Appendix B

# Pinal County Air Quality Control District Appendix F to the 2024 Annual Monitoring Network Plan

*Air Quality Division*
*September 23, 2024 Final Version*

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# *Appendix F*

## *Hidden Valley Annual $PM_{2.5}$ NAAQS Analysis*

# Pinal County Air Quality Control District

# 2024 Ambient Monitoring Network Plan and 2023 Data Summary

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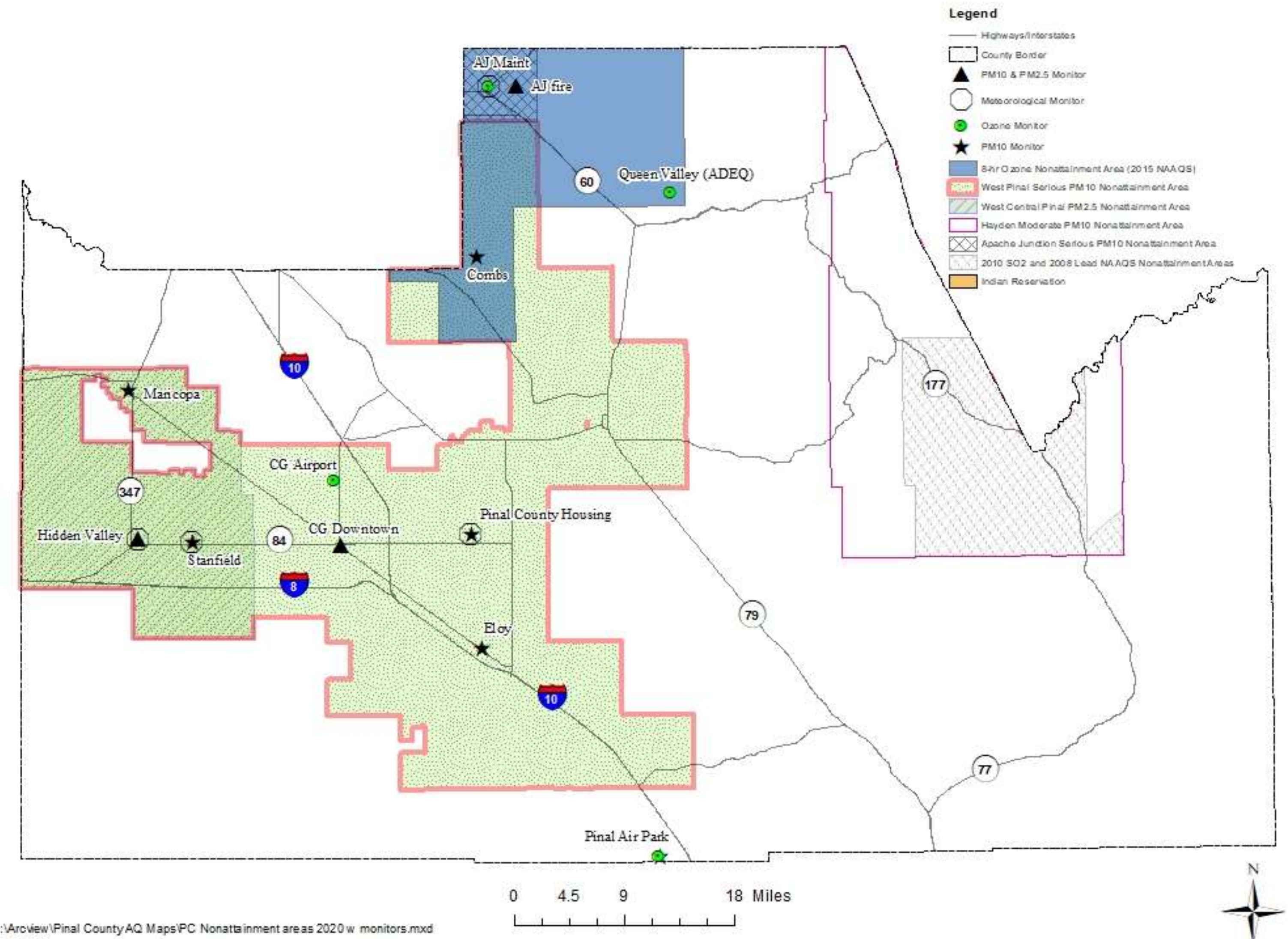
# Pinal County Air Quality Control District Monitoring Network and Nonattainment Areas

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# *Appendix F*

## *Hidden Valley Annual $PM_{2.5}$ NAAQS Analysis*

## Introduction

$PM_{2.5}$ has two National Ambient Air Quality Standards (NAAQS). The first is a daily 24-hour standard and the second is an annual mean averaged over 3 years. These standards are outlined in 40 CFR 50.7. All $PM_{2.5}$ monitors are eligible for comparison to the 24-hour standard. 40 CFR 58.30(a) states:

> "when micro- or middle-scale $PM_{2.5}$ monitoring sites collectively identify a larger region of localized high ambient $PM_{2.5}$ concentrations, such sites would be considered representative of an area-wide location and, therefore, eligible for comparison to the annual $PM_{2.5}$ NAAQS. $PM_{2.5}$ measurement data from monitors that are not representative of area-wide air quality but rather of relatively unique micro-scale, or localized hot spot, or unique middle-scale impact sites are not eligible for comparison to the annual $PM_{2.5}$ NAAQS. $PM_{2.5}$ measurement data from these monitors are eligible for comparison to the 24-hour $PM_{2.5}$ NAAQS. For example, if a micro- or middle-scale $PM_{2.5}$ monitoring site is adjacent to a unique dominating local $PM_{2.5}$ source, then the $PM_{2.5}$ measurement data from such a site would only be eligible for comparison to the 24-hour $PM_{2.5}$ NAAQS."

This document is an analysis of the Hidden Valley (HV) site against the standards listed in the CFR for application of the $PM_{2.5}$ monitor to the annual standard. The analysis will first review the spatial scale of the site and then move into land use around the site, the proximity of the sources to the site, the impacts of the sources on the site, and the uniqueness of the site.

## History of the Hidden Valley Site

The Hidden Valley site was established in December 2015 and began full operation on January 1, 2016. The site was a replacement for the Cowtown Road site which was established in November of 2001. The Cowtown Road site was designed to be the maximum concentration site within the Pinal County monitoring network and to evaluate $PM_{10}$ (initially upon setup) and $PM_{2.5}$ (starting in 2005) relative to sources including agriculture, feedlots, and unpaved roads.

Subsequently, the EPA determined that the Cowtown Road monitor was a unique middle-scale site in close proximity to a large feedlot complex and met the requirements of 40 CFR 58.30(a) to be excluded from comparison to annual $PM_{2.5}$ NAAQS. The EPA released the *Technical Support Document for the Determination that the Cowtown Road Monitor is Ineligible for Comparison with the Annual NAAQS*[1] on April 26, 2010. This EPA TSD confirmed that the Cowtown site was not applicable for comparison to the annual NAAQS.

In the fall of 2013, Pinal County was notified by the landowners of the Cowtown site that they would no longer allow Pinal County to use the property. A lease agreement was reached to allow Pinal County until January 20, 2016, to remove all equipment from the site. Pinal County worked with EPA Region IX and evaluated two potential sites for relocation. The Hidden Valley site was the proposed replacement site for the Cowtown Road site by Pinal County and was approved by EPA in October of 2015[2]. The Cowtown

Road site operated until December 31, 2015, when it was closed and replaced by the Hidden Valley site.

At the time of the relocation, Pinal County proposed in the relocation document to exclude the Hidden Valley $PM_{2.5}$ monitor from comparison to the annual NAAQS since the Hidden Valley site was selected to be very similar in scale and source impact to the Cowtown Road site and was the direct replacement for that site which was not eligible for comparison to the annual NAAQS. At the time of the approval for the relocation and in each subsequent Annual Monitoring Network plan, EPA elected not to make a formal decision on the applicability of the Hidden Valley $PM_{2.5}$ to the annual NAAQS[2].

## Spatial Scale

It is important to evaluate the spatial scale of any $PM_{2.5}$ site as part of the analysis of applicability to the annual $PM_{2.5}$ NAAQS. The spatial scale defines the physical dimensions of the air parcel nearest to a monitoring site throughout which actual pollutant concentrations are reasonably similar. It is determined by the characteristics of the area surrounding the air monitoring site and the site's distance from nearby air pollution sources.

40 CFR 58.30(a) identifies unique micro and middle scale sites as possibly being ineligible for comparison to the annual NAAQS. The Cowtown Road site was initially a micro scale site until 2011 when it was changed to a middle scale site in the Annual Network Plan. The site remained middle scale during the remainder of its operation. Part of the criteria EPA required when evaluating potential relocation sites for the Cowtown Road site was that the new site would need to have the characteristics to remain a middle scale site. 40 CFR 58.14(c)(6) states that "A SLAMS monitor not eligible for removal under any of the criteria in paragraphs (c)(1) through (c)(5) of this section may be moved to a nearby location with the same scale of representation if logistical problems beyond the State's control make it impossible to continue operation at its current site." The EPA, in the Cowtown site relocation approval letter dated October 22, 2015, noted that the new Hidden Valley site fulfilled the requirements of 40 CFR 58.14(c)(6) including that it is a nearby location with the same scale or representation[2]. The Hidden Valley site has been listed as middle scale in the Pinal County Annual Network Plan since it began operation.

To confirm that the site still meets with the same scale of representation, a review of the site was completed. 40 CFR 58 App. D 1.2(a) states that a "spatial scale of representativeness is described in terms of the physical dimensions of the air parcel nearest to a monitoring site throughout which actual pollutant concentrations are reasonably similar." To evaluate the Hidden Valley site for spatial scale a review of the land use and emission sources around the Hidden Valley site was conducted.

### Land Use

Like the Cowtown Road site, the Hidden Valley site is primarily surrounded by cattle feedlots and agricultural activity. One significant difference is that there are also dairy activities around the Hidden Valley site. Dairies are much more common within Pinal

County.  According to Arizona Cattle Feeders Association as cited in the *2022 Serious Area Particulate Plan for $PM_{10}$ for the West Pinal County Nonattainment Area*[3] there are only three feedlot operations remaining within Pinal County.  One is located next to the old Cowtown Road site, one is located next to the current Hidden Valley site and one is located between the Stanfield site and the City of Casa Grande.  There are significantly more dairy operations within Pinal County including directly next to the Hidden Valley site and also about the same distance from the Stanfield site as is the feedlot.  The old Cowtown site did not have any nearby dairy operations.  Figure 10 shows a map of all of Pinal County indicating all of the feedlot and dairy locations as well as the monitoring sites.  Figure 1 provides a map of the Hidden Valley and Stanfield land use areas indicating the feedlot and dairy locations as well as the locations of the monitoring sites including the old Cowtown Road site.  Figures 2 through 4 illustrate each monitoring site's land use in more detail.  The Hidden Valley $PM_{2.5}$ monitor (Figure 2) is approximately 0.275 km from a calving operation to its SE, 0.530 km to the dairy to the East, and 1.3 km to the feedlot to the East.  The old Cowtown Road site (Figure 3), located approximately 15.3 km NE of the Hidden Valley site, had very similar land use characteristics and site location with the exception of the dairy facility.  The closest feedlot was approximately 0.260 km to the SW of the Cowtown Road $PM_{2.5}$ monitor.

An evaluation of the other nearby site, the Stanfield site (Figure 4) shows that while it shares some similar characteristics, the Hidden Valley site is unique in its positioning relative to how close it is to the feedlots and dairies.  The Stanfield site, which is located approximately 7 km to the East of The Hidden Valley site has much of the same agricultural impact but the nearest feedlot or dairy facility is significantly farther away.  The nearest feedlot to the Stanfield site is located approximately 3.5 km to the E and the nearest dairy facility is located approximately 3.3 km to the NW.

Figure 1: Hidden Valley, Cowtown, and Stanfield sites Land Use

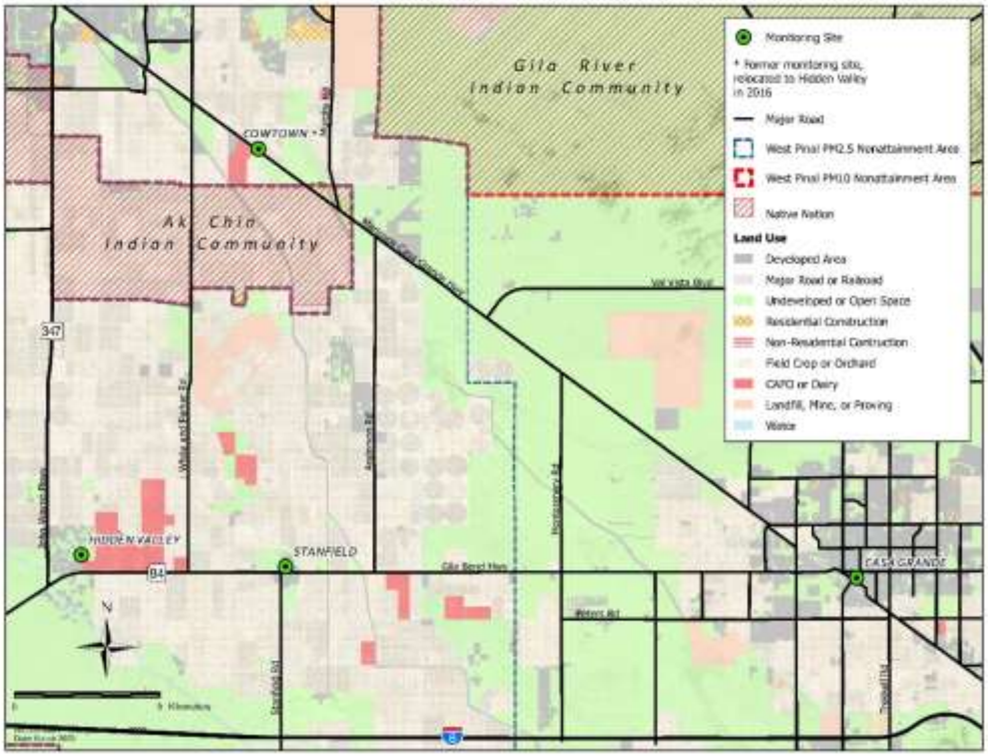



Figure 2: Hidden Valley Site Land Use

Figure 3: Cowtown Road Site Land Use

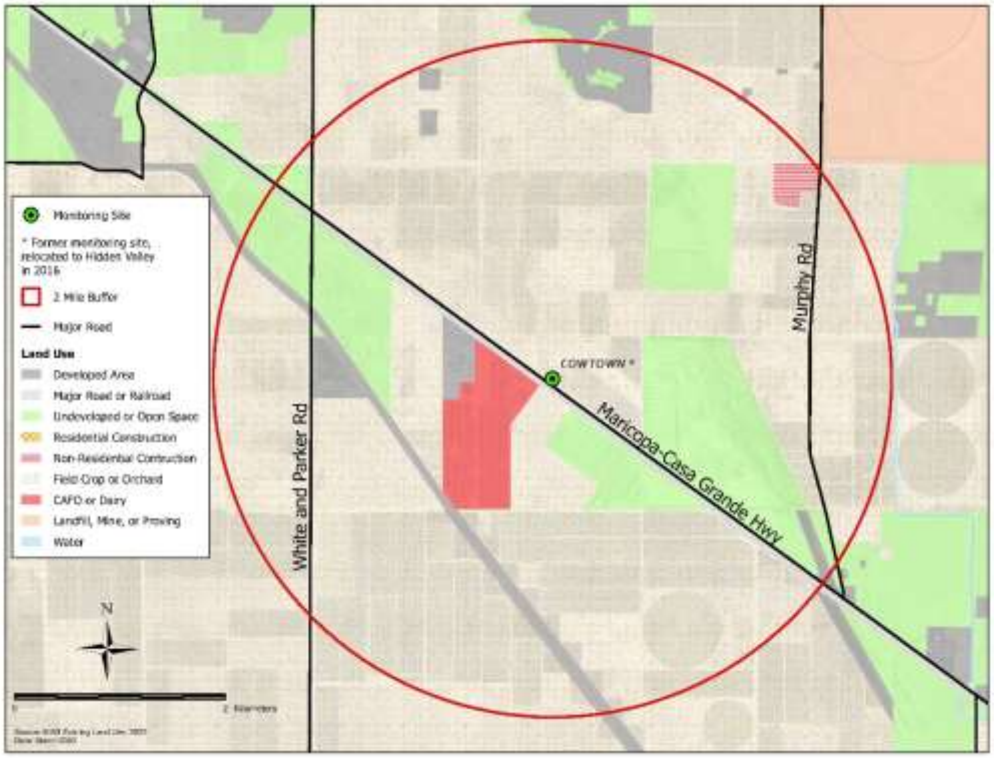
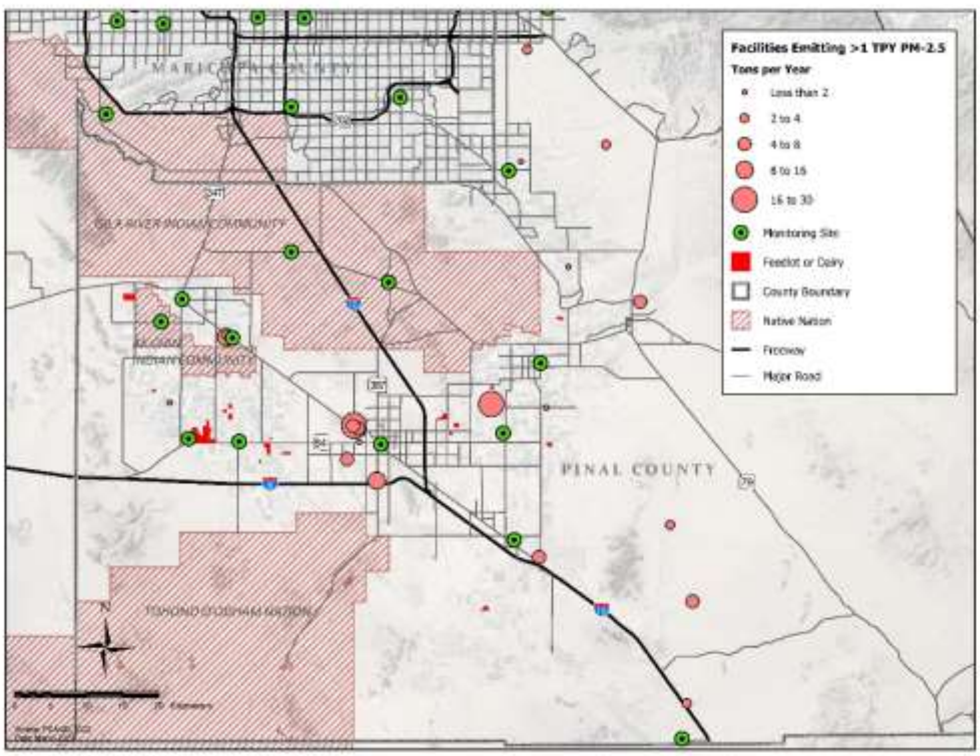



