APPENDIX C

Modeling & Source Apportionment

FINAL

Air Quality Modeling for Pinal County PM10 Nonattainment Area – 2008 Source Apportionment for Selected Design Days and Modeling Domains

prepared for:

Arizona Dept. of Environmental Quality

November 2013

prepared by:

Sierra Research, Inc.
1801 J Street
Sacramento, California 95811
(916) 444-6666

FINAL REPORT

Air Quality Modeling for Pinal County PM10 Nonattainment Area – 2008 Source Apportionment for Selected Design Days and Modeling Domains

prepared for:

Arizona Dept. of Environmental Quality

November 2013

Principal authors:

Robert G. Dulla
Wei Liu

Sierra Research, Inc.
1801 J Street
Sacramento, CA 95811
(916) 444-6666

Earl Withycombe
Consultant

Air Quality Modeling for Pinal County PM10 Nonattainment Area – 2008 Source Apportionment for Selected Design Days and Modeling Domains

Table of Contents

List of Figures

List of Tables

1. INTRODUCTION

The goal of this effort was to structure a U.S. Environmental Protection Agency (EPA) approved plume dispersion model to compute PM_{10} air quality impacts from arrays of significant emissions sources near existing permanent monitoring stations for use in improving base-year emission inventories and assessing the benefits of alternative control strategies in the Western Pinal County PM_{10} Nonattainment Area (Pinal County). From previous review of U.S. EPA guidance and discussions with EPA Region 9 staff, the Arizona Department of Environmental Quality (ADEQ) team preparing the Pinal County attainment plan (State Implementation Plan or SIP) chose 2008 as the base-year for planning purposes.[1]

The dual goals of this modeling effort were critical to the integrity of the completed plan. Separate emission inventories had been prepared for the areas surrounding and impacting four Pinal County Air Quality Control District (PCAQCD) monitoring stations in nonattainment status, and the predominance of area source emissions in these inventories required the use of dispersion modeling for stagnation meteorological conditions and distance-weighted approach for high wind conditions, to overcome the significant uncertainties in inventory accuracy that are inherent to these highly variable source categories. Also, because of the spatial distribution patterns of area sources surrounding the monitors, dispersion modeling was critical to the assessment of benefits of emission control measures that will differentially reduce emissions impacts at different monitors.

The need for a comprehensive modeling effort in support of attainment planning was further underscored by a prior determination that PM_{10} exceedances were caused at three of the four monitoring sites by two different sets of meteorological conditions. In late fall and winter months, the presence of regional high pressure cells combined with the absence of storm fronts passing through central Arizona produces stagnation (or low wind) conditions that reduce nocturnal mixing heights to tens of meters above the ground and concentrate emitted pollutants at ground-level. In the spring and summer, high wind conditions are periodically generated by monsoonal thunderstorms or strong eddy currents associated with the retreating circumpolar vortex. Because these two types of events are not typically accompanied by precipitation over Pinal County, both cause significant increases in windblown emissions sufficient to produce exceedances of PM_{10} standards.

[1] Pinal County PM Inventory Preparation Plan, prepared for the Arizona Department of Environmental Quality by Sierra Research, December 2012.

Air quality modeling combines information on meteorological conditions (e.g., wind speed, wind direction, mixing height, etc.) with emission estimates to calculate downwind pollutant concentrations at selected locations. For this planning process, AERMOD—an EPA-preferred Gaussian dispersion model for non-reactive pollutants for stagnation conditions, and an EPA-approved modified weighted rollback approach for high wind conditions—were selected to estimate hourly PM_{10} concentrations at monitoring stations produced by emissions of area sources located within specified modeling domains surrounding the monitoring stations. Because the PM_{10} ambient air quality standard exceeded in Pinal County is designed to limit short-term acute exposures and is measured over 24-hour averaging periods, the attainment demonstrations are required by EPA policy to show how PM_{10} concentrations would be reduced from levels recorded on exceedance days in the base year experiencing the strongest stagnation or high wind meteorological conditions. The selection of these "design days" is discussed in an accompanying report.

Different approaches were used to estimate emission impacts at monitors on low wind and high wind design days. On low wind days, AERMOD was run with meteorological data recorded at the subject monitor and emissions rates for each source within the modeling domain were calculated from reported activity data and best-representative emissions factors. For both high wind hours (>12 mph) and low wind hours (≤12 mph) on high wind days, a weighted rollback method was used to assess the relative contribution of each upwind source area to the hourly monitored PM_{10} contribution under assumptions of (1) emission factor uniformity within "disturbed" and "undisturbed" states of surface soil conditions and (2) an inverse relationship between the source's distance from the monitor and the emission impact at that monitor.

The weighted rollback method for high wind day analysis is based on modeling experiences related to development of the Maricopa Association of Government's (MAG) Five Percent Plan. Through experience gained in the preparation of PM_{10} SIPs, and in consultation with EPA, MAG determined that neither AERMOD nor photochemical grid models performed well in quantifying discrete area source contributions at downwind monitors under high wind conditions, and that attainment demonstrations relying on use of these models were not reliable. For this reason, MAG developed an alternate but more reliable approach that weights the contribution of each upwind source's emissions by the reciprocal of its distance to the monitor and assumes that each source's fractional contribution to the sum of weighted emissions is equal to that source's fractional contribution to the hourly PM_{10} concentration measured at the downwind monitor (i.e., that the impacts of emissions from nearby sources are proportionally greater than the impacts from remote sources, assuming equivalent emissions rates among sources). Individual source contributions, using this approach, can be determined through review of hourly and daily estimates of weighted emissions rates.

Under each of these methodologies, the degree of emissions reductions needed to achieve attainment of the 24-hour PM_{10} standard at designated monitors on respective stagnation and high wind design days—both in overall terms or by individual area source—can be quantified. Evaluation and selection of suites of control measures capable of demonstrating attainment at all monitors on all design days involve many different factors and are the subject of another accompanying report.

The remainder of this report discusses the data sources, analyses, and final design of air quality assessment methodologies used in the Pinal County PM_{10} plan for control strategy evaluation and attainment demonstration. Section 2 summarizes the development of an assessment methodology addressing stagnation design days, and Section 3 reviews the methodology developed to evaluate solutions for high wind design days. At the conclusion of development discussions, the methodologies are used to calculate design day impacts at each monitor, on the basis of emission inventories available at the time of this report's drafting, for comparison to hourly PM_{10} concentrations recorded at the stations on these design days.

###

2. STAGNATION DAY MODELING

A review of EPA guidelines and related fugitive dust modeling employed in attainment demonstrations prepared for Maricopa County determined that AERMOD is the most suitable model for evaluating hourly source contributions to PM_{10} exceedances recorded at Pinal County monitors on stagnation design days. AERMOD is a steady-state Gaussian plume dispersion model that assesses pollutant concentrations from a variety of source types. Adopted by EPA as a regulatory model on December 9, 2005, AERMOD contains improved algorithms for addressing low wind speed (near-calm conditions) and can provide estimates for conditions when wind speeds are less than 1 m/sec,[2,3] which are common on the selected stagnation design days.

<u>AERMOD Inputs</u>

Key inputs required for the successful use of AERMOD are summarized below.

- Emission Inventory – Hourly estimates of emissions were prepared using land parcel data provided by ADEQ and PCAQCD, activity data collected through field surveys, contacts with stakeholders, etc., and cited fugitive dust emission factors.

- AERMET-formatted Meteorological Data – AERMET is a preprocessor that converts raw meteorological measurements into formatted meteorological input files for AERMOD. The following data sources were used to configure AERMET to produce these input files:

    - The on-site meteorological data collected at the Cowtown, Pinal County Housing, and Stanfield monitoring stations, with parameters of wind direction, wind speed, and temperature. A wind speed threshold of 0.5 meters/second was specified for the upper limit of calm conditions.

    - Upper air meteorological data were derived from Tucson 2008 twice-daily soundings by the National Weather Service (NWS).

[2] "Revisions to the Guideline on Air Quality Models: Adoption of Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions," U.S. Environmental Protection Agency, Federal Register, Vol. 70, No. 216, p. 68218, November 9, 2005 (Attachment IV)
[3] User's Guide for AERMET, EPA-454/B-03-002, November 2004

- Cloud cover meteorological data were obtained from the records of the Phoenix NWS meteorological station at Sky Harbor Airport.

- The surface characteristics of albedo, Bowen Ratio and surface roughness appropriate to the areas surrounding the Cowtown, Pinal County Housing, and Stanfield monitoring stations were obtained from AERSURFACE.[4] Albedo is the portion of sunlight that is reflected from the surface of the ground, Bowen ratio is a measure of moisture available for evaporation, and surface roughness is a measure of the depth of the thin boundary layer at the ground surface that is protected from influences of wind-generated frictional drag by the small variability in ground surface elevation.[5,6] These parameters are functions of ground cover (land use) and affect the concentration calculations. Values of these parameters were calculated by monthly average by AERSURFACE for each of the Cowtown, Pinal County Housing, and Stanfield monitoring sites and are listed below in Tables 2-1, 2-2 and 2-3, respectively. Only data from October were used to represent the stagnation design day conditions.

Table 2-1
AERMET Stage 3 Meteorological Processing Parameters
Cowtown Monitoring Site

Sector Definition		
Sector	**Starting Angle (degree)**	**Ending Angle (degree)**
1	0	360

Seasonal Parameters				
Month	**Sector**	**Albedo**	**Bowen Ratio**	**Roughness Length (m)**
1	1	0.18	0.81	0.029
2	1	0.18	0.81	0.029
3	1	0.15	0.38	0.042
4	1	0.15	0.38	0.042
5	1	0.15	0.38	0.042
6	1	0.2	0.57	0.203
7	1	0.2	0.57	0.203
8	1	0.2	0.57	0.203
9	1	0.2	0.81	0.203
10	1	0.2	0.81	0.203
11	1	0.2	0.81	0.203
12	1	0.18	0.81	0.029

[4] U.S. EPA, AERSURFACE User's Guide, *http://www.epa.gov/scram001/7thconf/aermod/aersurface_userguide.pdf*
[5] Appendix W to Part 51—Guideline on air Quality Models, §8.3.c
[6] U.S. EPA. AERMOD Implementation Guide, March 19, 2009.

Table 2-2 AERMET Stage 3 Meteorological Processing Parameters Pinal County Housing Monitoring Site		
Sector Definition		
Sector	**Starting Angle (degree)**	**Ending Angle (degree)**
1	0	360

Seasonal Parameters				
Month	**Sector**	**Albedo**	**Bowen Ratio**	**Roughness Length (m)**
1	1	0.18	0.88	0.113
2	1	0.18	0.88	0.113
3	1	0.15	0.43	0.131
4	1	0.15	0.43	0.131
5	1	0.15	0.43	0.131
6	1	0.19	0.61	0.254
7	1	0.19	0.61	0.254
8	1	0.19	0.61	0.254
9	1	0.19	0.88	0.254
10	1	0.19	0.88	0.254
11	1	0.19	0.88	0.254
12	1	0.18	0.88	0.113

Table 2-3 AERMET Stage 3 Meteorological Processing Parameters Stanfield Monitoring Site		
Sector Definition		
Sector	**Starting Angle (degree)**	**Ending Angle (degree)**
1	0	360

Seasonal Parameters				
Month	**Sector**	**Albedo**	**Bowen Ratio**	**Roughness Length (m)**
1	1	0.18	0.8	0.069
2	1	0.18	0.8	0.069
3	1	0.15	0.37	0.086
4	1	0.15	0.37	0.086
5	1	0.15	0.37	0.086
6	1	0.2	0.57	0.238
7	1	0.2	0.57	0.238
8	1	0.2	0.57	0.238
9	1	0.2	0.8	0.237
10	1	0.2	0.8	0.237
11	1	0.2	0.8	0.237
12	1	0.18	0.8	0.069

- The wind measurement height[7] for each monitor was input as the onsite instrument height parameter to AERMET. AERMOD adjusts the wind speed at these measurement heights to other heights based on the AERMOD profile equation for wind speed.[8]

- AERMOD Particle Deposition Algorithm was activated to simulate the impacts of particle deposition on calculated PM_{10} concentrations.

