-Jan	31-Dec	8644	1.12	0.30
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][1]	1-Jan	31-Dec	8647	2.20	0.33
47-037-0040	Nashville, TN (I-40/I-24) [0040][1]	1-Jan	31-Dec	8371	1.77	0.43
22-071-0021	New Orleans, LA (I-610) [0021][1]	1-Jan	31-Dec	8248	2.70	0.73
06-001-0012	Oakland, CA (I-880) [0012][1]	1-Jan	31-Dec	8314	2.71	0.48
40-109-0097	Oklahoma City, OK (I-44) [0097][1]	17-Jun	31-Dec	4676	1.90	0.37
06-071-0026	Ontario, CA (I-10) [0026][1]	1-Jan	31-Dec	8571	2.71	0.72
42-101-0075	Philadelphia, PA (I-95) [0075][1]	1-Jan	31-Dec	8028	1.92	0.42
04-013-4020	Phoenix, AZ (I-10) [4020][1]	2-Sep	31-Dec	2871	3.40	0.89
41-067-0005	Portland, OR (I-5) [0005][1]	1-Jan	31-Dec	8112	1.83	0.44
44-007-0030	Providence, RI (I-95) [0030][1]	1-Jan	31-Dec	8323	3.66	0.61
51-760-0025	Richmond, VA (I-95) [0025][1]	1-Jan	31-Dec	8334	1.20	0.29
36-055-0015	Rochester, NY (I-490) [0015][1]	1-Jan	31-Dec	8360	1.29	0.26
06-067-0015	Sacramento, CA (I-5) [0015][1]	14-Oct	31-Dec	1812	1.30	0.33
06-073-1017	San Diego, CA (I-15) [1017][1]	24-Apr	31-Dec	5337	2.40	0.56
06-085-0006	San Jose, CA (US 101) [0006][1]	1-Jan	31-Dec	8264	2.72	0.67
53-033-0030	Seattle, WA (I-5) [0030][1]	1-Jan	31-Dec	8364	2.22	0.56
29-510-0094	St. Louis, MO (I-64) [0094][1]	1-Jan	31-Dec	8541	1.94	0.28
12-057-1111	Tampa, FL (I-275) [1111][1]	1-Jan	16-Dec	6377	1.94	0.29

AQS ID	Name Label	Start Date	End Date	No. of Reported Samples	1-hr Max. (ppm)	1-hr Mean (ppm)
04-013-4019	Tempe, AZ (I-10) [4019][1]	1-Jan	31-Dec	8669	1.90	0.44
11-001-0051	Washington DC, DC (DC-295) [0051][1]	1-Jun	31-Dec	4946	2.30	0.45
42-003-1376	Wilkinsburg, PA (I-376) [1376][1]	1-Jan	31-Dec	8336	5.56	0.46

