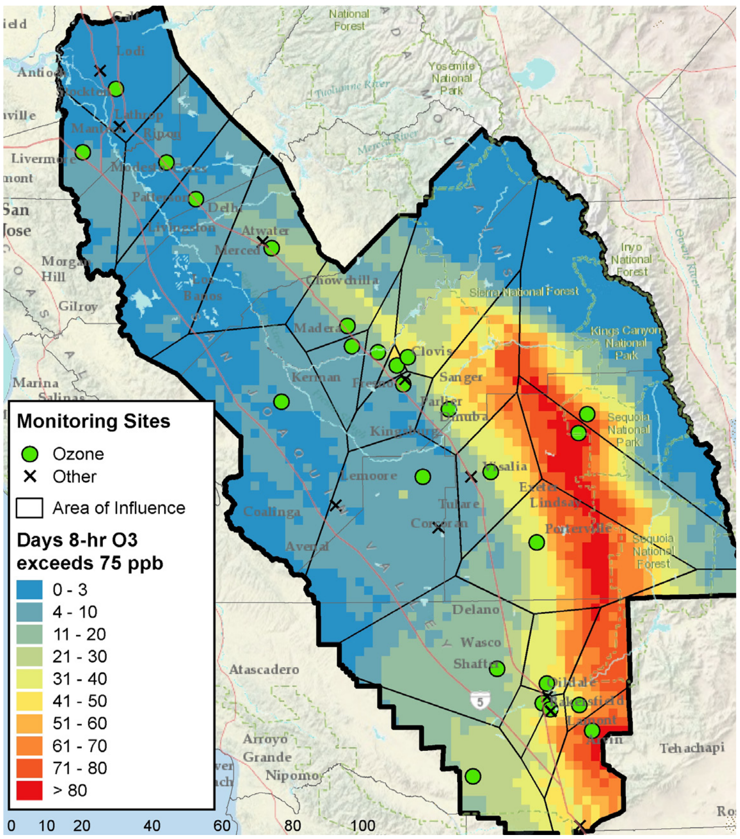
San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

2015 Air Monitoring Network Assessment



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2015 Air Monitoring Network Assessment

September 17, 2015

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1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) drafted the National Ambient Air Monitoring Strategy (NAAMS), with the purpose of optimizing U.S. air monitoring networks to achieve (with limited resources) the best possible scientific value while continuing to protect public and environmental health. An important element of NAAMS is a plan for periodic network assessments at national, regional, and local levels. A network assessment includes (1) evaluation of air monitoring objectives and budget, (2) evaluation of a monitoring network's effectiveness and efficiency relative to its objectives and cost, and (3) recommendations for network reconfigurations and improvements. Per 40 CFR Part 58 Subpart B, Section 58.10, EPA expects that a multi-level network assessment will be conducted every five years, beginning in 2010. This report satisfies the network assessment requirement for the year 2015 (U.S. Environmental Protection Agency, 2005, 2006).

1.1 BACKGROUND

Ambient air monitoring objectives and demographic characteristics change over time, thus motivating air quality agencies to re-evaluate and reconfigure their monitoring networks. Several factors have prompted the changes in air monitoring objectives: improvement in air quality, changes in population distribution and behaviors, changes in air quality mandates, and advancements in the scientific understanding of air quality phenomena. As a result of these changes, air monitoring networks in some regions may have unnecessary, redundant, or ineffective monitoring locations for some pollutants, while other regions may lack necessary monitors altogether.

Changes in $PM_{2.5}$ and ozone National Ambient Air Quality Standards (NAAQS) and other air monitoring objectives are motivating air quality agencies to refocus their monitoring resources on pollutants of emerging interest or persistent challenge, such as particulate matter less than 2.5 microns ($PM_{2.5}$), ground-level ozone and precursor compounds, and air toxics. In addition, agencies are interested in designing networks to protect today's population and environment while maintaining a focus on long-term air quality trends. Moreover, agencies are using new air monitoring technologies and developing an improved scientific understanding of air quality issues.

Monitoring networks should be designed and configured to address multiple, interrelated air quality issues (i.e., a multipollutant approach) and to support other types of air quality studies (e.g., photochemical modeling and emission inventory assessments). Reconfiguring air monitoring networks to help meet the needs of current air quality research will enhance the network's value to stakeholders, scientists, and the general public. Performing an air monitoring network assessment involves re-evaluation of a network's effectiveness and efficiency relative to its objectives and costs, and making recommendations for network reconfigurations and improvements.

1.2 NETWORK ASSESSMENT OBJECTIVES

The San Joaquin Valley (SJV) is an area with rich agricultural resources, abundant industry, and a growing population. The San Joaquin Valley Air Pollution Control District

(District) seeks to ensure that its monitoring network is (1) capable of effectively characterizing air quality and meteorology in the region and (2) meeting its monitoring objectives. The objectives of the District's air monitoring network are to assure compliance with NAAQS, determine control strategy effectiveness, support air quality forecasting, provide information that helps inform the public of air quality conditions and potential public health risks, and support air quality modeling.

The objectives of this network assessment are to identify and recommend adjustments to the District's criteria pollutants, Photochemical Assessment Monitoring Stations (PAMS), and meteorological monitoring network that may be needed to address air quality improvements, emissions reductions, population increases, and the five-year network assessment requirements set forth by the EPA. These requirements address questions as to whether sites are appropriately located to accomplish the following:

- determine the highest criteria pollutant concentrations expected to occur in the area covered by the network;
- measure typical concentrations in areas of high population density;
- determine the impact of significant sources or source categories on air quality;
- determine general background concentration levels;
- determine the extent of regional pollutant transport among populated areas; and
- measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts to support secondary standards.

Additionally, a network assessment can identify potentially redundant sites, areas where new sites may be needed, and evaluate new technologies that may add value to the air monitoring network.

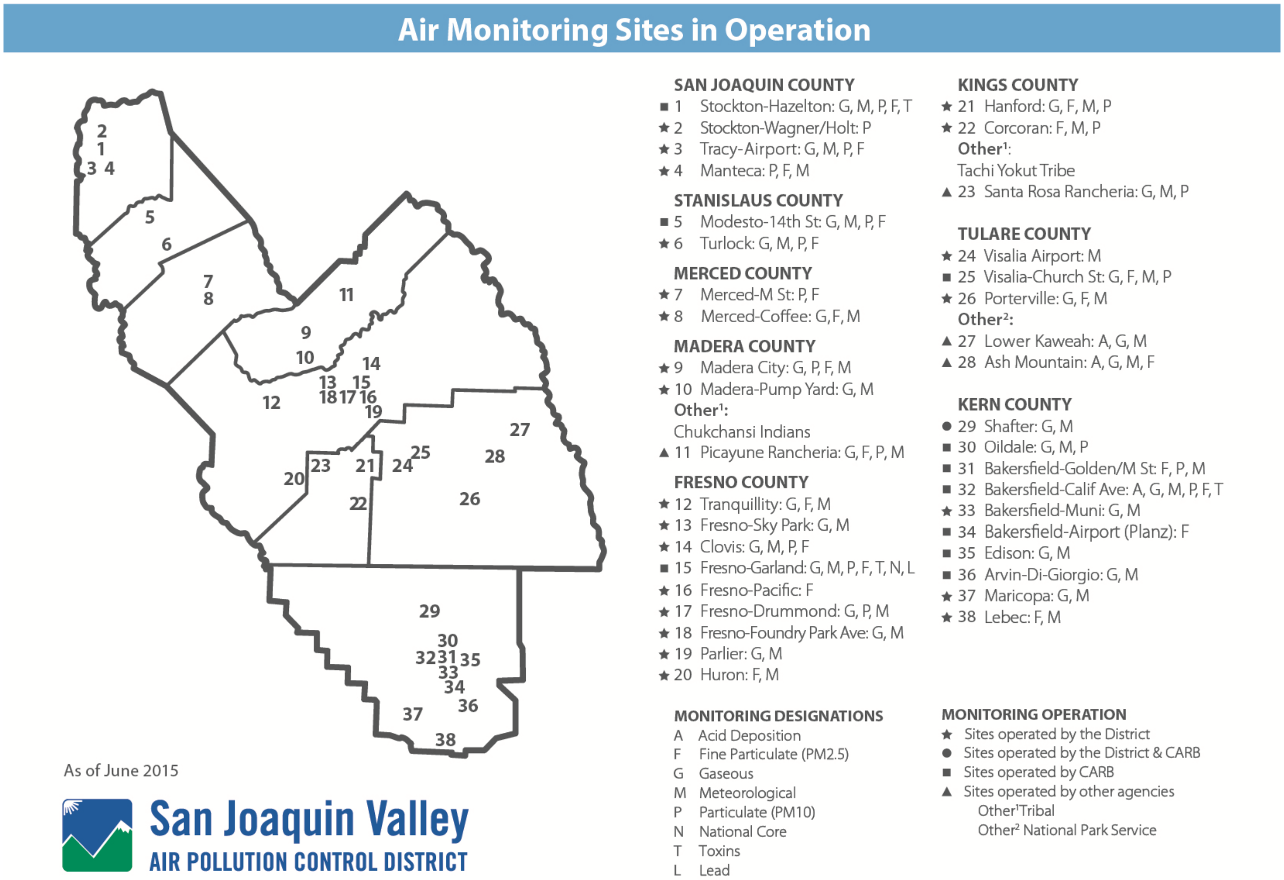
1.3 NETWORK OVERVIEW

The San Joaquin Valley covers an area of 23,490 square miles, and is home to one of the most challenging air quality problems in the nation. The Valley is designated nonattainment for federal PM2.5 and ozone standards, and is in attainment of the federal standards for lead (Pb), Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), and Carbon monoxide (CO). In addition, the Valley is an attainment/maintenance area for PM10. The Valley is home to approximately 4 million residents, and includes several major metropolitan areas, vast expanses of agricultural land, industrial sources, highways, and schools. To address the air quality needs of this expansive and diverse region, the District maintains a robust air monitoring program that meets federal requirements while providing vital information to the public.

The District's air monitoring network is a rich network that measures a variety of pollutants and has a long record of criteria pollutant data. Figure 1-1 is a map of the District's air monitoring network and the general network assessment study domain. In addition to the sites operated by the District, several other sites located in the SJV are operated by other jurisdictions (i.e., the California Air Resources Board – CARB, Tribal, and National Park Service). The map in Figure 1-1 below depicts the sites operated within the Valley as of

June 2015. Please note that the Picayune Rancheria tribal site is temporarily not operating as of 2015.

Figure 1-1. Map of Air Monitoring Sites Located in the San Joaquin Valley



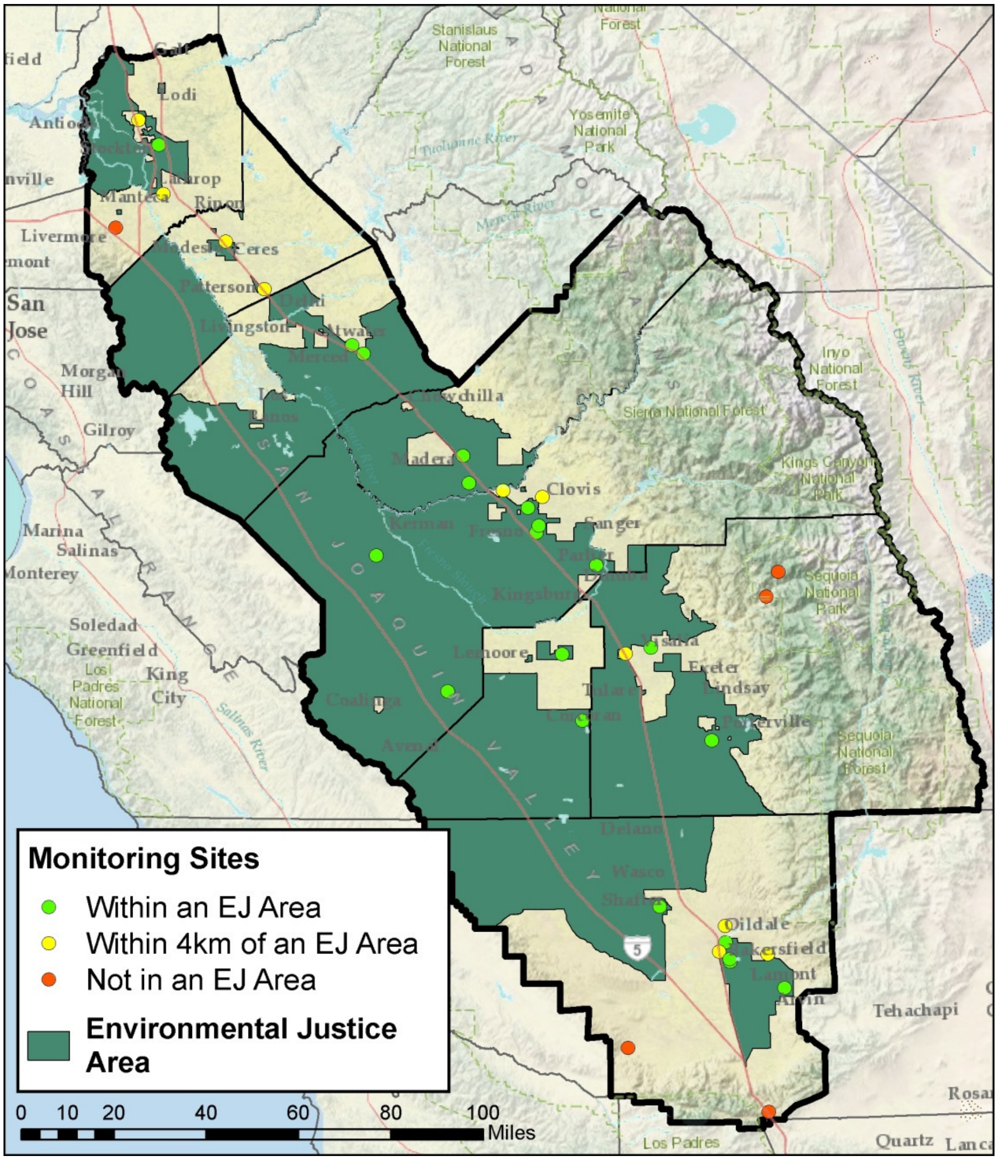
Environmental Justice Areas

The District has developed the Environmental Justice Strategy to identify and address any gaps in existing programs, policies and activities that may impede the achievement of environmental justice. This strategy is described in more detail at:

http://valleyair.org/Programs/EnvironmentalJustice/Amended%20EJ%20Strategy_June%202012.pdf

Figure 1-2 shows that a majority of the San Joaquin Valley air monitoring sites are within 4 km of an Environmental Justice designated area. The Tracy, Lebec, Maricopa, Sequoia – Lower Kaweah, and Sequoia – Ash Mountain air monitoring sites reside outside of Environmental Justice areas. 4 of the 5 sites listed above (excluding Maricopa) are placed in areas to either address transport between air basins or local residents special air qualty needs.

Figure 1-2. Proximity of San Joaquin Valley Air Monitoring Sites to Environmental Justice Areas



1.4 GUIDE TO THIS REPORT

The following sections of this report detail the analysis approach, findings, and recommendations from this network assessment. Section 2 includes a discussion of the technical approach and findings of the air monitoring network assessment. The technical approach and findings of the meteorological network assessment are discussed in Section 3.

2 TECHNICAL APPROACH AND FINDINGS OF THE AIR MONITORING NETWORK ASSESSMENT

The overall technical approach for conducting the network assessment of the District's criteria pollutant, PAMS, and meteorological monitoring network was divided into two main tasks: (1) performing the air monitoring network assessment and (2) performing the meteorological network assessment. The results of the air monitoring and meteorological analyses were first viewed independently and then synthesized and viewed holistically.

Table 2-1 lists the network assessment analyses that were used to address the monitoring objectives (as discussed in Section 1.2) and the following questions:

- Which sites provide the most value in terms of the number of pollutants measured, the length of data record, and data quality?
- Are sites appropriately located to determine the highest pollutant concentrations expected to occur in the area covered by the network?
- Are sites appropriately located to measure typical pollutant concentrations in areas of high population density?
- Are sites appropriately located to determine the impact of significant sources or source categories on air quality?
- Are sites appropriately located to determine general background concentration levels?
- Are sites appropriately located to determine the extent of regional pollutant transport among populated areas?
- Are sites appropriately located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts and to support secondary standards?
- Are there potentially redundant sites in the network?
- Are there areas where new sites may be needed?
- Are there new technologies that may add value to the air monitoring network?

The analyses listed in Table 2-1 are a subset of the analysis methods prescribed in the EPA's *Ambient Air Monitoring Network Assessment Guidance Document* (Raffuse et al., 2007).

Table 2-1. Summary of the Analyses Performed and the Monitoring Objectives or Questions Addressed

Objective or Question	Site-by-Site Analyses							Bottom-up Analyses		
	Data Above the Method Detection Limit (MDL)	Number of Parameters Measured	Length of Trend Record	Measured Concentrations	Deviation from NAAQS	Wind Rose Analyses	Correlation Analyses	Area-Served	Population Density/ Population Served/ Population Change	Emissions Served
Which sites provide the most value in terms of the number of pollutants measured, the length of data record, and data quality?	X	X	X							
Are sites appropriately located to determine the highest pollutant concentrations expected to occur in the area covered by the network?				X	X			X	X	
Are sites appropriately located to measure typical pollutant concentrations in areas of high population density?		X						X	X	
Are sites appropriately located to determine the impact of significant sources or source categories on air quality?										X
Are sites appropriately located to determine general background concentration levels?				X				X	X	X
Are sites appropriately located to determine the extent of regional pollutant transport among populated areas?				X				X	X	
Are sites appropriately located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts and to support secondary standards?								X		
Are there potentially redundant sites in the network?							X	X	X	
Are there areas where new sites may be needed?								X	X	X
Is the meteorological network adequate for characterizing regional surface and upper-air meteorology?		X				X	X			

A network assessment comprises several analysis methods that address specific objectives. The remainder of this section presents a summary of assessment recommendations (Section 2.1), a discussion of the technical approach and findings for the site-by-site and bottom-up analyses for the criteria pollutant network (Sections 2.2-2.4), and a discussion of the PAMS network (Section 2.5).

2.1 AIR MONITORING NETWORK ASSESSMENT AND RECOMMENDATIONS

The conclusions drawn from the monitoring network assessment are listed below. Methods, results, and discussions of these recommendations are provided in the assessment that follows.

Criteria Pollutants

- The current network accurately represents populated areas impacted by $PM_{2.5}$ and ozone pollution and meets regulatory requirements.
- Method Detection Limit (MDL) and data completion analyses reveal that the current criteria pollutant network sufficiently and accurately monitors criteria pollutants in the District.
- Tracy, Turlock, Madera-City, and Fresno–Drummond sites are the most valuable District operated sites for determining $PM_{2.5}$ and ozone NAAQS attainment.
- CARB-operated sites are important to monitoring Valley pollution. The District should implement comparable measurements at or near any discontinued CARB site in the future.
- Area- and population-served analyses of $PM_{2.5}$ and ozone monitoring networks prove that there are no redundant monitors.
- Population-served analysis indicates that the majority of District monitors are either in or within 4 km of Environmental Justice areas.
- There are some locations in the Valley, particularly the westside of Fresno and Kern Counties and the foothill region of Fresno and Madera Counties, which might benefit from additional PM2.5 and ozone monitoring if feasible in the future.
- Emissions-served analysis supports the addition of near-road nitrogen dioxide (NO_2) monitors along the highway 99 corridor, four of which are currently under development.
- Statistical correlation analysis among sites measuring $PM_{2.5}$ and ozone confirm the population- and emissions-served conclusions that the network is adequate.

PAMS

- Future changes to the EPA's PAMS monitoring requirements may reduce the number of PAMS sites operating in the District.
- Although MDL and data completion is low for some compounds, further analyses revealed that the current PAMS network sufficiently and accurately monitors the required compounds in the District.

- Photochemical modeling of 2007 ozone data supports that the current PAMS configuration is adequate.

Meteorology

- Statistical correlation analysis among sites measuring meteorological parameters indicates that there are no redundant monitors.
- Population-served analysis shows that the District's meteorological network is adequate.
- If feasible in the future, additional meteorological monitoring on the westside of Fresno and Kern counties and the foothill region of Fresno and Madera counties should be considered.
- There are a number of new, cost-effective and innovative technologies in upper and lower atmospheric monitoring in which the District can consider investing.

2.2 TECHNICAL APPROACH AND FINDINGS FOR THE AIR MONITORING NETWORK ASSESSMENT FOR CRITERIA POLLUTANTS

This section contains a description of the technical approach and discussion of criteria pollutant monitoring network analyses. The site-by-site analyses focus on assessing individual sites within the network and include a determination of the number of parameters monitored; the fraction of data reported; the fraction of data above the method detection limit (MDL); the measured concentrations; the deviation from NAAQS; and the length of trend record at each site. While sites operated by both the District and CARB were included in the site-by-site analyses, comments and recommendations were focused on only those sites operated by the District since the District has direct jurisdiction and the authority to implement site-specific recommendations.

2.2.1 Data Sources

The following data (and sources) were acquired and used to perform the air monitoring network assessment:

- **Air quality and PAMS data:** Air quality and PAMS data for 2013 was acquired from EPA's Air Quality System (AQS) (https://aqs.epa.gov/aqs/). The analyses in this report are based on monitored data from the year 2013 only.

- **Population data:** Spatially resolved population data (block-group polygons) were acquired from the U.S. Census Bureau for the SJV for 2010. Block-groups where converted to 1 km grid cells within a geographic information system (GIS). Since block-groups change for each decadal census, this normalization allowed population trends to be evaluated.

- **Emission Inventory data:** The most recent gridded emissions inventory was collected from CARB. Emissions are representative of a summer weekday in 2007.

2.2.2 Number of Parameters Monitored

Air quality monitoring sites with instruments that measure many pollutants and meteorological parameters are generally more valuable than sites that measure fewer parameters, assuming that the data collected are of high or similar quality. In addition, sites that measure several pollutants are generally more cost effective to operate. The District assessed and ranked each air quality and meteorological site by the number of parameters collected at each site. Figure 2-1 shows the number of parameters monitored. The height of each bar represents the total number of parameters monitored at that site. The parameters monitored at the PAMS and toxic sites are not individually counted in the chart below. Sites are ordered from left to right along the x-axis corresponding to their north to south geographic locations in the SJV.

The PAMS sites (Madera–Pump Yard, Clovis– Villa, Parlier, Bakersfield–Muni, and Shafter) are valuable sites because they measure the most parameters. Stockton-Hazelton, Fresno-Garland, and Bakersfield-California are important sites for criteria pollutants because they measure several parameters.

Figure 2-1. The Number of Parameters Monitored at Each Site

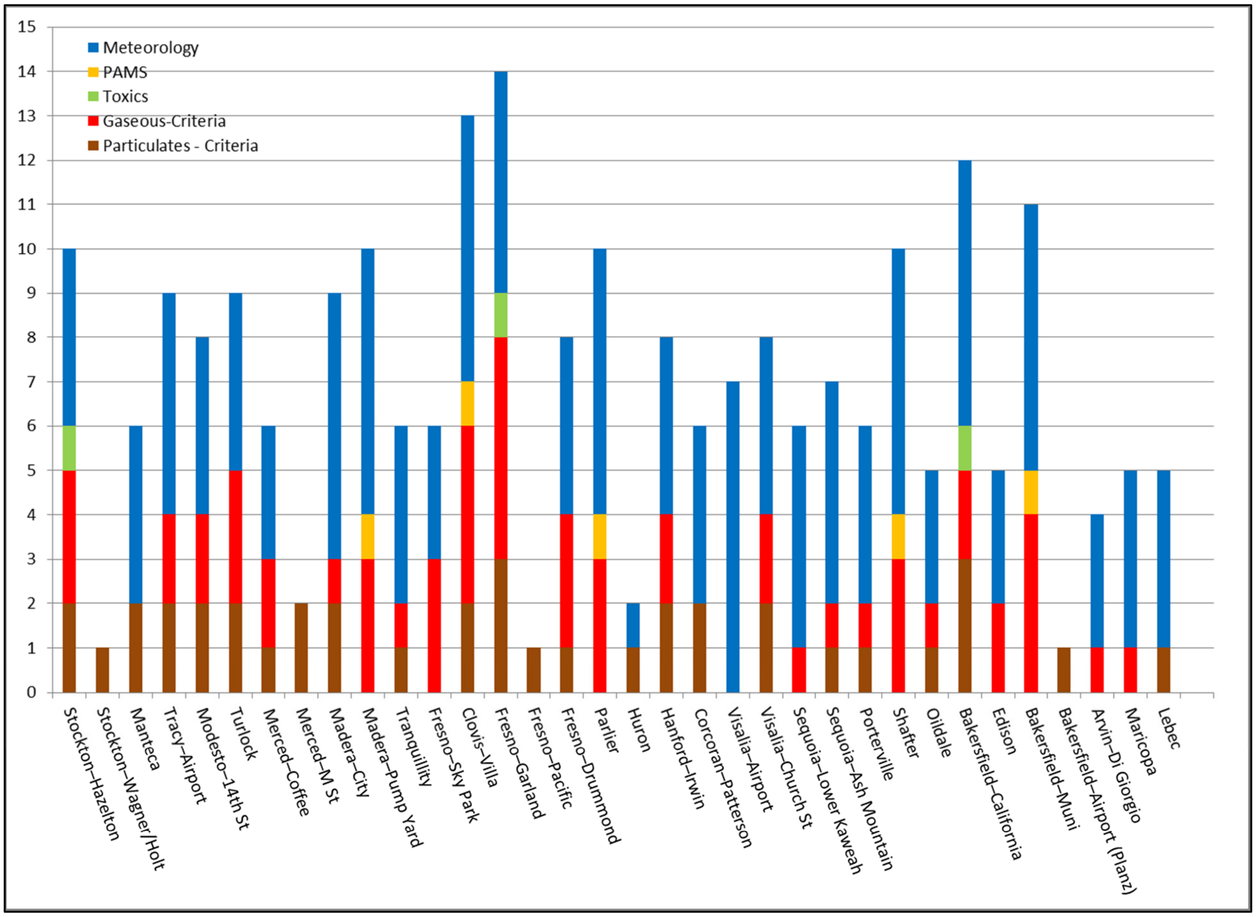
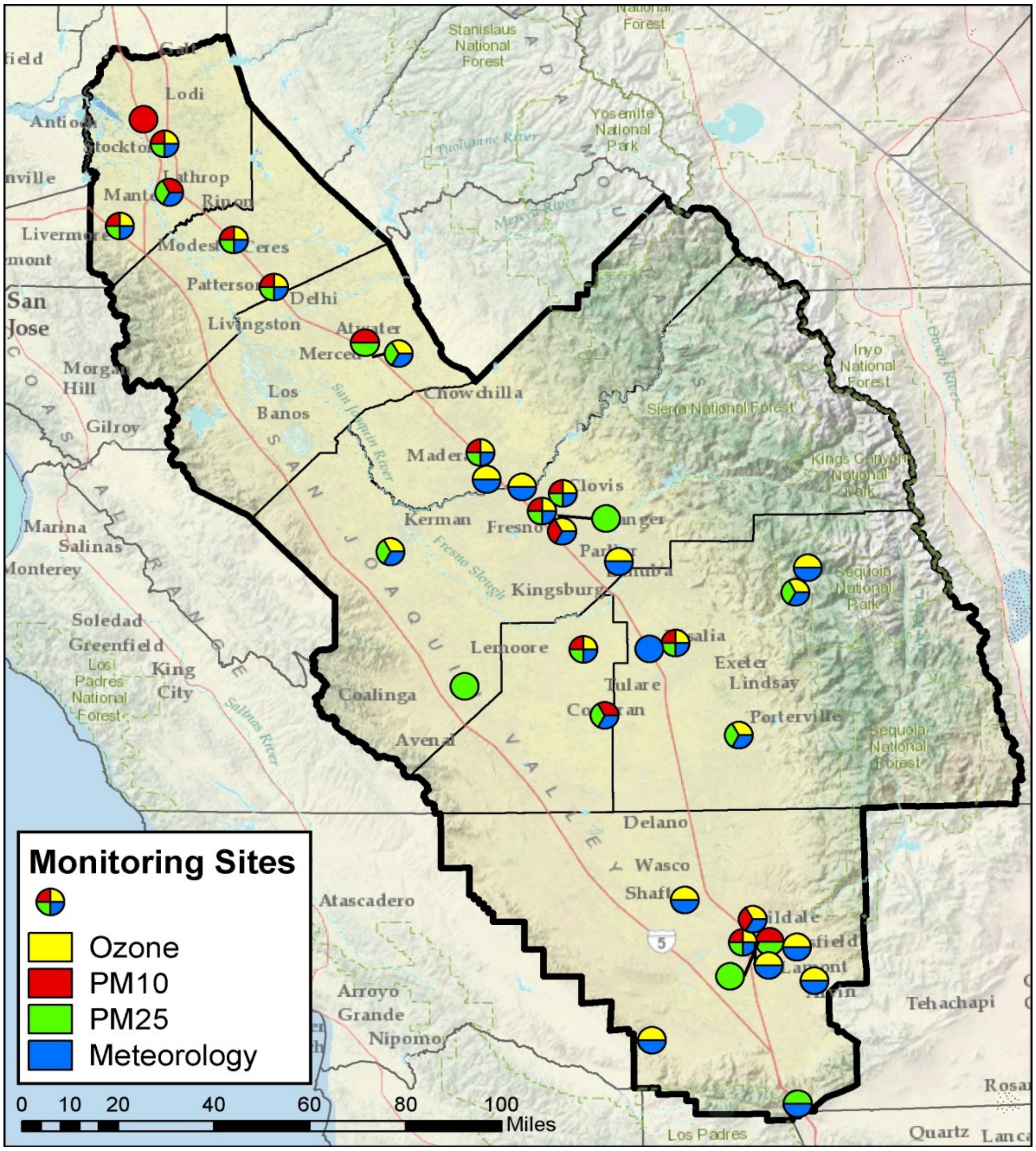


Figure 2-2 depicts the location of each monitor and the associated criteria pollutants measured (tribal monitors are not shown). Proper network analyses rely on the location of these monitoring sites relative to other monitors, nearby cities, influential geopraphic features, surrounding population, and meterology.

