Wyoming Ambient Monitoring Network Assessment 2010

Wyoming Department of Environmental Quality –
Air Quality Division
April 28, 2011

Executive Summary

The Wyoming Department of Environmental Quality – Air Quality Division (AQD) has the responsibility to protect, conserve, and enhance the quality of Wyoming's air resource. The AQD helps ensure that the ambient air quality in the State of Wyoming is maintained in accordance with the National Ambient Air Quality Standards (NAAQS). To carry out this goal, AQD operates and maintains a network of ambient air quality monitors and requires industrial sources of air pollutants to conduct source specific ambient air monitoring.

A Network Assessment is required to be performed and submitted to the U.S. Environmental Protection Agency (EPA) every five years. This assessment must include detailed monitoring network information along with analyses to evaluate monitoring sites and their objectives. The Wyoming monitoring network, as a whole, is designed to meet the following seven basic ambient air monitoring objectives:

1) Determine representative concentrations in areas of high population density.
2) Determine impact on ambient air quality from significant sources.
3) Determine general background concentration levels.
4) Determine the extent of regional pollutant transport among populated and remote or rural areas.
5) Determine welfare-related impacts in support of secondary standards.
6) Determine highest concentration expected to occur in the area covered by the network.
7) Research pollutant and meteorological behaviors in areas of concern.

For this Network Assessment, the AQD has used various statistical, graphical, and geographic information systems (GIS) spatial analyses to evaluate Wyoming's ambient and meteorological monitoring network with respect to AQD's monitoring objectives.

The Network Assessment was performed in two stages, Southwest Wyoming in 2008 and the remainder of the State in 2010. Results from both the Southwest Wyoming Network Assessment and the assessment of other areas of the State are discussed in this document. The AQD has analyzed the results and several conclusions were reached:

- Currently operating monitoring stations in the Wyoming Monitoring Network are meeting their intended objective(s).
- Currently operating monitoring stations in the Wyoming Monitoring Network are not redundant with each other.
- There is a need for population-based ozone monitoring in Pinedale, Casper, Rock Springs, and Gillette.
- There is a need for population-based monitoring for PM_{10} in Star Valley.
- Monitoring Stations should be deployed to monitor impacts from the Hiawatha and LaBarge Gas Fields.
- A monitoring station in the Wyoming Range would assist in quantifying transport from the west.
- Meteorological monitoring is needed in Farson and the northern portion of the Wyoming Range.
- The AQD will consider using trace-level gaseous monitors when deploying future stations with NO_2 or SO_2.

Several of these conclusions were generated from the Southwest Wyoming Network Assessment and have already been funded. A population-based monitoring station was deployed in Pinedale in 2009, which monitors for ozone, $PM_{2.5}$, NO_x, and meteorology. The AQD has committed to funding the Wyoming Range transport monitoring station, which will monitor for ozone, trace-level NO_x, PM_{10} and $PM_{2.5}$ and meteorology. The AQD has also committed funding for a meteorological tower in Farson. The Wyoming Range and Farson monitoring stations will be deployed in 2011. The Hiawatha monitoring station has been jointly funded by AQD and EPA as part of the 3-State Study. The 3-State Study is a cooperative monitoring and emission inventory study whose objective is to assist Wyoming, Colorado, and Utah to model for regional ozone. Due to the lack of power in the Hiawatha project area, this station will operate ozone and meteorology using solar and wind power and will be deployed in 2011.

For those conclusions that do not have permanent funding allocated now, the AQD has purchased a fleet of mobile monitoring stations that could be deployed to these locations on short-term basis (one year) to perform an initial investigation of air quality concentrations.

Table of Contents

Table of Figures

List of Tables

Acronyms

AQD	Wyoming Department of Environmental Quality –Air Quality Division
AQS	EPA's Air Quality System
ASOS	Automated Surface Observing System
BLM	Bureau of Land Management
CASTnet	Clean Air Status and Trends Network
CBSA	Core Based Statistical Area
CFR	Code of Federal Regulations
CO	Carbon Monoxide
EDAS	Eta Data Assimilation System
EIP	Emission Impact Potential
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FEM	Federal Equivalent Method
FRM	Federal Reference Method
GIS	Geographical Information Systems
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory model
IMPROVE	Interagency Monitoring of Protected Visual Environments
IQR	Inter-Quartile Range
km	kilometers
MDL	Minimum Detection Limit
Met.	Meteorology
m/s	Meters per second
N	Nitrogen
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NO	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
NPS	National Park Service
NSR	New Source Review
NWS	National Weather Service
OAQPS	EPA's Office of Air Quality Planning and Standards
O_3	Ozone
PM	Particulate Matter
PM_{10}	Particulate Matter less than 10 micrometers in aerodynamic diameter
$PM_{2.5}$	Particulate Matter less than 2.5 micrometers in aerodynamic diameter
ppb	parts per billion
PRB	Powder River Basin
RAWS	Remote Automated Weather System
ROD	Record of Decision
SPD	Spatial Probability Density
STI	Sonoma Technology, Incorporated
Systat	Systat brand statistical computer software
SO_2	Sulfur Dioxide
SO_x	Oxides of Sulfur
TEAK	Transported Emissions Assessment Kit

TEOM	Tapered Element Oscillating Microbalance
USFS	United States Forest Service
VOC	Volatile Organic Compounds
WAAQS	Wyoming Ambient Air Quality Standards
wd	Wind direction
ws	Wind speed

1 Introduction

The 2010 Network Assessment is intended to examine and evaluate the Wyoming ambient air monitoring network of sites to fulfill the requirements of 40 CFR Part 58.10(d), which calls for

"…an assessment of the air quality surveillance system every 5 years to determine, at a minimum, if the network meets the monitoring objectives defined in Appendix D to this part, whether new [monitoring stations] are needed, whether existing [monitoring stations] are no longer needed and can be terminated, and whether new technologies are appropriate for incorporation into the ambient air monitoring network".

The Wyoming monitoring network, as a whole, is designed to meet the following seven basic ambient air monitoring objectives:

1) Determine representative concentrations in areas of high population density.
2) Determine impact on ambient air quality from significant sources.
3) Determine general background concentration levels.
4) Determine the extent of regional pollutant transport among populated and remote or rural areas.
5) Determine welfare-related impacts in support of secondary standards.
6) Determine highest concentration expected to occur in the area covered by the network.
7) Research pollutant and meteorological behaviors in areas of concern.

For this Network Assessment, Wyoming Department of Environmental Quality – Air Quality Division (AQD) has used various statistical, graphical, and geographic information systems (GIS) spatial analyses to evaluate Wyoming's ambient and meteorological monitoring network with respect to AQD's monitoring objectives. The AQD used EPA's "Ambient Air Monitoring Network Assessment Guidance" (EPA454/D-07-001, Feb. 2007) along with other tools and ideas presented by EPA's Office of Air Quality Planning and Standards (OAQPS) (http://www.epa.gov/ttn/amtic/network-assessment.html).

The overall objective of this Network Assessment is to determine the most efficient and effective network for monitoring criteria pollutants, precursors, and meteorology. This Network Assessment focuses on the network of ambient air monitors that are operated by the AQD. However, ambient and meteorological monitoring operated by industry and federal agencies was considered to understand monitor coverage. AQD will not comment on the placement or adequacy of non-AQD monitoring sites in this Network Assessment.

Results of this Network Assessment will be used to guide future monitor placement, reconfiguration, and improvements in the Wyoming monitoring network. AQD may also determine, based on supporting data evaluation, potential areas where the monitors are no longer meeting their objective and can be removed. Before implementing any finding(s) of this Network Assessment, the AQD will need to evaluate resources and prioritize needs.

The Network Assessment was designed by AQD to use tools that were applicable to Wyoming's unique nature with respect to population density, geographic area, complex topography, and concentration of industrial sources. Because of Wyoming's unique nature, AQD's small Monitoring Section staff, and limited funding from EPA, AQD contracted with Sonoma Technology, Incorporated (STI) to assist in statistical and GIS spatial analyses for use in this Network Assessment. Technical products and analyses

from STI can be found in the appendices. A guide to how to interpret these technical work products is in Section 2.

The Network Assessment is designed to address the seven basic Wyoming ambient air monitoring objectives. Section 3 introduces AQD's ambient monitoring network and presents a historical review of the monitoring station data. The remainder of this Network Assessment is structured by monitoring objective. Sections 4 through 11 present the evaluation of the network by monitoring objective. Each section discusses monitoring stations that meet the stated objective along with supporting data evaluation and conclusions.

2 How to Interpret Data Products Used in this Network Assessment

For this Network Assessment, AQD has used various statistical, graphical, and geographic information systems (GIS) spatial analyses (known as data products) to evaluate Wyoming's ambient and meteorological monitoring network with respect to AQD's monitoring objectives. These data products reduce large amounts of data into a graphical form to help inform the data analyst or reader. This Section will introduce the reader to the different data products, how they were compiled, their use and limitations.

It should be noted that many of these data products use data that has been averaged by season or year. This is done to represent overall trends rather than specific incidents or days. Therefore, any conclusions reached may not apply to specific days where episodic events could occur. Additionally, some of these data products employ meteorological and spatial models, which have varying degrees of accuracy. Again, these are used to represent the overall big picture of the monitoring station and may not always account for microscale episodes that could occur at a monitoring station.

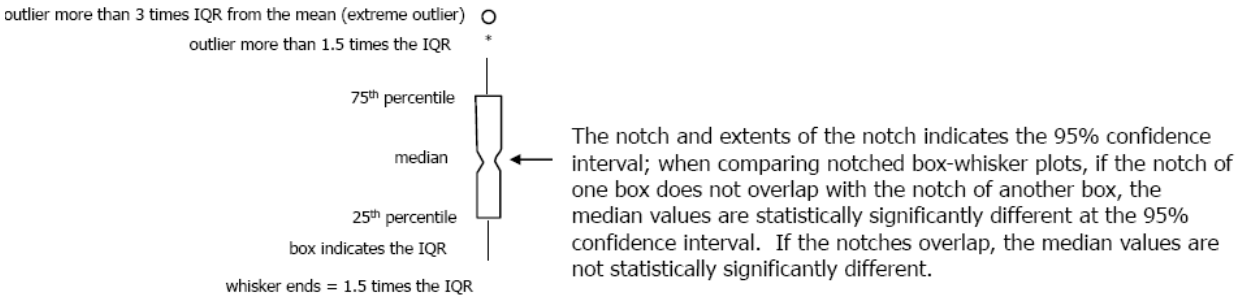
2.1 Statistical Analyses

The Network Assessment covers ambient and meteorological data collected from 2006-2008. In order to evaluate the data collected during this period, different summary statistics can be used. One effective way to compare data is a notched box and whisker plot. These plots are generated by a statistical software called Systat. These plots can be used to assess statistical significance between two or more sets of data. They can be used to assess the trend in concentrations at a monitoring station by evaluating data collected in different years. These plots can also be used to determine whether two or more chosen stations monitor significantly different concentrations.

Figure 2-1: How to interpret notched box-whisker plots

How to Interpret Notched Box-Whisker Plots

A notched box-whisker plot illustrates the distribution of concentrations. The notch is centered on the median concentration, widening to the size of the box to illustrate the 95% confidence interval in the median concentration value. The edges of the box illustrate the 25th and 75th percentile concentrations. The whiskers indicate values that are 1.5 times the interquartile range (IQR). Star outliers fall between 1.5 and 3 times the IQR. Circle outliers are greater than 3 times the IQR.



Graphic courtesy of STI

2.2 Geospatial Analyses

Geospatial analyses combine data such as emission inventories and population data with geographic data into products that can be easily evaluated on a map.

Census data describing population and population change was plotted on the Environmental Systems Research Institute (ESRI) ArcMap program to determine the spatial distribution of population in relation to the ambient monitoring network. STI pulled data from the U.S. Census Bureau for the years 2000-2007 at the block level to determine 2007 population and population change between 2000 and 2007. The monitors are then superimposed on to the graphic. This tool is used to analyze monitor placement that relates to AQD's Objective #1: Determine Representative Concentrations in Areas of High Population Density.

Figure 2-2: Example of population density and active/planned monitoring stations

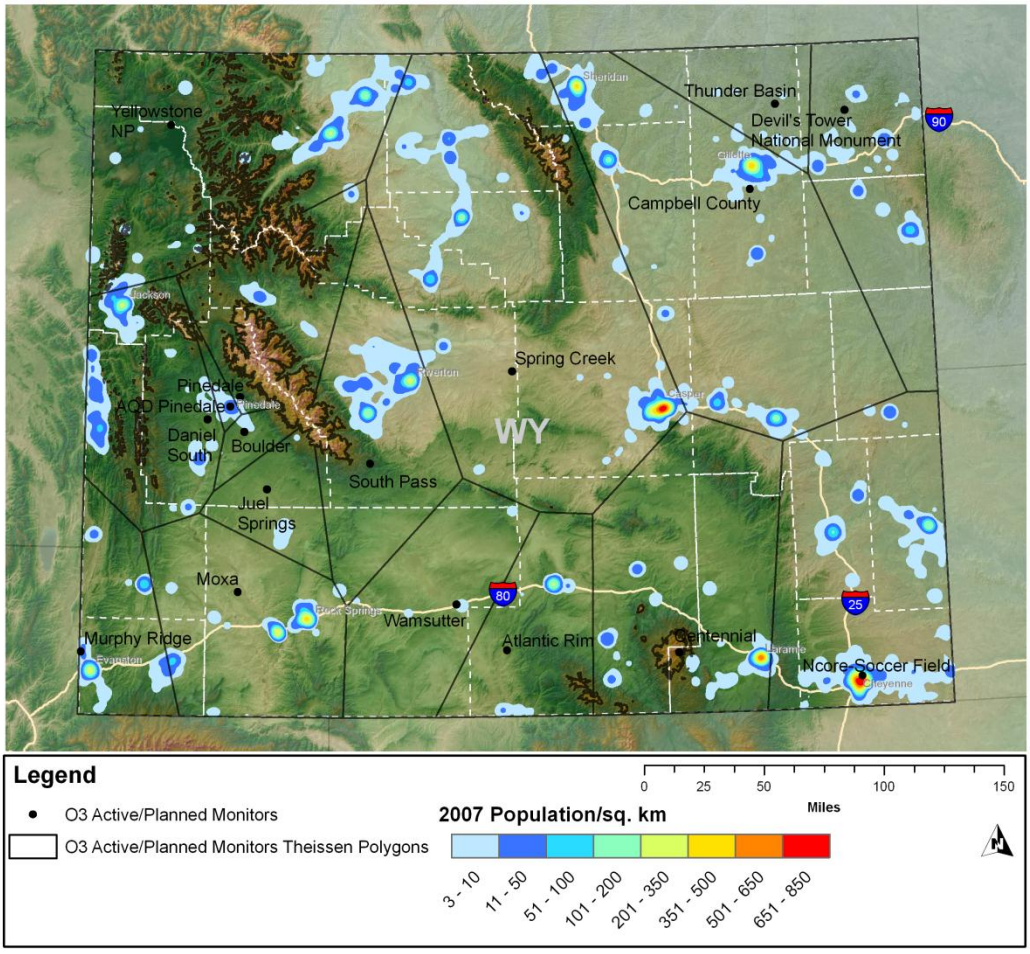
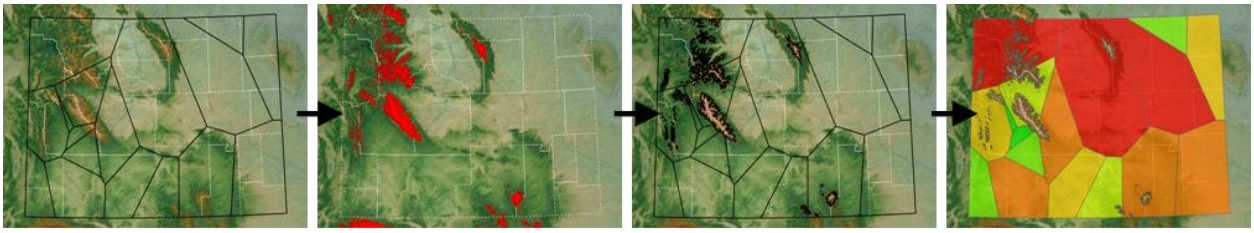


Figure 2-2 also shows shapes known as "Thiessen polygons" on the map. Thiessen polygons are applied as a standard technique in geography to assign a zone of influence or representativeness to the area around a given point (in this case, a monitoring site). Calculating Thiessen polygons is a simple quantitative method for determining an area of representation around a given site, which is known as the area-served. This technique involves drawing a centerline between each pair of monitors and

creating polygons from the intersections of the centerlines. However, Thiessen polygons do not take into account geographic features or meteorology.

To improve the physical representation of the area-served boundaries, the boundaries were adjusted to a maximum elevation of 3,000 meters, thus accounting for topographic barriers. Figure 2-3 depicts the four-step process for performing an area-served analysis.

Figure 2-3: Four Step Process of an Area Served Analysis



Theissen polygons developed for each monitoring site

Identify elevations above 3,000 meters

New polygons without areas where elevation is above 3,000 meters

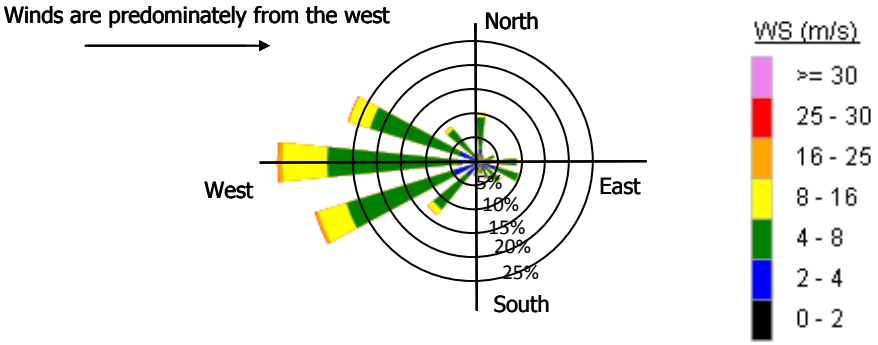
Area Served analysis (area values of each site polygon)

Although the final area served analyses were generated by STI for this project, they played a minor role in the evaluation process. This type of analysis does not lend itself well to Wyoming's complex topography and long distances between monitoring stations. In most cases, the large area-served polygons do not realistically represent the airshed that a monitoring station characterizes. Theissen polygons are included on some graphics for informational purposes only.

Evaluation of ground-based meteorological data is also an important part of evaluating site locations and the sources, which may be contributing to concentrations. One of the most useful tools for summarizing wind speed and direction is a wind rose.

Figure 2-4: How to interpret a wind rose

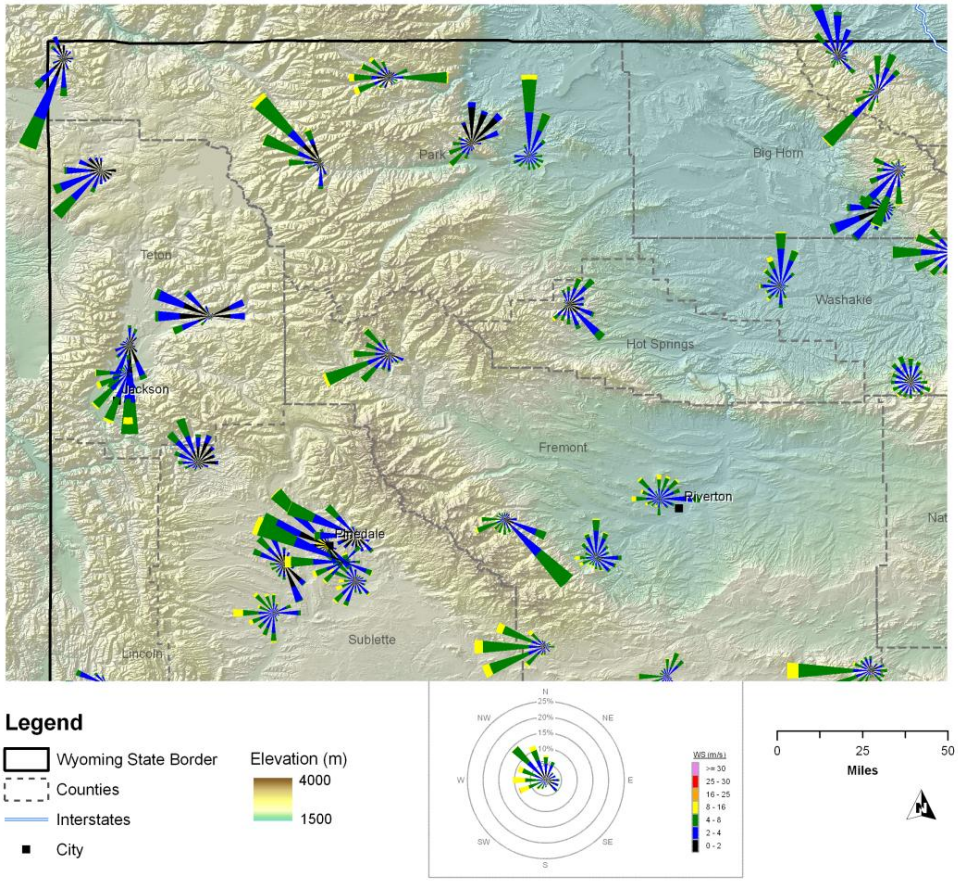
How to Interpret a Wind Rose
A wind rose provides a summary of wind patterns for a specific time period at a surface meteorological site. The length of the triangle emanating from the center of the wind rose to the edge of the outermost color of the triangle indicates the percentage of time that winds are from a specific direction (position on axes). The length of each colored area shows the percentage of time the winds are within a certain wind speed category.



