Chapter 3

PM2.5 Progress and Remaining Challenges

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Chapter 3: PM2.5 Progress and Remaining Challenges

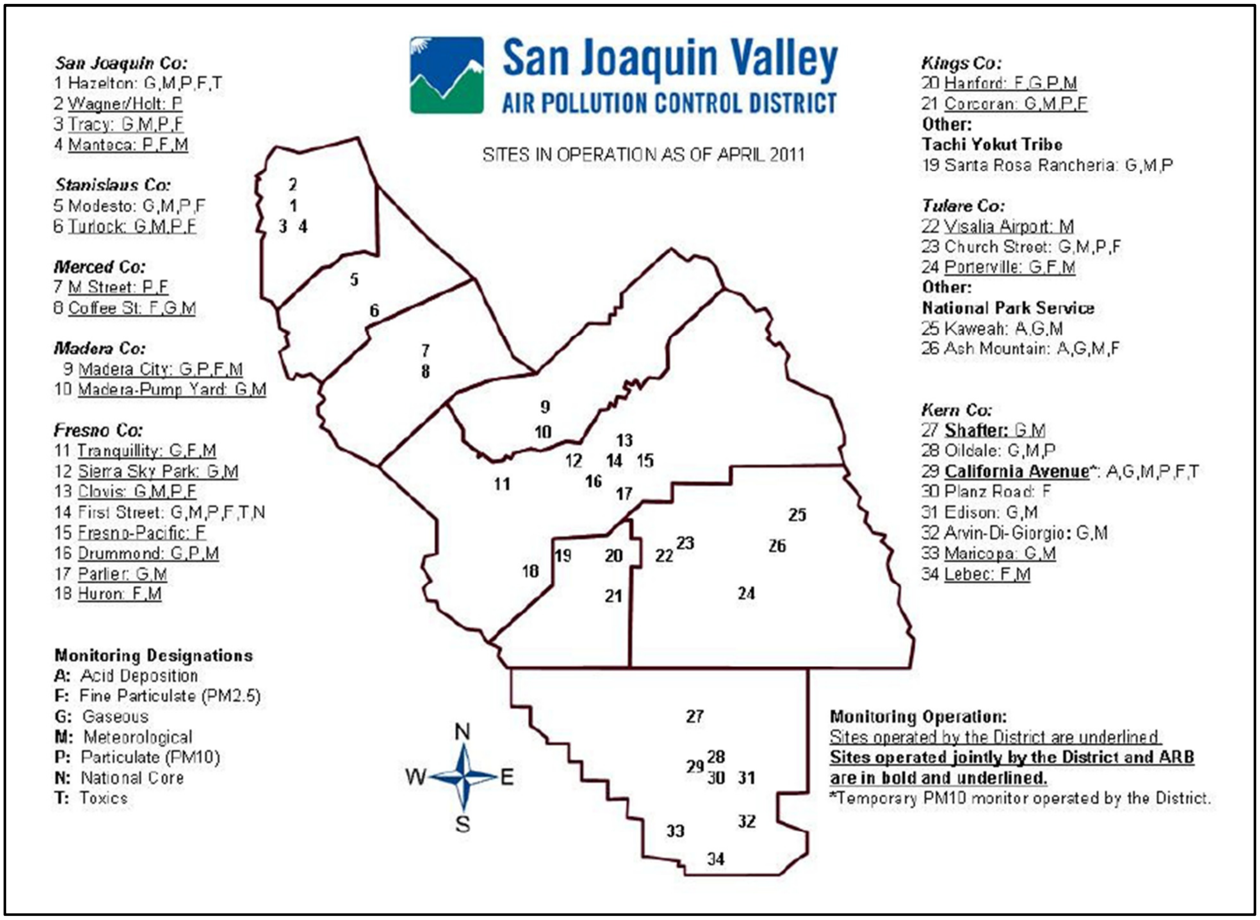
3.1 INTRODUCTION

This chapter provides an overview of recent trends in PM2.5 air quality across the San Joaquin Valley as well as a look at the reduction in the emissions inventory over the past few decades. Both the ambient air quality and the emissions inventory play a key role in the regional grid modeling that is used to project pollutant concentrations in the future. The results of the modeling analysis are presented here along with a summary of what reductions will be necessary to reach attainment. Finally, a discussion of the challenges standing in the way of further air quality progress in the San Joaquin Valley is included.

3.2 ANALYSIS OF PAST AND PRESENT PM2.5 TRENDS

Numerous pollutants and meteorological parameters are measured throughout the San Joaquin Valley on a daily basis. This is accomplished through the operation of an extensive air monitoring network managed by the District and the Air Resources Board (ARB). This network measures progress toward compliance with the National Ambient Air Quality Standards (NAAQS) in addition to providing real-time air quality measurements used for daily air quality forecasts, residential-wood burning declarations, Air Alerts, and the Real-Time Air Quality Advisory Network (RAAN). Air quality monitoring networks are designed to monitor areas with high population densities, areas with high pollutant concentrations, areas impacted by major pollutant sources, and areas representative of background concentrations. Together, the District and the ARB operate 34 air monitoring stations throughout the Valley, where 21 of these sites measure PM2.5. At each of the PM2.5 sites, PM2.5 samples are taken on a daily filter basis, an hourly real-time basis, or both. Figure 3-1 shows the Valley's air monitoring sites.

Figure 3-1: Air Monitoring Sites within the San Joaquin Valley Air District



PM2.5 is measured and expressed as the mass of particles contained in a cubic meter of air (micrograms per cubic meter, or μg/m^3). The data collected from the District's network of PM2.5 monitors is used to calculate design values for the 24-hour and annual PM2.5 standards, as outlined in Environmental Protection Agency (EPA) guidance and regulations.[1]

3.2.1 Air Quality Progress

Since 1999, when PM2.5 first began to be measured in the San Joaquin Valley, significant progress has been made in reducing concentrations throughout the region. Most metrics used to measure air quality progress may fluctuate from year to year, due to influential variable factors like meteorology and the economic climate. The trend is usually never linear due to the year to year changes, and so focusing on a comparison within a short timeframe can be misrepresentative and lead to shortsighted conclusions. Instead, the longer trend should be considered when assessing the progress of air quality improvement, providing a viewpoint of the bigger picture.