Figure 2-2. San Joaquin Valley Air Monitoring Sites



2.2.3 Data Completeness, Data Above MDL, Measured Concentrations, and Deviation from NAAQS Analyses

This section discusses the approach and results of several site-by-site analyses including data completeness, percent above the MDL, measured concentrations, and the deviation from the NAAQS.

Data Completeness

Sites with complete data sets are more valuable for air quality analysis and tracking than sites that have long periods of missing or invalidated data. Data completeness is a measure of the number of actual data records collected and reported at a monitoring site relative to the number of expected data records based on the sampling interval and frequency for a given parameter or pollutant. Data completeness is calculated by dividing the actual number of data records reported by the expected number of data records. The expected number of data records for a given pollutant is based on the length of monitoring season and the sampling frequency. For example, a continuous ozone monitor operating year-round would be expected to have 8,760 data records for one year of operation (1 measurement per hour x 24 hours x 365 days per year = 8,760).

Data completeness is presented as the percent of data records reported taking into account the sampling frequency. EPA recommends that data completeness of 85% is considered good for a given site, indicating that there are enough data to perform robust data analyses assuming the data are of high quality (Raffuse et al., 2007). Because of instrument calibration, data completeness will generally be 95-97% depending on how frequently an instrument is calibrated.

Percent Above the MDL

The MDL is a value at which a measured concentration is considered statistically distinguishable from zero. An assessment of the percent of data above the MDL is performed to identify the number of samples in a data set that are considered to have concentration values statistically distinguishable from zero. While samples below the MDL can be used for some purposes, such as stating that a concentration is below the MDL for comparison to NAAQS, they are not as useful for quantifying ambient concentrations, trends analysis, and/or air quality model validation. The percent above the MDL analysis provides an indicator of data quality and the usefulness of the data collected for performing air quality analyses.

Measured Concentrations

Measured concentrations analysis identifies sites that consistently measure high pollutant concentrations. For this analysis, the average and maximum concentration values were examined. Results of this analysis were used to determine whether each site is meeting its objective(s). For example, if the objective of a particular site is to measure high pollutant concentrations but that site routinely measures low concentrations, then we may conclude that the objective of the site should be changed or the site should be relocated to an area of high pollutant concentrations in order to meet its objective.

Deviation from NAAQS

The deviation from NAAQS analysis indicates sites that are important for monitoring NAAQS compliance. This analysis was not designed to determine attainment status, but rather to provide an estimate of whether concentrations observed at a particular site are close to the NAAQS. Sites routinely measuring concentration values close to the NAAQS are considered important for meeting the monitoring objective of determining NAAQS attainment. The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS compliance value (e.g., 1-hr, 8-hr, 4th highest maximum value, etc.). Small changes in measured pollutant concentrations can result in values above or below the NAAQS. In some cases, when information to determine the design value was not available, comparisons of the annual average or maximum pollutant concentrations were made. The deviation from NAAQS calculations presented here are not meant to be attainment calculations but general comparisons against the NAAQS to identify sites having measured values near (within 15% of) the NAAQS.

Summary and Discussion of Results

Tables 2-2 through 2-11 include a summary and discussion of the results of the analyses for data completeness, percent above MDL, measured concentrations, and deviation from NAAQS for sulfur dioxide, lead, ozone, nitrogen dioxide, PM_{10}, $PM_{2.5}$, and carbon monoxide for all sites in the SJV.

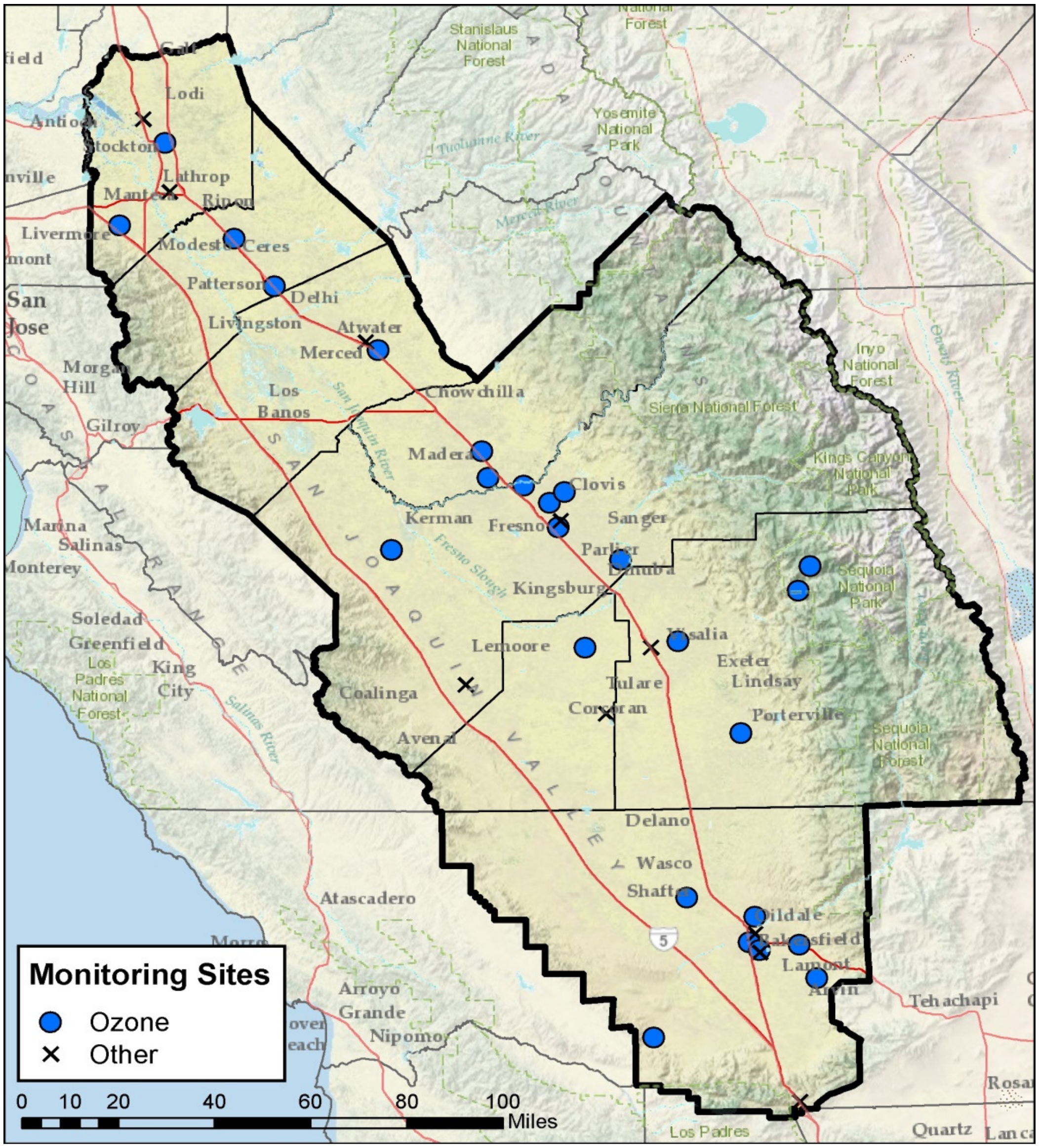
In Tables 2-2 through 2-11, the cells shaded in blue indicate the following:

- Percent complete – sites with a percent complete value less than 85%
- Percent above MDL – sites with a percent above MDL value less than 85%
- Deviation from NAAQS – sites with a deviation from NAAQS value that is within 15% of the NAAQS for the pollutant indicated.

Ozone (O_3)

Figure 2-3 shows the ozone monitoring network across the San Joaquin Valley. Overall, data completeness for 1-hr ozone is good. All sites with the exception of Tracy-Airport, Hanford-Irwin, and Bakersfield-Muni have data completeness of 80% or greater. Overall, the percent above MDL results are good. Several sites indicated in blue in Table 2-2 have percent above MDL values that are less than 85%; however, most of those values are greater than 80%, with the exception of Fresno-Garland at 79%. The low values at this site are worth noting because this site is in an urban area. Urban sites may measure chemically titrated ozone concentrations, which could account for the lower percent above MDL values.

Figure 2-3. Location of Ozone Monitoring Sites in the San Joaquin Valley



Deviation from NAAQS analysis indicates that all sites measure high ozone concentrations relative to the NAAQS for both the hourly and 8-hr average time intervals. Madera-City, Fresno-Sky Park, Clovis-Villa, Fresno-Drummond, Parlier, Porterville, Sequoia-Ash Mountain, Shafter, Bakersfield-California, Bakersfield-Muni, and Arvin-Di Giorgio are particularly valuable sites for measuring high concentrations.

Table 2-2. Summary of Data Completeness, Percent Above MDL, and Measured Concentrations Analyses for 1-Hr Ozone Data

1-Hour Ozone	% Complete	% Above MDL	Maximum Value	Deviation From NAAQS
Stockton-Hazelton	89	82	80	-45
Tracy-Airport	71	98	96	-29
Modesto-14th St	95	81	88	-37
Turlock	84	87	95	-30
Merced-Coffee	84	88	100	-25
Madera-City	84	95	121	-4
Madera-Pump Yard	84	91	100	-25
Tranquillity	93	96	87	-38
Fresno-Sky Park	85	93	114	-11
Clovis-Villa	86	86	123	-2
Fresno-Garland	95	79	103	-22
Fresno-Drummond	89	85	107	-18
Parlier	85	92	116	-9
Hanford-Irwin	79	92	104	-21
Visalia-Church St	94	84	95	-30
Sequoia-Lower Kaweah	81	100	106	-19
Sequoia-Ash Mountain	91	100	120	-5
Porterville	87	96	112	-13
Shafter	90	83	112	-13
Oildale	94	96	99	-26
Bakersfield-California	83	81	107	-18
Edison	95	99	101	-24
Bakersfield-Muni	80	88	109	-16
Arvin-Di Giorgio	95	97	109	-16
Maricopa	90	100	89	-36

Table reflects data for 2013.
Concentration data are reported in units of ppb.
Cells highlighted in blue in the % Complete column indicate sites with fewer than 85% of data reported as complete.
Ozone MDL = 5 ppb.
Cells highlighted in blue in the % Above MDL column indicate sites with fewer than 85% of data reported above the MDL.
Maximum value equals the 1-hr annual maximum.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS 1-hour average compliance value of 125 ppb.
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.

The deviation from NAAQS analysis for 8-hour average ozone in Table 2-3 indicates that Stockton–Hazleton, Tracy-Airport, Modesto-14th St, Merced-Coffee, Madera-City, Madera-Pump Yard, Tranquillity, Hanford-Irwin, Visalia-Church St, Sequoia-Lower Kaweah, Shafter, Oildale, and Maricopa are particularly important sites for determining NAAQS attainment because they measure concentration values that are close to (within 15%) the 8-hr ozone NAAQS. At Stockton-Hazleton and Modesto-14th St, the 3-yr averages of the 4th highest 8-hr daily maximum ozone measured concentrations were below the NAAQS.

Table 2-3. Summary of Data Completeness, Measured Concentrations, and Deviation from NAAQS Analyses for 8-Hr Average Ozone Data

8-Hour Ozone	% Complete	Maximum Value	4th Highest Value	Deviation From NAAQS
Stockton-Hazelton	97	67	67	-8
Tracy-Airport	97	82	79	+3
Modesto14thSt	99	82	75	0
Turlock	87	84	86	+11
Merced-Coffee	90	91	81	+6
Madera-City	85	101	84	+9
Madera-Pump Yard	89	88	79	+4
Tranquillity	97	78	77	+2
Fresno-Sky Park	90	100	88	+13
Clovis-Villa	94	104	94	+19
Fresno-Garland	99	93	89	+14
Fresno-Drummond	95	94	94	+19
Parlier	91	100	92	+17
Hanford-Irwin	85	98	84	+9
Visalia-Church St	99	84	80	+5
Sequoia -Lower Kaweah	99	89	85	+10
Sequoia-Ash Mountain	99	106	93	+18
Porterville	92	103	88	+13
Shafter	98	96	82	+7
Oildale	99	90	84	+9
Bakersfield-California	99	98	86	+11
Edison	99	86	86	+11
Bakersfield-Muni	87	102	87	+12
Arvin-Di Giorgio	99	94	89	+14
Maricopa	98	83	84	+9

Table reflects data for 2013.
Concentration data are reported in units of ppb.
Maximum value equals the 8-hr average annual maximum.
4th highest value is from 2011-2013.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS 8-hour average compliance value of 75 ppb.
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.

Nitrogen Dioxide (NO_2)

Figure 2-4 shows the location of the NO_2 sites in the San Joaquin Valley. The NO_2 analysis in Table 2-4 shows high percent above MDL values. While the Madera-Pump and Clovis-Villa sites have low data completeness, 48% and 73%, respectively, the measured concentrations and deviation from NAAQS analyses indicate that average NO_2 concentrations are well below the standard at all sites.

Figure 2-4. Location of NO_2 Monitoring Sites in the San Joaquin Valley

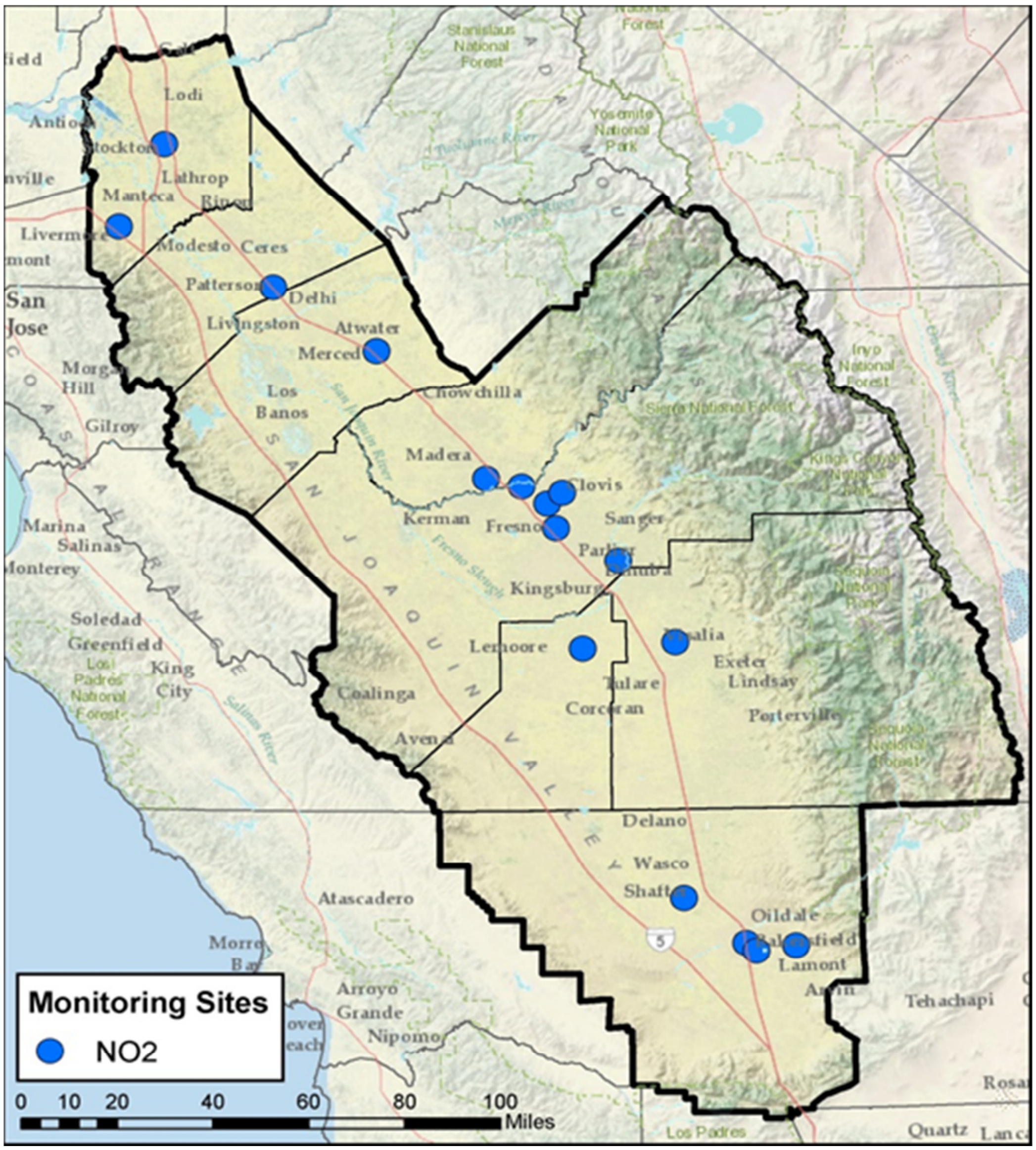


Table 2-4. Summary of Data Completeness, Percent above MDL, Measured Concentrations, and Deviation from NAAQS Analyses for NO_2

Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation From NAAQS
Stockton-Hazelton	89	100	62	15.8	-37.2
Tracy-Airport	80	99	34	6.4	-46.6
Turlock	89	100	54	10.7	-42.3
Merced- Coffee	84	100	52	7.6	-45.4
Madera-Pump Yard	48	100	60	7.9	-45.1
Fresno-Sky Park	84	100	118	8.5	-44.5
Clovis-Villa	73	100	54	10.7	-42.3
Fresno-Garland	93	100	60	13.1	-39.9
Fresno-Drummond	85	100	64	13.9	-39.1
Parlier	88	100	41	11.4	-41.6
Hanford-Irwin	84	100	58	10.3	-42.7
Visalia-Church St	94	100	62	12.7	-40.3
Shafter	94	100	59	14.0	-39
Bakersfield-California	77	100	55	13.2	-39.8
Edison	90	95	47	6.3	-46.7
Bakersfield-Muni	87	100	65	14.2	-38.8

Table reflects data for 2013.
Concentration data are reported in units of ppb.
Cells highlighted in blue in the % Complete column indicate sites with fewer than 85% of data reported as complete.
Nitrogen dioxide MDL = 1 ppb.
Maximum value equals the 1-hr annual maximum concentration.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS annual average compliance value of 53 ppb.

Particulate Matter (PM_{10})

Figure 2-5 shows the PM_{10} monitoring sites in the San Joaquin Valley. The summary of FRM PM_{10} monitoring data in Table 2-5 indicates that data completeness and percent above MDL are very good, with the exception of Bakersfield-California reporting a 59% data completeness. The highest observed maximum concentration of FRM PM_{10} occurred at Hanford-Irwin; which makes it the most valuable site for determining NAAQS attainment.

Figure 2-5. Location of PM10 Monitoring Sites in the San Joaquin Valley

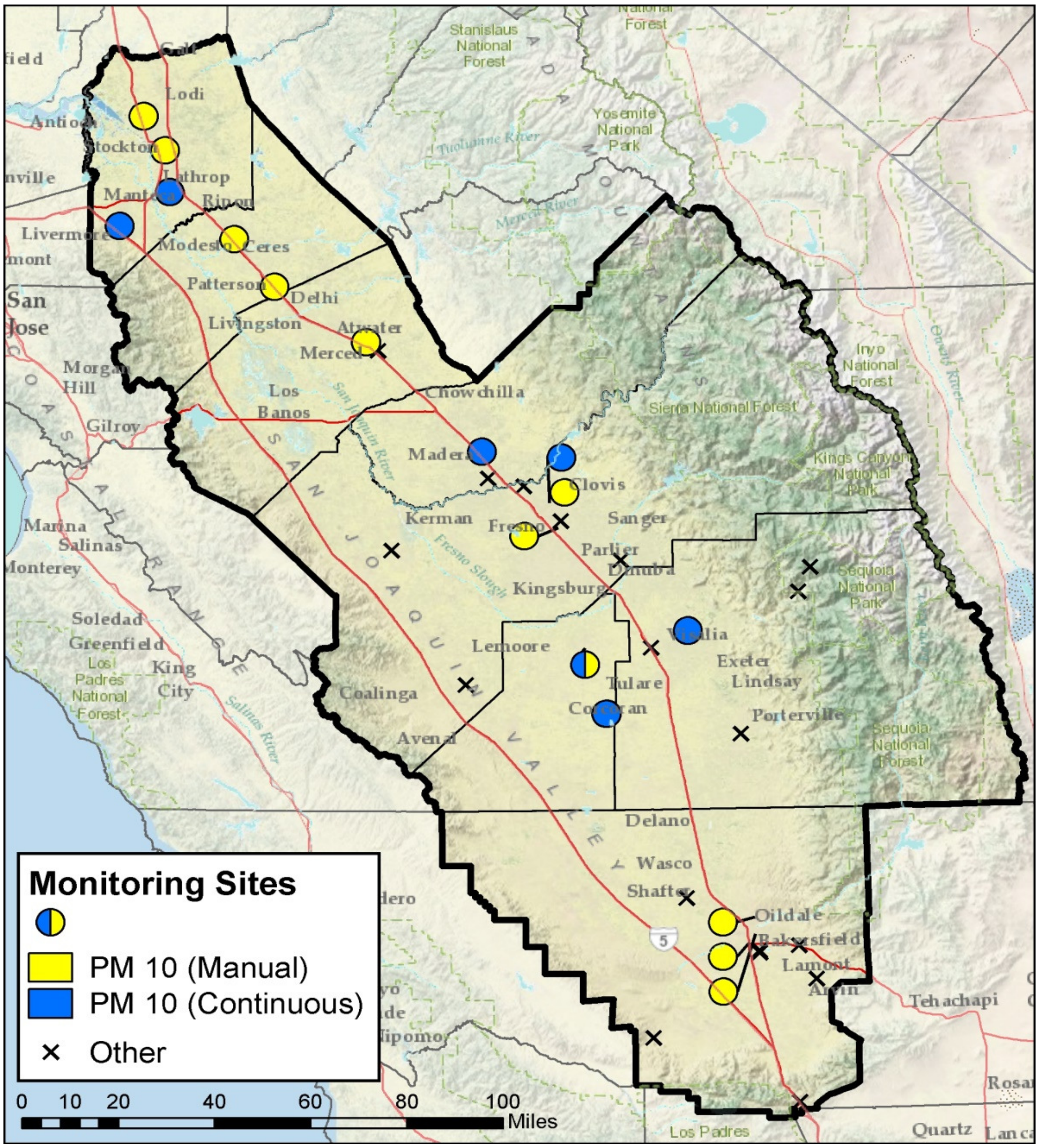


Table 2-5. Summary of Results of Data Completeness, Percent Above MDL, Measured Concentrations, and Deviation from NAAQS Analyses for Federal Reference Method (FRM) PM_{10} Measurements

Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation from NAAQS
Stockton-Wagner/Holt	79	100	62	24.8	-92
Stockton-Hazleton	95	100	90	30.8	-64
Modesto-14th St	98	100	73	30.0	-81
Turlock	98	100	79	35.2	-75
Merced-M St	85	100	77	36.4	-77
Clovis-Villa	90	100	119	35.6	-35
Fresno-Drummond	93	100	138	44.0	-16
Hanford-Irwin	93	100	177	49.9	+23
Visalia-Church St	93	100	15	43.9	+1
Oildale	95	100	13	51.4	-20
Bakersfield-California	59	100	120	48.6	-34

Table reflects data for 2013.
Concentration data are reported in units of $\mu g/m^3$.
Cells highlighted in blue in the % Complete column indicate sites with fewer than 85% of data reported as complete.
PM_{10} MDL= 2 $\mu g/m^3$ for 24-hr filter-based monitors.
Maximum value equals the annual daily maximum concentration.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS 24-hour average compliance value of 154 $\mu g/m^3$.
Cells highlighted in blue in the deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.
Some values in this table may be due to exceptional weather conditions (driest year on record, severe prolonged stagnation periods, strong surface-based temperature inversions, lowest relative humidity). Table does not include values due to exceptional events as defined by EPA.

The summary of continuous PM_{10} monitoring data in Table 2-6 indicates that data completeness and percent above MDL are very good for PM_{10} in Table 2-6, with the exception of Modesto-14th St and Fresno-Garland, with 68% and 50% data completeness, respectively. The daily maximum 24-hr calculated PM_{10} concentrations are highest at Hanford-Irwin and Corcoran-Patterson, and these sites are the most valuable for determining NAAQS attainment.

Table 2-6. Summary of Data Completeness, Measured Concentrations, and Deviation from NAAQS Analyses for 1-Hr Continuous PM_{10}

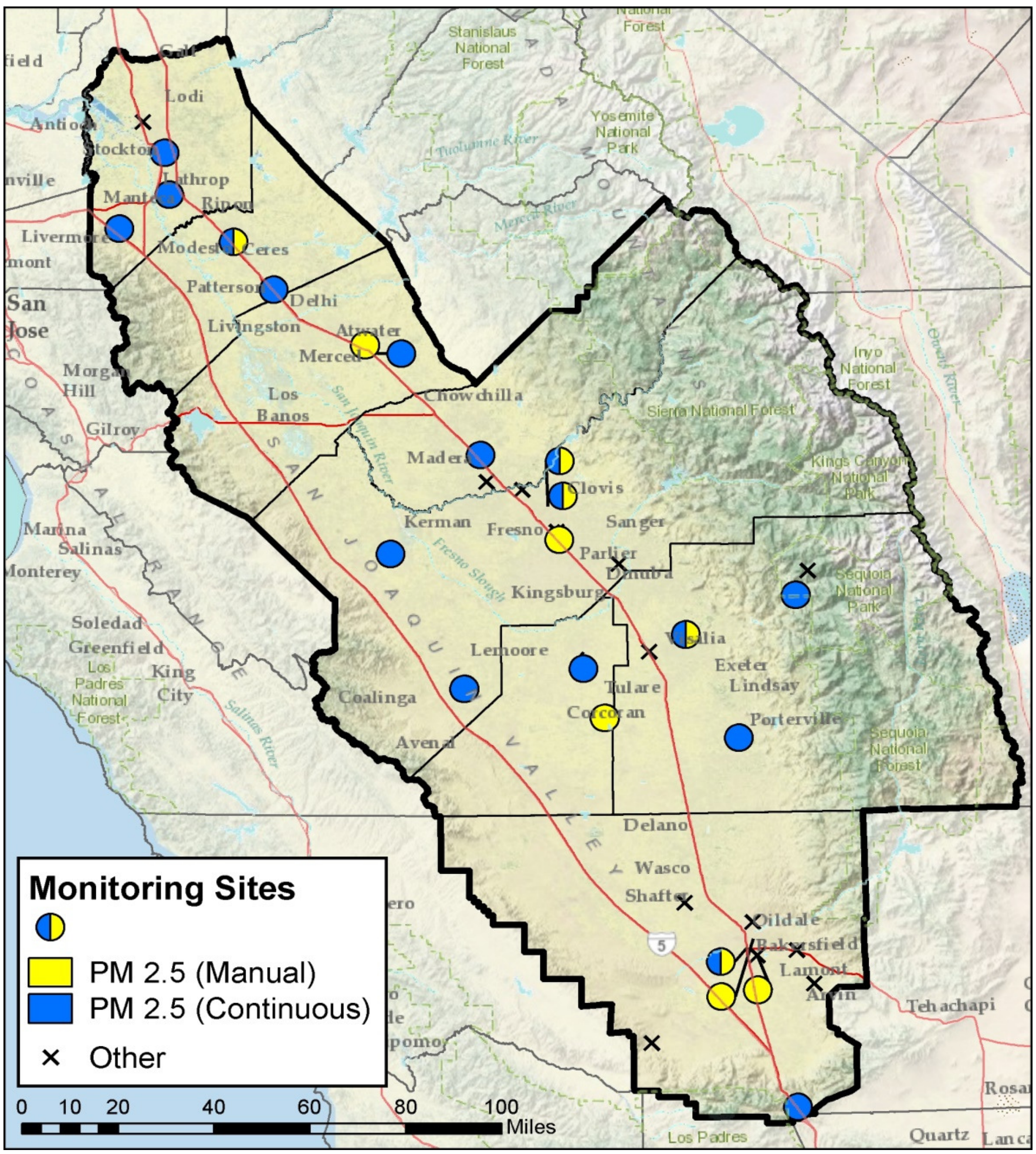
Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation from NAAQS
Manteca	94	100	140	32.2	-14
Tracy-Airport	89	100	73	21.9	-81
Modesto-14th St*	68	100	92	62.3	-62
Madera-City	90	100	110	36.3	-44
Fresno-Garland	50	100	132	43.4	-22
Hanford-Irwin	76	100	173	47.3	+19
Corcoran-Patterson	88	100	184	46.2	+30

Table reflects data for 2013.
Concentration data are reported in units of µg/m^3.
Cells highlighted in blue in the % Complete column indicate sites with fewer than 85% of data reported as complete.
PM_{10} MDL = -50 µg/m^3 for Manteca, Tracy-Airport, Madera-City, Hanford-Irwin, and Corcoran-Patterson.
PM_{10} MDL = 4 µg/m^3 for Modesto 14th St, and Fresno-Garland.
Maximum value equals the 24-hr maximum value calculated from 1-hr data.
*- Modesto-14th St shows only December 2013 data
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS 24-hour average compliance value of 154 µg/m^3.
Cells highlighted in blue in the deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.
Some values in this table may be due to exceptional weather conditions (driest year on record, severe prolonged stagnation periods, strong surface-based temperature inversions, lowest relative humidity). Table does not include values due to exceptional events as defined by EPA.