Graphic courtesy of STI

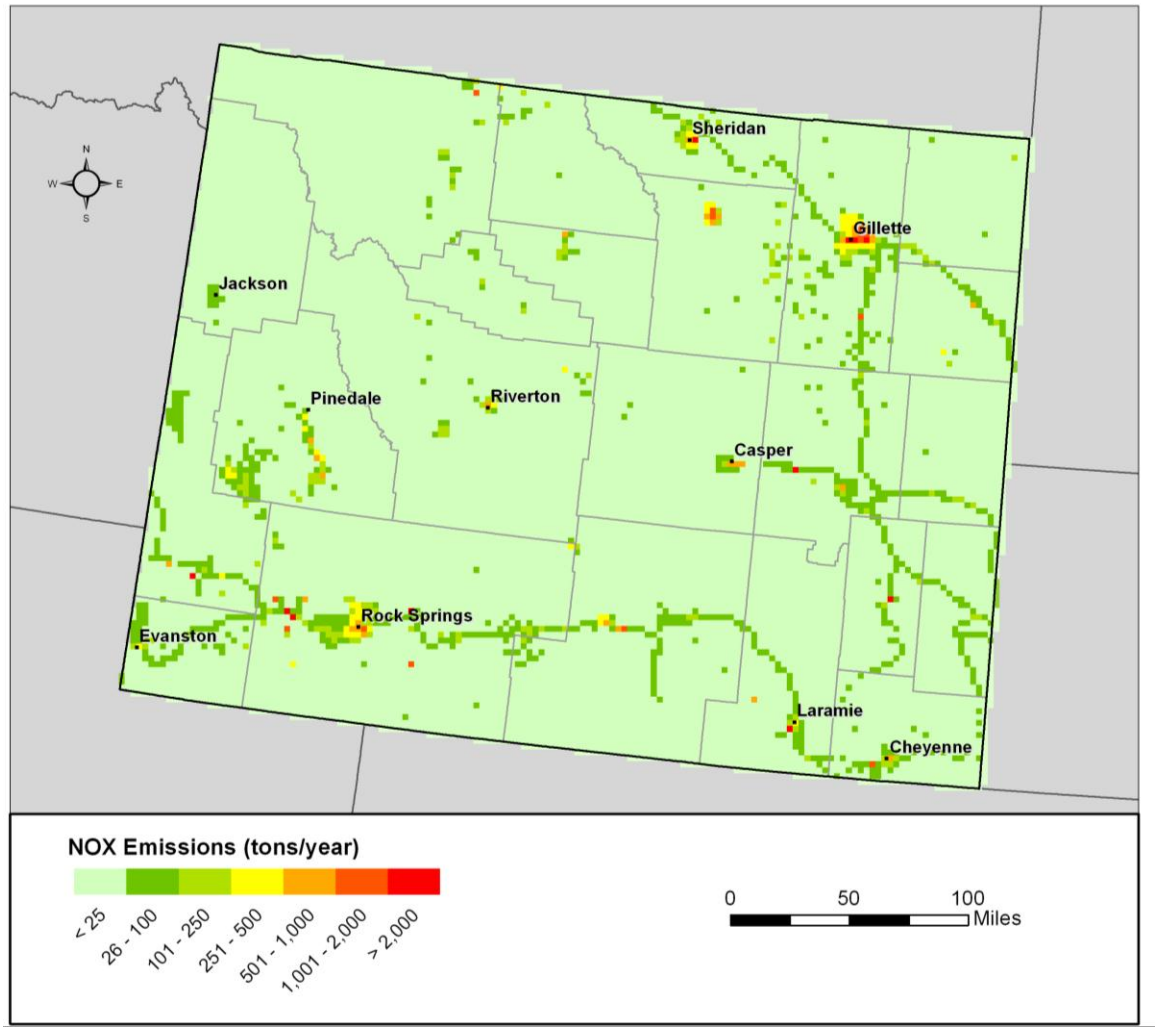
STI plotted these wind roses using ESRI ArcMap and their own proprietary software. When plotted on a map, these graphics can be useful in determining regional wind patterns and identifying areas where wind patterns shift based on topography.

Figure 2-5: Example of a wind rose map



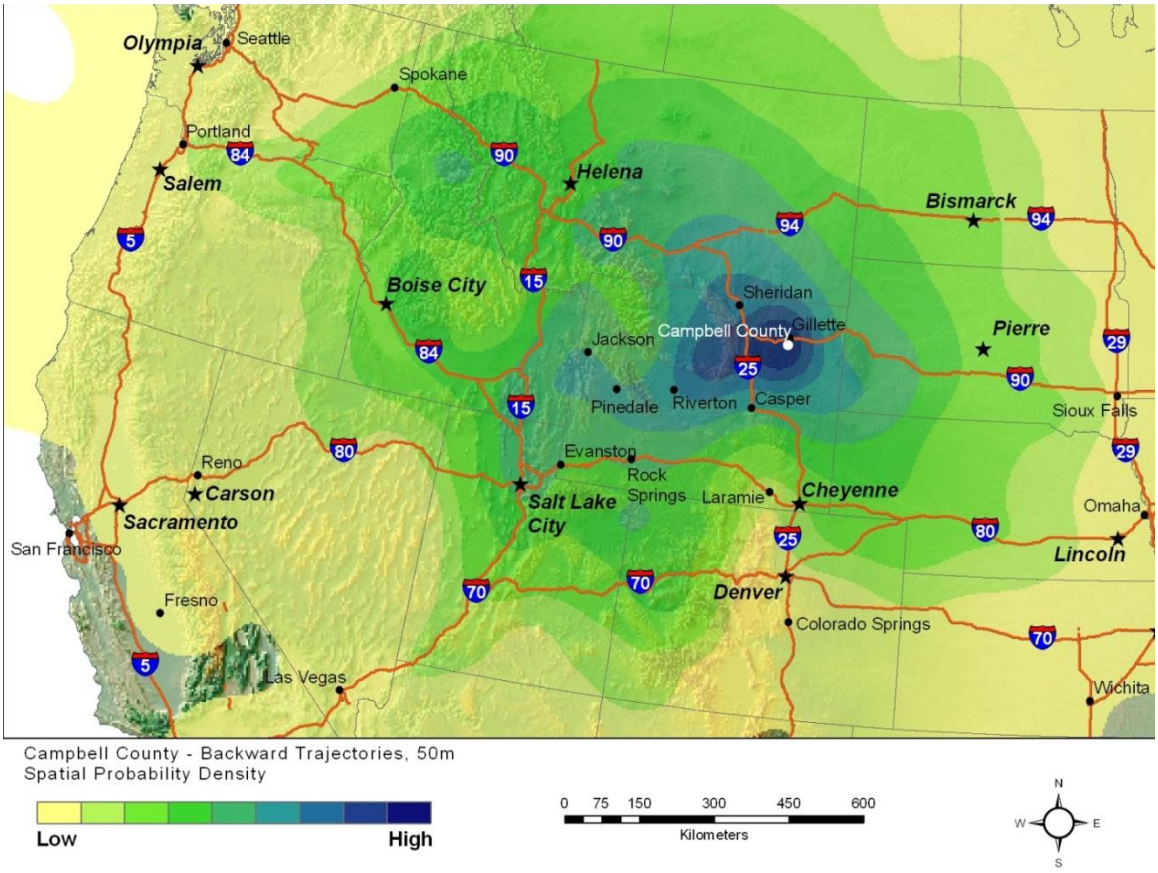
AQD also uses emission density plots to understand areas of concentrated emissions of pollutants and their distribution throughout the State. These maps use AQD's 2008 emission inventories, which are placed into 4 kilometer (km) by 4 km grids according to their location in Wyoming. The density of emissions is color coded; yellow to red colors denote areas of high emissions relative to the rest of the State. This typically indicates large point sources or groups of sources. These emission maps are used in conjunction with monitor locations and meteorological data to analyze the monitoring network.

Figure 2-6: Example of a Gridded Emission Density Map



Spatial probability density maps are also generated using STI's Transported Emissions Assessment Kit (TEAK) and ESRI ArcMap software. These maps show likely areas where air passed over before landing at the specified monitor. To produce these maps, STI used the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model to generate wind trajectories for the two days prior to an air parcel arriving at a monitor. These are called backtrajectories. HYSPLIT uses the Eta Data Assimilation System (EDAS) meteorological data from the years 2006-2008 to model the backtrajectories for each day in the specified time period. The areas of blue and darker green signify areas that air passed over most frequently before reaching the monitor. It should be noted that these models are not highly resolved, which means the wind's path gets averaged over a large distance and therefore usually doesn't reflect localized channeling from topography. This tool is useful for identifying the most frequent air patterns and areas where pollutants could be transported from before reaching the monitor.

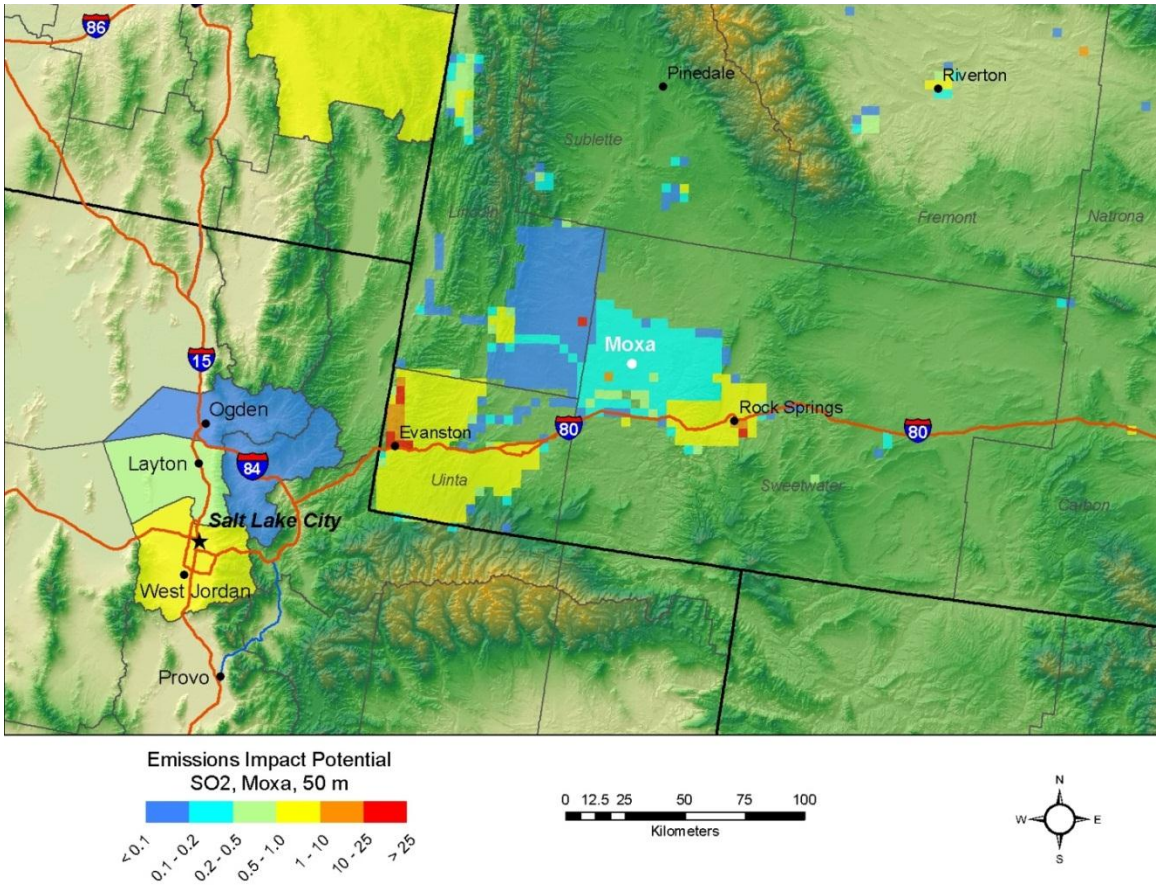
Figure 2-7: Example of a Spatial Probability Density Map



The spatial probability density plots can be combined with emission density plots into graphics that show "Emission Impact Potential". In basic terms, this metric is figured by the amount of time the backtrajectory moves over a county and the density of emissions in that county. The assumption is made from this calculation that the longer an air parcel spends over a place the more likely it is to carry those emission to the monitoring location. As stated earlier, these metrics are derived from models, and should only be used as a planning tool to understand possible influences on a monitor.

For this project, emission data was gathered at the 4 km grid-square level for Wyoming. Emission inventory data was gathered at the county level for states surrounding Wyoming. When viewing these graphics, the units are somewhat arbitrary. It is more important to identify the color pattern to understand possible influences. Yellow to red colors indicate a higher probability of emissions from that area influencing the monitor.

Figure 2-8: Example of an Emission Impact Potential Graphic



All of the statistical, graphical, and GIS spatial analysis data products are used together to determine if AQD's current network is meeting the objectives stated in Section 1, and if any additions or deletions need to occur to maximize the efficiency and effectiveness of the network.

3 Current AQD Monitoring Stations and Historical Data Evaluation

The AQD runs several monitoring stations throughout Wyoming that are designed to meet the objectives stated in Section 1. The AQD's Monitoring Section has greatly increased the scope of its monitoring program since the year 2000. The monitoring stations used in this evaluation were operating for a period of time between the years 2000 and 2008. Data for this evaluation was collected between the years 2006-2008, with the exception of trends evaluation, which used data collected between the years 2000-2008. Years 2006-2008 were the most recent data possible to give a consistent look between monitored data, population data, and emission inventories. Monitoring stations that began operations after 2006 are included in other evaluations, but did not have adequate data to conduct the historical evaluation.

3.1 Current AQD Monitoring Stations

Figure 3-1: Current AQD Monitoring Stations

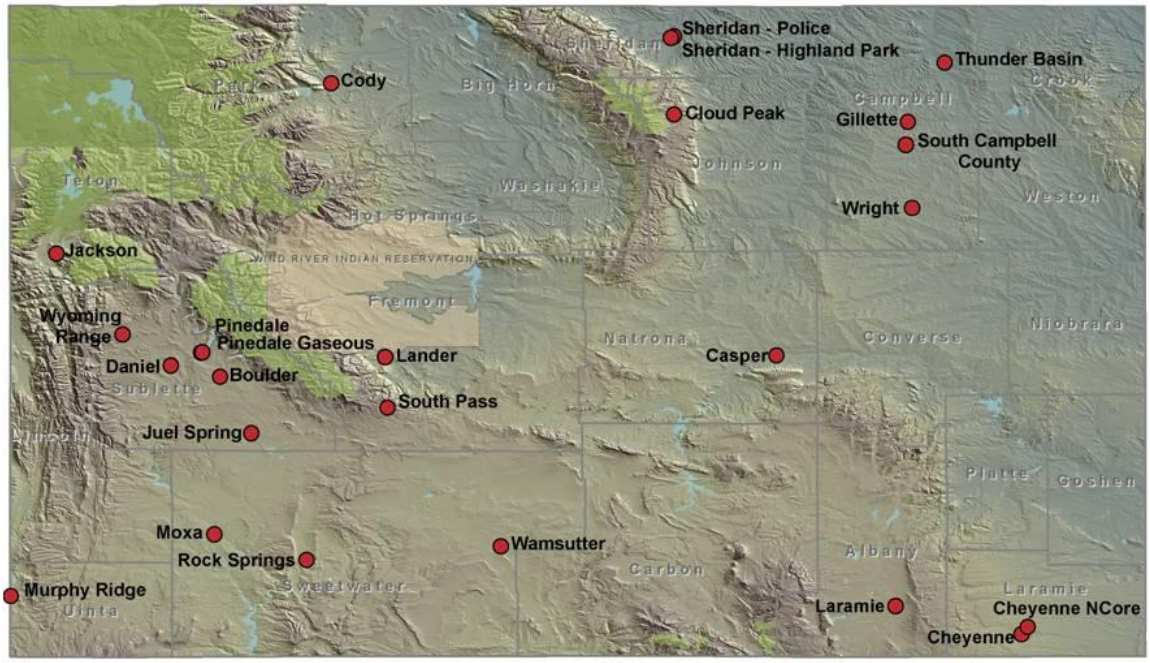


Table 3-1: Current AQD Monitoring Stations

Name	AQS ID	Beginning Date of Operation
Boulder	56-035-0099	9/1/2004
Casper	56-025-0001	Pre-1980
Cheyenne	56-021-0001	Pre-1980
Cheyenne NCore	56-021-0100	1/1/2011
Cloud Peak	56-019-9000	1/1/2002
Cody	56-029-0001	1/1/1975
Daniel	56-035-0100	7/1/2005

Name	AQS ID	Beginning Date of Operation
Gillette	56-005-1002	Pre-1980
Jackson	56-039-1006	6/8/2007
Juel Spring	56-035-1002	12/11/2009
Lander	56-013-1003	1/1/1987
Laramie	56-001-0006	Pre-1980
Moxa	56-037-0300	5/28/2010
Murphy Ridge	56-041-0101	1/1/2007
Pinedale	56-035-0705	7/1/2005
Pinedale Gaseous	56-035-0101	1/1/2009
Rock Springs	56-037-0007	1/1/1983
Sheridan	56-033-0003	1/1/1987
Sheridan Police	56-033-0002	10/5/1983
South Campbell County	56-005-0456	7/15/2003
South Pass	56-013-0099	3/12/2007
Thunder Basin	56-005-0123	5/1/2001
Wamsutter	56-037-0200	3/7/2006
Wright	56-005-0099	11/1/2002
Wyoming Range	56-035-0097	1/1/2011

Details regarding the current monitoring stations can be found in AQD's Annual Network Plan for 2010, which can be viewed at http://deq.state.wy.us/aqd/Annual%20Network%20Plans.asp

3.2 AQS Data Evaluation

As part of the Network Assessment, the AQD evaluated data from the AQD's monitoring stations that are reported to EPA's Air Quality System database (AQS). AQS is EPA's official reporting mechanism for the AQD's monitored data and the most complete database of AQD's monitored air quality data. Data for this evaluation was pulled from AQS, it is therefore important to understand the completeness and quality of data in AQS.

The AQD determined the data completeness of the 2000–2008 data for each monitoring station (by pollutant) on the basis of the total number of expected samples. To perform robust analyses, EPA recommends data completeness of greater than 85%; that is, a data set must be at least 85% complete to be representative of the sampling period. Data completeness is calculated by dividing the actual number of reported samples by the expected total number of samples. The actual number of samples may be less if there is a data acquisition system malfunction or if data is lost and not reported to the AQS system. AQD monitors met this 85% completeness goal with the exception of the following monitors:

Table 3-2: Monitoring Stations with less than 85% Data Completeness

Site ID	Site Name	Year	Pollutant
56-005-0892	Belle Ayr	2001	$PM_{2.5}$
56-005-0456	Campbell County	2005	PM_{10}

Based on this information, the AQD considers the data in AQS to be a good representation of data collected at AQD monitoring stations between the years 2000-2008. A table showing completeness for all monitoring stations (and pollutants) can be found in Appendix A.

Following the completeness evaluation, the AQD conducted a null and invalid data evaluation to determine how many samples collected over the time period (2000–2008) are reported with null or invalid sampling codes. This is used to indicate how many samples the AQD collected that were invalidated due to issues such as machine malfunction, calibration, operator error, etc. and is an indicator of overall data quality. The percentage of null or invalid samples is calculated from the number of actual data records (rather than the number of expected data records). The guidelines for acceptable number of invalid samples are different for each pollutant and are dictated by NAAQS data reduction requirements. For many pollutants the requirement is at least 75% data validity per quarter. For this evaluation, the AQD chose to note those sites, which have less than 85% data validity in a year. Please note this does not make the data unusable, rather it means that further investigation should be done prior to using the data for comparison to NAAQS or data analysis.

Table 3-3: AQD Monitoring Stations with less than 85% Data Validity by Pollutant and Year

Pollutant	Site ID	Site Name	Year(s)
O_3	56-005-0123	Thunder Basin	2008
	56-005-0456	Campbell County	2006,2008
NO_2	56-005-0123	Thunder Basin	2008
	56-005-0456	Campbell County	2006,2008
	56-005-0892	Belle Ayr	2004
	56-013-0099	South Pass	2008
	56-035-0099	Boulder	2008
$PM_{2.5}$	56-005-0899	Buckskin	2001,2006
	56-009-0819	Antelope	2001,2007
	56-035-0705	Pinedale High school	2008
	56-039-0006	Jackson	2002,2005
PM_{10}	56-005-1002	Gillette	2007
	56-005-0456	Campbell County	2006,2007
	56-013-0099	South Pass	2008
	56-013-1003	Lander	2003
	56-029-0001	Cody	2007
	56-035-0099	Boulder	2007
	56-035-0100	Daniel	2008
	56-039-0006	Jackson	2002

The AQD strives to collect high quality data at its monitoring stations. Since 2008, the AQD Monitoring Section has increased staff to manage monitoring stations to provide the highest quality data possible.

The complete table of data validity statistics for the AQD monitoring stations can be found in Appendix A.

The AQD also evaluated gaseous data collected that was below the minimum detection limit (MDL, i.e. the lowest detectable concentration a monitor can quantify). With current monitoring methods, especially for NO_2 and SO_2, the Federal Reference Method (FRM) and most associated Federal Equivalent Methods (FEMs) are not sensitive enough to capture low concentrations of these pollutants. This means the ambient air is cleaner than can be quantified by these monitors. Several of the AQD's monitoring stations employ these FRM and FEM methods. Table 3-3 details the evaluation of gaseous data below the MDL for the period of record

Table 3-4: Gaseous Data Collected Below the Minimum Detectable Limit

Pollutant	Site ID	Site Name	Percent below MDL
SO_2	56-013-0099	South Pass	98.8
	56-037-0200	Wamsutter	95.5
	56-041-0101	Murphy Ridge	90.7
NO_2	56-005-0892	Belle Ayr	57.9
	56-009-0819	Antelope	79.5
	56-013-0099	South Pass	54.6
	56-035-0100	Daniel	99.1
	56-041-0101	Murphy Ridge	86.5

The complete table of MDL statistics can be found in Appendix A. In 2009, AQD determined that SO_2 monitors at South Pass, Wamsutter, and Murphy Ridge should be shut down due to budget constraints and the low concentrations being collected. The AQD has not chosen to shut down any of the NO_2 monitors in the network, as the valid data can be used for episode analysis and modeling.

The methodology now exists to monitor NO_2 and SO_2 at lower levels with more accuracy. The AQD will consider using these trace-level monitors when deploying monitoring stations with NO_2 and SO_2 monitors in the future.

3.3 AQD Monitoring Station Trends

As part of the data evaluation, the AQD evaluated trends at those sites that have been running more than five years as of 2008. For this Network Assessment, this evaluation will be used to inform decisions to enhance or remove monitoring stations based on the magnitude and direction of the trend. The AQD evaluated sites for statistically significant trends (with 95% confidence or greater). The following table summarizes, by pollutant, statistically significant trends at the AQD's monitoring stations that have collected 5 or more years of valid data.

Table 3-5: AQD Monitoring Station Trend Summary

Pollutant	Total # of sites	Statistically significant increasing trend # of sites (site names)	Statistically significant decreasing trend # of sites (site names)	Trend not statistically significant # of sites
O_3	2	0	0	2
NO_2	2	0	1 (Thunder Basin)	1
$PM_{2.5}$	9	0	4 (Cheyenne, Sheridan PD, Sheridan Middle School, Jackson)	5
PM_{10}	12	1 (Sheridan PD)	3 (Lander, Cheyenne, Cody)	8

A table of the magnitude, direction and significance of the trend evaluation can be found in Appendix A. Based on this information, the AQD does not anticipate any changes to the monitoring network due to significant increases or decreases in concentration.

The AQD continues to evaluate the statistically significant increasing trend at the Sheridan Police Station site for PM_{10}. Since 2008, the AQD has changed the monitoring method to a continuous PM_{10} TEOM and installed a meteorological tower at this location. This allows the AQD to proactively evaluate PM_{10} concentrations and meteorological conditions in near real time. If warranted, the AQD can trigger supplementary PM controls as determined by the AQD's action plan.

3.4 Measured Concentration Analysis

The purpose of this evaluation is to quantify monitoring stations within the AQD's monitoring network that measure pollutant concentrations that are high, low, or close to the NAAQS. For this evaluation, the AQD reduced monitored values into the form of the NAAQS. All summary statistics are listed in Appendix A. This evaluation was not performed for SO_2 because of the substantial percentage of data collected below the Method Detection Limit (MDL).