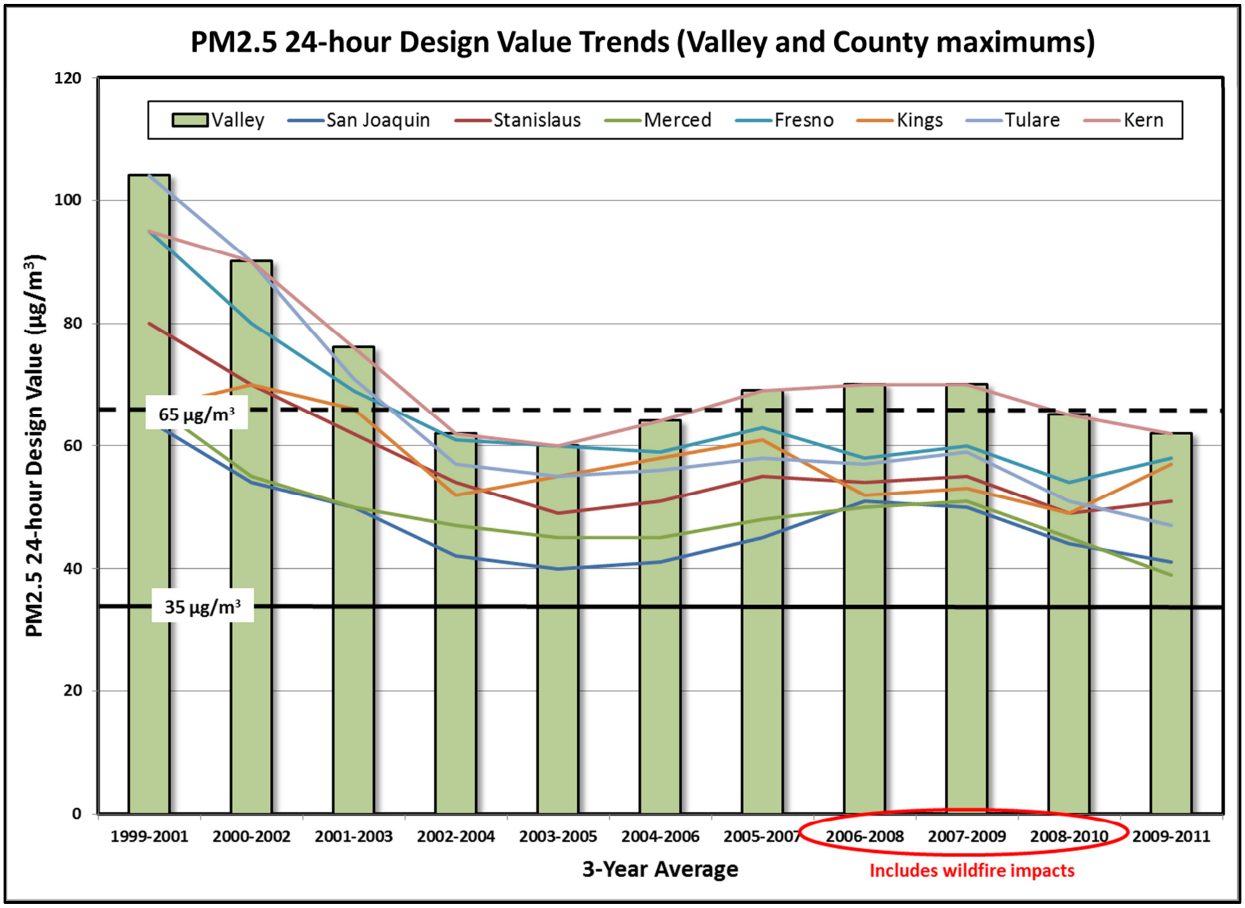
[1] EPA, *Guideline on Data Handling Conventions for the PM NAAQS* (April 1999) and Appendix N of 40 CFR Part 50.

There are a number of ways that air quality progress can be assessed. The design value is the official method used to determine whether an area is in attainment of a standard, yet other indicators can reveal more about what progress is being made. Comparing the days over the 24-hour average NAAQS threshold from year to year shows the progress in reducing the number of days with the highest concentrations, while quarterly averages can show the movement in larger datasets over time. Comparing the frequency distributions of PM2.5 at an air monitoring site between time periods can show a shift in which concentrations are more commonly occurring now compared to the past. Some of the conclusions from these analyses are included below, followed by a more detailed discussion in Appendix A, which also provides analysis results for a number of other air monitoring sites in the San Joaquin Valley.

Although there are many ways to assess air quality progress, the official metric used to determine whether a region is in attainment of a federal air quality standard is the *design value*. Under the 2006 PM2.5 federal standard a region must meet both the 24-hour average standard of 35 $\mu g/m^3$ and the annual average standard of 15 $\mu g/m^3$ in order to meet attainment. Details on how PM2.5 design values are calculated are provided in Appendix A of this plan.

As seen in Figure 3-2, the Valley and county maximum 24-hour average PM2.5 design value trends show that significant progress has been made in reducing concentrations. Comparing the Valley maximum 1999-2001 and 2009-11 design values reveals that a 40% reduction in this metric has taken place over this time period. This analysis also reveals a steep reduction in the county maximum design values over the same time period. Note that some of the county design values in 2011 have increased, partly due to the abnormal stagnation and poor air quality in late 2011.

Figure 3-2: Historical PM2.5 24-hour Design Value Trends



Historically, the Bakersfield-Planz air monitoring site has consistently been among the highest PM2.5 design values in the San Joaquin Valley. The following Figures 3-3 and 3-4 show the trend of the 24-hour and annual average design values at Bakersfield-Planz through the 2009-11 time period.