Particulate Matter ($PM_{2.5}$)

Figure 2-6 shows continuous and manual $PM_{2.5}$ monitors throughout the San Joaquin Valley. Table 2-7 reports that all FRM $PM_{2.5}$ 24-hr filter sites demonstrated good data completeness and percent above MDL. The measured concentrations and deviation from NAAQS analyses indicate that the concentrations are higher than the annual standard at all sites, except Merced M-St. The Modesto-14th and Merced M-St sites are valuable sites for determining NAAQS attainment. Analysis of continuous measurement $PM_{2.5}$ is reported in Table 2-8. All sites show good data completeness, except for Fresno-Garland, with data completeness at 49.5%. The measured concentrations and deviation from NAAQS analyses indicate that annual concentrations are higher than the standard at all sites with the exception of Manteca, which is below the standard.

Figure 2-6. Location of $PM_{2.5}$ Monitoring Sites in the San Joaquin Valley



Stockton-Hazleton, Manteca, Modesto-14th, and Merced-Coffee sites appear to be the most valuable for determining NAAQS attainment; however, note that the Deviation from NAAQS analysis is not meant to determine NAAQS compliance but to identify those sites that routinely measure concentrations close to the NAAQS.

Table 2-7. Summary of Data Completeness, Percent above MDL, Measured Concentrations, and Deviation from NAAQS Analyses for FRM $PM_{2.5}$ Measurements

Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation from NAAQS
Modesto-14th St	94	98.8	60.7	13.6	+1.6
Merced-M St	90	100	68.9	11.1	-0.9
Clovis-Villa	77	96.4	103.4	16.4	+4.4
Fresno-Garland	95	99.75	86	15.5	+3.5
Fresno-Pacific	83	100	95.4	14.7	+2.7
Corcoran-Patterson	91	98.8	104	15.0	+3.0
Visalia-Church St	96	100	124.2	16.6	+4.6
Bakersfield-California	85	99.5	113.3	16.4	+4.4
Bakersfield-Airport (Planz)	93	100	167.3	17.3	+5.3

Table reflects data for 2013.
Concentration data are reported in units of $\mu g/m^3$.
Cells highlighted in blue in the % Complete column indicate sites with fewer than 85% of data reported as complete.
$PM_{2.5}$ MDL = 2 $\mu g/m^3$ for 24-hr. filter-based monitors.
Maximum value equals the maximum daily average value.

Mean Value data from 2011-2013. At sites where FRM/FEM data is present, data was combined according to 40 CFR Part 50, Appendix N.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS annual average compliance value of 12.0 $\mu g/m^3$.
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.

Table 2-8. Summary of Data Completeness, Percent above MDL, Measured Concentrations, and Deviation from NAAQS Analyses for 1-Hr Continuous $PM_{2.5}$ Measurements

Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation from NAAQS
Stockton-Hazleton	94.5	100	62	13.9	+1.9
Manteca	97	98	54	10.2	-1.8
Tracy-Airport	86	89.1	56	7.5	
Modesto-14th St	98	97.5	83	13.6	+1.6
Turlock	95	97.4	75	15.6	+3.6
Merced-Coffee	98	98.6	75	13.3	+1.3
Madera-City	98	99.7	88	18.1	+6.1
Clovis-Villa	92	98.8	102	16.4	+4.4
Fresno-Garland	49.5	100	103	15.5	+3.5
Tranquillity	93	95.7	60	7.8	
Huron	90	96.4	72	13.7	
Hanford-Irwin	98	99.7	129	17.0	+5.0
Porterville	97	98.2	116	16.4	
Sequoia-Ash Mountain	77	100	25	8.5	
Lebec	97	83.0	42	7.7	

Table reflects data for 2013.

Concentration data are reported in units of $\mu g/m^3$.
Modesto-14th St, Fresno-Garland, Visalia-Church St, and Bakersfield-California real-time non-FEM $PM_{2.5}$ monitors not included in table above.
Cells highlighted in blue in the % Complete column indicate sites with fewer than 85% of data reported as complete.
$PM_{2.5}$ MDL = 2 $\mu g/m^3$ for 1-hr continuous monitors, except Sequoia-Ash Mountain monitor's MDL is -10 $\mu g/m^3$.
Cells highlighted in blue in the % Above MDL column indicate sites with fewer than 85% of data reported above the MDL.
Maximum value equals the 24-hr maximum value calculated from 1-hr data.
Mean Value data from 2011-2013. At sites where an FRM/FEM monitor is present, data was combined according to 40 CFR Part 50, Appendix N.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS annual average compliance value of 12.0 $\mu g/m^3$.
Deviation from NAAQS column only shows sites that have an FEM monitor
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.

Carbon Monoxide (CO)

As noted in 40 CFR 58 Appendix D Section 4.2, there are no minimum monitoring requirements for CO in the Valley except at near-road NO_2 monitors within Core Based Statistical Areas (CBSA) with a population of at least 1 million and at type 2 Photochemical Assessment Monitoring Stations (PAMS). As recommended by EPA to reduce redundancy, in the *2014 Air Monitoring Network Plan* the District evaluated non-mandatory CO monitoring sites and proposed the removal of three such sites in the Valley.

Figure 2-7 shows the location of the CO monitors in the San Joaquin Valley including the potential site closures. Stanislaus County currently has in operation two (2) CO monitors, located at the Modesto-14th and Turlock air monitoring sites. Due to the low CO concentrations in the SJV relative to the NAAQS and the new CO monitoring guidelines in 40 CFR 58 Appendix D Section 4.2, the District proposed the closure of the CO monitor at Turlock. The pollutant will continue to be measured in the county at the Modesto-14th site so as not to eliminate CO monitoring in the area.

Figure 2-7. Location of CO Monitoring Sites in the San Joaquin Valley, including proposed closures

Similarly Fresno County has in operation four (4) CO monitors, located at the Clovis, Fresno-Sierra Sky Park, Fresno-Garland, and Fresno-Drummond air monitoring sites.

The district similarly proposed closures of the CO monitors at Fresno-Sierra Sky Park and Fresno-Drummond. The pollutant will continue to be measured in the county at the Clovis site, as it is requires due to its status as a PAMS site, as well as at Fresno-Garland.

To support the findings, data completeness and deviation analysis was performed on all sites currently in operation. Table 2-9 demonstrates that data completeness and % above MDL for CO is good at all sites with the exception of Stockton-Hazelton and Modesto-14th which are14.9% above MDL. This is due to the low CO concentrations in the SJV relative to the NAAQS and the need for higher sensitivity instruments to achieve a higher percentage of data above MDL

Table 2-9. Summary of Data Completeness, Percent above MDL, Measured Concentrations, and Deviation from NAAQS Analyses for 8-Hr CO Measurements

Site Name	% Complete	% Above MDL	Maximum Value	Deviation From NAAQS
Stockton-Hazelton	82	14.9	1.8	-7.2
Modesto-14th St	92	14.9	2.1	-6.9
Turlock	85	100	1.6	-7.4
Fresno-Sky Park	88	100	2.3	-6.7
Clovis-Villa	86	100	1.7	-7.3
Fresno-Garland	94	94.5	2.3	-6.7
Fresno-Drummond	81	100	2.5	-6.5
Bakersfield-Muni	89	100	1.2	-7.8

Table reflects data for 2013
Concentration data are reported in units of ppm.
Cells highlighted in blue in the % Complete column indicate sites with fewer than 85% of data reported as complete.
CO MDL = 0.11 ppm at Fresno-Garland.
CO MDL = 0.5 ppm at Stockton-Hazelton and Modesto-14th
CO MDL = 0 ppm at Clovis-Villa and Bakersfield-Muni
CO MDL = 0.1 ppm at Turlock
CO MDL = 0.2 ppm Fresno-Sky Park and Fresno-Drummond
Cells highlighted in blue in the % Above MDL column indicate sites with fewer than 85% of data reported above the MDL.
Maximum value equals the 8-hr average maximum value at a site for 2013.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS 8-hr. average compliance value of 9 ppm.

Sulfur Dioxide (SO_2) and Lead (Pb)

Figures 2-8 and 2-9 show the location of the SO_2 and Pb monitors, respectively.

Figure 2-8. Location of SO_2 Monitor in the San Joaquin Valley

Figure 2-9. Location of Pb Monitor in the San Joaquin Valley

Table 2-10 and Table 2-11 report good data completeness and % above MDL for SO_2

and Pb at the Fresno-Garland site. This is due to the low SO_2 and Pb concentrations in the SJV relative to the NAAQS.

Table 2-10. Summary of Data Completeness, Percent Above MDL, Measured Concentrations, and Deviation from NAAQS Analyses for 1-Hr SO_2 Measurements

Site Name	% Complete	% Above MDL	Maximum Value	Deviation From NAAQS
Fresno-Garland	94	80.6	7	-68

Table reflects data for 2013.
Concentration data are reported in units of ppb.
SO_2 MDL = 0.2 ppb.
Cells highlighted in blue in the % Above MDL column indicate sites with fewer than 85% of data reported above the MDL.
Maximum value equals the 1-hr average maximum value at a site for 2013.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS 1-hr. average compliance value of 75 ppb.

Table 2-11. Summary of Data Completeness, Percent above MDL, Measured Concentrations, and Deviation from NAAQS Analyses for Pb Measurements

Site Name	% Complete	% Above MDL	Maximum Value	Deviation From NAAQS
Fresno-Garland	100	100	.01	-0.14

Table reflects data for 2013.
Concentration data are reported in units of $\mu g/m^3$.
Pb MDL = 0.001 $\mu g/m^3$.
Maximum value equals the 3-month rolling average at a site for 2013.
The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS 3-month rolling average compliance value of 0.15 $\mu g/m^3$.

Toxics

Toxics monitoring in the SJV is conducted by the CARB at the sites of Stockton-Hazelton, Fresno-Garland, and Bakersfield-California. Figure 2-10 shows where the toxics monitoring sites are located in the San Joaquin Valley. The District operates several PAMS sites that measure selected toxics compounds during the summer. The PAMS network assessment will be discussed in more detail in Section 2.5.

Figure 2-10. Location of Toxics Monitoring Sites in the San Joaquin Valley

2.2.4 Length of Trend Record Analysis

Monitors that have long historical data records are valuable for tracking pollutant trends and control strategy effectiveness. For the length of trend record analysis, the number of years of data collection was summed by site and pollutant. Table 2-12 shows the trend length by site and pollutant. Several sites in the San Joaquin Valley have long data records for multiple parameters. Most notably, the Stockton-Hazelton, Modesto-14th St., Turlock, Madera-Pump Yard, Fresno-Sky Park, Clovis–Villa, Fresno-Garland, Fresno-Drummond, Parlier, Hanford-Irwin, Visalia-Church St., Shafter, and Bakersfield–California sites have been monitoring for more than a decade.

The numbers in Table 2-12 represent the number of years of data collected at each site. Sites with ten or more years of data are marked “10+” and highlighted green.

Table 2-12. Length of Monitoring Analysis (Number of Years) through 2013

Site Name	Ozone	1-hr PM_{10}	24-hr PM_{10}	1-hr $PM_{2.5}$	24-hr $PM_{2.5}$	NO_2	CO	PAMS	Pb	SO_2	Met
Stockton-Wagner/Holt	0	0	10+	0	0	0	0	0	0	0	0
Stockton-Hazelton	10+	0	10+	4	0	10+	1	0	0	0	10+
Tracy-Airport^	9	9	0	9*	0	0	0	0	0	0	9
Manteca	0	0	3	0	4	0	0	0	0	0	4
Modesto-14th St	10+	1	10+	4	10+	0	1	0	0	0	10+
Turlock	10+		8	8	0	10+	10+	0	0	0	10+
Merced-M St	0	0	10+	0	10+	0	0	0	0	0	0
Merced-Coffee	10+	0	0	5	0	10+	0	0	0	0	10+
Madera-City	4	4	0	4	0	0	0	0	0	0	4
Madera-Pump Yard	10+	0	0	0	0	10+	0	10+	0	0	10+
Fresno-Sky Park	10+	0	0	0	0	10+	10+	0	0	0	10+
Tranquillity	5	0	0	5	0	0	0	0	0	0	5
Clovis-Villa	10+	0	10+	6	2	10+	10+	10+	0	0	10+
Fresno-Garland[1]	10+	10+	10+	10+	10+	10+	10+	0	10+	10+	10+
Fresno-Pacific	0	0	0	0	10+	0	0	0	0	0	
Fresno-Drummond	10+	0	10+	0	0	10+	10+	0	0	0	10+
Parlier	10+	0	0	0	0	10+	0	10+	0	0	10+
Huron	0	0	0	5	0	0	0	0	0	0	4
Hanford-Irwin	10+	4	10+	4	0	10+	0	0	0	0	10+
Corcoran-Patterson	0	10+	0	8*	10+	0	0	0	0	0	10+
Sequoia-Lower Kaweah	10+	0	0	0	0	0	0	0	0	0	10+
Sequoia-Ash Mountain	10+	0	0	7*	0	0	0	0	0	0	10+
Visalia-Church St	10+	0	10+	10+	10+	10+	0	0	0	0	10+
Visalia-Airport^	0	0	0	0	0	0	0	0	0	0	10+
Porterville	4	0	0	4	0	0	0	0	0	0	4
Shafter	10+	0	0	0	0	10+	0	10+	0	0	10+
Oildale	10+	0	10+	0	0	9	0	0	0	0	10+
Bakersfield-California	10+	0	10+	10+*	10+	10+	0	0	10+	0	10+
Bakersfield-Muni	2	0	0	0	0	0.5	0.5	2	0	0	0.5
Bakersfield-Airport (Planz)	0	0	0	0	10+	0	0	0	0	0	0

Table 2-12. Length of Monitoring Analysis (Number of Years) through 2013 (continued)

Site Name	Ozone	1-hr PM_{10}	24-hr PM_{10}	1-hr $PM_{2.5}$	24-hr $PM_{2.5}$	NO_2	CO	PAMS	Pb	SO_2	Met
Edison	10+	0	0	0	0	10+	0	0	0	0	10+
Arvin-Di-Giorgio[2]	5	0	0	0	0	0	0	0	0	0	5
Maricopa	10+	0	0	0	0	0	0	0	0	0	10+
Lebec	0	0	0	5*	0	0	0	0	0	0	5

[1] In December 2011, CARB moved the Fresno-First air monitoring station to Garland Avenue which is two blocks north of the previous site. The District considers the Fresno-First site (060190008) and the Fresno-Garland site (060190011) the same site which serves as an NCore site. After the relocation was complete, monitoring resumed as it was prior to the move.

[2] Arvin Di Giorgio is the replacement site for the Arvin-Bear Mountain site. The Arvin-Bear Mountain site was operational from June 1989 to January 2010 and measured ozone, meteorology, and PAMS parameters. The site was closed due to expiration of the lease.

* Non-Regulatory $PM_{2.5}$ monitor.

^ Site includes a lower air profiler.

2.3 AREA-SERVED, POPULATION-SERVED, POPULATION CHANGE, AND EMISSIONS-SERVED ANALYSES

The purpose of the area-served analysis is to estimate the spatial coverage of each monitoring site to identify potential spatial gaps or redundancies in the overall monitoring network. Performing the area-served analysis is a multi-step process. The first step in the area-served analysis was to compile a map of the air quality sites which included both the District sites and other agency sites within and surrounding the boundary, using GIS software, then apply Thiessen polygons to assign a zone of influence or representativeness to the area around a given point—in this case, a monitoring site. The polygon defines the area closest to each site.

After the area-served boundaries were developed for each site and pollutant, the population-served analysis was performed. The purpose of the population-served analysis was to determine the population coverage represented by each monitoring site and to identify the sites surrounded by the highest population densities. It is also of interest to examine those areas within the SJV that have undergone substantial growth over the past several years and to examine monitoring site locations relative to areas of population growth.

Taking the area- and population-served analyses one step further, an emissions-served analysis was performed. The emissions-served analysis examines the proximity of monitoring sites to emissions sources and emissions densities within each area-served boundary. This analysis was performed by overlaying spatially resolved emissions (or activity) data onto the area-served boundaries to investigate the potential emissions impacts on each monitoring site. The most recent gridded NO_x and $PM_{2.5}$ emissions data were collected from the California Air Resources Board. Emissions are representative of a summer weekday in 2007.

The following sections discuss the findings of the area-, population-, and emissions-served analyses for ozone and $PM_{2.5}$, the two criteria pollutants for which the District is currently designated non-attainment. Because an individual monitoring site may measure a number of pollutants, the analyses are performed by first identifying the pollutant-specific networks and then performing the analyses for each individual network. The results below are presented for each of the non-attainment pollutants in the Valley.

Figure 2-11. Population Change from 1990-2010 Relative to District Monitoring Sites

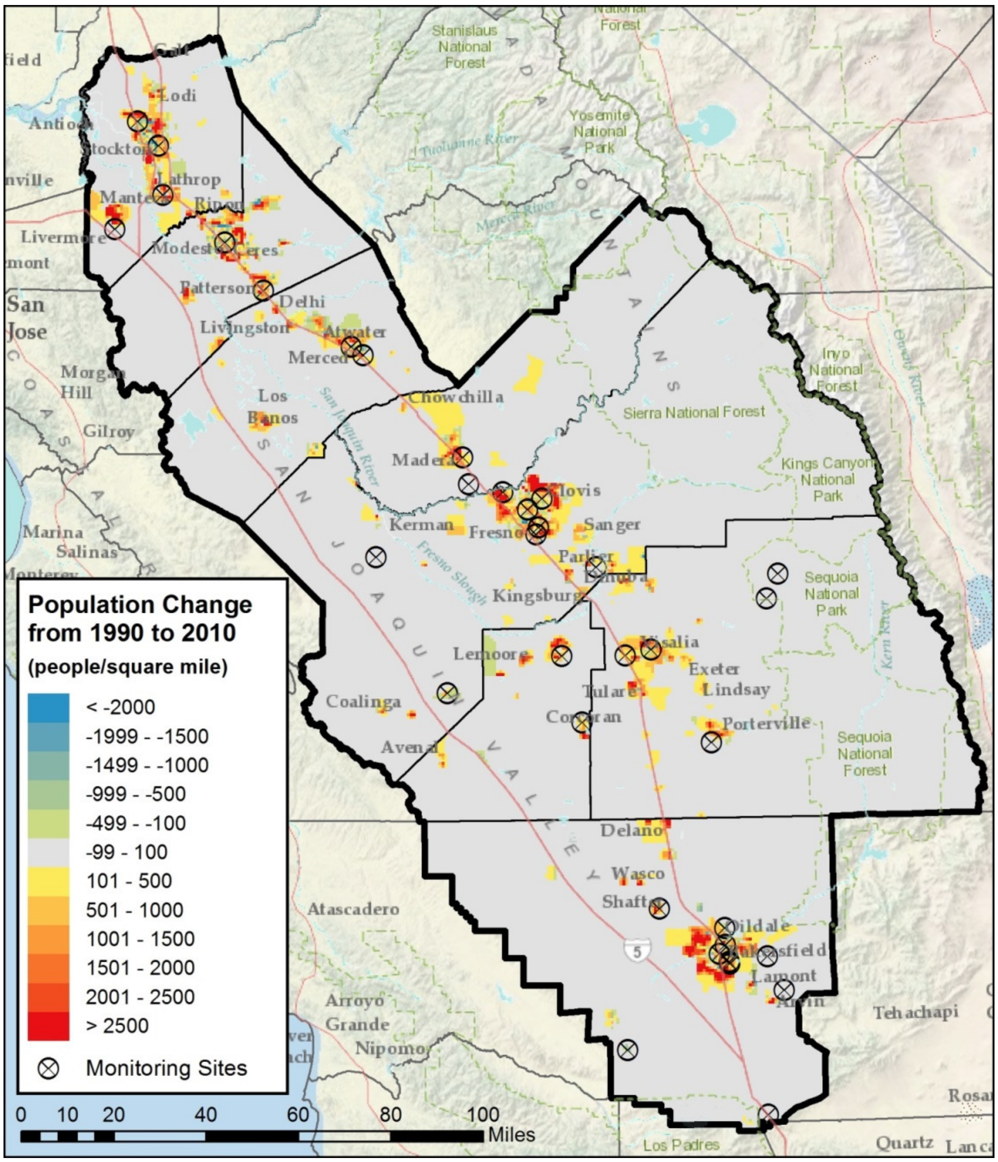


Figure 2-11 depicts the population change throughout the Valley and the proximity to all District monitoring sites. In many regions, areas that were once unpopulated are now fairly densely populated. As a result, human encroachment and associated increases in emissions activity may impact monitoring sites. These impacts can change site characteristics (e.g., a former rural site may now be an urban site). The results of the population change analysis indicate that the areas northeast of Clovis, west of Merced (Los Banos area), and west of Bakersfield all have high population growth. The most recent network additions at Madera and Manteca were placed in areas where population has continued to grow. As the Valley's population grows, the District will continually look for opportunities to expand the air monitoring network to continue to ensure adequate monitoring throughout the Valley.

2.3.1 Area and Emissions-served $PM_{2.5}$ Network

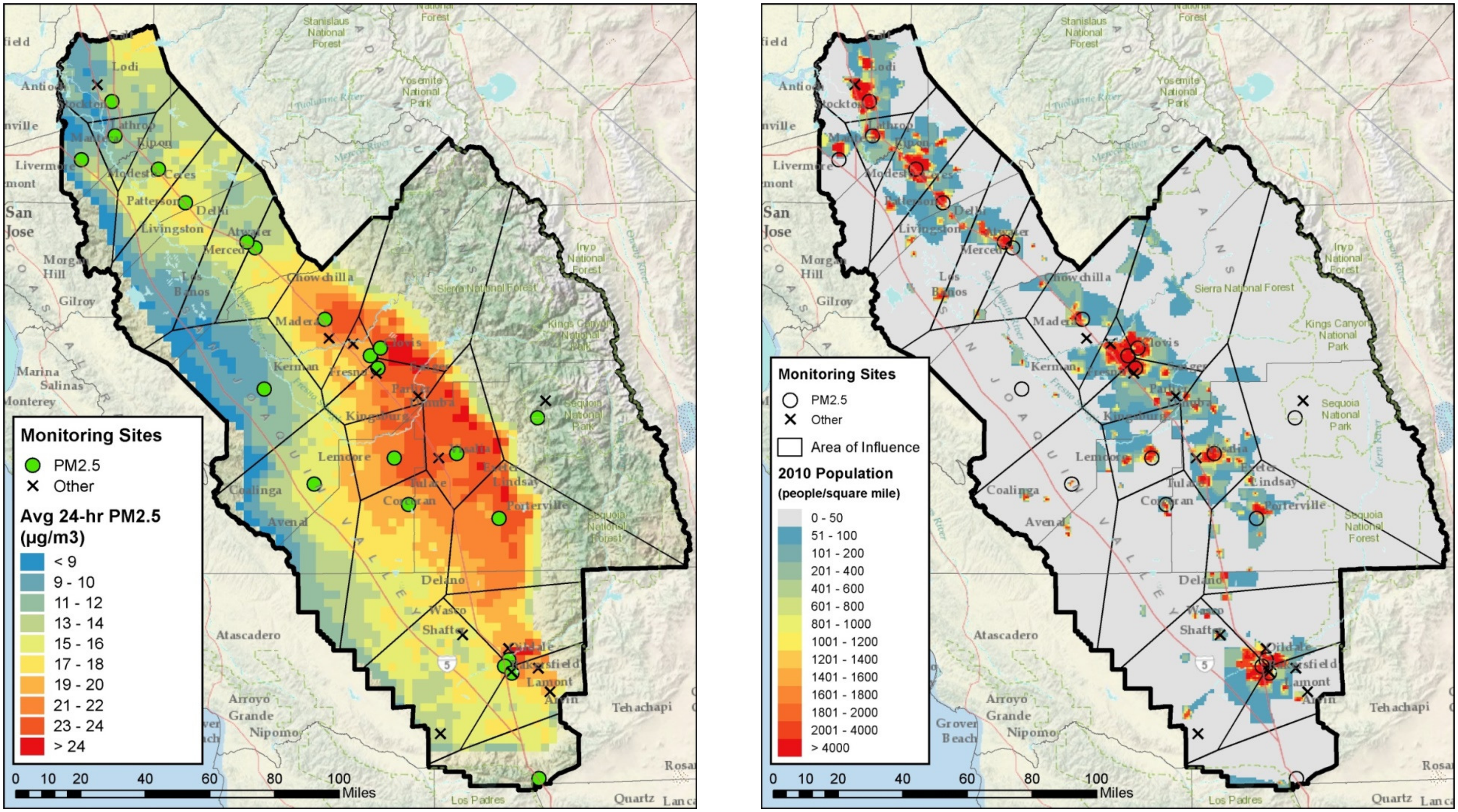
$PM_{2.5}$ monitoring in the SJV is aimed at measuring representative pollutant concentrations on both a neighborhood and an urban scale. By identifying area-served boundaries as they relate to average $PM_{2.5}$ concentrations, numbers of days $PM_{2.5}$ values exceed the NAAQS standard, and population density near the monitors, the District can determine the effectiveness of the current $PM_{2.5}$ network. Figures 2-12 and 2-13 depict the area of influence of the SJV $PM_{2.5}$ monitoring sites and the population density of each 1km^2 zone. Figure 2-12 compares the population density to the average $PM_{2.5}$ concentration in each zone. Figure 2-13 compares the population analysis to number of days each of the 4km^2 zones exceeds the $PM_{2.5}$ NAAQS of 35 µg/m^3.

From population density and $PM_{2.5}$ modeling analysis, the District can assess whether pollution in areas with significant populations is accurately represented by the nearest monitor. For example, the $PM_{2.5}$ monitor at Turlock serves a large, mostly unpopulated area that encompasses the City of Los Banos. Based upon analysis of the $PM_{2.5}$ concentrations represented in Figure 2-12, it is clear that the pollution levels are low in this populated pocket, so an additional site is unnecessary. An analysis of all the remaining $PM_{2.5}$ sites in the northern counties of San Joaquin, Stanislaus, Merced and Madera reveal that the $PM_{2.5}$ network covers the local populations and areas impacted by $PM_{2.5}$.

The Huron monitor in Fresno County has two population pockets within its area of influence, Coalinga and Avenal, which are also not near the monitor. If the District were to expand the $PM_{2.5}$ network in the future, it might be beneficial to capture emissions in southwest Fresno County. Further investigation would be necessary.