Figure 4: Stanfield Site Land Use

**Emission Sources:**

In addition to the agricultural and feedlot/dairy emissions, the site was reviewed for possible influences by industrial or other permitted emission sources as well as possible influence from particulate matter precursor pollutants. Figure 5 illustrates all permitted facilities emitting more than 1 tpy of $PM_{2.5}$. As shown in Figure 5, there are no permitted $PM_{2.5}$ sources that emit more than 1 tpy within a 15 km proximity to the Hidden Valley monitor. In contrast, the Casa Grande Downtown $PM_{2.5}$ monitor has several $PM_{2.5}$ sources nearby and is currently attaining both the current annual (7.0 ug/$m^3$) and 24-hour (15 ug/$m^3$) $PM_{2.5}$ NAAQS using 2021 – 2023 data. The lack of permitted industrial sources near the Hidden Valley monitor supports the primary sources at that monitor being the feedlot/dairy operations.

Figure 5: $PM_{2.5}$ Emission Sources in Pinal County




As part of the *2022 Serious Area Particulate Plan for $PM_{10}$ for the West Pinal County Nonattainment Area*[3], the Maricopa Association of Governments (MAG) performed a precursor pollutant study. That study is Attachment A within Appendices Volume 1 of the Serious Area Plan and is titled *Weight of Evidence Demonstration that Particulate Matter Precursors Do Not Significantly Contribute to $PM_{10}$ Exceedances in the West Pinal County $PM_{10}$ Nonattainment Area*. MAG followed EPA guidance using photochemical modeling to estimate the precursor pollutant impact on $PM_{2.5}$ concentrations within the West Pinal $PM_{10}$ Nonattainment Area. The results of the modeling indicate that none of the four precursor pollutants ammonia ($NH_3$), nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), and volatile organic compounds (VOC) significantly contribute to $PM_{2.5}$ concentrations. Figure 6 is from that document and summarizes the $PM_{2.5}$ impact from precursor pollutants.

Figure 6: CAMx Modeled Individual Precursor Pollutant Impacts on $PM_{2.5}$ Concentrations

| Monitoring Site | 2016-2018 PM-2.5 Design Value (DV) | 70% reduction of anthropogenic VOC | | 70% reduction of anthropogenic $NO_x$ | | 70% reduction of anthropogenic $NH_3$ | | 70% reduction of anthropogenic $SO_2$ | | EPA Contribution Threshold |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Resulting PM-2.5 DV (Sensitivity) | PM-2.5 Contribution from VOC | Resulting PM-2.5 DV (Sensitivity) | PM-2.5 Contribution from $NO_x$ | Resulting PM-2.5 DV (Sensitivity) | PM-2.5 Contribution from $NH_3$ | Resulting PM-2.5 DV (Sensitivity) | PM-2.5 Contribution from $SO_2$ | |
| Casa Grande | 19.3 | 18.9 | 0.4 | 19.1 | 0.2 | 18.8 | 0.5 | 19.3 | 0.0 | ≥ 1.5 |
| Hidden Valley | 34.3 | 34.2 | 0.1 | 34.2 | 0.1 | 34.1 | 0.2 | 34.3 | 0.0 | |

*Notes: All concentrations are in micrograms per cubic meter.*
*The design value is based on the 3-year average of the annual 98th percentile for 2016-2018.*
*High Wind Dust Events have been removed from calculation of the 2016-2018 design value.*

In 2005 Pinal County produced the *Pinal County Air Quality Control District Source Apportionment Study*[4]. The study was designed to identify the major particulate matter sources within the Pinal County agricultural basin using both collected samples and modeling. One major finding from the study was that "The Chemical Mass Balance analysis of the $PM_{2.5}$ filters from the "Cowtown Road" monitoring site indicates feedlot emissions contribute to $PM_{2.5}$ concentrations. When $PM_{2.5}$ ambient concentrations rise, feedlot emissions contribute more than 50% of observed impacts of $PM_{2.5}$."

The study was conducted at the Casa Grande Downtown, Coolidge (now closed), Cowtown Road, Pinal County Housing, and Stanfield sites. Figures 7 – 9 below are the $PM_{2.5}$ source contribution charts for the Casa Grande Downtown, Cowtown Road, and Stanfield sites.

Figure 7: $PM_{2.5}$ source contributions for the Casa Grande Downtown site

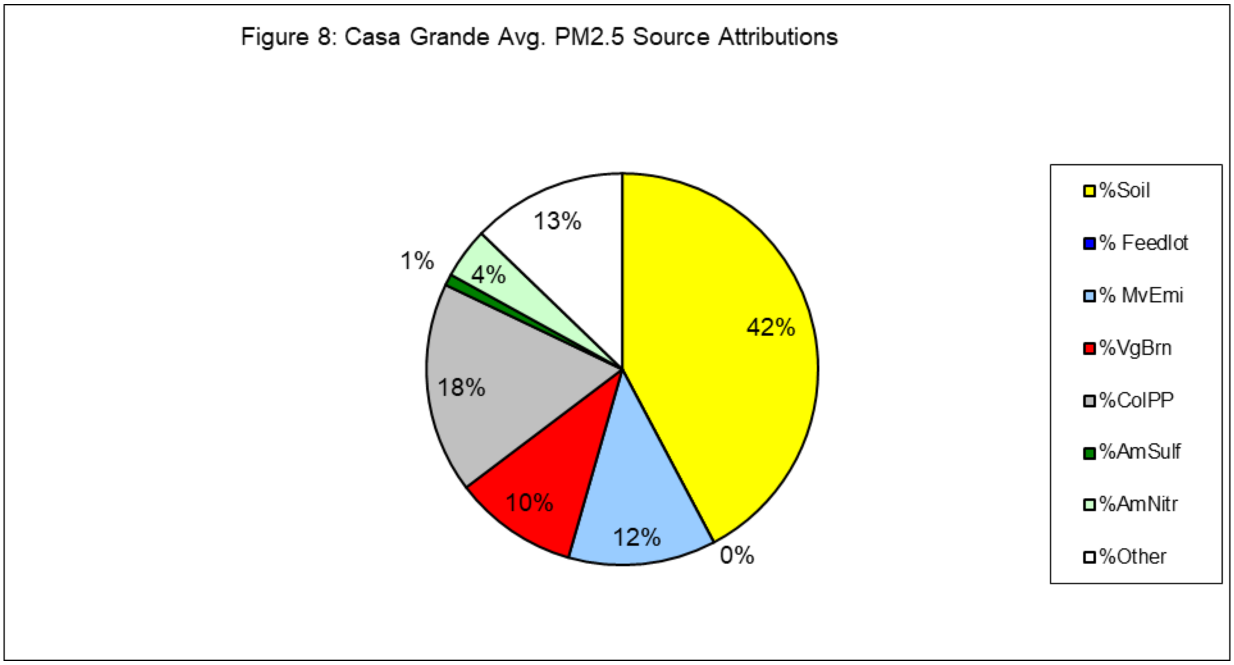



Figure 8: $PM_{2.5}$ source contributions for the Cowtown Road site

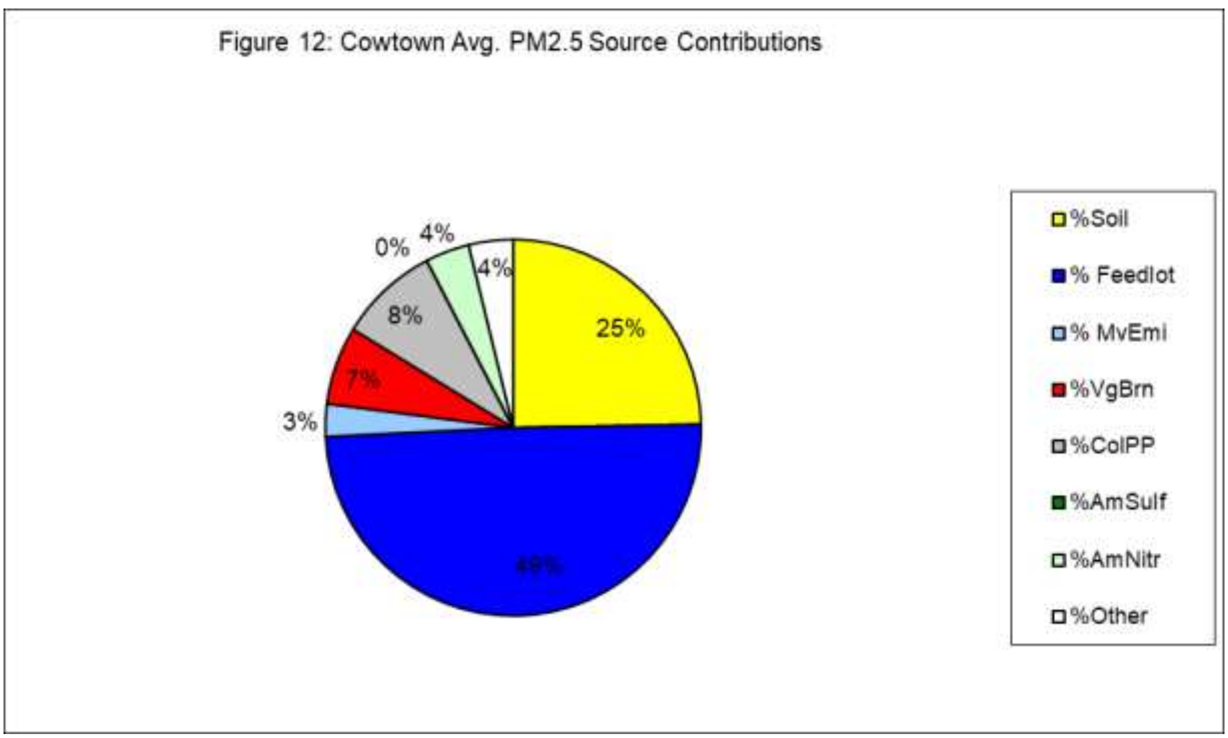
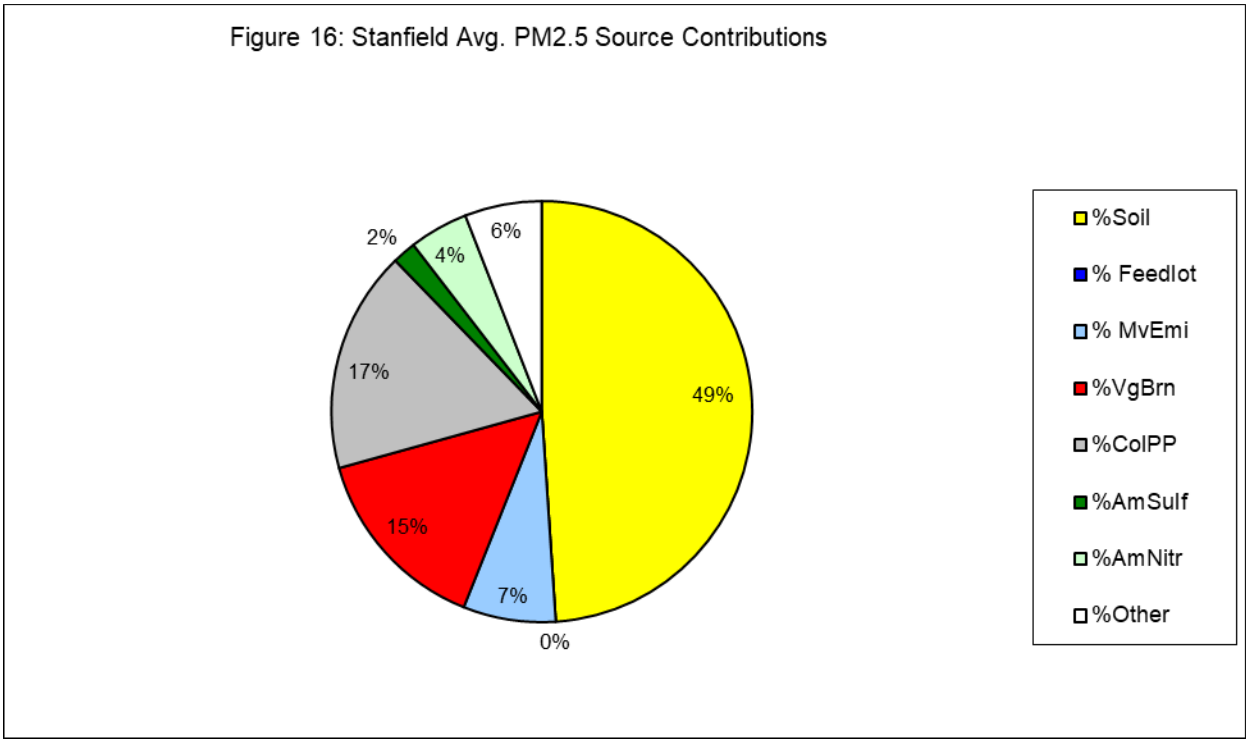


Figure 9: $PM_{2.5}$ source contributions for the Stanfield site




Both the Casa Grande Downtown and Stanfield sites show no impact on $PM_{2.5}$ concentrations from feedlot activity while the Cowtown Road site shows that 49% of the source contribution is from the feedlot. There was not a Hidden Valley site at the time of the study so there is no specific information for that site but it is reasonable to expect that it would look similar to the Cowtown Road site because they share many site characteristics including feedlot proximity.

The lack of any contribution to the $PM_{2.5}$ at the Stanfield site from a feedlot 3.5 km away indicates that the impact of the feedlot is localized and does not expand out to a significant area that would be represented by a larger spatial scale.

One thing not covered in that study was emission differences between feedlots and dairy facilities. In a study published in 2022 studying feedlot and dairy emissions in Texas[5], there were significantly larger emissions found from feedlots. The study included measured PM concentrations, meteorological data, distance of the monitors from the source, and AERMOD modeling to create an average emission factor for both feedlots and dairies. Based on their study they determined the emission factor for dairies to be 0.34 kg/1000hd/day, with hd being head of cattle. The emission factor for feedlots was found to be 6.47 kg/1000hd/day. That is a significant difference in emissions and there are only three feedlots located within Pinal County, including the one located next to the Hidden Valley site. Figure 10 shows the feedlots and dairies across all of Pinal County. Figures 11 – 13 show the Hidden Valley, Stanfield, and the old Cowtown Road sites in more detail.