Figure 3-3: Trend of 24-hour Average PM2.5 Design Values at Bakersfield-Planz

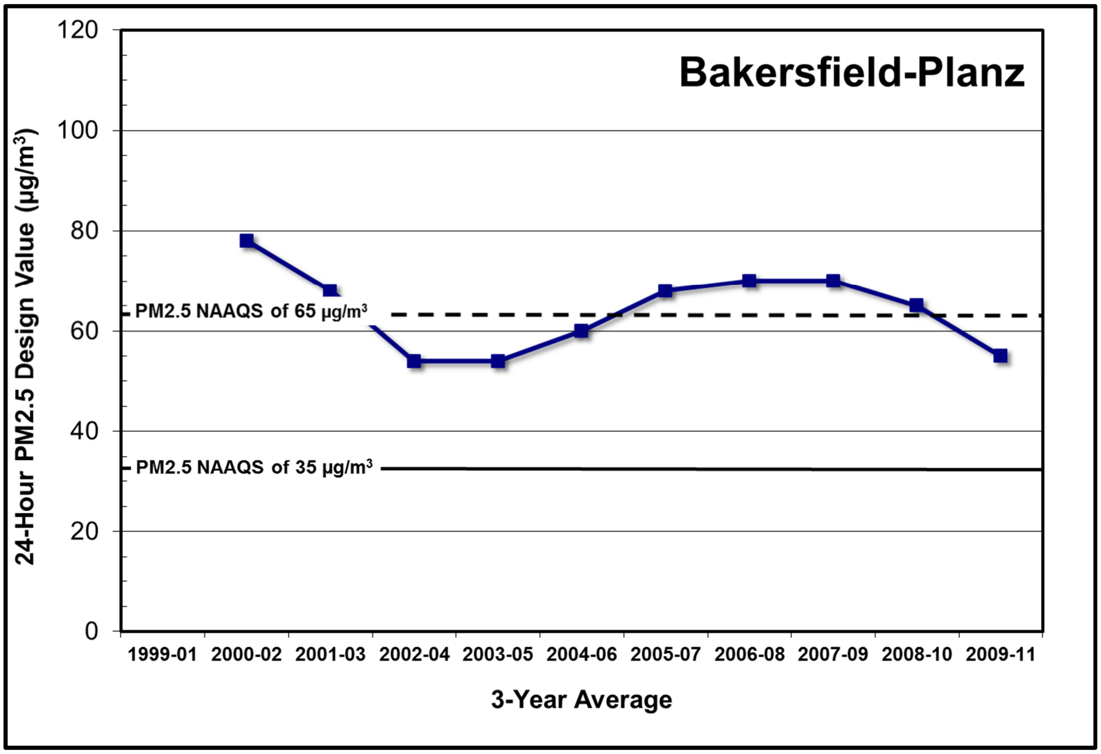
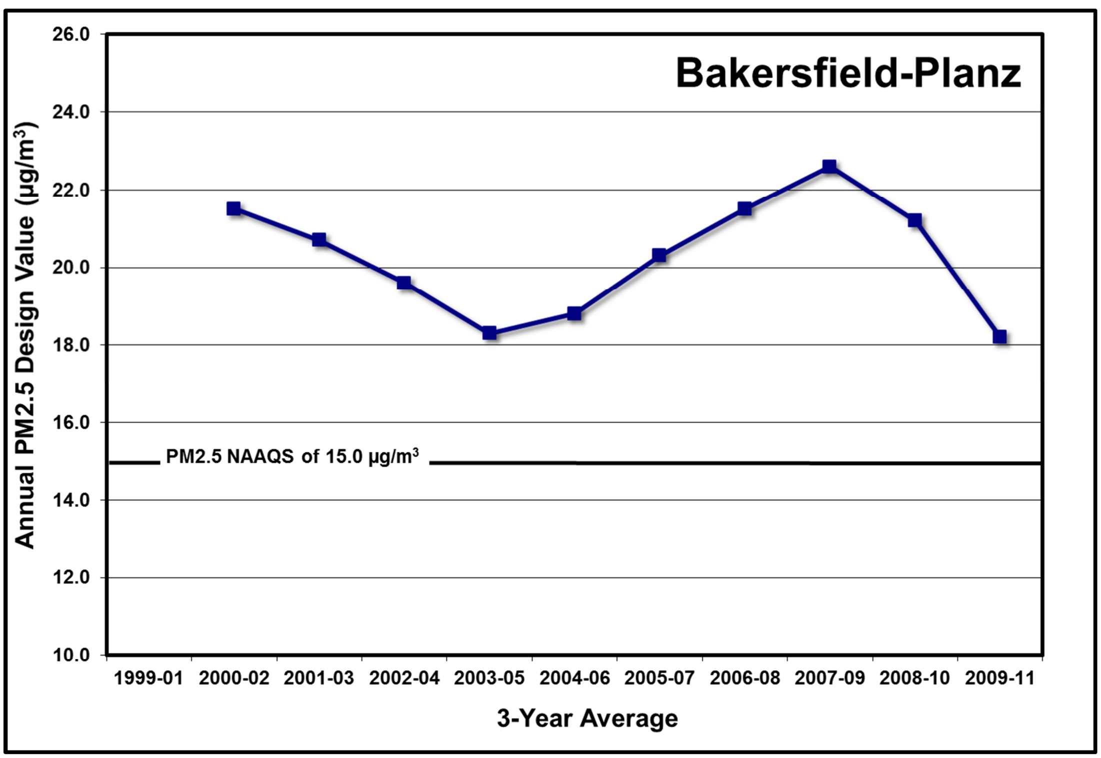