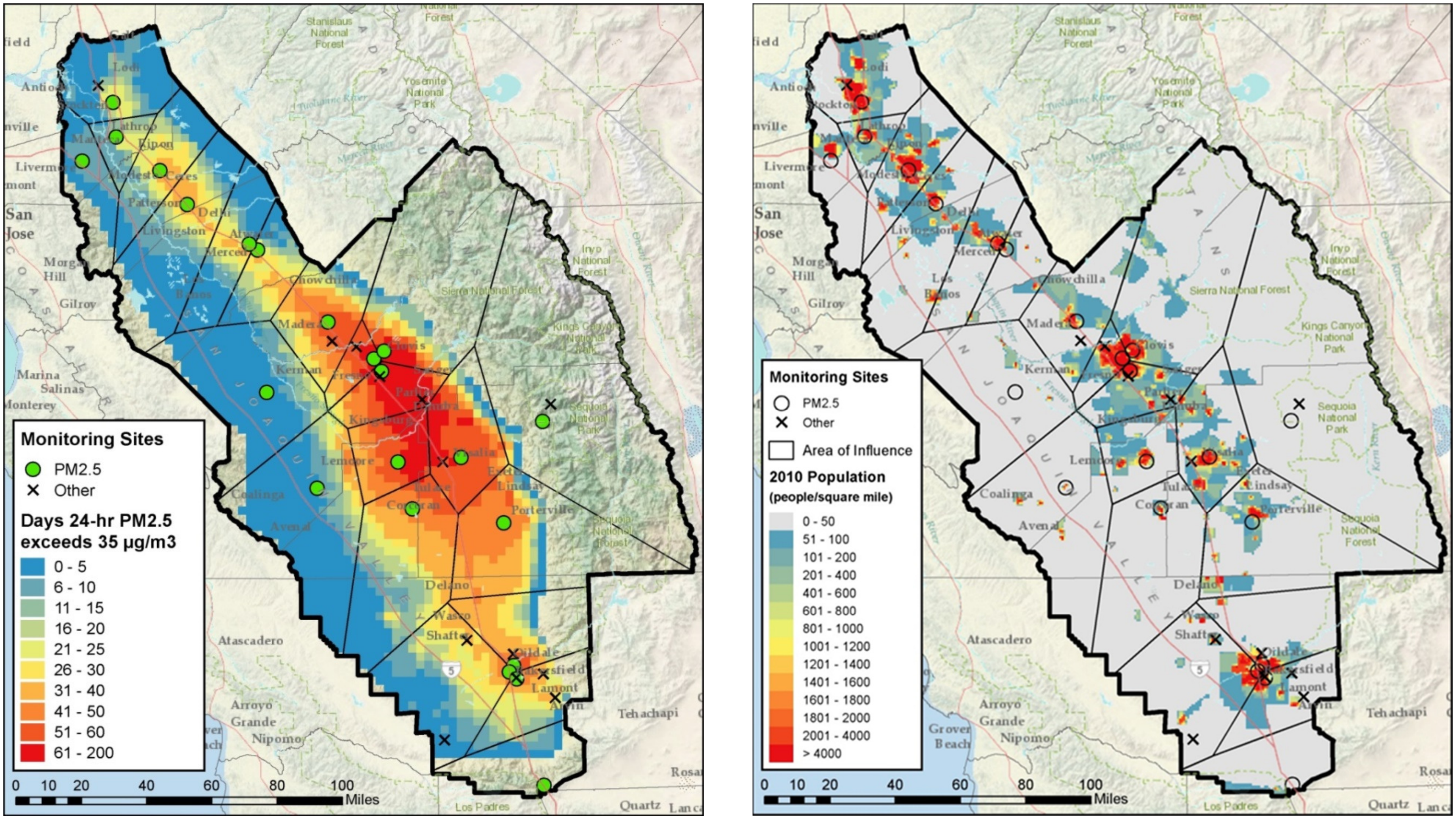
The monitor at Clovis-Villa serves a large area which includes the mountain region of Oakhurst, northeast of Clovis. If the District plans for future PM2.5 monitors, adding an Oakhurst site might provide useful information regarding local population exposure to PM2.5 pollution impacts in this populated area. Further investigation would be necessary. An analysis of all the remaining $PM_{2.5}$ sites in the southern counties of Fresno, Kings, Tulare, and Kern sufficiently cover the local populations and areas impacted by pollution.

Figure 2-12. On left, map of the areas served by the $PM_{2.5}$ monitoring sites in the San Joaquin Valley with the associated average 24-hr $PM_{2.5}$ concentrations for every $4km^2$ in the District on the valley floor. On right, map of the areas served by the $PM_{2.5}$ continuous monitoring sites in the San Joaquin Valley with the associated population/mi^2



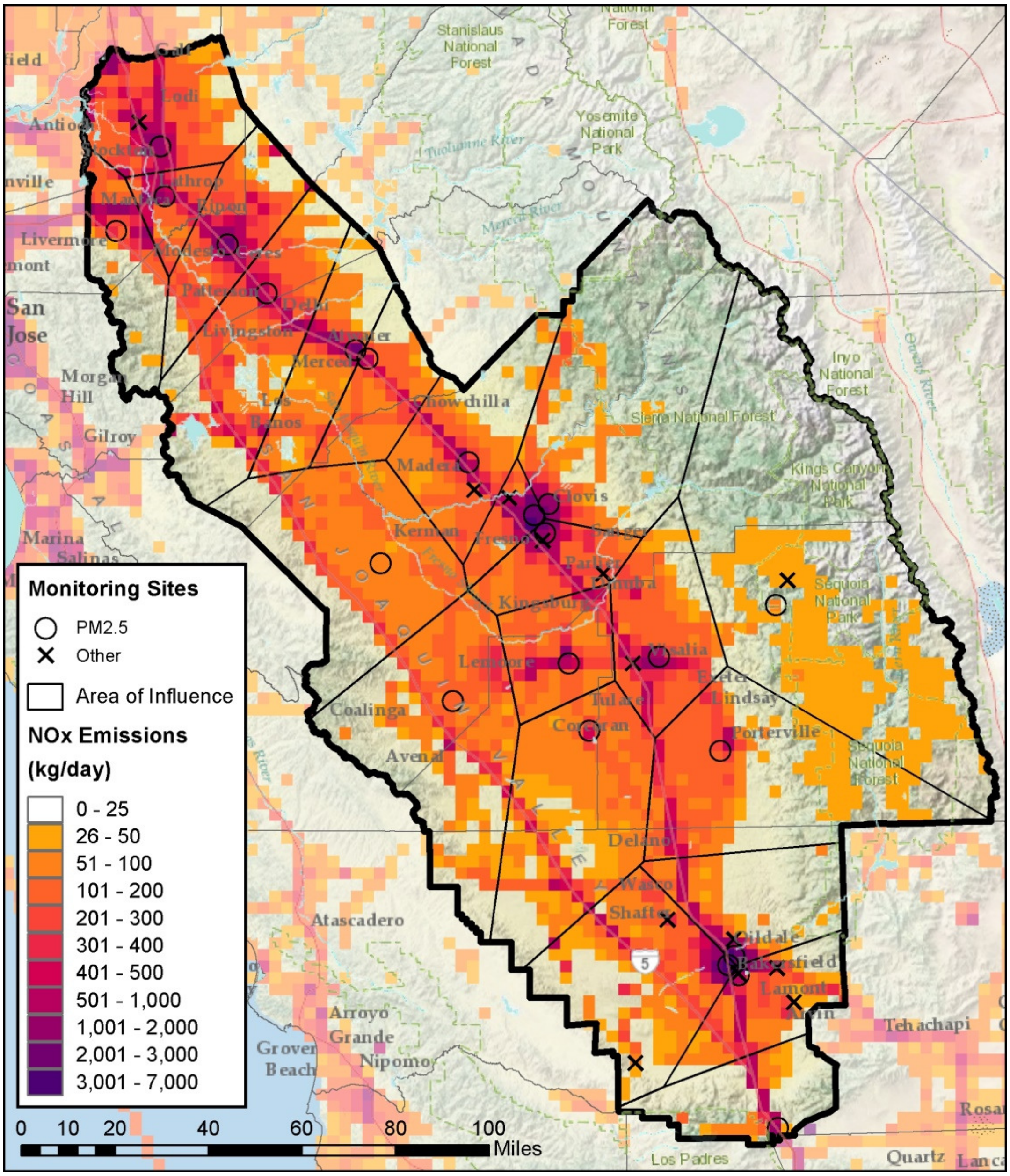
A similar analysis comparing regional population density to number of days over 35 $\mu g/m^3$ can give insight into whether significant populations are exposed to elevated pollution levels more frequently and help determine if an additional monitor is necessary to capture those concentrations more accurately. The District's analysis concludes that the network provides appropriate coverage for areas that may see frequent high concentrations of $PM_{2.5}$.

Figure 2-13. On left, map of the areas served by the $PM_{2.5}$ monitoring sites with the associated number days that the 24-hr $PM_{2.5}$ concentration exceeds the NAAQS. On right, map associated population/mi^2 for each area served



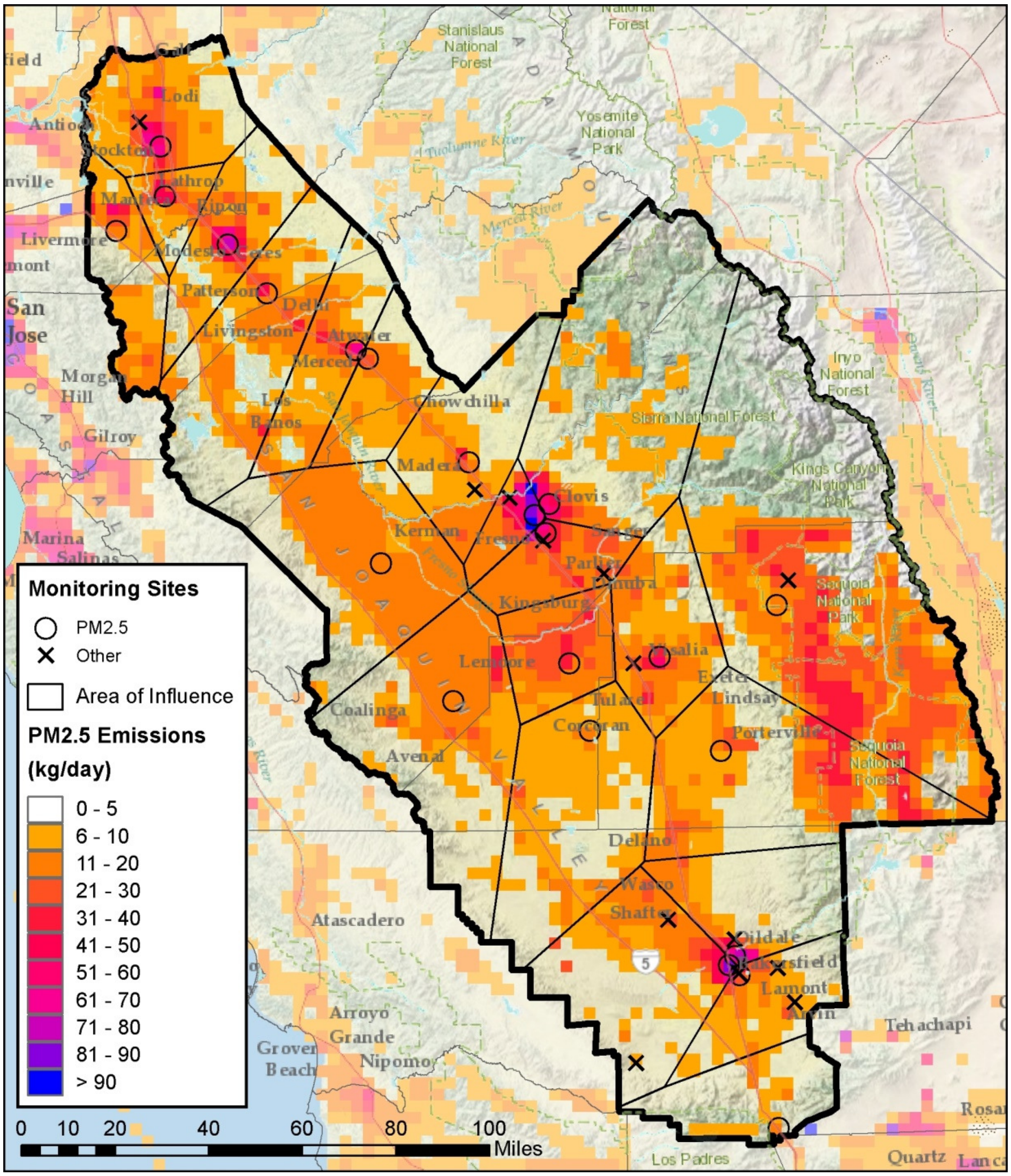
An emissions-served analysis of the $PM_{2.5}$ network can give further insight into whether locations which emit high pollution levels are accurately monitored. As expected, high NOx emissions are associated with freeways and largely-populated cities. As expressed above, and shown again in Figure 2-14 below, the large cities are appropriately served by this network. As for the emissions along the freeway, especially the 99 corridor, it was determined that additional monitors may be necessary in order to fully understand mobile-source NOx emissions in the valley. The District has four near-road NO_2 monitoring sites currently under development or construction to help fill the gaps indicated in the emissions-served map in Figure 2-14.

Figure 2-14. Map of NOx Emissions Assessed in Areas Served by $PM_{2.5}$ Monitors



Similarly, high $PM_{2.5}$ emissions are associated with freeways, largely-populated cities, as well as mountain regions where residential wood-burning and wildfires occur. As described in the population-served analysis, the large cities are appropriately served by the $PM_{2.5}$ network. Likewise, most areas with $PM_{2.5}$ emissions are captured by the current monitors.

Figure 2-15. Map of $PM_{2.5}$ Emissions Assessed in Areas Served by $PM_{2.5}$ Monitors



2.3.2 Area and Emissions-served Ozone Network

Like $PM_{2.5}$ monitoring, ozone monitoring in the SJV is aimed at measuring representative pollutant concentrations on both a neighborhood and an urban scale in order to better understand the local and regional causes, effects, and solutions to the non-attainment ozone problems faced by the District. By identifying area-served boundaries as they relate to maximum 1-hr ozone concentrations and numbers of days ozone values exceed the NAAQS standard, the district can determine the effectiveness of the current ozone network. Figures 2-16 and 2-17 depict the area of influence of the SJV ozone monitoring sites and the population density of each $4km^2$ zone. Figure 2-16 compares the population density to the maximum 8-hr ozone concentration in each of the $4km^2$ zone. Figure 2-17 compares the population analysis to number of days each zone exceeds the 8-hr NAAQS of 75 ppb ozone.

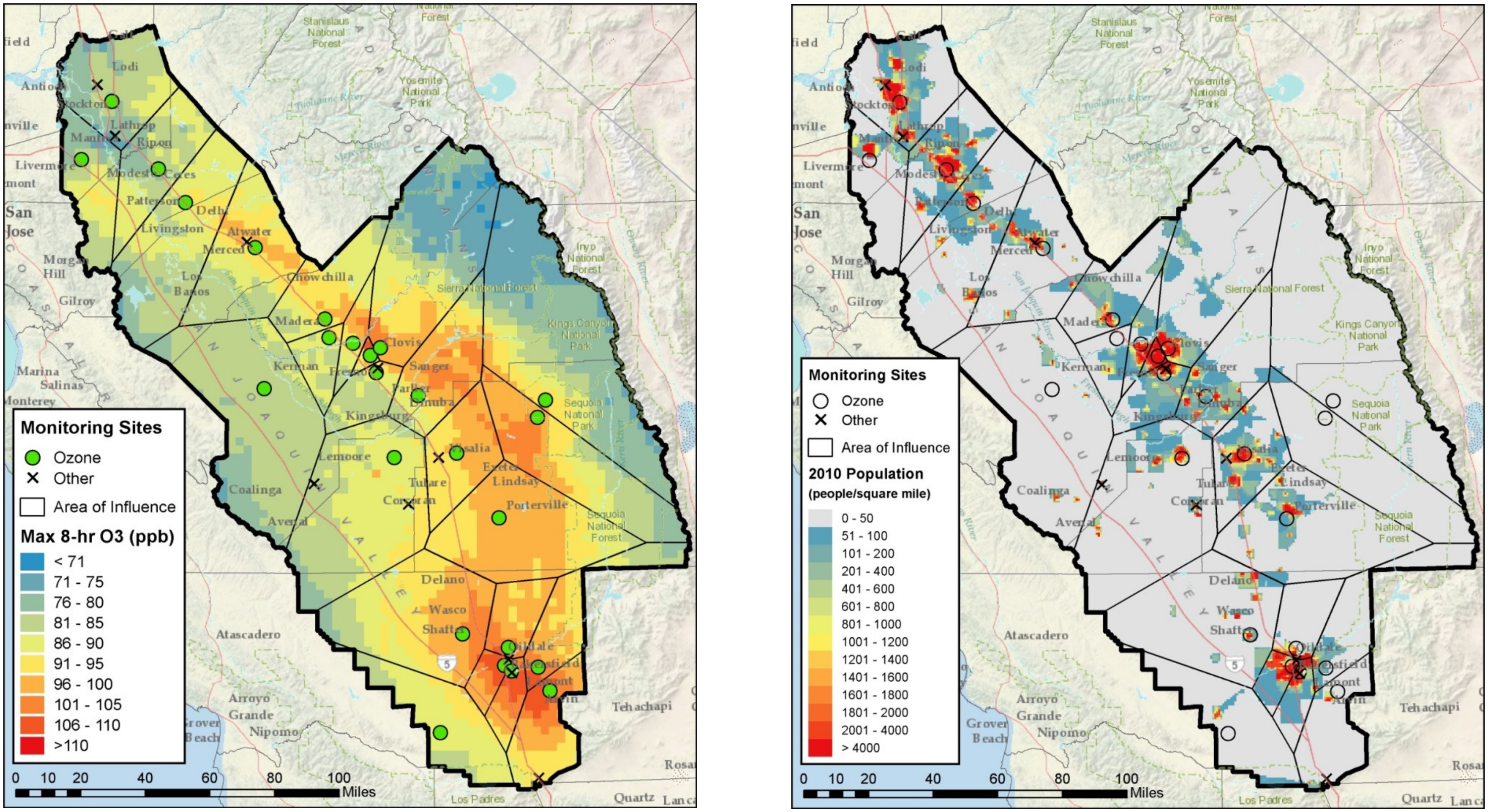
From population density and ozone modeling analysis, the District can assess whether areas with significant populations are accurately represented by their nearest monitor. Analysis of the ozone monitors in the northern counties of San Joaquin, Stanislaus, Merced, and Madera reveal that area and population are well-served. While it was mentioned that the site at Turlock serves a large area that encompasses the small local population of Los Banos, analysis of the modeled ozone concentrations in Figure 2-16 prove the pollutant concentrations are low so an additional site is not necessary.

There is a large grouping of ozone monitors located in the Fresno metropolitan area. The monitor at Clovis-Villa measures the gaseous and PM pollution parameters in the highly-populated area of Fresno County. As mentioned, this monitor is the closest to Oakhurst, a mountain community in Madera County. If the District plans for future ozone monitors, adding an Oakhurst site might provide useful information regarding local population exposure to ozone. Further investigation is necessary.

Further south, the Hanford site serves a vast area that encompasses many populated areas. The monitor is positioned far from a few small communities, including Corcoran to the south. Upon analysis of the modeled maximum 8-hr ozone concentrations in Figure 2-16, it appears that the pollution levels in Corcoran may sometimes vary from those in Hanford. As such, the ozone monitoring network may benefit from measuring ozone concentrations near Corcoran. Again, if network expansion occurs, the District could consider the addition of an ozone monitor at this already-existing site.

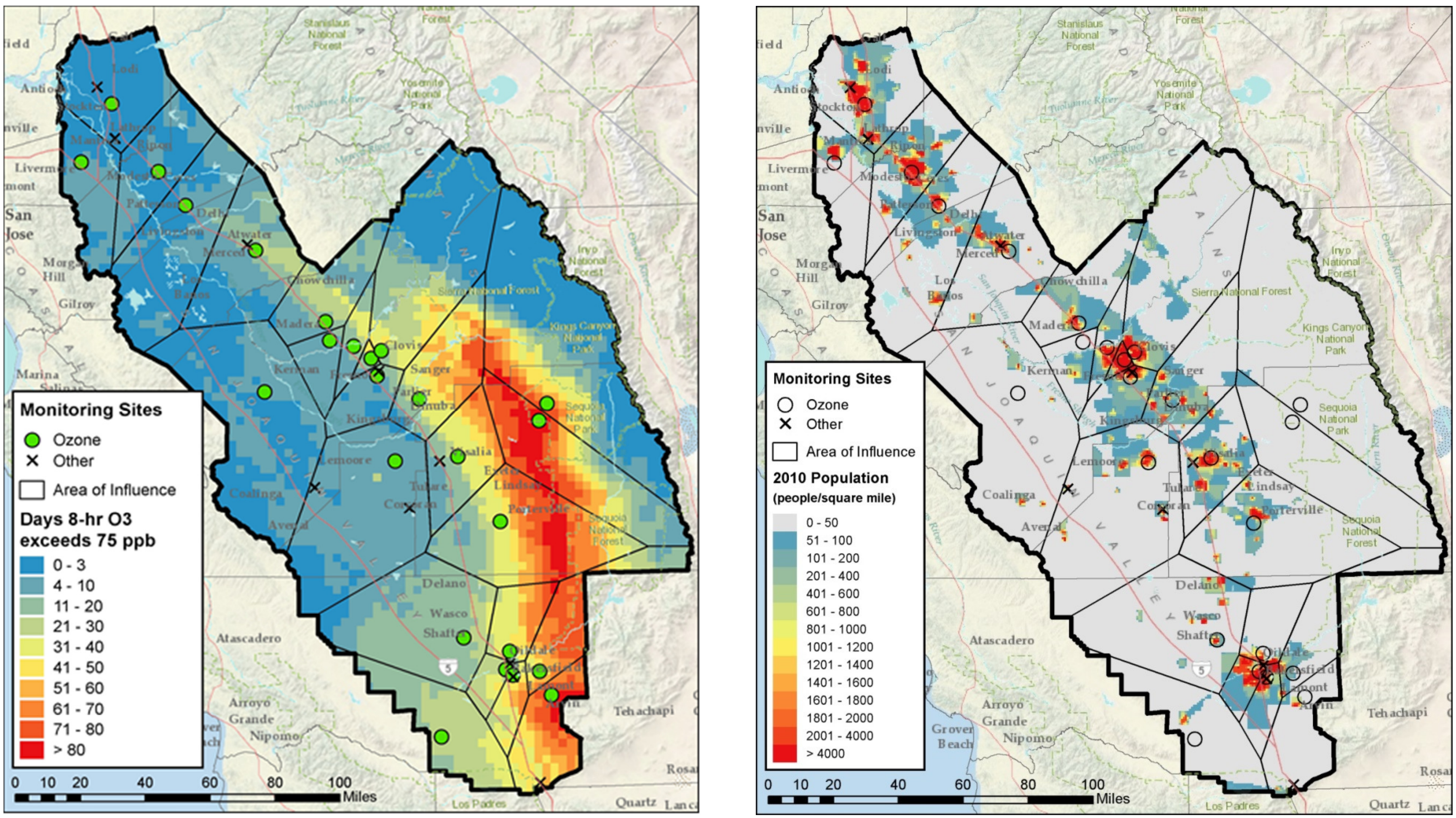
An assessment of all the remaining ozone sites in the southern counties of Fresno, Kings, Tulare, and Kern demonstrates that the network sufficiently covers the local populations and areas impacted by pollution.

Figure 2-16. On left, map of the areas served by the ozone monitoring sites in the San Joaquin Valley with the associated maximum 8-hr ozone concentrations in each zone in the District. On right, map of the areas served by the ozone monitoring sites in the San Joaquin Valley with the associated population/mi^2 for every 4km^2 zone in the District



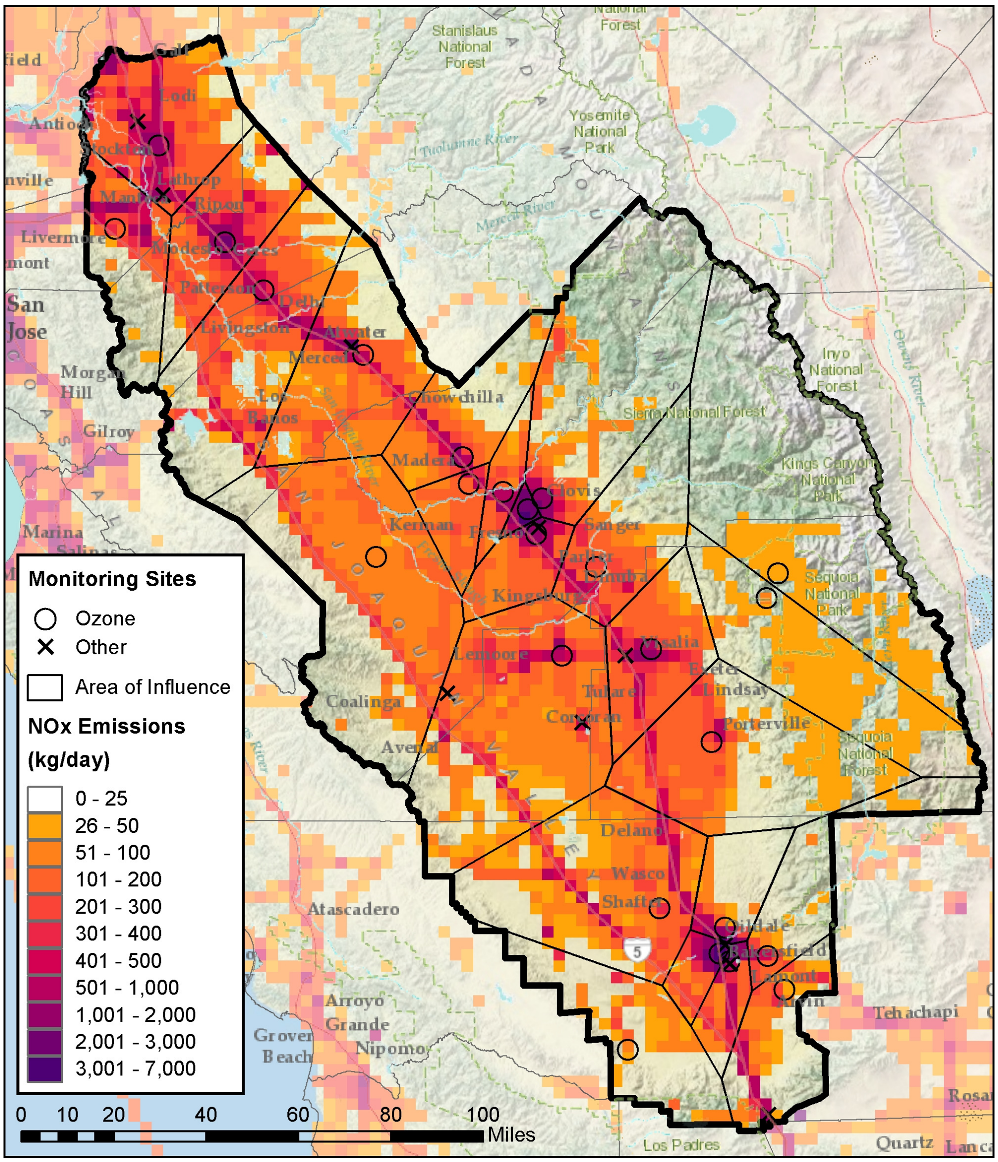
While the Turlock and Merced-Coffee monitors are positioned far from the city of Los Banos, modeled ozone concentrations (Figure 2-16) are low in this populated pocket. Furthermore, according to the analysis in Figure 2-17, there are likely fewer than three exceedance days in the area surrounding Los Banos, so an additional site is not necessary.

Figure 2-17. On left, map of the areas served by the Ozone monitoring sites in the SJV with the associated number days that the 8-hr ozone concentration exceeds the NAAQS in each zone. On right, map of the areas served by the ozone monitoring sites in the SJV with the associated population/mi² for every 4km² zone



An emissions-served analysis of the NOx compared to the ozone monitoring network can give further insight into whether locations that emit high pollution levels are accurately monitored. As mentioned above, high NOx emissions are associated with freeways and largely-populated cities. Figure 2-18 again confirms that the large cities are appropriately served by the ozone network. As for the emissions along the freeways, especially the 99 corridor, the District has four near-road NO_2 monitoring sites currently under development or construction to help fill the gaps indicated in the emissions-served map in Figure 2-18.

Figure 2-18. Map of NOx Emissions Assessed in Areas Served by Ozone Monitors



2.3.3 Site-to-Site Correlation Analyses

To identify possible redundancies in the pollutant monitoring network, the District ran Pearson correlation analyses for 24-hr $PM_{2.5}$ and 8-hr ozone concentrations using NetAssess, Ambient Air Monitoring Network Assessment Tool. The Pearson correlation coefficient (R) between site pairings shows how well the data agree. The R value is a measure of the linear relationship between two variables and ranges from -1.00 to 1.00. An R value of 1.00 means that there is a positive linear relationship between the data from two sites which might indicate a redundancy in the monitoring network for sites near each other. Figures 2-19 through 2-24 and Tables 2-13 and 2-14 below show the results of the correlation analyses. The eccentricity of the ellipses is proportional to how well the two sites correlate. An R value of 1.00 would be represented by a line while 0 would be a perfect circle. The distances between the sites are reported as kilometers in the center of the ellipses.

Figures 2-19, 2-20, and 2-21 are the 8-hr ozone correlation plots between sites in the northern, central, and southern San Joaquin Valley, respectively. Table 2-13 shows the R values for each correlation calculation. Figure 2-19 compares the northern SJV sites, all of which are spread apart. Due to the transport and formation components of ozone pollution which can cause a delay in ozone levels across a region, it would be expected that sites not near each other would not correlate as well as sites in the same metropolitan area. As such, many of the ellipses in Figure 2-19 are less linear and the average difference between the sites is greater than the sites closest together. As expected, the site furthest from all others, Stockton-Hazleton, shows the least correlation with the other sites. Additionally, as shown in the area- and emission-served analyses for ozone, there tends to be a southeastward trend in ozone pollution as the precursors are emitted, formed into ozone, and transported from the northern-most region down through the central monitors. Therefore, the central sites of Corcoran, Hanford, Tranquillity, and Fresno-Sky Park are more closely related than the distant northern sites.