  - Table 2-4 summarizes the particle parameters for modeling the Concentrated Animal Feeding Operations (CAFOs).[9]

Table 2-4
Particle Parameters for Modeling Concentrated Animal Feeding Operations (CAFO)

Particle size (µm)	0 - 1.8	1.8 - 3.1	3.1 - 6.2	6.2 - 9.9
Mass Fraction	0.14	0.07	0.27	0.52
Particle Density (mg/m^3)	2.5	2.5	2.5	2.5

  - For all other source categories, two sources of particle size data were available, as described below.

    1. The particle size data collected by dust jar[10] at Durango Complex and West 43rd Avenue monitors in 2008 detailed in the MAG Five Percent Plan, as listed in Table 2-5.

[7] Reported by PCAQCD to be 3 meters, 3.5 meters, and 9.2 meters at the PCH, Cowtown, and Stanfield monitoring stations, respectively.
[8] AERMOD Description of Model Formulation, Page 24, 4.1.1 Wind Speed Profiling. *http://www.epa.gov/ttn/scram/7thconf/aermod/aermod_mfd.pdf.*
[9] "Particulate matter emission rates from beef cattle feedlots in Kansas - Reverse dispersion modeling," H.F. Bonifacio et al, Journal of the Air & Waste Management Association (JAWMA) Vol. 63, No. 3, p. 350-361.
[10] Particulate matter deposition was monitored using dust fall jars over one-week periods at four locations surrounding each monitor. Particle Measurement Technology in Ventura, California, was retained to conduct particle counts using a laser counting technology. Only a portion of each solution was used in each count, allowing for the use of duplicate counts to quantify instrumental precision. The particle counts were converted to particle mass using standard conversion methods. See page 8-20 of the 2007 MAG Five Percent Plan for more details on the collection and quantification of particle size distribution.

Table 2-5 Particle Size Distributions Collected from Dust Jars for 2007 MAG Five Percent Plan				
Particle size (µm)	0 - 2.5	2.5 - 5.0	5.0 - 7.5	7.5 – 10.0
Mass Fraction	0.14	0.18	0.28	0.4

2. The particle size data collected by the Aerodynamic Particle Sizer (APS) Spectrometer[11] at Casa Grande Airport in July 2008, as listed in Table 2-6.

Table 2-6 Particle Size Distributions Collected by Aerodynamic Particle Sizer Spectrometer at Casa Grande Airport in July 2008				
Particle size (µm)	0 - 1.84	1.84 - 3.28	3.28 - 6.26	6.26 – 9.65
Mass Fraction	0.027	0.134	0.281	0.558

– While the results from both of these studies are similar, the land use surrounding the Durango Complex and West 43rd Avenue monitors more closely represents areas adjacent to the Cowtown, Pinal County Housing, and Stanfield monitors. Therefore, the particle parameters used in the MAG Five Percent Plan, as shown in Table 2-7, were used in Pinal modeling.

Table 2-7 Particle Parameters Used for Modeling Source Categories Other Than CAFO				
Particle size (µm)	0 - 2.5	2.5 - 5.0	5.0 - 7.5	7.5 – 10.0
Mass Fraction	0.14	0.18	0.28	0.40
Particle Density (mg/m^3)	2.5	2.5	2.5	2.5

- Flag pole receptor heights of 3 meters, 3.5 meters, and 4.8 meters for Pinal County Housing, Cowtown, and Stanfield sites, respectively, were used to represent the measurement height for each PM_{10} monitor. The following UTM Coordinates, (in NAD 83, zone 12) were assigned to receptor points representing these three PM_{10} monitors:

  Pinal County Housing: 446631.83(East), 3639334.80 (North);
  Cowtown: 409201.93 (East), 3652874.86 (North);
  Stanfield: 409999.82 (East), 3638528.80 (North).

[11] PCAQCD staff followed directions in the "Aerosol Instrument Manager Software for APS Spectrometers" Users Manual to quantify the particle size distribution for measurements collected by the APS Spectrometer. *http://www.yumpu.com/en/document/view/15444179/aerosol-instrument-manager-software-for-aps-spectrometers-tsi*

- Source parameters for significant source categories:
    - Unpaved Roads: Road links were modeled as area sources with release heights of 2 meters. The widths of these links were extracted from an ARCGIS shape file provided by PCAQCD and expanded by 10 foot mixing zones on each side,[12,13] and the lengths of these links were also extracted from the ARCGIS shape file provided by ADEQ.
    - Agriculture: Agricultural parcels were modeled as area sources with release heights of 2 meters. The horizontal dimensions of these area sources were extracted from the ARCGIS shape file provided by ADEQ.
    - Construction: Construction sites were modeled as area sources with release heights of 2 meters. The horizontal dimensions of these area sources were extracted from the ARCGIS shape file provided by PCAQCD. The method for determining the activity status of construction sites is discussed in an accompanying emission inventory report.[14]
    - CAFOs: Feedlots were modeled as area sources with release heights of 2.3 meters, based on recommendations contained in a feedlot emission and modeling study conducted in Kansas by Bonifacio et al.[15] The horizontal dimensions of these facilities were extracted from an ARCGIS shape file provided by ADEQ.
    - Industrial facilities: Stack and exhaust parameters for stationary equipment were derived from data contained in PCAQCD permit files. Facility-specific data are presented and discussed in an accompanying emission inventory report[14].
    - Railroads: Railroad links were modeled as area sources with release heights of 3.0 meters. The horizontal dimensions of these links were extracted from the ARCGIS shape file provided by ADEQ.

<u>Post-Processing Methodology</u>

Once AERMOD runs were completed, PM_{10} concentrations reported by the model as impacts at monitoring stations from modeling domain area source emissions were

[12] Ten foot wide mixing zones extending beyond the roadway outer edges have been found through research studies to be impacted by the bow wakes of trucks and cars in a manner that mixes vehicle exhaust pollutants and entrained road dust into these near-road areas, producing well mixed, uniform concentrations across the mixing zones and roadway surface prior to upward and downwind dispersion.

[13] *http://www.epa.gov/scram001/userg/regmod/caline3.pdf*. CALINE3 treats the region directly over the highway as a zone of uniform emissions and turbulence. This is designated as the mixing zone, and is defined as the region over the traveled way (traffic lanes, not including shoulders) plus three meters on either side.

[14] Chapter 3, *Pinal County PM_{10} Nonattainment Area 2008 Base Year Emissions for Selected Design Days and Modeling Domains.*

[15] Bonifacio, H.F, et al., ibid.

adjusted to account for the contributions of sources located outside of modeling domains as follows:

- Background – Although wind speeds during stagnant periods were extremely low, they are sufficient to allow for the transport of non-anthropogenic emissions from outside of the nonattainment area to the three low wind modeling domains. To account for the contribution of transported PM_{10}, non-anthropogenic background PM_{10} concentrations recorded at Organ Pipe Cactus National Monument were evaluated. This monitor, located 68 miles southwest of Tucson, is impacted by very little anthropogenic activity. The monitor is part of the IMPROVE monitoring network[16]. Filter-based measurements are collected every 3 days and 24-hour average concentrations of both PM_{10} and PM2.5 are stored online. PM_{10} data were downloaded from the IMPROVE network for October and November 2008, representing twenty (20) 24-hour averages. Using meteorological data collected on the same dates in Tucson (the closest representative monitoring site), the 20 Organ Pipe measurements were screened to eliminate days with high wind conditions. Analysis of the meteorological data identified one day with 10 hours of winds exceeding the 12 mph high wind threshold velocity, and a second day had one hour of winds exceeding the 12 mph threshold. On the basis of this analysis, the one day with 10 hours of high winds was excluded from the calculation of background conditions. The average of 24-hour concentrations for the remaining 19 days was 11.5 $\mu g/m^3$. This average concentration was added to the AERMOD-modeled hourly PM_{10} concentrations at each of the stagnation monitors representative of modeling domain emissions plus regional background contributions.

- Carryover – A comparison between the modeled concentrations (including background) and the monitored concentrations found significant shortfalls in the modeled estimates. This was thought to be the result of extremely low wind speeds which promote carryover (i.e., locally-emitted particulate matter remaining in the atmosphere for multiple hours and continuing to contribute to monitored concentrations before being removed by particle deposition). AERMOD does not account for carryover; concentrations are estimated for each hour based on particulate mass emitted within the modeling domain in that hour. To address the effect of carryover, modeled concentrations from the previous hour were added to the succeeding hour. The carryover concentrations, however, were adjusted to account for particle deposition that would occur over the second hour of suspension. Information on particle size distribution, mixing height, and particle deposition velocity was used to estimate the amount of deposition that would occur in the second hour. As noted above, two estimates of particle size distribution were used to configure AERMOD—values from feedlot emission studies[17] were used to represent CAFOs emissions, and values reported in the MAG Five Percent Plan based on sampling conducted with a dust jar in 2008 at Durango and West 43rd Avenue were used to represent emissions from all other

[16] *http://vista.cira.colostate.edu/improve/default.htm*
[17] Bonifacio, H.F, et al., ibid.

sources. Mixing height estimates for each of the design days were computed using AERMET. Estimates of settling velocities by particle size range were calculated using an online deposition velocity model.[18] The results of the analysis showed that PM_9 (i.e., particles 0 – 9 µm) would remain suspended in the second hour and that only PM9-10 would settle out during this period. Because the fraction of an area source's PM_{10} emissions that settles out by the second hour is dependent on the emission's particle size distribution, separate second-hour deposition fractions were calculated for CAFO and non-CAFO source emissions. These analyses reported that 87% of CAFO PM_{10} emissions would remain suspended during the second hour following release, and 84% of PM_{10} emissions from all other sources would remain suspended.

- Normalize – A comparison between the diurnal profiles of the modeled and monitored PM_{10} concentrations, after adjusting for background and carryover contributions, showed that modeled estimates were higher in some hours, and lower in other hours, than monitored concentrations at each of the monitoring stations. To reconcile these differences and to match the overall estimated concentrations with the 24-hour average design day PM_{10} measured concentration, the modeled values were normalized to the 24-hour monitored values. This was accomplished by calculating the % difference between the average 24-hour modeled and monitored concentrations (after subtracting out background) and using the % difference to adjust each estimated hourly concentration.

Tabular summaries of estimated hourly concentrations are presented in Tables 2-8 through 2-10 for Cowtown, Pinal County Housing, and Stanfield, respectively. These tables provide information on monitored wind speed, wind direction, PM_{10} concentration, modeled mixing height, and source-specific concentrations. Also included are the total hourly estimated concentrations, total daily source concentration, overall source apportionment, and R^2 value assessing the hourly correlation between modeled and monitored concentrations. Visual displays of monitored and modeled concentrations and mixing height are provided in Figures 2-1, 2-2, and 2-3. Figure 2-4 depicts the average daily source-specific contributions for each site.

[18] *http://www.filtration-and-separation.com/settling/settling.htm*, accessed in August, 2013.

