COLORADO
5 YEAR MONITORING NETWORK ASSESSMENT
2010

Colorado Department of Public Health and Environment

Prepared by the Air Pollution Control Division
Technical Services Program
June 30, 2010

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

AQS	Air Quality System.
AQS ID	9-digit site identification number in AQS database.
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CBSA	Core Based Statistical Area
CFR	Code of Federal Regulations
CSA	Combined Statistical Area
CSN	Chemical Speciation Network
CO	Carbon Monoxide
FEM	Federal Equivalent Method typically used by local and state agency to measure particulate matter and determine NAAQS attainment status.
FRM	Federal Reference Method typically used by local and state agency to measure particulate matter and determine NAAQS attainment status.
GC	Gas Chromatograph
HAPS	Hazardous Air Pollutants
IMPROVE	Interagency Monitoring of Protected Visual Environments
MSA	Metropolitan Statistical Area typically used by the EPA to study air quality trends in major metropolitan areas across the U.S.
NAA	Non-attainment Area
NAAQS	National Ambient Air Quality Standards used for determining attainment status.
NCore	National Core multi-pollutant monitoring stations
NO	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NO_X	Oxides of Nitrogen (ozone precursor)
NO_Y	Total Reactive Nitrogen Species (ozone precursor)
O_3	Ozone
PAMS	Photochemical Assessment Monitoring Station
Pb	Lead
$PM_{2.5}$	Particulate matter with an equivalent diameter less than or equal to 2.5 µm.
PM_{10}	Particulate matter with an equivalent diameter less than or equal to 10 µm.
QA	Quality Assurance
SIP	State Implementation Plan
SLAMS	State or Local Air Monitoring Stations
SO_2	Sulfur Dioxide
µm	Micrometer (10^{-6} meter)
US EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

1. INTRODUCTION

The Colorado Department of Public Health and Environment (CDPHE), Air Pollution Control Division's (APCD) 2010 Ambient Air Monitoring Network Assessment is an examination and evaluation of the APCD's network of air pollution monitoring stations. The Network Assessment is an extension of the Network Plan that is required by 40 CFR 58.10(d). It is required to be performed and submitted to the U.S. Environmental Protection Agency (EPA) every 5 years, with the initial assessment due by July 1, 2010. The assessment must include specific detailed monitoring network information, such as: (1) a re-evaluation of the objectives and budget for air monitoring, (2) an evaluation of a network's effectiveness and efficiency relative to its objectives and costs, and (3) recommendations for network reconfigurations and improvements.

This report describes the network of ambient air quality monitors operated by the APCD, analyzes their effectiveness and efficiency in regards to the overall network, makes recommendations for changes to the network, and includes a review of actions taken during 2009 as well as plans for action in the coming year.

1.1. Background and Key Issues

Over time the ambient air monitoring objectives can shift, one of the major reasons behind the re-evaluation and reconfiguration of many monitoring networks. The alteration of a monitoring network is done for several reasons. The first reason is in response to a change in air quality. Air quality has changed since the adoption of the Clean Air Act and National Ambient Air Quality Standards (NAAQS). An example of this is seen in the radical drop in the ambient concentrations of lead that were formerly present in the U.S. The second reason is for a change in population and behaviors. For instance, the U.S. population has grown, aged and shifted toward more urban and suburban areas over the past 40 or so years. In addition, rates of vehicle ownership and annual miles driven have also risen. The third reason is the establishment of new air quality objectives. New rules are constantly being instituted, including rules that will reduce air toxics, fine particulate matter ($PM_{2.5}$), and regional haze. The fourth reason is due to an improvement of the understanding of air quality issues and monitoring capabilities. The understanding of air quality issues and the capability to monitor air quality have both improved. Together, the enhanced understanding and capabilities can be used to design more effective air monitoring networks.

As a result of changes such as those listed above, the APCD's air monitoring network may have unnecessary or redundant monitors, or ineffective and inefficient monitoring locations for some pollutants, while other regions or pollutants may have a lack of monitors. This assessment will help APCD to optimize its current network to help better protect today's population and environment, while maintaining the ability to understand long-term historical air quality trends. In addition, the advantages of implementing new air monitoring technologies combined with the improved scientific understanding of air quality issues would greatly benefit the division's network, as well as the stakeholders, scientists and general public who use it.

1.2. Study Objectives

The objectives for this network assessment are three-fold. First, a determination of whether the existing network is meeting its intended monitoring objectives is necessary. Second, an evaluation of the network's adequacy for characterizing current air quality and impacts from future industrial and population growth will be considered. Third, potential areas where new monitors can be sited or removed to support network optimization, and/or to meet new monitoring objectives will be identified.

To meet these objectives, a suite of analyses will be performed to address the following questions about the network.

- How well does the current monitoring network support current objectives? Which objectives are being met; which objectives are not being met? Are unmet objective(s) appropriate concerns for APCD? If so, what monitoring is necessary to meet those unaddressed objectives? What are potential future objectives for the monitoring network?

- Are the existing sites collectively capable of characterizing all criteria pollutants? Are the existing sites capable of characterizing criteria pollutant trends (spatially and temporally)? If not, what areas lack appropriate monitoring? If needed, where should new monitors be placed? Does the existing network support future emissions assessment, reconciliation, and modeling studies? Are there parameters (at existing sites) or new sites that need to be added to support these objectives?

- Is the current monitoring network sufficient to adequately assess regional air quality conditions with respect to all criteria pollutants? If not, where should monitors be relocated or added to improve the overall effectiveness of the monitoring network? How can the effectiveness of the monitoring network be maximized?

1.3. Guide to This Report

The remainder of Section 1 gives an overview of the Colorado Air Monitoring Network and a description of the current state of air quality in the region. Section 2 describes APCD's technical approach to and results of performing a network assessment to analyze and understand the overall network in terms of its ability to meet monitoring objectives and recommend improvements. The following analyses were performed during the assessment:

- Number of Parameters Monitored
- Population Served
- Population Change
- Emissions Inventory
- Trends Impact
- Deviation from NAAQS
- Area Served
- Monitor to Monitor Correlation
- Measured Concentrations

Section 3 is a discussion of the meteorological network; regional meteorology influences air quality through physical and chemical processes. Section 4 is a description of monitoring being done by other agencies in the State. Section 5 summarizes the Federal requirements for monitoring in Colorado. Section 6 is a summary of the conclusions and recommendations to improve the Colorado monitoring network. Section 7 lists all the references cited in this document. Appendix A describes each monitoring site in detail.

1.4. Overview of the Colorado Air Monitoring Network

In 2010 the APCD plans to operate monitors at 63 locations. In 2009, the APCD operated monitors at 62 separate locations. Particulate monitors, including Total Suspended Particulates (TSP), Particulate Matter 10 microns and smaller (PM_{10}), and Particulate Matter 2.5 microns and smaller ($PM_{2.5}$) are the most abundant and widespread of monitoring types across the state. Currently, there are PM_{10} monitors at 29 separate locations, $PM_{2.5}$ monitors at 19 separate locations, and TSP-Pb in two locations. There are 23 meteorological sites in operation. These sites monitor wind speed, wind direction, resultant speed, resultant direction, standard deviation of horizontal wind direction and temperature. Three meteorological sites also monitor for relative humidity. Only six of the 63 locations will monitor for gaseous and particulate pollutants in addition to taking meteorological measurements. Only four of those six locations monitored for more than ten parameters, with each meteorological and particulate parameter monitored being counted individually. All four of these monitoring locations are in the Denver Front Range area.

The APCD currently operates two TSP sites, one with a collocated monitor, and one that was added at the Centennial Airport on 4/3/2010. Both are used for lead analysis. Only five of the 29 PM_{10} monitoring sites have continuous "hourly" measurements, while ten of the 19 $PM_{2.5}$ monitoring sites have continuous monitors. This difference reflects the age of the technology, as well as the availability and focus of EPA funding. Increasing the amount of automated versus manual monitoring will require modifications to the particulate network, since in the current network these are primarily manually operated monitors.

Thirty-eight of the 63 current monitoring sites have been in operation for ten or more years, and twenty of these have been in operation for 20 or more years. Ten monitoring sites have been in operation for more than 30 years. These sites are: Denver CAMP (45 years), Greeley-Hospital (43 years), Alamosa – Adams State College (40 years), Arvada (37 years), Welby (36 years), Pagosa Springs School (35 years), Lamar Power Plant and Steamboat Springs (34 years), Lamar Municipal (33 years) and Highland Reservoir (32 years). Conversely, 25 of the 63 monitoring sites have begun operation since the start of the year 2000.

Three of the ozone monitoring sites that are located on the western slope and have data included in this report are operated and maintained by a third party contractor, Air Resource Specialists (ARS). These are the Rifle, Palisade and Cortez monitoring sites. They keep the sites in proper working order and perform data retrieval and uploading into the AQS database, while the APCD conducts the independent auditing of the sites for Quality Assurance (QA) purposes.

1.4.1. Purpose of Network Assessment

The purpose of the Network Assessment is to provide a detailed evaluation of the APCD's current air quality monitoring network and its objectives. The assessment helps to (1) identify and remove "low value" monitors, and (2) locate any under monitored areas. The assessment is also an opportunity to look for "found money" to implement new monitoring efforts. This money could come from a shift in funding from low priority monitoring to high priority monitoring, causing an increase in network efficiency combined with a subsequent reduction in costs. It is required once every five years.

1.4.2. Monitoring Network Information

This section covers monitoring history and operations of the APCD, the process for network modifications, a list of the monitoring sites and their pertinent information and a description of the monitoring areas within the state.

1.4.2.1. APCD Monitoring History

The State of Colorado has been monitoring air quality statewide since the mid-1960s when high volume and tape particulate samplers, dustfall buckets, and sulfation candles were the best technology available for defining the magnitude and extent of the very visible air pollution problem. Monitoring for gaseous pollutants (carbon monoxide, sulfur dioxide, oxides of nitrogen and ozone) began in 1965 when the Federal Health and Human Services Department established the CAMP station in downtown Denver at the intersection of 21st Street and Broadway Street. This was the area that was thought to represent the best probability for detecting maximum levels of most of the suspected pollutants. Instruments were primitive by comparison with those of today, and frequently were out of service.

Under provisions of the original Federal Clean Air Act of 1970, the Administrator of the U.S. Environmental Protection Agency (EPA) established National Ambient Air Quality Standards (NAAQS) designed to protect the public's health and welfare. Standards were set for total suspended particulate matter (TSP), carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). In 1972, the first State Implementation Plan (SIP) was submitted to the EPA. It included an air quality surveillance system in accordance with EPA regulations of August 1971. That plan proposed a monitoring network of 100 monitors (particulate and gaseous) statewide. The system established as a result of that plan and subsequent modifications consisted of 106 monitors.

The 1977 Clean Air Act Amendments required States to submit revised SIP's to the EPA by January 1, 1979. The portion of the Colorado SIP pertaining to air monitoring was submitted separately on December 14, 1979, after a comprehensive review, and upon approval by the Colorado Air Quality Control Commission. The 1979 EPA requirements as set forth in 40CFR58.20 have resulted in considerable modification to the network. These, and subsequent modifications, are made to ensure consistency and compliance with Federal monitoring requirements. Station location, probe siting, sampling methodology, quality assurance and control practices and data handling procedures are all continued throughout any changes made to the network.

1.4.2.2. APCD Monitoring Operations

The APCD attempts to operate all of its monitors on a calendar year schedule. We attempt to begin operation of new monitors in January and to terminate existing monitors in December. Circumstances both in and out of our control make that desired schedule generally difficult to achieve. The primary reason for this is that the Division does not own either the land or the buildings where most of the monitors are located, and it is becoming increasingly more difficult to get property owner’s permissions for use due to risk/liability management issues.

When a modification to the State and Local Air Monitoring System (SLAMS) network is required, the Division will provide EPA Region VIII with the appropriate modification form prior to its implementation for their approval. All currently operating SLAMS monitors have been approved by EPA and meet the requirements set forth in 40CFR58, Appendices A, C, D and E.

1.4.2.3. Network Modification Procedures

The APCD develops changes to its monitoring network in several ways. New monitoring locations have been added as a result of community concerns about air quality. An example of this would be the PM_{10} monitors that were established in Cripple Creek and Hygiene. Other monitors have been established as a result of special studies. Examples of this would be the new ozone monitoring in Aurora, Rifle, Cortez, Aspen Park, Rist Canyon, and Palisade. The Denver Firehouse #6 carbon monoxide monitoring began when models showed that the area around the fire station could have elevated carbon monoxide concentrations. New monitors are also added or removed in response to changing Federal requirements.

The most common reasons for monitors being removed from the network are that either the land/building is modified, such that the site no longer meets current EPA siting criteria, or the area surrounding the monitor is being modified in a way that necessitates a change in the monitoring location. The most current example of this is the Pueblo PM_{10} monitoring site. The site was moved in 2009 because of the construction of a new multi-story building on the adjacent lot. Monitors are also removed from the network after review of the data shows that the levels have dropped to the point where it is no longer necessary to continue monitoring at that location. An example of this is the reduction of TSP lead (TSP-Pb) monitoring around the state from six monitors to one in 2006. However, new TSP-Pb monitors are currently being added due to a lowering of the lead standard in 2009. Another example of this type of change is the termination of carbon monoxide monitoring at the NJH-E location. The carbon monoxide concentrations at that location have dropped to the point that the Division, with EPA’s approval, felt that the monitor could be better used elsewhere in the system.

Finally, all monitors are reviewed on a regular basis to determine if they are continuing to meet their monitoring objectives. Has the population, land use or vegetation around the monitor changed significantly since the monitor was established? If it has is there a “better” location for the monitor?

Table 1 lists the locations and monitoring parameters of each site currently in operation, by county, alphabetically. It lists the AQS identification numbers for each site, the site address and coordinates, the start dates and the site elevations. It further breaks down the monitor type, orientation/scale and the sampling frequency for each site.

Table 1. Monitoring Locations and Parameters Monitored

AQS #	*Site Name*	*Address*		*Started*	*Ended*	*Latitude (dec. deg.)*	*Longitude (dec. deg.)*	*Elevation (m)*
Adams								
08 001 0006	Alsup Elementary School - Commerce City	7101 Birch St.		01/2001		39.826007	-104.937438	1,565
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	01/2001	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	
	$PM_{2.5}$	1	01/2001	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	
	$PM_{2.5}$ Collocated	2	01/2001	P.O. Neigh	Partisol 2025	SLAMS	1 in 6	
	$PM_{2.5}$	3	01/2001	P.O. Neigh	TEOM-1400ab	SPM	Continuous	
	$PM_{2.5}$ Speciation	5	01/2001	P.O. Neigh	SASS	Trends Spec	1 in 3	
	$PM_{2.5}$ Carbon	5	04/2009	P.O. Neigh	URG 3000N	Trends Spec	1 in 3	
	WS/WD/Temp	1	06/2003	Other	Met - One	Other	Continuous	
08 001 3001	Welby	3174 E. 78th Ave.		07/1973		39.838119	-104.94984	1,554
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	CO	1	07/1973	P.O. Neigh	Thermo 48C	SLAMS	Continuous	
	SO_2	2	07/1973	P.O. Neigh	API 100E	SLAMS	Continuous	
	NO	2	01/1976	P.O. Urban	API 200E	Other	Continuous	
	NO_2	1	01/1976	P.O. Urban	API 200E	SLAMS	Continuous	
	O_3	2	07/1973	P.O. Neigh	API 400E	SLAMS	Continuous	
	WS/WD/Temp	1	01/1975	Other	Met - One	Other	Continuous	
	PM_{10}	1	07/1990	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 6	
	PM_{10}	3	06/1990	P.O. Neigh	TEOM-1400ab	SLAMS	Continuous	
Alamosa								
08 003 0001	Alamosa – Adams State College	208 Edgemont Blvd		01/1970		37.469391	-105.878691	2,302
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	06/1989	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1	
08 003 0003	Alamosa – Municipal Bldg.	425 4th St.		04/2002		37.469584	-105.863175	2,301
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	04/2002	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1	
Arapahoe								
08 005 0002	Highland Reservoir	8100 S. University Blvd		06/1978		39.567887	-104.957193	1,747
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	06/1978	P.O. Neigh	API 400E	SLAMS	Continuous	
	WS/WD/Temp	1	07/1978	Other	Met - One	Other	Continuous	
08 005 0005	Arapaho Community	6190 S. Santa Fe Dr.		12/1998		39.604399	-105.019526	1,636

AQS #	Site Name	Address		Started	Ended	Latitude (dec. deg.)	Longitude (dec. deg.)	Elevation (m)
	College (ACC)							
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	$PM_{2.5}$	1	03/1999	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	
08 005 0006	Aurora - East	36001 E. Quincy Ave.		04/2009		39.63854	-104.56913	1,552
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	O_3	1	04/2009	P.O. Region	API 400A	SPM	Continuous	
	WS/WD/Temp	1	06/2009	Other	Met - One	Other	Continuous	
08 005 0007	Centennial Airport	7800 S. Peoria St.		04/2010		39.572304	-104.84881	1,774
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	TSP	1	4/2010	P.O. Neigh	TSP-GMW	SLAMS	1 in 6	
	Pb	1	4/2010	P.O. Neigh	TSP-GMW	SLAMS	1 in 6	
Archuleta								
08 007 0001	Pagosa Springs School	309 Lewis St.		08/1975		37.26842	-107.009659	2,165
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	PM_{10}	3	06/2001	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1	
Boulder								
08 013 0003	Longmont- Municipal Bldg.	350 Kimbark St.		06/1985		40.164576	-105.100856	1,520
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	PM_{10}	2	04/1985	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 6	
	$PM_{2.5}$	1	01/1999	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	
	$PM_{2.5}$	3	01/1985	P.O. Neigh	TEOM 1400ab	SPM	Continuous	
08 013 0009	Longmont - Main	451 Kimbark St.		11/1989		40.166586	-105.102402	1,519
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	CO	1	11/1989	P.O. Micro	Thermo 48C	SLAMS	Continuous	
08 013 0011	South Boulder Creek	1405 ½ S. Foothills Parkway		06/1994		39.957212	-105.238458	1,669
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	O_3	1	06/1994	H.C. Urban	API 400E	SLAMS	Continuous	
08 013 0012	Boulder Chamber of Commerce of Commerce	2440 Pearl St.		12/1994		40.021097	-105.263382	1,619
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	PM_{10}	1	12/1994	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 6	
	$PM_{2.5}$	1	01/1999	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	