For the central SJV monitors depicted in Figure 2-20, the Fresno area sites of Fresno-Garland, Fresno-Drummond, and Clovis correlated with one another well. Given their proximity and the regional nature of ozone pollution, we would expect that urban sites that are close together would approach R=1.00. Furthermore, the rural ozone sites of Parlier and Tranquillity don't correlate well with further sites. Similarly, the southern-most site in Figure 2-20 serves as a control group to demonstrate that a distant site will likely not see the same pollution levels.

The southern SJV monitors in Figure 2-21 continue with the trend. As mentioned, ozone pollution moves toward the southeast corner of the SJV, so sites in Kern County and southeastern Tulare County are likely to see a more even distribution of pollution levels. As expected, Porterville, Shafter, Arvin-Di Giorgio, Bakersfield-Muni, and Oildale have R values greater than 0.97 despite their distances. Furthermore, Hanford and Visalia, the sites that are upstream of the ozone transport, have R values less than 0.90.

Although many of the sites have R values greater than 0.95, this does not necessarily indicate that there are redundant sites. As discussed, ozone formation and transport is complex, so the local, short-lived differences between sites may not be captured in a simple correlation analysis. Additionally, the ozone network relies heavily on the spatial data obtained from these up and down stream monitoring site analyses. As described in the area- and emissions-served analysis section, these monitors are placed in strategic areas of large population or emissions and are therefore necessary components of the network.

Figures 2-22, 2-23, and 2-24 are the 24-hr average $PM_{2.5}$ correlation plots between sites in the northern, central, and southern San Joaquin Valley, respectively. Table 2-14 shows the R values for each correlation calculation. Unlike ozone, $PM_{2.5}$ pollution typically does not travel to distant sites and tends to be rather localized. As seen in all the $PM_{2.5}$ figures, the sites are much less agreeable and most R values are between 0.6 and 0.9 and don't necessarily increase with decreasing distance. Figure 2-22 compares the northern SJV sites, all of which are spread apart. The plots show that the R values are varied, which confirms the earlier assessment that each $PM_{2.5}$ monitor is a necessary part of the network. Figures 2-23 and 2-24 prove that this is also true for the central and southern sites, despite the closer proximity.

Figure 2-19. The 8-Hour Daily Maximum Ozone Concentrations Correlation Matrix for the Northern SJV Sites

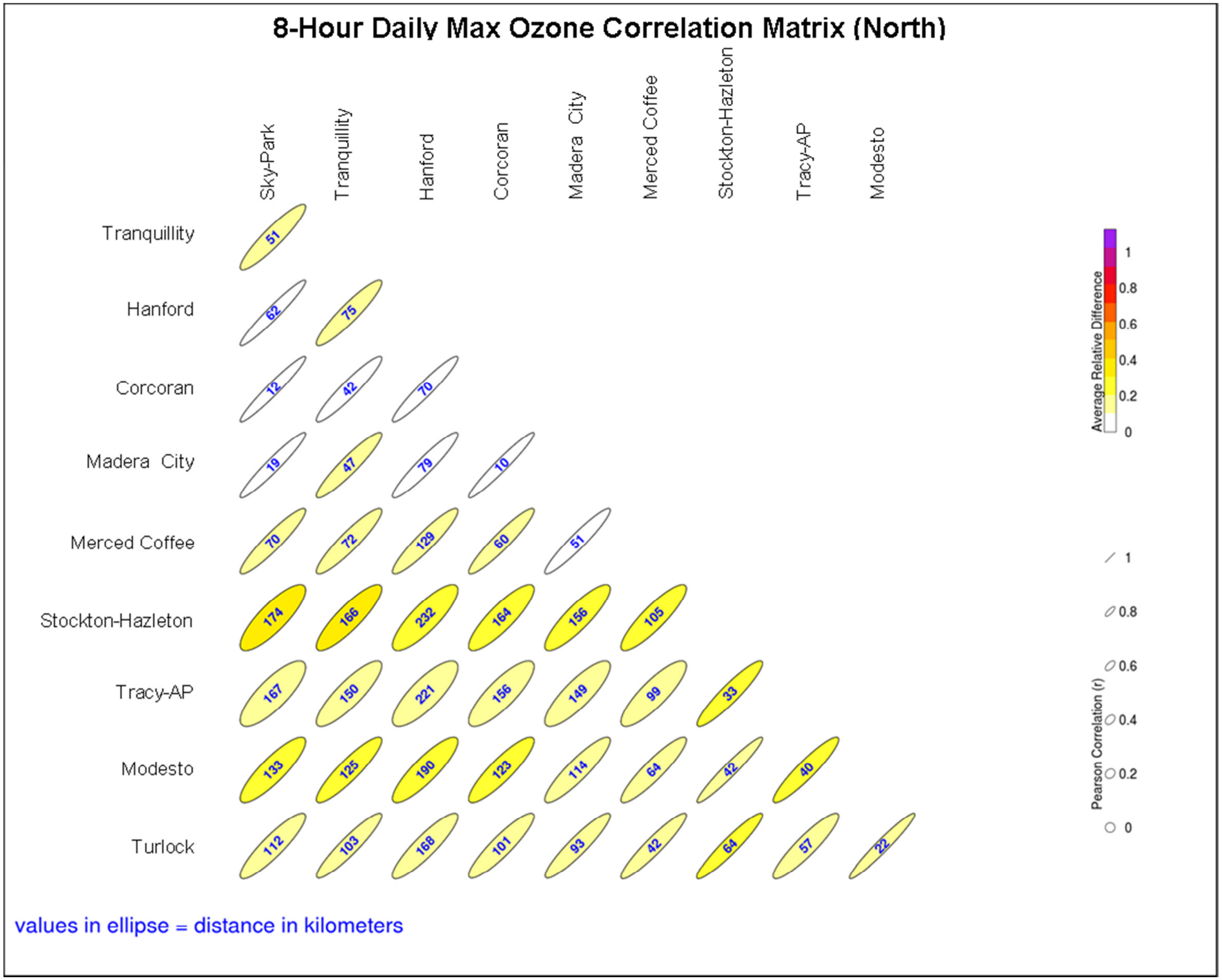


Figure 2-20. The 8-Hour Daily Maximum Ozone Concentrations Correlation Matrix for the Central SJV Sites

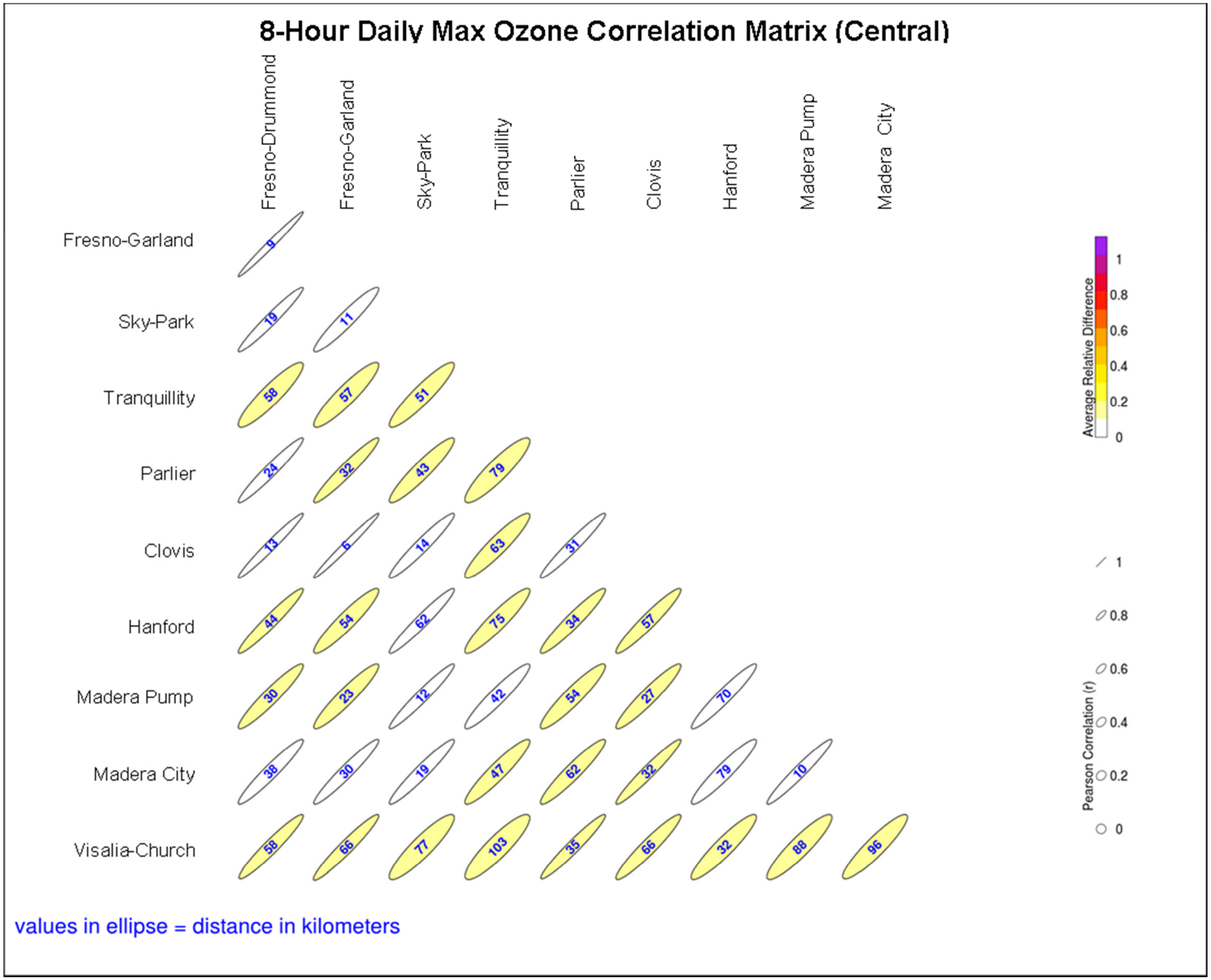


Figure 2-21. The 8-Hour Daily Maximum Ozone Concentrations Correlation Matrix for the Southern SJV Sites

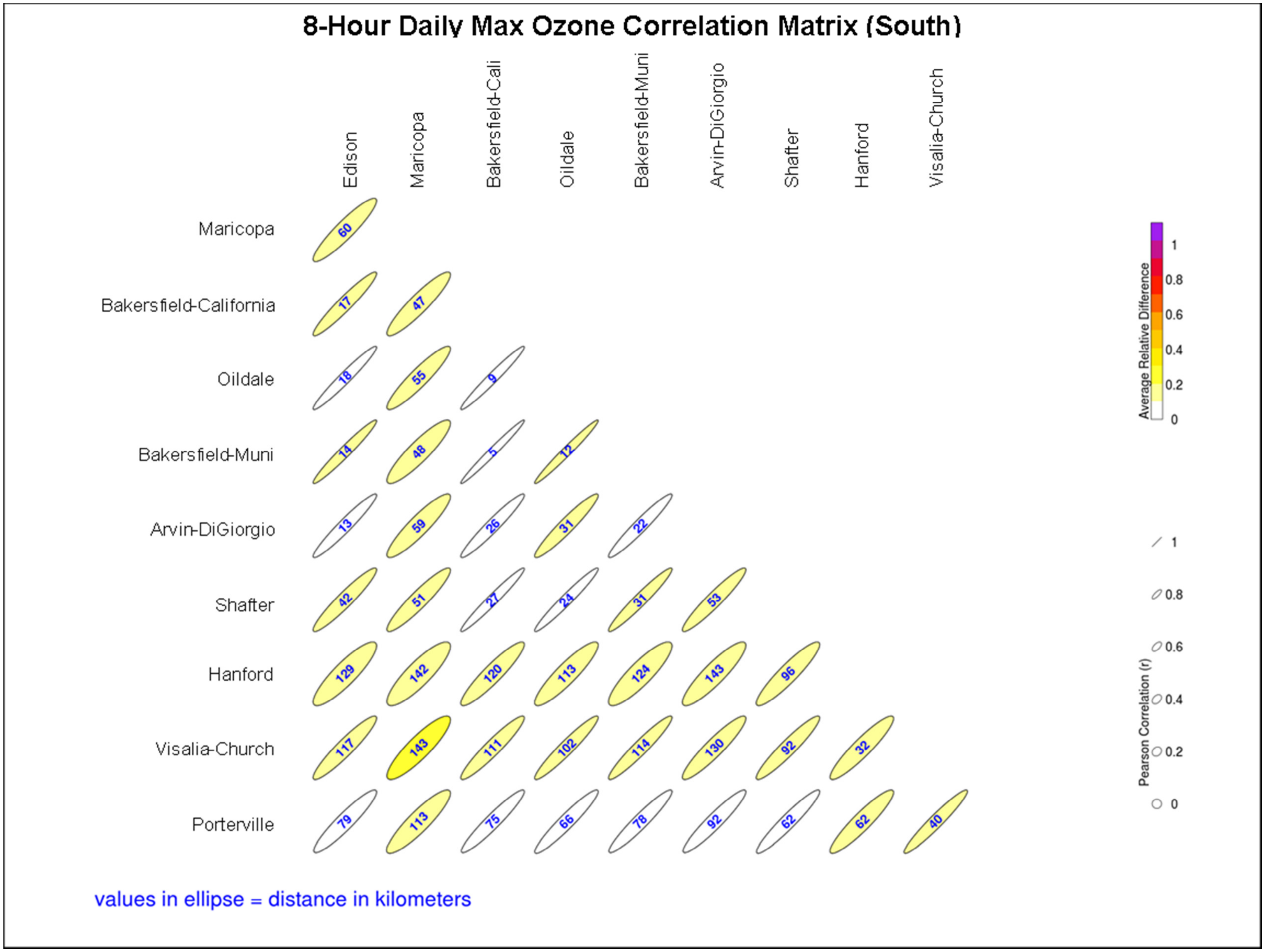


Table 2-13. 8-Hour Daily Max Ozone Pearson Correlations (r)

Sitename	Fresno-Drummond	Fresno-Garland	Fresno-SSP	Tranquillity	Parlier	Clovis	Edison	Maricopa	Bakersfield-Calif	Oildale	Bak-Muni	Arvin-DiGiorgio	Shafter	Hanford	Madera	Madera-City	Merced-Coffee	Stockton-Hazelton	Tracy-Airport	Modesto-14th	Turlock	SNP-Lower Kaweah	SNP-Ash Mountain	Visalia, Church
Fresno-Garland	0.99																							
Fresno-SSP	0.97	0.95																						
Tranquillity	0.91	0.92	0.92																					
Parlier	0.97	0.96	0.93	0.90																				
Clovis	0.98	0.99	0.96	0.93	0.97																			
Edison	0.92	0.92	0.88	0.86	0.92	0.92																		
Maricopa	0.89	0.88	0.86	0.87	0.87	0.89	0.92																	
Bakersfield-Calif	0.94	0.94	0.91	0.90	0.94	0.94	0.95	0.92																
Oildale	0.94	0.94	0.89	0.88	0.93	0.94	0.97	0.92	0.98															
Bak-Muni	0.93	0.94	0.86	0.85	0.92	0.94	0.97	0.90	0.99	0.98														
Arvin-DiGiorgio	0.91	0.91	0.88	0.87	0.93	0.92	0.96	0.91	0.96	0.95	0.96													
Shafter	0.93	0.94	0.91	0.92	0.94	0.94	0.95	0.93	0.98	0.97	0.96	0.95												
Hanford	0.96	0.93	0.97	0.93	0.95	0.95	0.88	0.86	0.92	0.90	0.88	0.90	0.92											
Madera	0.95	0.94	0.97	0.94	0.93	0.95	0.87	0.86	0.91	0.89	0.84	0.87	0.91	0.96										
Madera-City	0.96	0.96	0.96	0.94	0.95	0.97	0.87	0.84	0.93	0.91	0.89	0.89	0.92	0.94	0.97									
Merced-Coffee	0.93	0.92	0.94	0.92	0.91	0.92	0.87	0.84	0.90	0.89	0.86	0.86	0.89	0.93	0.94	0.95								
Stockton-Hazelton	0.86	0.87	0.83	0.87	0.82	0.86	0.80	0.75	0.84	0.83	0.80	0.79	0.84	0.84	0.86	0.87	0.88							
Tracy-Airport	0.82	0.84	0.81	0.86	0.79	0.83	0.78	0.76	0.81	0.80	0.79	0.77	0.81	0.81	0.83	0.84	0.85	0.93						
Modesto-14th	0.88	0.90	0.87	0.90	0.86	0.89	0.82	0.77	0.87	0.85	0.84	0.83	0.87	0.87	0.89	0.90	0.91	0.96	0.93					
Turlock	0.91	0.92	0.90	0.93	0.88	0.91	0.85	0.82	0.88	0.88	0.86	0.86	0.90	0.90	0.91	0.93	0.94	0.95	0.91	0.97				
SNP-Lower Kaweah	0.77	0.82	0.71	0.71	0.82	0.78	0.77	0.68	0.80	0.78	0.83	0.83	0.77	0.75	0.71	0.75	0.75	0.67	0.62	0.71	0.73			
SNP-Ash Mountain	0.87	0.89	0.82	0.80	0.90	0.87	0.89	0.83	0.89	0.89	0.92	0.91	0.87	0.84	0.80	0.83	0.84	0.73	0.70	0.76	0.80	0.92		
Visalia, Church	0.96	0.96	0.91	0.89	0.97	0.95	0.94	0.88	0.94	0.95	0.95	0.93	0.94	0.92	0.91	0.92	0.90	0.83	0.80	0.86	0.89	0.80	0.90	
Porterville	0.94	0.93	0.91	0.88	0.95	0.93	0.94	0.90	0.95	0.95	0.95	0.95	0.95	0.93	0.90	0.91	0.89	0.77	0.74	0.81	0.86	0.80	0.92	0.96

Figure 2-22. The 24-Hour Daily Average PM2.5 Concentrations Correlation Matrix for the Northern SJV Sites

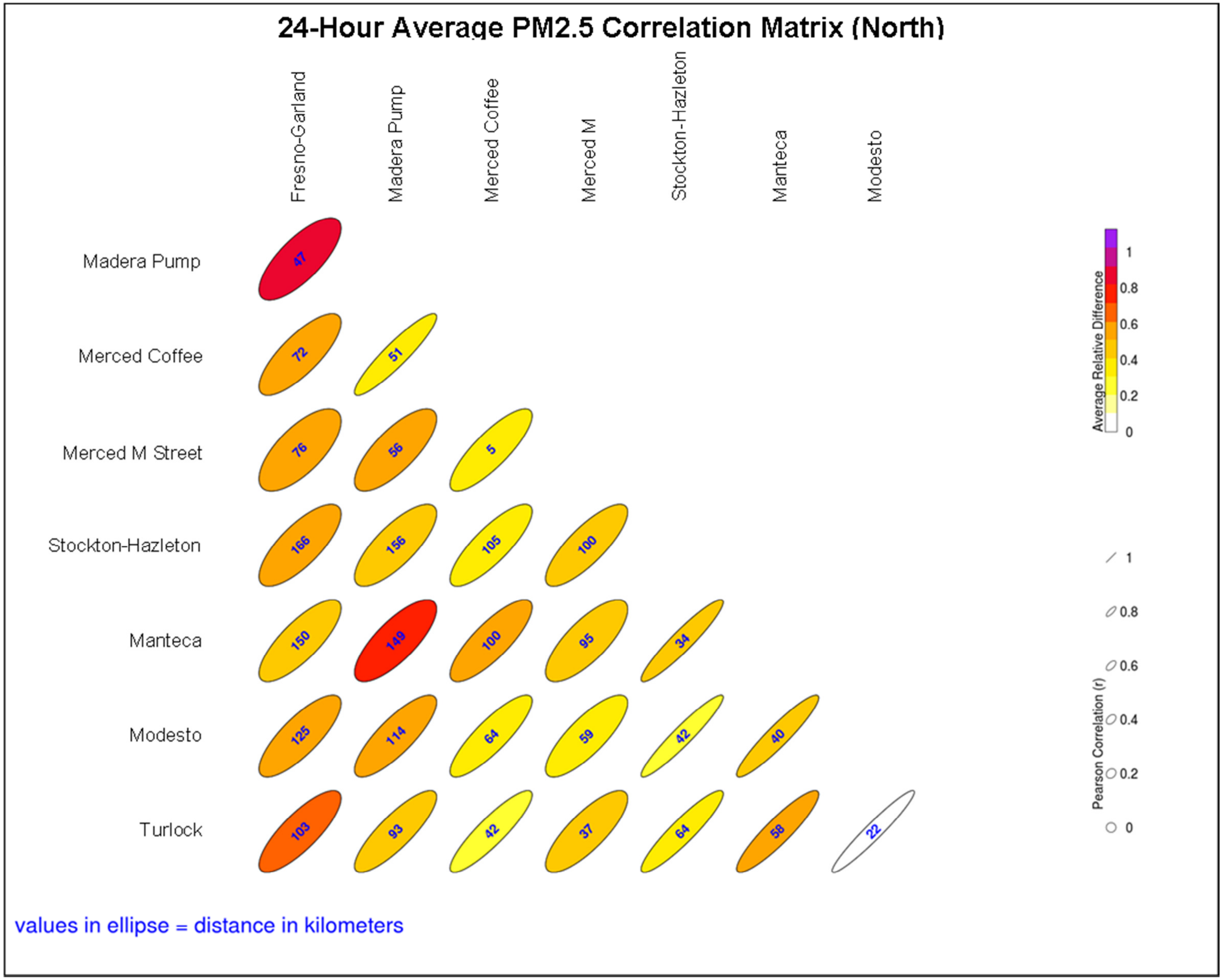


Figure 2-23. The 24-Hour Daily Average PM2.5 Concentrations Correlation Matrix for the Central SJV Sites

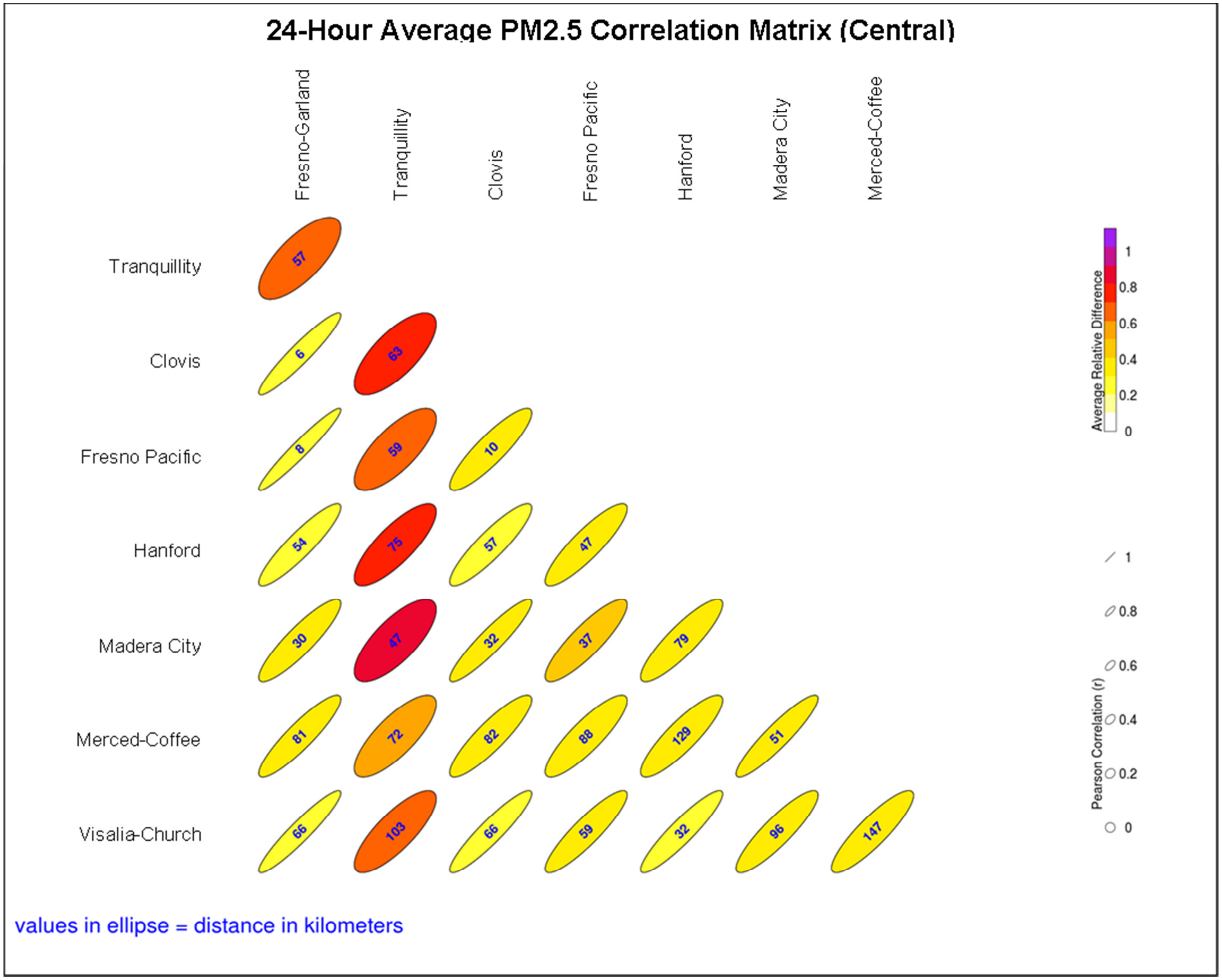


Figure 2-24. The 24-Hour Daily Average PM2.5 Concentrations Correlation Matrix for the Southern SJV Sites

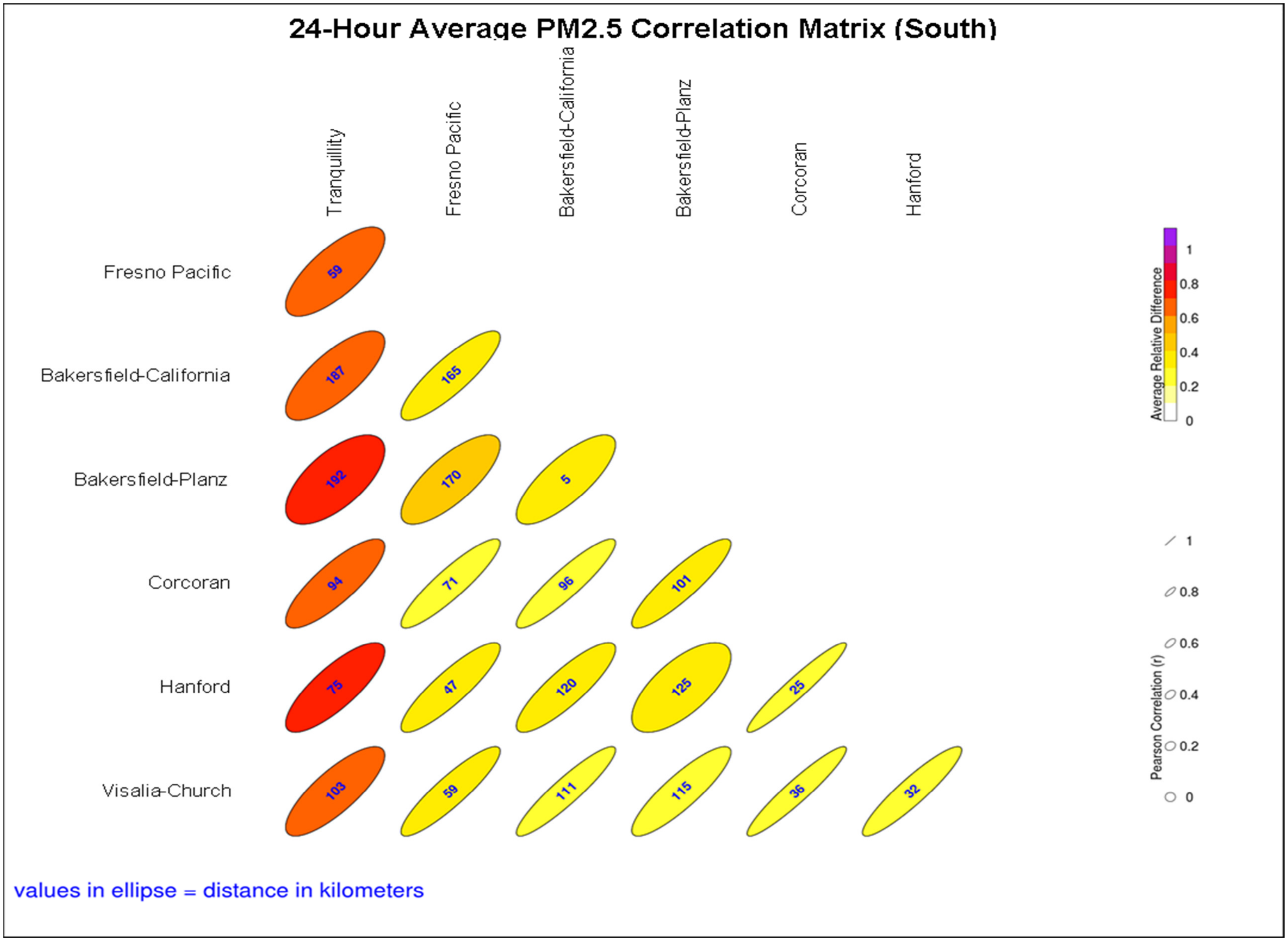


Table 2-14. 24-Hour Average PM2.5 Pearson Correlations (r)