The NO_2 evaluation showed that NO_2 concentrations were highest at the Belle Ayr and Jonah sites. The highest hourly concentrations were observed at Jonah and Belle Ayr, which were the only sites with hourly values greater than 100 ppb. Note that observations from Belle Ayr were taken only in 2006, while observations from Jonah were available for 2006, 2007, and part of 2008. NO_2 concentrations were lowest at Daniel South and South Pass sites, with average 1-hour concentrations less than 1 ppb. These sites are likely more representative of regional background concentrations than other sites in the area.

The evaluation of ozone data showed that median ozone concentrations were very similar across all sites with data from 2006 through 2008. The range of median concentrations was 43 to 51 ppb across all sites, and the range of standard deviation in the individual site ozone concentrations was narrow (8 to 11 ppb). Nonetheless, some of the differences in concentrations between sites were statistically

significant. For example, median ozone concentrations at Boulder were significantly higher than concentrations at other sites. Of more importance from a regulatory perspective; the Boulder, Jonah, and Thunder Basin monitoring stations averaged two or more days per year with 8-hour average ozone concentrations above 75 ppb. These sites are most likely to be important for determining NAAQS attainment.

$PM_{2.5}$ concentrations were very low at most monitoring sites. Wyoming has some of the lowest average concentrations of $PM_{2.5}$ observed in the contiguous United States, as demonstrated by long-term monitoring at Interagency Monitoring of Protected Visual Environments (IMPROVE) sites (Debell et al., 2006). Many of the $PM_{2.5}$ sites in Wyoming are suitable for assessing background concentrations. Conversely, very few of the monitoring sites had high $PM_{2.5}$ concentrations; although Lander and Sheridan Police Station had the highest concentrations in the monitoring network, both sites had median concentrations well below the annual NAAQS (15 $\mu g/m^3$) and none had more than a single observation above the 24-hour NAAQS 35 $\mu g/m^3$ between 2006 and 2008.

The PM_{10} evaluation showed that PM_{10} concentrations across the network are generally low. The Gillette, Laramie and Sheridan Police Department have the highest mean concentrations for the time period 2006-2008, 17 $\mu g/m^3$ at all three monitors. The Cody Monitoring station had the lowest mean concentration at 10 $\mu g/m^3$. All stations were well below the Annual PM_{10} Wyoming Ambient Air Quality Standard (WAAQS) 50 $\mu g/m^3$. Sheridan Police Department and Campbell County Monitoring Station had the highest 24-hour PM_{10} concentrations during the 2006-2008 time period.

The AQD does not recommend any changes at this time based on the measured concentration evaluation. The measured concentration evaluation may be used in future Network Assessments to evaluate changes in monitoring station design values.

4 Objective #1: Determine Representative Concentration in Areas of High Population Density

Monitoring stations have been placed throughout Wyoming to determine air quality concentrations in areas of high population density. The NAAQS are set to protect public health and monitoring stations are often placed in populated areas to ensure the air quality is meeting the NAAQS where people live and work. To determine the optimal use of resources, emissions are used in conjunction with population when siting population based monitoring.

4.1 Monitoring Stations that Meet this Objective

Figure 4-1: Monitoring Stations that Meet Objective #1

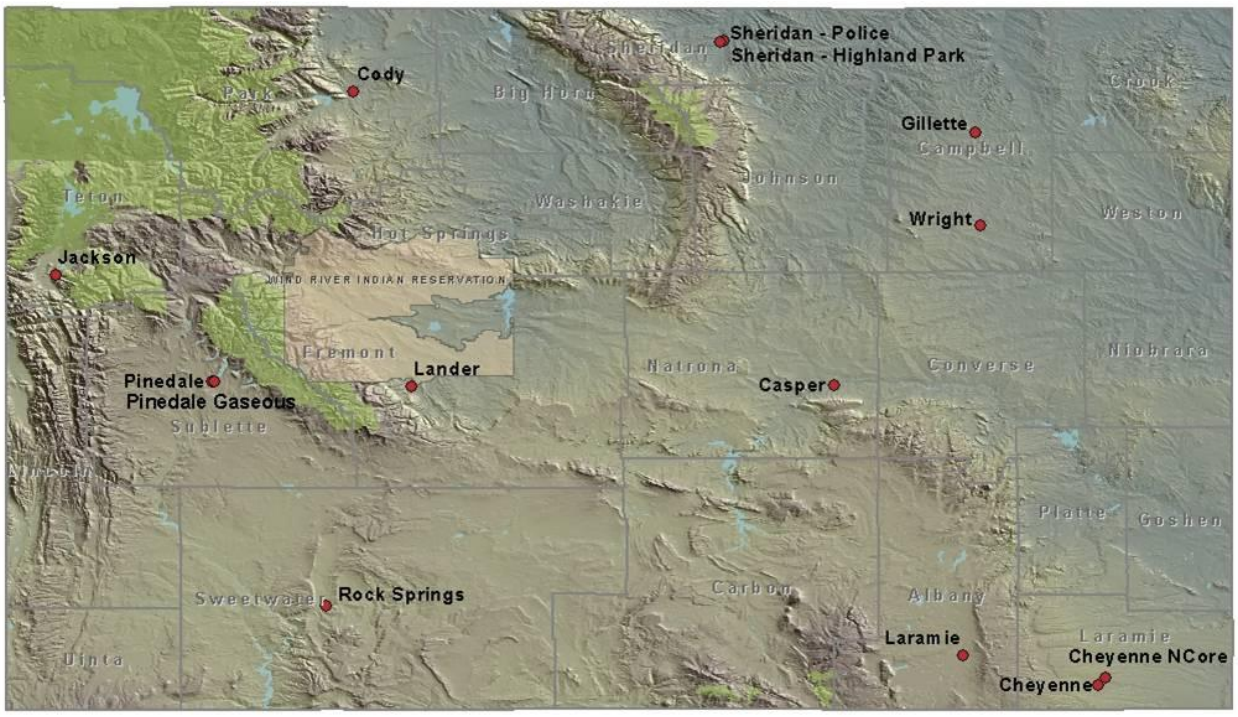


Table 4-1: Monitoring Stations that Meet Objective #1

AQS ID	Monitoring Station Name	Operating Agency	Ozone	NO_2	PM_{10}	$PM_{2.5}$	SO_2
56-025-0001	Casper	AQD			X	X	
56-021-0001	Cheyenne	AQD			X	X	
56-021-0100	Cheyenne NCore	AQD	X	X	X	X	X
56-029-0001	Cody	AQD			X	X	
56-005-1002	Gillette	AQD			X		
56-039-1006	Jackson	AQD			X	X	
56-013-1003	Lander	AQD			X	X	
56-001-0006	Laramie	AQD			X	X	
56-035-0705	Pinedale	AQD				X	

AQS ID	Monitoring Station Name	Operating Agency	Ozone	NO_2	PM_{10}	$PM_{2.5}$	SO_2
56-035-0101	Pinedale Gaseous	AQD	X	X		X	
56-037-0007	Rock Springs	AQD			X	X	
56-033-0003	Sheridan - Highland Park	AQD			X	X	
56-033-0002	Sheridan - Police	AQD			X	X	
56-005-0099	Wright	AQD			X		

4.2 Supporting Data Evaluation

For this evaluation, the AQD examined population data from the year 2007 in addition to population changes from 2000-2007 throughout the State in relation to current monitors. Figures 4-2 and 4-3 map population data throughout the State.

Figure 4-2: Wyoming Population per Square km for Year 2007

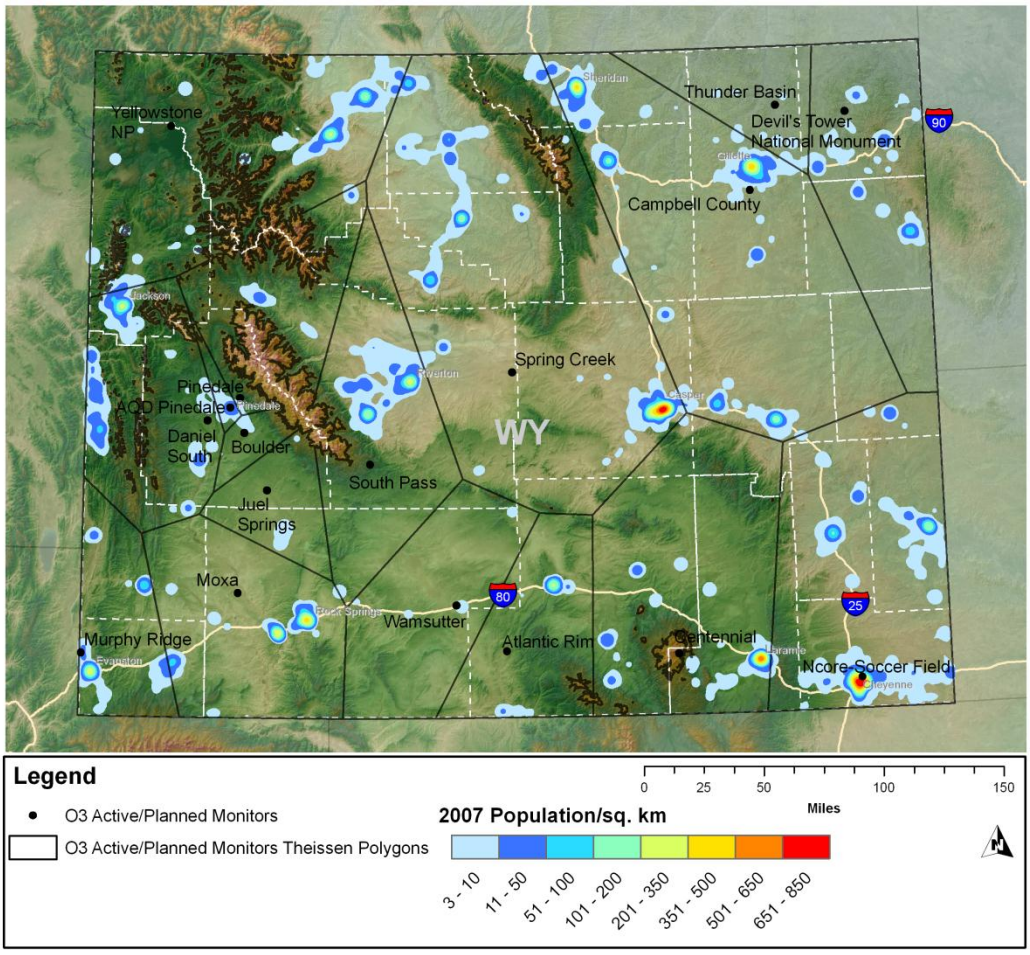


Figure 4-3: Wyoming Population Change from 2000-2007

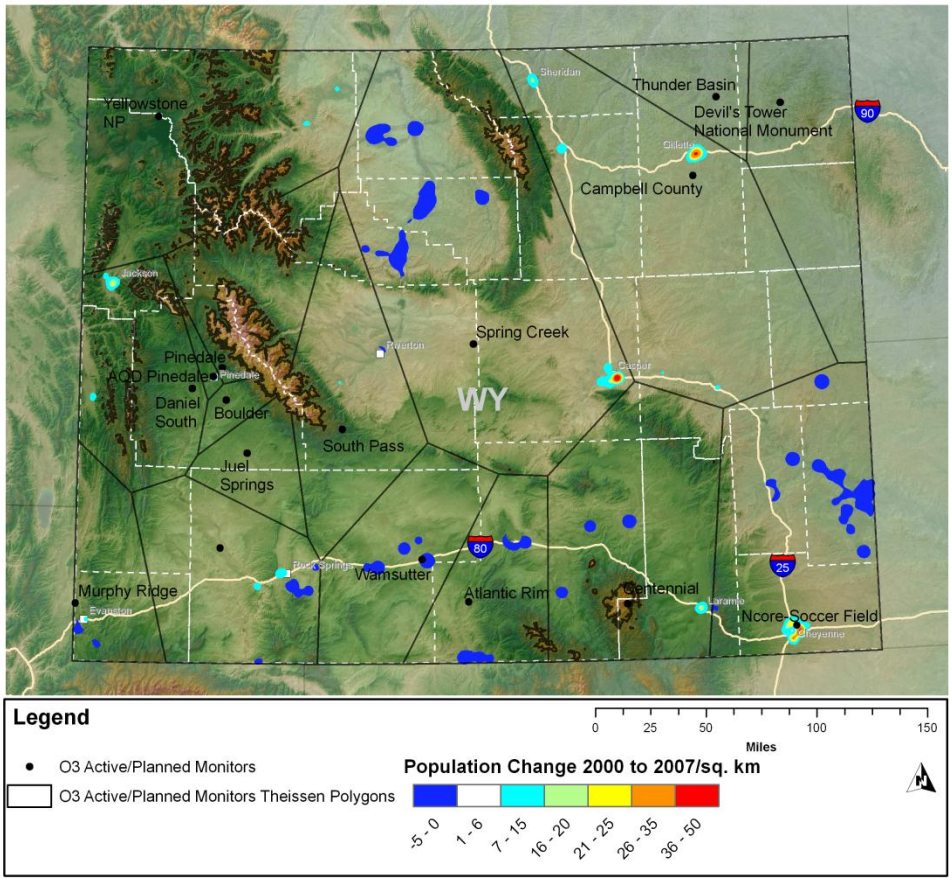


Figure 4-2 demonstrates that areas with population greater than 100 persons per square kilometer are covered by existing monitoring stations. Figure 4-3 also demonstrates that areas of population growth over 20 persons per square kilometer are also being represented by existing monitoring stations.

AQD also ranked cities and towns in terms of total population. Table 4-2 lists cities and towns with population greater than 1,000. Data was obtained from the State of Wyoming Economic Analysis Division for 2009.

Table 4-2: Estimate Population of Wyoming Cities and Towns

City/Town Name	2009 Est. Population	Wyoming County
Cheyenne	57,618	Laramie County
Casper	54,874	Natrona County
Laramie	28,850	Albany County
Gillette	28,726	Campbell County
Rock Springs	20,905	Sweetwater County
Sheridan	17,461	Sheridan County
Green River	12,411	Sweetwater County

City/Town Name	2009 Est. Population	Wyoming County
Evanston	11,958	Uinta County
Riverton	10,249	Fremont County
Jackson	9,915	Teton County
Cody	9,435	Park County
Rawlins	8,791	Carbon County
Lander	7,387	Fremont County
Douglas	6,212	Converse County
Powell	5,786	Park County
Torrington	5,688	Goshen County
Worland	5,054	Washakie County
Buffalo	4,888	Johnson County
Mills	3,574	Natrona County
Newcastle	3,404	Weston County
Wheatland	3,236	Platte County
Thermopolis	2,948	Hot Springs County
Kemmerer	2,513	Lincoln County
Evansville	2,504	Natrona County
Glenrock	2,466	Converse County
Lovell	2,325	Big Horn County
Pinedale	2,221	Sublette County
Lyman	2,034	Uinta County
Bar Nunn	1,926	Natrona County
Afton	1,906	Lincoln County
Saratoga	1,777	Carbon County
Greybull	1,774	Big Horn County
Wright	1,550	Campbell County
Lusk	1,429	Niobrara County
Sundance	1,339	Crook County
Basin	1,290	Big Horn County
Mountain View	1,235	Uinta County
Pine Bluffs	1,171	Laramie County
Marbleton	1,113	Sublette County
Dubois	1,088	Fremont County
Guernsey	1,064	Platte County

The cities of Cheyenne and Casper are far larger than any other cities in Wyoming. Additionally, Figure 4-3 shows that Cheyenne and Casper have experienced substantial population growth since 2000.

The AQD also assessed monitoring in areas designated Core Based Statistical Area (CBSA) by the census. EPA often requires monitoring based on the CBSA designation of an area. Table 4-3 shows Wyoming's CBSA's.

Table 4-3: 2009 Wyoming Core Based Statistical Areas

Core-Based Statistical Area Name	Counties Involved	Est. 2009 Population
Casper, WY Metropolitan Statistical Area	Natrona County	74,508
Cheyenne, WY Metropolitan Statistical Area	Laramie County, WY	88,854
Evanston, WY Micropolitan Statistical Area	Uinta County, WY	20,927
Gillette, WY Micropolitan Statistical Area	Campbell County, WY	43,967
Jackson, WY-ID Micropolitan Statistical Area	Teton County, WY	20,710
	Teton County, ID	9,337
Laramie, WY Micropolitan Statistical Area	Albany County, WY	33,979
Riverton, WY Micropolitan Statistical Area	Fremont County, WY	38,719
Rock Springs, WY Micropolitan Statistical Area	Sweetwater County, WY	41,226
Sheridan, WY Micropolitan Statistical Area	Sheridan County, WY	29,163

Total 2009 Wyoming Population by Core-Based Statistical Areas	**401,390**

Note: A Core Based Statistical Area, as defined by the US Census Bureau, is any urban metro area with over 50,000 population, or a micro area, which has more than 10,000 population.

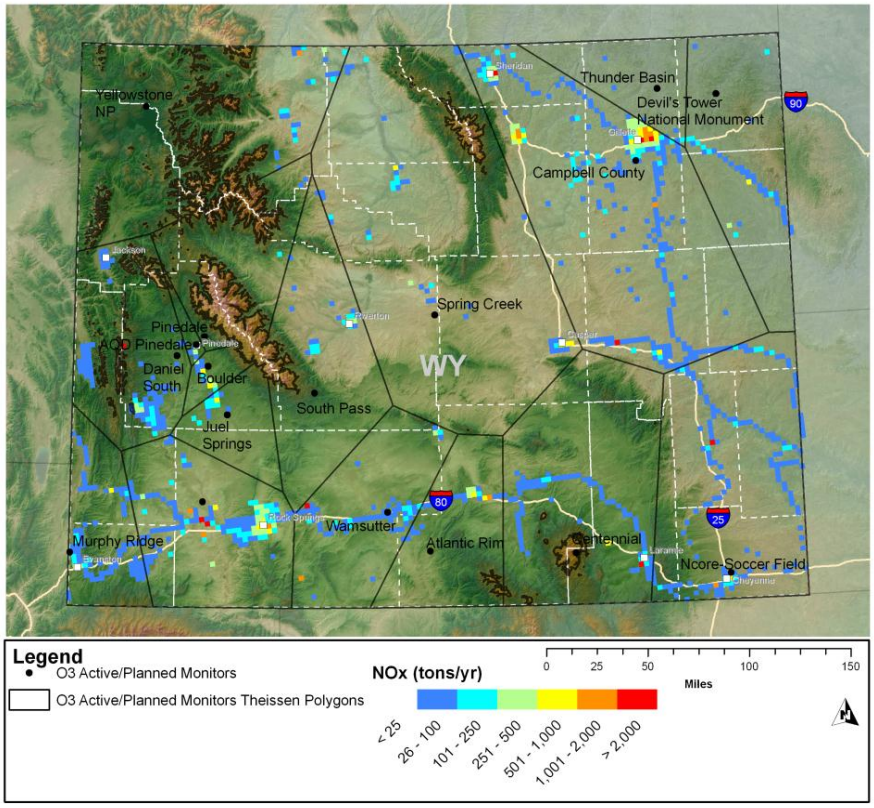
The identified locations are those listed by the US Census 2009 Statistical Areas List.

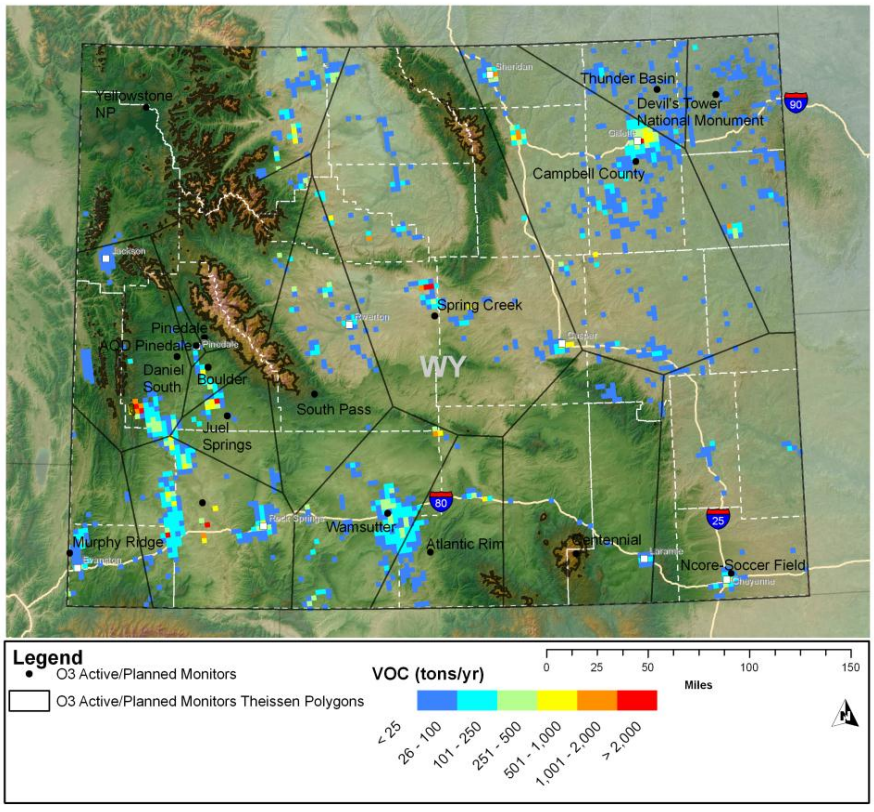
Wyoming has nine CBSA's and there is currently air quality monitoring in all of the CBSA's. All CBSA's have PM_{10} and $PM_{2.5}$ monitoring stations however, not all CBSA's have ozone monitoring. The Casper CBSA, a metropolitan statistical area, does not have ozone monitoring. Additionally, the Laramie and Sheridan micropolitan statistical areas do not currently have ozone monitoring. EPA's proposed 2009 Ozone Monitoring Rule calls for all metropolitan statistical areas and at least one micropolitan statistical area within the State to monitor for ozone.

To understand whether populated areas have representative monitoring in relation to pollutant emissions in their area, the AQD also evaluated the existing monitoring stations with respect to the gridded emission inventory. The AQD examined gridded emission inventory data for NO_x, SO_2, PM_{10}, and NO_x combined with VOCs to evaluate ozone. There was no $PM_{2.5}$ emission inventory data compiled for this Network Assessment, therefore the AQD evaluated the population based $PM_{2.5}$ network solely on the basis of total population and population change.

The following figures show examples of the gridded emission evaluation. The gridded emission graphics for all pollutants can be found in Appendix B. Figure 4-4 depicts gridded emissions of NO_x and VOC. NO_x and VOC emissions are precursors to ozone formation.