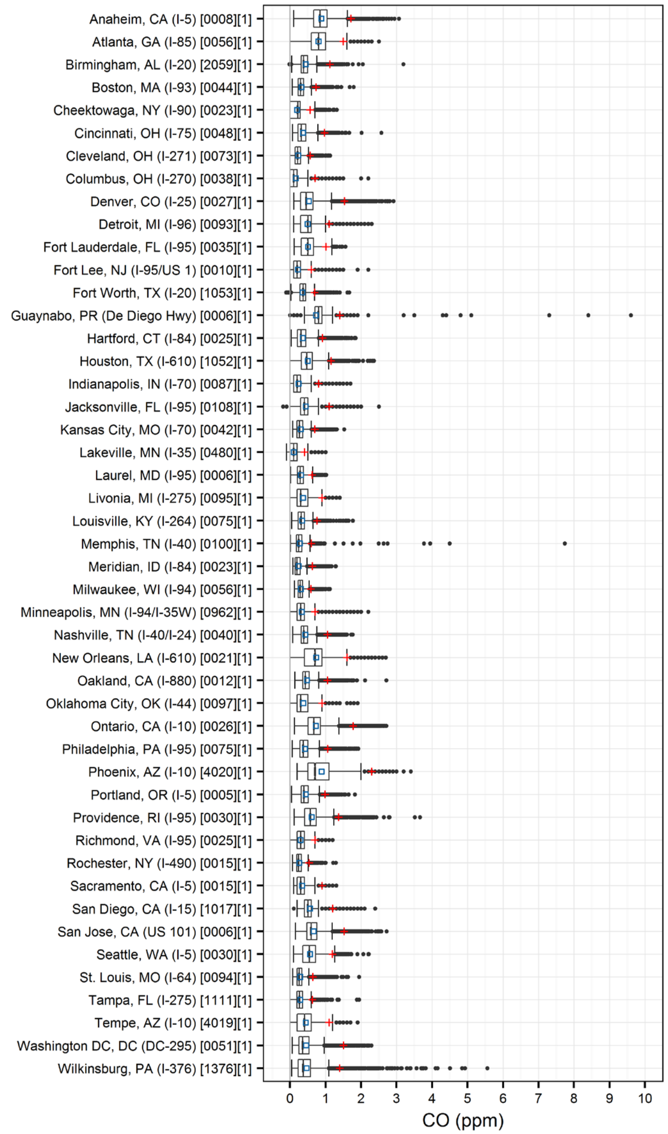

Figure A-1. Box plot of all hourly CO concentrations at the official near-road monitors in 2015. Sites are labeled as "City, State (Target Road) [Site ID][POC]." The vertical line at the notch indicates the median; the square indicates the mean; the crosshair indicates the 98th percentile; the box indicates the interquartile range (IQR); the whiskers indicate 1.5*IQR; and individual points are beyond 1.5*IQR.

Table A-2. $PM_{2.5}$ 1-hr maximum and 1-hr average (µg/m^3) at sites measuring continuous hourly $PM_{2.5}$, plus the number and date range of 2015 1-hr samples. One complete year of hourly data has 8,760 observations. Name labels are defined as "City, State (Target Road) [Site ID][POC]."

AQS ID	Name Label	Start Date	End Date	No. of Reported Samples	1-hr Max. (µg/m^3)	1-hr Mean (µg/m^3)
25-025-0044	Boston, MA (I-93) [0044][3]	1-Sep	31-Dec	2829	44.0	8.1
08-031-0027	Denver, CO (I-25) [0027][3]	1-Jan	31-Dec	8712	73.8	10.0
08-031-0028	Denver, CO (I-25) [0028][3]	1-Oct	31-Dec	1878	58.6	14.1
34-003-0010	Fort Lee, NJ (I-95/US 1) [0010][3]	1-Jan	31-Dec	8386	63.3	11.3
12-031-0108	Jacksonville, FL (I-95) [0108][3]	1-Jan	31-Dec	5577	124.2	8.2
29-095-0042	Kansas City, MO (I-70) [0042][4]	1-Jan	31-Dec	8592	166.3	7.3
27-037-0480	Lakeville, MN (I-35) [0480][3]	1-Jan	31-Dec	8625	134.0	7.2
24-027-0006	Laurel, MD (I-95) [0006][3]	1-Jan	31-Dec	7415	49.0	9.3
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][3]	1-Jan	31-Dec	8629	130.0	8.4
06-001-0012	Oakland, CA (I-880) [0012][3]	1-Jan	31-Dec	8694	67.0	10.0
42-101-0076	Philadelphia, PA (I-76) [0076][1]	2-Sep	31-Dec	2351	53.0	10.1
42-101-0075	Philadelphia, PA (I-95) [0075][1]	1-Jan	31-Dec	8229	58.0	10.7
04-013-4020	Phoenix, AZ (I-10) [4020][3]	2-Sep	31-Dec	2849	122.8	12.6
44-007-0030	Providence, RI (I-95) [0030][1]	1-Jan	31-Dec	8133	376.0	9.9
51-760-0025	Richmond, VA (I-95) [0025][3]	1-Jan	31-Dec	8759	69.9	10.1
06-085-0006	San Jose, CA (US 101) [0006][3]	1-Jan	31-Dec	8627	99.0	8.4
53-033-0030	Seattle, WA (I-5) [0030][3]	1-Jan	31-Dec	8549	55.7	9.4
29-510-0094	St. Louis, MO (I-64) [0094][4]	1-Jan	31-Dec	8495	94.2	9.2
12-057-1111	Tampa, FL (I-275) [1111][3]	1-Jan	16-Dec	8253	65.7	9.9
04-013-4019	Tempe, AZ (I-10) [4019][3]	1-Jan	31-Dec	8655	59.7	7.9
11-001-0051	Washington DC, DC (DC-295) [0051][1]	1-Jun	31-Dec	5115	239.0	11.0