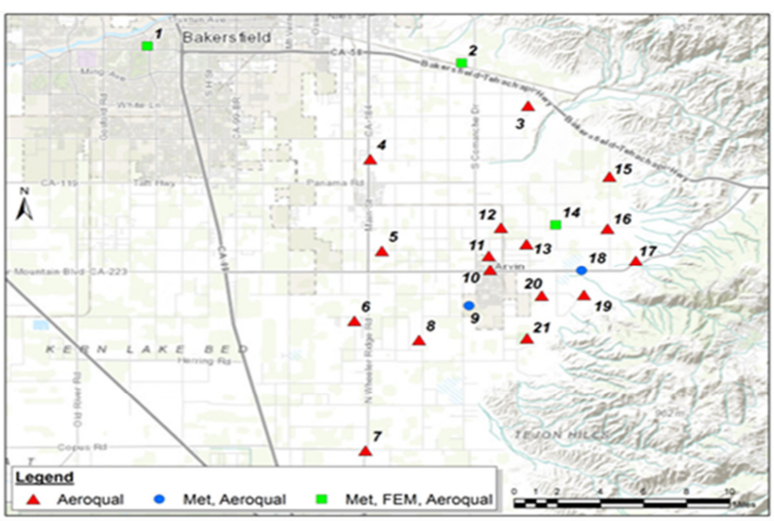
Sitename	Fresno-Garland	Tranquillity	Clovis	Fresno-Pacific College	Bakersfield-Calif	Bakersfield-Planz	Corcoran	Hanford	Madera-City	Merced-Coffee	Merced, M Street	Stockton-Hazelton	Manteca	Modesto-14th	Turlock
Tranquillity	0.73														
Clovis	0.94	0.72													
Fresno-Pacific College	0.96	0.74	0.89												
Bakersfield-Calif	0.86	0.75	0.83	0.86											
Bakersfield-Planz	0.68	0.65	0.62	0.76	0.78										
Corcoran	0.90	0.83	0.89	0.91	0.91	0.89									
Hanford	0.91	0.80	0.90	0.88	0.86	0.68	0.95								
Madera-City	0.90	0.75	0.93	0.87	0.81	0.62	0.87	0.88							
Merced-Coffee	0.91	0.78	0.89	0.87	0.78	0.62	0.91	0.87	0.92						
Merced, M Street	0.90	0.70	0.74	0.88	0.81	0.77	0.88	0.80	0.76	0.83					
Stockton-Hazelton	0.82	0.76	0.75	0.78	0.76	0.61	0.77	0.82	0.77	0.83	0.81				
Manteca	0.80	0.79	0.73	0.77	0.75	0.60	0.78	0.80	0.77	0.82	0.76	0.94			
Modesto-14th	0.87	0.80	0.80	0.82	0.79	0.62	0.83	0.86	0.82	0.86	0.81	0.95	0.94		
Turlock	0.89	0.81	0.85	0.85	0.78	0.61	0.86	0.89	0.85	0.89	0.80	0.92	0.91	0.96	
Visalia, Church	0.94	0.80	0.93	0.90	0.92	0.88	0.94	0.92	0.89	0.88	0.82	0.77	0.75	0.81	0.84

2.4 ARVIN SATURATION STUDY

The Arvin Saturation Study was an in-depth collection and investigation of ozone concentrations and patterns across the southeast valley portion of Kern County. In May 2013, the District contracted with Sonoma Technologies Inc. (STI) to conduct an ozone saturation study in the Arvin area. The purpose of this study was to measure the relative differences in ozone concentrations in Kern County with a focus on the Arvin area. A main driver behind the study was to assess the ozone network in the Bakersfield area and the region to the southeast of Bakersfield to observe whether the current network was adequate in capturing the peak concentrations. This analysis was especially important due to the closure of the long running Arvin-Bear Mountain ozone site in 2010 and the start-up of the Arvin-Di Giorgio replacement ozone site. The summary below provides a brief overview of this network assessment field study and analysis, which concluded that the current ozone network in the southeastern Kern County area is appropriately sited.

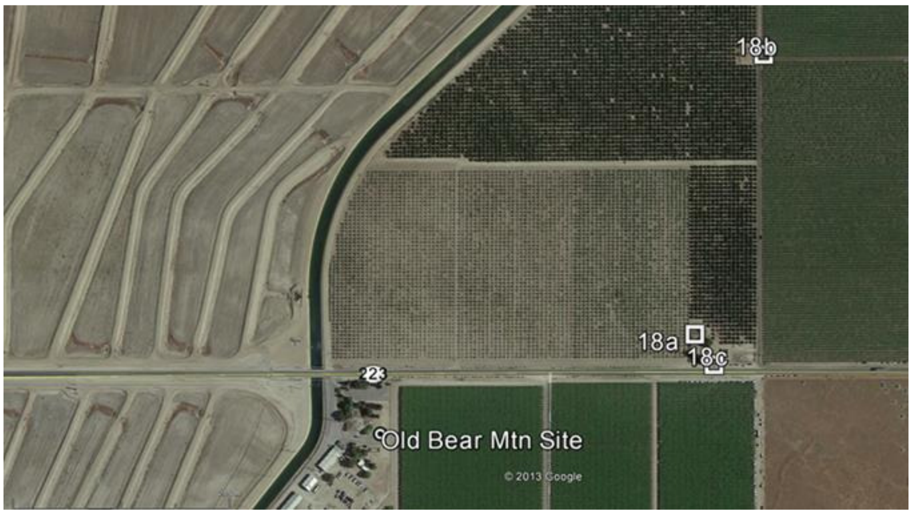
STI and their project partners (Providence Engineering and Environmental Group and Winegar Air Sciences) installed and operated a network of 23 temporary, small-scale ozone monitors (Aeroqual Series 500 ozone sensors) at 21 sites (see Figure 2-25) to collect ozone readings by the minute for approximately six weeks during the 2013 summer ozone season, beginning in mid-August until the end of September. The majority of the monitoring locations for this special study were clustered in and around the community of Arvin with a scattering of samplers farther from the community to examine ozone in the surrounding area. Three samplers were collocated at official air monitoring sites (including Di Giorgio) to continually ensure and verify accuracy of the samplers. Surface wind measurements were made at five sites: three permanent wind measurement locations at the ARB air monitoring stations (Bakersfield-California Street, Edison, and Di Giorgio), and two temporary locations established for this study near the Bear Mtn. site and at a site in the City of Arvin.

Figure 2-25. Saturation Study Monitor Locations



The District contacted the Arvin-Edison Water District requesting authorization for placement of one of the temporary monitors precisely at the same location as the former regulatory site; however, this request was denied. To represent the former regulatory monitoring location at Bear Mountain Road, two locations were selected 0.4 km (440 yards) east of the old regulatory site, with one sensor near the roadway and a second north of the roadway (see Figure 2-26). Other sites were established to capture ozone concentrations (1) to the west, where the sites would often be upwind of Arvin; (2) in Arvin, where most people in the area live; and (3) in and around the Bear Mtn. and Di Giorgio sites.

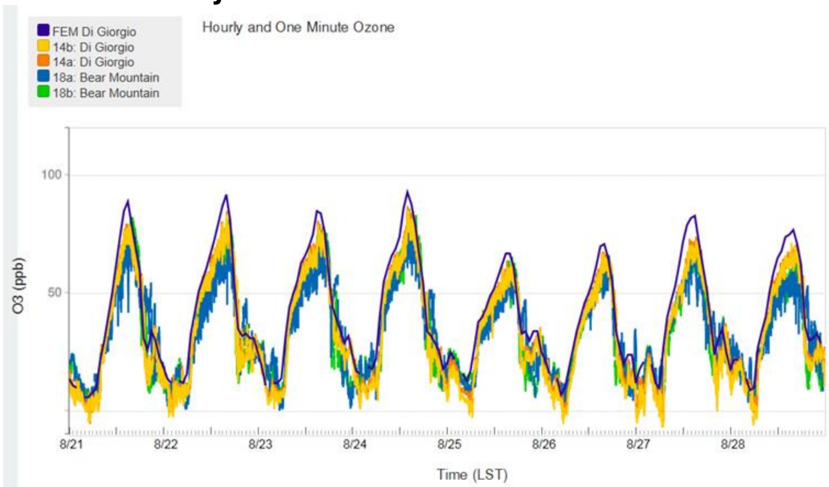
Figure 2-26. Bear Mountain Road Monitoring Sites



The picture above shows an aerial view around the old Bear Mountain regulatory monitoring site. Site 18a is about 440 m from the old Bear Mountain site. Site 18b is recessed from the road by about 300 m. Site 18c is the meteorological tower and is about 20 m from Site 18a.

All one-minute sensor data were transmitted in real time to STI's office and posted to a password-protected website for daily data review (see Figure 2-27). STI assured the quality of the data by reviewing time-series plots of ozone concentrations and sensor quality assurance metadata. Ozone concentrations (1-hr and 8-hr) were then calculated from the quality-controlled 1-minute data. Using the collocation measurements, STI calibrated the data to be near regulatory quality. Overall, data recovery rates were excellent at all sites. The ozone samplers functioned admirably during the study period and recorded hundreds of hours of ozone measurements that were effectively identical to measurements at the official monitoring sites.

Figure 2-27. Saturation Study Data Screenshot



This special study identified that the peak 1-hour and 8-hour locations varied from site to site each day. No specific site observed the highest value each day; and therefore, no specific site could be selected that would always observe the highest value. A return to the old Arvin-Bear Mountain site would not be justified as “selected to observe the peak value” as the site would not be expected to observe the peak value each day.

Additionally this special study showed that the old Arvin-Bear Mountain site was no longer the peak site in the area, even though the study was conducted during the time period when peak 1-hour ozone levels are expected. The parallel monitoring that showed that Arvin-Bear Mountain had a higher value than the Arvin-Di Giorgio site may reflect emissions and air quality patterns that no longer exist or, with absolute certainty, do not exist every year because emission levels have changed due to emission reduction strategies adopted by the District, ARB, and EPA.

In summary:

- If reductions of emissions have altered air quality to the point where the old Arvin-Bear Mountain is no longer the peak site; then a return to the old site is not justified.
- If air quality conditions are not as definitive and the old Arvin-Bear Mountain site may observe peak values on some years but not others; the case for return to the old Arvin-Bear Mountain site is not established because it would create an equivalent lack of monitoring for peak values at other sites which were shown to have higher values during the more recent year of special study monitoring.
- A wind shift of two (2) degrees from upwind areas, such as Bakersfield, will shift the peak by a one half of a mile (½) by the time the air parcel reaches either Arvin-Di Giorgio or Arvin-Bear Mountain. Since small variations in meteorology can create significant changes in how emissions are transported further downwind, the peak ozone location in the Arvin area is a moving target, and therefore the Arvin-Bear Mountain site is not expected to be the consistent peak.

The air quality improvement measured by this study in the Arvin area indicates that the federal 1-hour ozone standard is no longer exceeded at any of the sites in the study area. Therefore, site selection of an air monitoring station should be based on 8-hour maximums and the frequency of exceedances. This study indicates that Arvin-Di Giorgio is the site that better represents 8-hour exceedances and maximums than the old Arvin-Bear Mountain site.

2.4.1 Key Findings from the Arvin Saturation Study

With the successful completion of the saturation study, STI provided the District with a report that includes a number of findings and extensive supporting analysis (see Attachment A). Some of the key findings include:

1. The Arvin-Di Giorgio monitoring site is highly representative of worst-case high ozone concentrations in the Arvin area around the old Arvin-Bear Mountain monitor, and, in fact, Arvin-Di Giorgio generally measured higher concentrations than the Arvin-Bear Mountain sites.

    - On average, peak 1-hr ozone concentrations ranged from 3% - 15% higher at Arvin-Di Giorgio as compared to Arvin-Bear Mountain concentrations.
    - Arvin-Bear Mountain sites experienced fewer days exceeding the 8-hr ozone standard than the Arvin-Di Giorgio site. Concentrations exceeded the 8-hr standard six times at Arvin-Bear Mountain; whereas, concentrations exceeded the 8-hr standard at Arvin-Di Giorgio 11 times.

2. The Arvin-Di Giorgio monitoring site is highly representative of ozone concentrations measured in the City of Arvin. They are well-correlated and of essentially the same magnitude.

    - Relationships for high concentrations of ozone between the Arvin temporary monitors and official station monitors (Bakersfield-California, Arvin-Di Giorgio, and Edison) were evaluated, with the strongest correlation occurring between the City of Arvin and the Arvin-Di Giorgio monitoring station with an R^2 of 0.79.

3. Accurate equations were developed for predicting the City of Arvin's peak 1-hr and 8-hr ozone equations utilizing measurements from the air monitoring and meteorological network sites.

    - Predicted 1-hr and 8-hr ozone concentrations from the resulting equations versus the observed ozone were strongly correlated with an R^2 of about 0.92.

4. Accurate equations were developed for predicting Arvin-Bear Mountain's peak 1-hr and 8-hr ozone concentrations utilizing measurements from the air monitoring and meteorological network sites.

    - Predicted 1-hr and 8-hr ozone concentrations from the resulting equations versus the observed ozone were strongly correlated with an R^2 of about 0.90.

5. Strong gradients in peak 1-hr and 8-hr ozone concentrations are present within and around Arvin. Peak 1-hr ozone concentrations at each site on a given day can

vary by as much as 30 ppb. This suggests complex local wind flow patterns in and around the saturation study area.

6. The Arvin Saturation Study helped establish a clearer understanding of the diurnal patterns of ozone throughout the day in the Arvin area.

7. The temporary, small-scale sensors used for the Arvin Saturation Study were sufficiently accurate and precise to measure peak ozone concentrations and assess differences in ozone concentrations in and around Arvin.

The predictive equations that the Arvin Ozone Saturation Study produced can be used to calculate 1-hour ozone readings for Arvin-Bear Mountain, following the same procedures that are described in Attachment A (Arvin Ozone Saturation Study). The error for this predictive equation is 1 ppb. The 2012-2014 1-hour ozone design value generated by the predictive equation for Arvin-Bear Mountain is 102 ppb, which is attainment of the federal 1-hour ozone standard. See Table 2-15 for details.

Table 2-15. 2012-2014 Design Value for Arvin-Bear Mountain Using the Arvin Ozone Saturation Study Predictive Equation

Year	Date	Arvin-Di Giorgio (observed)	Arvin-Bear Mountain (calculated)
2012	July 11	122	110
2012	August 28	113	103
2012	August 13	111	102
2012	June 01	109	102
2012	August 10	109	99
2013	July 20	109	100
2013	September 13	106	99
2013	July 09	103	95
2013	July 19	103	95
2013	June 07	100	96
2014	September 11	109	101
2014	September 12	109	101
2014	June 09	108	101
2014	July 25	108	98
2014	June 30	105	not available[1]
Design Value 2012-2014		109	102

[1] The 12Z 500 MB height from Vandenberg Air Force Base, which is a key dependent variable, is missing for June 30, 2014.

2.5 TECHNICAL APPROACH AND FINDINGS FOR THE PAMS NETWORK ASSESSMENT

The PAMS program collects ambient air measurements in areas classified as serious, severe, or extreme ozone nonattainment, as required by Section 182(c)(1) of the Clean Air Act. The District is currently operating under the PAMS Alternative Network Plan Revision of April 21, 1995. PAMS are used to collect data for a target list of VOCs, nitrogen oxides (NO_x, NO_y), ozone, and surface and lower-air meteorological measurements. In 2006, EPA reduced minimum PAMS monitoring requirements to establish a network that meets the national objectives of the program while freeing up resources for states to tailor their networks to suit specific data needs.

2.5.1 Overview of the PAMS Network

The PAMS network was established in the mid-1990s in ozone nonattainment areas to provide information on the effectiveness of control strategies, emissions tracking, and trends. State and local air pollution control agencies are responsible for operation of the PAMS sites. The data collected at the PAMS sites include measurements of ozone, NO_x, CO, a target list of VOCs including several carbonyls, and surface and upper air meteorology.

The PAMS network design was developed specifically to characterize: 1) upwind and background ozone and ozone precursors; 2) ozone maximum precursor emissions; and 3) downwind ozone concentrations within a region for the purpose of understanding ozone precursor emissions, chemical transformation, patterns, and transport. PAMS sites are not specifically sited to monitor population exposure.

The PAMS network was designed to collect measurements at defined locations within an urban region to meet specific objectives based on a site's location relative to emissions and transport pathways. The site types and objectives are defined as follows:

- Type 1 – Upwind background ozone and precursors entering area of maximum precursor emissions
- Type 2 – Area of maximum ozone precursor emissions
- Type 3 – Site of maximum ozone occurring downwind from area of maximum precursor emission
- Type 4 – Extreme downwind monitoring sites

Two of the main goals of the PAMS network assessment are to 1) assess data quality; and 2) determine how well the PAMS sites are currently serving their objectives, that is, to determine if the PAMS sites actually meeting Type 1, 2, and 3 site objectives.

The District currently operates five PAMS monitoring sites; Madera-Pump Yard, Clovis-Villa, Parlier, Shafter, and Bakersfield-Muni. The District is required to have a Type 3 PAMS site in the Bakersfield MSA. The site was formerly located at the Arvin-Bear Mountain site, which is no longer in operation. The District will install Type 3 PAMS equipment when ARB establishes a permanent replacement site in the Arvin area that is capable of housing the PAMS equipment.

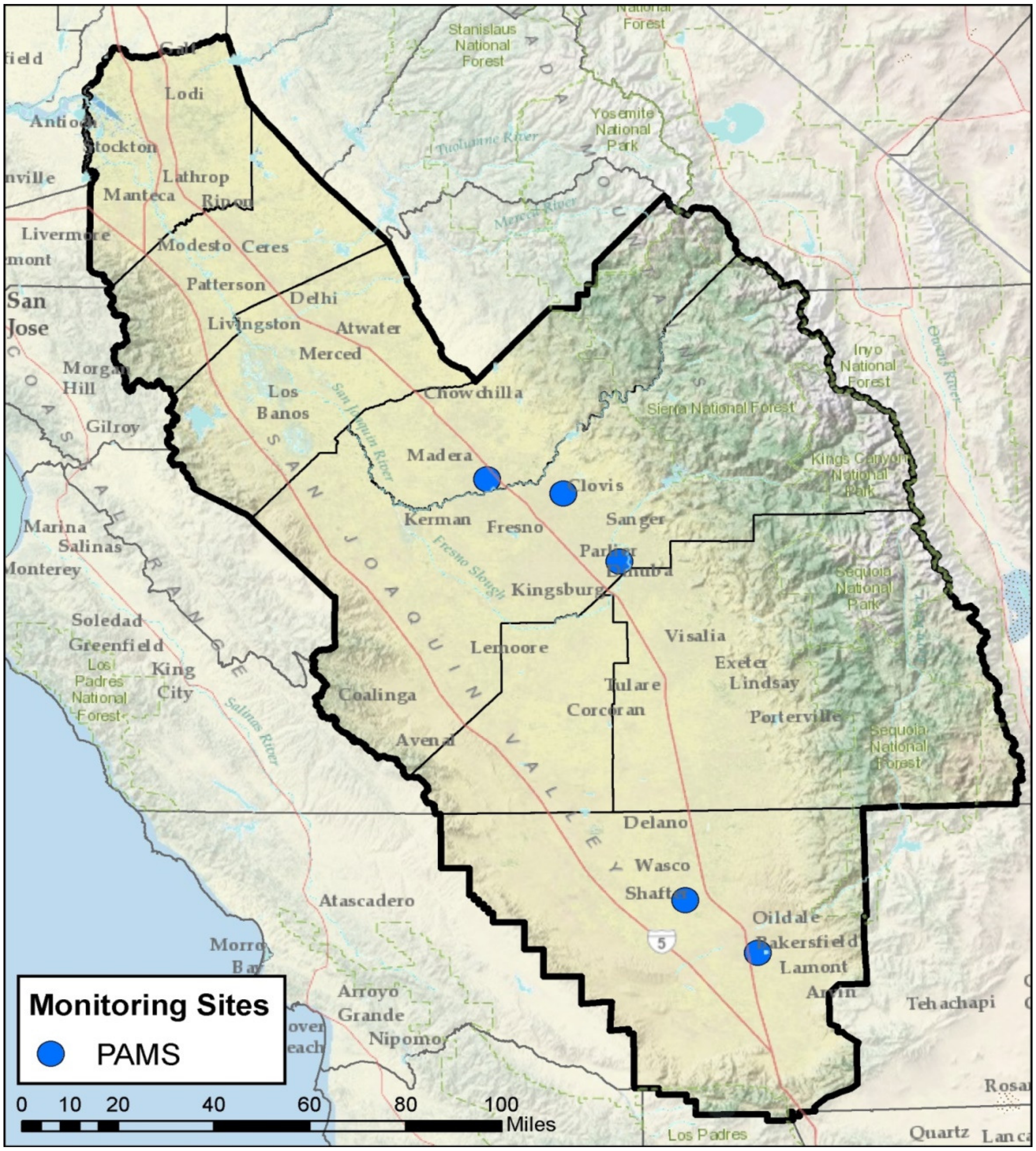
2.5.2 Recent PAMS Regulatory Changes

The U.S. Environmental Protection Agency (EPA) finalized revisions to the PAMS monitoring requirements on October 17, 2006 (71 FR 61236). The revisions greatly reduced the minimum PAMS requirements, which freed up resources and allowed states to tailor PAMS networks to suit their specific data needs. Overall, the changes significantly reduced the costs of the minimum PAMS monitoring requirements and allowed states to re-invest these savings in area-specific PAMS monitoring activities. Several changes specific to PAMS have been made as a result of the new monitoring rule:

- *Reduced number of required PAMS sites*. Only one Type 2 site is required per area, regardless of population, and Type 4 sites are not required. Only one Type 1 or one Type 3 site is required per area.
- *Reduced requirements for speciated VOC measurements*. Speciated VOC measurements are only required at Type 2 sites and one other site (either Type 1 or Type 3) per PAMS area.
- *Reduced carbon compound sampling*. Carbonyl compound sampling is required only in areas classified as serious or above for the 8-hr ozone standard.
- *Changed nitrogen monitoring*. Conventional NO2/NOx monitors are required only at Type 2 sites. High sensitivity NOy monitors is required at one site per PAMS area (either Type 1 or Type 3).
- *Additional CO monitoring*. High sensitivity CO monitors is required at Type 2 sites.

As of 2014, and in lieu of the current PAMS network design requirements, EPA is proposing to require that PAMS measurements are to be made at any existing NCore site in an ozone nonattainment area. When an existing NCore site is not as good a location for making PAMS measurements as an existing PAMS site, EPA recognizes that in limited situations it may be acceptable to continue monitoring at the existing PAMS site in support of ongoing research and to maintain trends information. Figure 2-28 shows the location of the PAMS sites in the San Joaquin Valley.

Figure 2-28. Location of PAMS Monitoring Sites in the San Joaquin Valley



2.5.3 PAMS Data Analyses

Several analyses are performed as part of the PAMS network assessment to address the objectives of the PAMS sites including the following: the percent above MDL (Table 2-16), the rate of data completeness (Table 2-17), the measured concentrations (Tables 2-18 and 2-19), the existence of trend patterns and maximum ozone locations (Figures 2-28 and 2-29).

Table 2-16. Summary of Percent above MDL for PAMS Sites

	% Above MDL by Site				
PAMS Target Compounds	Madera-Pump Yard	Clovis-Villa	Parlier	Shafter	Bakersfield-Muni
Trans-2-Pentene	4%	7%	9%	40%	17%
Trans-2-Butene	13%	6%	5%	19%	5%
Total NMOC		100%	100%	100%	100%
Toluene	13%	36%	32%	79%	84%
Styrene	33%	0%	0%	3%	22%
Propylene	96%	96%	90%	100%	99%
Propane	100%	100%	100%	100%	100%
P-Ethyltoluene	30%	40%	34%	72%	64%
P-Diethylbenzene	0%	0%	3%	15%	3%
O-Xylene	4%	4%	5%	21%	18%
O-Ethyltoluene	13%	16%	14%	38%	33%
N-Undecane	28%	19%	36%	62%	45%
N-Propylbenzene	57%	47%	47%	70%	55%
N-Pentane	91%	99%	98%	100%	100%
N-Octane	24%	32%	27%	74%	65%
N-Nonane	33%	32%	33%	72%	66%
N-Hexane	78%	97%	89%	100%	100%
N-Heptane	59%	82%	70%	100%	100%
N-Decane	13%	18%	15%	53%	44%
N-Butane	96%	100%	100%	100%	100%
M-Ethyltoluene	41%	66%	52%	91%	86%
Methylcyclopentane	59%	95%	80%	100%	99%
Methylcyclohexane	11%	27%	26%	81%	77%
M-Diethylbenzene	0%	1%	1%	0%	1%
M/P Xylene	3%	9%	6%	32%	32%
Isopropylbenzene	25%	71%	60%	46%	31%
Isoprene	65%	80%	40%	100%	78%
Isopentane	80%	87%	82%	96%	92%
Isobutane	87%	99%	97%	100%	100%
Formaldehyde		100%			100%
Ethylene	100%	100%	100%	100%	100%
Ethylbenzene	0%	1%	1%	4%	1%
Ethane	100%	100%	100%	100%	100%
Cyclopentane	2%	20%	13%	83%	64%
Cyclohexane	15%	36%	23%	64%	81%

Table 2-16. Summary of Percent above MDL for PAMS Sites (continued)

% Above MDL (continued)					
Site Name	Madera-Pump Yard	Clovis-Villa	Parlier	Shafter	Bakersfield-Muni
Cis-2-Pentene	2%	3%	3%	4%	4%
Cis-2-Butene	4%	1%	3%	6%	3%
Benzene	59%	85%	74%	98%	93%
Acetylene	100%	100%	100%	100%	100%
Acetone		64%			99%
Acetaldehyde		98%	100%	100%	100%
3-Methylpentane	54%	79%	64%	98%	99%
3-Methylhexane	22%	46%	34%	64%	88%
3-Methylheptane	4%	9%	5%	38%	49%
2-Methylpentane	59%	89%	68%	96%	97%
2-Methylhexane	22%	46%	38%	74%	91%
2-Methylheptane	22%	31%	33%	72%	72%
2,4-Dimethylpentane	7%	39%	34%	79%	93%
2,3-Dimethylpentane	13%	40%	35%	77%	95%
2,3-Dimethylbutane	24%	54%	36%	96%	96%
2,3,4-Trimethylpentane	9%	46%	35%	60%	97%
2,2-Dimethylbutane	7%	35%	24%	55%	58%
2,2,4-Trimethylpentane	74%	98%	93%	96%	99%
1-Pentene	13%	25%	20%	60%	27%
1-Butene	37%	31%	22%	57%	37%
1,3,5-Trimethylbenzene	24%	29%	20%	60%	55%
1,2,4-Trimethylbenzene	50%	68%	50%	83%	92%
Oxides of Nitrogen	11%	17%	96%	43%	45%
Nitric Oxide	1%	0%	8%	5%	4%
Ozone	98%	100%	99%	96%	97%

Table reflects data for June, July, and August 2013.
Cells highlighted in blue indicate sites with fewer than 85% of data reported above the MDL.
Blank cells indicate no data was collected.