AQS #	Site Name	Address		Started	Ended	Latitude (dec. deg.)	Longitude (dec. deg.)	Elevation (m)
08 013 1001	Boulder – CU – Athens	2102 Athens St.		12/1980		40.012969	-105.264212	1,622
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	$PM_{2.5}$	3	11/2004	P.O. Neigh	TEOM FDMS	SPM	Continuous	
Delta								
08 029 0004	Delta Health Dept	560 Dodge St.		08/1993		38.739213	-108.073118	1,511
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	08/1993	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 3	
Denver								
08 031 0002	Denver - CAMP	2105 Broadway		01/1965		39.751184	-104.987625	1,593
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	CO	2	01/1971	P.O. Micro	Thermo 48C	SLAMS	Continuous	
	SO_2	1	01/1967	P.O. Neigh	API 100E	SLAMS	Continuous	
	NO	1	01/1973	Other	API 200E	Other	Continuous	
	NO_2	1	01/1973	P.O. Neigh	API 200E	SLAMS	Continuous	
	WS/WD/Temp	1	01/1965	Other	Met - One	Other	Continuous	
	PM_{10}	1	01/1986	P.O. Micro	SA/GMW-1200	SLAMS	1 in 6	
	PM_{10} Collocated	2	08/1986	P.O. Micro	SA/GMW-1200	SLAMS	1 in 6	
	PM_{10}	3	01/1988	P.O. Micro	TEOM-1400ab	SLAMS	Continuous	
	$PM_{2.5}$	1	01/1999	P.O. Micro	Partisol 2025	SLAMS	1 in 1	
	$PM_{2.5}$ Collocated	2	09/2001	P.O. Micro	Partisol 2025	SLAMS	1 in 3	
	$PM_{2.5}$	3	01/1999	P.O. Micro	TEOM FDMS	SPM	Continuous	
08 031 0013	Denver - NJH-E	14th Ave. & Albion St.		01/1983		39.738578	-104.939925	1,620
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	$PM_{2.5}$	3	10/2003	P.O. Middle	TEOM FDMS	SPM	Continuous	
08 031 0014	Denver - Carriage	2325 Irving St.		06/1982		39.751761	-105.030681	1,621
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	2	01/1982	P.O. Neigh	API 400E	SLAMS	Continuous	
	WS/WD/Temp	1	01/1983	Other	Met - One	Other	Continuous	
08 031 0016	DESCI	1901 E. 13th Ave.				39.735700	-104.958200	1,623
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	Transmissometer	1	12/1989	Other	Optec LPV-2	SPM	Continuous	
	Nephelometer	1	12/2000	Other	Optec NGN-2	SPM	Continuous	
	Temp	1	12/1989	Other	Rotronics MP-101A	SPM	Continuous	
	Relative Humidity	1	12/1989	Other	Rotronics MP-101A	SPM	Continuous	
08 031 0017	Denver Visitor	225 W. Colfax		12/1992		39.740342	-104.991037	1,597

AQS #	Site Name	Address		Started	Ended	Latitude (dec. deg.)	Longitude (dec. deg.)	Elevation (m)
	Center							
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	PM_{10}	1	12/1992	P.O. Middle	SA/GMW-1200	SLAMS	1 in 1	
08 031 0019	Denver - Firehouse #6	1300 Blake St.		11/1993		39.748163	-105.002564	1,585
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	CO	1	11/1993	P.O. Micro	Thermo 48C	SLAMS	Continuous	
08 031 0021	Auraria Met Station	12th St. and Auraria Pkwy.		03/1999		39.746955	-105.003604	1,586
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	WS/WD/Temp (U)	1	03/1999	Other	Met - One	Other	Continuous	
	Relative Humidity	1	03/1999	Other	Rotronic	Other	Continuous	
	Temp (L)	2	03/1999	Other	Met – One	Other	Continuous	
08 031 0023	Denver – Swansea Elementary School	4650 Columbine St		07/2002		39.781083	-104.95665	1,583
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	$PM_{2.5}$	1	12/2004	P.O. Neigh	Partisol 2025	SPM	1 in 1	
08 031 0025	Denver Municipal Animal Shelter (DMAS)	678 S. Jason St.		07/2005		39.704005	-104.998113	1,594
	Parameter	POC	Started	Orient/Scale	Monitor	Type	Sample	
	CO (Trace)	1	04/2009	P.O. Neigh	Thermo 48E-TLE	NCore	Continuous	
	SO_2 (Trace)	1	+	P.O. Neigh	Ecotech 9850T	NCore	Continuous	
	NO_Y	1	+	P.O. Neigh	API 200EU	NCore	Continuous	
	O_3	1	04/2008	Neigh/Urban	API 400E	NCore	Continuous	
	WS/WD/Temp	1	07/2008	P.O. Neigh	Met - One	NCore	Continuous	
	Relative Humidity	1	+		Rotronic	NCore	Continuous	
	Barometric Pressure	1	+			NCore	Continuous	
	Solar Radiation	1	+			NCore	Continuous	
	Precipitation	1	+			NCore	Continuous	
	Temp (L)	2	07/2008	P.O. Neigh	Met - One	NCore	Continuous	
	TSP	1	07/2005	P.O. Neigh	TSP-GMW	SLAMS	1 in 6	
	TSP Collocated	2	07/2005	P.O. Neigh	TSP-GMW	SLAMS	1 in 6	
	Pb	1	07/2005	P.O. Neigh	TSP-GMW	SLAMS	1 in 6	
	Pb Collocated	2	07/2005	P.O. Neigh	TSP-GMW	SLAMS	1 in 6	
	PM_{10}	1	07/2005	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 6	
	PM_{10} Collocated	2	07/2005	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 6	

AQS #	*Site Name*	*Address*		*Started*	*Ended*	*Latitude (dec. deg.)*	*Longitude (dec. deg.)*	*Elevation (m)*
	PM_{10}	3	08/2005	P.O. Neigh	TEOM-1400ab	SLAMS	Continuous	
	$PM_{2.5}$	1	10/2007	P.O. Neigh	Partisol 2025	NCore	1 in 6	
	$PM_{2.5}$	3	10/2007	P.O. Neigh	TEOM FDMS	SPM	Continuous	
	$PM_{2.5}$ Speciation	5	11/2002	P.O. Neigh	SASS	Supplemental Speciation	1 in 6	
	$PM_{2.5}$ Carbon	5	04/2009	P.O. Neigh	URG 3000N	Supplemental Speciation	1 in 6	
Douglas								
08 035 0004	Chatfield State Park	11500 N. Roxborough Pk Rd		04/2004		39.534488	-105.070358	1,676
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	05/2005	H.C. Urban	API 400E	SLAMS	Continuous	
	WS/WD/Temp	1	04/2004	Other	Met - One	Other	Continuous	
	$PM_{2.5}$	1	07/2005	P.O. Neigh	Partisol 2025	SPM	1 in 3	
	$PM_{2.5}$	3	05/2004	P.O. Neigh	TEOM FDMS	SPM	Continuous	
Elbert								
08 039 0001	Elbert – Ben Kelly Road	24950 Ben Kelly Rd.		12/1998		39.231384	-104.63477	2,139
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	$PM_{2.5}$	1	05/1999	Back Region	Partisol 2025	SLAMS	1 in 6	
El Paso								
08 041 0013	U. S. Air Force Academy	USAFA Rd. 640		05/1996		39.958341	-104.817215	1,971
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	06/1996	P.O. Urban	ML 8810	SLAMS	Continuous	
08 041 0015	Colorado Springs Hwy. 24	690 W. Hwy. 24		11/1998		39.830895	-104.839243	1,824
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	CO	1	11/1998	P.O. Micro	Thermo 48C	SLAMS	Continuous	
	WS/WD/Temp	+		Other	Met – One	Other	Continuous	
08 041 0016	Manitou Springs	101 Banks Pl.		04/2004		38.853097	-104.901289	1,955
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	04/2004	P.O. Neigh	API 400A	SLAMS	Continuous	
08 041 0017	Colorado Springs Colorado College	130 W. Cache La Poudre		12/2007		38.848014	-104.828564	1,832
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	12/2007	P.O. Neigh	Partisol 2000	SLAMS	1 in 6	
	$PM_{2.5}$	1	12/2007	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	
	$PM_{2.5}$	3	01/2008	P.O. Neigh	TEOM FDMS	SLAMS	Continuous	

AQS #	Site Name	Address		Started	Ended	Latitude (dec. deg.)	Longitude (dec. deg.)	Elevation (m)
Fremont								
08 043 0003	Cañon City – City Hall	128 Main St.		10/2004		38.43829	-105.24504	1,626
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	10/2004	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 6	
Garfield								
08 045 0005	Parachute – High School	100 E. 2nd St.		01/1982		38.453654	-108.053269	1,557
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	05/2000	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 3	
	WS/WD/Temp	1	03/2010	Other	RM Young/Viasla	Other	Continuous	
08 045 0007	Rifle – Henry Bldg	144 3rd St.		05/2005		39.531813	-107.782298	1,627
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	05/2005	P.O. Neigh	SA/GMW-1200	SPM	1 in 3	
	$PM_{2.5}$	3	09/2008	P.O. Neigh	Thermo 1405 DF	SPM	Continuous	
	PM_{10}	3	09/2008	P.O. Neigh	Thermo 1405 DF	SPM	Continuous	
	$PM_{10-2.5}$	3	09/2008	P.O. Neigh	Thermo 1405 DF	SPM	Continuous	
	WS/WD/Temp	1	09/2008	Other	RM Young/Viasla	Other	Continuous	
08 045 0012	Rifle – Health Dept	195 W. 14th Ave.		06/2008		39.54182	-107.784125	1,629
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	06/2008	P.O. Neigh	API 400E	SPM	Continuous	
Gunnison								
08 051 0004	Crested Butte	603 6th St.		09/1982		38.867595	-106.981436	2,714
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	2	03/1997	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 3	
	PM_{10} Collocated	3	10/2008	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 6	
08 051 0007	Mt. Crested Butte - Realty	19 Emmons Rd.		07/2005		38.900392	-106.966104	2,866
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	07/2005	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1	
Jefferson								
08 059 0002	Arvada	9101 W. 57th Ave.		01/1973		39.800333	-105.099973	1,640
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	08/1973	P.O. Neigh	API 400E	SLAMS	Continuous	

AQS #	Site Name	Address		Started	Ended	Latitude (dec. deg.)	Longitude (dec. deg.)	Elevation (m)
	WS/WD/Temp	1	01/1975	Other	Met - One	Other	Continuous	
08 059 0005	Welch	12400 W. Hwy. 285		08/1991		39.638781	-105.13948	1,742
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	08/1991	P.O. Urban	API 400A	SLAMS	Continuous	
	WS/WD/Temp	1	11/1991	Other	Met - One	Other	Continuous	
08 059 0006	Rocky Flats - N	16600 W. Hwy. 128		06/1992		39.912799	-105.188587	1,802
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	09/1992	H.C. Urban	API 400E	SLAMS	Continuous	
	WS/WD/Temp	1	09/1992	Other	Met - One	Other	Continuous	
08 059 0008	Rocky Flats - SE	9901 Indiana St.		06/1992		39.87639	-105.165611	1,716
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	WS/WD/Temp	1	08/1991	Other	Met - One	Other	Continuous	
08 059 0011	NREL	2054 Quaker St.		06/1994		39.743724	-105.177989	1,832
	Parameter	**POC**	**Started**	**Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	06/1994	H.C. Urban	ML 8810	SLAMS	Continuous	
08 059 0013	Aspen Park	26137 Conifer Rd.		04/2009		39.540321	-105.296512	2,467
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	04/2009	P.O. Neigh	API 400E	SLAMS	Continuous	
	WS/WD/Temp	1	06/2009	Other	Met - One	Other	Continuous	
La Plata								
08 067 0004	Durango – River City Hall	1235 Camino del Rio		09/1985		37.277798	-107.880928	1,988
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	12/2002	P.O. Neigh	SA/GMW-1200	SLAMS	Continuous	
Larimer								
08 069 0009	Fort Collins – CSU - Edison	251 Edison Dr.		12/1998		40.571288	-105.079693	1,524
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	07/1999	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 3	
	PM_{10}	3	06/2009	P.O. Neigh	Thermo 1405 DF	SPM	Continuous	
	$PM_{2.5}$	1	07/1999	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	
	$PM_{2.5}$	3	06/2009	P.O. Neigh	Thermo 1405 DF	SPM	Continuous	
	$PM_{10-2.5}$	3	06/2009	P.O. Neigh	Thermo 1405 DF	SPM	Continuous	

AQS #	*Site Name*	*Address*		*Started*	*Ended*	*Latitude (dec. deg.)*	*Longitude (dec. deg.)*	*Elevation (m)*
08 069 0011	Fort Collins - West	3416 La Porte Ave.		05/2006		40.592543	-105.141122	1,571
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	05/2006	H.C. Urban	API 400E	SLAMS	Continuous	
08 069 0012	Rist Canyon	11835 Rist Canyon Rd.		04/2009		40.642135	-105.275105	2,058
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	04/2009	P.O. Urban	API 400E	SPM	Continuous	
	WS/WD/Temp	1	04/2009	Other	Met - One	Other	Continuous	
08 069 1004	Fort Collins - Mason	708 S. Mason St.		12/1980		40.57747	-105.07892	1,524
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	CO	1	12/1980	P.O. Neigh	Thermo 48C	SLAMS	Continuous	
	O_3	1	12/1980	P.O. Neigh	API 400E	SLAMS	Continuous	
	WS/WD/Temp	1	01/1981	Other	Met - One	Other	Continuous	
				Mesa				
08 077 0017	Grand Junction – Powell Bldg	650 South Ave.		02/2002		39.063798	-108.561173	1,398
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10} & NATTS Toxic Metals	3	01/2005	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	
	PM_{10} Collocated & NATTS	4	03/2005	P.O. Neigh	Partisol 2000	SLAMS	1 in 6	
	$PM_{2.5}$	1	11/2002	P.O. Neigh	Partisol 2025	SLAMS	1 in 6	
	$PM_{2.5}$	3	01/2005	P.O. Neigh	TEOM 1400ab	SPM	Continuous	
08 077 0018	Grand Junction - Pitkin	645 1/4 Pitkin Ave.		01/2004		39.064289	-108.56155	1,398
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	CO	1	01/2004	P.O. Micro	Thermo 48C	SLAMS	Continuous	
	WS/WD/Temp	1	01/2004	Other	Met - One	Other	Continuous	
	Relative Humidity	1	01/2004	Other	Rotronic	Other	Continuous	
08 077 0019	Clifton - Sanitation	Hwy. 141 & D Rd.		10/2006		39.062514	-108.457382	1,413
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	10/2007	P.O. Neigh	SA/GMW -1200	SLAMS	1 in 3	
08 077 0020	Palisade Water Treatment	Rapid Creek Rd.		05/2008		39.130575	-108.313853	1,512
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	04/2008	P.O. Urban	API 400E	SLAMS	Continuous	

AQS #	Site Name	Address		Started	Ended	Latitude (dec. deg.)	Longitude (dec. deg.)	Elevation (m)
	WS/WD/Temp	1	04/2008	Other	RM Young	Other	Continuous	
Montezuma								
08 083 0006	Cortez – Health Dept	106 W. North St.		06/2006		37.350054	-108.592337	1,890
	Parameter	**POC**	**Started**	**Scale**	**Monitor**	**Type**	**Sample**	
	O_3	1	04/2009	P.O. Urban	API 400E	SPM	Continuous	
	$PM_{2.5}$	1	06/2008	P.O Region	Partisol 2000	SPM	1 in 6	
Pitkin								
08 097 0006	Aspen - Library	120 Mill St.		05/2002		39.19104	-106.818864	2,408
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	05/2002	P.O. Neigh	SA/GWM 1200	SLAMS	1 in 3	
Prowers								
08 099 0001	Lamar Power Plant	100 N. 2nd St.		08/1975		38.090949	-102.613912	1,107
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	2	03/1987	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1	
08 099 0002	Lamar Municipal	104 E. Parmenter St.		12/1976		38.084688	-102.618641	1,107
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	2	03/1987	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1	
08 099 0003	Lamar Port of Entry	7100 US Hwy. 50		03/2005		38.113792	-102.626181	1,108
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	WS/WD/Temp	1	03/2005	Other	Met - One	Other	Continuous	
Pueblo								
08 101 0015	Pueblo – Fountain Magnet School	925 N. Glendale Ave.		06/2009		38.276099	-104.597613	1,433
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	04/2009	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1	
	$PM_{2.5}$	1	04/2009	P.O. Neigh	Partisol 2025	SLAMS	1 in 3	
Routt								
08 107 0003	Steamboat Springs	136 6th St.		09/1975		40.485201	-106.831625	2,054
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	2	03/1987	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1	
San Miguel								
08 113 0004	Telluride	333 W. Colorado Ave.		03/1990		37.937872	-107.813061	2,684
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**	
	PM_{10}	1	03/1990	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 3	

AQS #	***Site Name***	***Address***	***Started***	***Ended***	***Latitude (dec. deg.)***	***Longitude (dec. deg.)***	***Elevation (m)***
Summit							
08 117 0002	Breckenridge	501 N. Park Ave.	04/1992		39.491461	-106.047325	2,904
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**
	PM_{10}	1	04/1992	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 1
Weld							
08 123 0006	Greeley-Hospital	1516 Hospital Rd.	04/1967		40.414877	-104.70693	1,441
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**
	PM_{10}	2	03/1987	P.O. Neigh	SA/GMW-1200	SLAMS	1 in 3
	$PM_{2.5}$	1	02/1999	P.O. Neigh	Partisol 2025	SLAMS	1 in 3
	$PM_{2.5}$	3	02/1999	P.O. Neigh	TEOM - 1400ab	SPM	Continuous
08 123 0008	Platteville Middle School	1004 Main St.	12/1998		40.209387	-104.82405	1,469
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**
	$PM_{2.5}$	1	08/1999	P.O. Region	Partisol 2025	SLAMS	1 in 3
	$PM_{2.5}$ Speciation	5	08/1999	P.O. Region	SASS	Spec Trends	1 in 6
	$PM_{2.5}$ Carbon	5	04/2009	P.O. Neigh	URG 3000N	Spec Trends	1 in 6
08 123 0009	Greeley –County Tower	3101 35th Ave.	06/2002		40.386368	-104.73744	1,484
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**
	O_3	1	06/2002	P.O. Neigh	API 400E	SLAMS	Continuous
	WS/WD/Temp	1	+	Other	Met - One	Other	Continuous
08 123 0010	Greeley – West Annex	905 10th Ave.	12/2003		40.423432	-104.69479	1,421
	Parameter	**POC**	**Started**	**Orient/Scale**	**Monitor**	**Type**	**Sample**
	CO	1	12/2003	P.O. Neigh	Thermo 48C	SLAMS	Continuous

The following abbreviations were used in Table 1, with orientation (Orient) referring to the reason why the monitor was placed in that location, and Scale referring to the size of the area that concentrations from the monitor represent.