Figure 4-4: Gridded NO_x and Gridded VOC Emissions

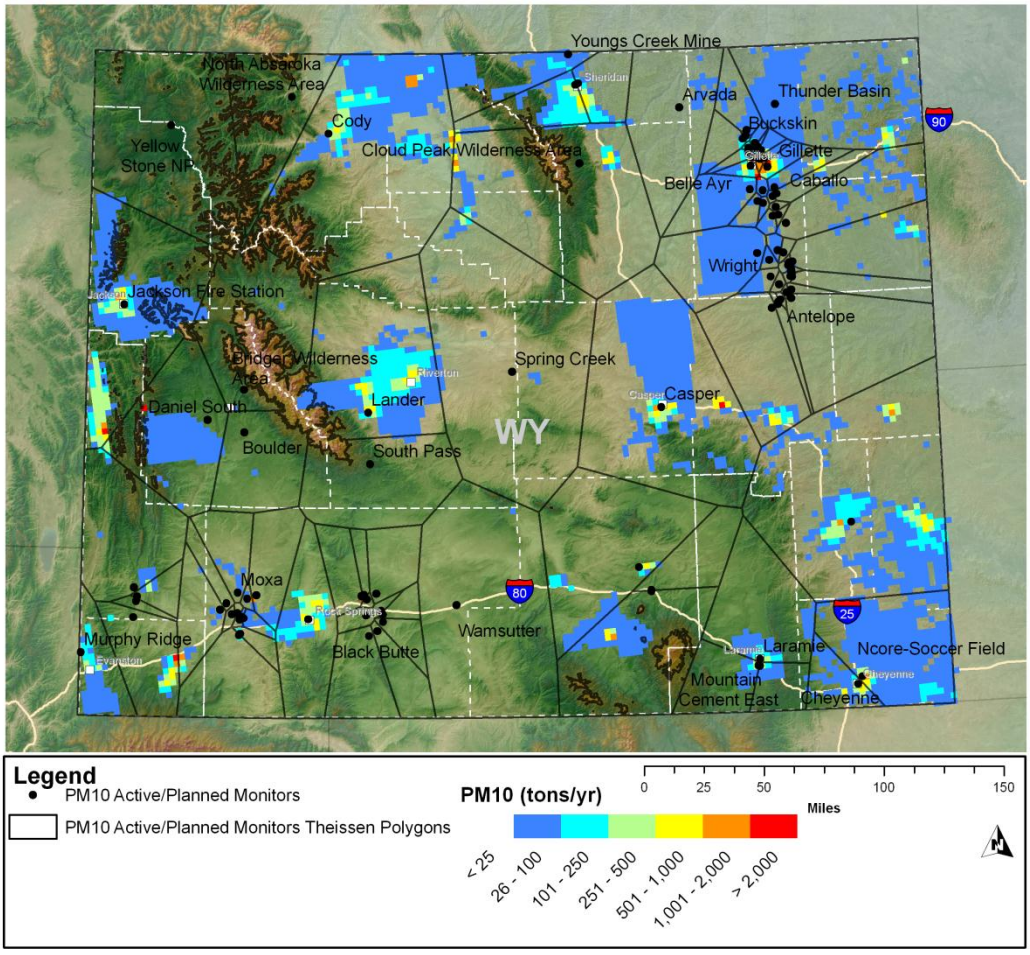




The NO_x and VOC gridded emissions graphics show populated areas, such as Gillette and Rock Springs, that have both NO_x and VOC emissions but do not currently have ozone monitoring within the city.

The AQD also evaluated gridded PM_{10} emissions. Figure 4-4 shows gridded emissions and PM_{10} monitoring stations in Wyoming.

Table 4-4: Gridded PM_{10} Emissions



This figure shows that Wyoming has many PM_{10} monitoring stations in populated areas. When these data were examined in conjunction with total population and population growth, the Star Valley area, had substantial PM_{10} emissions coupled with population growth that is not represented by current PM_{10} monitoring.

4.3 Conclusions

Based on the above mentioned evaluation, the AQD's current network is meeting its objective to determine representative concentrations in areas of high population density. The evaluation of the total population, population growth, and gridded emissions show that the current monitors meet this objective. AQD also evaluated the historical concentrations and redundancies in the historical data evaluation and found that no population-based monitors need to be removed at this time.

EPA's proposed 2009 Ozone Monitoring Rule calls for all metropolitan statistical areas within the State to monitor for ozone. Casper is the only Metropolitan Statistical Area in Wyoming that is not currently monitored for ozone. The AQD agrees that the Casper CBSA, which accounts for almost 15 % of Wyoming's total population, should have ozone monitoring. Based on the evaluation of total population, population growth, and monitored CBSA's Casper's large population and substantial growth since 2000 warrant population-based ozone monitoring.

The micropolitan statistical areas of Sheridan and Laramie are not currently monitored for ozone, however, the emissions analysis did not warrant further action on these areas at this time.

For the optimization of resources, the AQD evaluated populated areas coupled with emissions that may not be monitored currently. Based on this evaluation, the AQD found that there are emissions of NO_X and VOCs that could cause ozone formation from anthropogenic sources near the cities of Rock Springs and Gillette. Taking into consideration at all factors evaluated above (total population, population growth, and gridded emissions) these cities would benefit from population based ozone monitoring. The AQD also found that the Star Valley area's PM_{10} emissions and population growth warrant population-based PM_{10} monitoring.

Southwest Wyoming Network Assessment found that emissions from oil and gas development and elevated ozone concentrations in Sublette County warranted ozone, NO_x and $PM_{2.5}$ to be added in the Town of Pinedale. In 2009, the AQD deployed a new monitoring station in the Town of Pinedale.

As part of EPA's network assessment guidance, EPA also requested the states evaluate any environmental justice areas that may need monitoring. According to EPA, Environmental Justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.The AQD has evaluated possible environmental justice areas in Wyoming. The largest area is the Wind River Reservation in central Wyoming (pictured in Figure 4-1). The AQD does not have authority over air quality in this area. Therefore, the AQD cannot monitor on the Wind River Reservation. The AQD is also cognizant of residential areas around industrial facilities, which may be considered environmental justice areas. The Monitoring Section works closely with the AQD's New Source Review Program to understand modeled impacts to residential areas surrounding industrial facilities. In situations when modeled emissions may impact residential areas, the New Source Review Program may include ambient monitoring in permits. The Monitoring Section then oversees monitoring stations that are required by this process. Further information on industrial facilities that have monitoring stations can be found in Section 5.

5 Objective #2: Determine Impact on Ambient Air Quality from Significant Sources

Monitoring stations meeting this objective have been placed to determine impact from sources or groups of sources. For the purposes of this Network Assessment, the sources or groups of sources are industrial facilities that are considered anthropogenic in nature. Monitoring stations that meet this objective are usually placed at a location near the source or group of sources where impact from emissions are expected to occur. This is typically downwind of the source in the predominant wind direction.

These monitoring stations can be used to assist in tracking changes in pollutant levels. Changes that happen in air quality due to changes in pollutant emission levels can be straightforward or complex to track depending on the emitted pollutant and the complexity of chemical reactions it is subjected to in the air. Additionally, changes in ratios of monitored concentrations can also be tracked when examining trends in emissions. Monitoring stations used for this purpose are usually located in areas close to pollutant emission sources and house monitors specific to the pollutants being emitted from those sources.

Monitoring Stations meeting this objective can be administered by the AQD or by industry. The industry administered stations can be the result of an AQD New Source Review permit condition or a condition from another form of legally binding agreement, such as a settlement of an air quality permit violation or an Environmental Impact Statement (EIS) Record of Decision (ROD). While industry administers these stations, the AQD usually performs oversight to ensure data are collected per AQD and EPA regulations. Industry may also place monitoring stations voluntarily and may share those data with the AQD.

5.1 Monitoring Stations That Meet this Objective

Figure 5-1: Monitoring Stations That Meet Objective #2

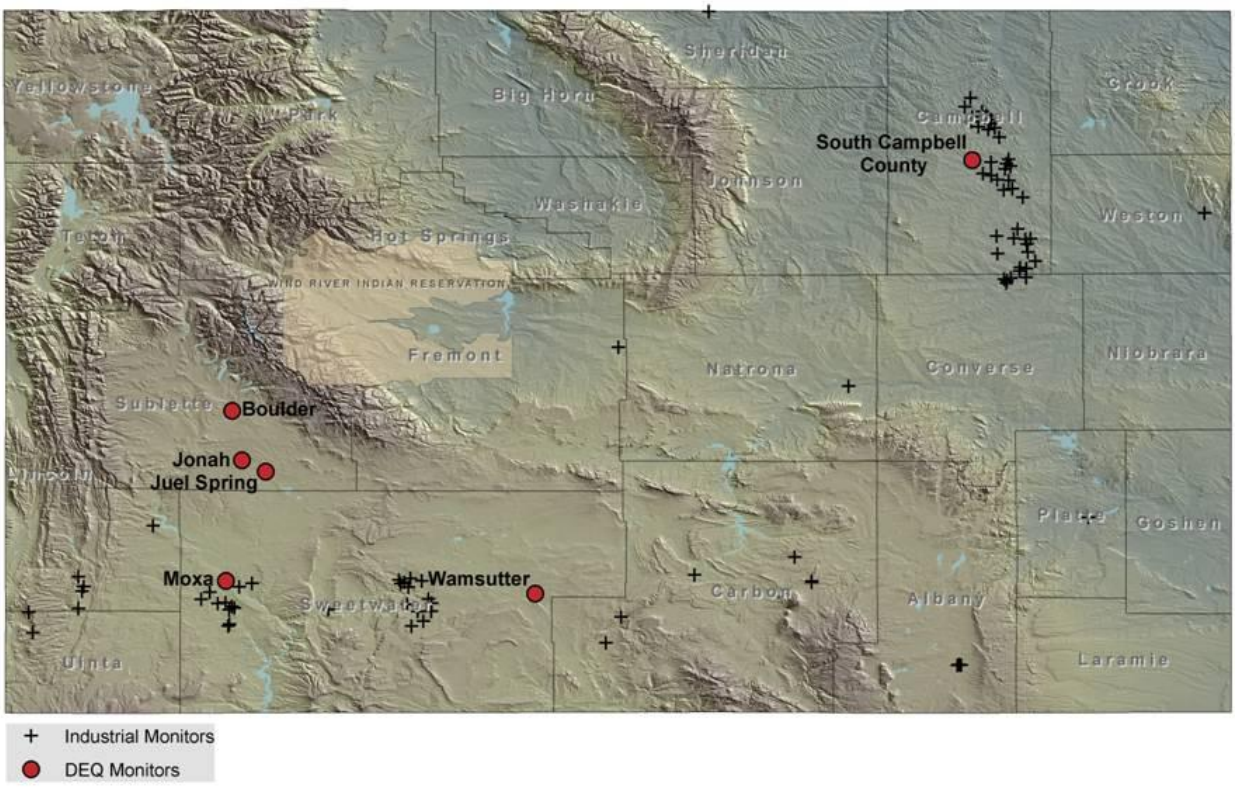


Table 5-1: AQD Monitoring Stations that Meet Objective #2

AQS ID	Monitoring Station Name	Operating Agency	Ozone	NO_2	PM_{10}	SO_2
56-035-0099	Boulder	AQD	X	X	X	
56-035-0098	Jonah	AQD	X	X	X	
56-035-1002	Juel Spring	AQD	X	X		
56-037-0300	Moxa	AQD	X	X	X	X
56-005-0456	South Campbell County	AQD	X	X	X	
56-037-0200	Wamsutter	AQD	X	X	X	X

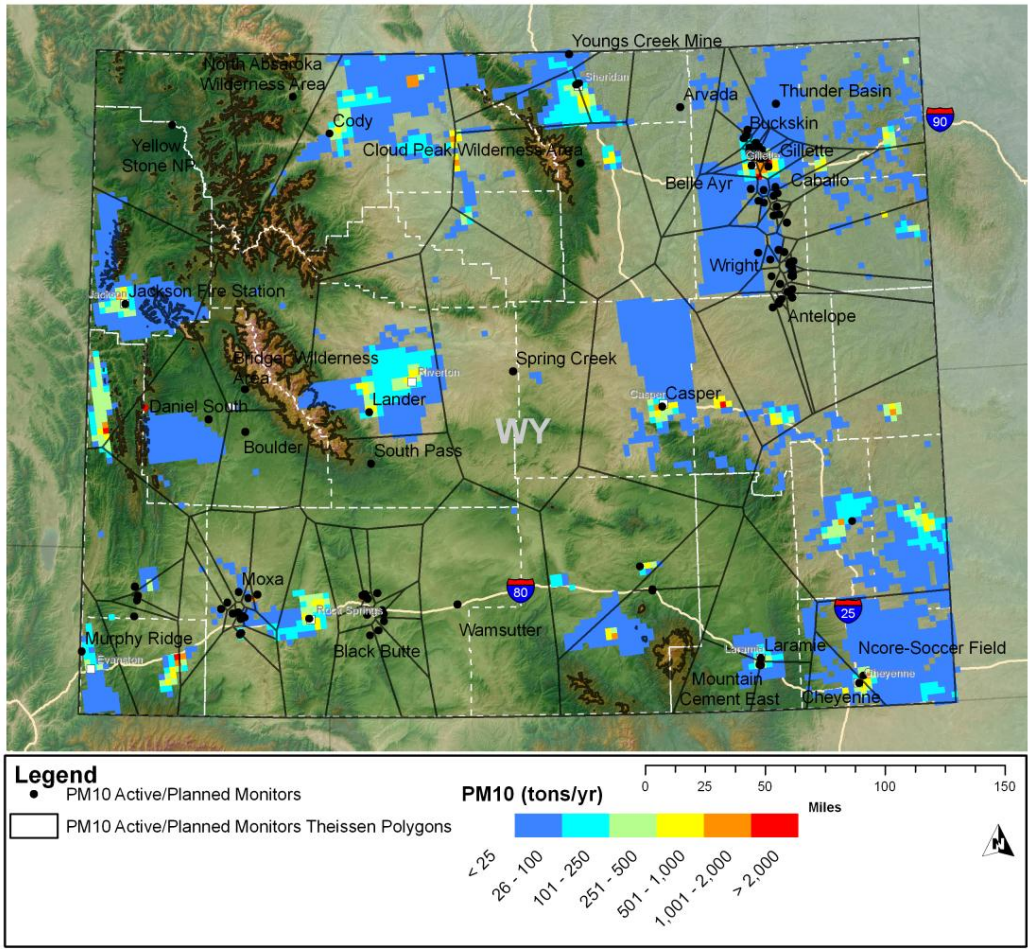
A table listing all of the industry administered stations can be found in Appendix C.

5.2 Supporting Data Evaluation

For this evaluation, the AQD examined gridded emissions in relation to current monitoring stations. These gridded emission maps show both industrial sources and “area sources”, which include agriculture and residential emissions.

The AQD evaluated gridded emissions of PM_{10}, SO_2, NO_x, and NO_x coupled with VOCs to determine areas that may need additional monitoring stations. Figures used for this evaluation can be found in Appendix C. For example, Figure 5-3 shows PM_{10} emissions and PM_{10} monitoring stations throughout Wyoming.

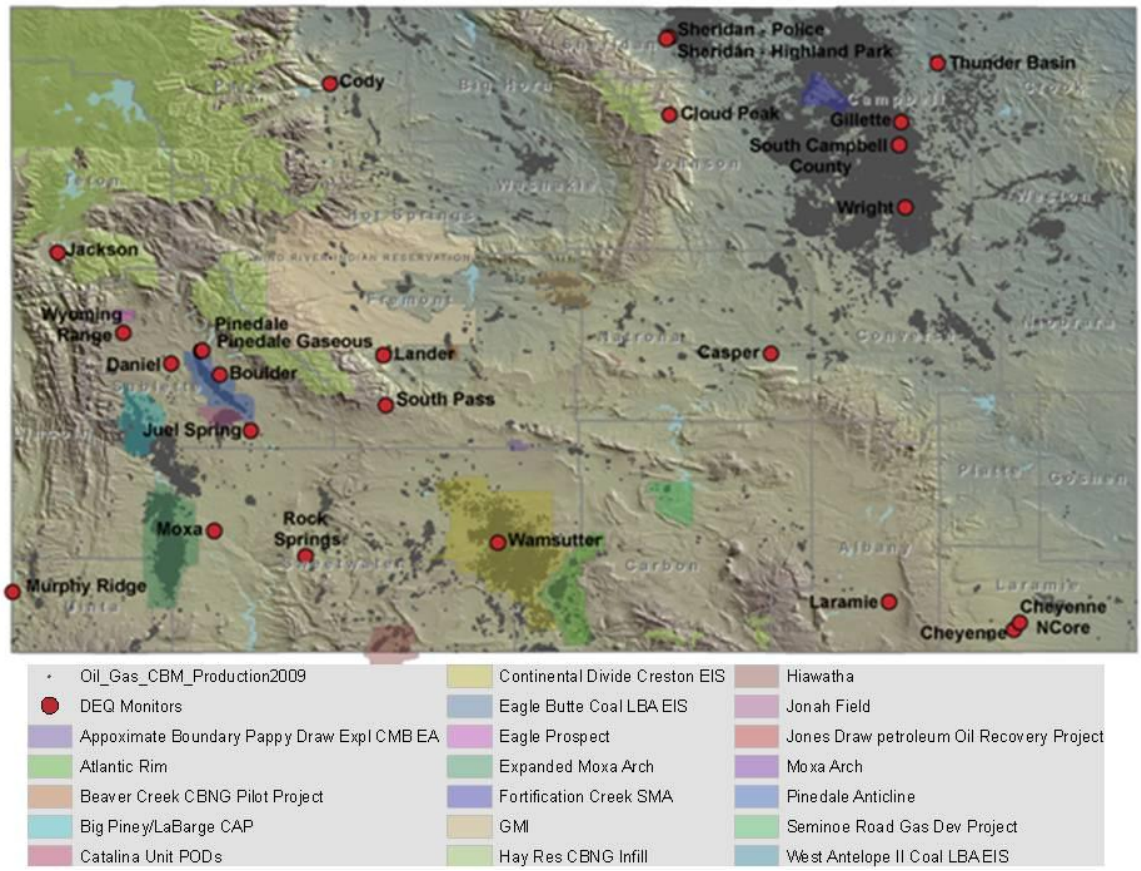
Figure 5-2: Gridded PM_{10} Emissions and PM_{10} Monitoring Stations



The AQD has an extensive network of PM_{10} monitoring stations throughout Wyoming. However, there are a few anthropogenic source areas that are not represented by PM_{10} monitoring.

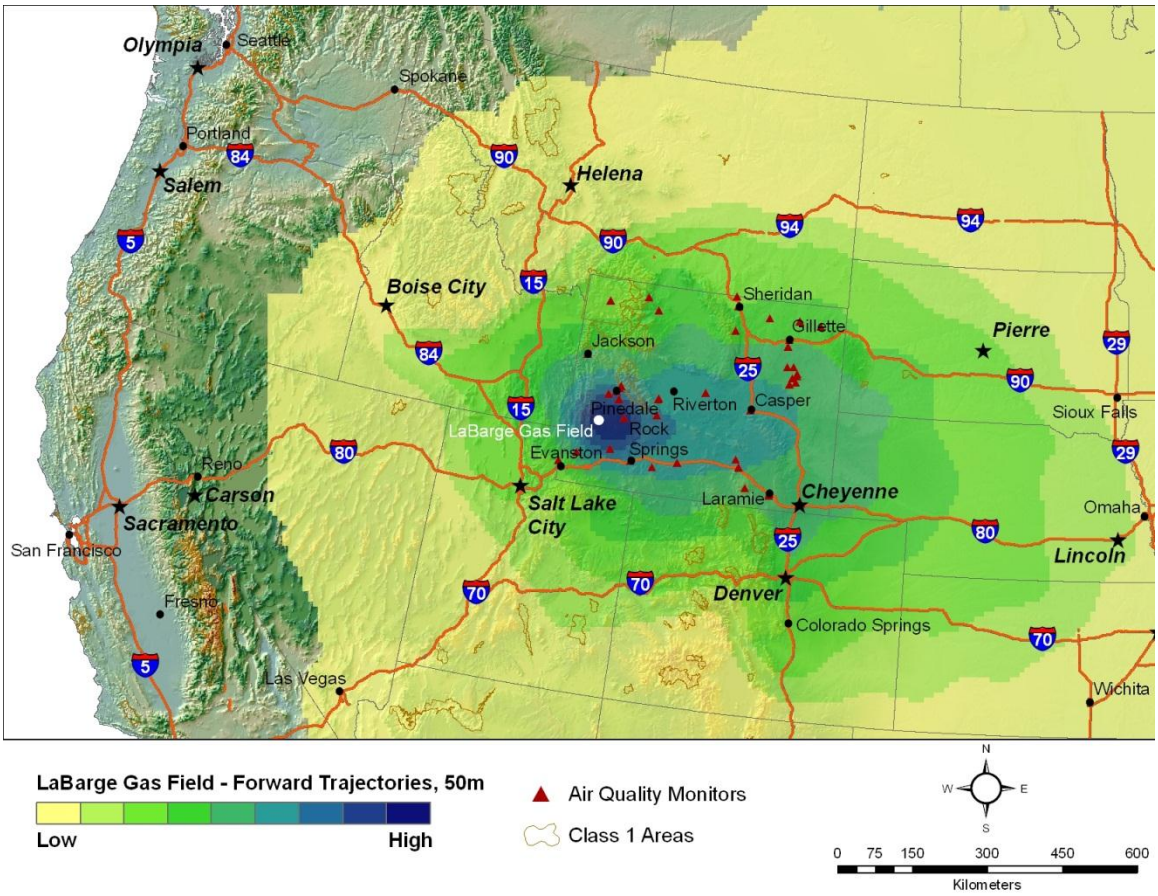
Due to significant proposals for oil and gas extraction, as well as other energy development activities in Wyoming, the AQD also evaluated proposed oil and gas project areas with respect to current monitoring stations. Specifically, LaBarge Platform, Hiawatha, Moxa Arch, and Continental Divide-Creston have a significant number of wells proposed (604, 4208, 1861, and 8950 respectively). Figure 5-3 depicts oil and gas wells throughout Wyoming in addition to proposed National Environmental Policy Act (NEPA) projects for oil and gas.

Figure 5-3: Proposed NEPA Oil and Gas Projects and Current AQD Monitoring



The AQD ran forward trajectories from LaBarge Platform (LaBarge) and Hiawatha Gas Fields to understand the possible areas of impact from those projects. At the time the STI analyses were performed, the Moxa (representing downwind impacts from Moxa Arch Field) and Wamsutter (representing infield impacts from Continental Divide-Creston Fields) monitors were already sited therefore the AQD analyzed the appropriateness of the location and found that they are well placed to monitor impacts from those projects. The spatial probability densities from these analyses (backtrajectory analysis) can be found in Appendix C. Figure 5-4 shows the spatial probability densities for LaBarge.