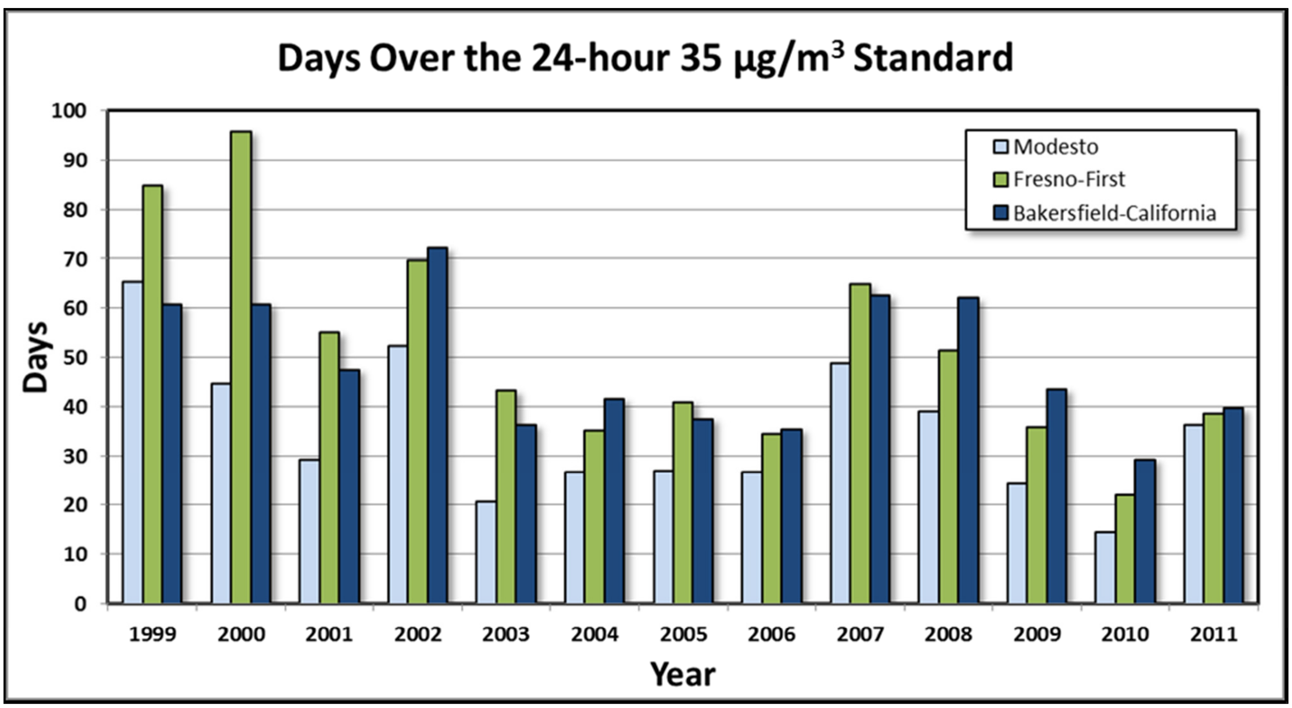
Figure 3-4: Trend of Annual Average PM2.5 Design Values at Bakersfield-Planz



Coming off of an increase in PM2.5 design values in the recent past, the Bakersfield-Planz air monitoring site is beginning to see a decrease in this metric. As seen in Figure 3-3, this site now has a 24-hour design value below the 1997 24-hour PM2.5 standard of 65 µg/m^3. Notably, the annual average design value in 2009-11 for Bakersfield-Planz has achieved an all-time low for the site at 18.2 µg/m^3 (see Figure 3-4). This downward trends will need to continue at all sites within the District as the San Joaquin Valley strives for attainment of the federal PM2.5 standards.

Another metric used for assessing the trend of PM2.5 is to consider the number of days that concentrations were over the PM2.5 24-hour NAAQS threshold of 35 µg/m^3. Focusing on the long term trend, and as seen in Figure 3-5 below, when comparing 1999 to 2011, the historical sites of Modesto, Fresno-First, and Bakersfield-California have experienced a 46% decrease in days exceeding a concentration of 35 µg/m^3. The year 2011 experienced an increase in days over the NAAQS threshold compared to 2010, however this was predominately due to unfavorable meteorology. Similar meteorology was experienced during the 1999-00 and 2000-01 winter seasons, yet there were a much greater number of days exceeding 35 µg/m^3 during these timeframes. This gives evidence that emissions have been reduced since 1999.