Figure 10: Feedlots and Dairies within Pinal County

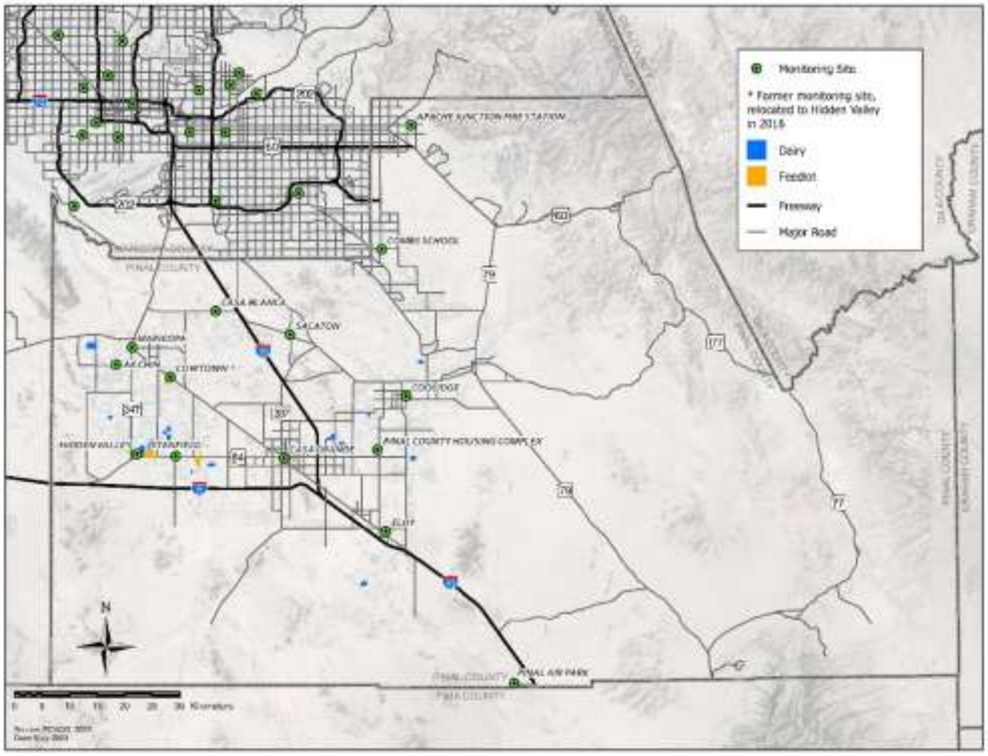



Figure 11: Feedlots and Dairies around the Hidden Valley Site

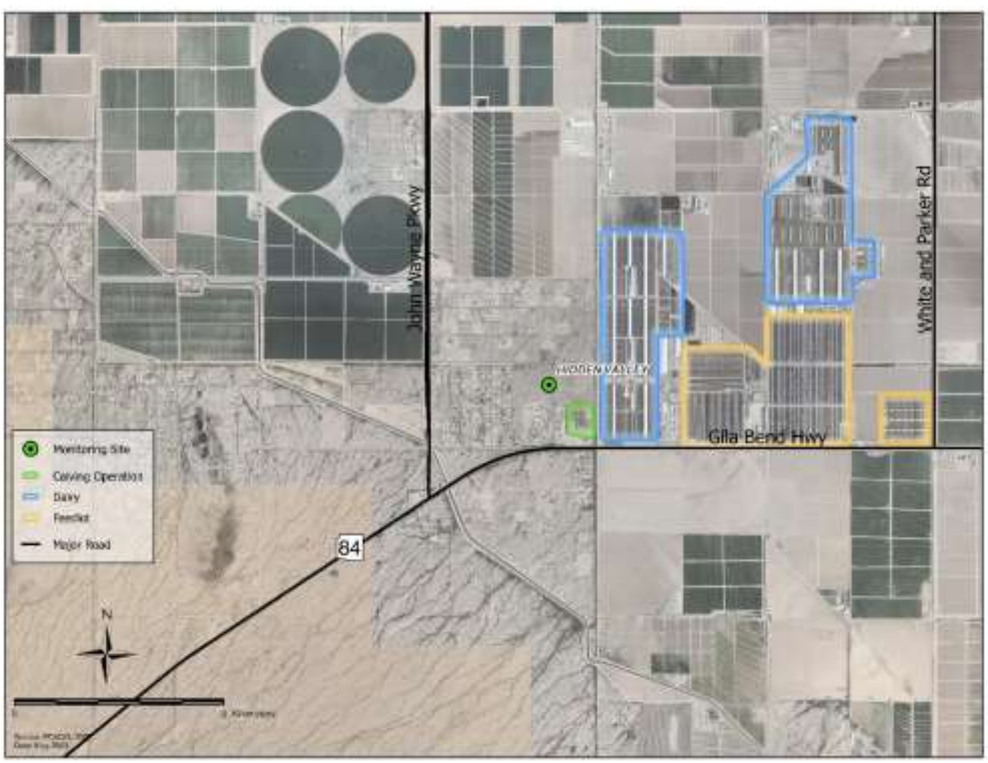


Figure 12: Feedlots and Dairies around the Stanfield Site


Figure 13: Feedlots and Dairies around the Cowtown Road Site

Based on source-specific land uses around the site, the proximity to one specific source (feedlot/dairy) and the relatively small area, the Hidden Valley site appears to best match the criteria of a middle scale site. This analysis confirms the analysis performed during the Cowtown Road site relocation process, approved by EPA, and its current representation in the Pinal County Annual Network Plan.

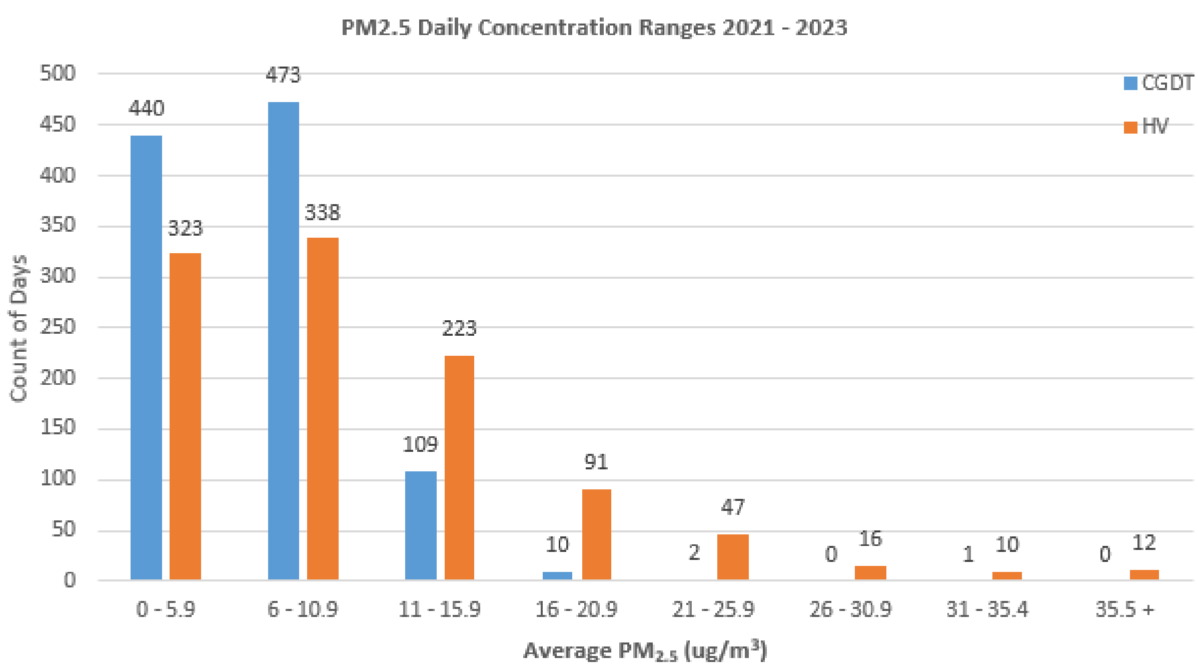
## Impact of the source on the monitor:

If the previously referenced study done in Texas[5] and its corresponding emission factors are correct then there would be an expected increase in $PM_{2.5}$ at the Hidden Valley site and the old Cowtown Road site as they were both within proximity to feedlots. The Stanfield site is significantly farther away from either a feedlot or dairy and the nearest dairy to the Casa Grande site is approximately 8.7 km away and the nearest feedlot is approximately 15.4 km away. To analyze the impact of the feedlot/dairy sources on the monitor two data comparisons were conducted to help evaluate the effects of the primary source on the monitor.

### Existing Site Data Review:

The first comparison was to compare $PM_{2.5}$ concentrations from nearby sites. The only nearby site with a Federal Equivalent Method (FEM) or Federal Reference Method (FRM) $PM_{2.5}$ monitor is the Casa Grande Downtown site. Figure 14 illustrates the number of days with daily $PM_{2.5}$ averages of set concentration ranges from 2021 - 2023.

Figure 14: Hidden Valley vs. Casa Grande Downtown Site $PM_{2.5}$ Daily Concentrations




The resulting data is not surprising given the conditions surrounding each site and the historical $PM_{2.5}$ data from each site. Both sites have the highest counts at the lowest concentrations but the Hidden Valley site has 85 days with $PM_{2.5}$ averages above 21.0

$ug/m^3$ while the Casa Grande Downtown site has only 3 such days. The Hidden Valley site is in a rural setting with mostly dirt roads and lots of agricultural activity. The Casa Grande Downtown site is within the city limits of Casa Grande and is a much more urban site located within a much larger population area with significantly different land use (i.e. developed) around the site. The surrounding areas including the roads are all paved. Figure 15 highlights the land uses around the Casa Grande Downtown site in comparison to those around the Hidden Valley site illustrated in Figure 2.

Figure 15: CGDT Site Land Use


**$PM_{2.5}$ Sensor Study:**

The second data comparison involved the installation of portable sensors that would measure $PM_{10}$ and $PM_{2.5}$. Pinal County Air Quality had recently been allowing Arizona State University to collocate some portable sensors at the Pinal County Housing site and they found the QuantAQ sensor to be the most accurate of the sensors they tested. Pinal County elected to use the QuantAQ sensors based on this history of successful comparison to FEM monitors. In addition to the Hidden Valley site, Pinal County decided to install the QuantAQ sensors at Stanfield, Casa Grande Downtown, and Maricopa. The sites were selected based on their location to the Hidden Valley site. In addition, these sites also provide a variety of source impacts, both similar (Stanfield) and very different (Casa Grande and Maricopa) from the Hidden Valley site. Prior to the start of the data collection, all of the sensors were collocated at the Hidden Valley site for a period of 10 days, from June 29, 2023, through July 09, 2023, to determine if the sensors could produce quality data. The results of the initial sample period show that each sensor had a negative bias but they correlated well against the FEM BAM 1020 located at the Hidden Valley site. Figure 16 below shows the correlation and $r^2$ value of each sensor against the BAM 1020.

Figure 16: QuantAQ Sensor vs. BAM 1020 Correlation

| | HV BAM 1020 | MOD-PM-01001 | MOD-PM-01003 | MOD-PM-01004 | MOD-PM-01002 |
|---|---|---|---|---|---|
| Avergae (ug/m3) = | 17.6 | 12.4 | 11.0 | 9.9 | 11.1 |
| Correlation = | | 0.917 | 0.924 | 0.925 | 0.923 |
| r2 = | | 0.841 | 0.853 | 0.856 | 0.852 |
| Slope Vs. MOD-PM-01003 = | 1.710 | 0.846 | | 1.058 | 0.979 |

The initial sample data was used to determine which sensor went to which site. From the study MOD-PM-01003 and MOD-PM-01002 had the closest total data average over the trial period. In addition, when the data was graphed, the slope of the regression line using MOD-PM-01003 and MOD-PM-01002 was the closest to 1.0 at 0.979. The sum of this initial data analysis determined that the two most similar sensors, MOD-PM-01003 (Hidden Valley) and MOD-PM-01002 (Stanfield), would be selected to go to the Hidden Valley and Stanfield sites respectively. The sensor data similarity was also important because the comparison between the two sites was one of the primary objectives of this data study. MOD-PM-01001 went to the Casa Grande Downtown site and MOD-PM-01004 went to the Maricopa site. The sensors were installed at their respective sites on July 12, 2023, and data for this study is from July 13, 2023, through February 25, 2024. The sensors were returned to the Hidden Valley site in March 2024 to complete another correlation test against the Hidden Valley BAM 1020 and each other. The sensors ran collocated again at the Hidden Valley site from April 1, 2024, through April 14, 2024; the results are shown in Figure 17.

Figure 17: QuantAQ Sensor vs. BAM 1020 Post-Study Correlation

| | HV BAM 1020 | MOD-PM-01001 | MOD-PM-01003 | MOD-PM-01004 | MOD-PM-01002 |
|---|---|---|---|---|---|
| Avergae (ug/m3) = | 7.6 | 3.0 | 3.1 | 2.9 | 2.9 |
| Correlation = | | 0.804 | 0.816 | 0.811 | 0.812 |
| r2 = | | 0.647 | 0.666 | 0.657 | 0.659 |
| Slope Vs. MOD-PM-01003 = | 1.351 | 0.959 | | 0.921 | 0.918 |

An analysis of the post-study correlation shows that each sensor's bias is slightly more negative than during the initial study. The correlation and $r^2$ values indicate that the data does not compare quite as well against the BAM 1020 as it did before the study. The sensors do still compare well against each other as indicated by both the average concentration and the slope when compared to the Hidden Valley sensor MOD-PM-01003.

Pinal County decided not to try and correct the QuantAQ data against the BAM 1020 data and decided instead to focus on a comparison of QuantAQ data across the sites. This decision was primarily made because the BAM 1020 only reports hourly concentrations and the focus of this study was done using 5-minute data to better correlate a concentration to a wind direction. Using hourly wind directions is much less accurate considering that wind direction can change frequently. Using 5-minute data helps keep a more accurate picture of the concentration versus wind direction. In some of the results, the BAM 1020 data will be displayed for reference purposes only if hourly data is used.

### Average $PM_{2.5}$ Concentration Analysis:

The design of the study was to compare stagnation conditions vs non-stagnation conditions at each site and to quantify the $PM_{2.5}$ concentration measured from various wind speeds and wind directions. In addition to the $PM_{2.5}$ data Pinal County also collected MET data (wind speed and wind direction) which was used to separate the data into each category. For the analysis done the wind direction was broken down into groups of $30^{o}$ segments and wind speeds were separated into categories of less than 2.5 mph, 2.5 – 5.0 mph, 5.0 – 12.0 mph, and > 12.0 mph.

To start the analysis the average concentration was compared at all the sites during the study period. This first analysis does not take wind speed or wind direction into consideration. Figure 18 shows the average concentration of all the sensors and the BAM 1020 for reference throughout the study period.

Figure 18: $PM_{2.5}$ Average (ug/$m^3$) Concentration at Each Site

| | HV BAM 1020 | HV QuantAQ | STNF QuantAQ | CGDT QuantAQ | MCPA QuantAQ |
|---|---|---|---|---|---|
| All Data Average | 9.9 | 6.8 | 6.7 | 6.0 | 4.0 |

Looking just at the total data averages at the sites yields both expected and unexpected results. The first expected result is that both the Casa Grande Downtown and Maricopa sites have lower averages than either the Hidden Valley or Stanfield sites, with Maricopa being the lowest site. This order was expected as it correlates to the recorded $PM_{10}$ data collected at each site over their years of operation. The Casa Grande Downtown site has a BAM 1020 at the site so we know from historical data that the site is consistently lower than the Hidden Valley site (See Appendix C of this Annual Network Plan for historical data at each site). It is also important to note that the Casa Grande Downtown site has more permitted facilities emitting $PM_{2.5}$ than the Maricopa site (see Figure 5). In addition to the lack of permitted $PM_{2.5}$ sources, the Maricopa site has the benefit of being located within a city, like the Casa Grande Downtown site, and has most of the surrounding area paved to eliminate significant fugitive dust contributions. The unexpected result from the total data average is that the Hidden Valley site has only a slightly higher concentration than the Stanfield site. This is a bit surprising as the $PM_{10}$ data from both sites has historically shown that the Hidden Valley site has a significantly higher $PM_{10}$ concentration than the Stanfield site. This is the first $PM_{2.5}$ data at the Stanfield site and, at least during this study, indicates that the $PM_{2.5}$ concentrations at the Hidden Valley site are only slightly greater than those at the Stanfield site.

**Directional $PM_{2.5}$ Concentration Analysis:**

One of the primary focuses of the study was to compare the Hidden Valley and Stanfield sites since they share many similarities. With that focus in mind, the remainder of the analysis was performed on just those two sites. To start the Hidden Valley and Stanfield analysis, the first step was to separate the data into $30^o$ segments and compare the average concentration from each segment. Figure 19 is a map of the Hidden Valley and the Stanfield sites and each site's surrounding areas with each of the $30^o$ segments marked for reference. The feedlots and dairies are also marked as they were in Figures 11 and 12. Figure 20 is a table summarizing the main land uses around each site. This table was created using the information in Figure 2 and Figure 4.

Figure 19: Hidden Valley and Stanfield Sites and Study Segments

Figure 20: Summary Table of the land uses around the Hidden Valley and Stanfield Sites

| Degree Section | Hidden Valley | Stanfield |
|---|---|---|
| 30-60 | Agriculture, dairy, developed area, undeveloped area | Agriculture, developed area, undeveloped area |
| 60-90 | Agriculture, dairy, developed area, undeveloped area | Agriculture, developed area, undeveloped area |
| 90-120 | Agriculture, CAFO, dairy, undeveloped area | Agriculture, developed area, undeveloped area |
| 120-150 | Agriculture, CAFO, dairy, undeveloped area | Agriculture, developed area, undeveloped area |
| 150-180 | Agriculture, CAFO, dairy, undeveloped area | Agriculture, developed area, undeveloped area |
| 180-210 | Developed area, undeveloped area | Agriculture, developed area, undeveloped area |
| 210-240 | Developed area, undeveloped area | Agriculture, developed area, undeveloped area |
| 240-270 | Developed area, undeveloped area | Agriculture, developed area, undeveloped area |
| 270-300 | Agriculture, developed area, undeveloped area | Agriculture, developed area, undeveloped area |
| 300-330 | Agriculture, developed area, undeveloped area | Agriculture, developed area, undeveloped area |
| 330-360 | Agriculture, developed area, undeveloped area | Agriculture, dairy, developed area, undeveloped area |

Data was separated into each segment and the resulting averages are summarized in Figures 21 and 22, with Figure 21 representing the Hidden Valley site and Figure 22 representing the Stanfield site. This part of the analysis does not consider wind speed.