Table A-3. $PM_{2.5}$ 24-hr maximum, 98th percentile of 24-hr values, and annual average (µg/m^3) by site during 2015, plus the number and date range of 2015 24-hr values. One complete year of hourly duration data comprises 365 averages; one complete year of 24-hr samples has approximately 122 observations (1-in-3 day frequency) and 61 observations (1-in-6 day frequency). Name labels are defined as "City, State (Target Road) [Site ID][POC]".

AQS ID	Name Label	Sample Duration	Freq.	Start Date	End Date	No. of Samples or Averages	24-hr Max. (µg/m^3)	Annual Average (µg/m^3)	98th Percentile of 24-hr Values (µg/m^3)
13-121-0056	Atlanta, GA (I-85) [0056][1]	24-hr	daily	1-Jan	31-Dec	329	27.5	10.4	18.9
01-073-2059	Birmingham, AL (I-20) [2059][1]	24-hr	1-in-6	12-Jan	26-Dec	59	26.2	11.8	25.7
25-025-0044	Boston, MA (I-93) [0044][1]	24-hr	1-in-3	3-Jan	29-Dec	119	20.8	6.7	16.3
25-025-0044	Boston, MA (I-93) [0044][3]	hourly	daily	1-Sep	31-Dec	118	21.3	8.1	19.7
36-029-0023	Cheektowaga, NY (I-90) [0023][1]	24-hr	1-in-3	6-Jan	29-Dec	115	25.2	9.2	23.0
08-031-0027	Denver, CO (I-25) [0027][1]	24-hr	1-in-3	2-Jan	29-Dec	122	29.1	9.0	26.0
08-031-0027	Denver, CO (I-25) [0027][3]	hourly	daily	1-Jan	31-Dec	365	53.0	10.0	28.1
08-031-0028	Denver, CO (I-25) [0028][3]	hourly	daily	7-Oct	31-Dec	75	39.5	14.1	35.9
34-003-0010	Fort Lee, NJ (I-95/US 1) [0010][3]	hourly	daily	1-Jan	31-Dec	348	34.6	11.3	27.1
48-439-1053	Fort Worth, TX (I-20) [1053][1]	24-hr	1-in-3	22-Mar	26-Dec	81	21.1	9.3	20.5
09-003-0025	Hartford, CT (I-84) [0025][1]	24-hr	1-in-3	3-Jan	26-Dec	115	24.8	9.8	24.2
48-201-1052	Houston, TX (I-610) [1052][1]	24-hr	1-in-3	15-Apr	30-Dec	77	27.0	12.5	26.8
18-097-0087	Indianapolis, IN (I-70) [0087][1]	24-hr	1-in-3	3-Jan	29-Dec	121	54.9	11.5	23.2
12-031-0108	Jacksonville, FL (I-95) [0108][3]	hourly	daily	1-Jan	31-Dec	229	24.8	8.2	17.9
29-095-0042	Kansas City, MO (I-70) [0042][4]	hourly	daily	1-Jan	31-Dec	360	41.9	7.4	17.1
27-037-0480	Lakeville, MN (I-35) [0480][3]	hourly	daily	1-Jan	31-Dec	360	33.3	7.1	19.5
24-027-0006	Laurel, MD (I-95) [0006][3]	hourly	daily	1-Jan	31-Dec	299	31.9	9.3	23.0
26-163-0095	Livonia, MI (I-275) [0095][1]	24-hr	1-in-3	9-Jan	29-Dec	114	31.5	9.5	29.3