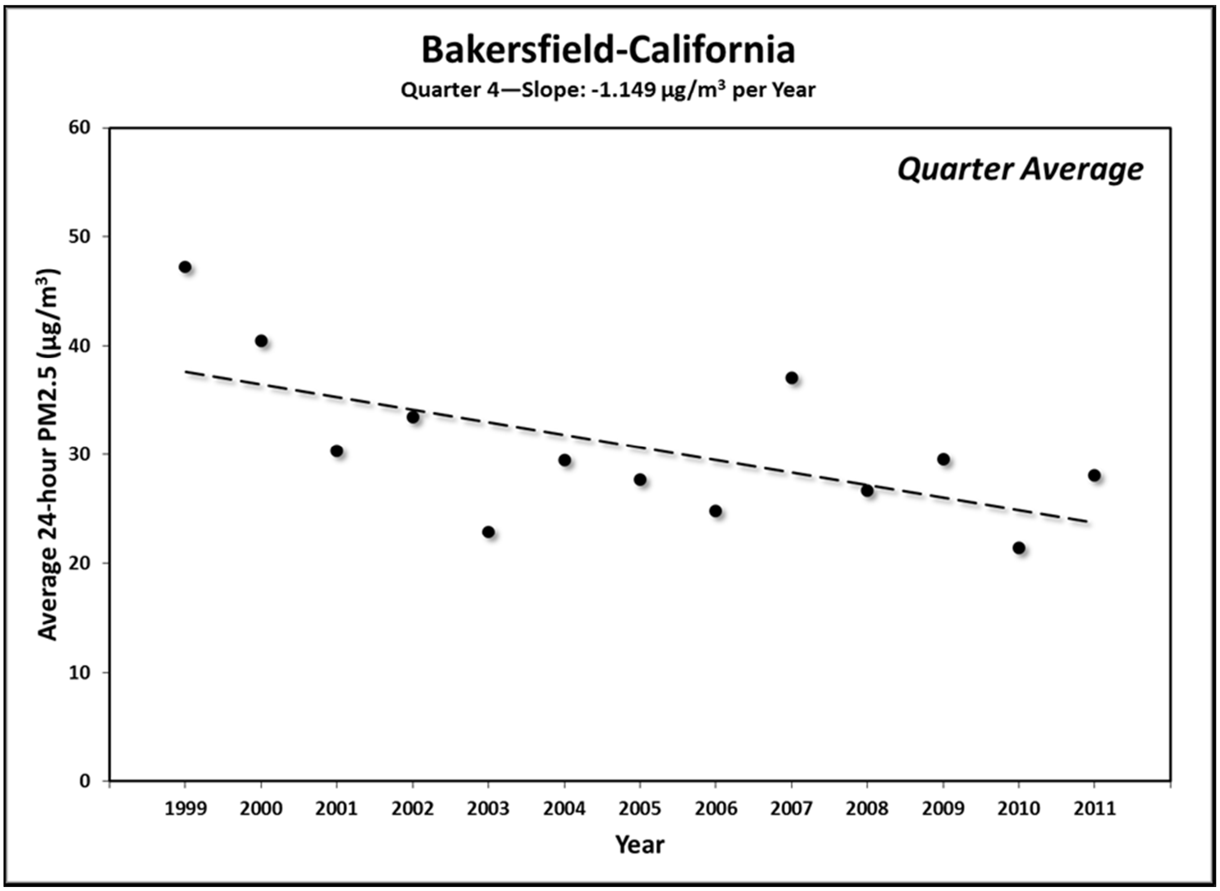
Figure 3-5: Annual Trends in Days over 35 µg/m^3



Since the Valley's highest PM2.5 concentrations occur during the Fall and Winter months, the 1st (January through March) and 4th (October through December) quarters tend to have the highest average concentrations. Observing the trend in these quarterly averages can shed light on how the peak of the PM2.5 season is changing over time.

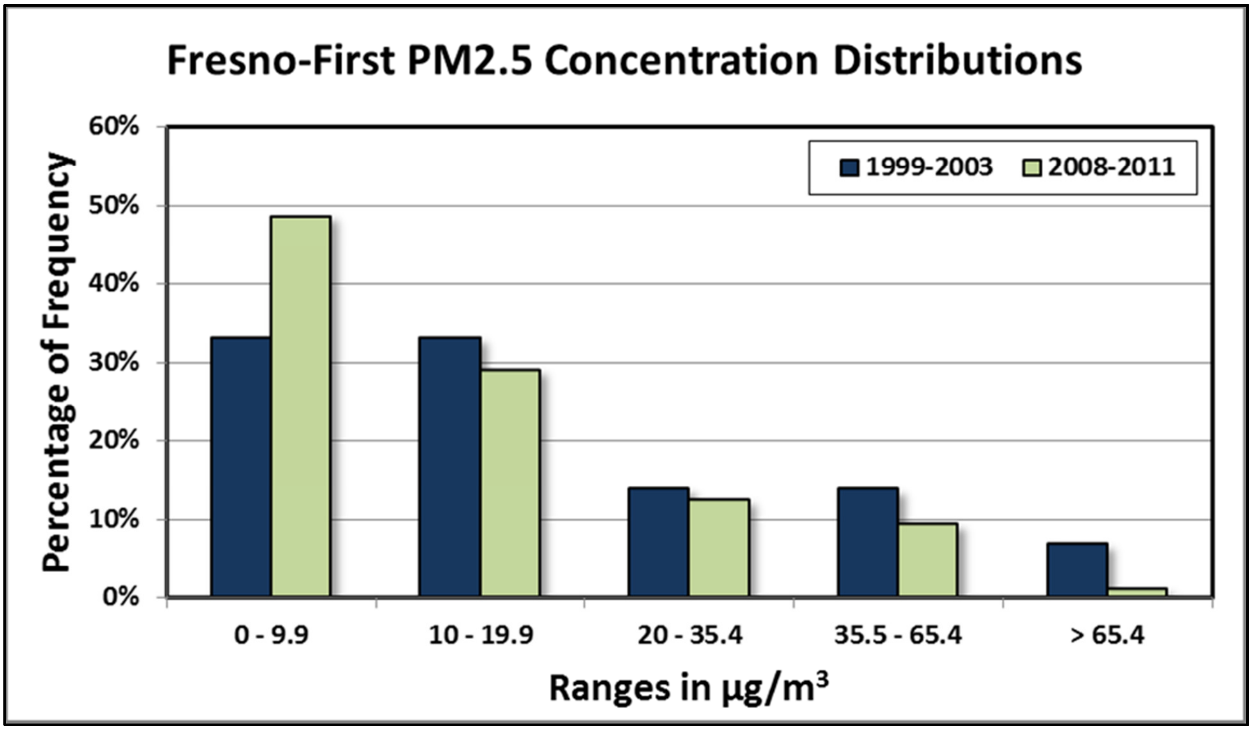
As seen in Figure 3-6, the Bakersfield-California site is typical of the trend in 4th quarter averages among the PM2.5 sites in the San Joaquin Valley. At this Bakersfield site the 4th quarter average PM2.5 showed a downward trend of 1.15 µg/m^3 per year. It will be important for this trend of reductions in the quarterly averages to continue as the District comes closer to attaining the annual average PM2.5 standard of 15 µg/m^3, which is calculated on a quarterly average basis. For the expanded results of this analysis, see Appendix A.