Table 2-8
Stagnation Day Modeling Performance at Cowtown on 10/29/2008, AERMOD Simulation of Monitored Concentrations (µg/m^3)

Hour	WSPD (m/s)	WD	Mixing Height	PM_{10} Observation	Railroad	Point	Background	Construction	CAFOs	Agriculture		Unpaved Road					Paved Road	Total
										Non-Tribal	Tribal	AG Road	Public Dirt	Private Dirt	Trail	Tribal Road		
1	1.0	153.0	45.0	402.3	1.7	0.1	11.5	0.0	44.5	0.0	0.0	0.0	8.0	0.1	0.0	0.0	1.2	67.1
2	1.3	178.0	102.0	343.0	2.0	0.1	11.5	0.0	40.6	0.0	0.0	0.0	8.6	0.1	0.0	0.5	1.6	65.0
3	1.5	133.0	145.0	417.8	1.4	0.1	11.5	0.0	7.3	0.0	0.0	0.0	3.5	0.1	0.0	0.7	1.4	26.0
4	1.7	153.0	210.0	125.4	1.2	0.1	11.5	0.0	48.6	0.0	0.0	0.0	3.3	0.1	0.0	0.2	1.1	66.2
5	0.9	152.0	56.0	248.4	2.3	0.2	11.5	0.0	541.1	0.0	0.0	0.0	19.9	0.2	0.0	0.0	3.6	578.8
6	0.5	198.0	12.0	156.5	3.7	0.7	11.5	0.0	522.6	0.0	0.0	0.0	58.5	0.1	0.0	3.5	11.0	611.8
7	1.3	198.0	105.0	294.2	2.4	0.6	11.5	0.0	101.0	10.7	0.1	28.9	64.6	0.0	0.0	18.0	13.3	251.0
8	1.3	182.0	159.0	171.8	0.9	0.1	11.5	0.0	29.1	13.0	0.1	44.2	46.5	0.0	0.0	19.1	9.0	173.6
9	1.1	184.0	190.0	136.3	0.4	0.1	11.5	0.0	5.8	4.5	0.0	26.3	24.8	0.1	0.0	9.4	4.3	87.2
10	0.5	252.0	251.0	219.5	0.2	0.3	11.5	0.1	40.8	1.6	0.0	20.0	12.4	1.1	0.0	4.6	1.7	94.4
11	0.7	327.0	541.0	165.8	0.1	2.9	11.5	3.4	35.3	0.5	0.0	15.0	7.0	1.5	0.0	1.1	0.8	79.2
12	1.1	348.0	891.0	103.2	0.0	3.4	11.5	3.3	0.5	0.0	0.0	6.4	0.7	0.7	0.0	0.0	0.2	26.7
13	1.2	13.0	1180.0	76.3	0.0	1.0	11.5	1.1	0.0	0.0	0.0	3.6	0.1	0.3	0.0	0.0	0.0	17.7
14	1.8	326.0	1391.0	61.7	0.0	2.0	11.5	1.0	0.0	0.0	0.0	3.7	1.1	0.3	0.0	0.0	0.1	19.8
15	1.4	328.0	1545.0	38.5	0.0	3.9	11.5	0.9	0.2	0.0	0.0	4.4	4.8	0.3	0.0	0.0	0.2	26.2
16	1.1	336.0	1636.0	41.5	0.0	2.0	11.5	0.8	0.2	0.0	0.0	4.8	5.0	0.4	0.0	0.0	0.2	24.9
17	0.8	4.0	1656.0	103.2	0.0	0.1	11.5	1.1	0.1	0.0	0.0	5.3	1.5	0.4	0.0	0.0	0.1	20.2
18	1.5	327.0	167.0	60.6	0.0	0.1	11.5	0.7	0.0	0.0	0.0	28.4	1.2	2.7	0.0	0.0	0.2	44.7
19	0.5	347.0	49.0	67.2	0.0	0.7	11.5	0.0	0.0	0.0	0.0	21.6	0.9	8.3	0.0	0.0	0.3	43.3
20	0.8	286.0	30.0	300.9	2.3	1.1	11.5	0.0	547.8	0.0	0.0	0.0	14.7	7.2	0.0	0.0	7.8	592.4
21	1.2	131.0	56.0	383.6	4.1	0.5	11.5	0.0	492.2	0.0	0.0	0.0	19.6	3.3	0.0	4.5	13.5	549.3
22	0.7	158.0	28.0	194.8	3.9	0.3	11.5	0.0	451.3	0.0	0.0	0.0	29.8	1.4	0.0	4.1	8.8	511.1
23	1.5	149.0	168.0	228.4	2.4	0.2	11.5	0.0	425.4	0.0	0.0	0.0	24.9	0.1	0.0	0.2	3.4	468.1
24	1.8	149.0	245.0	189.2	0.9	0.1	11.5	0.0	66.0	0.0	0.0	0.0	6.8	0.1	0.0	0.0	1.2	86.6
R-Square[a]					0.4	0.2		0.2	0.1	0.0	0.0	0.1	0.1	0.0	0.3	0.0	0.2	0.1
Average			461.4	188.8	1.2	0.9	11.5	0.5	141.7	1.3	0.0	8.9	15.3	1.2	0.0	2.7	3.6	188.8
Percentage Contribution					0.7%	0.5%	6.1%	0.3%	75.0%	0.7%	0.0%	4.7%	8.1%	0.6%	0.0%	1.5%	1.9%	100.0%

a. R^2 between hourly modeled and monitored concentrations

Figure 2-1
Modeled vs Monitored Stagnation Day PM_{10} Concentrations ($\mu g/m^3$) at Cowtown (CTW)
10/29/2008

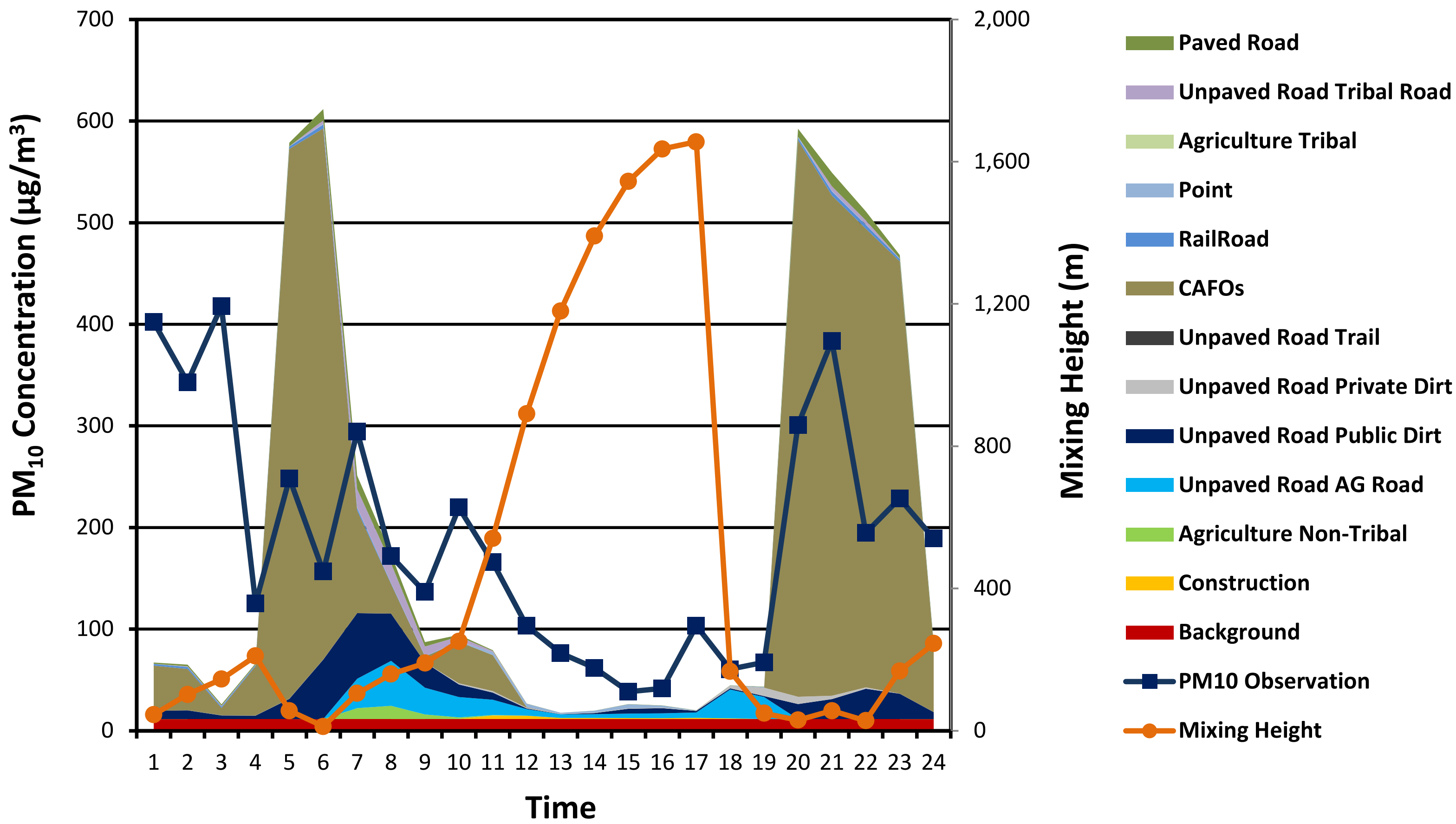


Table 2-9
Stagnation Day Modeling Performance at PCH on 10/29/2008, AERMOD Simulation of Monitored Concentrations (μg/m^3)