Figure 21: Average $PM_{2.5}$ (ug/m$^3$) Concentrations from each segment at the Hidden Valley Site

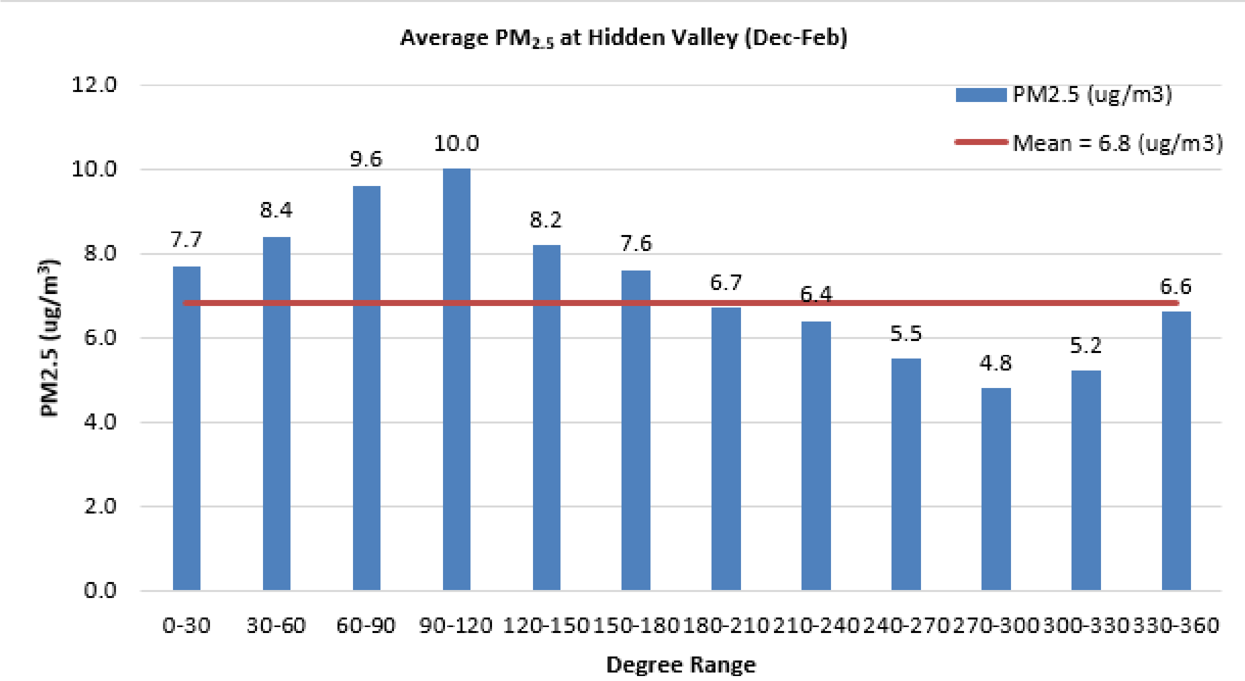
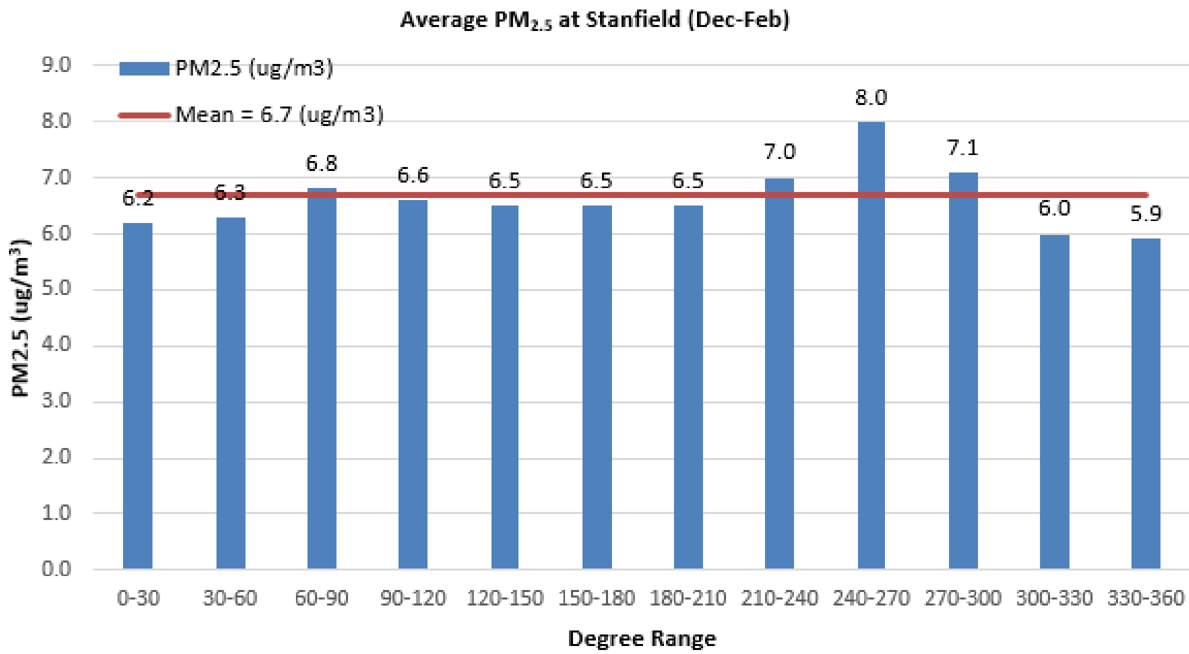


Figure 22: Average $PM_{2.5}$ ($ug/m^3$) Concentrations from each segment at the Stanfield Site




While both sites have a similar overall average concentration it is clear that the Hidden Valley site is getting significant contributions from a specific range while the Stanfield site is almost completely uniform in terms of concentration. At the Hidden Valley site the range from 0-180 degrees shows concentrations above the average. Even more specifically, the highest concentrations come from the 30-150 degree range. The land uses in these degree ranges include agriculture, undeveloped land, and the feedlot/dairy operations. At the Stanfield site, the only range with elevated concentrations is the 210-300 degree range with only the 240-270 range being significantly elevated. That degree range has land uses that include agriculture, developed land, and undeveloped land.

### Wind Speed vs. $PM_{2.5}$ Concentration Analysis:

The next part of the analysis focused on the wind speed component to try and identify if the sources were local or transported. For this analysis, the data used in Figures 21 and 22 were broken down further into the following wind speed ranges: less than 2.5 mph, 2.5 – 5.0 mph, 5.0 – 12.0 mph, and > 12.0 mph. Figures 23 and 24 summarize the results.

Figure 23: Average $PM_{2.5}$ Concentration Using Wind Speed at the Hidden Valley Site

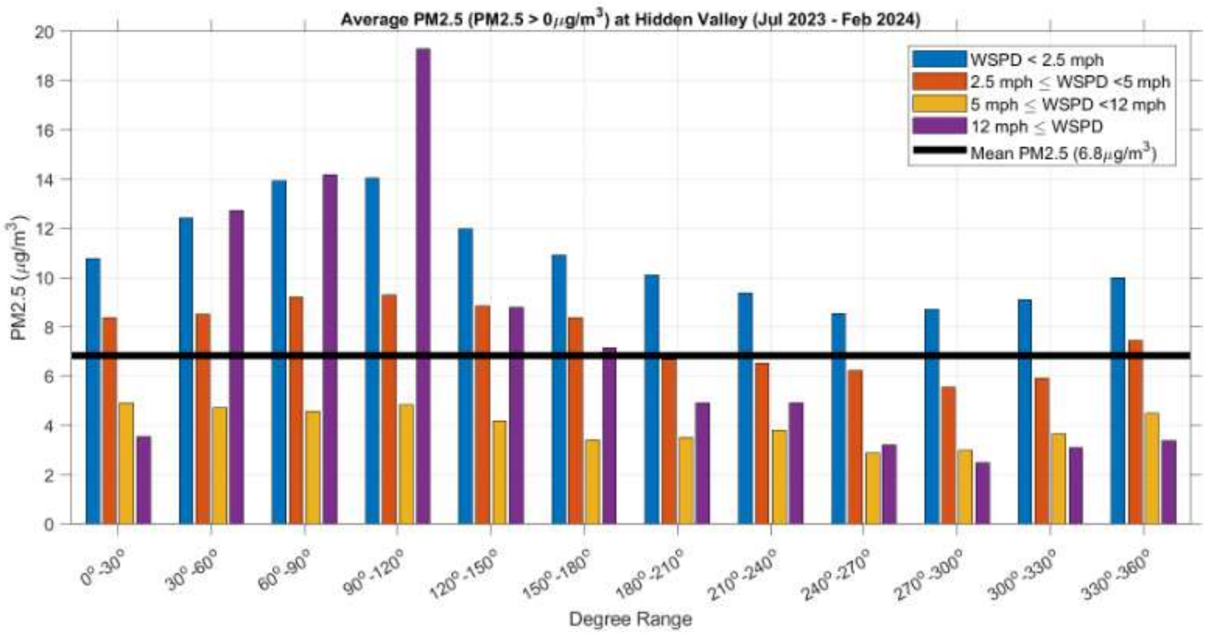
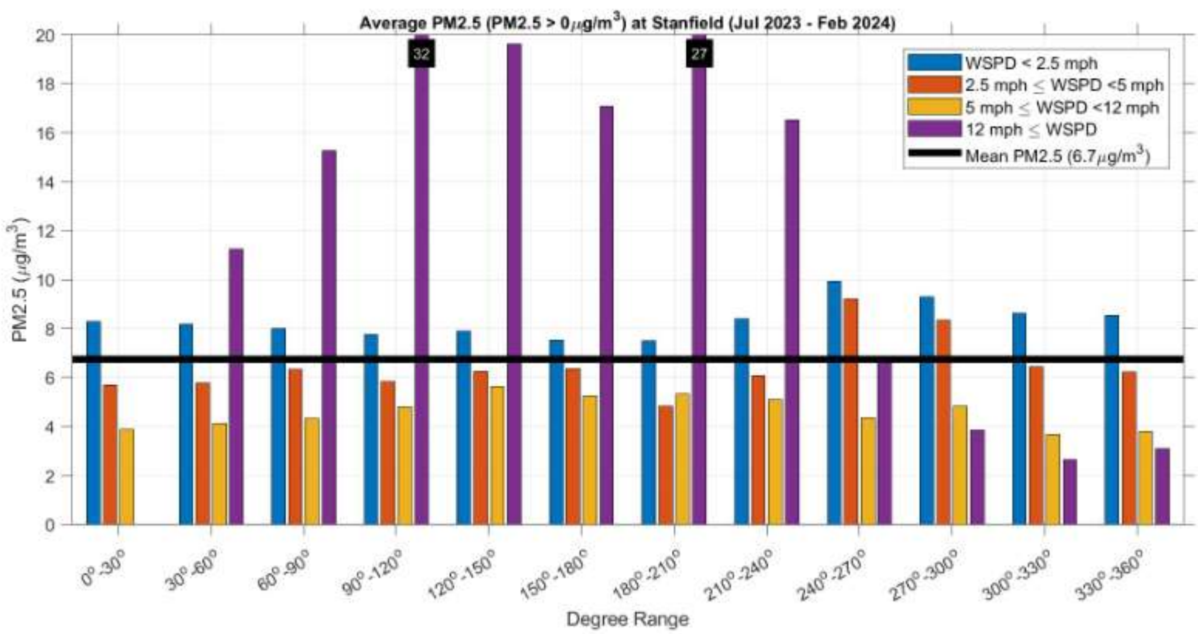



Figure 24: Average $PM_{2.5}$ Concentration Using Wind Speed at the Stanfield Site




As with the simple average concentration data, there are stark differences between the Hidden Valley and Stanfield sites. The primary finding from this data for the Hidden Valley site is that from all degree ranges the average concentration is greater than the overall average when the wind speed is below 2.5 mph and the overall averages are the greatest when the wind speed is less than 2.5 mph. In all sections except one, the highest average concentrations are during the lowest wind speed. This indicates that the impacts on the Hidden Valley monitor are primarily local. It is worth noting that the one wind direction section ($90^o$-$120^o$) that has high concentrations during high wind conditions has land uses including agriculture, feedlot and dairy operations, and undeveloped land.

At the Stanfield site, the picture is completely different. Wind speeds above 12.0 mph have the highest average concentrations. The average concentrations with wind speeds below 2.5 mph are the second highest which indicates that there are some local effects on the site as well. The 30 – 240 degree range has the highest concentrations coming from wind speeds greater than 12.0 mph.

### Seasonal $PM_{2.5}$ Concentration Analysis:

Because we know there are significant changes throughout the year an analysis was performed to evaluate the seasonal changes on each site. For this analysis, the data used in Figures 21 and 22 was broken down into summer (June – September), fall (October – November), and winter (December – February) seasons. The spring season was not captured during this study but is normally March through May. To demonstrate the conditions in the area the average monthly temperatures and monthly rainfall were calculated since 2016, the year the Hidden Valley monitor became active. The data came from the National Weather Service for Casa Grande, Arizona (https://www.weather.gov/) and the results are shown in Figure 25.

Figure 25: Temperature and Rainfall in Casa Grande, Arizona

| Month | Average Rainfall (inches) | Average Temperature (°C) | Maximum Temperature (°C) |
|---|---|---|---|
| January | 0.92 | 11.4 | 19.8 |
| February | 0.45 | 12.7 | 21.8 |
| March | 0.23 | 16.6 | 25.7 |
| April | 0.13 | 20.1 | 30.2 |
| May | 0.09 | 24.8 | 35.1 |
| June | 0.27 | 30.6 | 40.6 |
| July | 0.88 | 33.5 | 41.4 |
| August | 0.95 | 32.4 | 40.5 |
| September | 0.56 | 29.3 | 38.2 |
| October | 0.65 | 23.2 | 32.5 |
| November | 0.31 | 16.3 | 25.4 |
| December | 1.51 | 11.1 | 19.4 |

Arizona typically receives a limited amount of rain throughout the year and it is concentrated during the end of the summer and the winter seasons. During the winter season, the temperatures are at their lowest while the rainfall is at its highest. This trend flips in the spring and summer, especially May and June when the rainfall drops to its lowest amount and the temperatures are almost at their peak. This combination leads to dry soil conditions. The "monsoon season" in Arizona is typically defined as June 15th through September 30th and is identified by large-scale wind shifts that bring moisture in addition to strong winds[6]. This is a simplistic description of the weather patterns and is only meant to provide some reference on the seasonal temperature and rainfall conditions.

In the seasonal breakdown for this analysis, the summer period should capture the dry season in Arizona and also the monsoon storms. Both conditions lead to elevated average $PM_{2.5}$ concentrations. The fall season should capture the transition to the winter season and the winter season should capture Arizona's colder and less dry conditions. Figures 26 – 28 summarize the Hidden Valley data and Figures 29 – 31 summarize the Stanfield data.