Orientation
P.O. - Population oriented
Back - Background orientation
SPM - Special Projects Monitor
H.C. - Highest Concentration
POC - Parameter Occurrence Code

Scale
Micro - Micro-scale
Neigh - Neighborhood Scale
Middle - Middle Scale
Urban - Urban Scale
Regional - Regional Scale

Also included in the above table are listings as “Other” which are meteorological monitors that do not include either orientation or scale. The “+” in the “Start” column indicates that the monitor has not been installed.

1.4.2.4. Description of Monitoring Areas in Colorado

The state has been divided into five multi-county areas that are generally based on topography. The areas are: (1) the Eastern Plains, (2) the Northern Front Range, (3) the Southern Front Range, (4) the Mountains, and (5) the Western Counties. These divisions are a somewhat arbitrary grouping of monitoring sites that have similar characteristics.

The Eastern Plains consist of those counties east of the urbanized I-25 corridor to the eastern border of Colorado from the northern to the southern border. These counties are generally rolling agricultural plains below the elevation of 6,000 feet.

The Front Range counties are generally those along the I-25 corridor from the northern border of Colorado to the southern border. They are split into north and south areas with the Palmer Ridge being the dividing area. While the northern counties all have a direct association with I-25, that association is not as well defined in the southern counties. Teller, Fremont, Custer, Alamosa and Costilla counties are included with the Southern Front Range Counties because they have more in common meteorologically with that group than they do with the Mountain counties.

The Mountain counties are generally those counties along the Continental Divide. The Western Counties are those adjacent to the Utah border. Other divisions can and have been made, but these five divisions seemed appropriate for this report. Figure 1 shows the approximate boundaries of these areas.

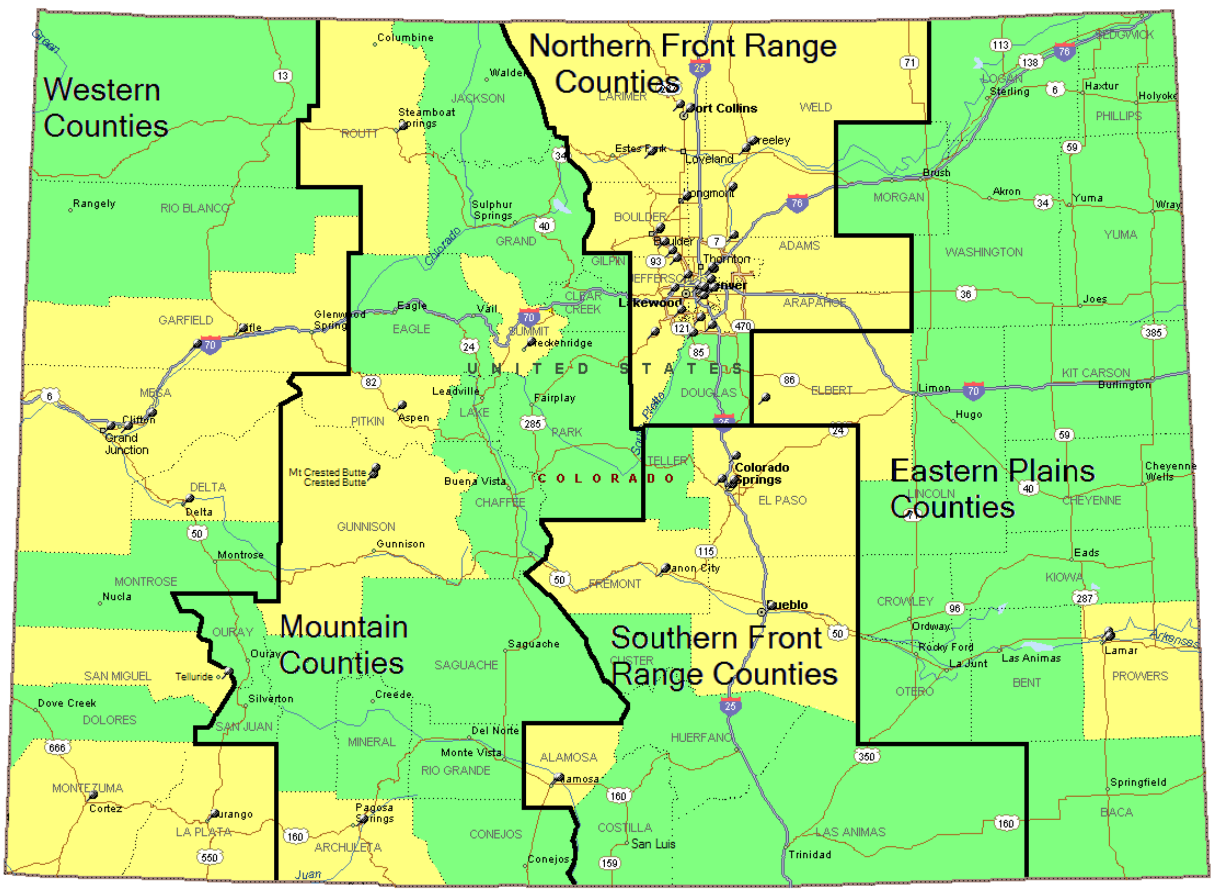


Figure 1. Monitoring Areas in Colorado[1]

[1] Counties with monitors are in yellow and the pin symbols on the map show the approximate location of the monitors within the county.

1.4.2.4.1. Eastern Plains Counties

The Eastern Plains Counties are those east of the urbanized I-25 corridor. Historically, there have been a number of communities that were monitored for particulates and meteorology but not for any of the gaseous pollutants. In the northeast along the I-76 corridor, the communities of Sterling, Brush and Fort Morgan have been monitored. Along the I-70 corridor only the community of Limon has been monitored for particulates. Along the US-50/Arkansas River corridor the Division has monitored for particulates in the communities of La Junta, Rocky Ford and Trinidad. These monitors were all discontinued in the late 1970's and early 1980's after a review showed that the concentrations were well below the standard and trending downward.

Currently, there are two PM_{10} monitoring sites in Lamar, a background $PM_{2.5}$ monitor in Elbert County, but no gaseous pollutant monitors in the area. The Lamar monitors did record 5 separate exceedances of the 24-hour PM_{10} standard in 2009. These have been associated with high winds and dry conditions that occur anytime of the year, but especially in the springtime. The Elbert County monitor is located on the Palmer Divide and operates as a background $PM_{2.5}$ monitor. This monitor provides baseline $PM_{2.5}$ readings away from urban sources of manmade particulates.

1.4.2.4.2. Northern Front Range Counties

The Northern Front Range Counties are those along the urbanized I-25 corridor from the Colorado/Wyoming border to just south of the city of Castle Rock. This area has the majority of the larger cities in the state. The majority of monitors are located in the Denver metropolitan area (Denver-metro) and the rest are located in or near Boulder, Fort Collins, Greeley, Longmont and Platteville.

Currently, there are 28 gaseous pollutant monitors and 23 particulate monitors in the Northern Front Range area. There are 7 CO, 16 O_3, 2 NO_2 and 2 SO_2 monitors. There are 9 PM_{10}, 13 $PM_{2.5}$, and 2 TSP/Pb monitors. There were no NAAQS exceedances of CO, NO_2, SO_2, PM_{10} or TSP/Pb in 2009. There were two exceedances of the $PM_{2.5}$ NAAQS. One exceedance was at the Boulder Chamber of Commerce site (08 013 0012). It occurred on 09/01/2009, and was due to a nearby wildfire. The second exceedance was at the Greeley – Hospital site. There were O_3 NAAQS exceedances at eleven different sites in 2009. These sites were Welby (08 001 3001), Highland (08 005 0002), Aurora East (08-005-0006), South Boulder Creek (08 013 0011), Chatfield State Park (08 035 0004), Arvada (08 059 0002), Welch (08 059 0005), Rocky Flats North (08 059 0006), NREL (08 059 0011), Aspen Park (08 059 0013) and Ft. Collins West (08 069 0011).

1.4.2.4.3. Southern Front Range Counties

The Southern Front Range Counties are those along the urbanized I-25 corridor from south of the city of Castle Rock to the southern Colorado border. The cities with monitoring in the area are Colorado Springs, Pueblo, Cañon City and Alamosa. These last two cities are not strictly in the Front Range I-25 corridor but meteorologically fit better with those cities than they do the Mountain Counties. Colorado Springs is the only city in the area that is monitored for carbon monoxide and ozone by the APCD. The other cities are only monitored for particulates. In the past the APCD has conducted particulate monitoring in both Walsenburg and Trinidad but that monitoring was discontinued in 1979 and 1985 respectively, due to low concentrations.

Currently, there are 3 gaseous pollutant monitors and 8 particulate monitors in the Southern Front Range area. There are 1 CO and 2 O_3 monitors in the Colorado Springs area. There are 5 PM_{10} and 3 $PM_{2.5}$ monitors in the region. There were two exceedances of the PM_{10} NAAQS in 2009, one at the Alamosa – Municipal site (08 003 0003) and one at the Alamosa – Adams State College site (08 003 0001). There were no NAAQS exceedances of CO or $PM_{2.5}$ in 2009.

1.4.2.4.4. Mountain Counties

The Mountain Counties are generally those that are on or near the Continental Divide. They consist of mostly small towns located in tight mountain valleys. Their primary monitoring concern is with particulate pollution from wood burning and road sanding. These communities range from Steamboat Springs in the north to

Breckenridge in the I-70 corridor, as well as Aspen, Crested Butte and Mt. Crested Butte in the central mountains and Pagosa Springs in the south.

Currently, there are no gaseous and 6 particulate monitoring sites operated by the APCD in the Mountain Counties region. The Pagosa Springs School monitor (08 007 0001) did record three exceedances of the PM_{10} NAAQS in 2009.

1.4.2.4.5. Western Counties

The Western Counties are generally smaller towns, and are usually located in fairly broad river valleys. Grand Junction is the only large city in the area, and the only location that monitors for carbon monoxide and air toxics on the western slope. The other Western County locations monitor only for particulates. They are located in Cortez, Delta, Durango, Palisade, Parachute, Rifle and Telluride.

A special study on ozone conducted in the summer of 2007 looked at ozone concentrations in two areas of the Western Counties. These areas were along the southwestern border with New Mexico in the Four Corners area near Cortez, and along the I-70 corridor from Glenwood Springs to Grand Junction. The results of this study led to a determination that new ozone monitoring sites were needed and subsequently established at Cortez, Palisade and Rifle.[2]

Currently, there are 4 gaseous pollutant monitors and 11 particulate monitors in the Western Counties area. There are 1 CO and 3 O_3 monitoring sites. There are 8 PM_{10} and 3 $PM_{2.5}$ monitoring sites. There were no NAAQS exceedances for ozone or carbon monoxide in 2009. There were three PM_{10} NAAQS exceedances in 2009, two at the Durango – River City Hall site (08 067 0004) and one at the Delta Health Dept. site (08 029 0004). There were six $PM_{2.5}$ NAAQS exceedances at the Grand Junction – Powell site (08 077 0017) in 2009.

1.4.2.5. State-wide Population Statistics

Table 2 is a listing of the projected population statistics by county. The counties have been grouped into Planning and Management Regions (per Colorado Executive Orders of November 1972, 1973 and 1986, and October 1998), Metropolitan Statistical Areas (per the US Office of Management and Budget, June 30, 1993), and Sub-state Regions (i.e., Front Range, Western Slope, Eastern Plains, etc.). The Sub-state Regional grouping typically varies from data user to data user. For the purposes of this assessment, the groupings used were as similar to the State's five monitoring regions as possible. Detailed descriptions of the regions and areas can be found at: http://www.dola.state.co.us/dlg/demog/population/geoarea.pdf. (Colorado State Demography Office)

[2] The draft report for this passive ozone study is currently being internally reviewed by the APCD.

Table 2. Projected Population Statistics and Monitors by County and Metropolitan Statistical Area[3]

REGIONS/Counties	Projected Population			Percent Change		CO	SO_2	NO_X	NO_Y	O_3	WS WD T	Rel. Hum	Precip	TSP	Pb	PM_{10} Hi-Vol & Crs.	PM_{10} Lo-Vol & Cont.	$PM_{2.5}$ FRM & Carb.	$PM_{2.5}$ Cont. & SASS
	July, 2010	July, 2015	July, 2020	2010 - 15	2010 -20														
COLORADO	***5,171,798***	***5,632,137***	***6,186,161***	***1.7%***	***2.0%***	***9***	***2***	***2***		***21***	***20***	***3***		***3***	***3***	***31***	***8***	***21***	***15***
FRONT RANGE	***4,243,767***	***4,599,832***	***5,012,326***	**2.1%**	**1.8%**														
Adams	447,760	497,159	548,709	2.1%	2.3%														
	08 001 0006 Alsup Elementary School - Commerce City										1						1	1 1/C 1/E	1 1/S
	08 001 3001 Welby					1	1	1		1	1					1	1		
Arapahoe	578,444	626,155	677,125	1.6%	1.7%														
	08 005 0002 Highland Reservoir									1	1								
	08 005 0005 Arapahoe Community College																	1	
	08 005 0006 Aurora East									1	1								
	08 005 0007 Centennial Airport													1	1				
Broomfield	58,629	65,359	72,468	2.2%	2.4%														
Denver	631,809	674,642	700,455	1.3%	1.1%														
	08 031 0002 Denver CAMP					1	1	1			1					1 1/C	1	1 1/C	1
	08 031 0013 Denver NJH																		1
	08 031 0014 Denver Carriage									1	1								
	08 031 0017 Denver Visitor Center															1			
	08 031 0019 Denver Firehouse #6					1													
	08 031 0021 Auraria Met										1	1							
	08 031 0023 Denver Swansea Elementary																	1	
	08 031 0025 Denver Animal Shelter					1	+		+	1	1	+	+	1 1/C	1 1/ C	1 1/C	1	1 1/E	1 1/S
Douglas	296,072	334,708	388,905	2.5%	3.1%														
	08 035 0004 Chatfield State Park									1	1							1	1
Jefferson	551,938	574,370	608,282	0.8%	1.0%														
	08 059 0002 Arvada									1	1								

[3] Population statistics included in this table were taken from data generated by the Colorado State Demography Office, and are readily available at: http:// www.dola.state.co.us/dlg/demog/pop_totals.html. (Colorado State Demography Office)

REGIONS/Counties	Projected Population			Percent Change		CO	SO_2	NO_X	NO_Y	O_3	WS WDT	Rel. Hum	Precip	TSP	Pb	PM_{10} Hi-Vol & Crs.	PM_{10} Lo-Vol & Cont.	$PM_{2.5}$ FRM & Carb.	$PM_{2.5}$ Cont. & SASS
	July, 2010	July, 2015	July, 2020	2010 - 15	2010 -20														
	08 059 0005 Welch									1	1								
	08 059 0006 Rocky Flats - N									1	1								
	08 059 0008 Rocky Flats - SE										1								
	08 059 0011 NREL									1									
	08 059 0013 Aspen Park									1	1								
BOULDER PMSA/Co	**305,268**	**324,285**	**344,098**	**1.2%**	**1.3%**														
	08 013 0003 Longmont – Municipal Bldg.															1		1	1
	08 013 0009 Longmont – Main					1													
	08 013 0011 South Boulder Creek									1									
	08 013 0012 Boulder Chamber of Commerce															1		1	
	08 013 1001 Boulder CU/Athens																		1
NORTH FRONT RANGE	***564,233***	***629,496***	***717,050***	***2.2%***	***2.7%***														
FORT COLLINS MSA	**300,804**	**327,242**	**362,134**	**1.7%**	**2.0%**														
	08 069 0009 Fort Collins – CSU - Edison															1 1/R	1	1	1
	08 069 0011 Fort Collins - West									1									
	08 069 0012 Rist Canyon									1	1								
	08 069 1004 Fort Collins - Mason					1				1	1								
GREELEY MSA	**263,429**	**302,254**	**354,916**	**2.8%**	**3.5%**														
	08 123 0006 Greeley Hospital															1		1	1
	08 123 0008 Platteville																	1 1/E	1/S
	08 123 0009 Greeley - Tower									1	+								
	08 123 0010 Greeley - West Annex					1													
SOUTH FRONT RANGE	***809,614***	***873,659***	***955,236***	***0.79%***	***1.8%***														