Table 2-17. Summary of Data Completeness for PAMS Sites

	Percent Completeness				
Street Address	Madera-Pump Yard	Clovis-Villa	Parlier	Shafter	Bakersfield-Muni
Trans-2-Pentene	96%	92%	99%	98%	95%
Trans-2-Butene	96%	92%	99%	98%	95%
Total NMOC	0%	89%	72%	63%	66%
Toluene	96%	92%	98%	98%	95%
Styrene	13%	2%	28%	65%	6%
Propylene	96%	92%	99%	98%	95%
Propane	96%	92%	99%	98%	95%
P-Ethyltoluene	96%	92%	99%	98%	95%
P-Diethylbenzene	96%	92%	99%	98%	95%
O-Xylene	58%	89%	68%	98%	95%
O-Ethyltoluene	96%	92%	99%	98%	95%
N-Undecane	96%	92%	99%	98%	95%
N-Propylbenzene	96%	92%	99%	98%	95%
N-Pentane	96%	92%	99%	98%	95%
N-Octane	96%	92%	99%	98%	95%
N-Nonane	96%	92%	99%	98%	95%
N-Hexane	83%	92%	92%	98%	95%
N-Heptane	96%	92%	99%	98%	95%
N-Decane	96%	92%	99%	98%	95%
N-Butane	96%	92%	99%	98%	95%
M-Ethyltoluene	96%	92%	99%	98%	95%
Methylcyclopentane	96%	92%	99%	98%	95%
Methylcyclohexane	96%	92%	99%	98%	95%
M-Diethylbenzene	96%	92%	99%	98%	95%
M/P Xylene	67%	92%	81%	98%	95%
Isopropylbenzene	8%	9%	6%	27%	8%
Isoprene	96%	92%	99%	98%	95%
Isopentane	96%	92%	99%	98%	95%
Isobutane	96%	92%	99%	98%	95%
Formaldehyde		99%			99%
Ethylene	96%	92%	99%	98%	95%
Ethylbenzene	63%	89%	75%	98%	95%
Ethane	96%	92%	99%	98%	95%
Cyclopentane	96%	92%	99%	98%	95%
Cyclohexane	96%	92%	99%	98%	95%

Table 2-17. Summary of Data Completeness for PAMS Sites (continued)

Percent Completeness (Continued)					
Street Address	Madera-Pump Yard	Clovis-Villa	Parlier	Shafter	Bakersfield-Muni
Cis-2-Pentene	96%	92%	99%	98%	95%
Cis-2-Butene	96%	92%	99%	98%	95%
Benzene	96%	92%	99%	98%	95%
Acetylene	96%	92%	99%	98%	95%
Acetone		99%			99%
Acetaldehyde		29%	99%	71%	99%
3-Methylpentane	96%	92%	99%	98%	95%
3-Methylhexane	96%	92%	99%	98%	95%
3-Methylheptane	96%	92%	99%	98%	95%
2-Methylpentane	96%	92%	99%	98%	95%
2-Methylhexane	96%	92%	99%	98%	95%
2-Methylheptane	96%	92%	99%	98%	95%
2,4-Dimethylpentane	96%	92%	99%	98%	95%
2,3-Dimethylpentane	96%	92%	99%	98%	95%
2,3-Dimethylbutane	96%	92%	99%	98%	95%
2,3,4-Trimethylpentane	96%	92%	99%	98%	95%
2,2-Dimethylbutane	96%	92%	99%	98%	95%
2,2,4-Trimethylpentane	73%	91%	90%	98%	95%
1-Pentene	96%	92%	99%	98%	95%
1-Butene	96%	92%	99%	98%	95%
1,3,5-Trimethylbenzene	96%	92%	99%	98%	95%
1,2,3-Trimethylbenzene	96%	92%	99%	98%	95%
1,2,4-Trimethylbenzene	96%	92%	99%	98%	95%
Oxides of Nitrogen	28%	91%	91%	96%	85%
Nitric Oxide	14%	88%	90%	96%	47%
Nitrogen Dioxide	28%	91%	91%	96%	85%
Ozone	83%	80%	91%	95%	85%

Table reflects data for June, July, and August 2013.
Cells highlighted in blue indicate sites with fewer than 85% of data reported as complete.

Table 2-18. Maximum Concentration for PAMS Sites

Maximum Concentration (parts per billion carbon, ppbc)					
Street Address	**Madera-Pump Yard**	**Clovis-Villa**	**Parlier**	**Shafter**	**Bakersfield-Muni**
Trans-2-Pentene	0.2	0.6	0.4	0.8	2.1
Trans-2-Butene	0.7	10	0.3	1.6	0.3
Total NMOC	100	400	50	2210	450
Toluene	3.2	12.7	18.3	22.8	22.4
Styrene	1	0	0	2	1.2
Propylene	4.1	62.8	2.5	8.2	3.1
Propane	11.9	58	29	184	48.7
P-Ethyltoluene	0.5	1	0.7	1.2	1.4
P-Diethylbenzene	0.1	1.2	1.3	0.1	1.3
O-Xylene	1.7	1.4	7	4.3	2.3
O-Ethyltoluene	0.4	0.5	0.5	0.9	0.6
N-Undecane	0.4	3.4	0.6	2.6	0.6
N-Propylbenzene	0.5	0.8	0.7	0.8	0.6
N-Pentane	2.7	6.3	3.8	15.6	11.6
N-Octane	0.4	0.6	0.7	1.3	0.9
N-Nonane	0.4	3.2	1.7	2	0.7
N-Hexane	1	2.2	1.9	4.8	5.2
N-Heptane	0.7	1.6	1.4	3.7	3.1
N-Decane	0.3	4	0.5	6.2	0.7
N-Butane	3.5	26.1	7.6	22.1	24.5
M-Ethyltoluene	1	1.1	1.1	2.2	1.6
Methylcyclopentane	1	2	2.4	4.4	6.8
Methylcyclohexane	0.4	0.6	0.6	1.4	3.6
M-Diethylbenzene	0.1	0.3	0.2	0.1	0.2
M/P Xylene	2.7	4	6.8	13.3	6.7
Isopropylbenzene	0.3	0.5	0.5	3.2	0.3
Isoprene	0.8	10.8	1.1	3.6	2.2
Isopentane	2.4	22.7	8.6	24.6	23.9
Isobutane	10.9	23.4	17	74.8	15.6
Formaldehyde		4.5			5.9
Ethylene	3.8	8.2	3.4	3.2	5.2
Ethylbenzene	1.1	3.4	2.4	3.7	1.9
Ethane	8	49.3	9.4	16.2	26.1
Cyclopentane	0.2	8.8	0.5	1.7	1.8
Cyclohexane	0.7	3.1	3	2.9	3.8

Table 2-18. Summary of Maximum Concentration for PAMS Sites (continued)

Maximum Concentration (ppbc)					
Street Address	Madera-Pump Yard	Clovis-Villa	Parlier	Shafter	Bakersfield-Muni
Cis-2-Pentene	0.2	0.5	1.5	0.3	5.6
Cis-2-Butene	0.4	6.7	0.2	1.2	0.2
Benzene	3	2	3.3	14.8	2.3
Acetylene	1	2.8	6.2	2.7	4.4
Acetone		104.9			24.5
Acetaldehyde		4.8			19.3
3-Methylpentane	0.9	1.5	1.4	3.8	4.1
3-Methylhexane	1.1	3.6	2.6	5.1	4.1
3-Methylheptane	0.2	0.4	0.4	1	0.7
2-Methylpentane	2.2	3.2	3.5	8.3	9.2
2-Methylhexane	0.4	1.5	1.3	5	3.5
2-Methylheptane	2.2	0.7	0.9	1.1	1.1
2,4-Dimethylpentane	0.2	1.4	0.4	0.8	2.3
2,3-Dimethylpentane	0.2	2.6	1.4	1.5	3.3
2,3-Dimethylbutane	0.4	1.3	0.7	1.5	3
2,3,4-Trimethylpentane	0.3	0.7	0.5	0.5	4.6
2,2-Dimethylbutane	0.2	3.6	0.6	1.5	3.4
2,2,4-Trimethylpentane	0.9	1.9	5.1	1.6	10.8
1-Pentene	0.9	1.7	0.7	0.5	0.5
1-Butene	1.6	11.6	1.1	1.8	0.8
1,3,5-Trimethylbenzene	0.5	0.5	0.5	1.7	1
1,2,3-Trimethylbenzene	0.6	1.4	1.1	4.5	1.5
1,2,4-Trimethylbenzene	1	1.6	1.4	4.9	2.5
Oxides of Nitrogen	31.0	36.0	47.0	98.7	75.0
Nitric Oxide	13.0	15.0	34.0	66.5	40.0
Nitrogen Dioxide	4.8	28.0	24.0	58.5	51.0
Ozone	100	123	116	112	109

Table reflects data for June, July, and August 2013.

2.5.4 Discussion of the PAMS Network Assessment

The finding from the percent above MDL analysis shows that although approximately only one-third of the measured PAMS target compounds reported equal to or greater than 85% above the MDL, this indicates that only one-third of the PAMS target compounds are present in the atmosphere in any detectable amounts. Samples from an air basin containing all of the possible target compounds would not be expected. The data completeness analysis demonstrates that about 90% of the measured PAMS target compounds are equal to or greater than 85% complete, indicating that there is good sampling protocol, compound recovery, and identification for those compounds that were above the MDL. The above two analyses suggest that the sites in the SJV appear to be suitable for long-term trend analysis for ozone, total non-methane organic compounds (TNMOC), and for those ozone precursors that have a greater than 85% of data reported above the MDL and a greater than 85% completeness.

Table 2-19 shows the total parts per billion carbon (ppbc) of the Maximum Concentration of all PAMS Compounds the Northern PAMS sites (excluding the carbonyl compounds that were measured only at Type 2 sites). The data demonstrates that of the three sites, the Madera-Pump Yard had the lowest summed component value, which is appropriate for the upwind background site. Clovis-Villa had the highest summed component value at 195% greater than Madera-Pump, which is appropriate given it is an upwind, background site. Lastly, the Parlier site is substantially less than Clovis-Villa due to downwind dilution effects, but it is still 32% more than Madera-Pump, which again is appropriate for the downwind site.

Figures 2-29 and 2-30 depict photochemical modeling of 2007 data, from both PAMS and non-PAMS sites, used to support the attainment demonstration in the District's *2013 Plan for the Revoked 1-Hour Ozone Standard*. In these figures, Parlier is situated in the downwind plume of increased ozone concentrations from Clovis, as discussed above, but it is no longer in the area of the maximum ozone occurring downwind. According to Figure 2-29, the current areas of maximum downwind ozone would be northeast of Parlier in the vicinity of the towns of Navelencia and Orange Cove in Fresno County, and to the southeast of Parlier in the vicinity of the towns of Orosi and Lemon Cove in Tulare County. According to Figure 2-31, the area of maximum downwind ozone would be even further east and southeast of Parlier in areas of higher elevation. This change in areas of maximum downwind ozone concentrations is the result of successful implementation of control strategies and do not require the relocation of the PAMS Type 3 site. The site needs to remain in its current location for continuity in measuring and tracking the changes in emission and transport patterns over time.

Table 2-19. Summation of Maximum Concentration of all PAMS Compounds

(a) Fresno MSA

Site Type	1	2	3
Site Objective	Upwind background ozone and precursors	Area of maximum ozone precursor emissions	Site of maximum ozone occurring downwind
Location	Madera-Pump Yard	Clovis-Villa	Parlier
Ave. ppbc	334	988	442
> Site 1	-	195%	32%

(b) Bakersfield MSA

Site Type	1	2	3
Site Objective	Upwind background ozone and precursors	Area of maximum ozone precursor emissions	Site of maximum ozone occurring downwind
Location	Shafter	Bakersfield-Muni	Arvin
Ave. ppbc	3,050	1,025	Not Applicable
> Site 1		-66%	Not Applicable

Figure 2-29. Photochemical Modeling of 2007 data showing Maximum 8-Hour Average Ozone data

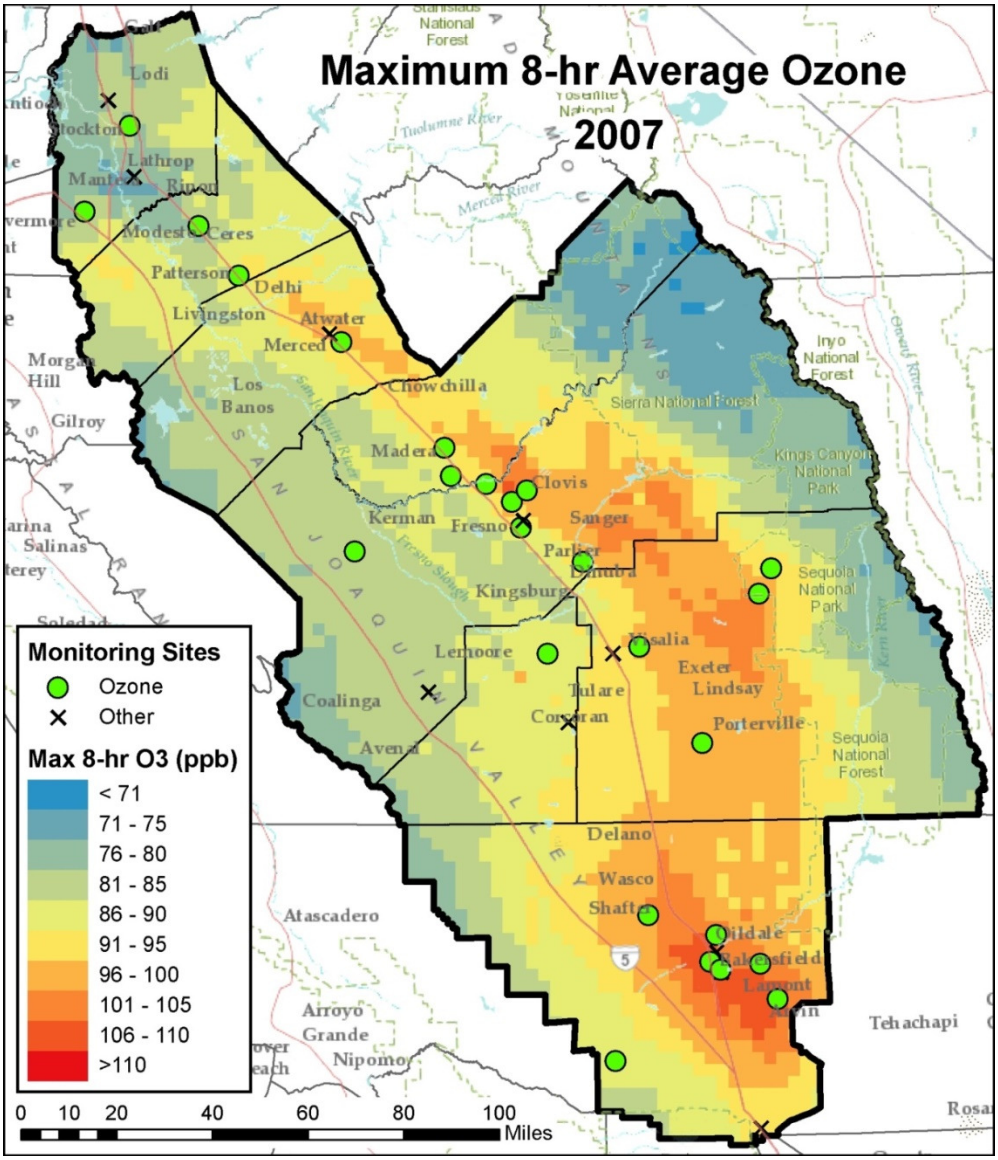


Figure 2-30. Photochemical Modeling of 2007 data showing Days 8-hour Ozone exceeds the NAAQS (75 ppb)

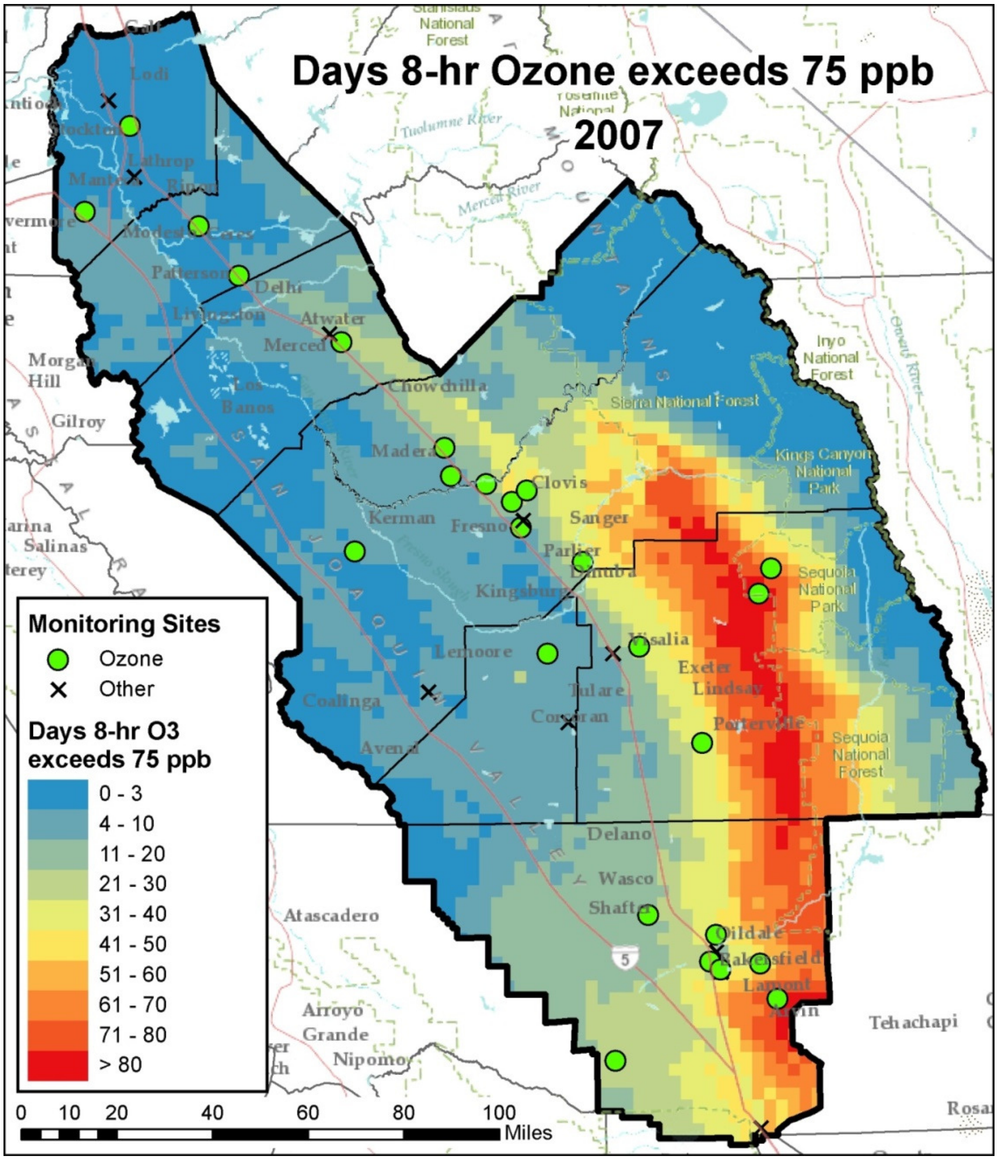
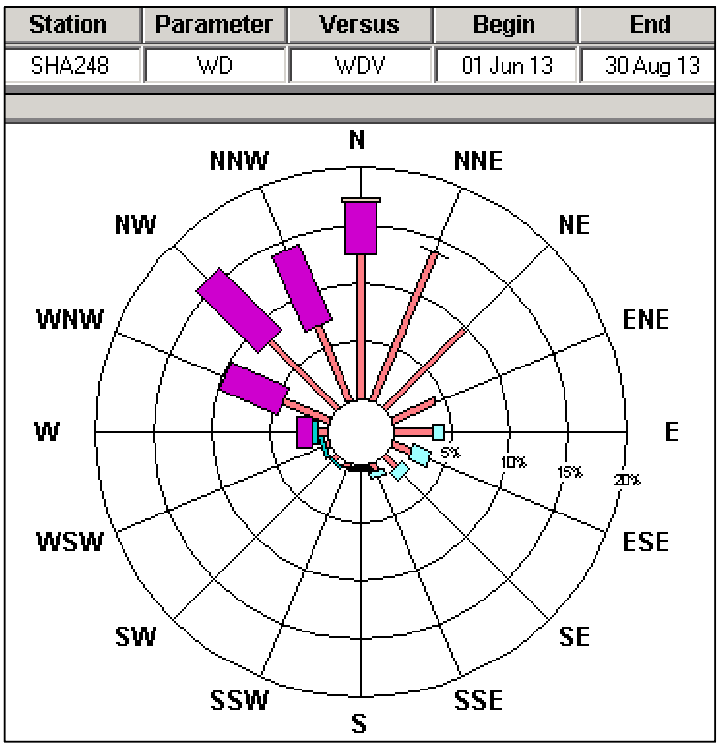


Table 2-19b reports the results for the Bakersfield MSA. The maximum ozone occurring at the downwind site Arvin-Di Giorgio does not currently collect PAMS data as the site consists of a temporary shelter with insufficient room for PAMS equipment. Figure 2-29 and Figure 2-30 show that Shafter has lower ozone concentrations than Bakersfield-Muni. The Figure 2-31 demonstrates that nearly 60% of Shafter's wind flow is from the northwest and is upwind of Bakersfield-Muni.

Photochemical modeling in Figure 2-30 and 2-31 shows that the Arvin Type 3 site (when it is approved by ARB and a permanent structure built) will be positioned correctly for the maximum downwind ozone concentration.

Figure 2-31. Shafter Wind Rose from June 1, 2013 through August 30, 2013



3 TECHNICAL APPROACH AND FINDINGS FOR THE METEORLOGICAL NETWORK ASSESSMENT

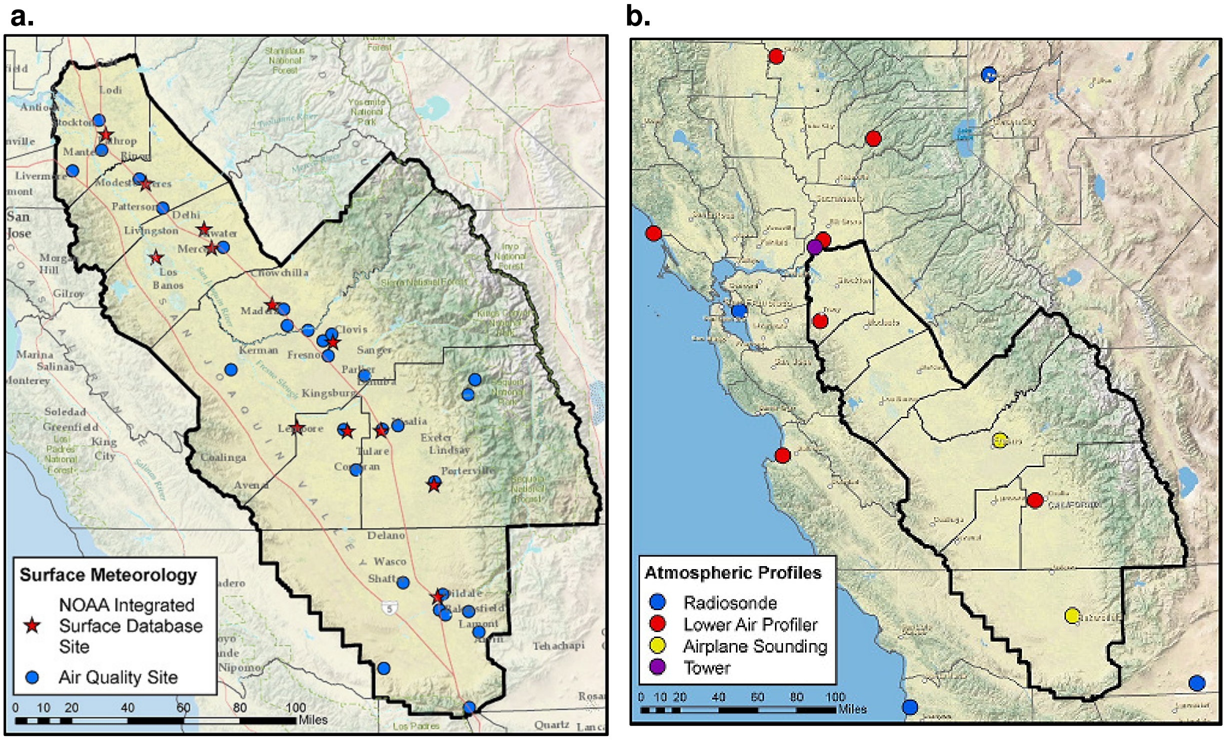
Accurate representation of the spatial and temporal characteristics of a region's meteorology is needed to understand the physical and chemical processes that influence air quality and to help determine ways to mitigate future air quality impacts. The main meteorological conditions that influence air quality include transport of pollutants by winds, recirculation of air by local wind patterns, horizontal dispersion of pollution by wind, variations in sunlight due to clouds and seasons, temperature, moisture, vertical mixing, and dilution of pollution within the atmospheric boundary layer.

A variety of meteorological parameters are measured for the various District programs affected by weather. Such programs include air quality forecasting, PAMS analysis, exceptional events reporting, long–term air pollution control planning, and pollutant trend assessment. These activities help protect public health and increase air quality awareness of what can be done to reduce air pollution.

Figure 3-1 shows a map of the surface meteorological sites and atmosphere profile sites operating in and around the San Joaquin Valley. The meteorological parameters measured by the surface network include outdoor temperature, wind speed, wind direction, barometric pressure, relative humidity, and solar radiation. The atmosphere profile sites measure wind speed, wind direction, temperature, barometric pressure and/or, relative humidity throughout the atmosphere.

Figure 3-1. Maps of the locations measuring various meteorological parameters within and around District Boundaries

a. **b.**

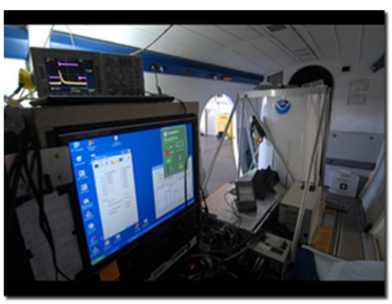


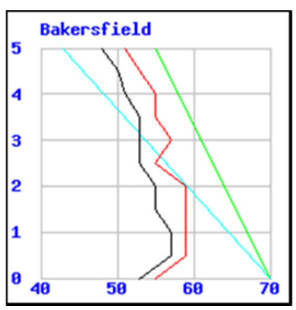
Atmospheric profiler sites:

Radiosondes launched twice a day are meteorological instrument packs suspended beneath a six foot wide hydrogen or helium balloon. Once the balloon is launched, meteorological measurements are recorded and transmitted to a ground receiver as the balloon ascends to high altitudes.
Source: NWS Radiosonde Observations - Factsheet
http://www.erh.noaa.gov/gyx/weather_balloons.htm

Lower air (atmosphere) profilers capture vertical temperature, wind speed, and direction profiles.
Wind Profilers Added to Vaisala Product Range
Source:
http://www.vaisala.com/Vaisala%20Documents/Vaisala%20News%20Articles/VN158/VN158_Wind_Profilers_Added_to_Vaisala_Product_Range.pdf

Airplane soundings are vertical temperature profiles, and sometimes other variables that are captured by a plane equipped with meteorological instruments. The measurements are taken during portions of the plane's ascent or descent flight track.





Source: *ESRL*/*GSD* Aircraft Data (AMDAR) Information
http://amdar.noaa.gov/FAQ.html#sounding

The meteorological tower at Walnut Grove measures temperature, wind speed, and direction from the surface up to 2,000 feet above ground level.
Source: Walnut Grove Tower Meteorological Data
http://tbsys.serveftp.net/wg/wgup/towerpro.htm

The goal of the meteorological network assessment presented in this section was to assess the number of meteorological parameters measured by the network, conduct wind rose and correlation analyses, and address the following questions:

- Are meteorological sites appropriately located to determine the extent of regional pollutant transport among populated areas?
- Are there potentially redundant meteorological sites in the network?
- Are there areas where new meteorological sites may be needed?
- Are there new technologies that may add value to the meteorological network?
- Is the meteorological network adequate for characterizing regional surface and lower atmosphere meteorology?

The remainder of this section describes the technical approach and findings of the meteorological network assessment.

3.1 SURFACE METEOROLOGICAL NETWORK ASSESSMENT

To evaluate the surface meteorological network, the District reviewed meteorological data obtained from the EPA's AQS and the National Climatic Data Center (NCDC). The data sets included relative humidity, barometric pressure, temperature, wind speed, and wind direction data collected in the San Joaquin Valley during 2013. The District used these data to determine meteorological data completeness and quality for each site.

3.1.1 Data Completeness

Data completeness was compiled using AMP430 AQS Report. Table 3-1 shows a summary of the data completeness by parameter for all sites in the San Joaquin Valley air basin and shows the operator of each site.

Table 3-1 shows 30 sites measuring meteorology in the San Joaquin Valley, the agencies operating those sites, and the 2013 meteorological data completeness. The findings were as follows:

- 6 of 9 sites had more than 85% data completeness for all of the meteorological parameters measured which included relative humidity, barometric pressure, temperature, wind speed, and wind direction.
- Data completeness for 9 of 12 sites measuring relative humidity was 95% or greater.
- Data completeness for 18 of 21 sites measuring barometric pressure was 99% or greater.
- Data completeness for 23 of 29 sites measuring temperature was 89% or greater.

- Data Completeness for 25 of 29 sites measuring wind speed and wind direction parameters 89% or greater.