Figure 26: Average $PM_{2.5}$ Concentration Using Wind Speed at the Hidden Valley Site (Jul-Sep)

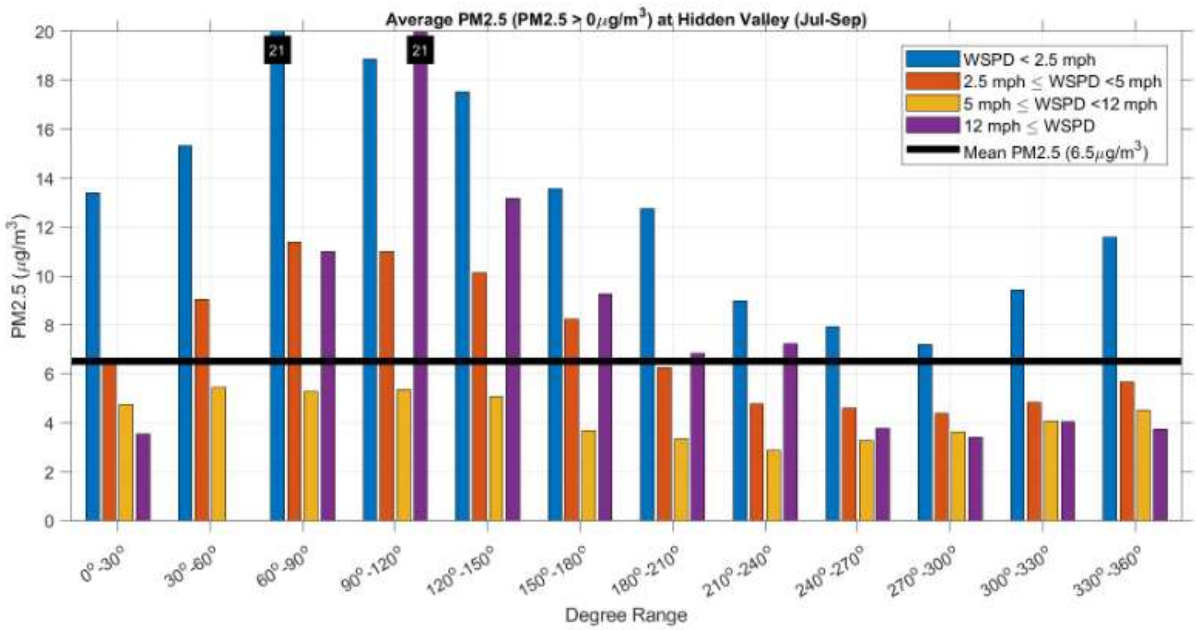


Figure 27: Average $PM_{2.5}$ Concentration Using Wind Speed at the Hidden Valley Site (Oct-Nov)

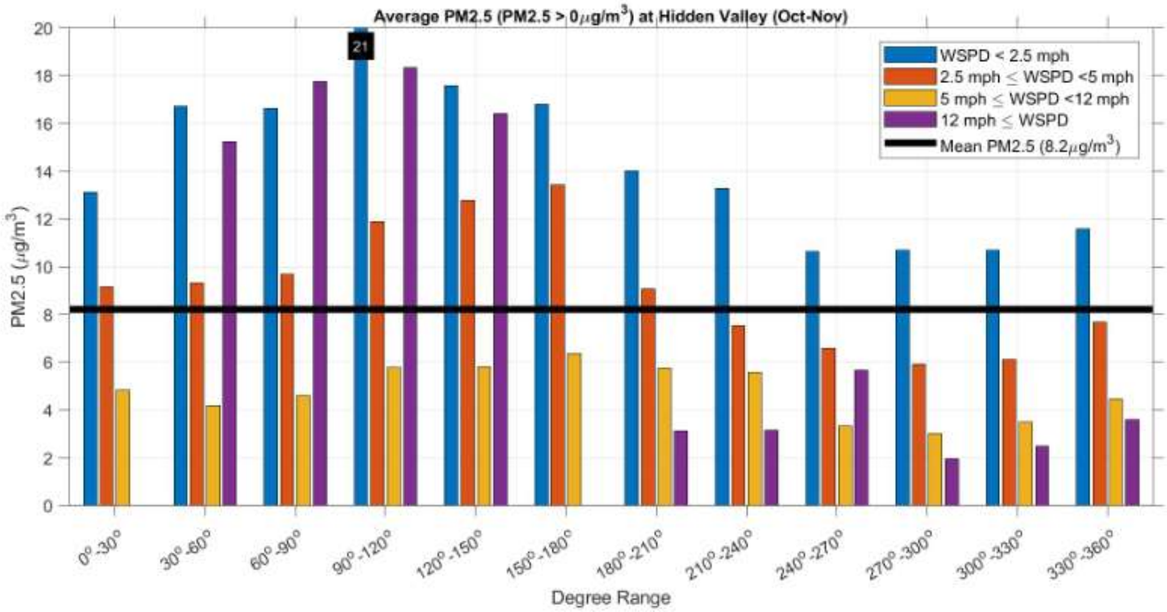



Figure 28: Average $PM_{2.5}$ Concentration Using Wind Speed at the Hidden Valley Site (Dec-Feb)

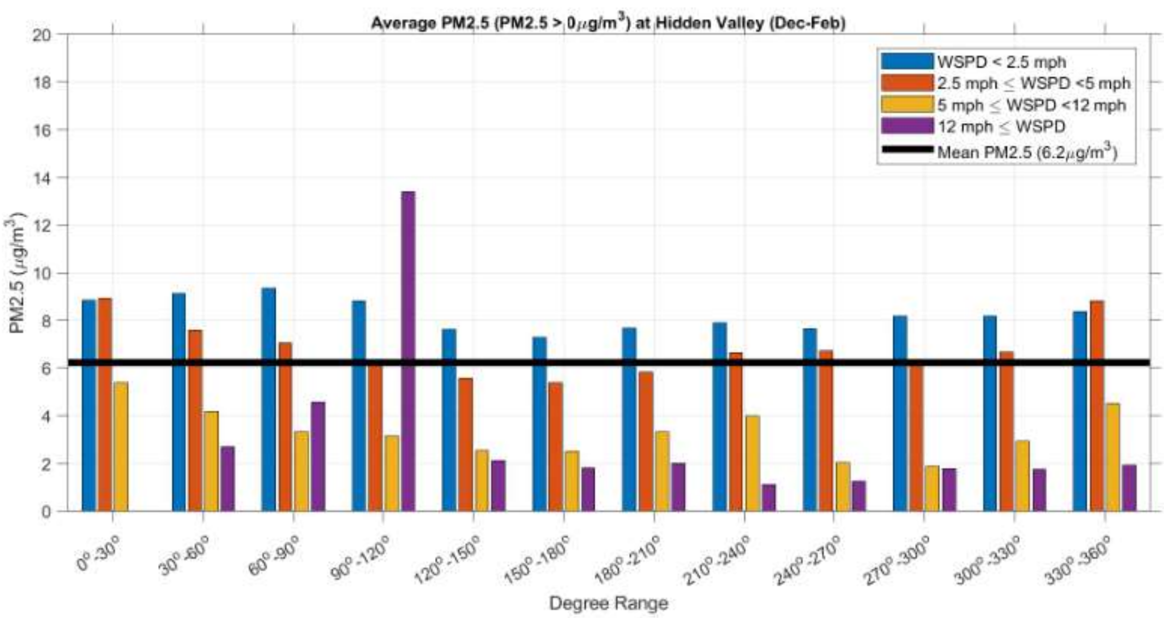


Figure 29: Average $PM_{2.5}$ Concentration Using Wind Speed at the Stanfield Site (Jul-Sep)

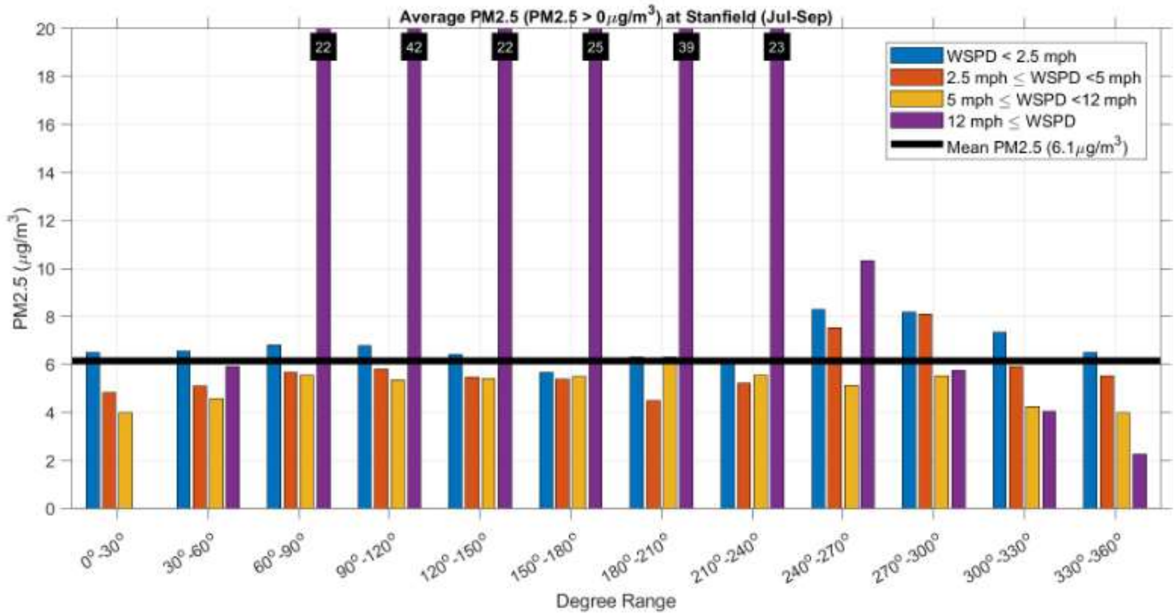



Figure 30: Average $PM_{2.5}$ Concentration Using Wind Speed at the Stanfield Site (Oct-Nov)

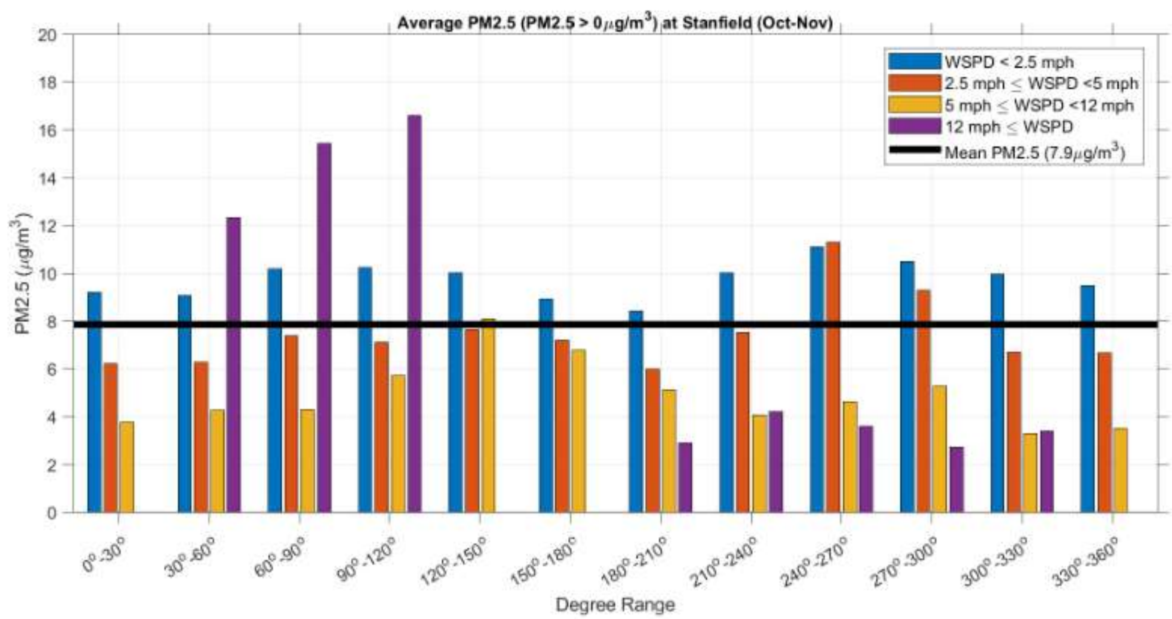
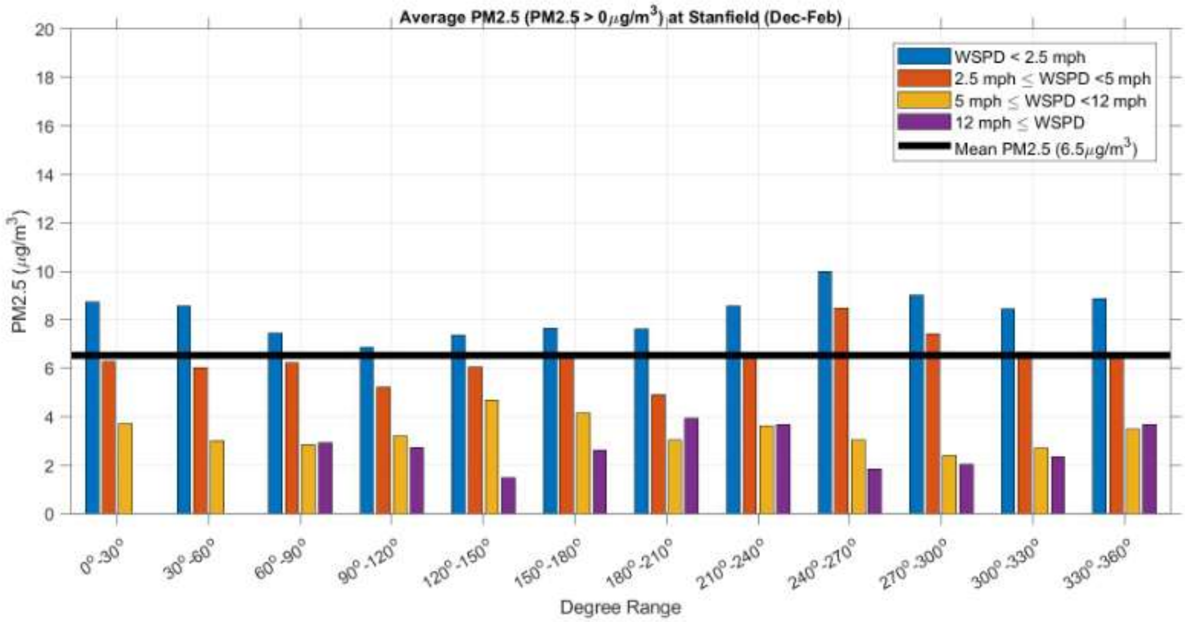


Figure 31: Average $PM_{2.5}$ Concentration Using Wind Speed at the Stanfield Site (Dec-Feb)



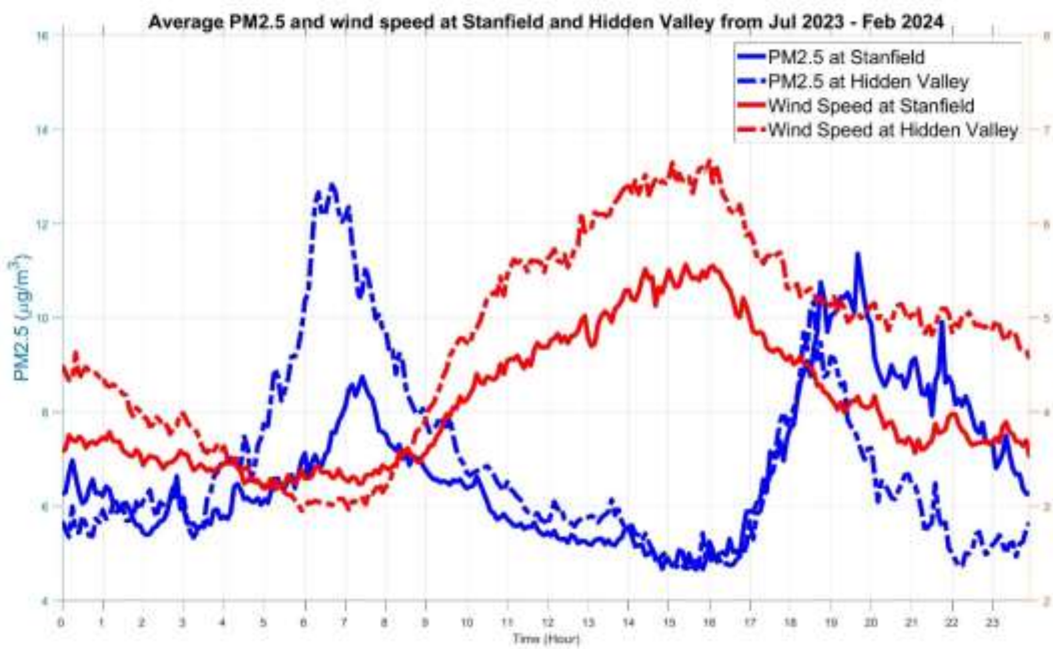

The data at the Hidden Valley site looks very similar from July – November. Average concentrations during all wind speed ranges are elevated in the 30 – 150 degree range. The concentration during wind speeds greater than 12.0 mph is increased during this time but the concentrations are still the greatest from wind speeds less than 2.5 mph. In the winter season (December - February) average concentrations are relatively similar across all degree ranges with the exception of a spike with wind speeds above 12.0 mph coming from the 90 – 120 degree range. The land uses in this section are agriculture, the feedlot and dairy operations, and undeveloped land.

The Stanfield site shows high average concentration spikes with wind speeds above 12.0 mph from the 60 – 240 degree ranges during the summer period (July – September), which is most likely the impact of the monsoon storms and associated wind. The fall period (October – November) shows an increase in the average concentration across all degree ranges with wind speeds under 2.5 mph. There also continue to be impacts with wind speeds above 12.0 mph from the 30 – 120 degree ranges. Much like the Hidden Valley site, during the winter season (December – February) the average concentrations are relatively even from all degree ranges with wind speeds below 2.5 mph being the most significant.

### Diurnal $PM_{2.5}$ Concentration Analysis:

A historical data review of both $PM_{10}$ (Hidden Valley and Stanfield) and $PM_{2.5}$ (Hidden Valley) using the data from the FEM monitors at each site shows that there are two distinct periods of elevated concentrations. There is a morning concentration spike and also an evening spike. In an attempt to identify and evaluate peak $PM_{2.5}$ concentrations during this study a diurnal concertation graph was created using the study data from both sites. Figure 32 illustrates this data and reveals the spikes in $PM_{2.5}$ concentration along with the corresponding wind speed.

Figure 32: Diurnal $PM_{2.5}$ Concentration at the Hidden Valley and Stanfield Sites




The two elevated concentration times are easily identified. The first is from approximately 04:00 – 09:00 and affects both sites. The Hidden Valley site shows a much greater spike in the $PM_{2.5}$ concentration versus the Stanfield site and both sites have similarly low wind speeds. At both sites, this first spike occurs during the lowest wind speeds of the day. Both sites then show dramatic $PM_{2.5}$ concentration decreases throughout the day as the wind speed increases. In the evening hours the wind speeds drop again as the second $PM_{2.5}$ concentration spike occurs from approximately 17:00 - 20:00. This second spike is more impactful at the Stanfield site. It is important to note that these times are approximately at sunrise and sunset and would also be impacted by a temperature inversion that would keep $PM_{2.5}$ and other pollutants from dispersing like they would during the daytime hours.