AQS ID	Name Label	Sample Duration	Freq.	Start Date	End Date	No. of Samples or Averages	24-hr Max. (µg/m³)	Annual Average (µg/m³)	98th Percentile of 24-hr Values (µg/m³)
06-037-4008	Long Beach, CA (I-710) [4008][1]	24-hr	daily	1-Jan	31-Dec	336	48.8	12.7	35.9
21-111-0075	Louisville, KY (I-264) [0075][1]	24-hr	1-in-3	3-Jan	29-Dec	119	26.0	10.0	23.9
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][3]	hourly	daily	1-Jan	31-Dec	360	34.2	8.5	18.8
22-071-0021	New Orleans, LA (I-610) [0021][1]	24-hr	1-in-3	3-Jan	29-Dec	121	22.4	9.0	21.2
06-001-0012	Oakland, CA (I-880) [0012][3]	hourly	daily	1-Jan	31-Dec	363	37.3	10.0	30.1
40-109-0097	Oklahoma City, OK (I-44) [0097][1]	24-hr	1-in-3	9-Apr	29-Dec	73	29.6	9.2	24.1
06-071-0027	Ontario, CA (SR-60) [0027][1]	24-hr	daily	1-Jan	31-Dec	337	52.8	14.3	40.4
42-101-0076	Philadelphia, PA (I-76) [0076][1]	hourly	daily	3-Sep	31-Dec	91	33.1	10.5	30.2
42-101-0075	Philadelphia, PA (I-95) [0075][1]	hourly	daily	1-Jan	31-Dec	339	37.1	10.7	27.5
04-013-4020	Phoenix, AZ (I-10) [4020][3]	hourly	daily	3-Sep	31-Dec	120	35.3	12.6	34.5
41-067-0005	Portland, OR (I-5) [0005][1]	24-hr	1-in-3	6-Jan	29-Dec	110	61.5	7.9	26.6
44-007-0030	Providence, RI (I-95) [0030][1]	hourly	daily	1-Jan	29-Dec	332	92.5	9.9	22.8
51-760-0025	Richmond, VA (I-95) [0025][3]	hourly	daily	1-Jan	31-Dec	365	27.8	10.1	22.4
36-055-0015	Rochester, NY (I-490) [0015][1]	24-hr	1-in-3	6-Jan	29-Dec	111	21.8	8.0	21.4
06-085-0006	San Jose, CA (US 101) [0006][3]	hourly	daily	1-Jan	31-Dec	359	46.9	8.4	27.7
53-033-0030	Seattle, WA (I-5) [0030][3]	hourly	daily	1-Jan	31-Dec	358	26.6	9.3	20.8
29-510-0094	St. Louis, MO (I-64) [0094][4]	hourly	daily	1-Jan	31-Dec	349	39.4	9.2	20.8
12-057-1111	Tampa, FL (I-275) [1111][3]	hourly	daily	1-Jan	15-Dec	339	26.0	9.9	22.7
04-013-4019	Tempe, AZ (I-10) [4019][3]	hourly	daily	1-Jan	31-Dec	365	22.6	7.9	17.3
11-001-0051	Washington DC, DC (DC-295) [0051][1]	hourly	daily	1-Jun	31-Dec	214	34.1	11.0	28.4
11-001-0051	Washington DC, DC (DC-295) [0051][2]	24-hr	1-in-3	2-Jun	29-Dec	73	32.5	11.1	29.8

Appendix B: Summary of 2014 Data and Comparison to 2015 Data

Tables B-1 and B-2 and **Figure B-1** summarize $PM_{2.5}$ concentrations at the official near-road sites during 2014. Since our data pull in May 2015, when all 2014 data were supposed to be final and certified, there was one change in the $PM_{2.5}$ data reported in 2014. Philadelphia now reports $PM_{2.5}$ data starting on January 5, 2014, instead of March 6, 2014. With 51 more 24-hr values reported for 2014, Philadelphia now has one day when $PM_{2.5}$ was above 35 µg/m^3 (40.4 µg/m^3), and the 98th percentile for 2014 is now 27.7 µg/m^3. The annual average for $PM_{2.5}$ in Philadelphia is 11.9 µg/m^3, 1.4 µg/m^3 higher than reported in the Phase 1 final report.