Hour	WSPD	WD	Mixing Height	PM_{10}	Background	Neighborhood Unpaved Road	Neighborhood Paved Road	Point	Construction	Nonroad	Dairy	Agriculture	Unpaved Road				Paved Road	Total
													AG Road	Public Dirt	Private Dirt	Trail		
1	1.0	100.2	49.0	91.4	11.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	1.6	0.0	0.2	19.6
2	0.6	122.1	24.0	86.1	11.5	5.4	0.1	0.0	0.0	0.1	0.0	0.0	0.0	14.0	21.0	0.0	0.4	52.4
3	0.5	73.5	19.0	72.5	11.5	5.7	0.2	0.0	0.0	0.1	0.0	0.0	0.0	48.7	16.5	0.0	0.6	83.3
4	0.5	144.0	19.0	67.8	11.5	1.4	0.3	0.0	0.0	0.1	0.0	0.0	0.0	34.3	0.0	0.0	0.8	48.5
5	0.5	246.0	19.0	76.6	11.5	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	15.1	24.9	0.0	1.4	54.3
6	0.5	142.8	19.0	60.1	11.5	4.4	1.4	0.0	0.0	0.1	0.0	0.0	0.0	12.7	57.8	0.0	3.6	91.5
7	0.5	189.5	19.0	145.8	11.5	14.2	1.2	0.0	0.0	0.1	0.0	5.8	0.0	0.0	124.4	11.1	12.9	181.1
8	0.5	276.0	36.0	287.0	11.5	13.8	0.0	0.3	0.0	0.1	0.0	28.2	36.4	130.2	110.4	14.5	10.9	356.2
9	0.7	133.5	146.0	179.2	11.5	5.2	0.1	1.9	0.0	0.0	0.0	27.3	59.6	116.9	32.0	4.4	2.0	260.8
10	0.5	300.9	273.0	455.2	11.5	6.8	0.1	6.5	0.0	0.0	0.0	16.9	49.7	46.9	9.8	0.2	0.3	148.8
11	0.6	18.9	601.0	234.8	11.5	9.9	0.0	6.1	0.0	0.0	0.0	10.7	35.6	40.6	5.6	0.2	0.2	120.3
12	0.7	259.9	956.0	85.6	11.5	6.2	0.0	2.4	0.0	0.1	0.1	2.4	15.5	9.3	5.5	0.1	0.1	53.3
13	0.6	308.7	1245.0	71.4	11.5	4.4	0.0	1.7	0.0	0.1	0.0	2.4	7.7	11.8	5.3	0.2	0.1	45.2
14	1.2	263.9	1458.0	62.7	11.5	4.0	0.0	1.1	0.0	0.0	0.0	1.8	5.4	9.7	5.2	0.2	0.1	39.0
15	1.0	292.9	1613.0	65.6	11.5	4.8	0.0	0.8	0.0	0.0	0.0	1.3	4.3	10.0	4.8	0.2	0.1	37.9
16	0.7	244.0	1705.0	54.5	11.5	4.1	0.0	1.2	0.0	0.0	0.2	1.2	5.3	8.4	6.2	0.3	0.2	38.8
17	0.7	294.0	1724.0	40.8	11.5	5.9	0.0	1.3	0.0	0.0	0.2	2.1	8.1	14.0	7.0	0.4	0.3	50.9
18	0.5	300.1	26.0	368.4	11.5	19.9	0.0	0.6	0.0	0.1	0.0	57.8	274.1	393.4	49.0	3.0	1.6	811.1
19	0.5	53.0	19.0	588.4	11.5	21.9	0.3	0.0	0.0	0.3	0.0	47.3	226.2	535.1	48.6	2.4	3.0	896.6
20	0.5	57.4	19.0	453.5	11.5	14.6	0.4	0.0	0.0	0.4	0.0	0.0	0.0	283.8	14.7	0.0	2.8	328.3
21	0.5	91.7	19.0	281.6	11.5	25.4	0.3	0.0	0.0	0.3	0.0	0.0	0.0	133.5	25.2	0.0	2.1	198.2
22	0.5	82.1	19.0	199.3	11.5	20.2	0.4	0.0	0.0	0.2	0.0	0.0	0.0	118.5	16.4	0.0	1.6	168.8
23	0.5	128.4	19.0	128.6	11.5	6.4	0.6	0.0	0.0	0.2	0.0	0.0	0.0	88.1	20.7	0.0	1.2	128.6
24	0.5	187.8	19.0	114.4	11.5	3.3	0.3	0.0	0.0	0.1	0.0	0.0	0.0	17.5	24.1	0.0	1.6	58.4
R-Square[a]					N/A	0.5	0.0	0.0	0.2	0.3	0.1	0.4	0.4	0.7	0.1	0.0	0.0	0.6
Average			419.4	178.0	11.5	8.7	0.2	1.0	0.0	0.1	0.0	8.6	30.3	87.4	26.5	1.6	2.0	178.0
Percentage Contribution					6.5%	4.9%	0.1%	0.6%	0.0%	0.1%	0.0%	4.8%	17.0%	49.1%	14.9%	0.9%	1.1%	100.0%

a. R^2 between hourly modeled and monitored concentrations

Figure 2-2
Modeled vs Monitored Stagnation Day PM_{10} Concentrations (µg/m^3) at Pinal County Housing (PCH)
10/29/2008

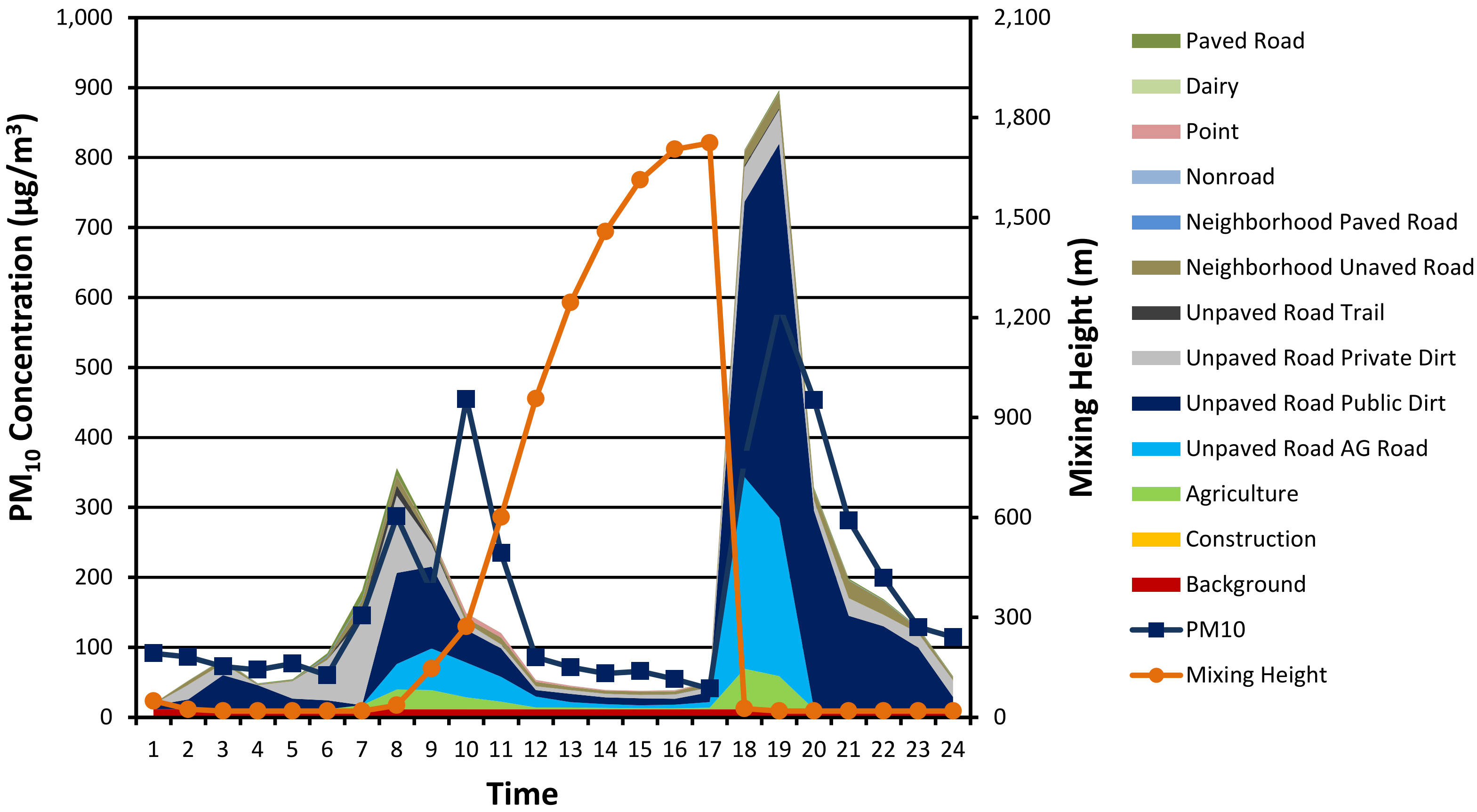


Table 2-10
Stagnation Day Modeling Performance at STF on 10/29/2008, AERMOD Simulation of Monitored Concentrations (μg/m^3)

Hour	WSPD (m/s)	WD	Mixing Height	PM_{10}	Background	Neighborhood Paved Road	Neighborhood UnPaved Road	Construction	Non road	CAFOs	Agriculture	Unpaved Road				Paved Road	Total
												AG Road	Public Dirt	Private Dirt	Trail		
1	1.0	251.9	27.0	46.0	11.5	0.1	0.2	0.0	0.0	0.0	0.0	0.0	1.1	0.7	0.0	1.4	15.0
2	1.0	159.9	31.0	79.0	11.5	0.2	1.7	0.0	0.0	0.0	0.0	0.0	5.9	17.6	0.0	1.5	38.3
3	1.6	139.5	57.0	76.8	11.5	0.2	1.9	0.0	0.0	0.0	0.0	0.0	6.4	20.8	0.0	0.4	41.2
4	1.3	155.2	42.0	63.0	11.5	0.2	0.5	0.0	0.0	0.0	0.0	0.0	4.8	5.5	0.0	0.5	23.0
5	1.2	99.4	41.0	144.0	11.5	0.4	0.1	0.0	0.0	178.1	0.0	0.0	13.1	1.7	0.0	3.3	208.3
6	0.9	108.0	24.0	183.5	11.5	3.0	2.9	0.0	0.0	276.3	0.0	0.0	64.5	34.8	0.0	7.2	400.2
7	0.8	179.6	21.0	187.7	11.5	6.2	10.0	0.0	0.0	105.6	3.2	165.2	81.1	102.2	0.9	8.3	494.2
8	0.8	171.9	21.0	307.2	11.5	5.8	10.9	0.0	0.0	0.0	17.6	287.3	77.4	106.2	2.2	7.3	526.2
9	0.7	183.8	98.0	226.0	11.5	2.7	4.3	2.4	0.0	0.0	13.1	243.1	61.6	43.9	2.0	3.2	387.9
10	1.6	82.4	266.0	133.2	11.5	0.6	0.8	2.0	0.0	0.4	4.0	114.2	22.3	5.9	1.4	0.3	163.5
11	1.4	121.4	539.0	126.2	11.5	0.2	0.6	0.0	0.0	1.4	4.8	29.1	10.4	3.6	0.7	0.1	62.6
12	1.3	129.8	888.0	116.1	11.5	0.2	0.7	0.0	0.0	1.2	2.6	25.3	10.4	8.4	0.2	0.2	60.8
13	1.3	165.8	1177.0	101.7	11.5	0.3	0.8	0.4	0.0	0.3	1.3	13.9	5.7	8.1	0.1	0.2	42.5
14	0.9	112.1	1387.0	69.7	11.5	0.4	1.0	0.3	0.0	1.6	1.5	12.8	5.4	7.7	0.3	0.2	42.6
15	1.0	67.2	1541.0	65.5	11.5	0.4	1.6	0.0	0.0	1.6	2.0	14.9	6.4	4.7	0.7	0.2	44.0
16	1.1	94.3	1632.0	43.8	11.5	0.7	1.6	0.0	0.0	1.9	1.9	13.3	6.5	3.5	0.9	0.3	42.1
17	1.3	59.4	1652.0	43.8	11.5	1.2	1.8	0.0	0.0	1.6	2.1	15.9	5.2	2.4	1.5	0.3	43.5
18	1.2	5.3	45.0	509.1	11.5	4.3	10.9	0.0	0.0	0.0	19.5	229.2	279.4	0.2	1.0	0.3	556.4
19	1.1	297.8	35.0	341.7	11.5	4.0	17.4	0.0	0.0	0.0	15.5	185.6	233.4	11.6	0.1	0.8	480.0
20	0.8	296.4	21.0	628.5	11.5	1.8	16.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	1.1	50.4
21	1.3	260.5	44.0	124.8	11.5	0.8	9.3	0.0	0.0	2.2	0.0	0.0	6.3	13.7	0.0	3.4	47.2
22	1.0	253.8	28.0	72.7	11.5	0.1	2.8	0.0	0.0	1.9	0.0	0.0	10.3	7.5	0.0	5.7	39.8
23	1.3	169.3	43.0	93.1	11.5	0.3	1.8	0.0	0.0	0.0	0.0	0.0	12.2	13.3	0.0	3.1	42.3
24	1.6	163.9	58.0	106.6	11.5	0.3	1.2	0.0	0.0	0.0	0.0	0.0	12.8	12.1	0.0	0.6	38.4
R-Square[a]						0.4	0.7	0.0	0.0	0.0	0.3	0.3	0.4	0.1	0.0	0.0	0.3
Average			404.9	162.1	11.5	1.4	4.2	0.2	0.0	23.9	3.7	56.2	39.3	19.0	0.5	2.1	162.1
Percentage Contribution					7.1%	0.9%	2.6%	0.1%	0.0%	14.8%	2.3%	34.7%	24.2%	11.7%	0.3%	1.3%	100.0%

a. R^2 between hourly modeled and monitored concentrations

Figure 2-3
Modeled vs Monitored Stagnation Day PM_{10} Concentrations ($\mu g/m^3$) at Stanfield (STF)
10/29/2008