To better understand the impacts of these specific time periods on the sites, the analysis of the average $PM_{2.5}$ concentration by degree section and the analysis of $PM_{2.5}$ concentration during various wind speeds was performed on just these two time periods. The results are summarized in Figures 33 through 40, with Figures 33 through 36 representing the morning spike and Figures 37 through 40 representing the evening.

Figure 33: Average $PM_{2.5}$ (ug/m$^3$) Concentrations from Each Segment at the Hidden Valley Site (04:00 – 09:00)

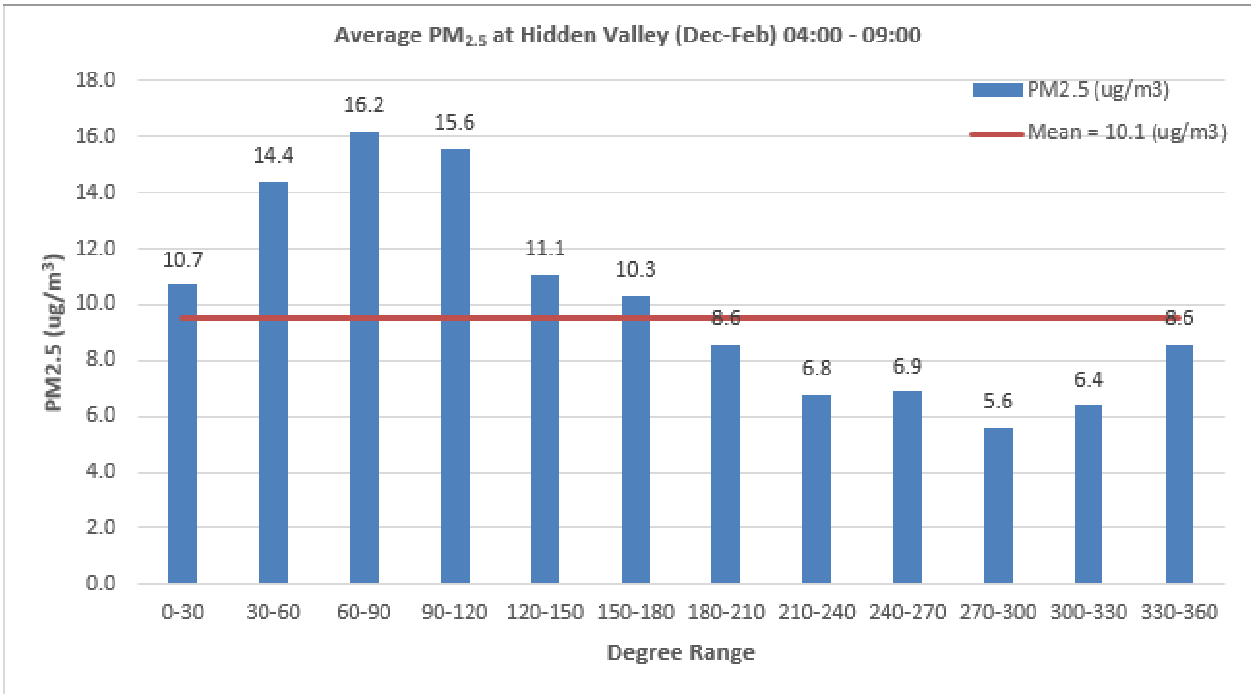



Figure 34: Average $PM_{2.5}$ Concentration Using Wind Speed at the Hidden Valley Site (04:00 – 09:00)

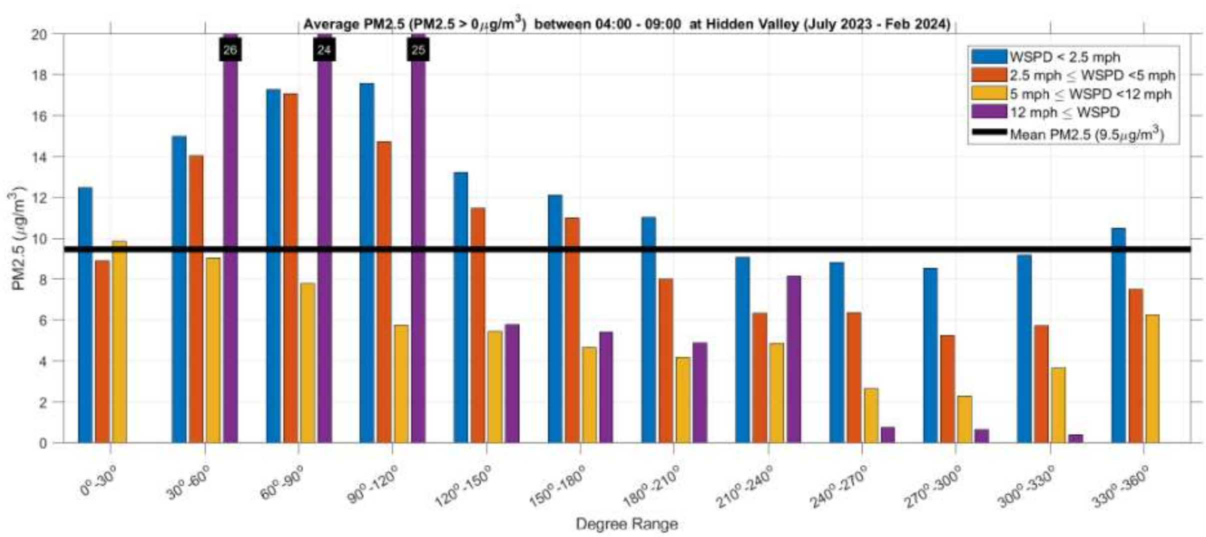


Figure 35: Average $PM_{2.5}$ (ug/m$^3$) Concentrations from each segment at the Stanfield Site (04:00 – 09:00)

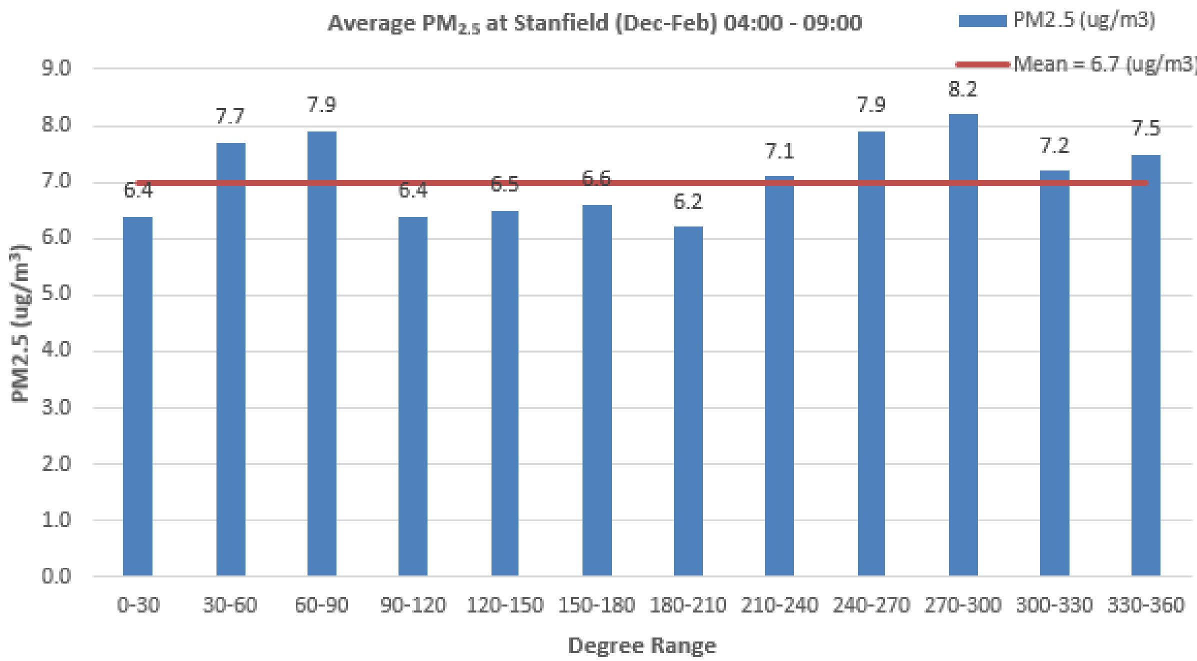
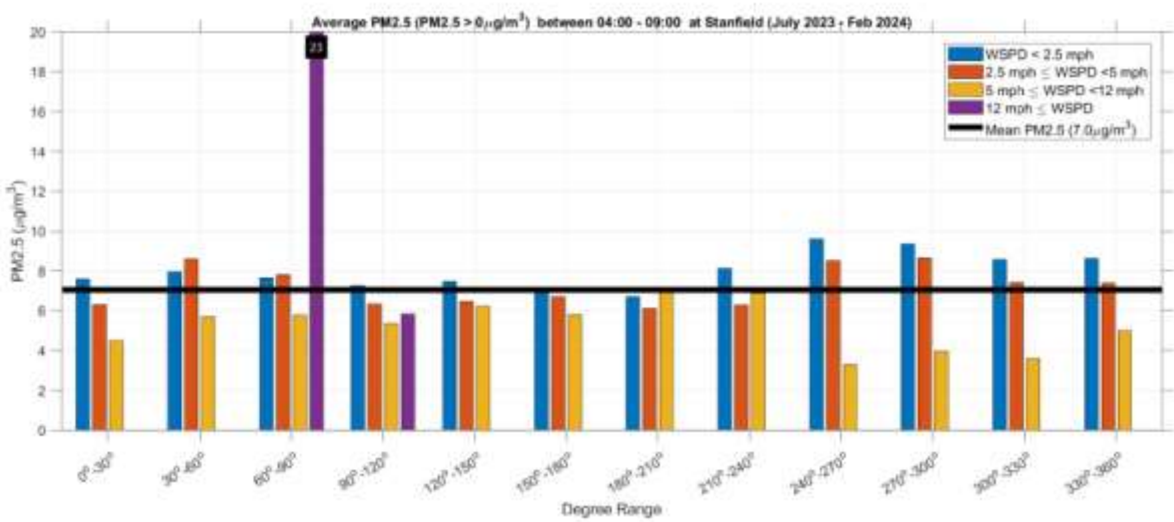



Figure 36: Average $PM_{2.5}$ Concentration Using Wind Speed at the Stanfield Site (04:00 – 09:00)




Most of the results from the analysis of the morning spike look similar to those from the entire data set. At the Hidden Valley site, the concentrations are above the average from the 0 – 180 degree range but the highest concentration range comes from the 30 – 150 degree range. From all degree ranges the concentration is higher during the lowest wind speeds. One significant difference is that from the 30 – 120 degree range, the highest concentration comes from the highest wind speeds (greater than 12.0 mph). In this time range there are also larger contributions from the 2.5 – 5.0 mph wind speed as compared to the whole data set.

The Stanfield data looks similar to the full data set in that there are not significantly increased average concentrations from one degree section. There are slightly elevated concentrations from the 30 – 90 degree ranges and the 240 – 300 degree ranges. The 240 – 300 degree range increase was also seen in the total data set. One significant difference in the Stanfield data during the morning spike is the concentration relative to the wind speed. With the exception of the 60 – 90 degree range the concentration from all degree sections is relatively constant regardless of the wind speed. There is a significant concentration spike seen at the highest wind speed from the 60 – 90 degree range. The land uses in that direction include agriculture, developed land, and undeveloped land.

One other important note during this morning spike is that the average concentrations at the Hidden Valley site are around twice those at the Stanfield site. From the 30 – 120 degree range, the average concentrations are between 14 and 16 ug/m$^3$ while at the Stanfield site, the concentrations from the 240 – 300 degree range are around 8 ug/m$^3$. The concentration differences within the Hidden Valley site are significantly different as well with a maximum average of 16.2 ug/m$^3$ and a minimum of 5.6 ug/m$^3$. At the Stanfield site, the separation between the maximum (8.2 ug/m$^3$) and minimum (6.2 ug/m$^{3)}$ concentrations is much smaller.

Figure 37: Average $PM_{2.5}$ (ug/m$^3$) Concentrations from Each Segment at the Hidden Valley Site (17:00 – 20:00)

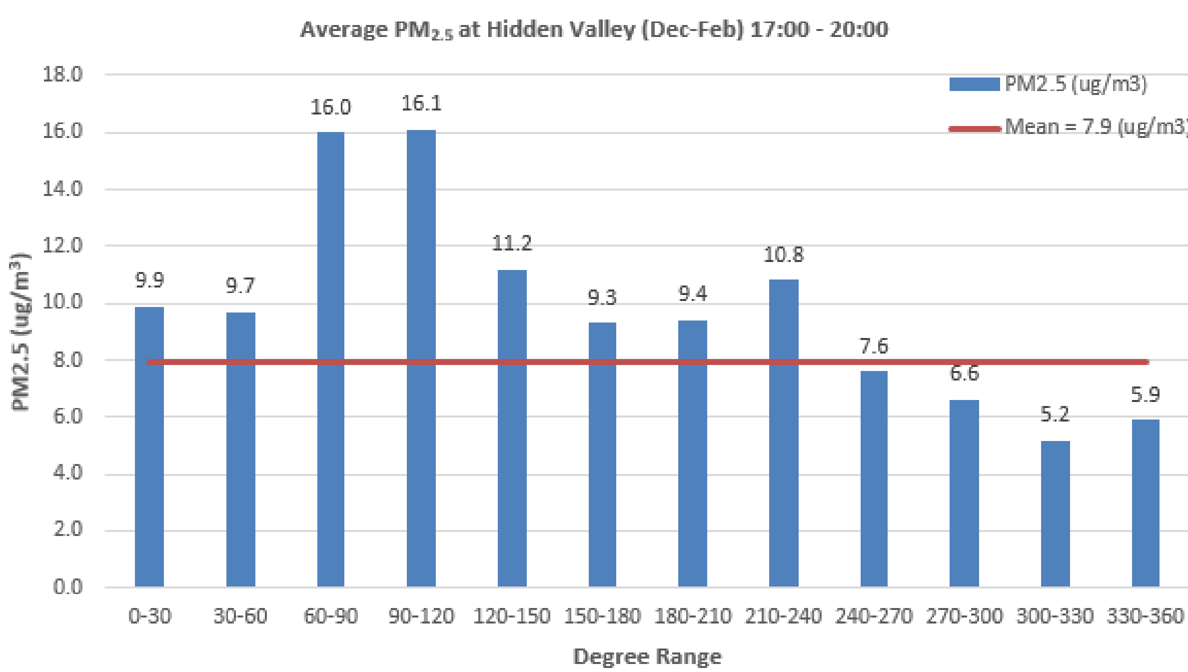


Figure 38: Average $PM_{2.5}$ Concentration Using Wind Speed at the Hidden Valley Site (17:00 – 20:00)

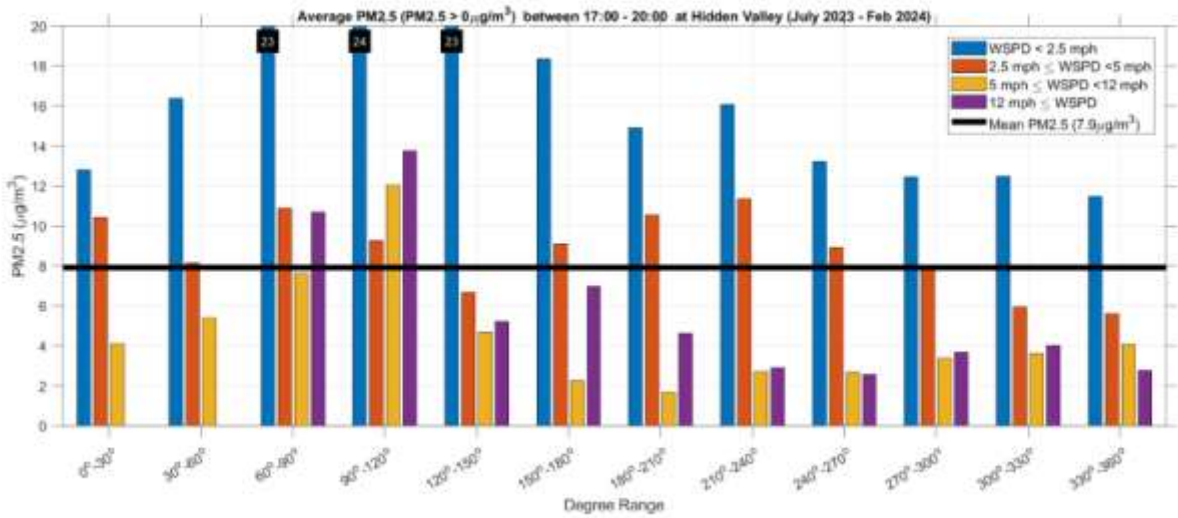



Figure 39: Average $PM_{2.5}$ (ug/m$^3$) Concentrations from each segment at the Stanfield Site (17:00 – 20:00)