REGIONS/Counties	Projected Population			Percent Change		CO	SO_2	NO_X	NO_Y	O_3	WS WDT	Rel. Hum	Precip	TSP	Pb	PM_{10} Hi-Vol & Crs.	PM_{10} Lo-Vol & Cont.	$PM_{2.5}$ FRM & Carb.	$PM_{2.5}$ Cont. & SASS
	July, 2010	July, 2015	July, 2020	2010 - 15	2010 -20														
COLO. SPRINGS MSA	**647,229**	**698,723**	**763,736**	**1.5%**	**1.8%**														
El Paso	624,314	673,324	735,428	1.5%	1.8%														
	08 041 0013 USAFA									1									
	08 041 0015 Colorado Springs - Hwy-24					1					+								
	08 041 0016 Manitou Springs									1									
	08 041 0017 Colorado Springs - Colorado College																1	1	1
Teller	22,915	25,399	28,308	2.1%	2.4%														
PUEBLO MSA	**162,385**	**174,936**	**191,500**	**1.5%**	**1.8%**														
	08 101 0015 Pueblo – Fountain Magnet School															1		1	
WESTERN SLOPE	***577,799***	***648,602***	***743,772***	***2.3%***	***2.9%***														
REGION 9	**94,252**	**105,445**	**119,230**	**2.3%**	**2.7%**														
Archuleta	13,284	15,547	18,360	3.2%	3.8%														
	08 007 0001 Pagosa Springs School															1			
Dolores	2,041	2,205	2,410	1.6%	1.8%														
La Plata	52,114	58,479	66,262	2.3%	2.7%														
	08 067 0004 Durango – River City Hall															1			
Montezuma	26,243	28,613	31,562	1.7%	2.0%														
	08 083 0006 Cortez									1								1	
San Juan	570	601	636	1.1%	1.2%														
REGION 10	**105,333**	**119,424**	**136,120**	**2.5%**	**2.9%**														
Delta	32,737	37,356	43,227	2.7%	3.2%														
	08 029 0004 Delta Health Dept.															1			
Gunnison	15,366	16,394	17,766	1.3%	1.6%														
	08 051 0004 Crested Butte															1 1/C			
	08 051 0007 Mt. Crested Butte Realty															1			
Hinsdale	901	1002	1107	2.1%	2.3%														

REGIONS/Counties	Projected Population			Percent Change		CO	SO_2	NO_X	NO_Y	O_3	WS WDT	Rel. Hum	Precip	TSP	Pb	PM_{10} Hi-Vol & Crs.	PM_{10} Lo-Vol & Cont.	$PM_{2.5}$ FRM & Carb.	$PM_{2.5}$ Cont. & SASS
	July, 2010	July, 2015	July, 2020	2010 - 15	2010 -20														
Montrose	43,218	49,417	56,638	2.7%	3.1%														
Ouray	4,946	5,748	6,430	3.1%	3.0%														
San Miguel	8,165	9,507	10,952	3.1%	3.4%														
	08 113 0004 Telluride															1			
REGION 11	**257,686**	**287,761**	**333,943**	**2.2%**	**3.0%**														
Garfield	60,110	70,571	90,151	3.3%	5.0%														
	08 045 0005 Parachute – High School															1			
	08 045 0007 Rifle - Henry Building										1					1 1/R			1
	08 045 0012 Rifle – Health Dept.									1									
Mesa	150,430	165,428	184,592	1.9%	2.3%														
	08 077 0017 Grand Junction - Powell																1 1/C	1	1
	08 077 0018 Grand Junction - Pitkin					1					1	1							
	08 077 0019 Clifton															1			
	08 077 0020 Palisade Water Treatment									1	1								
Moffat	15,032	15,941	17,965	1.2%	2.0%														
Rio Blanco	7,774	8,407	10,031	1.6%	2.9%														
Routt	24,340	27,394	31,204	2.4%	2.8%														
	08 107 0003 Steamboat Springs															1			
REGION 12	**120,528**	**135,972**	**154,479**	**2.4%**	**2.8%**														
Eagle	56,674	64,639	72,824	2.7%	2.8%														
Grand	14,996	16,852	19,763	2.4%	3.2%														
Jackson	1,462	1,535	1,626	1.0%	1.1%														
Pitkin	17,445	19,240	21,478	2.0%	2.3%														
	08 097 0006 Aspen - Library															1			
Summit	29,951	33,706	38,788	2.4%	3.0%														
	08 117 0002 Breckenridge															1			
CENTRAL MTNS.	***137,609***	***154,267***	***176,047***	***2.3%***	***2.8%***														
CLR CRK. & GILPIN	**14,834**	**16,234**	**17,944**	**1.8%**	**2.1%**														

REGIONS/Counties	Projected Population			Percent Change		CO	SO_2	NO_X	NO_Y	O_3	WS WD T	Rel. Hum	Precip	TSP	Pb	PM_{10} Hi-Vol & Crs.	PM_{10} Lo-Vol & Cont.	$PM_{2.5}$ FRM & Carb.	$PM_{2.5}$ Cont. & SASS
	July, 2010	July, 2015	July, 2020	2010 - 15	2010 -20														
Clear Creek	9,490	10,390	11,515	1.8%	2.1%														
Gilpin	5,344	5,844	6,429	1.8%	2.0%														
PARK COUNTY	**17,704**	**21,381**	**27,046**	**3.8%**	**5.3%**														
REGION 13	**79,693**	**88,822**	**100,359**	**2.2%**	**2.6%**														
Chaffee	17,513	19,467	22,625	2.1%	2.9%														
Custer	4,324	5,120	6,027	3.4%	3.9%														
Fremont	48,819	53,099	58,283	1.7%	1.9%														
	08 043 0003 Cañon City - City Hall															1			
Lake	9,037	11,136	13,424	4.3%	4.9%														
REGION 14	**25,378**	**27,830**	**30,698**	**1.9%**	**2.1%**														
Huerfano	8,296	9,121	10,079	1.9%	2.1%														
Las Animas	17,082	18,709	20,619	1.8%	2.1%														
SAN LUIS VALLEY	**49,334**	**52,900**	**56,909**	**1.4%**	**1.5%**														
Alamosa	16,487	18,170	19,984	2.0%	2.1%														
	08 003 0001 Alamosa – Adams State College															1			
	08 003 0003 Alamosa - Municipal															1			
Conejos	8,472	8,869	9,259	0.9%	0.9%														
Costilla	3,495	3,628	3,772	0.7%	0.8%														
Mineral	1014	107	1,131	1.1%	1.2%														
Rio Grande	12,593	13,245	14,206	1.0%	1.3%														
Saguache	7,273	7,918	8,557	1.7%	1.8%														
EASTERN PLAINS	***163,289***	***176,536***	***197,107***	***1.6%***	***2.1%***														
REGION 1	**72,813**	**77,996**	**85,326**	**1.4%**	**1.7%**														
Logan	21,924	23,965	26,667	1.8%	2.2%														
Morgan	28,953	31,477	35,362	1.7%	2.2%														
Phillips	4,583	4,658	4,786	0.3%	0.4%														
Sedgwick	2,572	2,679	2,806	0.8%	0.9%														
Washington	4,755	4,812	4,864	0.2%	0.2%														
Yuma	10,026	10,405	10,841	0.7%	0.8%														

REGIONS/Counties	Projected Population			Percent Change		CO	SO_2	NO_X	NO_Y	O_3	WS WD T	Rel. Hum	Precip	TSP	Pb	PM_{10} Hi-Vol & Crs.	PM_{10} Lo-Vol & Cont.	$PM_{2.5}$ FRM & Carb.	$PM_{2.5}$ Cont. & SASS
	July, 2010	July, 2015	July, 2020	2010 - 15	2010 -20														
REGION 5	**39,819**	**46,215**	**57,533**	**3.0%**	**4.4%**														
Cheyenne	2,015	2,131	2,260	1.1%	1.2%														
Elbert	23,715	29,488	40,051	4.5%	6.9%														
	08 039 0001 Elbert County – Ben Kelley Road																	1	
Kit Carson	8,420	8,682	8,954	0.6%	0.6%														
Lincoln	5,669	5,914	6,268	0.8%	1.1%														
REGION 6	**50,657**	**52,325**	**54,248**	**0.7%**	**0.7%**														
Baca	4,120	4,122	4,164	0.0%	0.1%														
Bent	6,265	6,481	6,681	0.7%	0.7%														
Crowley	6,344	6,684	7,084	1.0%	1.2%														
Kiowa	1,473	1,511	1,558	0.5%	0.6%														
Otero	19,014	19,716	20,518	0.7%	0.8%														
Prowers	13,441	13,811	14,243	0.5%	0.6%														
	08 099 0001 Lamar Power Plant															1			
	08 099 0002 Lamar - Municipal															1			
	08 099 0003 Lamar Port of Entry											1							

+ - indicates monitors that will be installed in 2010
C - Collocated monitors
S - SASS $PM_{2.5}$ monitor
E – $PM_{2.5}$ Carbon monitor

1.5. Current State of Air Quality in the Region

Currently, all areas represented by SLAMS and SPM sites are in attainment for carbon dioxide, nitrogen dioxide, sulfur dioxide, lead, PM_{10} and $PM_{2.5}$. There are five ozone monitoring sites that are in non-attainment status for the 3-year average of the 4^{th} maximum concentration for the years 2007 through 2009. There were fourteen total exceedances for PM_{10} at eight different monitoring sites in 2009. The Lamar Power Plant (08 099 0001), Lamar Municipal (08 099 0002), Pagosa Springs School (08 007 0001) and Durango – River City Hall (08 067 0004) sites all recorded more than one exceedance in 2009. Many of these exceedances are due to naturally occurring events. A number of natural event data which have not yet received concurrence from EPA are listed here.

Table 3 summarizes the 2009 CO, O_3, NO_2, SO_2, PM_{10}, $PM_{2.5}$ and Pb concentration data for those sites operated by the APCD.

Table 3. Summary of 2009 CO, O_3, NO_2, SO_2, PM_{10}, $PM_{2.5}$ and Pb Concentration Data

Site ID	Pollutant										
	CO (ppm)		O_3 (ppm)	NO_2 (ppm)		SO_2 (ppm)		PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)		Lead (µg/m^3)
	8-hour	1-hour	4th max 8-hr	Annual	1-hr (98%)	Annual	24-hour	24-hr	Annual	24-hr (98%)	3-month max
08 001 0006								96	8.12	21.7	
08 001 3001	2.0	2.8	0.072	0.015	0.064	0.001	0.01	54			
08 003 0001								207			
08 003 0003								157			
08 005 0002			0.069								
08 005 0005									7.23	16.4	
08 005 0006			0.066								
08 007 0001								255			
08 013 0003								40	7.29	19.0	
08 013 0009	1.9	3.5									
08 013 0011			0.073								
08 013 0012								38	6.44	15.1	
08 029 0004								186			
08 031 0002	2.5	6.9						47	7.52	18.0	
08 031 0014			0.063								
08 031 0017								53			
08 031 0019	1.8	3.6									
08 031 0023									7.66	17.3	
08 031 0025	N/A	N/A	0.062	N/A	N/A	N/A	0.01	48	7.25	19.3	0.011
08 035 0004			0.071						5.70	18.2	
08 039 0001									3.91	9.7	
08 041 0013			0.060								
08 041 0015	2.7	3.8									
08 041 0016			0.064								
08 041 0017								35	5.59	11.2	
08 043 0003								38			
08 045 0005								88			
08 045 0007								83			
08 045 0012			0.062								
08 051 0004								99			
08 051 0007								93			

Site ID	Pollutant: CO (ppm)		O_3 (ppm)	NO_2 (ppm)		SO_2 (ppm)		PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)		Lead ($\mu g/m^3$)
	8-hour	**1-hour**	**4th max 8-hr**	**Annual**	**1-hr (98%)**	**Annual**	**24-hour**	**24-hr**	**Annual**	**24-hr (98%)**	**3-month max**
08 059 0002			0.070								
08 059 0005			0.070								
08 059 0006			0.079								
08 059 0011			0.070								
08 059 0013			0.067								
08 067 0004								203			
08 069 0009									6.78	16.6	
08 069 0011			0.073								
08 069 0012			0.067								
08 069 1004	1.9	3.5	0.061								
08 077 0017								65	9.75	41.0	
08 077 0018	2.2	2.3									
08 077 0019								147			
08 077 0020			0.063								
08 083 0006			0.063						6.80	15.0	
08 097 0006								47			
08 099 0001								233			
08 099 0002								176			
08 101 0012								99			
08 107 0003								83			
08 113 0004								130			
08 117 0002								101			
08 123 0006									7.83	25.7	
08 123 0008									7.51	23.0	
08 123 0009			0.067								
08 123 0010	2.3	4.3									

Notes:

NAAQS Standards		
	8-hour CO = 9 ppm 1-hour CO = 35 ppm	CO values represent the maximum 8-hour and 1-hour concentrations in 2009
	8-hour O_3 = 0.075 ppm	O_3 values represent the 4th highest 8-hour average concentration in 2009
	Annual NO_2 = 0.053 ppm 1-hour NO_2 = 0.100 ppm	NO_2 1-hour values represent the 98th percentile concentration in 2009
	Annual SO_2 = 0.030 ppm 24-hour SO_2 = 0.14 ppm	SO_2 24-hour values represent the 2nd highest concentration in 2009
	24-hour PM_{10} = 150 $\mu g/m^3$	PM_{10} 24-hour values represent the highest average concentration in 2009
	Annual $PM_{2.5}$ = 15.0 $\mu g/m^3$	$PM_{2.5}$ annual values represent the mean of the 2009 quarterly avg. concentrations
	24-hour $PM_{2.5}$ = 35 $\mu g/m^3$	$PM_{2.5}$ 24-hour values represent the 98th percentile concentration in 2009
	3-month Pb = 0.15 $\mu g/m_3$	Lead 3-month values represent the maximum concentration in 2009 Remaining annual data represent the arithmetic mean value for 2009

2. TECHNICAL APPROACH

2.1. Preliminary Assessment of the Current Network

The first step in performing a network assessment is gaining an understanding of the current and historical network, regional characteristics and the objectives for each monitoring site. To complete this step, a thorough review of each of the sites in the network was performed. APCD staff travelled to each site and performed a site evaluation. Monitor coordinates were verified, as were distances to roadways, obstacles, etc. In addition, new site photos were taken. All files were updated, and the process of verifying the monitoring sites' objectives began. These files are available from the APCD.

2.2. Data Quality Assessment

Before the air monitoring network assessment was performed, air quality data for all sites operated by APCD in Colorado were acquired for the years 2004 through 2008. The data quality assessment involved performing an assessment of data completeness for each of the monitor types in the APCD's network. The data is presented below beginning with the gaseous monitors and is followed by the particulate data.

2.2.1. Gaseous Monitors

The following sections are a discussion on the quality of the gaseous data collected by the APCD. It only covers the years 2004 through 2008, as that is the time period of interest for this network assessment.

2.2.1.1. Carbon Monoxide

Table 4 shows the data completeness record for carbon monoxide monitors from 2004 through 2009. All sites recorded 94 percent or greater completeness of the data set. The data generated at all sites for this time period meets the EPA requirements of 75 percent or greater completeness for robust analyses.

Table 4. CO Data Completeness for 2004 through 2009

Site ID	Percent Complete					
	2004	2005	2006	2007	2008	2009
08 001 3001	99%	99%	99%	99%	95%	96%
08 013 0009	96%	99%	97%	99%	98%	96%
08 031 0002	99%	99%	99%	99%	99%	95%
08 031 0019	96%	99%	98%	99%	99%	66%
08 041 0015	96%	99%	95%	99%	98%	98%
08 069 1004	98%	99%	99%	99%	99%	98%
08 077 0018	97%	99%	99%	99%	94%	89%
08 123 0010	97%	99%	99%	99%	99%	98%

- Highlighted field indicates the monitor was shut down part way through the year for an extensive remodel of the site where it is located.

2.2.1.2. Ozone

Table 5 shows the data completeness record for ozone monitors from 2004 through 2009. All sites but one recorded 91 percent or greater completeness of the data set for each year. The Highland Reservoir site only shows 24 percent completeness for 2008 as the site was shut down due to new building construction at the site. The sites that show dashes (---) instead of percentage values were not in operation for those particular years.

The data generated at all sites but those with incomplete data sets for the 2004 through 2009 time period meets the EPA requirements of 75 percent or greater completeness for robust analyses. Those sites with incomplete data sets will not be included in certain assessment analyses.

Table 5. O_3 Data Completeness for 2004 through 2009

Site ID	Percent Complete					
	2004	2005	2006	2007	2008	2009
08 001 3001	94%	99%	97%	99%	93%	92%
08 005 0002	99%	97%	98%	99%	24%	99%
08 005 0006	-----	-----	-----	-----	-----	80%
08 013 0011	96%	97%	98%	98%	96%	99%
08 031 0014	99%	96%	97%	98%	96%	99%
08 031 0025	-----	-----	-----	-----	98%	96%
08 035 0004	92%	99%	97%	97%	100%	99%
08 041 0013	95%	98%	99%	99%	94%	99%
08 041 0016	99%	99%	99%	99%	99%	100%
08 045 0012	-----	-----	-----	-----	99%	96%
08 059 0002	99%	95%	97%	99%	97%	99%
08 059 0005	99%	98%	99%	99%	99%	94%
08 059 0006	99%	94%	99%	96%	99%	97%
08 059 0011	98%	95%	99%	99%	99%	97%
08 059 0013	-----	-----	-----	-----	-----	96%
08 069 0011	-----	-----	99%	99%	97%	96%
08 069 0012	-----	-----	-----	-----	-----	98%
08 069 1004	98%	91%	98%	97%	99%	99%
08 077 0020	-----	-----	-----	-----	99%	98%
08 083 0006	-----	-----	-----	-----	99%	95%
08 123 0009	96%	97%	99%	99%	94%	99%

-Highlighted field indicates monitor was shut down for most of the year due to new building construction at the site.