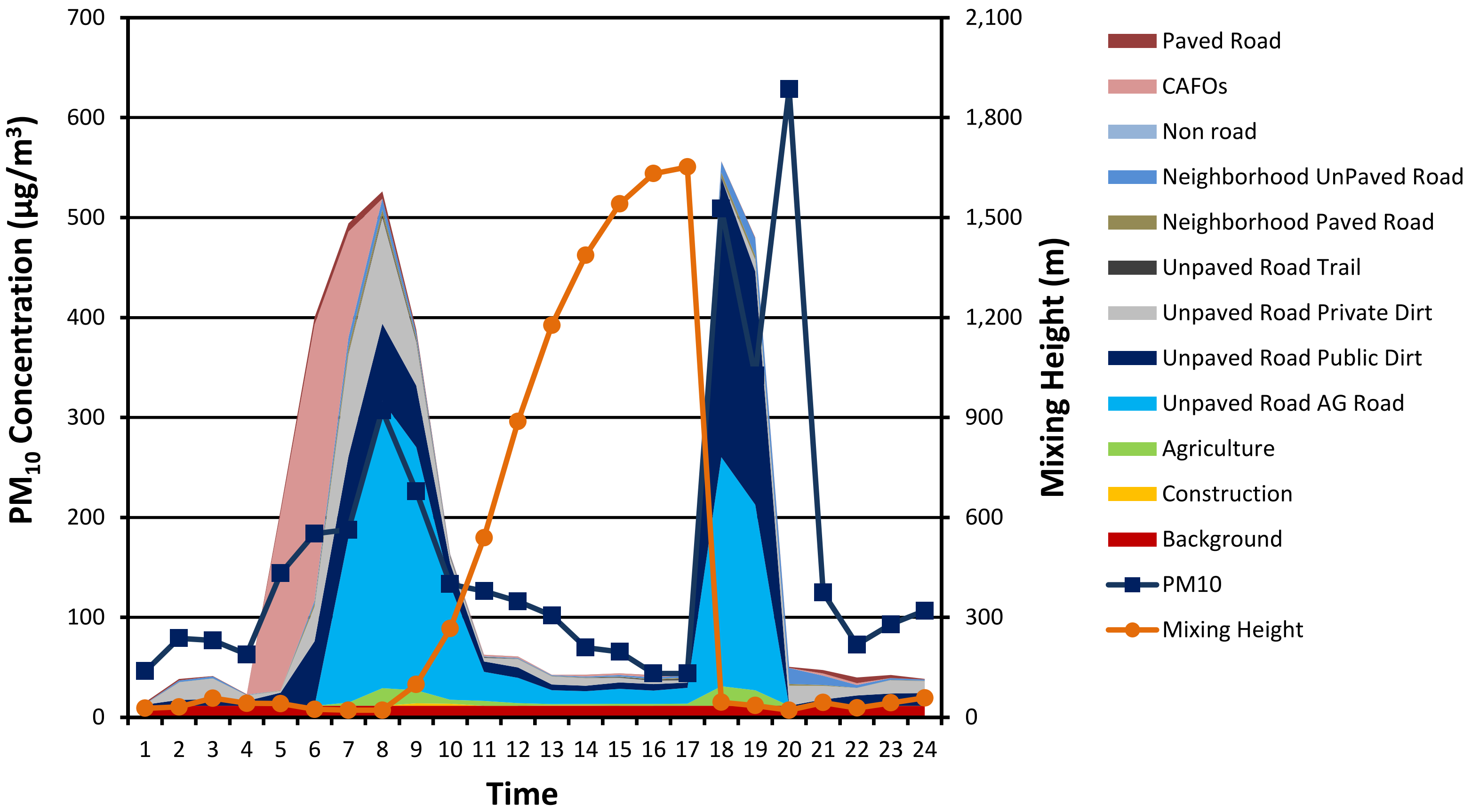
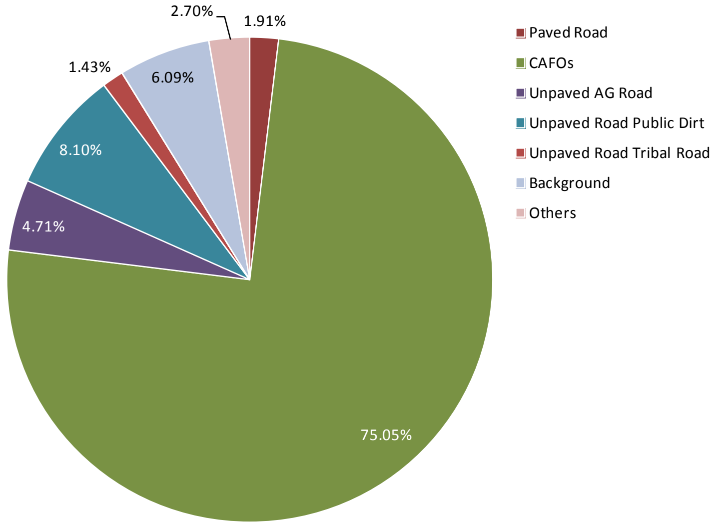
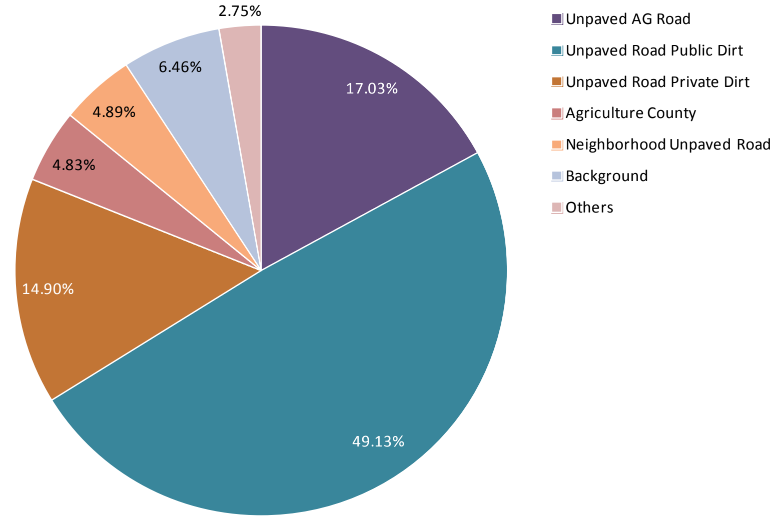


Figure 2-4
Stagnation Design Day Source Contributions

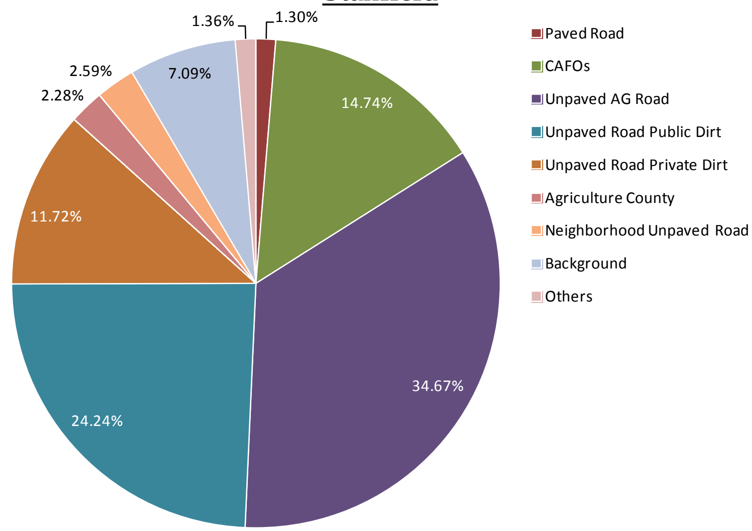
Cowtown



Pinal County Housing



Stanfield



3. HIGH WIND DAY MODELING

High wind design days selected for Pinal County PM_{10} monitoring sites included both high wind hours (when hourly average wind speeds exceeded 12 mph) and low wind hours. During high wind hours, windblown PM_{10} emissions are generally much greater than those generated by mechanical sources. However, as discussed in the emission inventory report, emission from sources of mechanically generated PM_{10} were included in the modeling of windblown PM_{10} emissions in order to fully account for all source contributions during high wind hours. On low wind hours, the assumption that all PM_{10} emissions are generated by mechanical sources and none are produced by wind entrainment was utilized. The remainder of this section describes how high wind hour emissions were treated and how the benefits from high wind control measures were evaluated.

The method used to assess high wind hour source apportionment and to provide a basis for demonstrating attainment is the weighted rollback method, a demonstration approach that was employed in MAG's Five Percent Plan[19] and approved by EPA. As discussed in the Five Percent Plan:

> *The fundamental assumption underlying any rollback method is that pollutant concentrations are directly proportional to total emissions over the area of interest. A weighted rollback approach applies a distance reduction factor to the emissions of each source in the modeling domain to help assess the impact of emissions as distance from the monitor increases. The reduction factor is calculated based upon the distance between each source and the impacting monitor.*

The concept for this approach came from a saturation monitoring study in which Maricopa County placed a string of temporary PM_{10} continuous monitors along the Salt River channel west of the permanent monitors in the Salt River industrial zone (e.g., West 43rd Avenue and Durango Complex stations). Data were collected for an extended period, and differences between sequential monitored concentrations were calculated during high wind hours when winds generally followed a path parallel to the line connecting the temporary and permanent monitors. The results of that analysis and the AERMOD analysis of alternate weighting factors determined that distance weighting (1/distance, where distance is measured from the centroid of the source to the monitor)

---

[19] Chapter 6, Attainment Demonstration, "MAG Five Percent Plan for PM-10 for Maricopa County Nonattainment Area," May 2012

was an appropriate mechanism to evaluate the impacts of PM_{10} emissions from individual land parcels within back-trajectory modeling domains. MAG used this approach to evaluate all high wind hour emission estimates.

Because MAG had not experienced a low wind/stagnation violation of the PM_{10} standard since 2007, the Five Percent Plan focused on modeling windblown fugitive dust produced during high wind hours. This resulted in the distance-weighted modeling approach cited above to assess impacts at monitors. Low wind monitor impacts were not modeled; instead, emission inventory estimates for the low wind domains were simply quantified[20] to represent the basis for low wind hour concentrations.

In contrast to MAG, Pinal County experienced violations under both low wind/stagnation and high wind conditions. A review of low wind hour concentrations on high wind days found that they exceeded high wind hour concentrations at each of the monitors. Based on this finding, decisions were made (1) to model the effect of low wind hour mechanically generated emissions and (2) to model both mechanically-generated emissions and windblown dust emissions during high wind hours.

As noted in the accompanying base year emission inventory document, mechanically driven emissions were quantified for the low wind domains at each monitor for each hour of the high wind design days. Because the areal extent of these domains encompassed the high wind domains, mechanically driven emissions for sources located within the high wind domains were extracted from the low wind domains for the high wind hours using 45º arcs centered on and opening in the direction opposite to the vector-average wind direction for each high wind hour. The rationale supporting this choice was that the areal extent of the low wind domains should approximate the modeling domains used for high winds. A similar approach was adopted to define the areal boundaries of low wind hour domains to be modeled.[21] Parcel-specific emissions within the low wind and high wind domains were weighted in proportion to their distance from the monitor. This approach ensured that both high and low wind hourly emissions were weighted in the same manner so as to be additive and facilitate control strategy benefit analysis.