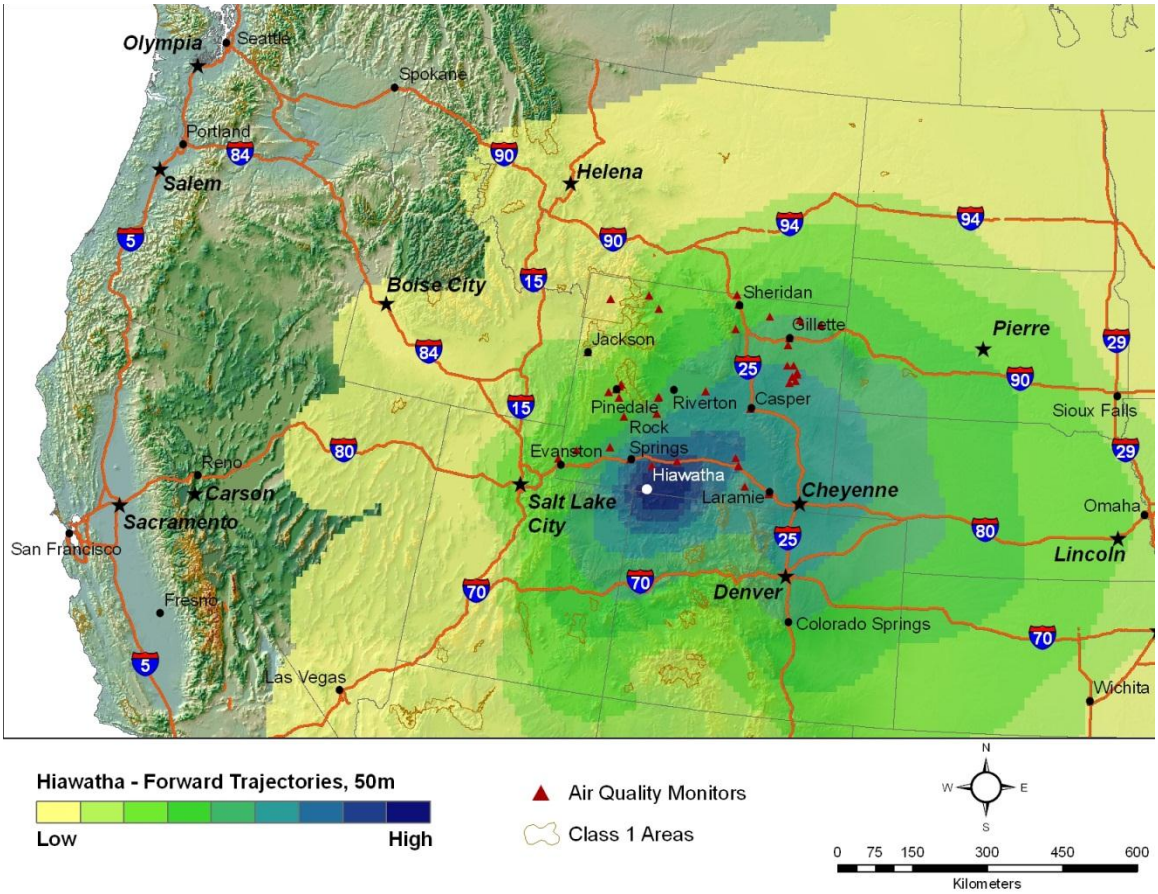
Figure 5-4: Spatial Probability Density Analysis for the LaBarge Gas Field



This figure shows possible emissions transport from the LaBarge. The majority of the air parcel endpoints are located to the east of LaBarge. A complicating factor in determining impacts from LaBarge is the Jonah and Pinedale Anticline Gas Fields that are located on the eastern side of the Upper Green River Basin (see Figure 5-4). A monitoring station located between the LaBarge and Pinedale Anticline/Jonah Fields would monitor impacts from the LaBarge and would also be useful in any upcoming modeling that would take place regarding ozone nonattainment for the Upper Green River Basin.

Figure 5-6 shows possible emissions transport from the Hiawatha project area.

Figure 5-5: Spatial Probability Density from Hiawatha Gas Field



The majority of the air parcel endpoints are localized around the Hiawatha Field. Considering the proposed number of wells for the Hiawatha Field, downwind monitoring would be advantageous to monitor for possible changes in air quality as development proceeds. Therefore, a monitoring station to represent impacts from the development in Hiawatha would be best placed near the field.

5.3 Conclusions

Based on these evaluations, the AQD has concluded that current monitors meet the objective of determining impact on ambient air quality from significant sources. The AQD evaluated anthropogenic source placement and gridded emission inventories in relation to current AQD and industry administered monitoring and determined that no changes are needed for the current monitoring stations.

The AQD has determined that additional monitoring may be needed downwind of the Hiawatha and LaBarge Platform project areas. This is based on the current emissions along with activity projections based on scoping documents and forward trajectories. At this time, the AQD and EPA have jointly allocated funding for monitoring near the Hiawatha Field, which will be deployed in 2011. Additionally, the AQD has a fleet of mobile monitoring stations that could be used to monitor the LaBarge Gas Field.

As new projects on federal lands are proposed, the AQD Planning Section reviews the Environmental Impact Statements that pertain to air quality. This poses an opportunity for the AQD to work with the federal land managers and the project proponent to propose monitoring stations to monitor impacts from project emissions.

The Monitoring Section also proactively works with the AQD's New Source Review Program when facilities apply for permits. Monitoring stations may be required in addition to, or in lieu of, modeling impacts. The Monitoring Section oversees monitoring stations that are required in permits to ensure the monitoring is compliant with EPA regulations and can be compared to the NAAQS.

6 Objective #3: Determine General Background Concentration Levels

Monitoring sites have been placed throughout the State to evaluate the monitored general background levels. The concept of background can be a difficult one to define in terms of air quality. For the purposes of this Network Assessment, monitoring stations that monitor general background will be free of localized anthropogenic source influences. However, these monitoring stations may be affected by long range transport of anthropogenically formed pollutants or natural sources such as biogenic emissions from plants as well as wildfire.

6.1 Monitoring Stations that Meet this Objective

Figure 6-1: Monitoring Stations that Meet Objective #3

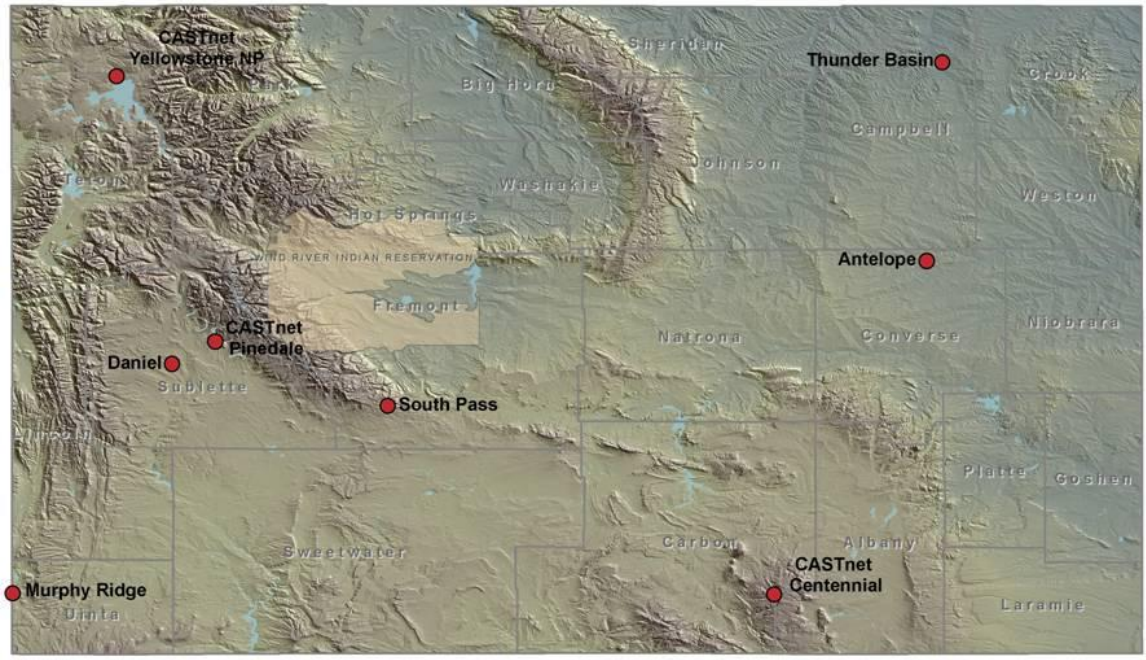


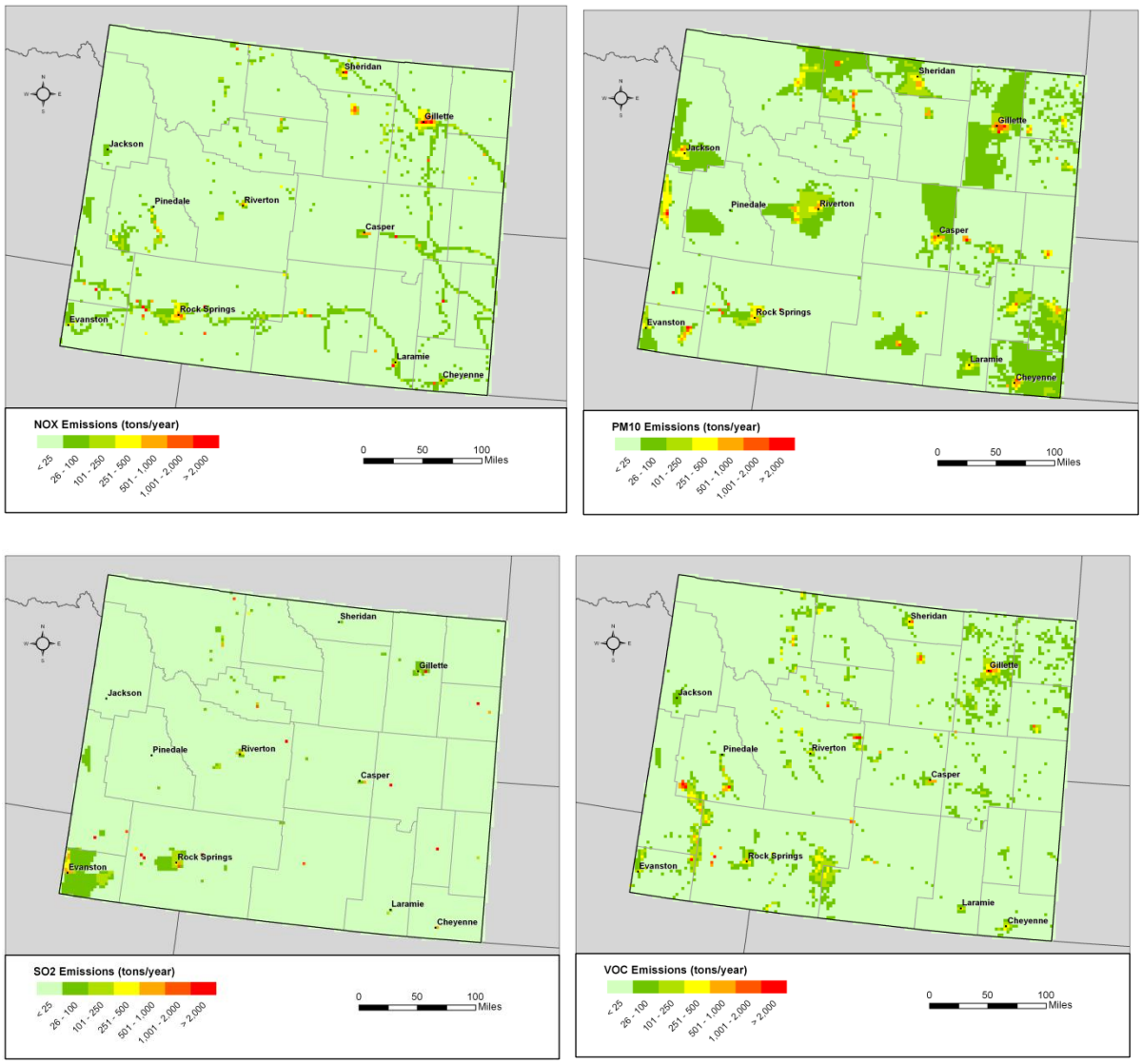
Table 6-1: Monitoring Stations that Meet Objective #3

AQS ID	Monitoring Station Name	Operating Agency	Ozone	NO_2	PM_{10}	$PM_{2.5}$	CO	SO_2
56-005-0123	Thunder Basin	AQD	X	X		X		
56-009-0819	Antelope	AQD		X		X		
Not in AQS	CASTnet Pinedale	EPA	X					
56-001-9000	CASTnet Centennial	EPA	X					
56-039-1011	CASTNet Yellowstone	NPS						
56-013-0099	South Pass	AQD	X	X	X			X
56-041-0101	Murphy Ridge	AQD	X	X	X		X	
56-035-0100	Daniel	AQD	X	X	X			

6.2 Supporting Data Evaluation

For this evaluation, the AQD examined gridded emissions in relation to current monitoring stations. As stated above, for this evaluation, background monitors should be free of any localized anthropogenic source influence. Figure 6-2 displays the gridded emissions of PM_{10}, NO_x, SO_2, and VOCs in Wyoming.

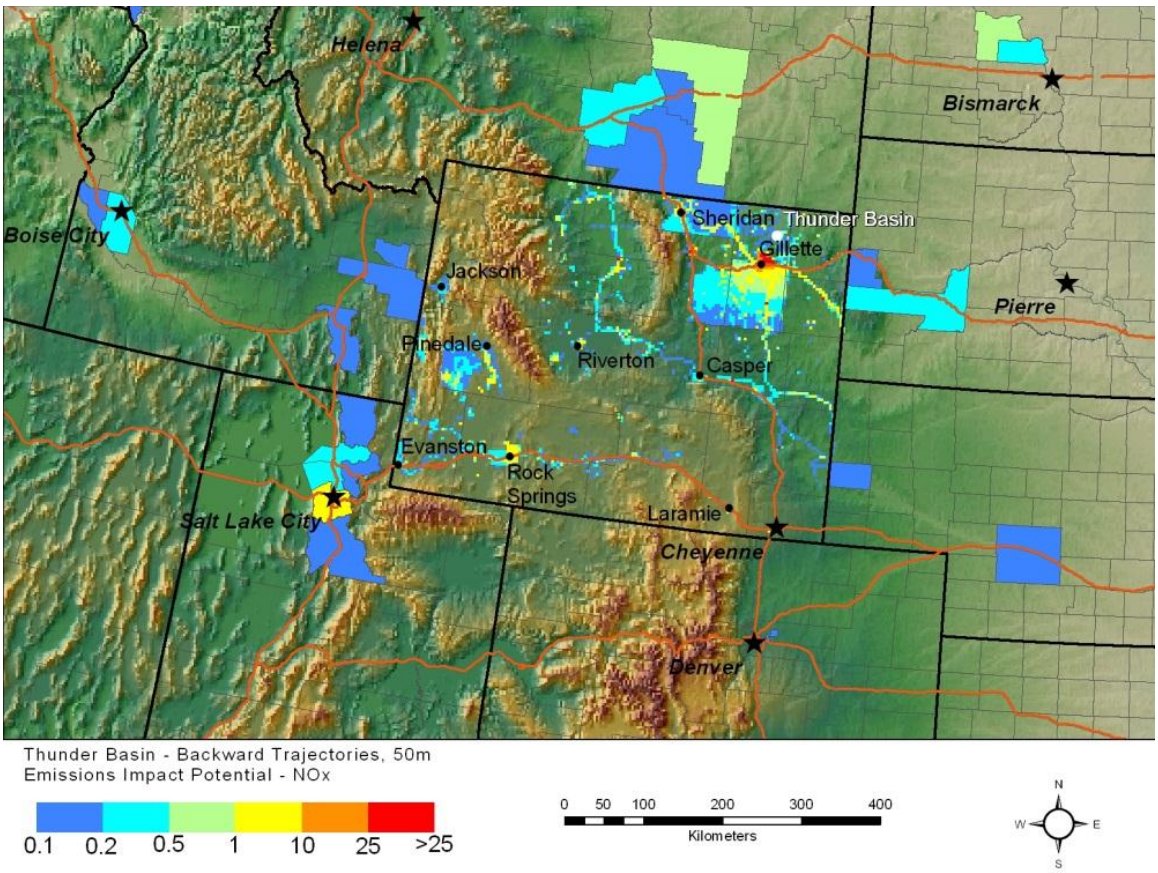
Figure 6-2: Statewide Gridded Emissions for NO_X, PM_{10}, SO_2, VOCs



When comparing Figure 6-2 to the locations of background monitoring stations (Figure 6-1) there are no sources in the immediate vicinity (i.e., localized) of any of these monitors.

In order to understand what emissions could be affecting monitoring that meet this objective, the AQD examined the backtrajectories and emission impact potentials for NO_x, PM_{10}, VOCs, and SO_2 at these monitoring stations. For example, Figure 6-3 shows the emission impact potential for NO_x at the Thunder Basin Monitoring Station.

Figure 6-3: Emission Impact Potential for NO_X at Thunder Basin Station



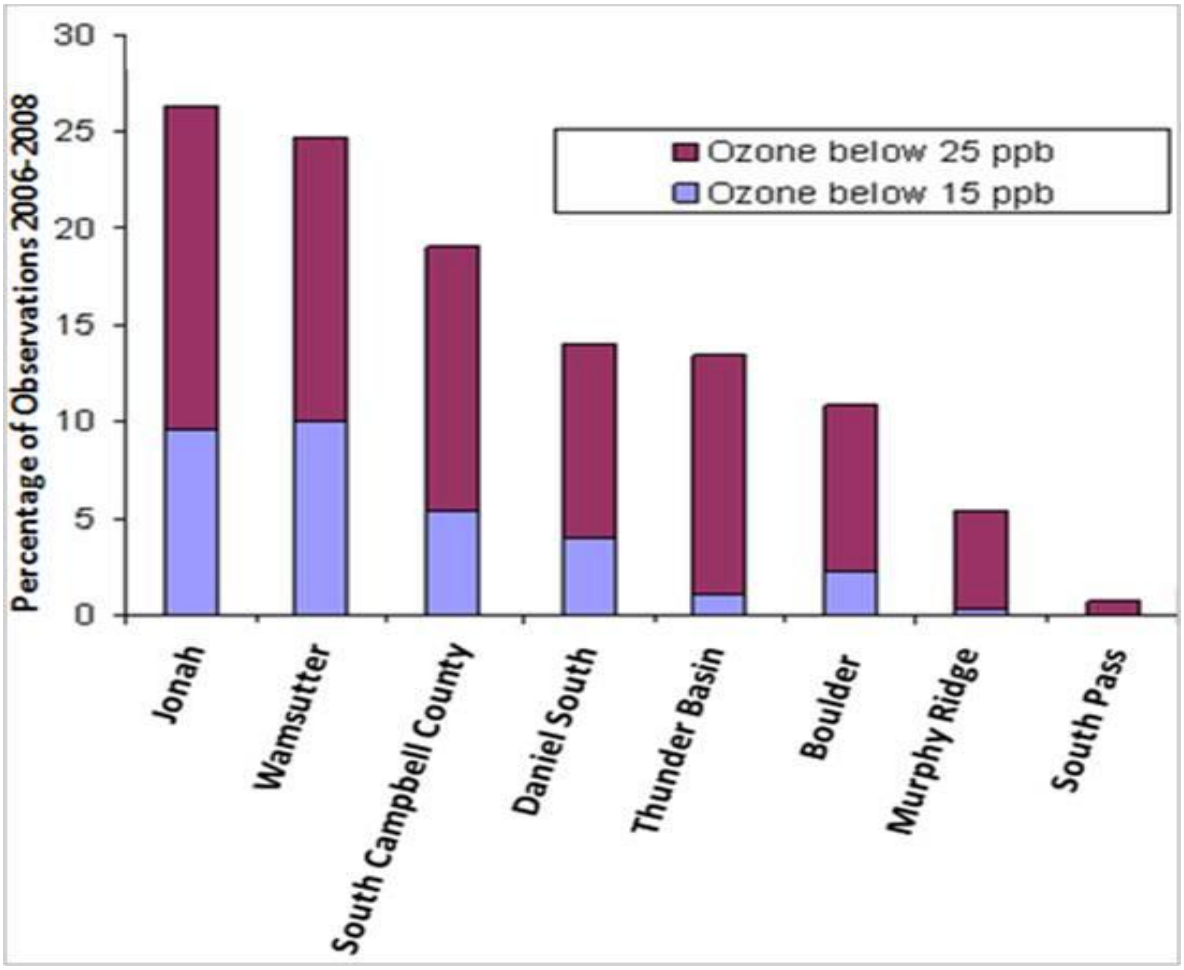
[

Figure 6-3 shows the spectrum of areas that could contribute to NO_x concentrations at the Thunder Basin monitoring station. NO_x emissions in Campbell and Johnson Counties have the greatest potential of being monitored at the Thunder Basin monitoring station. Therefore, the majority of the time pollutants reaching this monitoring station are not localized. Spatial Probability densities and Emission Impact Potential graphics for AQD monitoring stations that meet this objective can be found in Appendix D. The AQD did not find any deficiencies in the network during this evaluation.

From time to time, episodic conditions may occur where pollutants may stagnate in the area of the monitor. Any monitoring data user should be careful to examine the ground based meteorological characteristics of the monitored data that is being used to be sure they are representative for the intended purpose.

For ozone in particular, background concentrations can be complicated to assess because lower concentrations may be indicative of ozone titration by nitrogen oxide (NO) from local emissions. The AQD evaluated the fraction of ozone concentrations below typical northern hemisphere background levels as discussed in Vingarzan (2004) for all ozone monitoring stations. Concentrations below 25 ppb are rare in the northern hemisphere at mid-latitudes, and concentrations below 15 ppb are almost certainly the result of titration of ozone by NO. Figure 6-4 illustrates the result of this evaluation.

Figure 6-4: Percentage of Ozone Data Below 25 ppb



Murphy Ridge, Yellowstone NP, and South Pass had the least fraction of observations below 25 ppb and 15 ppb. These sites may be most representative of background concentrations.

6.3 Conclusions

All of the general background AQD monitoring sites are still meeting their objective to determine general background concentration levels. AQD has examined the 4 km gridded emission inventories in conjunction with site location and ground-based meteorology. It is important to note that there are some criteria pollutants that are capable of traveling long distances, such as $PM_{2.5}$ and ozone, which are more regional in nature. Therefore, monitoring stations that are sited to obtain background concentrations may still be monitoring regionally transported pollutants and, at times, these levels may be higher than levels monitored at source oriented or population oriented monitoring stations.

Additionally, the existing network of sites is adequate to determine general background concentration levels for the State and no new background monitoring stations are needed at this time. AQD has examined existing site locations and 4 km gridded emission inventory to determine that existing monitoring stations are adequate to provide sufficient coverage in regard to background concentration levels. A proactive approach is in place when point sources request new or modification permitting

actions, AQD's Monitoring Section works closely with AQD's New Source Review (NSR) Program to determine if more location specific background data is needed for that project. Many facility and industry operated monitors aid in the general background concentration measurements throughout the State.

7 Objective #4: Determine Extent of Regional Pollutant Transport Among Populated Areas and Remote or Rural Areas

Monitoring stations meeting this objective are meant to monitor regional-level pollutants that have traveled long distances and are entering a state, county, or a geographically defined area. These monitoring stations may be placed on political borders or at higher elevations in an effort to monitor air passing over the station. Since the inlets to the monitors are only a few meters off the ground, the monitor may not catch all pollutants that are passing in the upper atmosphere. However, this monitored data can be used in conjunction with models to gain understanding of long-range pollutant transport.