2.2.1.3. Nitrogen Dioxide

Table 6 shows the data completeness record for nitrogen dioxide monitors from 2004 through 2009. The Welby site recorded 85 percent or greater completeness of the data set, while the Denver – CAMP site did not. Quality control issues were discovered at this site that led to the invalidation of a large portion of data from 2008 through 2009. The data generated at the remaining site for 2004 though 2008 meets the EPA requirements of 75 percent or greater completeness for robust analyses.

Table 6. NO_2 Data Completeness for 2004 through 2009

	Percent Complete					
Site ID	2004	2005	2006	2007	2008	2009
08 001 3001	89%	87%	85%	92%	86%	84%
08 031 0002	92%	90%	89%	87%	35%	14%

-Highlighted fields indicate missing data due to QA issues.

2.2.1.4. Sulfur Dioxide

Table 7 shows the data completeness record for sulfur dioxide monitors from 2004 through 2009. The Welby site recorded 87 percent or greater completeness of the data set, while the Denver – CAMP site did not. Quality assurance issues were discovered at this site that led to the invalidation of a large portion of data from 2008 through 2009. The data generated at the remaining site for 2004 though 2007 meets the EPA requirements of 75 percent or greater completeness for robust analyses.

Table 7. SO_2 Data Completeness for 2004 through 2009

Site ID	Percent Complete					
	2004	2005	2006	2007	2008	2009
08 001 3001	94%	94%	87%	94%	90%	92%
08 031 0002	87%	89%	90%	94%	36%	32%

-Highlighted fields indicate missing data due to QA issues.

2.2.2. Particulate Monitors

The following sections are a discussion on the quality of the particulate data collected by the APCD. It only covers the years 2004 through 2009, as that is the time period of interest for this network assessment.

2.2.2.1. PM_{10}

Table 8 shows the data completeness record for PM_{10} monitors from 2004 through 2009. Most of the sites have a data completeness record showing percentages of 78 or higher for the above mentioned time period. Sites with data completeness that is less than 75 percent for any given year will not be used in certain assessment analyses.

Table 8. PM_{10} Data Completeness for 2004 through 2009

Site ID	Percent Complete					
	2004	2005	2006	2007	2008	2009
08 001 0006	96%	97%	95%	94%	97%	97%
08 001 3001	93%	92%	93%	97%	100%	90%
08 003 0001	86%	85%	89%	83%	86%	86%
08 003 0003	90%	94%	82%	90%	80%	84%
08 007 0001	97%	58%	98%	98%	97%	97%
08 013 0003	87%	66%	92%	89%	90%	93%
08 013 0012	89%	89%	93%	95%	98%	98%
08 029 0004	90%	93%	91%	87%	94%	96%
08 031 0002	93%	97%	97%	95%	95%	95%
08 031 0017	96%	92%	95%	94%	99%	94%
08 031 0025	-----	70%	93%	97%	97%	98%
08 041 0017	-----	-----	-----	-----	100%	93%
08 043 0003	80%	87%	93%	92%	95%	89%
08 045 0005	78%	93%	98%	98%	85%	92%
08 045 0007	-----	96%	100%	97%	100%	93%
08 051 0004	97%	93%	98%	94%	100%	93%
08 051 0007	-----	93%	93%	96%	98%	93%
08 067 0004	88%	93%	99%	94%	98%	91%
08 069 0009	97%	89%	98%	99%	99%	95%
08 077 0017	98%	87%	99%	85%	95%	92%
08 077 0019	-----	-----	-----	100%	99%	93%
08 097 0006	*59%*	*57%*	*68%*	97%	99%	93%
08 099 0001	98%	99%	99%	99%	99%	95%
08 099 0002	92%	89%	97%	97%	99%	95%
08 101 0015	-----	-----	-----	-----	-----	-----
08 107 0003	90%	90%	96%	98%	81%	87%
08 113 0004	94%	80%	96%	93%	92%	93%

Site ID	Percent Complete					
	2004	**2005**	**2006**	**2007**	**2008**	**2009**
08 117 0002	*60%*	*73%*	84%	89%	89%	83%
08 123 0006	98%	98%	95%	97%	97%	92%

- Highlighted sites were temporarily shut down to perform required maintenance and repairs on the roof.

- Italicized values indicate the monitors experienced QA difficulties causing invalid data in the data set.

2.2.2.2. $PM_{2.5}$

Table 9 shows the data completeness record for $PM_{2.5}$ monitors from 2004 through 2009. Most of the sites have a data completeness record showing percentages of 75 or higher for the above mentioned time period. Sites with data completeness less than 75 percent for any given year will not be used in certain assessment analyses.

Table 9. $PM_{2.5}$ Data Completeness for 2004 through 2009

Site ID	Percent Complete					
	2004	**2005**	**2006**	**2007**	**2008**	**2009**
08 001 0006	94%	94%	99%	98%	98%	97%
08 005 0005	95%	98%	99%	98%	97%	93%
08 013 0003	95%	99%	93%	99%	95%	98%
08 013 0012	84%	90%	97%	96%	100%	94%
08 031 0002	85%	92%	96%	97%	98%	99%
08 031 0023	75%	89%	93%	93%	96%	99%
08 031 0025	-----	-----	-----	100%	98%	98%
08 035 0004	-----	86%	93%	97%	99%	98%
08 039 0001	85%	90%	75%	79%	98%	90%
08 041 0017	-----	-----	-----	-----	80%	91%
08 069 0009	92%	99%	98%	99%	98%	97%
08 077 0017	95%	98%	100%	93%	95%	99%
08 083 0006	-----	-----	-----	-----	94%	95%
08 101 0015	-----	-----	-----	-----	-----	-----
08 123 0006	88%	99%	94%	96%	94%	98%
08 123 0008	86%	93%	92%	86%	95%	97%

2.2.2.3. TSP/Pb

Table 10 shows the data completeness record for TSP/Pb monitors from 2004 through 2009. All sites have a data completeness record showing percentages of 89 or higher for the above mentioned time period. When compiling the network analyses, only the 2005 through 2009 data will be used at this site since the monitors did not start operating until 2005.

Table 10. TSP/Pb Data Completeness for 2004 through 2009

Site ID	Percent Complete					
	2004	**2005**	**2006**	**2007**	**2008**	**2009**
08 031 0025 - TSP	-----	93%	97%	97%	97%	92%
08 031 0025 - Pb	-----	89%	95%	95%	97%	100%

2.3. Summary of Findings and Recommendations from the Data Quality Assessment

The results of the data quality assessment indicate that the data quality overall is very good for the APCD's sites. Nearly all sites indicate a high percentage of data completeness. Those sites that do not exhibit this quality will not be used in these particular network assessment analyses. The biggest issues appear to be with the PM_{10} monitors in 2004 and 2005. For 2006 through 2009 all but one of the sites has a completeness record of 80 percent or better. A continuation of the increase in quality of future data sets is recommended so that all sites can be included in future network assessment analyses.

2.4. Air Monitoring Network Assessment Analyses

The determination of the types of analyses to be performed was ultimately defined by the purposes of the APCD's monitoring network. As derived from the table of Typical Purposes for Ambient Air Monitoring Networks (Table 2-1) in Sonoma Technology, Inc.'s (STI) "Analytical Techniques for Technical Assessments of Ambient Air Monitoring Networks, " the purposes of the APCD's network are (in no certain order): (1) to establish regulatory compliance, (2) to develop a scientific understanding of air quality by supporting other types of assessments of analyses, (3) to understand historical trends in air quality, (4) to characterize specific geographic locations or emissions sources, (5) to track the spatial distribution of air pollutants, and (6) to evaluate population exposures to air pollution. (Sonoma Technologies, Inc., 2005) STI further breaks down the purposes of a network with examples of objectives for each purpose. Based on these examples, APCD chose the following eleven objectives as being those that most accurately define the overall purposes of the network: (1) determine background concentrations, (2) establish regulatory compliance, (3) track pollutant concentration trends, (4) assess population exposure (5) evaluate emissions reductions, (6) evaluate the accuracy of model predictions, (7) assist with forecasting, (8) locate maximum pollutant concentrations, (9) assure proper spatial coverage of regions, (10) source apportionment, and (11) environmental justice. (Sonoma Technologies, Inc., 2005)

A suite of analysis techniques was used to assess the air monitoring network as not all of the analysis methods address all of the network objectives. STI defines 3 types of analysis technique categories: site-by-site, bottom-up, and network optimization. From page 2-3 of their document, "Site-by-site comparisons rank individual monitors according to specific monitoring purpose; bottom up analyses examine data other than ambient concentrations to assess optimal placement of monitors to meet monitoring purposes; and network optimization analyses evaluate proposed network design scenarios." (Sonoma Technologies, Inc., 2005) Some of the analysis techniques fall under multiple assessment types. Table 11 lists the objectives of the APCD's monitoring network, as well as the type of analysis performed to evaluate each one.

Table 11. Network Assessment Analyses Performed

Site-by-Site Assessment	
Assessment Technique	**Objective(s) Assessed**
Number of parameters monitored	overall site value model evaluation source apportionment
Trends impact	trend tracking historical consistency emission reduction evaluation
Measured concentration	maximum concentration location model evaluation regulatory compliance population exposure
Deviation from NAAQS	regulatory compliance forecasting assistance
Area served	spatial coverage

	interpolation background concentrations
Population served	population exposure
Bottom-up Assessment	
Technique	**Objective(s) Assessed**
Emission inventory	emission reduction evaluation maximum precursor location
Population change	population exposure environmental justice maximum precursor location
Network Optimization Assessment	
Monitor to monitor correlation	model evaluation spatial coverage interpolation

2.4.1. CO Network

In the following sub-sections are the results of the network analyses performed for the CO monitoring network. It should be noted here that although the CO monitor at the NCore site is not yet reporting data to the EPA, it is included in these analyses, where appropriate, as it will be online before the end of 2010. It is also important to keep in mind the fact that the overall scores for some of the monitors may be artificially lowered since those sites could not be included in all of the analyses performed here. This is mainly due to a lack of usable data for the appropriate time periods.

The EPA has set the levels of the primary CO standards at values not to exceed 9 ppm over an 8-hour moving average, and 35 ppm over a 1-hour average. (US EPA, 2009 ed.) The secondary standards are set to be the same as the primary standards.

2.4.1.1. Number of Parameters Monitored

This analysis was performed by counting the number of other parameters that are measured at the monitoring site. Sites having the most parameters measured are ranked the highest. Each monitoring instrument was counted as one parameter, meaning collocated monitors were counted individually. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—model evaluation and source apportionment. Sites with collocated measurements of several pollutants are more cost-effective to keep in operation than those sites measuring only one parameter. The main advantage of this method is its simplicity to perform. The disadvantages of the method include: (1) it does not "weight" the measurements by pollutant, as some pollutant measurements may be more useful than others; and, (2) up-to-date information on the pollutants measured at particular sites can be difficult to acquire.

Table 12 lists the CO network sites, the total number of parameters monitored at each site, and the score associated with each monitor's ranking. Sites with greater than 20 parameters monitored received a 1, between 15 and 20 parameters received a 0.75, between 10 and 15 parameters received a 0.5, between 5 and 10 received a 0.25, and less than 5 parameters monitored received a 0 (zero).

As shown in the table, three of the sites monitor for greater than or equal to ten parameters. The site measuring 21 parameters would be considered the most valuable for the network objectives of emission inventory reconciliation and source apportionment. Site 08 031 0025 is the NCore site at the Denver Municipal Animal Shelter.

Table 12. CO Number of Parameters Monitored and Assessment Score

AQS ID	Total Number of Parameters Monitored	Score
08 031 0025	21	1.00
08 031 0002	13	0.50
08 001 3001	10	0.25
08 069 1004	5	0.25
08 077 0018	6	0.25
08 013 0009	1	0.00
08 031 0019	1	0.00
08 041 0015	4	0.00
08 123 0010	1	0.00

2.4.1.2. Population Served

It has been well established that large populations are associated with high emissions. For this analysis, sites are ranked based on the total number of people they represent. Calculating the population served by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the population within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was for 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas of high population and have large areas of representation. It addresses the network objectives of population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) small network densities give very little usable information, and (3) highly resolved population data may be difficult to work with. The main advantage is that it assesses the sites importance for population exposure.

Figure 2 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction site in the west to the Front Range sites in the east, and from the Fort Collins site in the north to the Colorado Springs site in the south. The dots mark the locations of the CO network monitors, and the red lines mark the highways in the area.

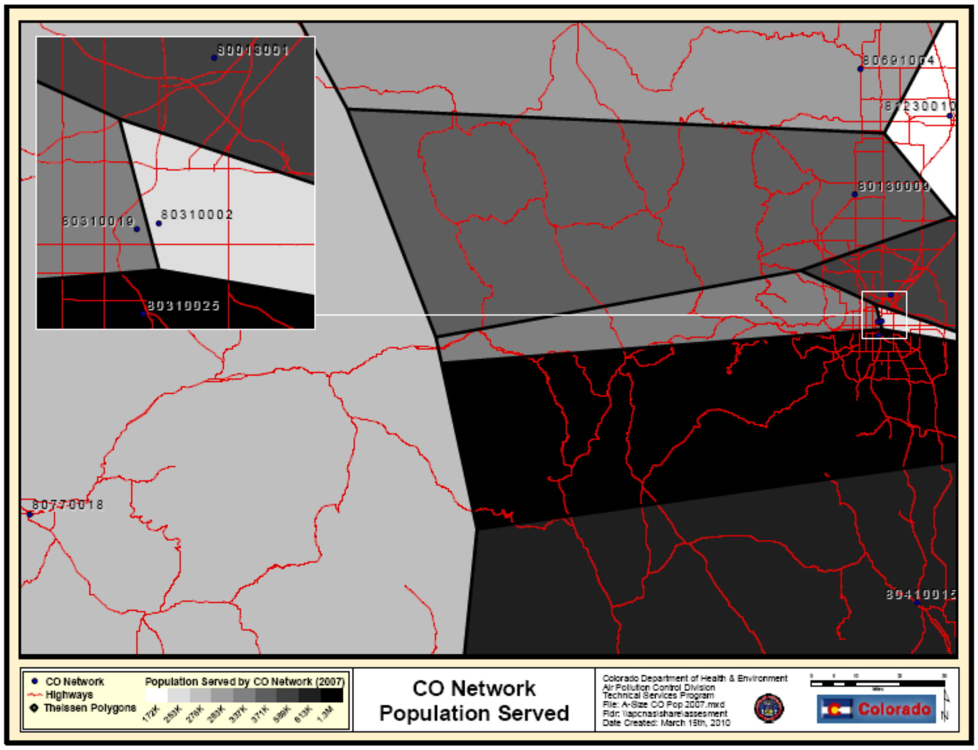


Figure 2. CO Population Served Map

Table 13 lists the CO network sites, the total number of people served in the monitoring area, and the score associated with each monitor's ranking. Sites serving 400,000 people or greater received a 1, between 300,000 and 399,999 people received a 0.75, between 200,000 and 299,999 people received a 0.5, between 100,000 and 199,999 people received a 0.25 and less than 100,000 people received a 0 (zero).

As shown in the table and the figure, three sites serve populations of greater than or equal to 400,000 people. The site serving 1,362,387 people would be considered to be the most valuable for the network objective of population exposure. Site 08 031 0025 is the NCore site at the Denver Municipal Animal Shelter.

Table 13. CO Population Served Analysis Scores

AQS ID	2007 Population	Score
08 031 0025	1,362,387	1.00
08 041 0015	612,512	1.00
08 001 3001	589,395	1.00
08 013 0009	371,594	0.75
08 031 0019	337,425	0.75
08 069 1004	283,055	0.50
08 077 0018	276,956	0.50
08 031 0002	253,135	0.50
08 123 0010	172,127	0.25

2.4.1.3. Population Change

As population rates increase so to do the potentials for emissions activity. For this analysis, sites are ranked based on the population increase in the area of representation. Calculating the population change by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the 2000 census-tract and latest block-group populations within each area of representation.

The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population change values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was from the 2000 census and from 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas with high rates of population growth and large areas of representation. It addresses the network objectives of maximum precursor location, population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) highly resolved population data may be difficult to work with, and (3) changing census boundaries make it difficult to compare populated areas over time. The main advantages are: (1) the flexibility of the method, (2) that it assesses the sites importance for population exposure, (3) its helpfulness in determining where monitoring may be required in the future, and (4) its aid in identifying monitors near which emissions may have substantially changed.

Figure 3 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction site in the west to the Front Range sites in the east, and from the Fort Collins site in the north to the Colorado Springs site in the south. The dots mark the locations of the CO network monitors, and the red lines mark the highways in the area.