Non-Anthropogenic Background

Evaluations of meteorological conditions on high wind design days revealed that winds capable of entraining surface soil particles (i.e., having hourly average speeds $\geq$ 12 mph) were consistently from the northeast direction during high wind hours. One of the closest PM_{10} monitors outside the boundary of the Western Pinal County nonattainment area and generally upwind in a northeasterly direction from the four high wind exceedance monitors is a station located in the small community of Queen Valley. The community of Queen Valley was recorded in the 2010 Census as having a permanent population of 788. The permanent population is augmented in winter by seasonal residents drawn by the relatively moderate climate. Land use in the area is predominately residential, light

[20] 2012 Five Percent Plan TSD, page V-75

[21] Boundaries for both low and high wind hour domains on high wind days are displayed in Chapter 2 of the emission inventory document.

commercial use, and recreation (e.g., the nearby golf course). The topography of the area is generally hilly or mountainous, with the Queen Creek wash running east to west through the community. PM_{10} source emissions near the site are low and limited to contributions from vehicular traffic and residential and commercial activities. In general, roadways in Queen Valley are paved, with the exception of roads outside the populated area. The Queen Valley site was selected to represent PM_{10} concentrations near the upwind boundary of the nonattainment area during high wind hours.

Because the Queen Valley PM_{10} monitoring period included days during which no high wind hours were recorded, the days for which 24-hour average PM_{10} concentrations were available were screened to identify the subset of high wind days. Because the Queen Valley site does not record meteorological conditions, meteorological data were obtained from a monitoring station located in Superior, Arizona, approximately 12 miles to the east. The Queen Valley data were screened to eliminate days with fewer than 6 hours of high winds (> 12 mph), to be consistent with the criteria used to define days eligible for high wind design day designation, and days when high winds were predominantly from directions other than the northeast. This produced a 6-day data set, with an average concentration of 17.5 $\mu g/m^3$. An analysis of high wind days at Organ Pipe Cactus National Monument, the background site used in the MAG Five Percent Plan, produced a 5-day data set with an average concentration of 18.5 $\mu g/m^3$, demonstrating that the Queen Valley high wind day concentrations were in the same range as those collected at Organ Pipe, a rural site with almost no anthropogenic activity or disturbance nearby. The 6-day average of 17.5 $\mu g/m^3$ recorded at Queen Valley was selected to represent the background PM_{10} level in high wind rollback calculations.

A summary of the source contributions to overall weighted emissions is presented by hour for each monitor and design day in Tables 3-1 through 3-4 for Pinal County Housing, Cowtown, Maricopa, and Stanfield monitoring sites, respectively. Also presented is information on hourly wind speed, wind direction, mixing height, and monitored concentration. While these variables employ different units (e.g., degrees, miles/hour, $\mu g/m^3$, etc.), insight into source apportionment can be gained by contrasting the modeled diurnal profiles of individual source categories and the monitored diurnal profiles of the four sites on designated high wind design days. Visual displays of the source-specific hourly weighted emission estimates and monitored concentrations are displayed in Figures 3-1 through 3-4. Figure 3-5 summarizes the average daily source-specific contributions for each site.

The methodology for computing high wind emission factors is presented in an accompanying base year emission inventory document.[22] Independent of the relationships developed between windblown PM_{10} emission factors and hourly-average wind speed, the analysis of emission factors in the accompanying document includes discussions of particle saltation initiation times and soil reservoir depletion that also play a role in the diurnal profile of windblown PM_{10} emissions on high wind days.

[22] Ibid.

Table 3-1
Distance-Weighted Emissions for the High Wind Day at PCH on 1/1/2008

Hour	SPD mph (H=10m)	WD	PM_{10} Observation ($\mu g/m^3$)	Paved Road	Dairies	Cleared Area	Desert Shrubland	Developed Rural Lands	Developed Urban Lands	Agriculture	Unpaved Road				Total
											AG Road	Public Dirt	Private Dirt	Trail	
1	1.6	303.8	28.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.1	0.0	1.4
2	1.5	318.0	21.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.8	0.0	2.9
3	2.0	335.4	22.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.8	0.0	2.0
4	2.5	333.7	24.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	1.3
5	5.9	352.2	16.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.9	0.0	2.6
6	3.2	299.6	19.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.5	0.0	5.1
7	3.9	339.3	16.2	0.9	0.0	0.0	0.0	0.0	0.0	14.1	29.8	12.6	6.8	0.4	64.5
8	5.7	5.0	22.7	1.0	0.0	0.0	0.0	0.0	0.0	14.0	40.2	13.3	3.8	0.0	72.2
9	4.8	53.9	34.7	0.6	0.0	0.0	0.0	0.0	0.0	15.2	39.5	75.7	3.4	0.2	134.7
10	16.3	41.2	871.2	0.0	0.0	43.9	138.5	57.8	6.8	1317.0	144.1	50.5	28.0	4.8	1791.3
11	21.4	46.3	919.3	0.0	0.0	131.0	383.8	160.2	23.0	4185.3	398.3	117.7	69.7	15.6	5484.5
12	25.1	49.6	1136.1	0.0	0.0	236.3	692.5	289.0	41.5	7546.0	685.7	211.5	123.1	28.0	9853.6
13	23.6	48.5	790.7	0.0	0.0	101.5	297.5	124.2	17.8	3248.2	316.0	101.7	56.2	12.1	4275.1
14	22.9	48.3	946.1	0.0	0.0	49.8	146.0	60.9	8.7	1600.5	174.7	63.2	35.2	6.0	2145.1
15	19.2	47.6	320.0	0.0	0.0	24.1	76.2	31.8	3.7	695.0	96.4	43.3	19.1	2.7	992.5
16	22.3	53.6	397.9	0.0	0.0	32.3	94.7	39.5	5.7	1045.0	128.3	125.9	22.1	4.0	1497.4
17	19.9	53.6	281.9	0.0	0.0	29.5	93.1	38.9	4.6	851.2	111.2	104.4	17.3	3.3	1253.5
18	15.0	50.6	65.8	0.0	0.0	7.6	24.8	10.4	1.1	212.9	55.8	28.7	7.9	0.9	350.0
19	15.5	54.6	50.9	0.0	0.0	5.4	17.7	7.4	0.8	142.1	12.1	43.1	6.2	0.5	235.4
20	19.4	58.1	61.5	0.0	0.0	6.7	21.2	8.8	1.0	190.0	16.3	24.2	5.9	0.7	274.8
21	19.3	56.7	70.6	0.0	0.0	8.0	25.4	10.6	1.2	228.0	19.6	24.8	7.0	0.8	325.5
22	19.2	57.4	67.6	0.0	0.0	8.0	25.4	10.6	1.2	228.0	19.6	22.3	4.4	0.8	320.4
23	17.2	55.7	32.7	0.0	0.0	2.4	7.7	3.2	0.4	69.2	5.9	14.3	1.9	0.3	105.4
24	14.9	54.6	139.3	0.0	0.0	4.8	15.8	6.6	0.7	126.4	10.8	13.1	2.2	0.5	180.9
R-Square[a]				0.1	0.0	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.7	0.7
Average			264.9	0.1	0.0	28.8	85.8	35.8	4.9	905.3	96.0	45.8	17.7	3.4	1223.8
Percentage Contribution				0.0%	0.0%	2.4%	7.0%	2.9%	0.4%	74.0%	7.8%	3.7%	1.4%	0.3%	100.0%

a. R^2 between hourly distance-weighted emissions and monitored concentrations

Figure 3-1
Distance-Weighted Emissions for Pinal County Housing (PCH) Monitor on High Wind Day 1/1/2008

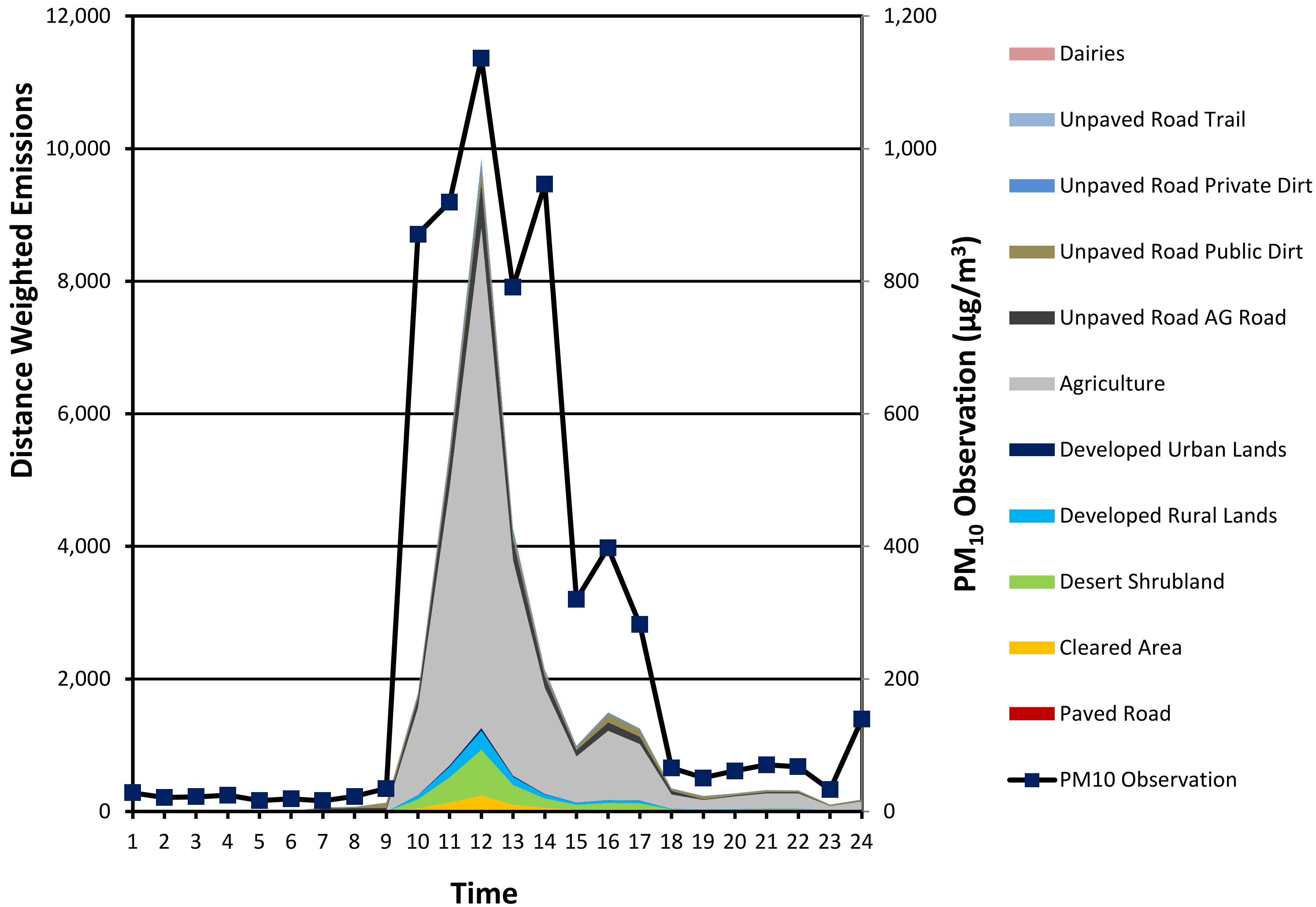


Table 3-2
Distance-Weighted Emissions for the High Wind Day Modeling Domain at Cowtown on 04/27/2008