In both 2014 and 2015, there were three sites with an annual average $PM_{2.5}$ concentration greater than 12 µg/m^3, though in both years not all sites had a full year of data reported. In 2014, five sites in four cities reached or exceeded the $PM_{2.5}$ thresholds. Annual averages were greater than 12 µg/m^3 at Cincinnati (two monitors) and Indianapolis. The Baltimore and Louisville sites also show annual averages equal to 12 µg/m^3, though Baltimore did not have a complete year of monitoring data in 2014. In 2015, the Ontario (Riverside), Houston, and Long Beach sites had annual average concentrations greater than 12 µg/m^3. Both Ontario and Long Beach have data from January through September 2015; Houston reported data from April 15 through September 2015.

In 2014, there were 16 days across all sites when 24-hr $PM_{2.5}$ concentrations were greater than 35 µg/m^3. These occurred in Cincinnati, Denver, Indianapolis, Kansas City, Louisville, Philadelphia, and St. Louis during either February 2–19, March 6–8, or July 4 (Louisville only). However, the 98th percentile of 24-hr $PM_{2.5}$ concentrations did not exceed 35 µg/m^3 at any site. In 2015, there were 13 days across all sites when 24-hr $PM_{2.5}$ concentrations were greater than 35 µg/m^3. These occurred in Denver, Kansas City, Indianapolis, Long Beach, Oakland, Ontario, Providence, San Jose, and St. Louis. The 98th percentile of 24-hr $PM_{2.5}$ concentrations at Ontario and Long Beach also exceeded 35 µg/m^3, though with only 9 months of data thus far available.

Table B-1. $PM_{2.5}$ 1-hr maximum and 1-hr average (µg/m^3) at sites measuring continuous hourly $PM_{2.5}$, plus the number and date range of 2014 1-hr samples. One complete year of hourly data comprises 8,760 observations. Name labels are defined as "City, State (Target Road) [Site ID][POC]."

AQS ID	Name Label	Duration	Start Date	End Date	No. of Reported Samples	1-hr Max. (µg/m^3)	1-hr. Average (µg/m^3)
08-031-0027	Denver, CO (I-25) [0027][3]	hourly	1-Jan	31-Dec	8254	87	10.1
12-031-0108	Jacksonville, FL (I-95) [0108][3]	hourly	1-Apr	31-Dec	5120	99.1	10.3
29-095-0042	Kansas City, MO (I-70) [0042][4]	hourly	1-Jan	31-Dec	8568	64.3	7.7
24-027-0006	Laurel, MD (I-95) [0006][3]	hourly	7-Apr	31-Dec	6291	72	12
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][3]	hourly	1-Jan	31-Dec	8406	61	9.8
06-001-0012	Oakland, CA (I-880) [0012][3]	hourly	1-Feb	31-Dec	7977	132	8.6
42-101-0075	Philadelphia, PA (I-95) [0075][1]	hourly	5-Mar	31-Dec	6614	69.5	10.5
44-007-0030	Providence, RI (I-95) [0030][1]	hourly	1-Apr	31-Dec	6125	40	8.4
06-085-0006	San Jose, CA (US 101) [0006][3]	hourly	1-Sep	31-Dec	2867	41	7
53-033-0030	Seattle, WA (I-5) [0030][3]	hourly	21-May	31-Dec	5153	49.6	10
29-510-0094	St. Louis, MO (I-64) [0094][4]	hourly	1-Jan	31-Dec	7774	91.5	10.9
04-013-4019	Tempe, AZ (I-10) [4019][3]	hourly	1-May	31-Dec	5629	116	9.8

Table B-2. $PM_{2.5}$ 24-hr maximum, 98th percentile of 24-hr values, and annual average (µg/m^3) by site during 2014, plus the number and date range of 2014 24-hr values reported as of Dec 2015. One complete year of hourly duration data comprises 365 averages; one complete year of 24-hr samples comprises approximately 122 observations (1-in-3 day frequency) and 61 observations (1-in-6 day frequency).