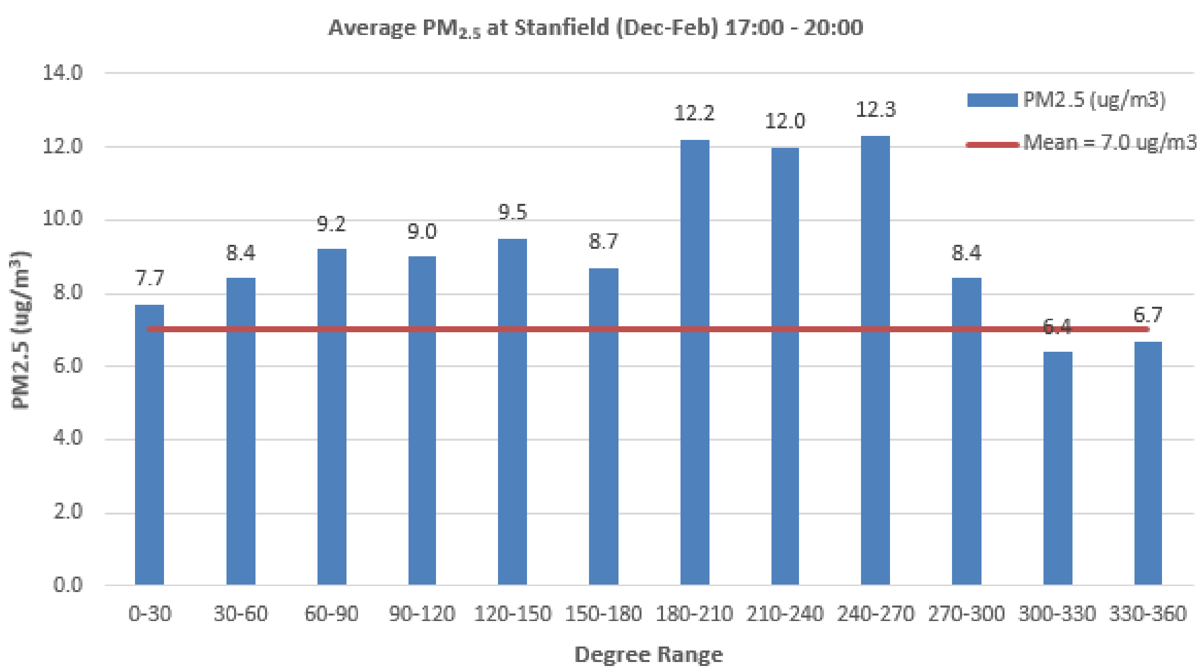
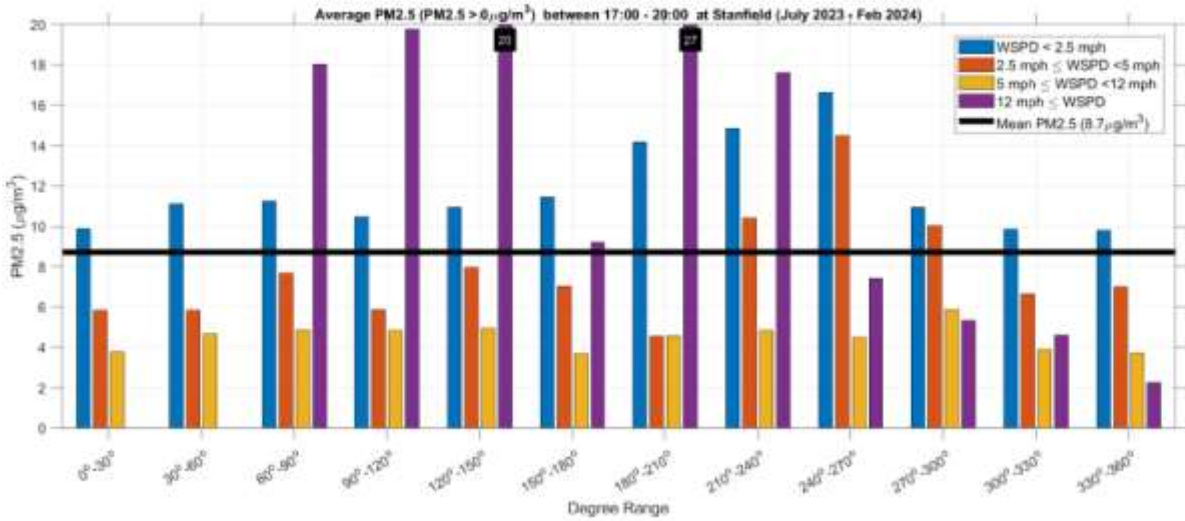


Figure 40: Average $PM_{2.5}$ Concentration Using Wind Speed at the Stanfield Site (17:00 – 20:00)




For the afternoon spike, the Hidden Valley site shows increased concentrations across a wider degree range. The $PM_{2.5}$ concentrations are above the average from $0^{o}$ – $240^{o}$. Land uses from that range include agriculture, developed land, the feedlot and dairy operations, and undeveloped land. Within that range, the 60 – 120 degree range is significantly higher and has the same land uses. Similarly to the full data set, the average concentrations are the highest with the lowest wind speeds and the concentrations are always above the average during those lowest wind speeds.

Unlike most of the Stanfield data, the evening spike shows that the 180 – 270 degree range has elevated $PM_{2.5}$ concentrations. That degree range has land uses including agriculture, developed land, and undeveloped land. As seen with the full data set, the 60 – 240 degree ranges have the highest concentration during the highest wind speeds with the concentrations during the lowest wind speeds being the second highest.

## Impact of the Percentage of Wind Direction on $PM_{2.5}$ Concentrations:

The next analysis performed was to evaluate the $PM_{2.5}$ contribution from each wind direction section. This was done by sorting the data by wind direction and calculating the relative percentage of the $PM_{2.5}$ concentration from each wind direction section. Because we know from historical data that the wind direction is not evenly distributed across all the sections, the percentage of data that came from each wind direction section was also calculated and charted. Figures 41 and 42 summarize the results with Figure 41 representing the Hidden Valley site and Figure 42 representing the Stanfield site.

Figure 41: $PM_{2.5}$ Contributions at the Hidden Valley Site

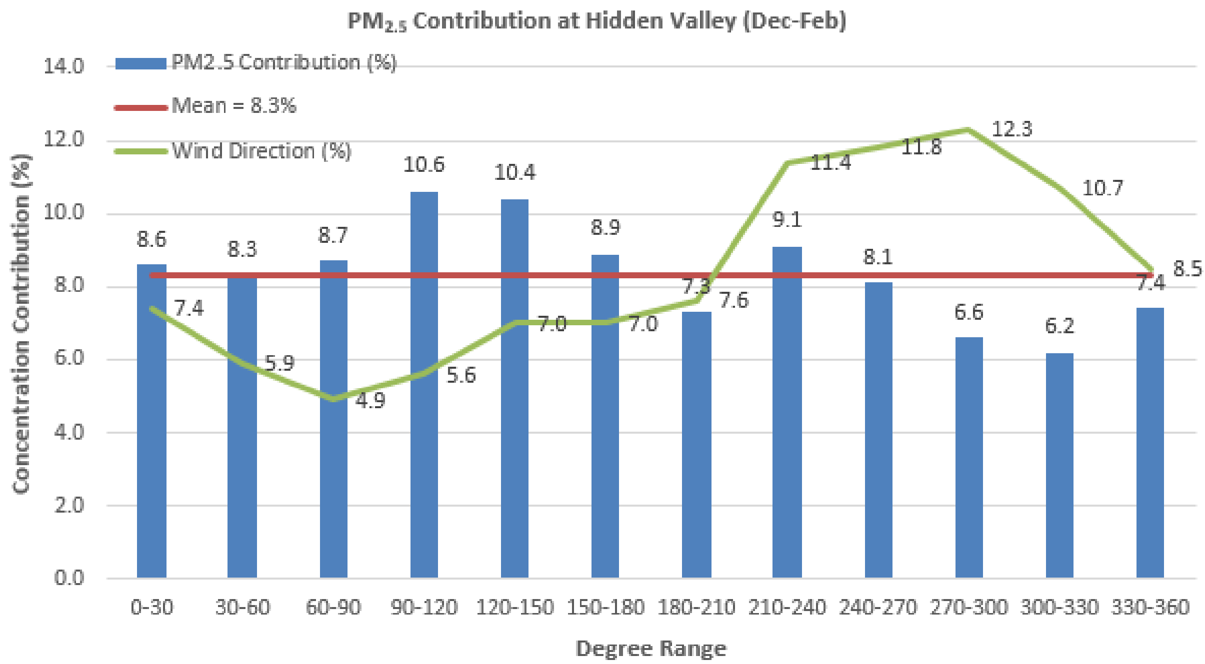
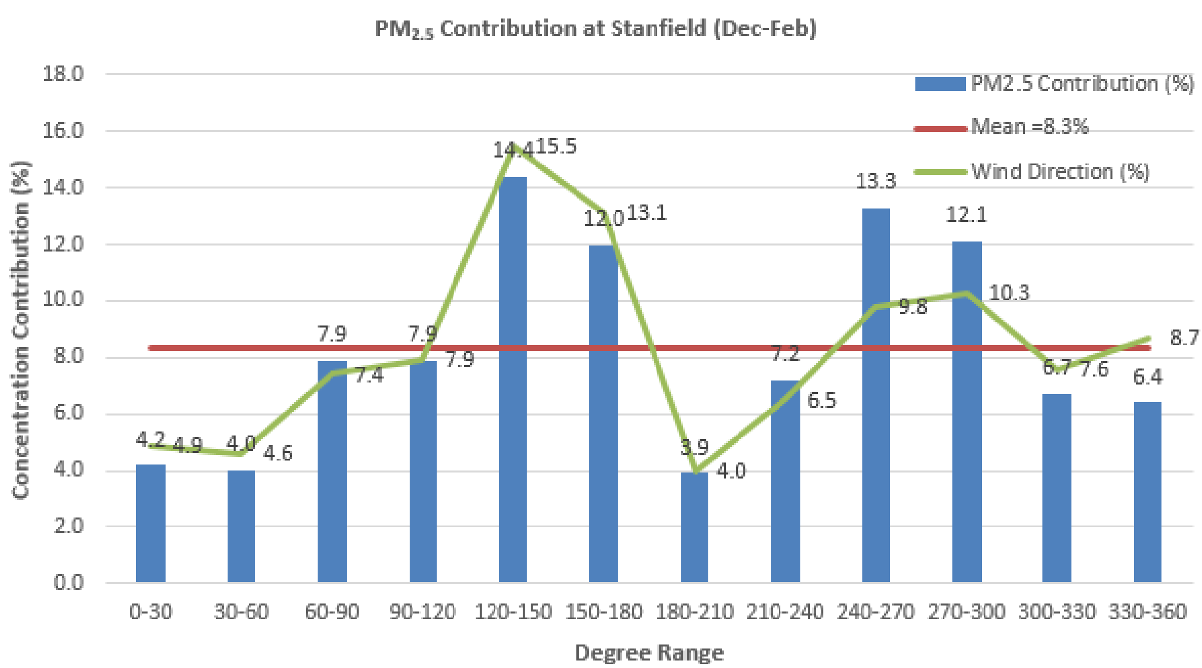



Figure 42: $PM_{2.5}$ Contributions at the Stanfield Site




There are some immediate differences evident between the two sites. At the Stanfield site, the $PM_{2.5}$ concentration contribution closely follows the percentage of data from each wind direction. This result further supports the data in Figure 22. With no significant source at the Stanfield site, the contributions come primarily from the prominent wind direction. There is a slight increase in contribution in the 240 – 300 degree range but that was also seen in Figure 22 and has land uses that include agriculture, developed land, and undeveloped land. Also in that direction, but further away, are the feedlot/dairy operations that are impacting the Hidden Valley site.

The Hidden Valley site data does not at all follow that trend of $PM_{2.5}$ contribution correlating to wind direction percentage. The wind direction sections with the highest $PM_{2.5}$ contributions ($60^o$ – $180^o$) have some of the lowest wind direction rates. In addition, the wind direction sections ($240^o$ – $330^o$) with the highest wind direction percentages have the lowest $PM_{2.5}$ contributions. The wind direction sections from $60^o$ – $180^o$ have the highest $PM_{2.5}$ contribution while having about half as much of the wind coming from those sections. This points to a distinct $PM_{2.5}$ source in the 60 – 180 degree range, which has land uses of agriculture, developed land, feedlot/dairy facilities, and undeveloped land.

As was done with previous analyses, the $PM_{2.5}$ contribution percentage for degree direction was evaluated during the morning and evening $PM_{2.5}$ concentration spike periods. Figures 43 and 44 represent the morning spike and Figures 45 and 46 represent the evening spike.

Figure 43: $PM_{2.5}$ Contributions at the Hidden Valley Site (04:00 – 09:00)

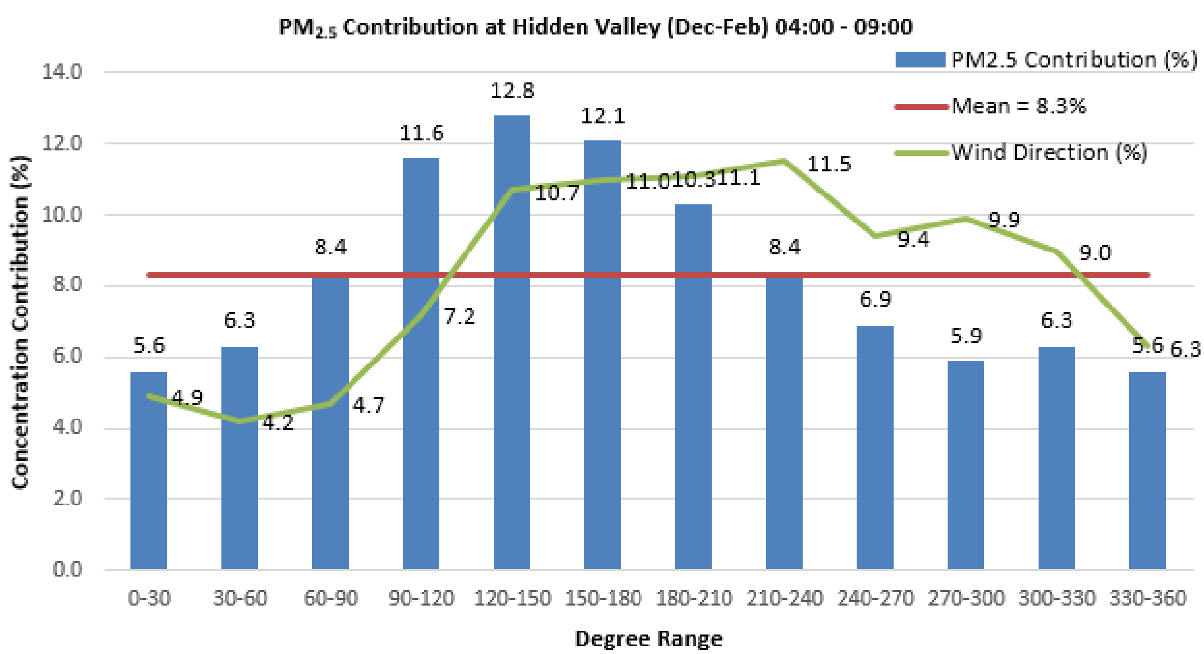
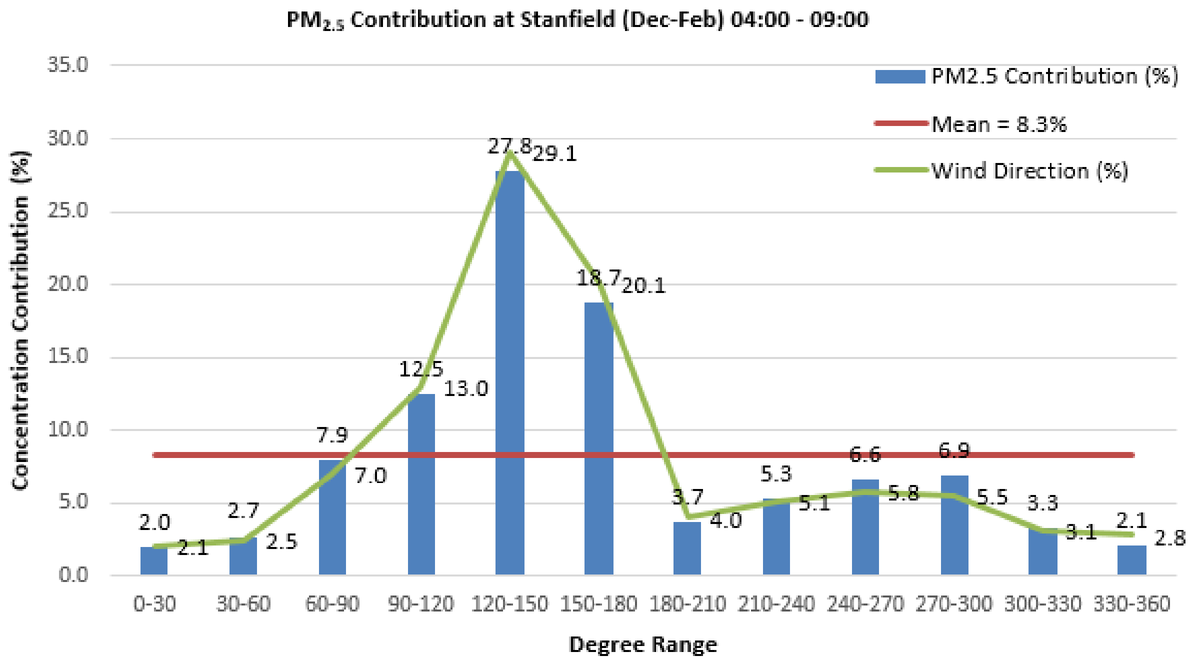


Figure 44: $PM_{2.5}$ Contributions at the Stanfield Site (04:00 – 09:00)




Like with the full data set, the $PM_{2.5}$ contribution very closely follows the wind direction percentage during the morning spike at the Stanfield site. At the Hidden Valley site, the $PM_{2.5}$ contribution more closely follows wind direction percentage but the 30 – 180 degree range still shows higher than average concentrations with a lower percentage of wind and the 210 – 330 degree ranges show lower concentrations with a higher percentage of the wind.