Hour	SPD mph (H=10m)	WD	PM_{10} Observation ($\mu g/m^3$)	Rail Road	Point Sources	Paved Road	Construction	Cleared Area	Desert Shrubland		Developed Rural Lands	Developed Urban Lands	CAFOs	Agriculture		Unpaved Road					Total
									County	Tribal				County	Tribal	AG Road	Public Dirt	Private Dirt	Trail	Tribal Road	
1	6.1	332.4	68.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.3
2	0.7	320.5	73.0	0.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.9	0.0	0.0	6.2
3	5.9	314.7	88.1	0.9	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0	0.0	0.2	0.3	0.0	0.0	10.2
4	3.9	84.4	59.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.7	0.0	0.0	0.0	0.8
5	2.2	25.7	92.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.6	0.0	0.0	1.8
6	2.4	156.6	492.9	0.0	9.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	111.2	0.0	0.3	0.0	20.4	0.0	0.0	0.3	142.0
7	1.6	229.1	326.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	300.1	2.0	9.7	9.4	27.6	0.0	0.0	2.9	351.9
8	2.1	11.6	222.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.3	0.1	8.4	0.2	0.0	38.5
9	10.9	33.2	372.4	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	1.9	28.0	29.0	10.2	0.1	0.2	78.2
10	20.0	52.9	886.8	0.0	0.0	0.0	219.8	22.3	528.0	141.0	63.9	1.3	0.0	1078.9	1.8	42.2	40.7	23.4	0.4	0.6	2164.1
11	17.6	44.4	107.7	0.0	0.0	0.0	58.3	5.9	140.0	37.4	16.9	0.3	0.0	292.8	2.0	32.1	32.7	9.1	0.1	0.4	628.0
12	15.7	43.0	122.3	0.0	0.0	0.0	26.6	2.7	63.9	17.1	7.7	0.2	0.0	138.0	2.0	30.6	39.3	9.7	0.0	0.5	338.3
13	17.7	37.0	72.0	0.0	0.0	0.0	54.4	5.5	130.6	34.9	15.8	0.3	0.0	272.6	2.0	29.6	33.3	18.8	0.0	0.4	598.0
14	14.7	44.0	38.4	0.0	0.0	0.0	18.2	1.9	48.0	12.8	5.8	0.1	0.0	101.3	2.0	29.0	37.0	10.2	0.1	0.5	266.9
15	16.1	49.6	36.4	0.0	0.0	0.0	26.9	2.7	64.7	17.3	7.8	0.2	0.0	139.8	1.8	27.6	39.3	9.6	0.2	0.6	338.7
16	15.1	50.7	23.1	0.0	0.0	0.0	21.5	2.3	56.7	15.1	6.9	0.1	0.0	118.0	1.9	27.7	38.1	9.4	0.2	0.6	298.5
17	12.1	59.4	69.7	0.0	0.0	0.0	4.1	0.4	10.8	2.9	1.3	0.0	0.0	29.4	1.1	25.6	35.1	6.0	0.2	0.6	117.6
18	9.2	68.9	101.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	1.1	20.0	35.7	4.1	0.2	0.9	70.2
19	5.2	40.9	230.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	13.9	4.8	0.0	0.2	19.0
20	4.0	8.0	72.9	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	9.8	0.0	0.0	10.2
21	2.9	37.2	79.7	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	5.9	11.1	0.0	0.1	17.3
22	3.0	35.3	42.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	5.1	2.9	0.0	0.1	8.2
23	3.8	111.6	232.5	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4.4	0.9	0.0	0.1	5.9
24	4.7	9.3	127.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.1
R-Square[a]				0.0	0.1	0.0	0.5	0.5	0.4	0.4	0.4	0.5	0.1	0.4	0.0	0.1	0.1	0.1	0.2	0.1	0.5
Average			168.3	0.1	0.4	0.1	17.9	1.8	43.4	11.6	5.3	0.1	17.7	91.2	1.2	13.8	18.3	6.3	0.1	0.4	229.7
Percentage Contribution				0.0%	0.2%	0.0%	7.8%	0.8%	18.9%	5.1%	2.3%	0.0%	7.7%	39.7%	0.5%	6.0%	8.0%	2.8%	0.0%	0.2%	100.0%

a. R^2 between hourly distance-weighted emissions and monitored concentrations

Figure 3-2
Distance-Weighted Emissions for Cowtown (CWT) Monitor on High Wind Day
4/27/2008

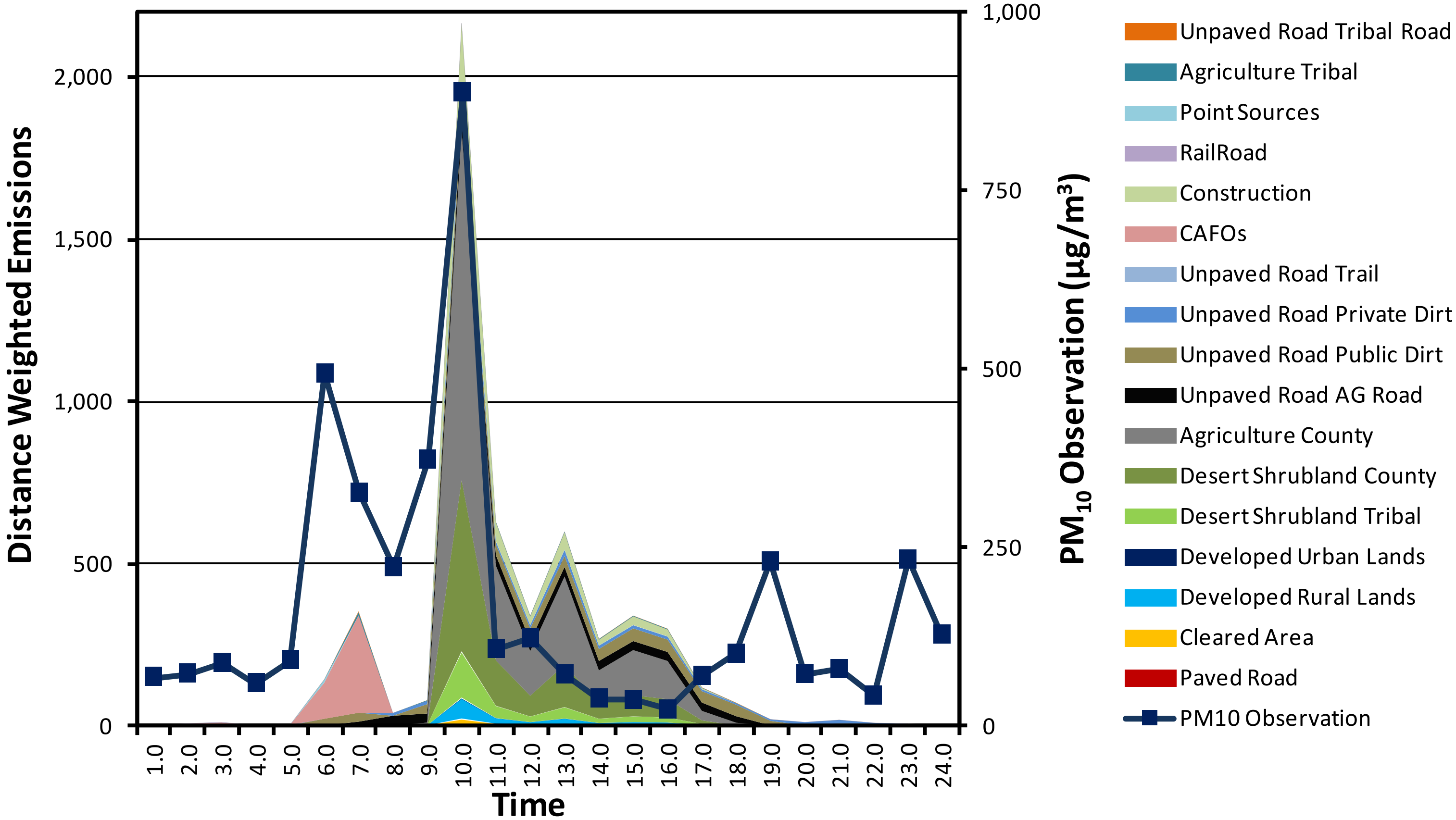


Table 3-3 Distance-Weighted Emissions for the High Wind Day Modeling Domain at Maricopa on 10/27/2008																			
												Agriculture		Unpaved Road					
Hour	SPD mph (H=10m)	WD	PM_{10} Observation ($\mu g/m^3$)	Rail Road	Paved Road	Construction	CAFOs	Cleared Area	Desert Shrubland	Developed Rural Lands	Developed Urban Lands	County	Tribal Land	AG Road	Public Dirt	Private Dirt	Trail	Tribal Road	Total
1	3.8	160.0	239.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.4	0.0	0.0	1.2
2	2.0	106.0	143.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
3	1.3	6.0	70.3	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7
4	1.3	348.0	73.8	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
5	2.5	290.0	98.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	1.1
6	2.0	241.0	91.8	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.8
7	1.3	215.0	129.8	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0.0	3.1	7.4
8	5.6	82.0	160.4	0.0	6.8	55.5	0.0	0.0	0.0	0.0	0.0	0.5	0.3	10.1	3.2	1.4	0.0	0.0	77.7
9	13.0	84.0	326.2	0.0	0.0	232.1	0.0	55.7	32.4	22.4	23.4	82.5	0.3	14.8	3.7	3.8	0.3	0.0	471.2
10	16.1	85.0	852.9	0.0	0.0	1222.0	0.0	340.5	189.2	130.6	155.2	506.1	0.3	43.5	9.9	16.6	1.5	0.0	2615.3
11	18.3	81.0	496.5	0.0	0.0	1098.9	0.0	304.1	169.0	116.6	138.6	452.1	0.3	40.5	8.7	14.0	1.4	0.0	2344.2
12	16.3	82.0	293.2	0.0	0.0	511.2	0.0	132.8	73.8	50.9	60.5	197.7	0.3	23.4	6.1	8.7	0.6	0.0	1066.0
13	17.0	79.0	176.0	0.0	0.0	444.0	0.0	113.3	63.0	43.5	51.7	168.8	0.3	21.5	5.2	6.7	0.5	0.0	918.4
14	16.8	74.0	141.9	0.0	0.0	375.7	0.0	88.1	49.0	33.8	40.2	131.4	0.3	17.4	3.8	3.9	0.4	0.2	744.3
15	15.4	72.0	84.8	0.0	0.0	200.6	0.0	38.4	22.4	15.4	16.1	57.1	0.3	11.8	0.7	2.2	0.2	0.7	365.9
16	13.6	71.0	76.6	0.0	0.0	120.5	0.0	13.9	8.1	5.6	5.8	21.0	0.3	9.3	0.2	1.2	0.1	0.7	186.9
17	13.0	72.0	68.6	0.0	0.0	105.3	0.0	9.3	5.4	3.7	3.9	14.2	0.3	9.1	0.2	1.0	0.1	0.6	153.1
18	8.7	62.0	60.4	6.6	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	5.9	0.0	0.3	0.0	0.6	18.2
19	7.2	61.0	56.2	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.3	3.0
20	7.4	68.0	45.1	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.2	2.1
21	9.6	70.0	36.1	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.2	2.4
22	9.8	80.0	30.8	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	2.7
23	9.2	82.0	33.2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.5	0.0	0.0	1.9
24	8.9	78.0	38.7	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	1.4
R-Square[a]				0.0	0.1	0.8	0.0	0.8	0.8	0.8	0.8	0.8	0.1	0.7	0.8	0.8	0.8	0.0	0.8
Average			159.4	0.3	1.1	181.9	0.0	45.7	25.5	17.6	20.6	68.0	0.2	8.6	1.8	2.6	0.2	0.3	374.5
Percentage Contribution				0.1%	0.3%	48.6%	0.0%	12.2%	6.8%	4.7%	5.5%	18.2%	0.0%	2.3%	0.5%	0.7%	0.1%	0.1%	100.0%

a. R^2 between hourly distance-weighted emissions and monitored concentrations

Figure 3-3
Distance-Weighted Emissions for Maricopa Monitor on High Wind Day
10/27/2008