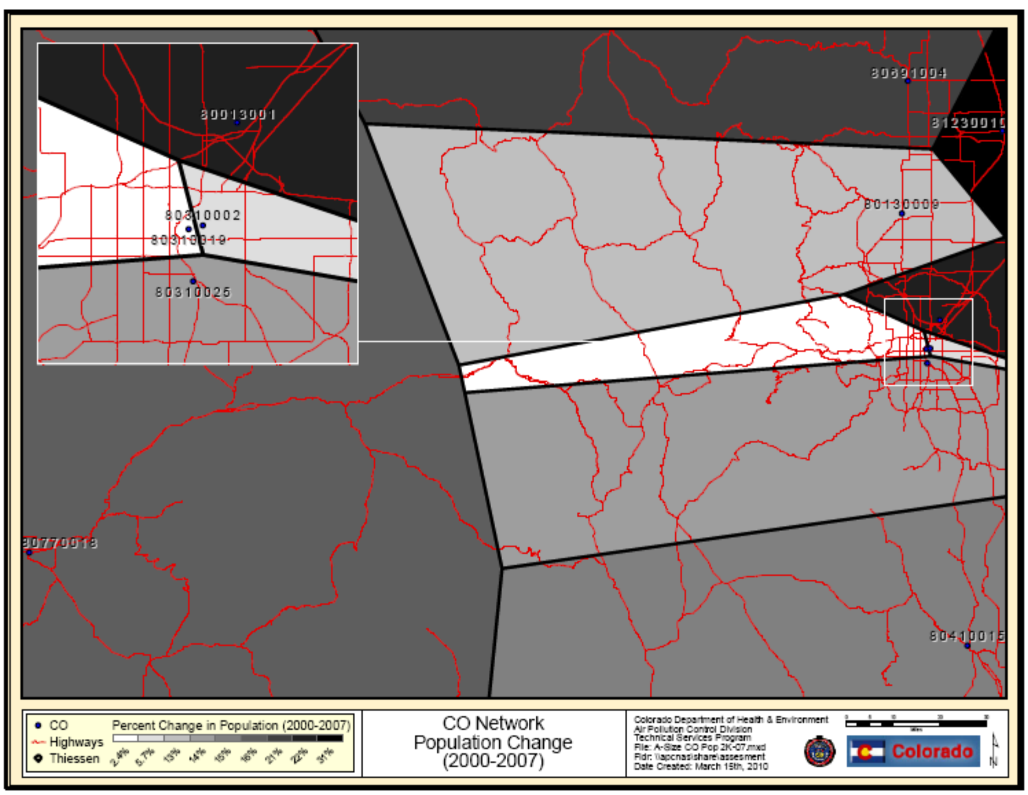


Figure 3. CO Population Change Map

Table 14 lists the CO network sites, the total population change from 2000 to 2007 in the monitoring area, and the score associated with each monitor's ranking. Sites with a 40 percent or greater change received a 1, between 30 and 39 percent received a 0.75, between 20 and 29 percent received a 0.5, between 10 and 19 percent received a 0.25 and less than 10 percent received a 0 (zero).

As shown in the table and the figure, no sites serve areas that experienced a population change of 40 percent or greater. The site with a 31 percent increase in population would be considered to be the most valuable for the network objective of population exposure. Site 08 123 0010 is the Greeley West – Annex Building site. The large population change in this area is likely due to the increase in oil/natural gas drilling and the transient working population associated with it.

Table 14. CO Population Change Analysis and Scores

AQS ID	% Population Change	Score
08 123 0010	31	0.75
08 001 3001	21	0.50
08 069 1004	16	0.25
08 077 0018	16	0.25
08 041 0015	15	0.25
08 031 0025	14	0.25
08 013 0009	13	0.25
08 031 0002	6	0.00
08 031 0019	2	0.00

2.4.1.4. Emissions Inventory

Emission inventory data are used to find locations where emissions of pollutants of concern are concentrated. These locations are then compared to the current network and proposed new monitoring sites to determine if the network captures the areas of maximum emissions. The emissions inventory data used in this report are from the 2007 emissions inventory, as the 2008 inventory was not yet completed at the time of this report.

For this analysis a gridded emission inventory for the State was mapped out. It was then overlain on the Thiessen polygon map generated for other analyses. From there, the point sources (and their associated emissions data) that were within each polygon were used to calculate the emissions density in tons per year per square mile (TPY/mi^2). The area source emissions, including vehicle emissions, were not included in the emissions sums for this analysis. Only the sums of the point source emissions were used. The sum of the total point source emissions in each polygon was divided by the area of the polygon. The distances from each point source to the monitor were then used to calculate an average distance from the monitor to the point sources. This average distance was used to rank the monitors based on their average proximity to the point sources. Sites with a five mile or less distance received a 1, between 5 and 10 miles received a 0.75, between 10 and 20 miles received a 0.5, between 20 and 30 miles received a 0.25 and a distance greater than or equal to 30 miles received a 0 (zero).

Sites scoring a one indicate areas that are adequately monitored, and not in need of any immediate changes. Sites scoring a zero indicate areas that may need additional monitors. One advantage of this method is that it is scalable in complexity and spatial resolution. In addition, it helps in finding areas where primary pollutant concentrations are high. The disadvantages include: (1) emission inventory data are not always current or may be incomplete or inaccurate, (2) emission inventory quality varies by pollutant and source type, (3) more useful high resolution emission inventory data are not readily available and difficult to produce, and (4) the method does not account for pollutant transport. The objectives assessed by this technique are emission reduction evaluation and maximum precursor location.

Figure 4 is a map of the 2007 CO emissions inventory. It shows CO emissions point sources in a four kilometer gridded scale (colored squares), as well as the non-point source emissions (black and white) by county. The majority of the CO emissions sources lie in the Front Range area, as would be expected since the majority of the State's population is also in that area.

As shown in Table 15 and Figure 4, there is only one site with an average distance between the monitor and the point sources of less than five miles. This is the Welby site. The closest point source to the monitor is roughly 1 mile away, with the furthest source being nearly 55 miles away. The low average monitor distance would seem to indicate that this area is well monitored, and was ranked as such.

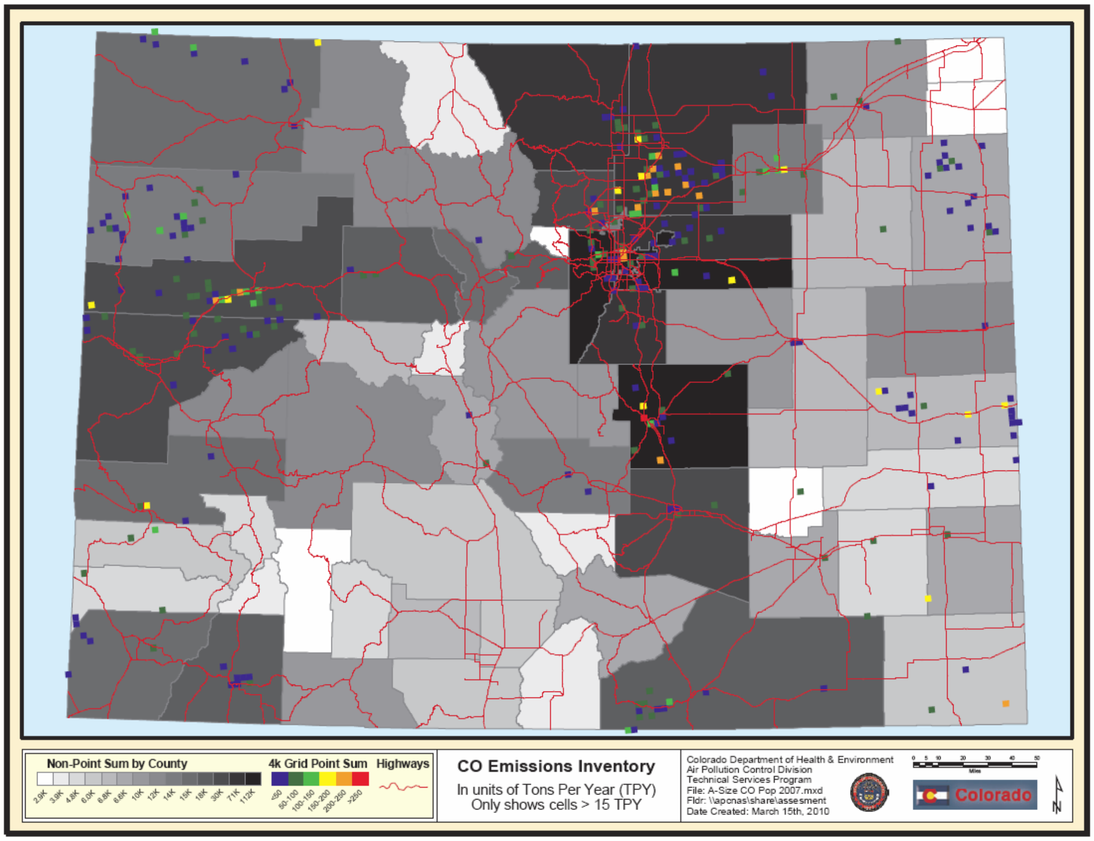


Figure 4. CO Emissions Inventory for 2007

Table 15. CO Emission Inventory Analysis and Scores

AQS ID	Sum Emissions (TPY)	Polygon Area (mi^2)	Emissions Density (TPY/mi^2)	Avg. Dist. from Point Sources to Monitor (mi)	Score
08 001 3001	3,238	981	3	3.4	1.00
08 041 0015	11,097	4,849	2	12.3	0.50
08 123 0010	7,956	1,353	6	13.1	0.50
08 013 0009	3,136	4,622	1	12.5	0.50
08 031 0019	1,011	1,016	1	15.5	0.50
08 031 0002	473	81	6	12.8	0.50
08 077 0018	9,485	15,595	1	42.1	0.00
08 069 1004	1,938	3,183	1	85.5	0.00
08 031 0025	1,343	4,322	0	65.5	0.00

2.4.1.5. Trends Impact

This analysis was performed by ranking the sites based on the length of the continuous measurement record of the pollutant of interest. Sites that have a long historical record are very valuable for tracking pollutant trends, and therefore have the most importance according to this assessment technique. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—trend tracking and emission reduction evaluation. In addition, it provides a measure of the historical consistency of the data sets generated. The main advantages of this method are its simplistic analytical approach, and its usefulness for identifying long-term trend sites. The main disadvantages of the method are: (1) that it doesn't take into account changes in population, emission, or meteorology; (2) the magnitude and direction of past trends are not necessarily good predictors of future trends; and, (3) the length of a continuous record does not ensure that data are of good quality throughout the time period.

Table 16 lists the CO network sites, the total number of years the site has been in operation monitoring for CO, and the score associated with each monitor's ranking. Sites with greater than 30 years in operation received a 1, between 20 and 30 years received a 0.75, between 10 and 20 years received a 0.5, between 5 and 10 years received a 0.25, and less than 5 years monitored received a 0 (zero).

As shown in the table, three sites have been monitoring for greater than or equal to 30 years. The site monitoring for 39 years would be considered the most valuable for the network objectives of trend tracking and emission reduction evaluation. Site 08 031 0002 is the Denver - CAMP site.

Table 16. CO Trends Impact Analysis Scores

AQS ID	Years in Operation	Score
08 031 0002	39	1.00
08 001 3001	37	1.00
08 069 1004	30	1.00
08 013 0009	21	0.75
08 031 0019	17	0.50
08 041 0015	12	0.50
08 123 0010	7	0.25
08 077 0018	6	0.25
08 031 0025	1	0.00

2.4.1.6. Deviation from NAAQS

For this analysis, sites that measure design values that are very close to the NAAQS exceedance threshold are ranked higher than those sites with values well above or below it. Sites that are close to the threshold are considered more valuable for the purpose of determining NAAQS compliance, whereas sites well above or below do not provide as much information. The main advantage of this analysis is that it gives the ability to assess monitor importance for determining NAAQS compliance. The disadvantages of the analysis are: (1) if design values vary from year to year, historical data should be included in the analysis, and (2) care is needed in interpreting absolute differences. The objectives assessed by this analysis are regulatory compliance and forecasting assistance.

The technique is based on the difference between the standard and actual measurements. The design values are calculated as they apply to regulatory compliance. For CO, the values were calculated and compared to both the 8-hour and 1-hour standards. The absolute value of the percent difference between the measured design value and the standard is used to score each monitor. Monitors having the smallest absolute percent difference rank as most important. Sites that were less than a 10% difference from the NAAQS received a 1, between 10 to 20% received a 0.75, between 20 to 30% received a 0.5, between 30 to 40% received a 0.25, and greater than 40% received a 0 (zero).

The maximum 8-hour and 1-hour concentrations found in the 2004 to 2009 time period were used for the 8-hour and 1-hour NAAQS comparisons. The maximum value for the time period was used to show how far below the standard the sites are using the "worst" numbers for the six year period in question, instead of using data from the most recent year. Table 17 and Table 18 list the analysis results and scores for each of the primary CO standards. All sites received scores of zero for both standards, as all design values were well below the exceedance threshold. Figure 5 and Figure 6 illustrate the results graphically, showing the absolute percent difference value over the monitor's approximate geographic location.

Figure 5. Deviation from NAAQS 8-hr CO Standard Map

Table 17. Deviation from NAAQS 8-hr CO Standard Analysis Scores

AQS ID	2004-2009 Max 8-hr Std. Design Value (ppm)	NAAQS 8-hr Std. Value (ppm)	Absolute Percent Difference	Score
08 123 0010	5	9	44%	0.00
08 013 0009	4	9	56%	0.00
08 031 0002	4	9	56%	0.00
08 031 0019	4	9	56%	0.00
08 041 0015	4	9	56%	0.00
08 069 1004	4	9	56%	0.00
08 001 3001	3	9	67%	0.00
08 077 0018	2	9	78%	0.00

Figure 6. **Deviation from NAAQS 1-hr CO Standard Map**

Table 18. **Deviation from NAAQS 1-hr CO Standard Analysis Scores**

AQS ID	2004-2009 Max 1-hr Std. Design Value (ppm)	NAAQS 1-hr Std. Value (ppm)	Absolute Percent Difference	Score
08 031 0002	9	35	74%	0.00
08 031 0019	9	35	74%	0.00
08 041 0015	8	35	77%	0.00
08 069 1004	8	35	77%	0.00
08 077 0018	7	35	80%	0.00
08 123 0010	7	35	80%	0.00
08 013 0009	5	35	86%	0.00
08 001 3001	4	35	89%	0.00

2.4.1.7. Area Served

For this analysis, sites are ranked based on their area of coverage. Calculating the area of representation of a particular monitor requires GIS software. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon area values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

This method gives the most weight to rural sites and those on the edges of urban areas or other monitor clusters. It addresses the network objectives of background concentration, spatial coverage and interpolation. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) it does not take into account population or emissions, and (3) it may artificially weight monitors at the edge of the analysis domain. The main advantages are: (1) the simplicity and quickness of performing the method, and (2) it gives weight to remote and urban boundary sites that are necessary for proper interpolation.

Figure 7 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction site in the west to the Front Range sites in the east, and from the Fort Collins site in the north to the Colorado Springs site in the south. The dots mark the locations of the CO network monitors, and the red lines mark the highways in the area.

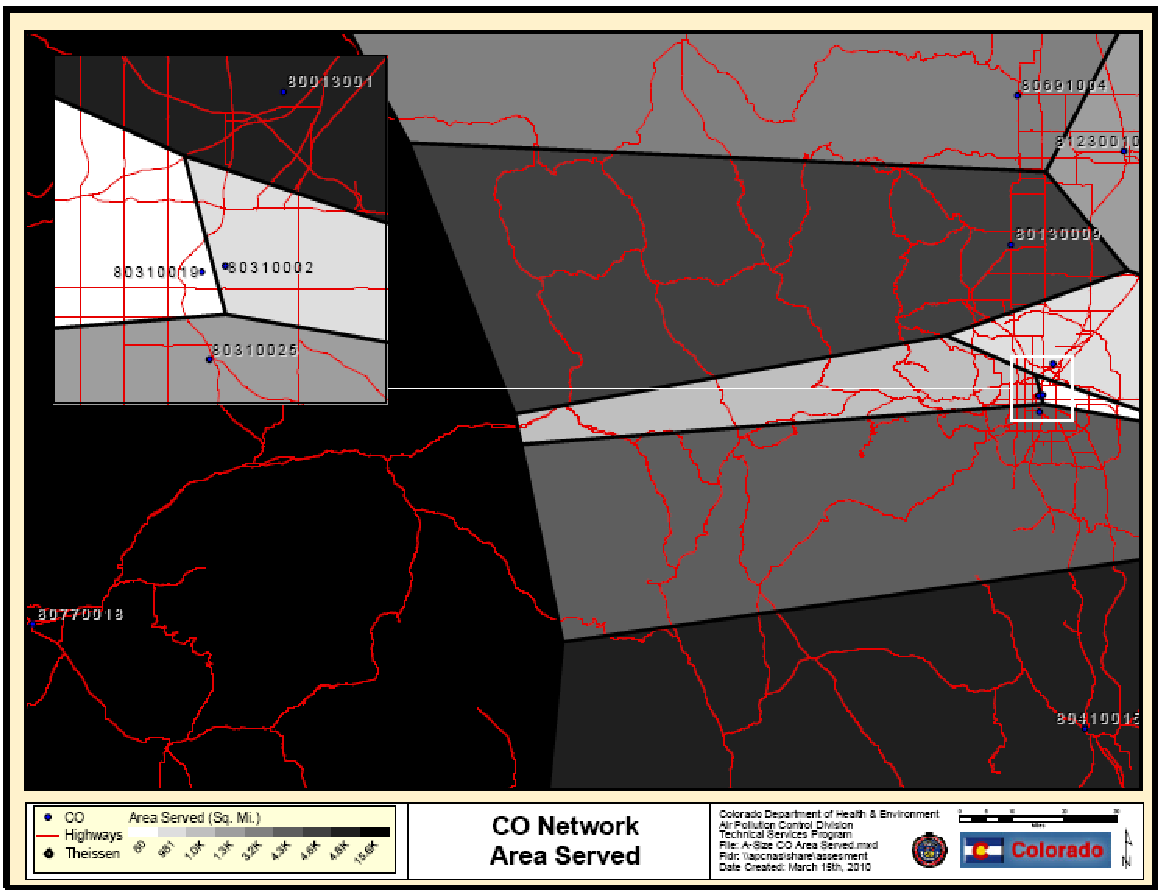


Figure 7. CO Area Served Map

Table 14 lists the CO network sites, the total area served by the monitoring area, and the score associated with each monitor's ranking. Sites with an area served of 7,500 square miles or greater received a 1, between 5,000 and 7,499 square miles received a 0.75, between 2,500 and 4,999 square miles received a 0.5, between 250 and 2,500 square miles received a 0.25 and less than 250 square miles received a 0 (zero).