7.1 Monitoring Stations that Meet this Objective:

Figure 7-1: Monitoring Stations that Meet Objective #4

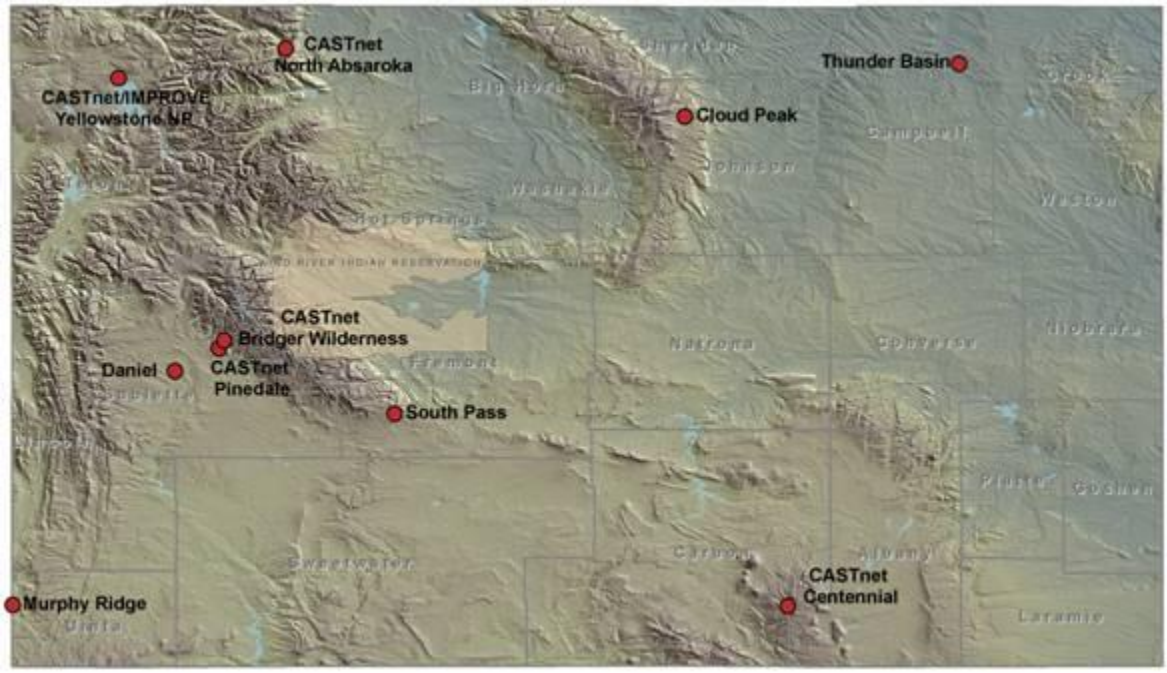


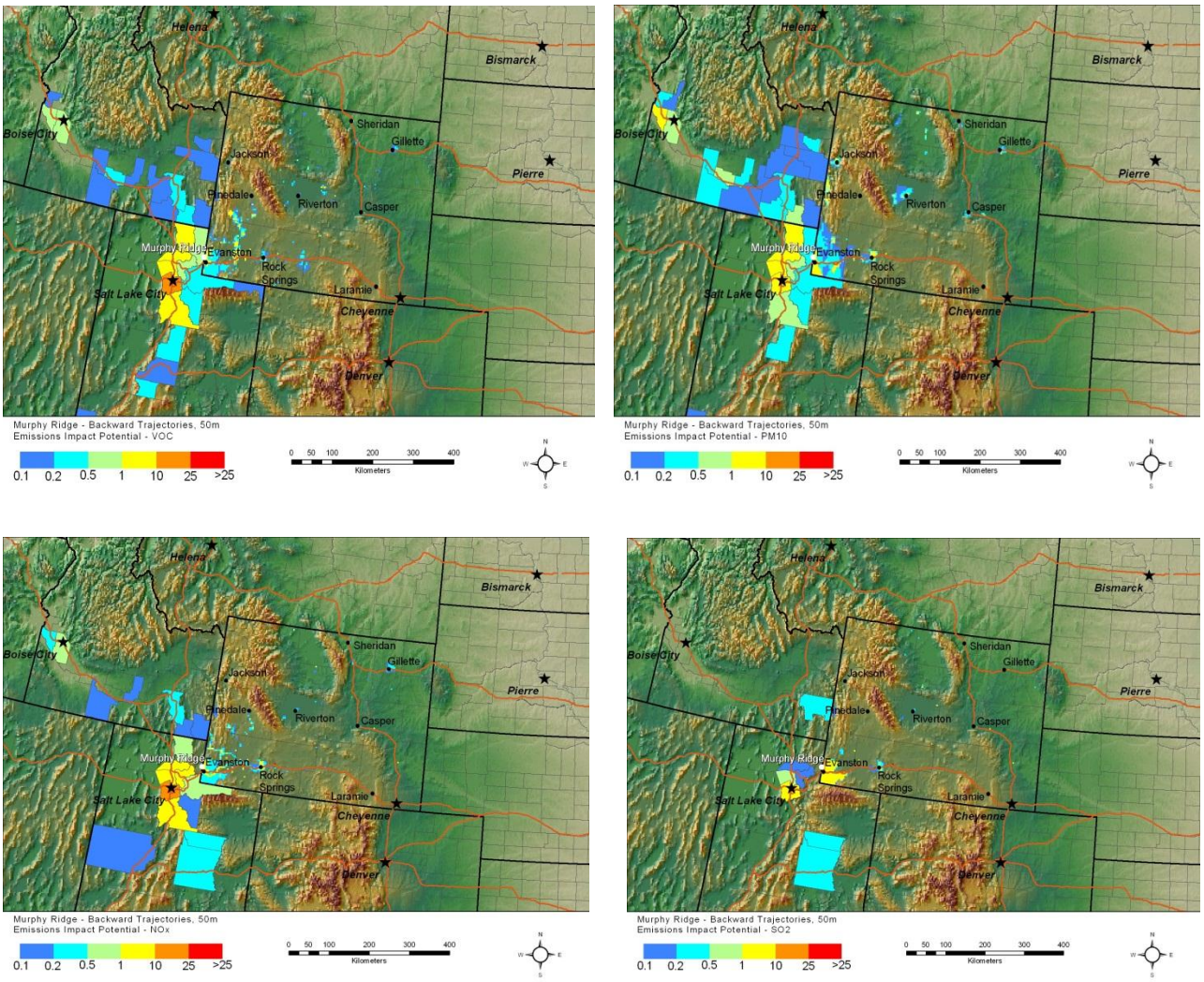
Table 7-1: Monitoring Stations that Meet Objective #4

AQS ID	Monitoring Station Name	Operating Agency	Ozone	NO_2	PM_{10}	$PM_{2.5}$	SO_2
56-035-9000	IMPROVE Bridger	USFS				X	
56-001-9000	CASTNet Centennial	EPA	X				
56-019-9000	Cloud Peak	AQD				X	
56-035-0100	Daniel	AQD	X	X	X		
56-041-0101	Murphy Ridge	AQD	X	X	X		
56-029-9002	IMPROVE North Absaroka	USFS				X	
Not in AQS	CASTNet Pinedale	EPA	X				
56-013-0099	South Pass	AQD	X	X	X		X
56-005-0123	Thunder Basin	AQD	X	X		X	
56-039-9000	CASTNet Yellowstone NP	NPS	X				
	IMPROVE Yellowstone	NPS				X	

7.2 Supporting Data Evaluation

The AQD examined backtrajectories and emission impact potential analyses to understand regional pollutant transport. The evaluation included PM_{10}, NO_x, SO_2, and VOCs for AQD monitoring stations that meet this objective. These figures and supporting data can be found in Appendix E.
For example, Figure 7-2 shows the possible areas of emissions that may influence the Murphy Ridge monitoring station.

Figure 7-2: Emission Impact Potential for VOCs, PM_{10}, NO_x, and SO_2 at the Murphy Ridge Monitoring Station

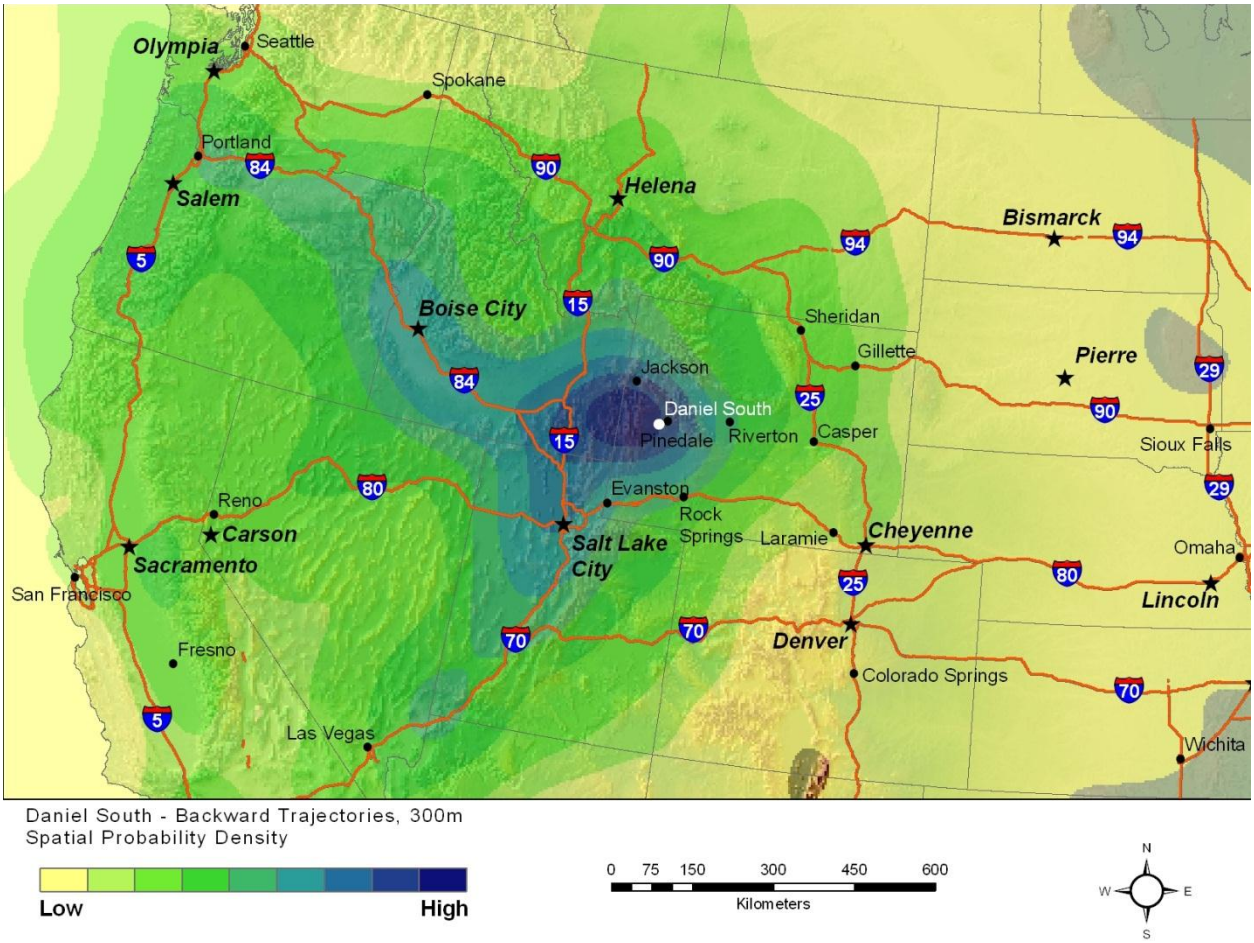


The Murphy Ridge monitoring station can be affected by emissions from not only southwest Wyoming, but also from northern Utah and southeastern Idaho. Therefore, the Murphy Ridge monitoring station is well suited to meet the objective of monitoring regional transport of emissions. The AQD did not find any deficiencies in the network as the result of this evaluation.

The AQD, in cooperation with Sublette County Commissioners, hired STI to evaluate air transport into Sublette County, Wyoming. STI's final report on this study "An Air Parcel Transport Corridor Analysis for Sublette County, Wyoming" can be found in Appendix E. Sublette County was focused on this issue because the area is currently violating the NAAQS for ozone. It is important to understand all sources, both localized and transported, to be able to model ozone and decrease concentrations.

The following graphics show backtrajectory density from the Daniel monitoring station. Areas of blues and green indicate that winds pass over these locations most often prior to reaching the monitoring station. The patterns of backtrajectories from the Daniel monitoring station indicate that it is typically monitoring air transported from Idaho and the Wasatch Front in Utah including Salt Lake City.

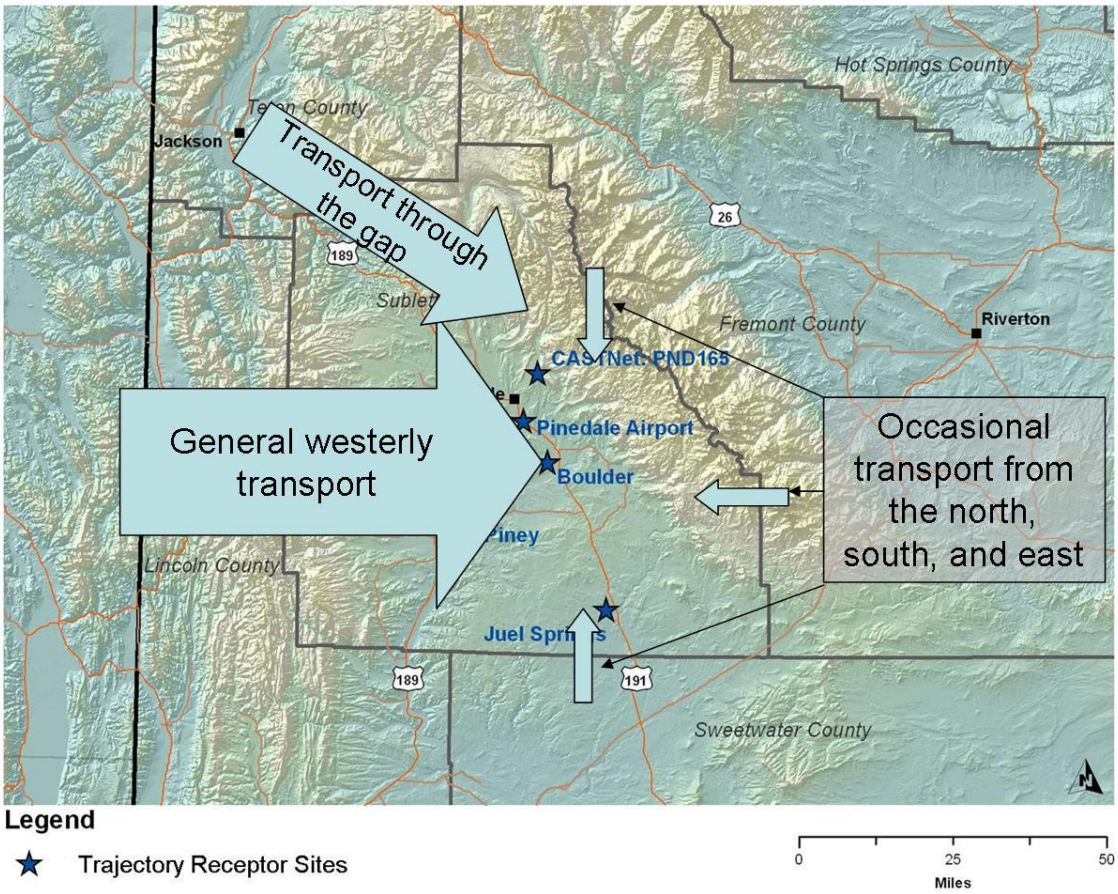
Figure 7-3: Spatial Probability Densities of Daniel Backtrajectories



There are also parcels of air that originate within Sublette County, Wyoming. These situations usually occur in the winter, when stagnation can persist for several days. Any monitoring data user should be careful to examine the ground based meteorological characteristics of the monitored data to be sure they are representative for the intended purpose.

The Transport Corridors Analysis also evaluated other monitoring stations within Sublette County to understand transport of air into the region. The following figure shows the general conclusions of the Analysis.

Figure 7-4: Transport Evaluation for Sublette County



The Analysis showed that most air is transported from the west over the Wyoming Range, while there is also transport from the northwest through a geographic gap between the Wyoming Range and the Gros Ventre Range.

7.3 Conclusions

The current AQD monitoring stations are still meeting their objective of determining regional pollutant transport among populated areas and remote areas. These monitoring stations are gathering regional values that will provide data for the populated and remote areas of the State. It is important to note that in limited situations, meteorological characteristics can dictate whether a monitoring station is monitoring transported or local pollutants. For example, when the winds are stagnant for several days, a monitor is likely to be only monitoring locally generated pollutants. Therefore, an analysis of ground-based meteorological characteristics should be conducted to be sure the monitored data is appropriate for the intended purposes.

The AQD has examined existing site locations, backtrajectory, and emission impact potential analyses and has determined that additional monitoring stations in western Wyoming may be beneficial to help understand transport into Sublette County.

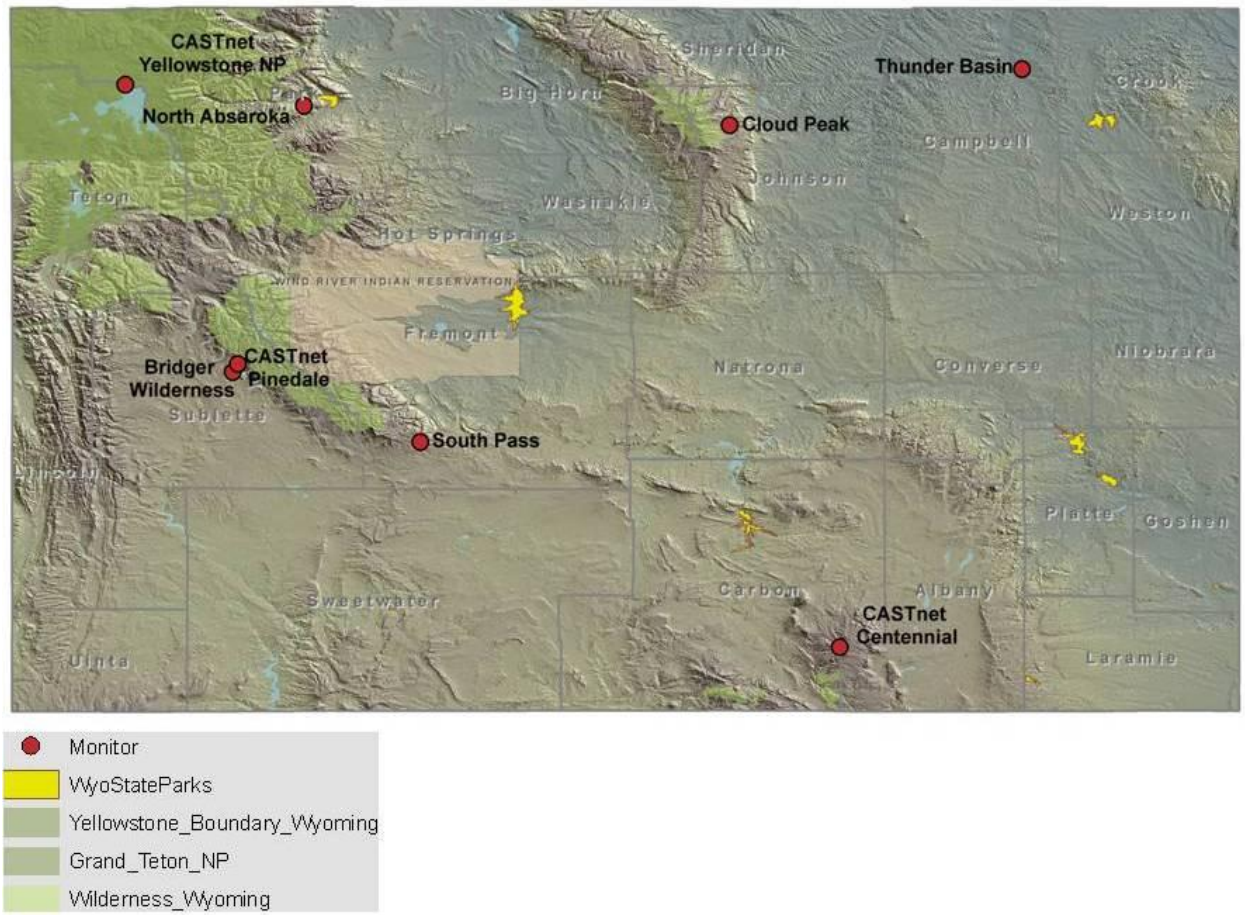
Based on these evaluations the AQD is planning to deploy a monitor in the northern areas of the Wyoming Range in 2011 to help assess transport from the west. Additionally, Cimarex Corporation is planning to deploy a monitoring station in the southern end of the Wyoming Range as part of a lease agreement with the Bureau of Land Management (BLM). A firm date of deployment is not known by the AQD. The AQD is supportive of this monitoring station and believes it could be used for additional transport information.

8 Objective #5: Determine Welfare Related Impacts in Support of Secondary Standards

Monitoring stations meeting this objective are meant to monitor for welfare related impacts. Welfare related impacts are impacts that are not associated with human health. These can be effects such as visible haze, damage to plants from air pollutants, or changes in the ecosystem due to pollutant concentrations. These monitors may not employ Federal Reference or Equivalent Methods (which are needed to determine readings for health-based standards), but are typically long-term, proven methods that are part of a national monitoring program with a quality assurance plan. As EPA begins to regulate welfare-based standards by use of the secondary NAAQS process, more welfare-based monitors may need to be deployed to understand how areas comply with these standards.

8.1 Monitoring Stations that Meet this Objective

Figure 8-1: Monitoring Station that Meet Objective #5



Note: this map includes State Parks GIS layer as of 3/28/2011, which may not include all State Parks as some are currently being surveyed

Table 8-1: Monitoring Stations that Meet Objective #5

AQS ID	Monitoring Station Name	Operating Agency	Ozone	NO_2	PM_{10}	$PM_{2.5}$	SO_2
56-019-9000	Cloud Peak	AQD/IMPROVE				X	
56-005-0123	Thunder Basin	AQD/IMPROVE	X	X		X	
56-035-9000	Bridger Wilderness	USFS				X	
56-029-9002	North Absaroka	USFS				X	
56-033-0099	South Pass	AQD	X	X	X	X	X
56-039-9000	Yellowstone NP 2	NPS				X	
Not in AQS	Pinedale CASTNet	EPA	X				
56-001-9000	Centennial CASTNet	EPA	X				

8.2 Supporting Data Evaluation

AQD examined statewide 4-km gridded emissions of VOC, NO_x, and SO_2 along with placement of sensitive ecosystems such as wilderness areas and State and National Parks to determine rural and more remote areas of possible welfare related impacts.