Figure 3-6: Trend of 4th Quarter Average at Bakersfield-California



Analyzing the change in the frequency of specific concentrations occurring at an air monitoring site can show how an entire body of data has shifted over time. To display this comparison, frequency distributions were calculated for the four-year timeframes of 1999-2003 and 2008-2011, and plotted in Figure 3-7 seen below. In this analysis, the spectrum of PM2.5 concentrations was separated into bins so that each observation within each of the four-year time periods would fall into one of these ranges. Figure 3-7 shows the results of this analysis for the Fresno-First air monitoring site. As can be observed, the frequency of higher concentrations was greater during 1999-2003 when compared to 2008-2011. Alternatively, lower concentrations were more frequent in 2008-2011 when compared to 1999-2003. This frequency shift toward the lower concentrations shows that progress is being made at reducing exposure to high levels of PM2.5. In addition, Figure 3-6 also reveals a dramatic decrease in the percentage of days that exceeded the 1997 24-hour PM2.5 standard of 65 µg/m^3. Please refer to Appendix A for more details on this analysis.

Figure 3-7: Concentration Frequency Distribution Comparison at Fresno-First



Undoubtedly, PM2.5 air quality has improved since 1999, yet the District still faces difficult challenges in attaining the tightening EPA standards. Continuing the improvement of the San Joaquin Valley's air quality will take involvement and investment from both the regulated community and the general public.

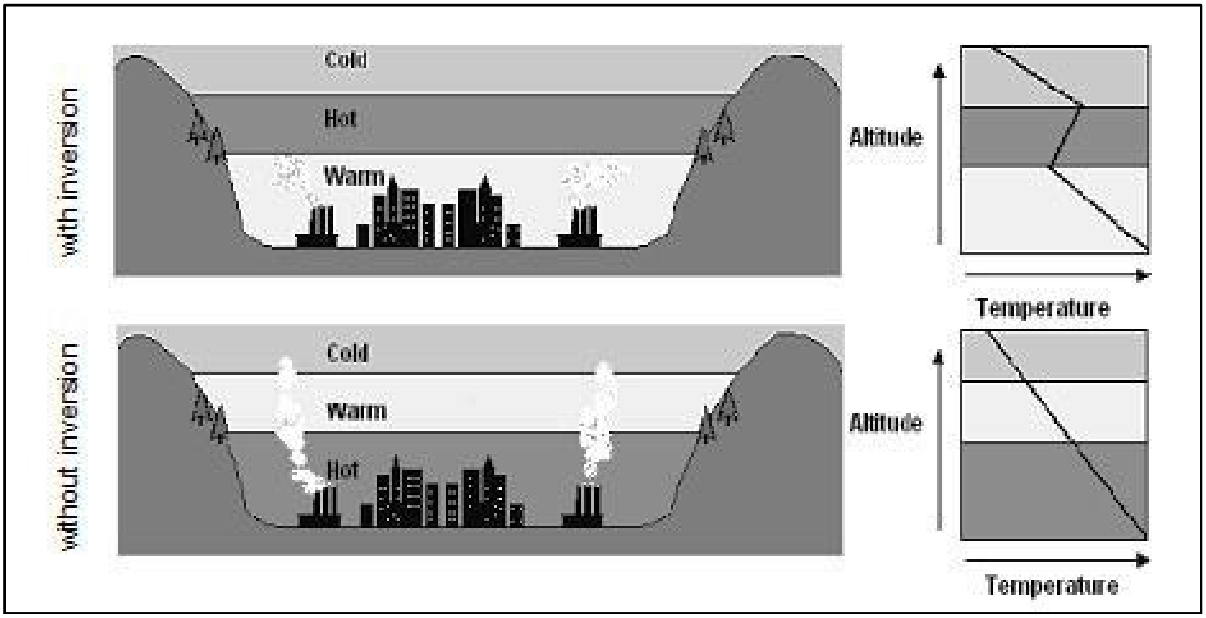
3.2.2 Challenges of the Natural Environment

The San Joaquin Valley, as seen in Figure 3-8, is an inter-mountain valley encompassing nearly 25,000 square miles. Surrounded by mountain ranges to the west, east, and south, the air flow through the Valley can be blocked, which can rapidly deteriorate dispersion conditions. Often during the winter high-pressure systems can cause the atmosphere to become stable for longer periods of time, where wind flow is calm and air movement is minimized. These stable weather systems can also cause temperature inversions which exacerbate the build-up of pollution.