As shown in the table and the figure, one site serves an area that is greater than or equal to 7,500 square miles. The site serving an area of 15,595 square miles would be considered to be the most valuable for the network objective of spatial coverage. Site 08 077 0018 is the Grand Junction – Pitkin Shelter site.

Table 19. CO Area Served Analysis Scores

AQS ID	Area (sq. mi)	Score
08 077 0018	15,595	1.00
08 041 0015	4,849	0.50
08 013 0009	4,622	0.50
08 031 0025	4,322	0.50
08 069 1004	3,183	0.50
08 123 0010	1,353	0.25
08 031 0019	1,016	0.25
08 001 3001	981	0.25
08 031 0002	81	0.00

2.4.1.8. Monitor to Monitor Correlation

In this analysis, sites are ranked based on the correlation of their measured design values with those of the other monitors in the network. Monitors measuring concentrations that correlate well with concentrations at another monitor are considered redundant, and are consequently scored low. Monitors with concentrations that do not correlate with other monitored concentrations that are nearby are considered unique, and as such have more value for spatial monitoring objectives. These monitors are scored high. The advantages of this method are that it gives a measure of the site's uniqueness and representativeness, and that it is useful for identifying redundant sites. The disadvantages are that it requires large amounts of data with a high data completeness rate, and that the correlations are likely pollutant specific. The objectives assessed by this analysis are model evaluation, spatial coverage and interpolation.

Sites that do not correlate well with other sites have unique temporal concentration variation relative to other sites, and are likely to be important for assessing local emissions, transport and spatial coverage. It is assumed here that sites having an r-squared value of 0.6 or greater are well correlated. Sites having an r^2 value of 0.6 or higher when compared to the other CO sites were counted. The analysis was scored as follows: sites correlating with zero or one sites at 0.6 or greater scored a one, those correlating with two other sites at 0.6 or greater scored a 0.75, those correlating with three other sites at 0.6 or greater scored a 0.5, those correlating with four other sites at 0.6 or greater scored a 0.25, and those correlating with five or more sites at 0.6 or greater scored a 0 (zero).

Site-to-site correlation coefficients and average relative differences were calculated for the November through February daily maximum 8-hour carbon monoxide concentrations for the monitors along the Front Range Urban Corridor, and the Grand Junction monitor.

Figure 8 shows a plot of the r-squared values for carbon monoxide monitoring sites versus their distance from each other (in kilometers) for Colorado (November through February, 2004 through early 2009). This plot shows the tendency of the r-square value to decrease with increasing distance between the sites. Table 20 lists the score results for the analysis. All sites received a score of one, as there were no monitors that correlated with more than one other monitor. This indicates that all the sites are equally important for the purposes of this analysis.

Table 20. CO Monitor to Monitor Analysis Scores

AQS ID	# Monitors Correlated at ≥ 0.6	Score
08 001 3001	0	1.00
08 013 0009	0	1.00
08 031 0002	1	1.00
08 031 0019	1	1.00
08 041 0015	0	1.00
08 069 1004	0	1.00
08 077 0018	0	1.00
08 123 0010	0	1.00

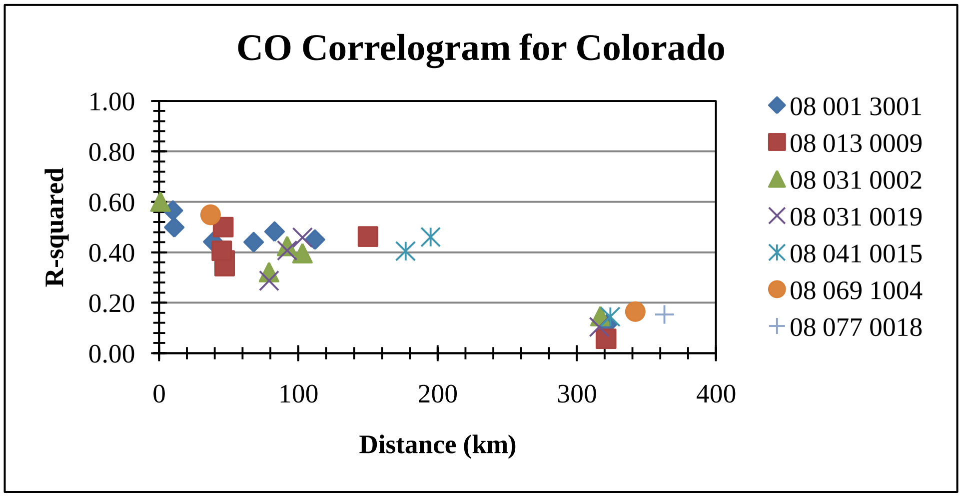


Figure 8. CO Correlogram for Front Range

Table 21 shows the average relative differences between carbon monoxide monitors for the same time periods. Correlations are generally low and average relative differences are generally high compared with the statistics for the ozone monitors. Mean daily max 8-hour carbon monoxide concentrations for these sites range from 0.96 ppm to 1.26 ppm for these time periods. With such low concentrations, it's possible that both correlations and average relative differences are strongly affected by instrument noise and measurement uncertainties. The Grand Junction data was not included in this part of the analysis, as it scored very low correlation values and it was determined that the relative differences would provide no additional useful information.

Table 21. CO Average Relative Differences

	08 001 3001	08 013 0009	08 031 0002	08 031 0019	08 041 0015	08 069 1004	08 123 0010
08 001 3001	--						
08 013 0009	0.34	--					
08 031 0002	0.37	0.43	--				
08 031 0019	0.32	0.41	0.26	--			
08 041 0015	0.38	0.39	0.36	0.37	--		
08 069 1004	0.36	0.32	0.43	0.40	0.39	--	
08 123 0010	0.39	0.39	0.40	0.43	0.37	0.34	--

2.4.1.9. Measured Concentrations

For this analysis, sites are ranked based on the difference between the maximum pollutant concentrations measured and the value of the standard. The sites that measure high design values are ranked higher than those that measure low values. The objectives assessed by this analysis are maximum concentration location, model evaluation, regulatory compliance and population exposure. The main advantage of the technique is that it identifies key sites from a regulatory perspective, based on the maximum concentrations. The disadvantages are that it does not account for monitor-siting problems, and that is only focuses on high concentrations. Low concentration monitors may be useful for representing rural locations or background concentrations.

Sites that measure high design values are important for assessing NAAQS compliance and population exposure, and for performing model evaluations. The analysis is scored as follows: design values that are equal to or greater than 100% of the NAAQS are given a 1, values between 95 and 100% of the NAAQS receive a 0.75, values between 90 and 95% of the NAAQS received a 0.5, values between 80 and 90% of the NAAQS receive a 0.25, and values less than or equal to 80% of the NAAQS receive a 0 (zero).

Table 22 and Table 23 show the scores for the maximum design values recorded at each site, as well as the analysis scores and site rankings. Figure 9 and Figure 10 illustrate the results graphically, using the value of the difference between the standard and the design value to mark the approximate geographic location of the monitor. Values in green are below the standard and values in red are above it. All sites in the network scored zeros when the maximum design values were compared to the primary CO standards.

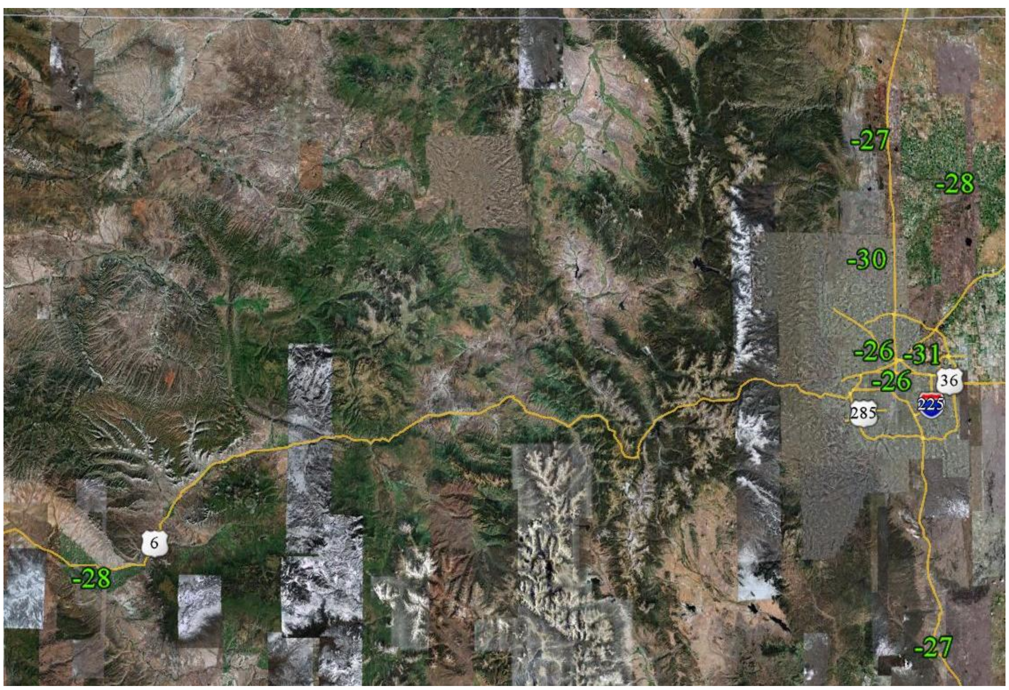


Figure 9. CO Maximum Measured Concentration 1-hr Standard Map

Table 22. CO Measured Concentration 1-hr Standard Analysis Scores

AQS ID	2004-2009 Max 1-hr Std. Design Value (ppm)	NAAQS 1-hr Std. Value (ppm)	Difference (ppm)	% NAAQS	Score
08 031 0002	9	35	-26	26%	0.00
08 031 0019	9	35	-26	26%	0.00
08 041 0015	8	35	-27	23%	0.00
08 069 1004	8	35	-27	23%	0.00
08 077 0018	7	35	-28	20%	0.00
08 123 0010	7	35	-28	20%	0.00
08 013 0009	5	35	-30	14%	0.00
08 001 3001	4	35	-31	11%	0.00

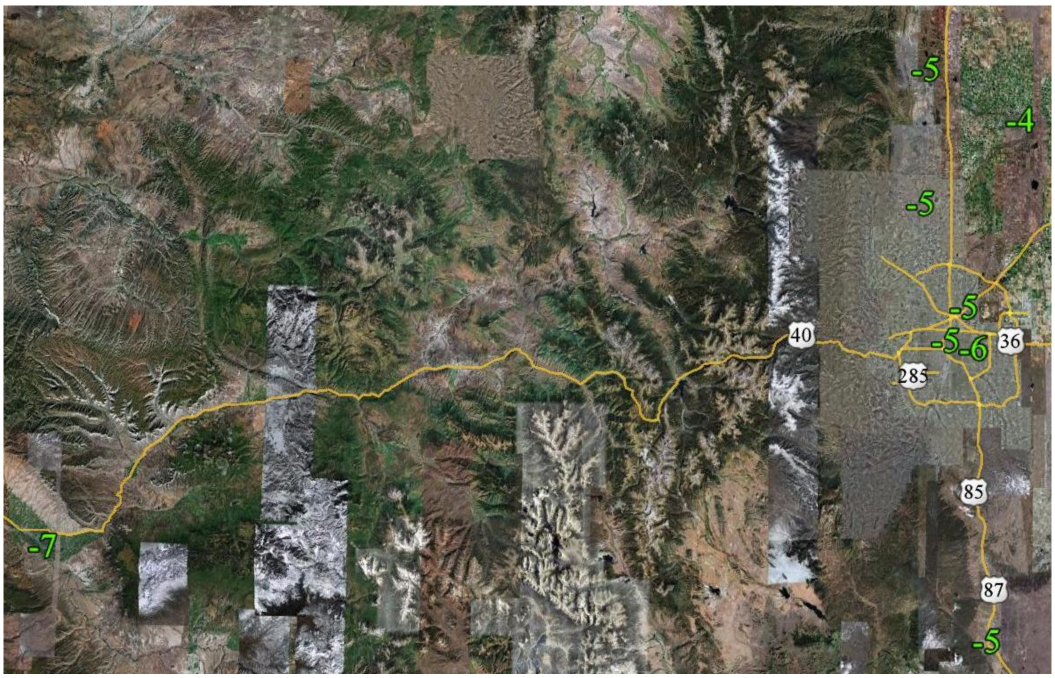


Figure 10. CO Maximum Measured Concentration 8-hr Standard Map

Table 23. CO Measured Concentration 8-hr Standard Analysis Scores

AQS ID	2004-2009 Max 8-hr Std. Design Value (ppm)	NAAQS 8-hr Std. Value (ppm)	Difference (ppm)	% NAAQS	Score
08 123 0010	5	9	-4	56%	0.00
08 013 0009	4	9	-5	44%	0.00
08 031 0002	4	9	-5	44%	0.00
08 031 0019	4	9	-5	44%	0.00
08 041 0015	4	9	-5	44%	0.00
08 069 1004	4	9	-5	44%	0.00
08 001 3001	3	9	-6	33%	0.00
08 077 0018	2	9	-7	22%	0.00

2.4.1.10. Summary/Conclusions and Recommendations

Table 24 lists a summary of the results from each analysis performed on the CO monitoring network. The highest scoring monitor, and thus the most important for the purposes of this assessment, is site 08 001 3001, also known as the Welby site. The lowest scoring monitor is at the Denver – DMAS site. Its score was nearly half that of the Welby monitor. The score was affected by the fact that it could not be used in five of the analyses. The Measured Concentration and Deviation from NAAQS analyses were unable to be performed as there was not enough data available to calculate the design values. The monitor to monitor correlation was also not performed for the same reason.

Table 24. Summary of CO Network Analyses Scores

AQS ID	# Parameters Monitored	Population Served	Population Change	Emissions Inventory	Trends Impact	Deviation from 8-hr NAAQS	Deviation from 1-hr NAAQS	Area Served	Monitor to Monitor Correlation	Measured Concentration Difference from 8-hr NAAQS	Measured Concentration Difference from 1-hr NAAQS	*Total Score*
08 001 3001	0.25	1.00	0.50	1.00	1.00	0.00	0.00	0.25	1.00	0.00	0.00	***5.00***
08 013 0009	0.00	0.75	0.25	0.50	0.75	0.00	0.00	0.50	1.00	0.00	0.00	***3.75***
08 041 0015	0.00	1.00	0.25	0.50	0.50	0.00	0.00	0.50	1.00	0.00	0.00	***3.75***
08 031 0002	0.50	0.50	0.00	0.50	1.00	0.00	0.00	0.00	1.00	0.00	0.00	***3.50***
08 069 1004	0.25	0.50	0.25	0.00	1.00	0.00	0.00	0.50	1.00	0.00	0.00	***3.50***
08 077 0018	0.25	0.50	0.25	0.00	0.25	0.00	0.00	1.00	1.00	0.00	0.00	***3.25***
08 031 0019	0.00	0.75	0.00	0.50	0.50	0.00	0.00	0.25	1.00	0.00	0.00	***3.00***
08 123 0010	0.00	0.25	0.75	0.50	0.25	0.00	0.00	0.25	1.00	0.00	0.00	***3.00***
08 031 0025	1.00	1.00	0.25	0.00	0.00	N/A	N/A	0.50	N/A	N/A	N/A	***2.75***

N/A = Score unavailable. Total score is affected.

According to the guidelines of the network analyses, sites like DMAS, Denver – Firehouse #6 (08 031 0019), and Greeley – West Annex (08 123 0010) would be sites to consider for removal due to their low scores. However, as the DMAS site is the future NCore site, this monitor cannot be removed. The Greeley monitor also cannot be removed, as it is a SIP required monitor. In fact, none of the monitors can be removed from the CO network, as they are all needed to fulfill SIP requirements.

2.4.2. O_3 Network

In the following sub-sections are the results of the network analyses performed for the O_3 monitoring network. It is important to keep in mind the fact that the overall scores for some of the monitors may be artificially lowered since those sites could not be included in all of the analyses performed here. This is mainly due to a lack of usable data for the appropriate time periods.

In March 2008, the EPA set the level of the primary O_3 standard at a design value not to exceed 0.075 ppm (US EPA, 2009 ed.). This value is determined by taking the 3-year average of the 4th maximum 8-hour ozone concentration. The EPA is currently set to establish a new primary ozone standard in the range of 0.060 to 0.070 ppm in August 2010 (US EPA, 2010). At the same time, a new secondary standard in the range of 7 to 15 ppb-hours could also be set (US EPA, 2010).

2.4.2.1. Number of Parameters Monitored

This analysis was performed by counting the number of other parameters that are measured at the monitoring site. Sites having the most parameters measured are ranked the highest. Each monitoring instrument was counted as one parameter, meaning collocated monitors were counted individually. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—model evaluation and source apportionment. Sites with collocated measurements of several pollutants are more cost-effective to keep in operation than those sites measuring only one parameter. The main advantage of this method is its simplicity to perform. The disadvantages of the method include: (1) it does not "weight" the measurements by pollutant, as some pollutant measurements may be more useful than others; and, (2) up-to-date information on the pollutants measured at particular sites can be difficult to acquire.

Table 25 lists the O_3 network sites, the total number of parameters monitored at each site, and the score associated with each monitor's ranking. Sites with greater than 20 parameters monitored received a 1, between 15 and 20 parameters received a 0.75, between 10 and 15 parameters received a 0.5, between 5 and 10 received a 0.25, and less than 5 parameters monitored received a 0 (zero).

As shown in the table, two of the sites monitor for greater than or equal to ten parameters. The site measuring 21 parameters would be considered the most valuable for the network objectives of emission inventory reconciliation and source apportionment. Site 08 031 0025 is the NCore site at the Denver Municipal Animal Shelter.