Figure 8-2: Statewide gridded emissions of NO_X, SO_2, and VOCs

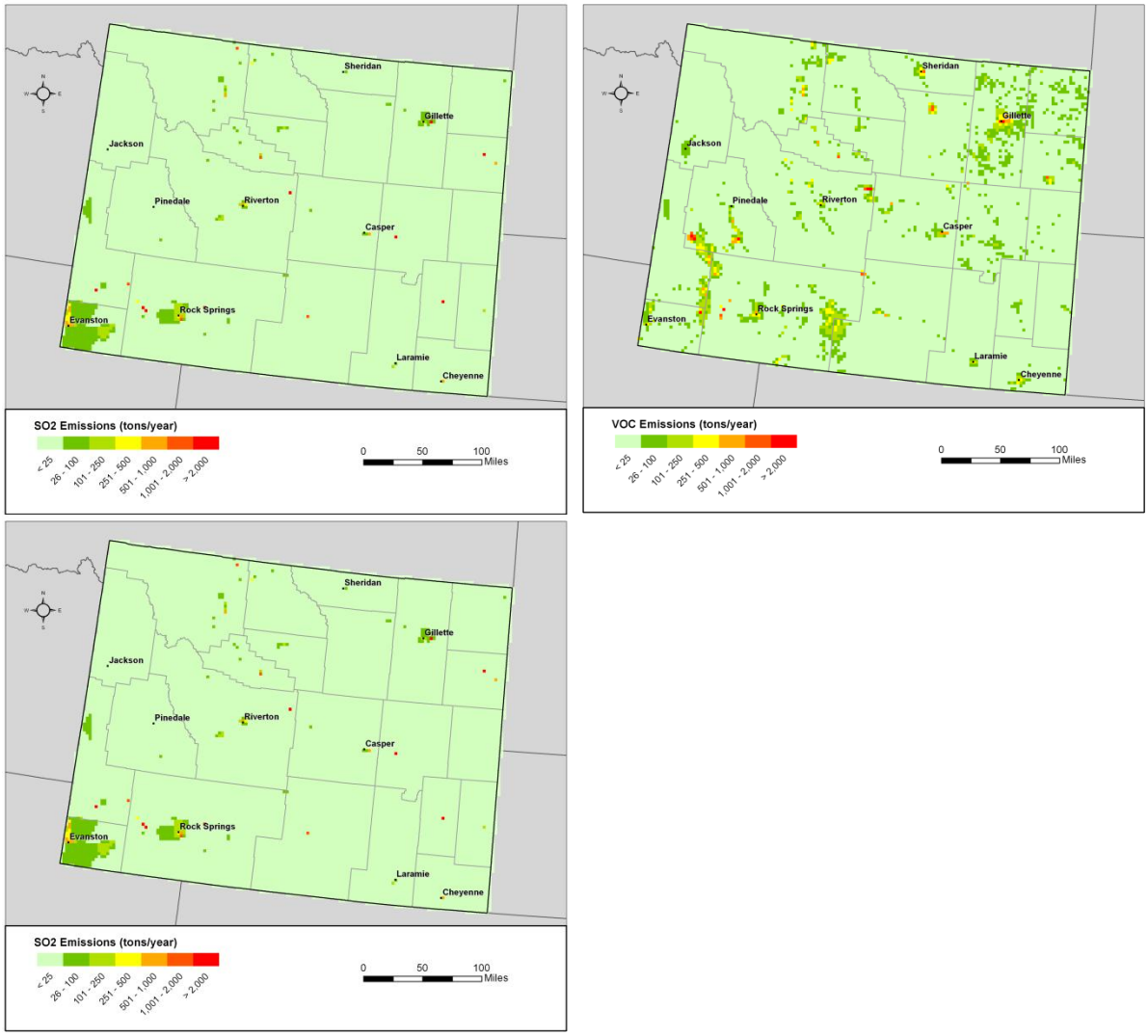
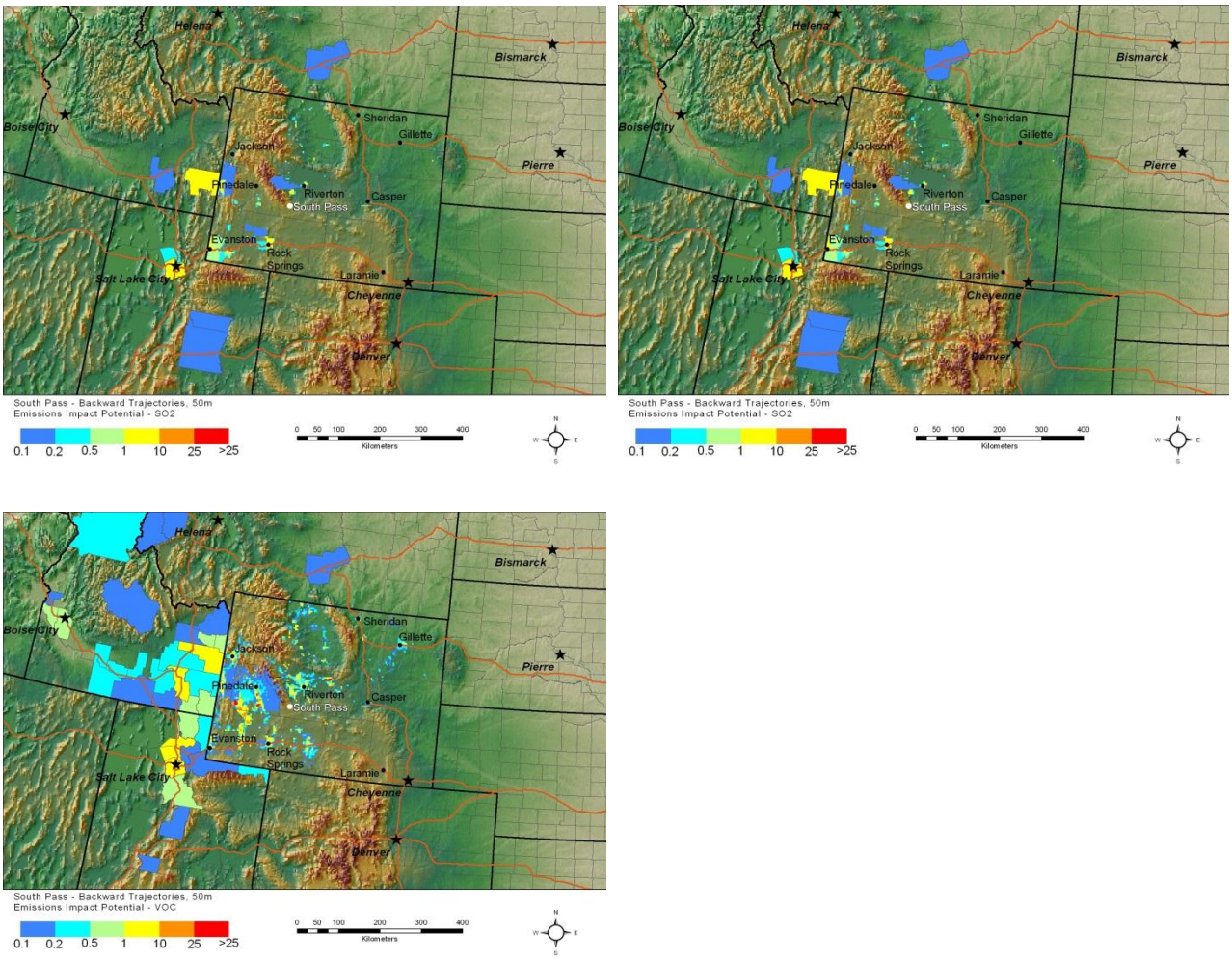


Figure 8-2 shows areas where emissions may be close to sensitive ecosystems. However, it is important to note that many secondarily formed pollutants that can contribute to plant or ecosystem damage are regional in nature and can travel long distances before depositing. Therefore, it is also important to understand transport patterns and regional emissions.

The AQD evaluated emission impact potential analyses for NO_x, VOCs, and SO_2 to understand transport of these pollutants to AQD monitors currently sited near sensitive ecosystems. These figures and supporting data can be found in Appendix F

For example, Figure 8-3 depicts areas of SO_2 emissions that may reach the South Pass monitoring station.

Figure 8-3: Emission Impact Potential for SO_2, NO_2, and VOCs at South Pass



This figure depicts that South Pass can be affected by emissions from near-by areas such as Sublette County and Sweetwater county as well as farther away areas like Idaho and the Wasatch Front in Utah including Salt Lake City. No deficiencies were found in the network as a result of this evaluation.

8.3 Conclusions

AQD has examined emissions inventories, backtrajectories, and emission impact potential analyses for AQD's sites. Based on these data, the AQD monitoring stations are still meeting their objective to determine welfare related impacts in support of secondary standards. AQD monitoring stations are located to understand welfare-related impacts and to assist in understanding the relationship between criteria pollutants and secondary (i.e., welfare) related pollutants. At this time the AQD does not believe additional monitoring stations are needed to determine welfare related impacts in support of secondary standards. This conclusion is based on the gridded emissions evaluation and the proximity of these emissions to sensitive ecosystems.

AQD is awaiting EPA's decision on the reconsideration of the 2008 ozone NAAQS as well as EPA's proposed changes to ozone monitoring regulations (proposed in 2009) to understand requirements and obligations for determining welfare related impacts of ozone. AQD is expecting EPA to promulgate secondary NAAQS that will specify ozone measurements related to adverse effects to plant health and the associated monitoring requirements to determine compliance.

In the interim, AQD believes it has adequate monitoring stations to monitor ozone concentrations in forested and/or grassland areas. Many of the monitors that could be used for this type of determination are sponsored by EPA and Federal Land Managers.

AQD currently supports the IMPROVE Network by paying for analysis and operators at three sites in Wyoming (Thunder Basin, Cloud Peak, and North Absaroka). AQD also heavily supports National Atmospheric Deposition Program (NADP) monitoring in Wyoming through individual funding agreements at several sites. AQD believes these programs are solid foundations for understanding secondary particulate impacts.

AQD is actively following EPA rulemaking regarding secondary standards for particulate, NO_x, and SO_x. Once these secondary standards are promulgated, AQD can evaluate whether additional monitoring stations are needed.

9 Objective #6: Determine Highest Concentrations Expected to Occur in Areas Covered by the Network

Monitors that meet this objective are placed in areas where high concentrations are expected (also referred to as hot spots). These monitoring stations can be associated with non-attainment areas or they can be part of a specialized monitoring network. Most of the time, monitors sited for this objective are considered indicators for compliance with respect to the NAAQS.

9.1 Monitoring Stations that Meet this Objective

Figure 9-1: Monitoring Stations that Meet Objective #6

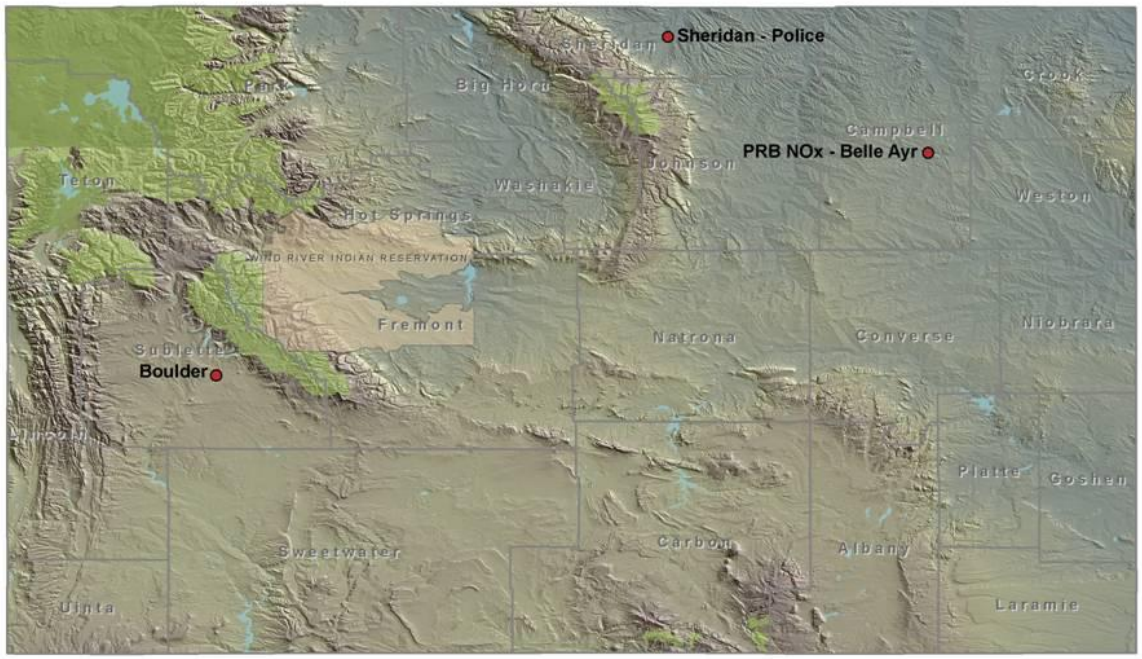


Table 9-1: Monitoring Stations that Meet Objective #6

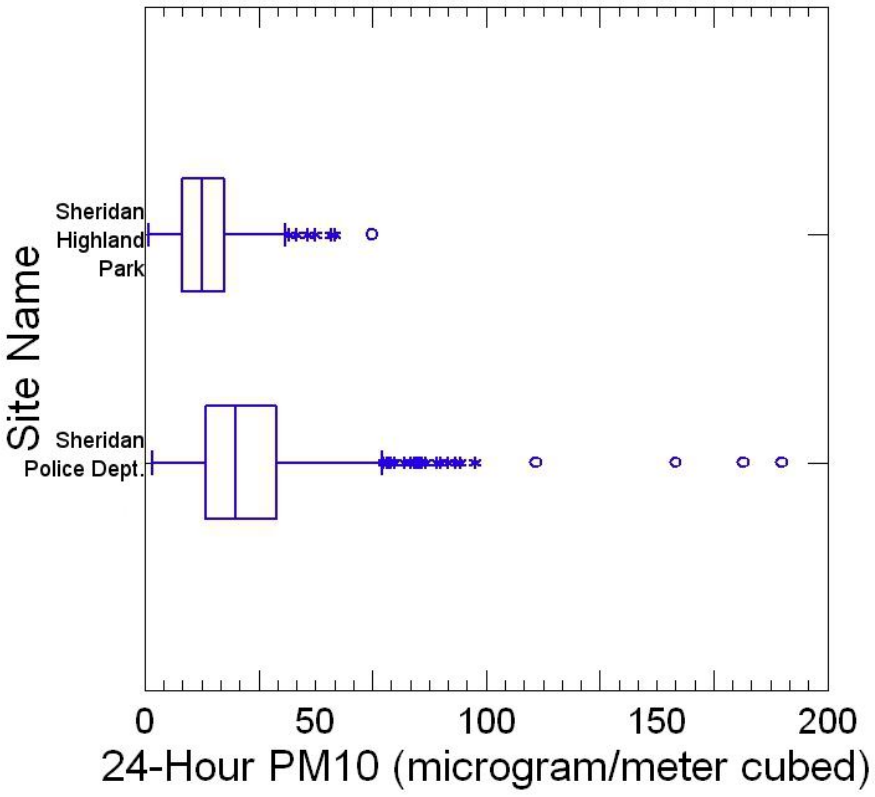
AQS ID	Monitoring Station Name	Operating Agency	Ozone	NO_2	PM_{10}	$PM_{2.5}$
56-033-0002	Sheridan – Police Station	AQD			X	X
56-005-0893	PRB NO_x – Belle Ayr	AQD		X		
56-035-0099	Boulder	AQD	X	X	X	

9.2 Supporting Data Evaluation

For existing monitoring stations, AQD examined site-to-site correlations based on the non-attainment area, proposed non-attainment areas, or a specialized network.

Wyoming only has one non-attainment area, the City of Sheridan, which is a designated area for annual PM_{10}. The following figure shows comparison between Sheridan Police Station PM_{10} values, sited to represent the highest concentrations, and Sheridan Highland Park PM_{10} values, which was sited to represent a typical residential area in Sheridan.

Figure 9-2: 2006-2008 24-hour. Average PM_{10} at Sheridan Monitoring Stations

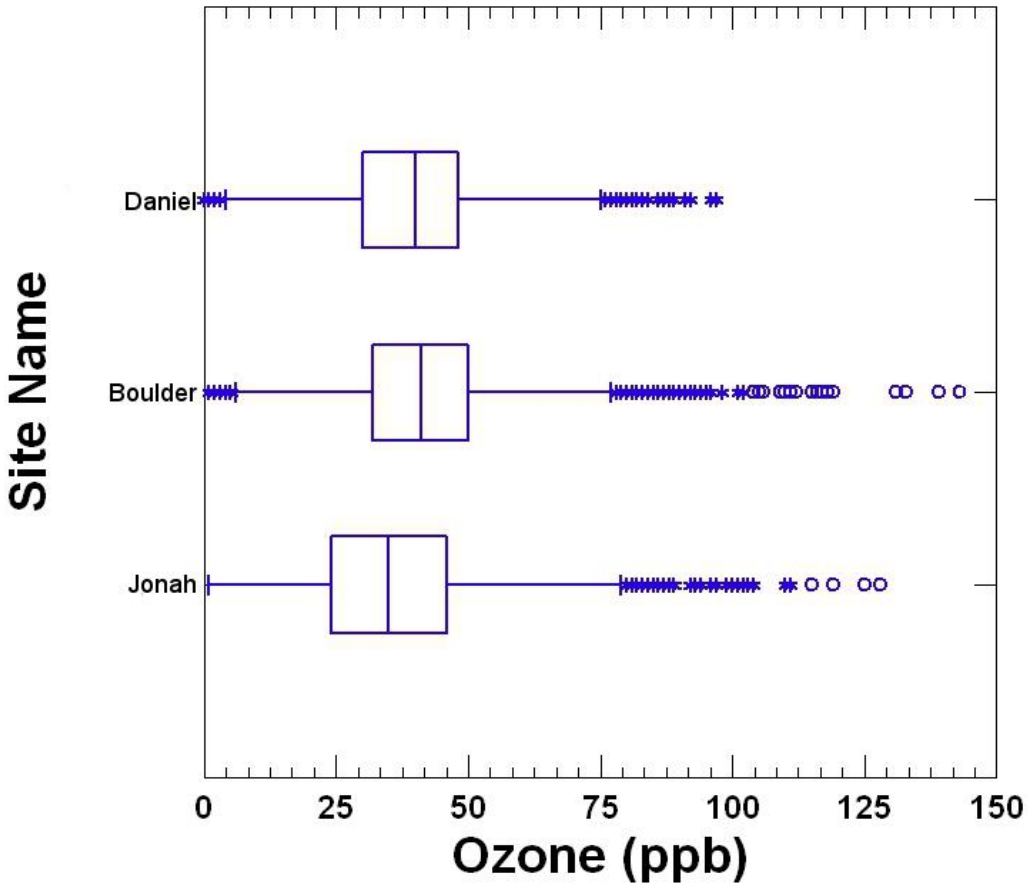


This comparison shows that both the mean PM_{10} concentrations and the outliers at the Police Station are significantly higher than the Highland Park concentrations. Therefore, the Sheridan Police Department monitoring station is still meeting its objective.

Wyoming's Governor has recommended Sublette County and surrounding areas in Lincoln and Sweetwater Counties be designated non-attainment for ozone. However, that recommendation has not been acted upon by EPA due to the reconsideration of the 2008 Ozone NAAQS. AQD has identified the Boulder monitoring station as consistently having the highest ozone concentrations during elevated

ozone episodes in the recommended non-attainment area. The following box/whisker plot compares Boulder to other monitoring stations in the recommended non-attainment area.

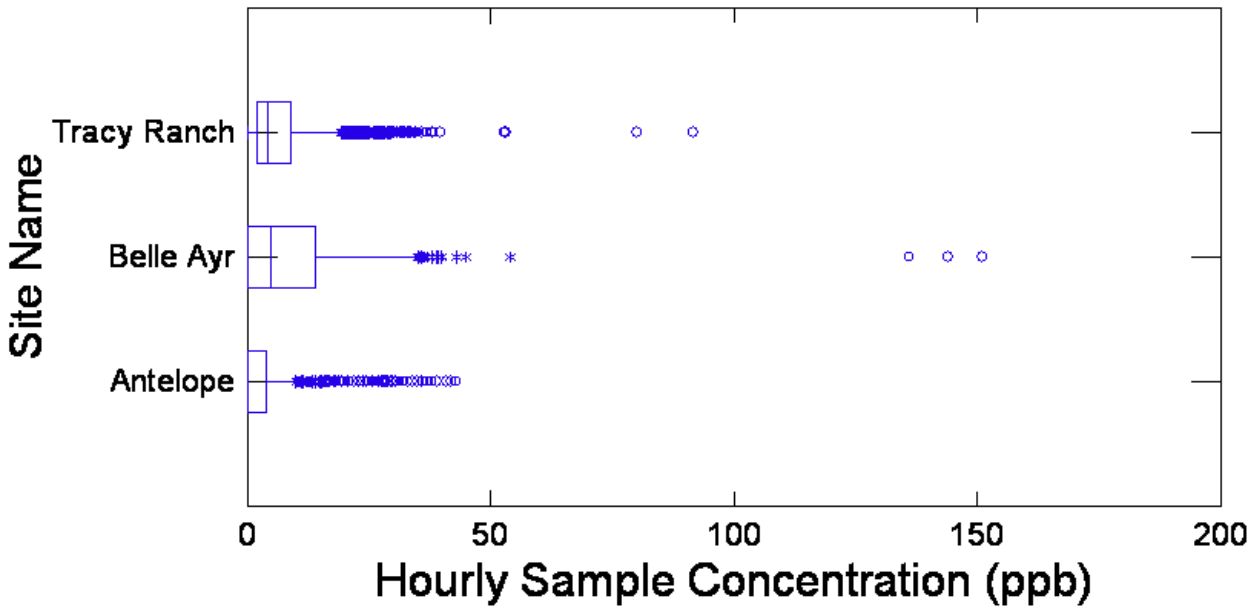
Figure 9-3: Box Plot of 2006-2008 Hourly Averaged Ozone at Sublette County Ozone Monitors



This comparison demonstrates that the mean concentrations monitored at Boulder are not significantly different than Daniel and Jonah. However, the Boulder site has more outliers and extreme outliers monitored at the site. Since the form of the ozone NAAQS relies on the fourth highest value, these extreme outliers will play a role in the attainment determination.

In the Powder River Basin (PRB), the AQD operates a NO_x Monitoring Network to understand NO_x concentrations in and near the PRB coal mines. AQD considers the monitoring station at the Belle Ayr Mine to have the maximum expected NO_2 concentrations due to placement inside a railroad loop. Only 2006 data was used for this comparison because the NO_x network was shut down for two years due to a shortage in funding.

Figure 9-4: Box and Whisker Plot of 2006 NO_2 Data from the PRB



This comparison shows that Belle Ayr regularly experienced higher concentrations than the other two monitors (demonstrated by the 75th percentile value) and consistently higher value outliers and extreme outliers. However, when these data were evaluated for the form of the recently promulgated 1-hour NO_2 NAAQS, there was not a significant difference between Tracy Ranch, Antelope, and Belle Ayr. The AQD will need to reevaluate this monitoring with respect to its objective during the next Network Assessment.

The AQD examined gridded emission inventory maps to evaluate other areas, which may warrant additional monitors meeting this objective. These maps can be found in Appendix G. AQD did not find any other areas that require further monitoring with respect to this objective.

9.3 Conclusions

The AQD found that current monitoring meets the objective of determining the highest concentrations expected to occur in areas covered by the network. AQD examined statistical data analyses of monitoring stations that meet this objective. Based on these analyses, all monitoring stations exhibit higher concentrations overall than other monitoring stations in the area. Additionally, based on the emissions evaluation and previous monitoring data records these monitoring stations are properly located to pick up the expected maximum concentrations. However, the AQD will need to reevaluate the PRB NO_x network with respect to 1-hour NO_2 concentrations to define the appropriate maximum concentration location.