AQS ID	Name Label	Sample Duration	Freq.	Start Date (2014)	Last Reported Date (2014)	No. of Samples or Avgs	24-hr Max (µg/m^3)	98th Pctl of 24-hr Values (µg/m^3)	Annual Avg (µg/m^3)
01-073-2059	Birmingham, AL (I-20) [2059][1]	24-hr	1-in-6	5-Jan	31-Dec	61	25.3	24.5	11.2
25-025-0044	Boston, MA (I-93) [0044][1]	24-hr	1-in-3	2-Jan	31-Dec	116	15	14.9	6.3
36-029-0023	Cheektowaga, NY (I-90) [0023][1]	24-hr	1-in-3	10-Jul	31-Dec	55	22.7	21.9	7.4
39-061-0048	Cincinnati, OH (I-75) [0048][1]	24-hr	1-in-6	2-Jan	28-Dec	60	29.1	28.5	13.3
39-061-0048	Cincinnati, OH (I-75) [0048][4]	24-hr	1-in-6	11-Jan	25-Dec	59	35.5	34	12.6
08-031-0027	Denver, CO (I-25) [0027][1]	24-hr	1-in-3	8-Jan	28-Dec	120	48.3	30.8	9.4
08-031-0027	Denver, CO (I-25) [0027][3]	hourly	daily	1-Jan	31-Dec	345	57	30.2	10.1
09-003-0025	Hartford, CT (I-84) [0025][1]	24-hr	1-in-3	6-Mar	31-Dec	83	18	17.9	7.6
18-097-0087	Indianapolis, IN (I-70) [0087][1]	24-hr	1-in-3	1-Feb	31-Dec	131	40.7	33.9	13.1
12-031-0108	Jacksonville, FL (I-95) [0108][3]	hourly	daily	1-Apr	31-Dec	216	30.6	26.6	10.3
29-095-0042	Kansas City, MO (I-70) [0042][4]	hourly	daily	1-Jan	31-Dec	359	37.3	18.4	7.7
24-027-0006	Laurel, MD (I-95) [0006][3]	hourly	daily	8-Apr	31-Dec	261	25.9	22	12
21-111-0075	Louisville, KY (I-264) [0075][1]	24-hr	1-in-3	2-Jan	31-Dec	120	50	26.9	12
27-053-0962	Minneapolis, MN (I-94/I-35W) [0962][3]	hourly	daily	1-Jan	31-Dec	349	33.2	23	9.8

AQS ID	Name Label	Sample Duration	Freq.	Start Date (2014)	Last Reported Date (2014)	No. of Samples or Avgs	24-hr Max (µg/m^3)	98th Pctl of 24-hr Values (µg/m^3)	Annual Avg (µg/m^3)
06-001-0012	Oakland, CA (I-880) [0012][3]	hourly	daily	1-Feb	31-Dec	334	26	19.4	8.6
42-101-0075	Philadelphia, PA (I-95) [0075][1]	hourly	daily	6-Mar	31-Dec	280	22.8	20.8	10.5
44-007-0030	Providence, RI (I-95) [0030][1]	hourly	daily	5-Apr	31-Dec	250	20.4	17.6	8.4
06-085-0006	San Jose, CA (US 101) [0006][3]	hourly	daily	1-Sep	31-Dec	120	24.3	21.7	7
53-033-0030	Seattle, WA (I-5) [0030][3]	hourly	daily	22-May	31-Dec	216	33.7	21	10
29-510-0094	St. Louis, MO (I-64) [0094][4]	hourly	daily	1-Jan	31-Dec	322	52.3	29.3	10.9
04-013-4019	Tempe, AZ (I-10) [4019][3]	hourly	daily	1-May	31-Dec	238	29.2	21.8	9.8