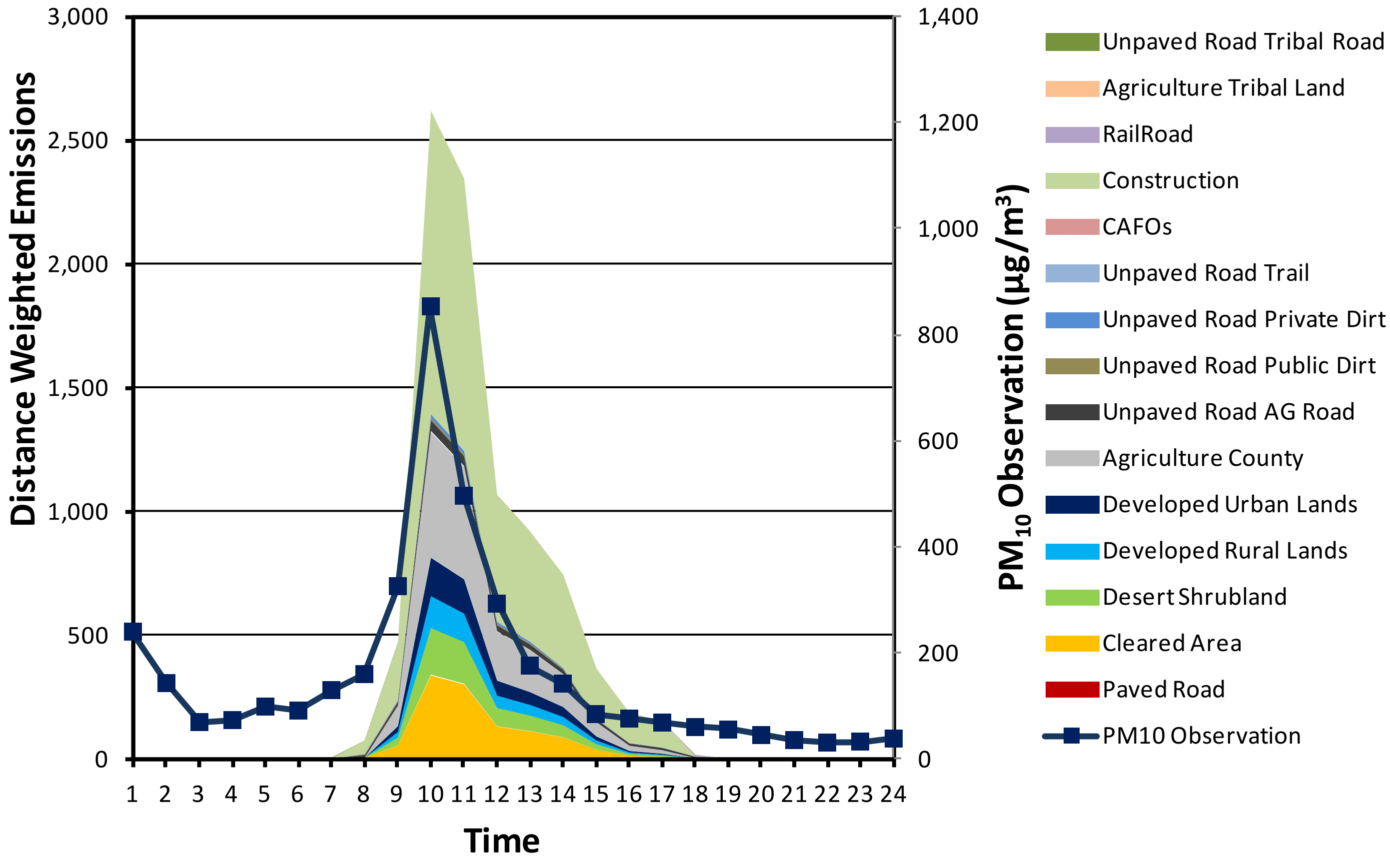


Table 3-4 Distance-Weighted Emissions for the High Wind Day Modeling Domain at STF on 11/21/2008																
												Unpaved Road				
Hour	SPD mph (H=10m)	WD	PM_{10} Observation ($\mu g/m^3$)	Paved Road	Construction	CAFOs	Cleared Area	Desert Shrubland	Developed Rural Lands	Developed Urban Lands	Agriculture	AG Road	Public Dirt	Private Dirt	Trail	Total
1	4.1	119.2	112.4	0.1	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.3	0.0	3.9
2	3.5	161.6	59.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.8	0.0	2.1
3	3.9	117.3	157.4	0.1	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.7	0.0	6.3
4	4.3	125.4	158.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	1.4
5	3.7	274.2	102.3	0.1	0.0	27.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	27.8
6	4.0	240.9	234.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.1	0.0	3.8
7	15.9	85.5	357.4	0.0	0.0	53.8	10.8	66.3	4.1	0.9	350.1	62.0	36.8	41.8	2.7	629.3
8	18.3	81.9	326.6	0.0	0.0	74.4	17.8	108.7	6.7	1.5	566.0	77.3	43.2	27.0	4.6	927.2
9	20.4	82.2	584.6	0.0	0.0	254.5	78.0	477.6	29.4	6.7	2445.9	188.7	61.0	41.8	18.8	3602.2
10	19.9	81.1	429.2	0.0	0.0	107.9	28.9	177.2	10.9	2.5	915.0	97.9	45.1	66.8	7.6	1459.8
11	20.0	80.2	334.3	0.0	0.0	75.9	19.7	120.5	7.4	1.7	626.1	76.9	37.6	44.6	5.4	1015.9
12	18.2	80.4	186.1	0.0	0.0	44.2	9.1	55.6	3.4	0.8	295.3	57.1	39.5	66.8	2.9	574.7
13	14.7	79.2	93.9	0.0	0.0	9.4	3.3	21.1	1.3	0.3	110.3	46.5	36.8	47.8	1.5	278.3
14	13.4	78.5	65.1	0.0	0.0	4.0	1.4	8.9	0.6	0.1	53.8	43.7	40.9	75.7	1.1	230.2
15	12.3	75.3	64.8	0.0	0.0	1.6	0.6	3.6	0.2	0.0	33.3	43.0	46.0	60.1	0.9	189.5
16	9.9	77.2	65.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	41.2	50.3	63.9	0.8	168.7
17	7.1	74.7	87.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	42.1	46.9	46.5	0.8	149.5
18	4.7	73.8	104.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	12.5	42.3	42.3	38.7	0.9	137.1
19	6.3	75.1	88.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.8	40.7	0.0	64.7
20	5.6	86.2	56.1	0.3	0.0	38.5	0.0	0.0	0.0	0.0	0.0	0.0	16.8	31.0	0.0	86.5
21	2.6	158.4	98.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	2.8	0.0	8.3
22	2.2	230.2	249.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.9	0.0	2.3
23	2.9	270.1	171.6	0.1	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	8.8
24	2.4	291.4	99.5	0.0	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	8.4
R-Square[a]				0.1	0.0	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.1	0.0	0.7	0.7
Average			178.6	0.1	0.0	29.8	7.1	43.3	2.7	0.6	226.3	34.1	24.2	29.2	2.0	399.4
Percentage Contribution				0.0%	0.0%	7.5%	1.8%	10.8%	0.7%	0.2%	56.7%	8.5%	6.1%	7.3%	0.5%	100.0%

a. R^2 between hourly distance-weighted emissions and monitored concentrations

Figure 3-4
Distance-Weighted Emissions for Stanfield (STF) Monitor on High Wind Day
11/21/2008

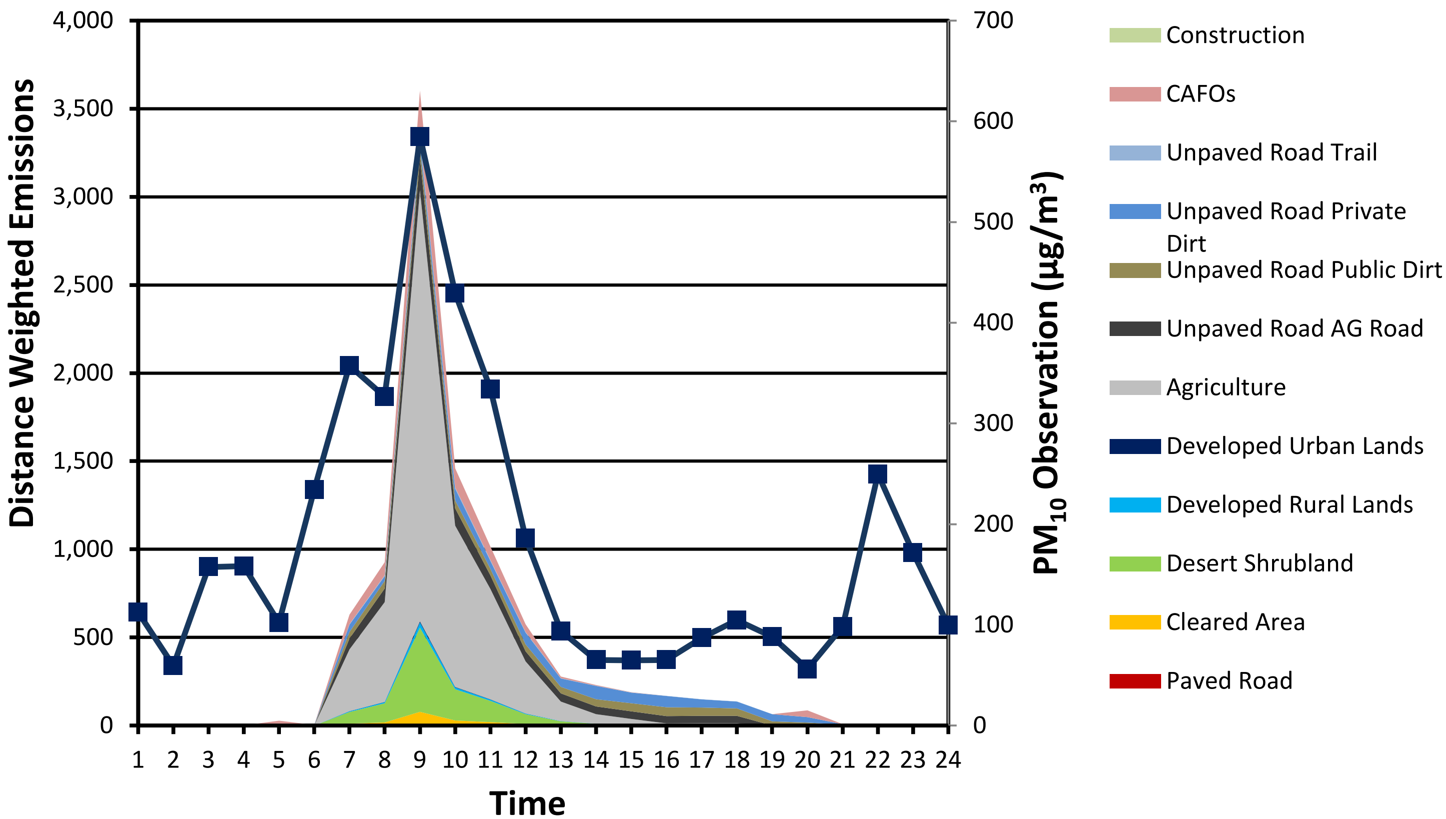


Figure 3-5
High Wind Design Day Source Contributions