Figure 45: $PM_{2.5}$ Contributions at the Hidden Valley Site (17:00 – 20:00)

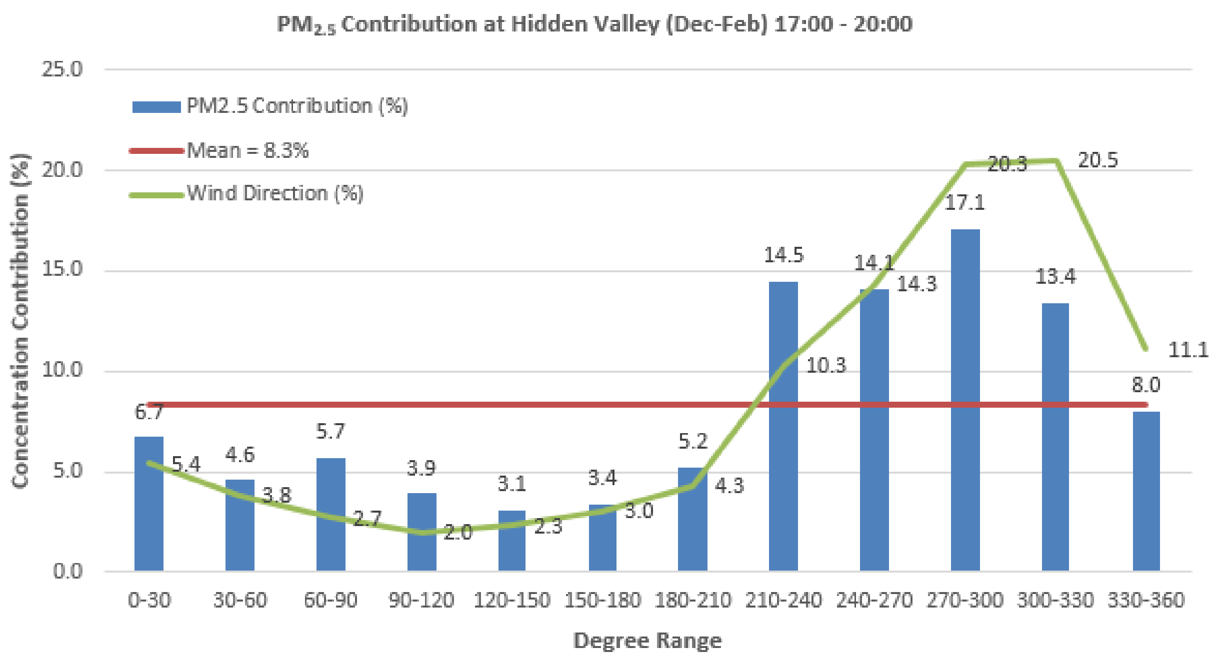
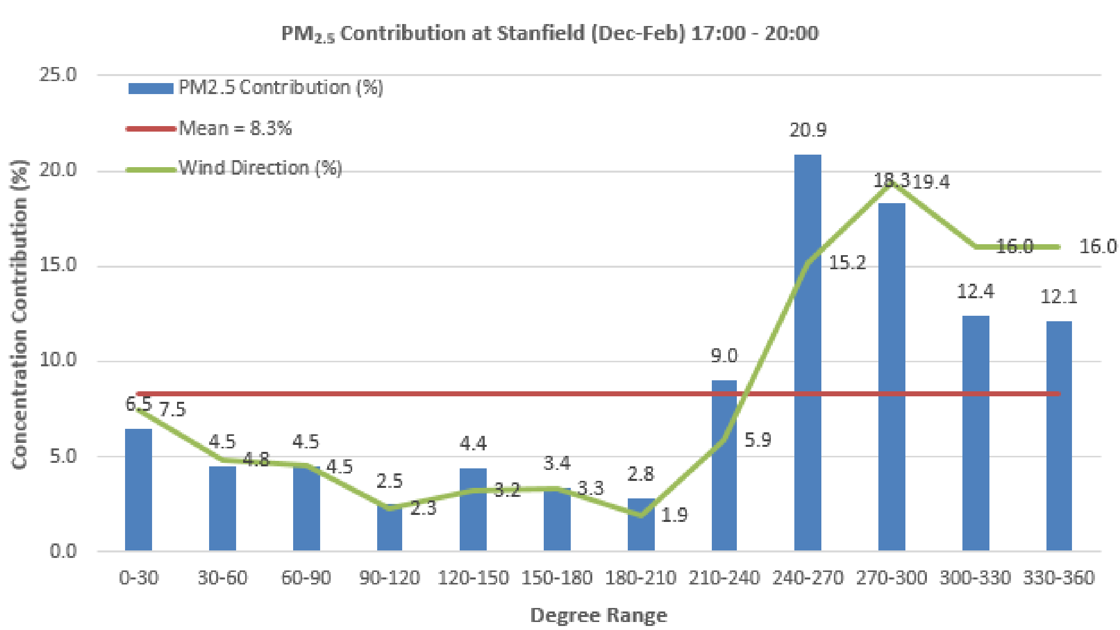



Figure 46: $PM_{2.5}$ Contributions at the Stanfield Site (17:00 – 20:00)




During the evening spike both the Hidden Valley and Stanfield $PM_{2.5}$ contributions follow the wind direction percentages. The most significant difference is at the Hidden Valley site where the highest contribution percentage has shifted to the 210 – 360 degree range. This range is primarily composed of undeveloped desert land.

After completing this analysis on these two peak $PM_{2.5}$ concentration periods a few trends were identified. At the Stanfield site, the average $PM_{2.5}$ concentration remains relatively even across each degree section but the percent of contribution follows the percentage of the wind direction. Each spike period has a different degree range as the primary contributor but both follow the wind direction percentage. This indicates that there is no primary source impacting the Stanfield site during these periods.

At the Hidden Valley site, the two time periods show different impacts on the monitor. The morning time period average concentration and the percent of the total concentration are both greatest from the direction of the feedlot/dairy complex. The contribution percentage more closely follows the wind percentage but there is still evidence that the feedlot/dairy complex is the dominant source even when there is low wind percentage from that degree range. The evening period is completely different at the Hidden Valley site. The contribution percentage is from a completely different degree range and more closely follows the wind percentage. This would indicate that during the evening spike period, the site is most impacted by the undeveloped desert land from the dominant wind direction and not the feedlot/dairy complex.

**Study Summary:**

Several important findings were revealed through this sensor study. The first is that while both the Hidden Valley and Stanfield sites have similar overall $PM_{2.5}$ concentrations, the impacts on each site are very different. Analyzing the average $PM_{2.5}$ concentration from each of the degree sections shows that at the Hidden Valley site, there are higher average concentrations from the direction of the feedlot/dairy operations. At the Stanfield site, there are no specific directional impacts with the exception of one section primarily associated with an agricultural field. An analysis of wind speed vs $PM_{2.5}$ concentration also shows differences, with the Stanfield site mostly influenced by wind speeds greater than 12.0 mph and the Hidden Valley site mostly impacted by wind speeds less than 2.5 mph. At the Stanfield site wind speeds less than 2.5 mph have the second highest $PM_{2.5}$ concentrations. This indicates that the primary impacts at the Hidden Valley site are local sources while the Stanfield site is impacted by both local and transported sources.

A more detailed analysis of the relationship between the percentage of wind from each directional section and $PM_{2.5}$ concentration contributions again shows significant differences between the two sites. At the Stanfield site, the $PM_{2.5}$ concentration contribution follows the wind direction percentages indicating a strong relationship between the $PM_{2.5}$ contribution and the direction of the wind. This finding supports the lack of a specific source impacting the site and shows that the directional impact follows the wind direction. At the Hidden Valley site, this pattern is not the same. The degree sections with the highest wind percentage have some of the lowest $PM_{2.5}$ concentration contributions and the degree sections with the lowest wind percentage have the highest $PM_{2.5}$ concentration contributions. This pattern indicates that a specific source is causing the $PM_{2.5}$ contributions despite the wind direction. These sections with the highest percentage of $PM_{2.5}$ contributions also correlate to the feedlot/dairy complex.

A diurnal analysis indicated that there are two primary spikes in $PM_{2.5}$ concentration that affect both sites. During the morning spike, from approximately 04:00 through 09:00, both sites have elevated $PM_{2.5}$ concentrations but the Hidden Valley site has the higher concentration. During this time period, both sites are also experiencing the lowest wind speeds of the day. At the Hidden Valley site, the maximum $PM_{2.5}$ concentration contributions are coming from the 90 – 180 degree sections, which again correlates to the feedlot/dairy complex. With the wind speeds so low during this time the feedlot/dairy complex is still the dominant source even though the 180 – 240 degree section has the greatest wind percentage. The combination of these factors indicates that the Hidden Valley site is being impacted by the feedlot/dairy complex during this event while the Stanfield site is being impacted by agriculture fields.

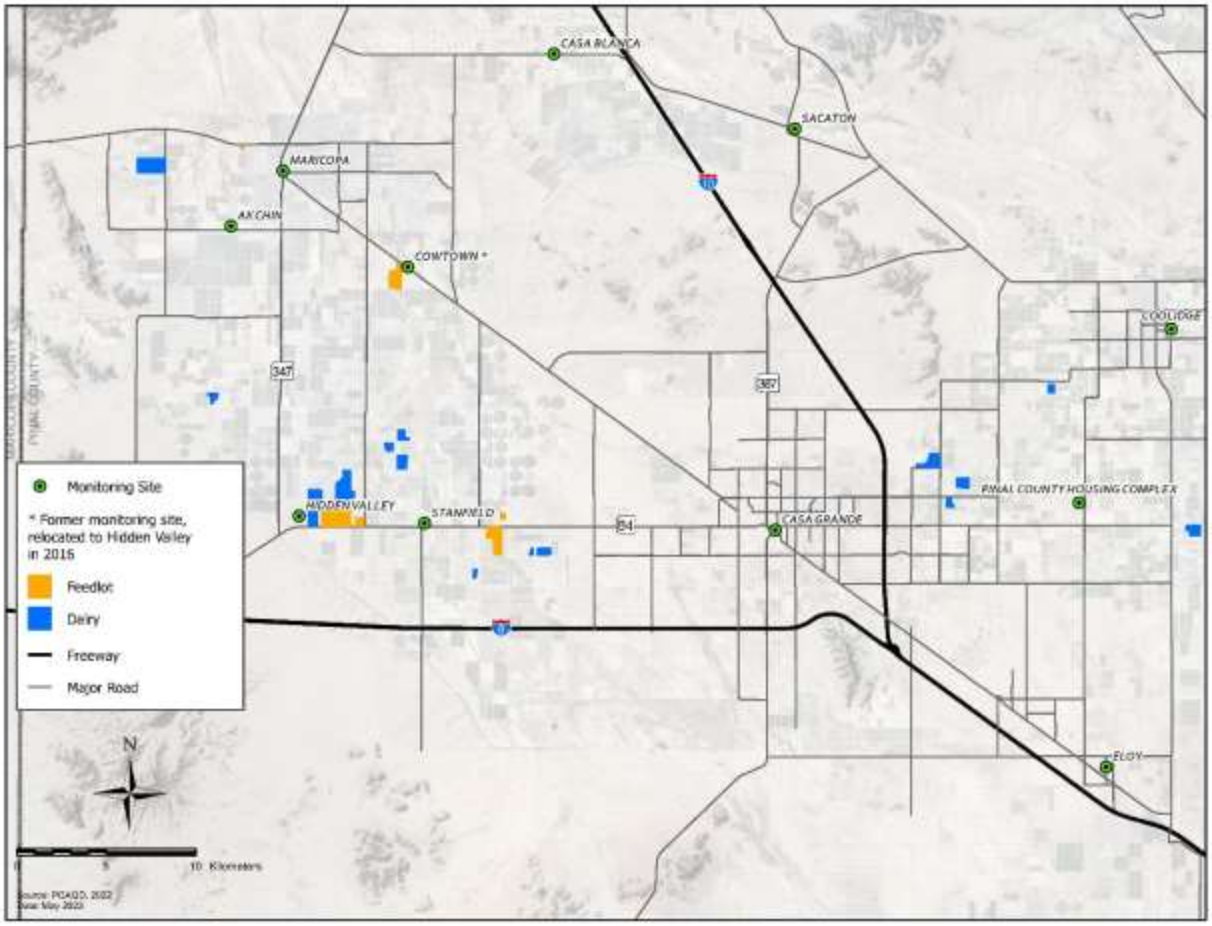
The evening spike shows the Stanfield site has the higher $PM_{2.5}$ concentration. The detailed analysis during this time indicates that the Stanfield site is again impacted by an agriculture field but from a different direction. At the Hidden Valley site, the $PM_{2.5}$ concentration contribution more closely follows the wind direction percentage. The wind speeds are also higher during this event so the primary source is not the feedlot/dairy complex but undeveloped desert land following the primary wind direction.

Overall, the Stanfield site is impacted by sources from the primary wind direction during all times of the day. At the Hidden Valley site, the feedlot/dairy complex is the primary source regardless of wind direction with the exception of the evening spike period where the primary source changes to the undeveloped desert land that is upwind from the monitor.

## Uniqueness

When evaluating the uniqueness of the Hidden Valley site it is important to look at more than just the land use around the site. Pinal County has other feedlots and dairies in addition to those next to the Hidden Valley, Cowtown, and Stanfield sites. Figure 47 shows the County area surrounding the Casa Grande, Maricopa, Stanfield, and Hidden Valley region highlighting all of the feedlots/dairies and monitoring sites that are operated by both Pinal County and local tribal agencies.

Figure 47: Feedlot/Dairy Distribution around the Hidden Valley Site




The Hidden Valley site is by far the closest current site to any feedlot or dairy. The site is 0.275 km from a calving operation (40 acres), 0.530 km from a dairy (~970 acres) and it is 1.3 km from the largest feedlot in the region (~509 acres). The next closest would be the old Cowtown Road site (0.260 km) which was next to a smaller feedlot operation of approximately 424 acres. After those two sites, the next closest is the Stanfield site which is significantly farther away. The nearest Dairy to the Stanfield site is 3.3 km away (607 acres spread across three smaller operations) and the nearest feedlot is 3.5 km away (227 acres).

All three of those sites also have a significant amount of agricultural activity near them. What separates the Hidden Valley site from any other site and any other location in Pinal County is the combination of the agricultural activities with the extremely close proximity of the site to the largest active feedlot in the County as well as the proximity to the dairy. There are only three active feedlots in Pinal County and only the Hidden Valley complex is combined with Dairy activities. The Hidden Valley site is not representative of any other location within Pinal County making it a very unique site. This is all evidenced by the increasing $PM_{10}$ and $PM_{2.5}$ concentrations as you move from more urban areas like the Casa Grande Downtown site to a rural site like the Stanfield site and then the significantly increased concentrations (and PM exceedances) at the

Hidden Valley site located within a very small proximity of a large feedlot/dairy complex.

## Conclusion

40 CFR 58.30(a) provides clear direction on the applicability of the annual $PM_{2.5}$ NAAQS at each monitoring site. There are two criteria, the spatial scale of the site and the presence of a unique dominating source. This analysis for the Hidden Valley site was designed to evaluate both parts of the CFR requirement. Based on the analysis of the land use and emission sources around the Hidden Valley site it meets the definition of a middle scale site. The analysis of the possible sources surrounding the site indicated that a feedlot/dairy complex is the prominent source with no other permitted $PM_{2.5}$ emission sources within proximity of the site. The $PM_{2.5}$ data comparison between the Hidden Valley site and the nearby Stanfield site, which has most of the same site characteristics and sources with the exception of the feedlot/dairy complex, indicates that the Hidden Valley site is heavily influenced by the feedlot/dairy complex. The Stanfield site data does not show a significant directional influence and the percentage of $PM_{2.5}$ contribution follows the percentage of wind direction from each degree section, thus indicating a clear connection. The Hidden Valley site on the other hand has significantly increased average $PM_{2.5}$ concentrations from the direction of the feedlot/dairy complex. In addition, the percentage of $PM_{2.5}$ contribution is greatest from the direction of the feedlot/dairy complex even though it receives less than half as much of the wind direction percentage. PCAQCD believes that the sum of this analysis is that the Hidden Valley site is a middle scale site with a unique source that causes a significant impact on the site and therefore the Hidden Valley site is ineligible for comparison to the annual NAAQS based on the direction in 40 CFR 58.30(a).

## References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