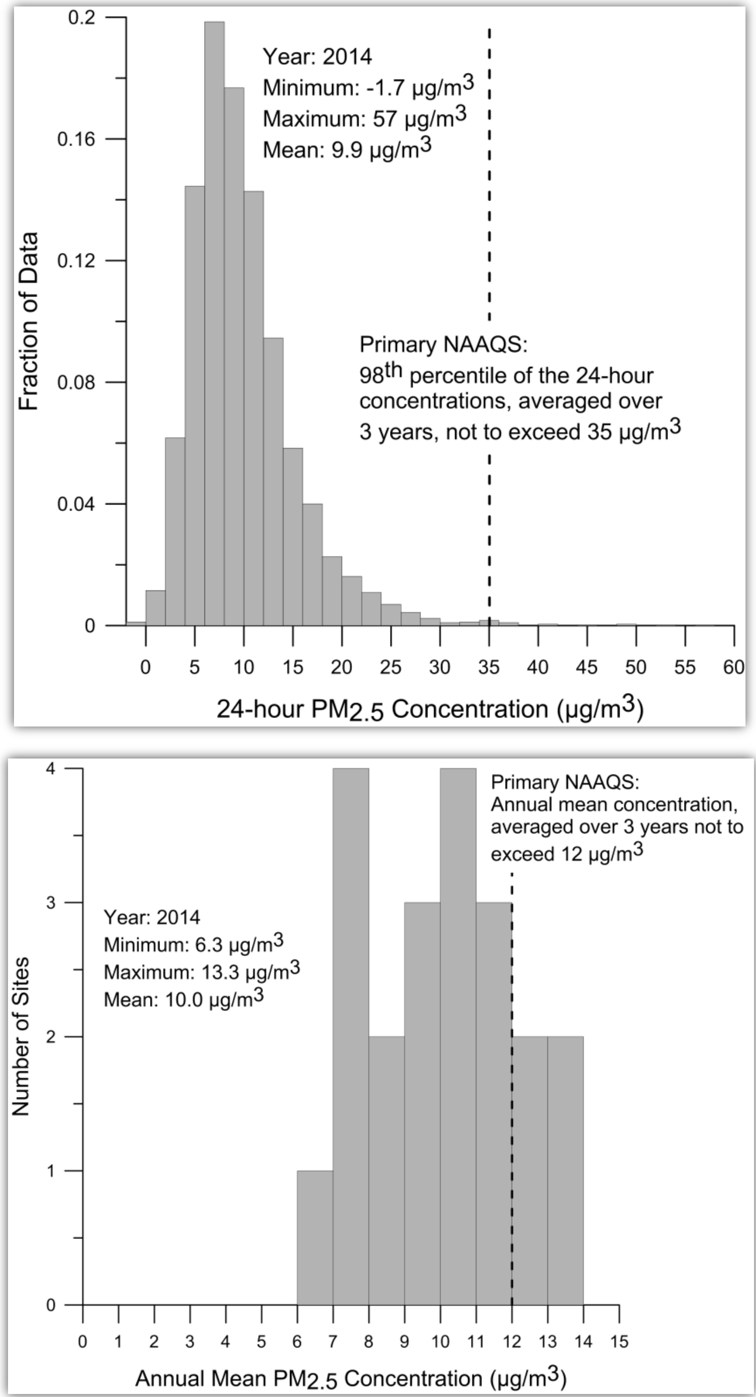

Figure B-1. Distribution of 24-hr (top) and annual average (bottom) $PM_{2.5}$ concentrations at the official near-road monitors in 2014. NAAQS thresholds are also indicated. Of the five sites with averages at or above 12 µg/m^3, one site has an incomplete data record for 2014.