Table 3-1. Data Completeness for Sites Measuring Meteorology in the San Joaquin Valley

Site Name	Site Operator	Data Completeness (%)				
		Relative Humidity	Barometric Pressure	Temperature	Wind Speed	Wind Direction
Stockton-Hazelton	CARB	99		99^	91*	91**
Manteca	SJVAPCD		100	100	99	99
Tracy-Airport	SJVAPCD		99	100	99	99
Modesto-14th St	CARB			100^	100*	100**
Turlock	SJVAPCD		99	99	99	99
Merced-Coffee	SJVAPCD			100	98	98
Madera–City	SJVAPCD	99	99	99	95	99
Madera-Pump Yard	SJVAPCD	100	100	98	100	100
Tranquillity	SJVAPCD		100	98	98	98
Fresno-Sky Park	SJVAPCD			96	100	100
Clovis-Villa	SJVAPCD	99	99	99	99	99
Fresno-Garland	CARB	63	70	71	100*	100**
Fresno–Drummond	SJVAPCD		100	100	100	100
Parlier	SJVAPCD	97	99	98	100	100
Huron	SJVAPCD		100			
Hanford-Irwin	SJVAPCD		100	89	100	100
Corcoran-Patterson	SJVAPCD		100	94	100	100
Visalia Airport	SJVAPCD	99	99	99	99	99
Visalia-Church St	CARB		33	41	41*	41**
Sequoia-Lower Kaweah	NPS	77		83	82*	82**
Sequoia-Ash Mountain	NPS	95		99	99*	99**
Porterville			100	100	99	99
Shafter	CARB	99	99	99	41	41
Oildale	CARB			100	100*	100**
Bakersfield-California Ave	CARB	41	41	41	80*	80**
Edison	CARB			100	100*	100**
Bakersfield-Muni	SJVAPCD	95	100	99	99	98
Arvin-Di Giorgio	CARB			75	89*	89**
Maricopa	SJVAPCD		99	99	99	99
Lebec	SJVAPCD		100	100	99	99

Table reflects data from 2013.
Gray cells – parameter not measured at the site
Yellow highlighted cells indicate data completeness below an 85% target.
* - Resultant Wind Speed ** - Resultant Wind Direction
^ - Virtual Temperature

3.1.2 Site-to-Site Correlation Analyses

To identify possible redundancies in the surface meteorological network, the District conducted Pearson correlation analyses for hourly outdoor temperature, relative humidity, and solar radiation from 2013 AQS data. The Pearson correlation coefficient (R) between site pairings shows how well the data agree. The R value is a measure of the linear relationship between two variables and ranges from -1.00 to 1.00. An R value of 1.00 means that there is a positive linear relationship between the data from two sites which could indicate a redundancy in the monitoring network for sites near each other. Figures 3-1 through 3-5 and Tables 3-2 through 3-6 below show the results of the correlation analyses.

Outdoor Temperature

The outdoor temperature correlations are quite good, and reflect the geographic and environmental characteristics of the San Joaquin Valley. As shown in Table 3-2 below, the correlations between the Clovis, Fresno-Drummond, and Fresno-Sky Park sites are particularly high (R = 1.00), because those three sites are all located near one another in the Fresno metropolitan area. These high correlation values indicate that further investigation into monitor redundancy in this area may be needed. The correlations for the foothill and mountain sites are also good, which are indicative of seasonal and climatic similarities at those sites.

Relative Humidity

Overall, the correlations for relative humidity for the valley floor and the mountain sites are good, but the range is also wider than the outdoor temperature correlations exhibited. Relative humidity can vary and change significantly depending on location, time of day, and season. Such variations in relative humidity can cause fluctuations in ozone and particulate concentrations that are challenging to forecast and evaluate. The variability among sites, as indicated by the large range of correlation values, demonstrates that there is little monitor redundancy.

Solar Radiation

The solar radiation correlations for the valley floor sites are very good and are representative of the daily diurnal pattern of daylight hours as well as effects of cloud cover and the seasonal changes in sun angle. Due to the regional nature of solar radiation, high correlation among sites is expected.

3.1.3 Discussion of Surface Meteorological Network Assessment

A comparison of surface meteorological parameters shows the expected amount of variability between sites. Temperature, humidity, and solar radiation measured at mountain sites tend to be more variable from site to site while the Valley floor sites all correlate well with one another, especially as the distance between the sites decreases. Correlation analysis between sites revealed a strong linear relationship between outdoor temperature readings among most Valley sites near one another. Outdoor temperatures tend to be regional and rarely differ by more than a few degrees across large portions of the valley. This might indicate that these monitors should be investigated for redundancy. Correlations for the remaining meteorological parameters reveal that there are no other redundant parameters in the District. Additionally, meteorological parameters such as wind speed and direction can be highly localized and short-lived, so the differences between sites may not be captured in a simple correlation analysis. Analyzing the pollutants and wind direction during high wind or localized pollution events is extremely important during exceptional events such as high winds or fires. It is therefore important to continue surface meteorological monitoring at the sites already in use.

Figure 3-2. Outdoor Temperature Correlations

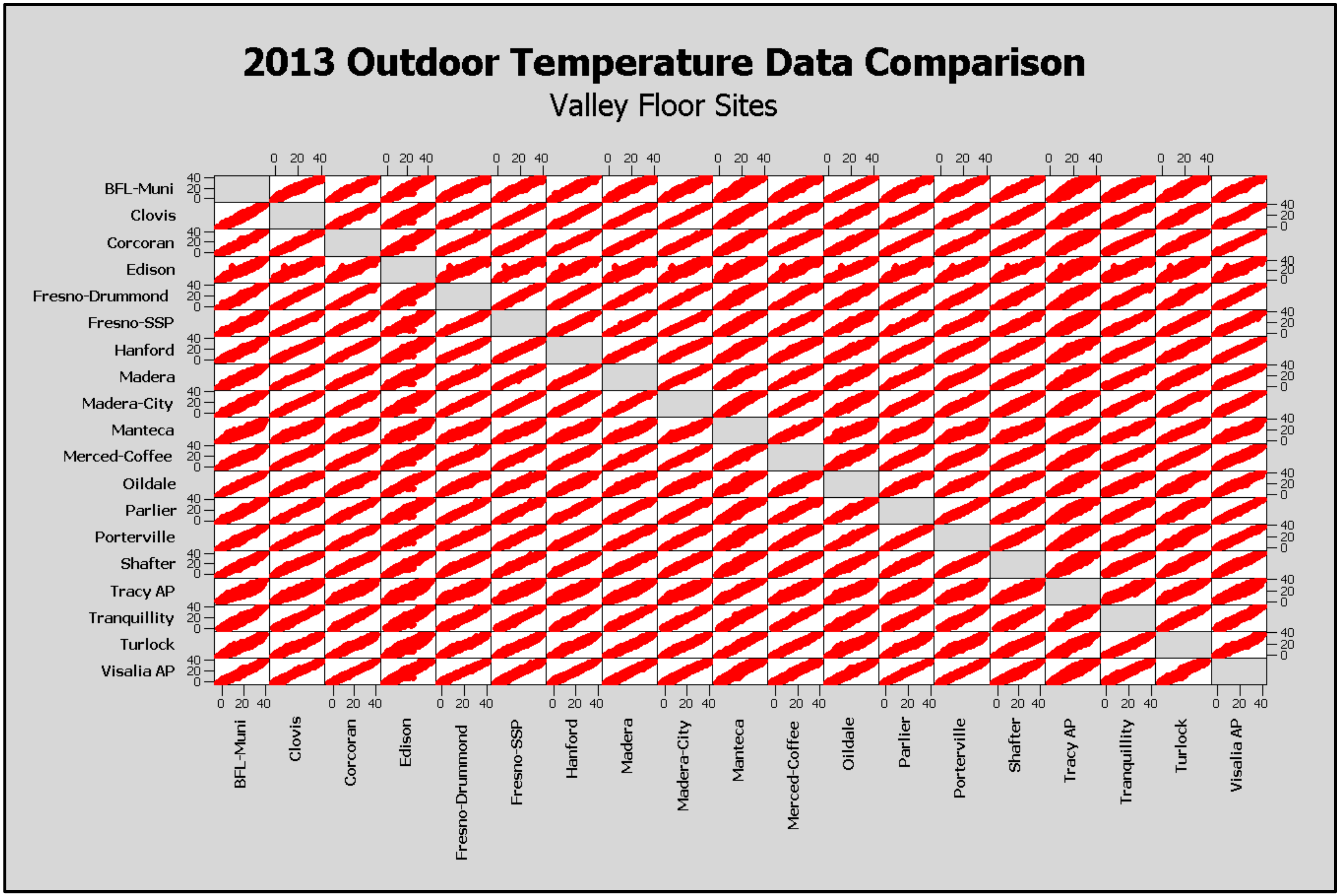


Table 3-2. Outdoor Temperature R Values for Valley Floor Sites

2013 Outdoor Temperature Data Comparison - Pearson Correlation Coefficients																		
Valley Floor Sites																		
	BFL-Muni	Clovis	Corcoran	Edison	Fresno-Drummond	Fresno-Sky Park	Hanford	Madera	Madera-City	Manteca	Merced-Coffee	Oildale	Parlier	Porterville	Shafter	Tracy AP	Tranquillity	Turlock
Clovis	0.99																	
Corcoran	0.99	0.99																
Edison	0.96	0.96	0.96															
Fresno-Drummond	0.99	1.00	0.99	0.95														
Fresno-Sky Park	0.98	1.00	0.99	0.97	0.99													
Hanford	0.98	0.99	0.99	0.95	0.99	0.99												
Madera	0.97	0.99	0.99	0.96	0.99	1.00	0.99											
Madera-City	0.98	1.00	0.99	0.96	1.00	1.00	0.99	0.99										
Manteca	0.95	0.97	0.97	0.94	0.97	0.97	0.97	0.97	0.97									
Merced-Coffee	0.98	0.99	0.99	0.96	0.99	0.99	0.99	0.99	1.00	0.98								
Oildale	0.99	0.99	0.98	0.97	0.98	0.98	0.98	0.97	0.98	0.95	0.97							
Parlier	0.99	0.99	0.99	0.96	0.99	0.99	0.99	0.99	0.99	0.96	0.99	0.98						
Porterville	0.99	0.99	0.99	0.97	0.99	0.99	0.98	0.98	0.99	0.96	0.98	0.99	0.99					
Shafter	0.98	0.99	0.99	0.98	0.98	0.99	0.98	0.98	0.99	0.96	0.98	0.98	0.99	0.99				
Tracy AP	0.93	0.95	0.95	0.91	0.95	0.95	0.95	0.95	0.95	0.98	0.96	0.94	0.94	0.94	0.93			
Tranquillity	0.97	0.99	0.99	0.96	0.99	0.99	0.99	0.99	0.99	0.98	0.99	0.97	0.98	0.98	0.98	0.96		
Turlock	0.97	0.98	0.98	0.95	0.98	0.99	0.98	0.99	0.99	0.99	0.99	0.97	0.98	0.97	0.97	0.97	0.99	
Visalia AP	0.99	0.99	1.00	0.96	0.99	0.99	0.99	0.99	0.99	0.96	0.99	0.99	1.00	0.99	0.98	0.95	0.98	0.98

Figure 3-3. Outdoor Temperature Correlations for the Foothill and Mountain Sites

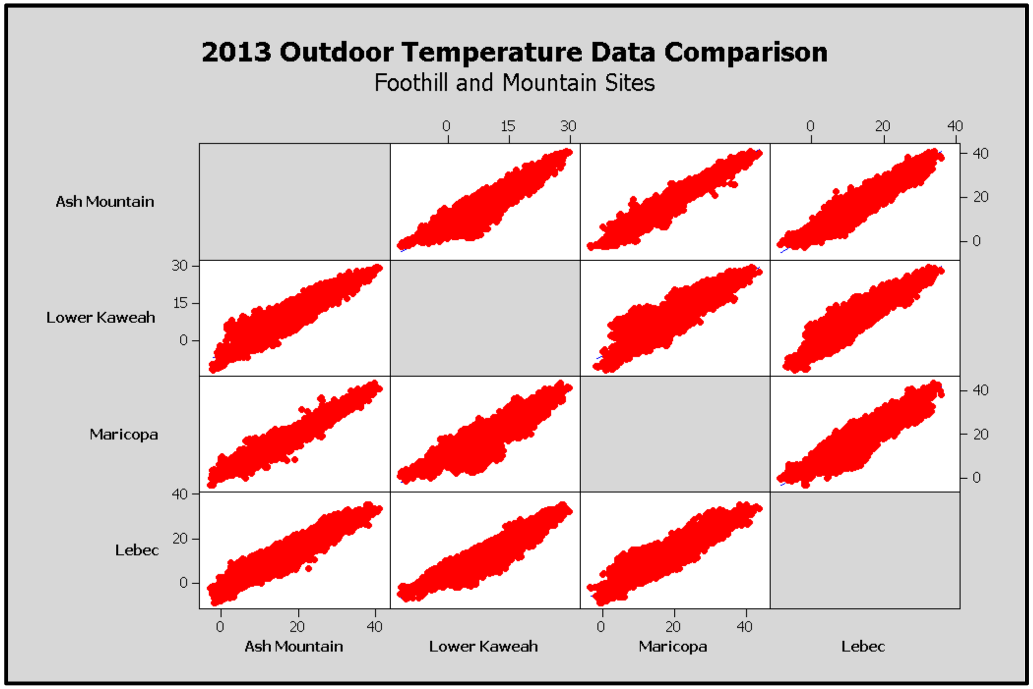


Table 3-3. Outdoor Temperature R Values for the Foothill and Mountain Sites

2013 Outdoor Temperature Data Comparison Pearson Correlation Coefficients Foothill and Mountain Sites			
	Ash Mountain	Lower Kaweah	Maricopa
Lower Kaweah	0.95		
Maricopa	0.98	0.92	
Lebec	0.96	0.93	0.94

Figure 3-4. Relative Humidity Correlations for Valley Floor Sites

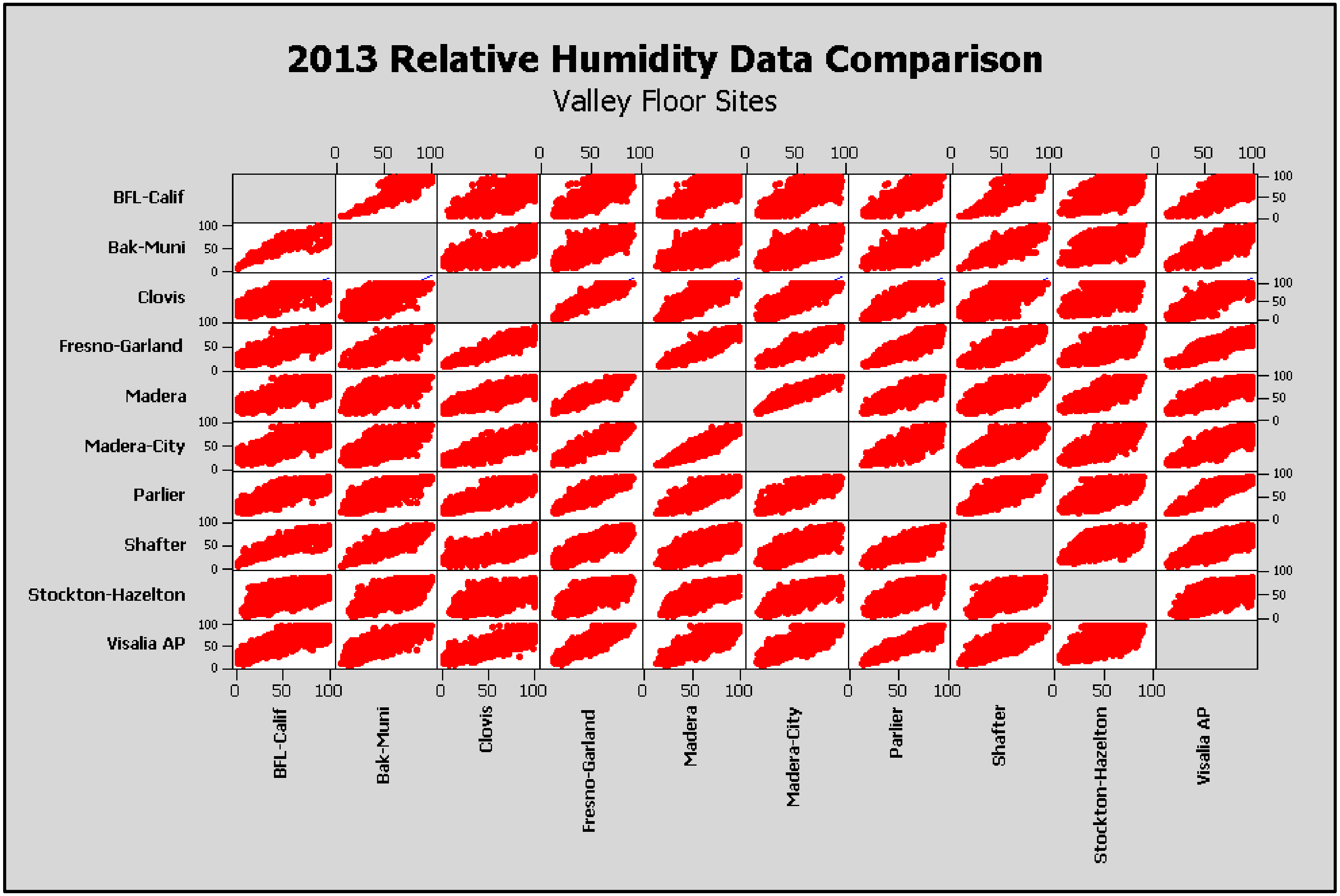


Table 3-4. Relative Humidity R Values for Valley Floor Sites

2013 Relative Humidity Data Comparison - Pearson Correlation Coefficients									
Valley Floor Sites									
	BFL-Calif	Bak-Muni	Clovis	Fresno-Garland	Madera	Madera-City	Parlier	Shafter	Stockton-Hazelton
Bak-Muni	0.97								
Clovis	0.85	0.83							
Fresno-Garland	0.90	0.90	0.93						
Madera	0.87	0.86	0.92	0.96					
Madera-City	0.87	0.89	0.92	0.97	0.97				
Parlier	0.89	0.88	0.92	0.94	0.92	0.92			
Shafter	0.94	0.94	0.84	0.92	0.90	0.90	0.90		
Stockton-Hazelton	0.77	0.78	0.81	0.85	0.88	0.88	0.79	0.83	
Visalia AP	0.90	0.90	0.92	0.95	0.93	0.94	0.96	0.90	0.80

Figure 3-5. Relative Humidity Correlations for the Ash Mountain and Lower Kaweah Sites

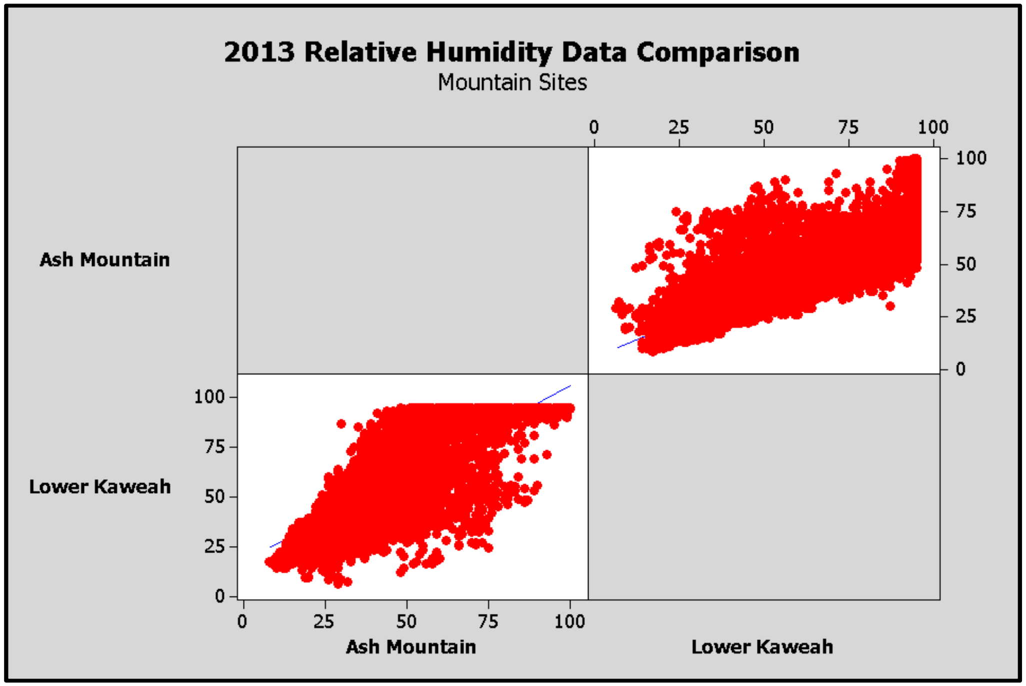


Table 3-5. Relative Humidity R Values for the Ash Mountain and Lower Kaweah Sites

2013 Relative Humidity Data Comparison Pearson Correlation Coefficients	
Foothill and Mountain Sites	
	Lower Kaweah
Ash Mountain	0.78

Figure 3-6. Solar Radiation Correlations for Valley Floor Sites

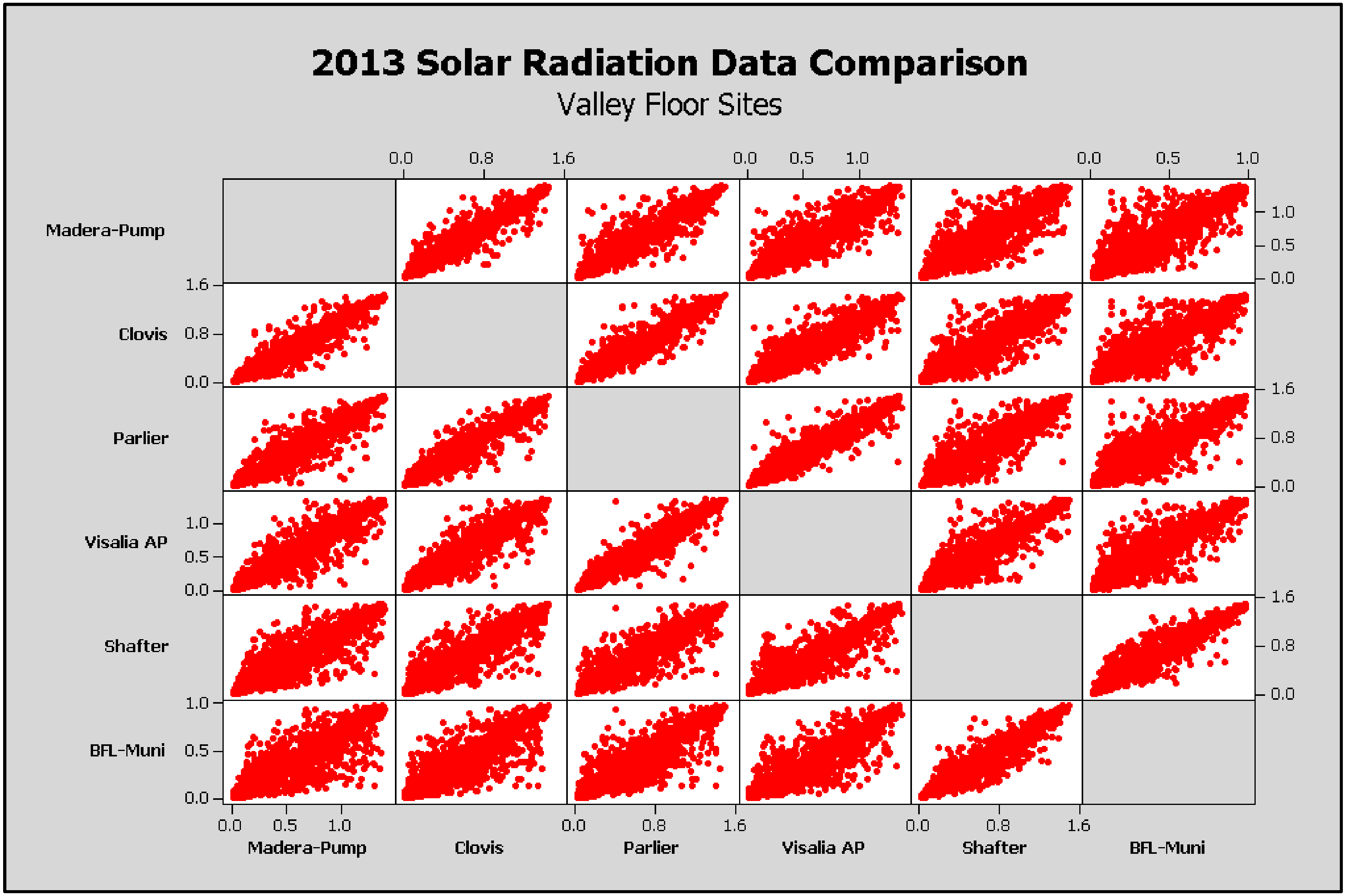


Table 3-6. Solar Radiation R Values for Valley Floor Sites

2013 Solar Radiation Data Comparison Pearson Correlation Coefficients					
Valley Floor Sites					
	Madera-Pump	Clovis	Parlier	Visalia AP	Shafter
Clovis	0.99				
Parlier	0.99	0.99			
Visalia AP	0.98	0.99	0.99		
Shafter	0.98	0.98	0.98	0.99	
BFL-Muni	0.97	0.98	0.98	0.98	0.99

3.1.4 Wind Rose Analyses

The ability of the surface meteorological network to represent the spatial and temporal variations of meteorological flow patterns that affect the San Joaquin Valley largely depends on site location. In 2010, Sonoma Technologies, Inc. (STI) conducted a detailed wind rose analysis which assessed the District's meteorological network's representativeness. The analysis is found in the District's *Ambient Air Quality Monitoring Network Assessment for the San Joaquin Valley*, which was submitted to the EPA with the *San Joaquin Valley Air Pollution Control District's Air Monitoring Network Plan* in July 2010. The District examined wind roses which showed prevailing wind directions at various locations and helped determine that the District's meteorological network is representative of the San Joaquin Valley air flow patterns.

All valley sites are located in or near populated areas and tend to be around the higher pollution regions. The meteorological sites currently in operation are appropriately located to determine the extent of regional pollutant transport among populated areas. The west side of the Valley may be underrepresented by surface meteorological sites. If feasible in the future, the addition of meteorological sites along the base of the foothills in western SJV could better capture the effects of up/downslope flows along the coastal range and marine-layer infiltration. As mentioned previously, a meteorological monitor located northeast of Clovis in the mountains near Oakhurst could assist in understanding local population exposure to pollutant concentrations.

3.2 LOWER ATMOSPHERE PROFILER NETWORK ASSESSMENT

In depth studies have shown that marine air intrusion, the Fresno Eddy, and the nocturnal jet are meteorological phenomena that directly influence air quality in the San Joaquin Valley. As mentioned in the previous section, a meteorological instrument known as a lower atmosphere profiler (LAP) captures these airflow patterns and provides useful data for air quality forecasting and analyses. A LAP is a remote sensing Doppler radar that produces a vertical and horizontal wind profile up to approximately 3,000 meters (9,842 feet) above ground level. The District currently operates two Vaisala LAP-3000 Wind Profilers that produce profiles ranging 60 – 3,000 meters above ground level. Each LAP also has an integrated Radio Acoustic Sounding System (RASS) which adds virtual temperature to the profile and increases the LAP's capabilities.

The District's LAPs are located at the Tracy and Visalia Airport sites. The LAP network meets the requirements outlined in 40 CFR Part 58 and adequately captures and represents the unique air flows in the SJV based the locations and the data measured by the profilers. Additionally, an in depth examination of the District's LAP network by STI in 2010 evaluated the profilers' location adequacy and data sufficiency. This evaluation was presented in the aforementioned 2010 Air Monitoring Network Assessment.

3.2.1 Technology Advancements

Sonic Anemometer

The District's surface meteorological network includes measuring wind speed and direction with cup anemometers. However an alternate instrument that is available is the sonic anemometer which is very cost effective. Sonic anemometers use ultrasonic sound waves to measure wind speed and direction. They have no moving parts and are maintenance-free. The District may investigate use of sonic anemometers in the future.
Source: Vaisala WINDCAPUltrasonic Sensor Technology
http://www.vaisala.com/Vaisala%20Documents/Technology%20Descriptions/WINDCAP_technology.pdf

Ceilometer

EPA is proposing revisions to measuring meteorology in the PAMS network, including requiring agencies to measure mixing heights using ceilometers. Ceilometers use lasers to measure cloud ceilings and mixing heights. According to Eresmaa et al., mixing heights are measured based on changes in particulate concentrations at the top of the boundary layer (2006). These instruments are more cost effective and have smaller footprints than LAPs. Once the rule is finalized, the District will investigate the cost effectiveness of added ceilometers to the PAMS network.

Sodar

Although EPA does not require measurement of upper air wind speed and direction, it recognizes that continuing operation of LAPs is appropriate as part of the Enhanced Monitoring Plan if an agency finds the data valuable.

A less expensive alternative to LAPs is the sodar (SOnic Detection And Ranging). Sodars use sound waves to measure vertical turbulence structure and wind profiles in the lower layer of the atmosphere. Some functions include:

- Measure wind up to 600 meters AGL
- Less noisy than LAPs
- Can run on solar power
- Can measure mixing heights depending on the model
- Operate unmanned
- Have high temporal and vertical resolution

Source: http://www.sodar.com/about_sodar.htm

For now, the District will continue to operate the LAPs but may also consider exploring the use of alternative meteorological measurement technology in the future.

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