Figure 3-8: The San Joaquin Valley Air Basin

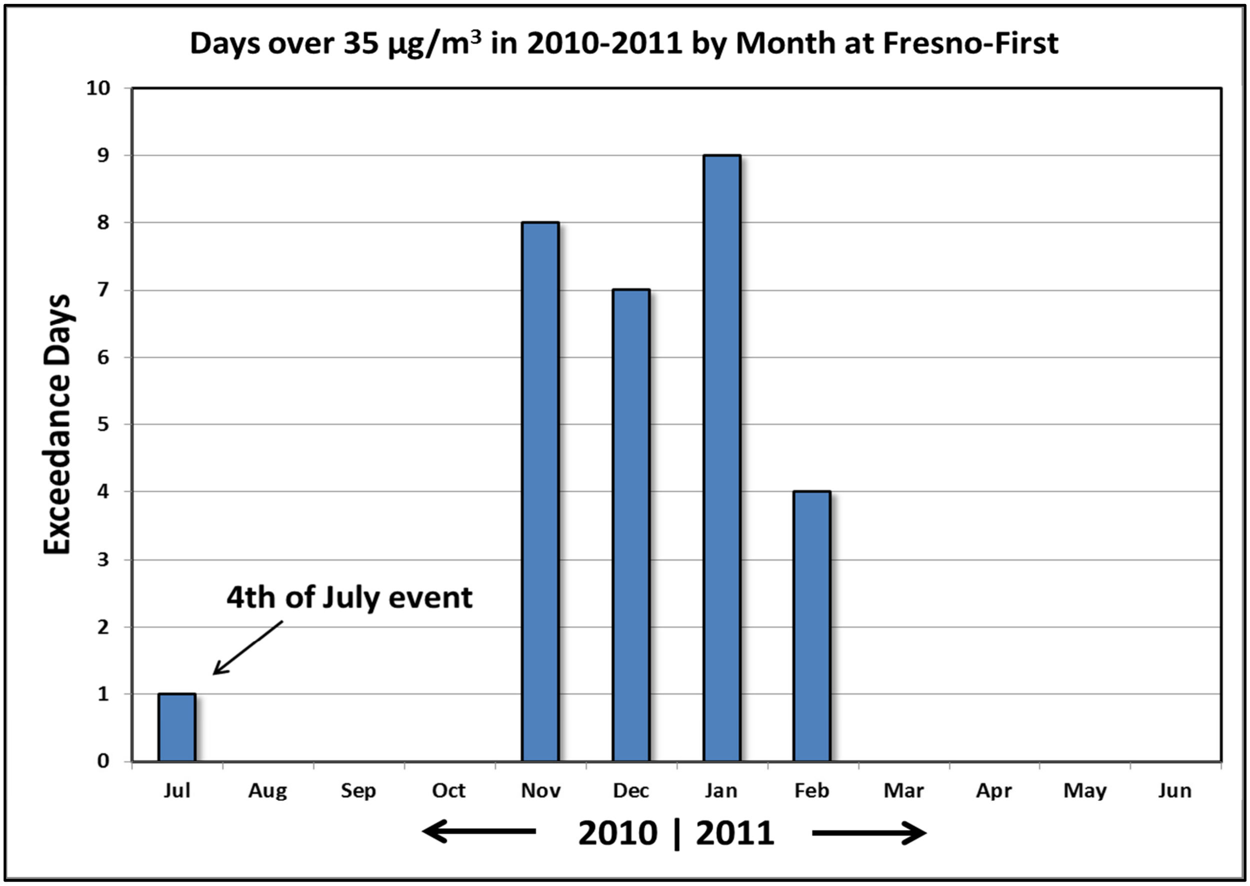
Normally, temperature decreases with increasing altitude, but under the effect of a temperature inversion, the temperature in a portion of the atmosphere will *increase* with altitude, causing warmer air to be above cooler air. As Figure 3-9 displays, this reversal of the "normal" pattern impedes the upward flow of air, causing poor dispersion and trapping emissions near the surface. Since this inversion is often lower than the height of the surrounding mountain ranges, the Valley effectively becomes a bowl with a lid on top trapping emissions near the surface. When dispersion both horizontally (transport flow) and vertically (rising air) are minimized, PM2.5 concentrations can build quickly. These naturally occurring meteorological conditions working against the San Joaquin Valley creates a challenge for the region. Under stagnant air flow and temperature inversions, the Valley needs sharp emissions reductions in order to attain the PM2.5 NAAQS.

Figure 3-9: The Atmosphere with/without a Temperature Inversion



Due to the frequent stagnant conditions during the winter in the San Joaquin Valley, PM2.5 concentrations tend to be the highest from November to February. As an example, Figure 3-10 below shows the number of days per month during the 2010-11 timeframe when the Fresno-First air monitoring site exceeded the 2006 PM2.5 NAAQS threshold of 35 µg/m^3. Cleary PM2.5 is a problem most heavily experienced during the winter months.

Figure 3-10: Days over 35 µg/m³ by Month at Fresno-First from 2010-2011



3.3 THE EMISSIONS INVENTORY FOUNDATION

As reviewed in the previous section, a major indicator of air quality improvement is the trend of ambient pollutant concentrations. However, a more foundational indicator of progress is the emissions inventory. The emissions inventory is an estimate indicating how much direct pollution is going into the air as a result of various activities.

The District uses the emissions inventory to serve as a foundation for the development of control strategies; determine the effectiveness of permitting and control programs; provide input into ambient receptor, aerosol, photochemical, and statistical models; fulfill reasonable further progress requirements; and screen sources for compliance investigations.

3.3.1 Emissions Inventory Categories

To reduce the Valley's PM2.5 levels further, Chapter 4 of this plan presents a control strategy that is based on an exhaustive evaluation of the emissions inventory of directly emitted PM2.5 as well as relevant PM2.5 precursors. Typically, an emissions inventory is organized by emissions source categories. Source categories consist of several broad groups:

- **Mobile sources** – motorized vehicles
  - On-road sources include automobiles, motorcycles, buses, and trucks;
  - Other or off-road sources include farm and construction equipment, lawn and garden equipment, forklifts, locomotives, boats, aircraft, and recreational vehicles.
- **Stationary sources** – fixed sources of air pollution
  - Power plants, refineries, and manufacturing facilities;
  - Aggregated point sources - facilities (such as gas stations and dry cleaners) that are not typically inventoried individually but are estimated as a group and reported as a single source category.
- **Area sources** –human activity that takes place over a wide geographic area
  - Includes consumer products, fireplaces, tilling, and unpaved road dust.
- **Natural sources** – naturally occurring emissions
  - Geogenic sources, such as petroleum seeps;
  - Biogenic sources, such as emissions from plants;
  - Wildfire sources.