AQD has examined the 4-km gridded emission inventory along with all monitoring station locations within Wyoming and concluded that areas with concentrated emissions are represented with monitoring stations at this time. AQD will continue to evaluate this objective with the promulgation of

new NAAQS. Additionally, the AQD Monitoring Section continues to work with the NSR and Compliance Programs to evaluate the need for monitoring in areas with high emission density.

10 Monitoring Objective #7: Research Pollutant and Meteorological Behaviors in Areas of Concern

As industrial or population growth occurs or as NAAQS are lowered, the need may arise to study air quality or meteorology of an area more closely. Monitors deployed for pollutant research will usually be deployed for abbreviated time frames (e.g. less than 3 years) in areas of concern. The research may or may not use Federal Reference methods/Federal Equivalent Methods (FRM/FEM's) and components will vary depending on the air quality concern. Longer-term meteorological monitoring (3-5 years) can also be deployed to better understand local meteorological conditions or for use in modeling. The AQD strives to be on the forefront of understanding the air quality issues and improving monitoring capabilities to design a more effective air monitoring network throughout the State.

10.1 Monitoring Stations that Meet this Objective

For this evaluation, the AQD will focus on the adequacy of the meteorological monitoring network. AQD will not list specifics of air quality special studies in this document as these studies have been documented in the Annual Network Plans and the on the AQD's website. This information can be obtained on AQD's website: http://deq.state.wy.us/aqd/

Figure 10-1 depicts meteorological monitoring stations in Wyoming. This includes several different types of stations. Stations noted as "AQS" in the figure below are AQD and industrial stations that are loaded into the EPA's AQS system. These sites all meet EPA's Quality Assurance Requirements for air pollution measurement and most meet EPA's guidance for air quality modeling applications. Sites called "Non-AQS industrial" are industrial sites that AQD oversees but have not been added into EPA's AQS system. "NWS" sites are run by the National Weather Service, Federal Aviation Administration, and Department of Defense ASOS (Automated Surface Observing System). Finally, "RAWS" sites (Remote Automated Weather Stations) are operated by the Bureau of Land Management and U.S. Forest Service. Please note that RAWS sites have a lower level of Quality Assurance than the AQS or NWS sites.

Figure 10-1: Meteorological Monitoring Stations in Wyoming

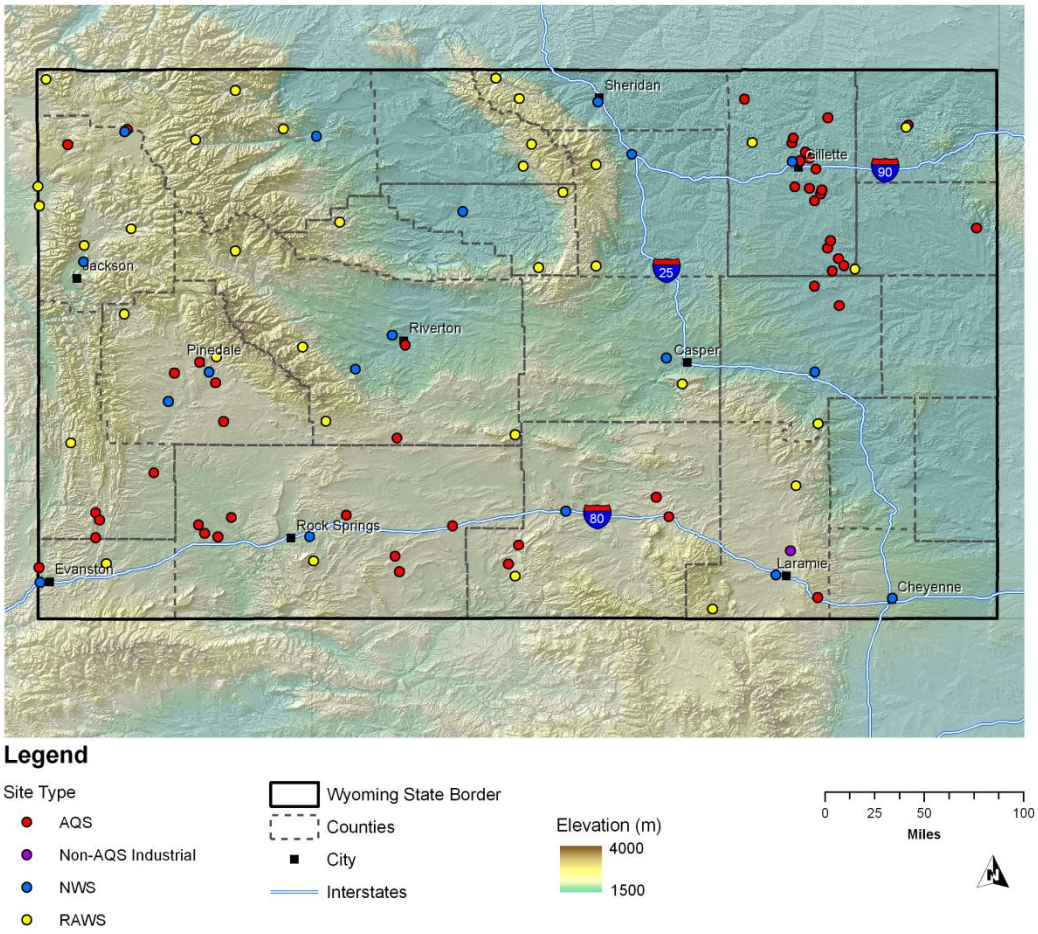


Table 10-1: AQD Meteorological Stations that Meet this Objective

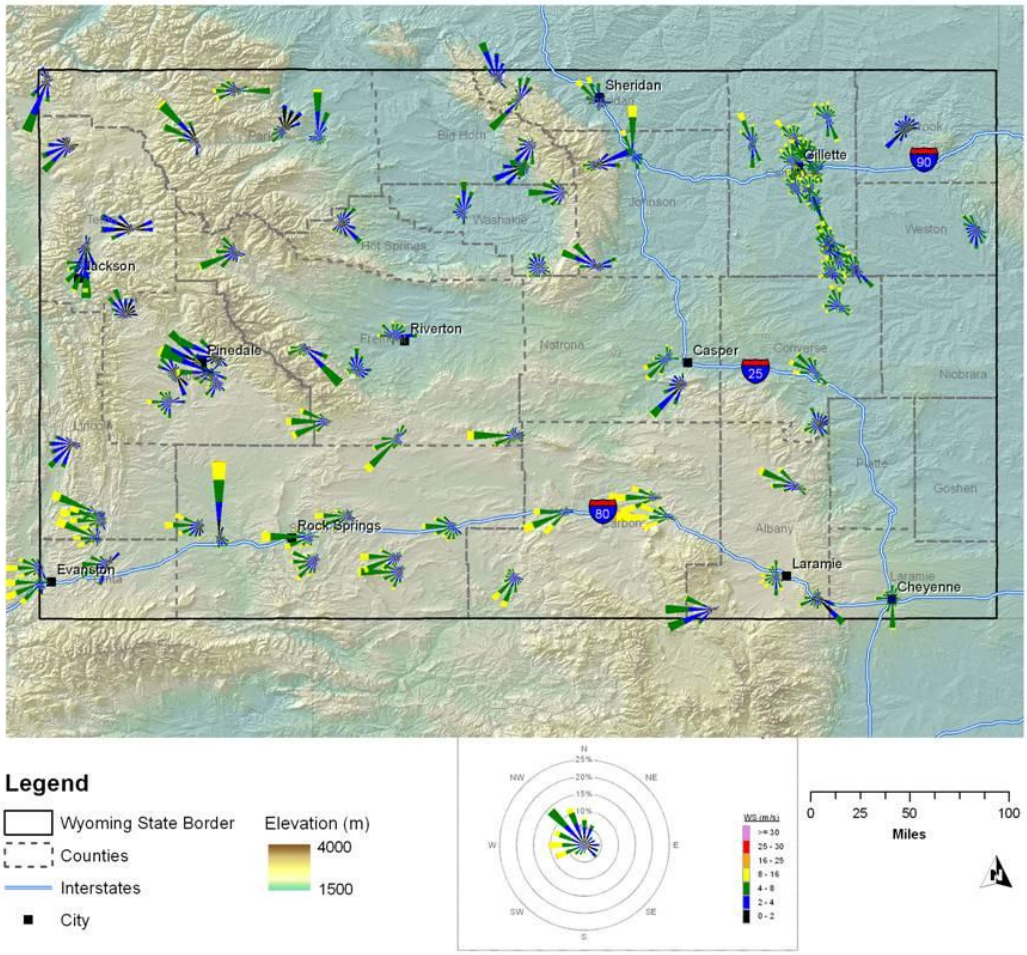
AQS ID	Monitoring Station Name	Operating Agency	Wind Speed	Wind Direc-tion	Temp.	Delta Temp.	Relative Humidity	Precip.	Solar Radia-tion	Barometric Pressure
56-035-0098	Jonah	AQD	X	X	X	X	X	X	X	X
56-035-0101	Pinedale Gaseous	AQD	X	X	X		X			
56-005-0123	Thunder Basin	AQD	X	X	X		X			
56-035-0099	Boulder	AQD	X	X	X	X	X	X	X	X
56-035-0100	Daniel	AQD	X							
56-035-1002	Juel Spring	AQD	X	X	X	X	X	X	X	X
56-037-0200	Wamsutter	AQD	X	X	X	X	X	X	X	X
56-041-0101	Murphy Ridge	AQD	X	X	X	X	X	X	X	X
56-005-0456	Campbell County	AQD	X	X	X		X			

A complete list of meteorological stations evaluated in this assessment can be found in Appendix H.

10.2 Monitoring Data Evaluation

The AQD evaluated meteorological data specifically wind speed, direction and frequency, throughout the State. The AQD not only examined its meteorological stations, but also stations operated by industry and federal land managers. These data were evaluated for quality and assembled in to a wind rose map. Figure 10-2 depicts annual wind roses along with topographical relief of Wyoming.

Figure 10-2: Wind Rose Map of Wyoming

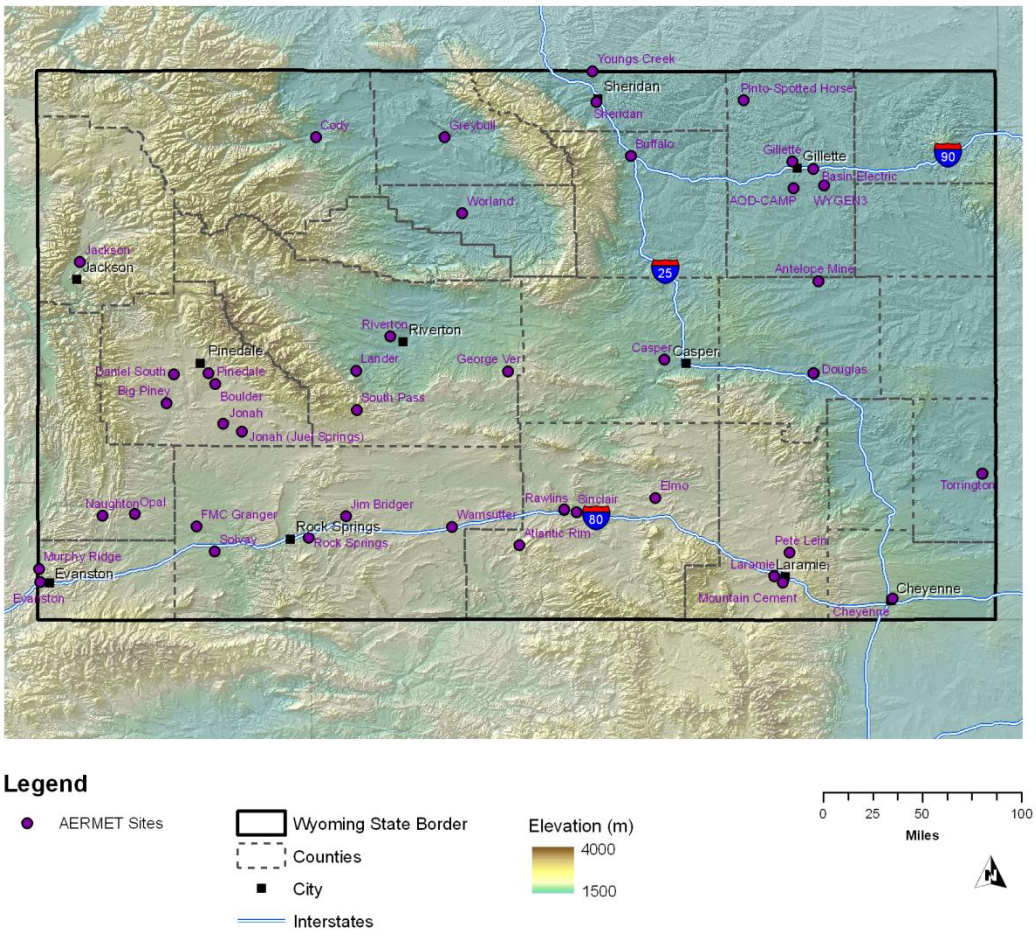


Examination of windroses in Figure 10-2 shows data issues in existing meteorological data sets. For example, the set collected near Green River (General Chemical industrial site) exhibits almost all data from northerly winds, which does not seem likely compared to the surrounding data sets. Additionally, the Cheyenne data set also shows some unlikely influence from the south and does not reflect high velocity winds typical of Cheyenne. Further investigation of these data sets is warranted based on this plot.

The AQD also evaluated this plot for spatial coverage around the State. Based on Figure 10-2, areas in eastern and central Wyoming have relatively sparse coverage by meteorological towers. The AQD also evaluated available data sets for air quality modeling to see if gaps in meteorology may have been covered by stations that did not have complete data sets from the years 2005-2009. Figure 10-3 shows meteorological data sets that have been processed for the AERMET program or those sites that can be

processed for the AERMET program. The AERMET program provides meteorological data for the AERMOD air quality dispersion modeling program.

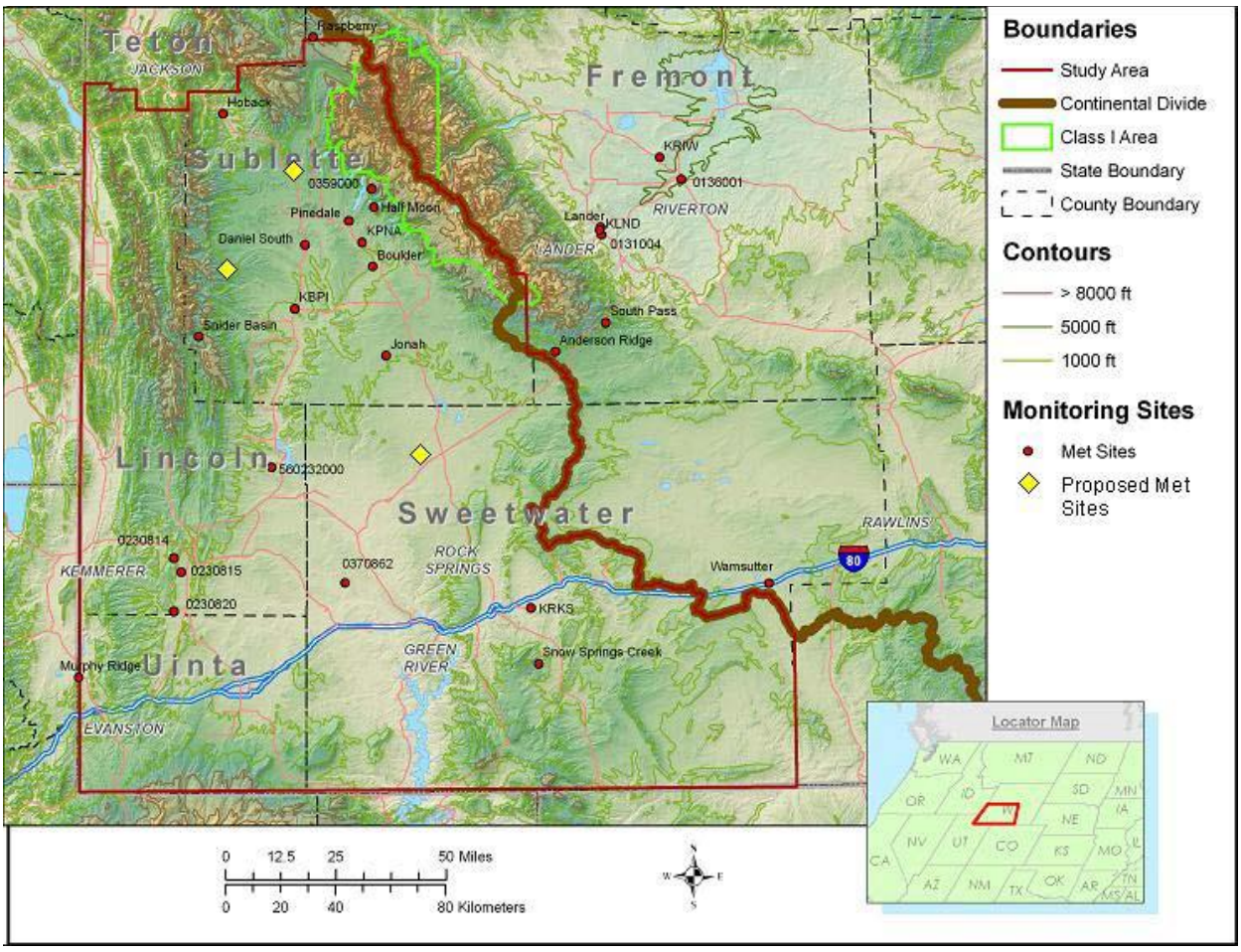
Figure 10-3: Map of AERMET Processed Meteorological Data Sets



These stations, combined with stations listed in Table 10-1, cover meteorological gaps in central and south eastern Wyoming.

During the Southwest Wyoming Network Assessment, the AQD performed a detailed look at southwest Wyoming meteorology due to concerns about properly representing meteorology during elevated ozone events. Figure 10-4 shows a close-up of southwest Wyoming and active meteorological sites.

Figure 10-4: Active Meteorological Monitoring Stations in Southwest Wyoming



Locations the AQD found that could benefit the understanding of meteorology in southwest Wyoming are depicted by yellow diamonds.

10.3 Conclusions

Based on the evaluation of meteorological sites in Wyoming, the AQD found that current sites are meeting their objective of researching meteorological behaviors in areas of concern. The AQD found that there are areas that may benefit from additional meteorological monitoring. These areas include Farson, as well as north and west of Daniel.

The AQD has committed funding to meteorological monitoring in the town of Farson, which will be deployed in 2011. The AQD has also committed to meteorological monitoring at the Wyoming Range monitoring station, which will be deployed in 2011. The Wyoming Range station will be located north and west of Daniel, in the foothills of the Wyoming Range. Additionally, Cimarex Corporation is planning to deploy a meteorological monitoring station in the southern end of the Wyoming Range as part of a lease agreement with the BLM. A firm date of deployment is not known by the AQD. The AQD is supportive of this monitoring station and believes it could be used for additional meteorological information.

11 Network Assessment Conclusions

This Network Assessment used various statistical, graphical, and geographic information systems (GIS) spatial analyses to evaluate Wyoming's ambient and meteorological monitoring network with respect to AQD's monitoring objectives.

1) Determine representative concentrations in areas of high population density.
2) Determine impact on ambient air quality from significant sources.
3) Determine general background concentration levels.
4) Determine the extent of regional pollutant transport among populated and remote or rural areas.
5) Determine welfare-related impacts in support of secondary standards.
6) Determine highest concentration expected to occur in the area covered by the network.
7) Research pollutant and meteorological behaviors in areas of concern.

The Network Assessment was performed in two stages, Southwest Wyoming in 2008 and the remainder of the State in 2010. Results from both the Southwest Wyoming Network Assessment and the assessment of other areas of the State are discussed in this document. The AQD has analyzed the results and several conclusions were reached.

During the historical data review, the AQD found that several of the SO_2 and NO_2 monitors in the AQD Monitoring Network recorded a significant portion of their data below the method detection limit. The AQD has committed to evaluate the use of trace-level methods for these pollutants when placing new monitoring stations in the future.

Through this Network Assessment, the AQD has determined that currently operating monitoring stations are meeting their intended objective(s). Monitoring stations were evaluated against their intended objective to ensure that significant changes in population, emission, or other factors have not influenced the monitoring location making it unsuitable for the intended purpose.

The AQD has also determined that the current monitoring stations in the Wyoming Network are not redundant with each other. Due to Wyoming's complex topography, meteorology and widespread monitoring network, the monitoring stations have unique value.

Based on the evaluation of Objective #1: Determine representative concentrations in areas of high population density , the AQD has determined that there is a need for ozone monitoring in Pinedale, Casper, Rock Springs, and Gillette. The growing, high population density of Casper warrants ozone monitoring. Additionally, population combined with nearby sources of NO_x and VOCs would justify ozone monitoring in Rock Springs and Gillette locations as well. The AQD has already placed ozone monitoring in the Town of Pinedale based on a recommendation from the 2008 Southwest Wyoming Network Assessment. The AQD also has mobile monitoring trailers that could be deployed to monitor for ozone in the other cities.

Through the Southwest Wyoming Network Assessment, the AQD also determined that population based monitoring for PM_{10} in Star Valley is justified. Total population and growth coupled with PM_{10} emissions in the Star Valley area near Afton justify potential monitoring in the area. The AQD has mobile monitoring trailers that could be deployed to monitor for PM_{10} in this area.

The evaluation of Objective 2: Determine impact on ambient air quality from significant sources, demonstrated the need to monitor for impacts from the LaBarge and Hiawatha Gas Fields. Proposals for significant well development in these areas coupled with ongoing nearby oil and gas development warrant placement of monitoring stations to monitor possible impacts to ambient air quality. The AQD and EPA have jointly committed to fund a monitoring station near the Hiawatha Gas Field. The AQD also has mobile monitoring trailers that could be deployed to monitor impacts near the LaBarge Gas Field.

The evaluation of Objective # 4: Determine the extent of regional pollutant transport among populated and remote or rural areas determined that a station could be added in the Wyoming Range to quantify transport from the west. The evaluation showed that air parcels can transport pollutants from Idaho and Utah over the Wyoming Range and in to Sublette County. In 2011, the AQD will add a monitoring station in the northern end of the Wyoming Range.

The AQD as also determined that Farson and the northern Wyoming Range would benefit from additional meteorological monitoring. Due to Wyoming's complex topography, monitoring stations are often only representative of immediate areas. Wyoming has committed funding to place a meteorological tower at Farson and the Wyoming Range transport monitoring station in 2011.

During the course of evaluating monitoring station based on the AQD's network objectives, several observations were made regarding the objectives themselves and the network assessment process. First, the AQD found that monitoring stations, which represent background (Objective #3) and transport (Objective #4) are closely related. Second, monitoring stations can meet several different objectives. It may be less complicated to analyze the network by pollutant rather than objective. The AQD will analyze these observations in preparation for the 2011 Annual Network Plan.

References

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