3.3.2 The Nature and Formation of PM2.5

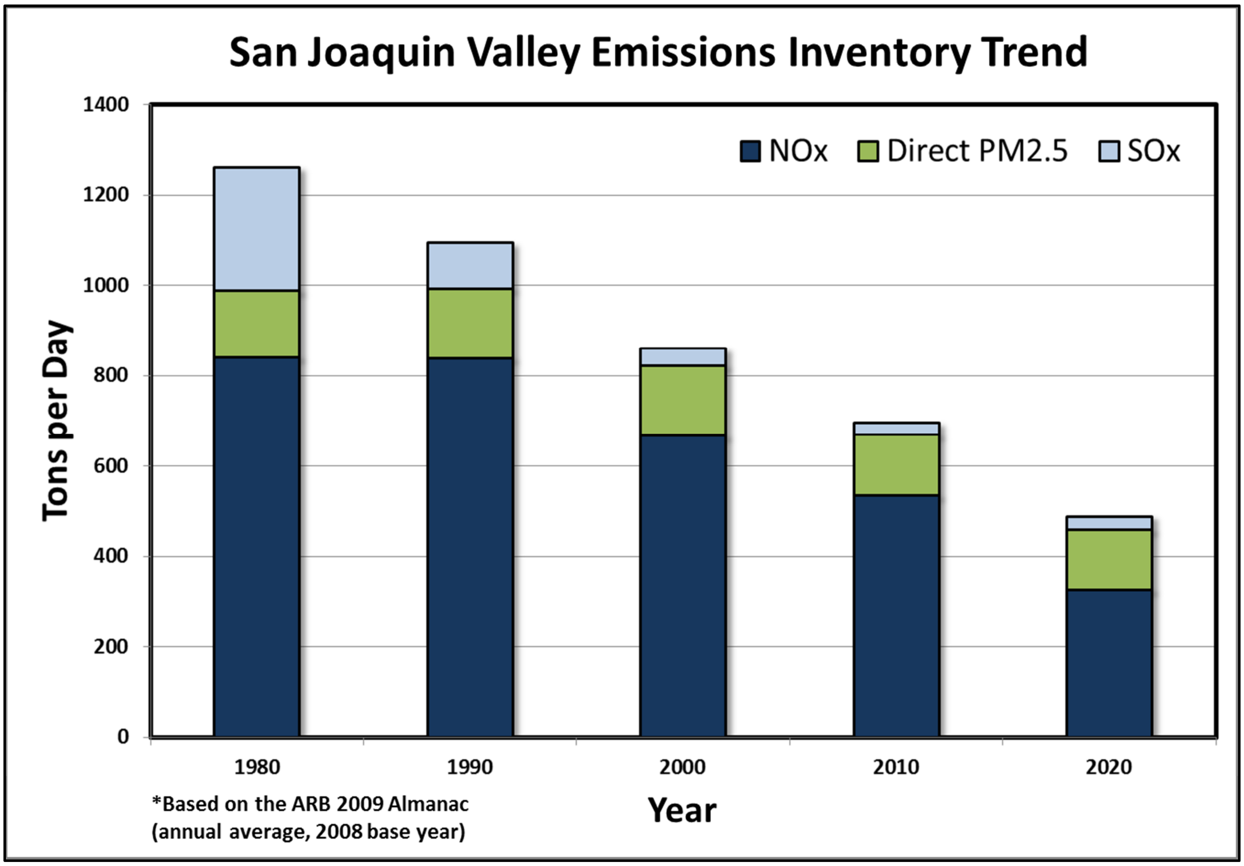
As opposed to ozone (O_3), which is a molecule known to consist of three oxygen atoms, PM2.5 can potentially be composed of any material that is has an aerodynamic diameter of 2.5 microns or less. PM2.5 can be emitted directly as primary PM from various sources or form secondarily through chemical reactions in the atmosphere. Among the chemical precursors that can form secondary PM2.5 are nitrogen oxides (NOx), volatile organic compounds (VOCs), sulfur dioxide (SO2), and ammonia (NH3). In addition, naturally occurring emissions from biogenic sources like plants and forests can also add to the formation of PM2.5.

The resulting ambient PM2.5 mixture can include aerosols (fine airborne solid particles and liquid droplets) consisting of components of nitrates, sulfates, elemental carbons, organic carbon compounds, acid aerosols, trace metals, geological materials, and more. The complex formation and composition of PM2.5 requires a versatile planning effort, where various components of the mass may be targeted for reduction. A control strategy that targets reductions among the precursors of PM2.5 has been shown to have a positive impact in reducing the total formed mass. Direct PM2.5 and a variety of its precursors are tracked and projected within the emissions inventory.

3.3.3 Trends in Reductions of Regional Emissions

The District has made significant progress in reducing direct PM2.5 emissions as well as its precursors. These reductions are a result of the many rules and programs put in place by the District and the California Air Resources Board (ARB) that have been effective in the past, and will continue to have a positive effect in the future. Figure 3-11 shows the trend of NOx, direct PM2.5, and SOx emissions over the last three decades along with a projection to 2020. A sharp downward trend since 1990 can be observed in the NOx emissions. The trend of direct PM2.5 and SOx emissions has also been steadily declining. In light of the District's increasing population over this same time period, this reduction highlights the success of the control measures adopted and enforced by regulatory agencies.

Figure 3-11: Emissions Inventory Trends Since 1980



Appendix B of this plan contains a more detailed description of the emission inventory as well as detailed tables showing the inventories for directly emitted PM2.5, NOx, and SOx.

3.4 PROJECTED FUTURE AIR QUALITY AND IDENTIFYING THE GOAL

One of the aspects of an attainment plan is to project what the emissions of an area will be like in the future. If these forecast emissions are shown to be in attainment before the deadline, then this provides evidence that the strategic approach taken in this plan to attain the standard will be successful. Regional grid modeling is a method used to forecast air quality years into the future, while accounting for photochemistry, aerosol chemistry, physics, meteorology, and the growth and control of emissions over time based on projected industry trends and current emissions regulations. See Appendix E for details on the modeling approach taken for this plan.

3.4.1 Results of Modeling Analysis

The modeling results showing the projected future PM2.5 concentrations will be included here upon the completion of the analysis. A future draft of this plan will include these details.

3.4.2 Emissions Reductions Target for Attainment

As the modeling analysis is completed as specified in the previous section, the emissions inventory target will also be known. A future draft of this plan will include these details.

3.4.3 Other Analyses Adding to the Weight of Evidence

To add to the evidence that the District is making progress in reducing PM2.5 in the San Joaquin Valley, the ARB and the District are conducting a number of supporting analyses. These analyses may include:

- PM2.5 speciation analysis;
- Meteorological adjusted trends;
- Positive matrix factorization;
- Chemical mass balance;
- Speciated linear rollback.

The details and results of these supporting analyses will available in future plan drafts.