Table 25. O_3 Number of Parameters Monitored and Assessment Scores

AQS ID	Total Number of Parameters Monitored	Score
08 031 0025	21	1.00
08 001 3001	10	0.50
08 069 1004	5	0.25
08 035 0004	6	0.25
08 083 0006	6	0.25
08 059 0002	4	0.00
08 005 0002	4	0.00
08 031 0014	4	0.00
08 059 0005	4	0.00
08 059 0006	4	0.00
08 013 0011	1	0.00
08 059 0011	1	0.00
08 041 0013	1	0.00
08 123 0009	4	0.00
08 041 0016	1	0.00
08 069 0011	1	0.00
08 045 0012	1	0.00
08 059 0013	4	0.00
08 005 0006	4	0.00
08 077 0020	4	0.00
08 069 0012	4	0.00

2.4.2.2. Population Served

It has been well established that large populations are associated with high emissions. For this analysis, sites are ranked based on the total number of people they represent. Calculating the population served by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the population within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was for 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas of high population and have large areas of representation. It addresses the network objectives of population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) small network densities give very little usable information, and (3) highly resolved population data may be difficult to work with. The main advantage is that it assesses the sites importance for population exposure.

Figure 11 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Palisade site in the west to the Front Range sites in the east, and from the Fort Collins sites in the north to the Colorado Springs sites in the south. The dots mark the locations of the O_3 network monitors, and the red lines mark the highways in the area.

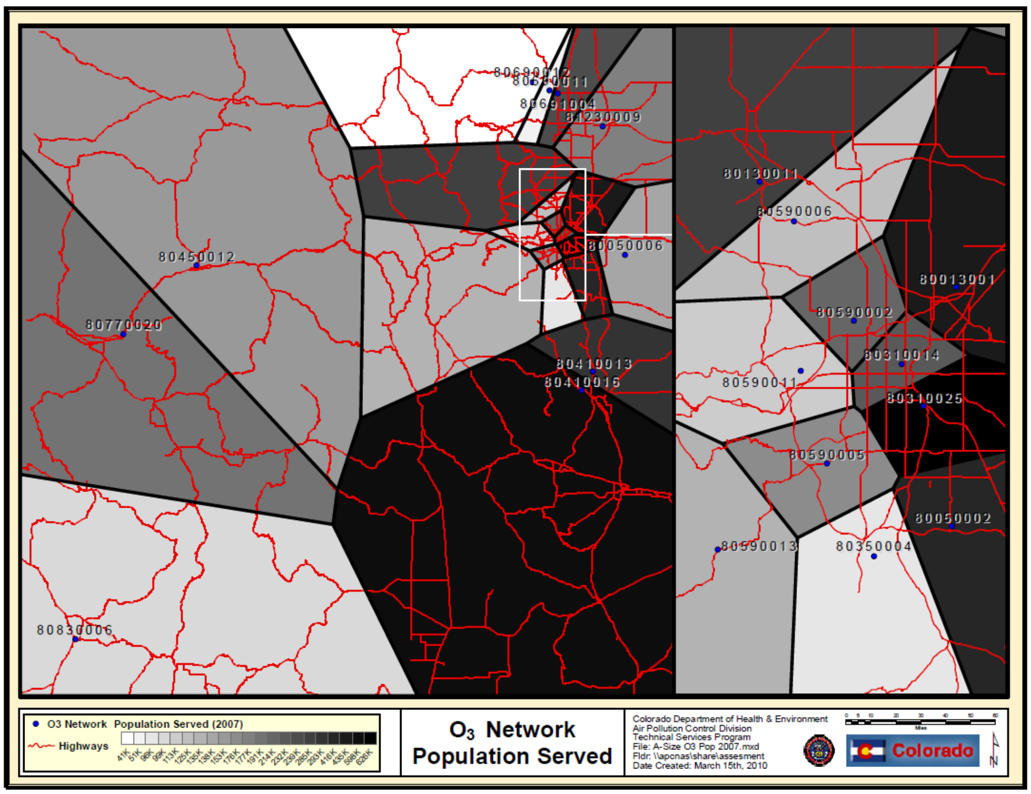


Figure 11. **O_3 Population Served Map**

Table 26 lists the O_3 network sites, the total number of people served in the monitoring area, and the score associated with each monitor's ranking. Sites serving 400,000 people or greater received a 1, between 300,000 and 399,999 people received a 0.75, between 200,000 and 299,999 people received a 0.5, between 100,000 and 199,999 people received a 0.25 and less than 100,000 people received a 0 (zero).

As shown in the table and the figure, four sites serve populations of greater than or equal to 400,000 people. The site serving 646,561 people would be considered to be the most valuable for the network objective of population exposure. However, this site is in a location where ozone is depressed by NOx titration. Ozone concentrations here are lower than may be true of much of the area represented by the polygon. Site 08 031 0025 is the NCore site at the Denver Municipal Animal Shelter.

Table 26. O_3 Population Served Analysis and Scores

AQS ID	2007 Population	Score
08 031 0025	646,561	1.00
08 041 0016	639,071	1.00
08 001 3001	554,292	1.00
08 005 0002	537,322	1.00
08 041 0013	361,415	0.75
08 013 0011	320,523	0.75
08 069 1004	280,968	0.50
08 031 0014	238,494	0.50
08 123 0009	237,322	0.50
08 077 0020	224,320	0.50
08 059 0002	216,803	0.50
08 005 0006	204,834	0.50
08 059 0005	183,371	0.25
08 045 0012	176,706	0.25
08 059 0013	148,630	0.25
08 059 0006	148,358	0.25
08 035 0004	116,935	0.25
08 059 0011	115,698	0.25
08 083 0006	112,599	0.25
08 069 0011	54,147	0.00
08 069 0012	47,220	0.00

2.4.2.3. Population Change

As population rates increase so to do the potentials for emissions activity. For this analysis, sites are ranked based on the population increase in the area of representation. Calculating the population change by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the 2000 census-tract and latest block-group populations within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population change values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was from the 2000 census and from 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas with high rates of population growth and large areas of representation. It addresses the network objectives of maximum precursor location, population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) highly resolved population data may be difficult to work with, and (3) changing census boundaries make it difficult to compare populated areas over time. The main advantages are: (1) the flexibility of the method, (2) that it assesses the sites importance for population exposure, (3) its helpfulness in determining where monitoring may be required in the future, and (4) its aid in identifying monitors near which emissions may have substantially changed.

Figure 12 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction site in the west to the Front Range sites in the east, and from the Fort Collins site in the north to the Colorado Springs site in the south. The dots mark the locations of the O_3 network monitors, and the red lines mark the highways in the area.

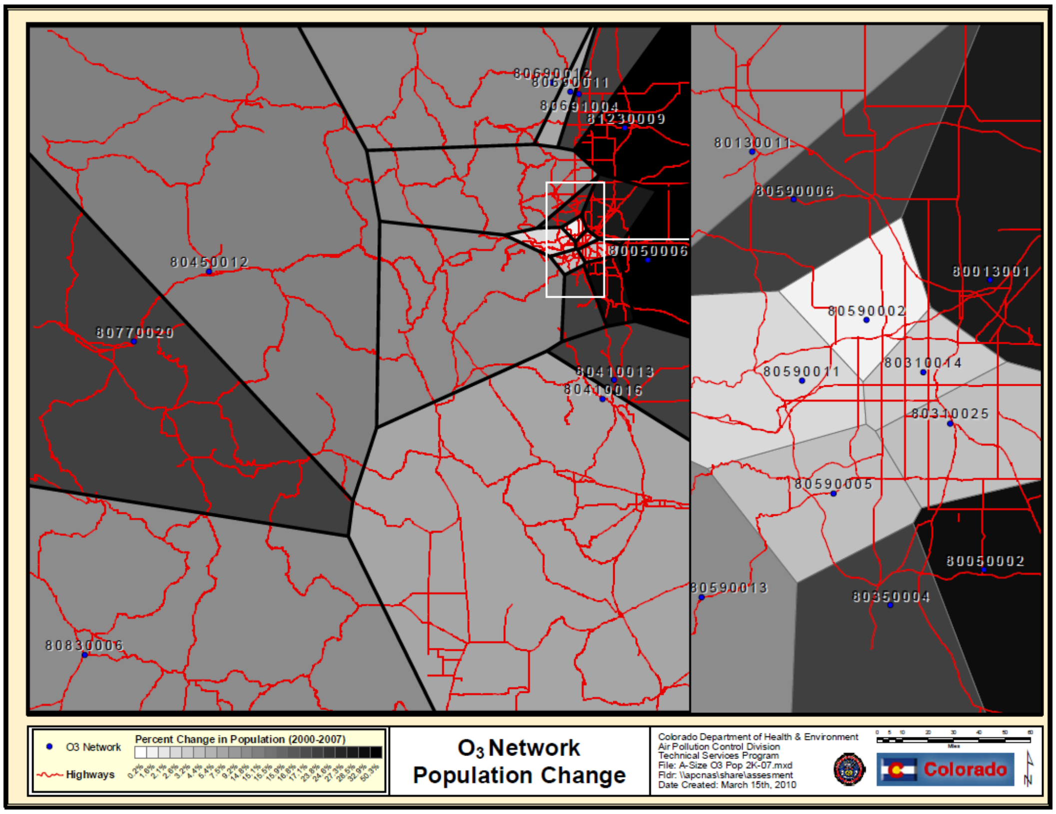


Figure 12. O_3 Population Change Map

Table 27 lists the O_3 network sites, the total population change from 2000 to 2007 in the monitoring area, and the score associated with each monitor's ranking. Sites with a 40 percent or greater change received a 1, between 30 and 39 percent received a 0.75, between 20 and 29 percent received a 0.5, between 10 and 19 percent received a 0.25 and less than 10 percent received a 0 (zero).

As shown in the table and the figure, one site serves an area that experienced a population change of 40 percent or greater. The site with a 48 percent increase in population would be considered to be the most valuable for the network objective of population exposure. Site 08 005 0006 is the Aurora East site. The large population change in this area is due to the increase in urban development that is taking place in the area.

Table 27. O_3 Population Change Analysis and Scores

AQS ID	Population % Change	Score
08 005 0006	48	1.00
08 123 0009	34	0.75
08 005 0002	29	0.50
08 001 3001	27	0.50
08 041 0013	23	0.50
08 035 0004	22	0.50
08 059 0006	18	0.25
08 069 1004	18	0.25
08 077 0020	17	0.25
08 045 0012	15	0.25
08 069 0012	15	0.25
08 083 0006	14	0.25
08 013 0011	12	0.25
08 059 0013	10	0.25
08 041 0016	7	0.00
08 069 0011	6	0.00
08 059 0005	4	0.00
08 031 0025	3	0.00
08 031 0014	3	0.00
08 059 0011	2	0.00
08 059 0002	1	0.00

2.4.2.4. Emissions Inventory

Emission inventory data are used to find locations where emissions of pollutants of concern are concentrated. These locations are then compared to the current network and proposed new monitoring sites to determine if the network captures the areas of maximum emissions. The emissions inventory data used in this report are from the 2007 emissions inventory, as the 2008 inventory was not yet completed at the time of this report.

For this analysis a gridded emission inventory for the State was mapped out. It was then overlain on the Thiessen polygon map generated for other analyses. From there, the point sources (and their associated emissions data) that were within each polygon were used to calculate the emissions density in tons per year per square mile (TPY/mi^2). The area source emissions, including vehicle emissions, were not included in the emissions sums for this analysis. Only the sums of the point source emissions were used. The sum of the total point source emissions in each polygon was divided by the area of the polygon. The distances from each point source to the monitor were then used to calculate an average distance from the monitor to the point sources. This average distance was used to rank the monitors based on their average proximity to the point sources. Sites with a five mile or less distance received a 1, between 5 and 10 miles received a 0.75, between 10 and 20 miles received a 0.5, between 20 and 30 miles received a 0.25 and a distance greater than or equal to 30 miles received a 0 (zero).

It should be noted here that emissions are problematic with ozone, as it is a secondary pollutant and can't be directly correlated with emissions. Ozone is more likely to be high at a significant distance from sources, and more likely to be low within a high density emissions area due to NOx and/or VOC titration. Because the relationship between emissions and ozone is a complex function of meteorology and photochemistry, the scoring of this analysis is flawed. However, in an effort to maintain a common scoring system throughout the analysis of each parameter network, these sites were scored according to the guidelines listed in the paragraph above.

Sites scoring a one indicate areas that are adequately monitored, and not in need of any immediate changes. Sites scoring a zero indicate areas that may need additional monitors. One advantage of this method is that it is scalable in complexity and spatial resolution. In addition, it helps in finding areas where primary pollutant concentrations are high. The disadvantages include: (1) emission inventory data are not always current or may be incomplete or inaccurate, (2) emission inventory quality varies by pollutant and source type, (3) more useful high resolution emission inventory data are not readily available and difficult to produce, and (4) the method does not account for pollutant transport. The objectives assessed by this technique are emission reduction evaluation and maximum precursor location.

Figure 13 and Figure 14 are maps of the 2007 VOC and NO_2 emissions inventories. They show VOC and NO_2 emissions point sources in a four kilometer gridded scale (colored squares), as well as the non-point source emissions (black and white) by county. The majority of the VOC and NO_2 emissions sources lie in the Front Range area, as would be expected since the majority of the State's population is also in that area.

As shown in Table 28 and Table 29, and Figure 13 and Figure 14, there are seven sites with an average distance between the monitor and the point sources of less than five miles. The top scores for both the VOC and NO_2 emissions analyses were for six of the same seven sites. The difference was that the Fort Collins West site (08 069 0011) was in the top seven for the VOCs but not the NO_2, and the Highland Reservoir site (08 005 0002) was a top seven site for the NO_2 but not on the VOCs. The high scores and low average distance from the O_3 monitors to the point sources indicate that these areas are monitored well based on the precursor source locations. The top scoring site for both analyses was the Arvada site.

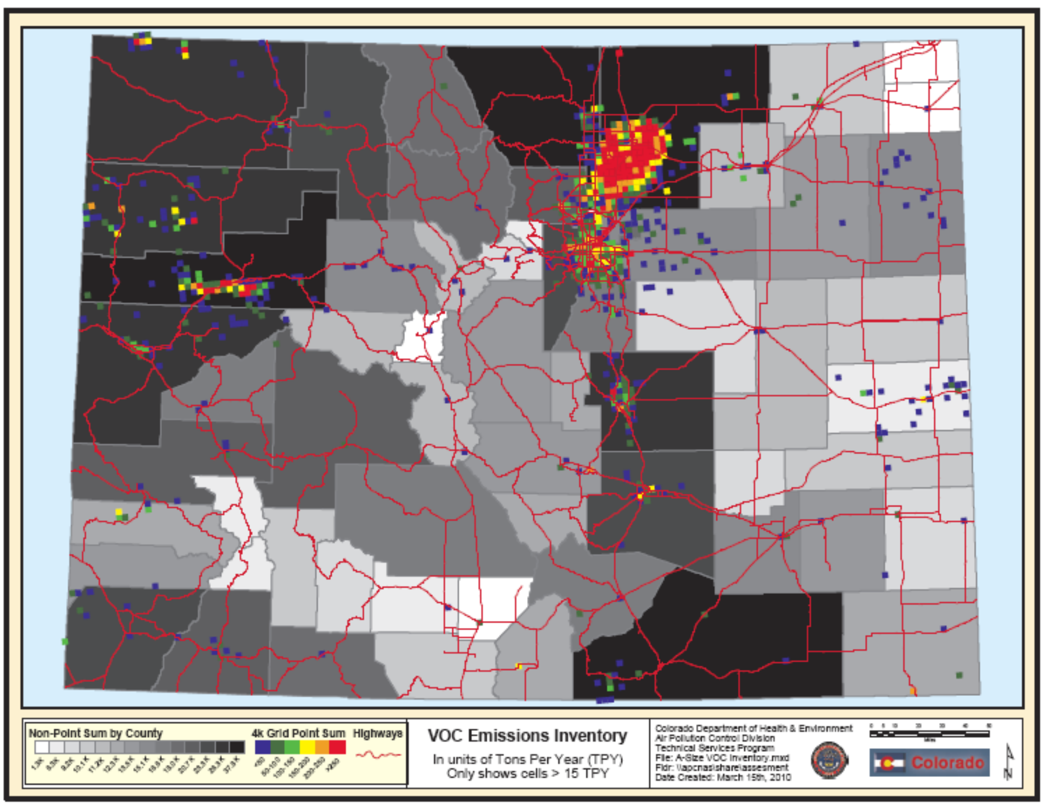


Figure 13. VOC Emissions Inventory Map 2007

Table 28. VOC Emissions Analysis Scores

AQS ID	Sum Emissions (TPY)	Polygon Area (mi^2)	Emissions Density (TPY/mi^2)	Avg. Dist. from Point Sources to Monitor (mi)	Score
08 059 0002	1,513	53	28	2	1.00
08 031 0014	1,390	35	40	2	1.00
08 069 0011	1,965	269	7	2	1.00
08 059 0005	714	80	9	3	1.00
08 059 0011	4,827	189	26	3	1.00
08 035 0004	315	334	1	3	1.00
08 031 0025	27,986	99	283	5	1.00
08 005 0002	956	338	3	6	0.75
08 069 1004	2,166	805	3	7	0.75
08 059 0006	1,013	135	7	8	0.75
08 001 3001	17,946	498	36	9	0.75
08 013 0011	14,054	2,487	6	13	0.50
08 123 0009	31,671	2,214	14	13	0.50
08 059 0013	204	4,244	0	30	0.00
08 045 0012	163,070	15,667	10	30	0.00
08 077 0020	8,919	9,137	1	31	0.00
08 083 0006	3,519	11,004	0	36	0.00
08 069 0012	35	4,285	0	39	0.00
08 041 0016	47,708	15,774	3	47	0.00
08 041 0013	10,935	1,642	7	63	0.00
08 005 0006	11,020	1,594	7	66	0.00

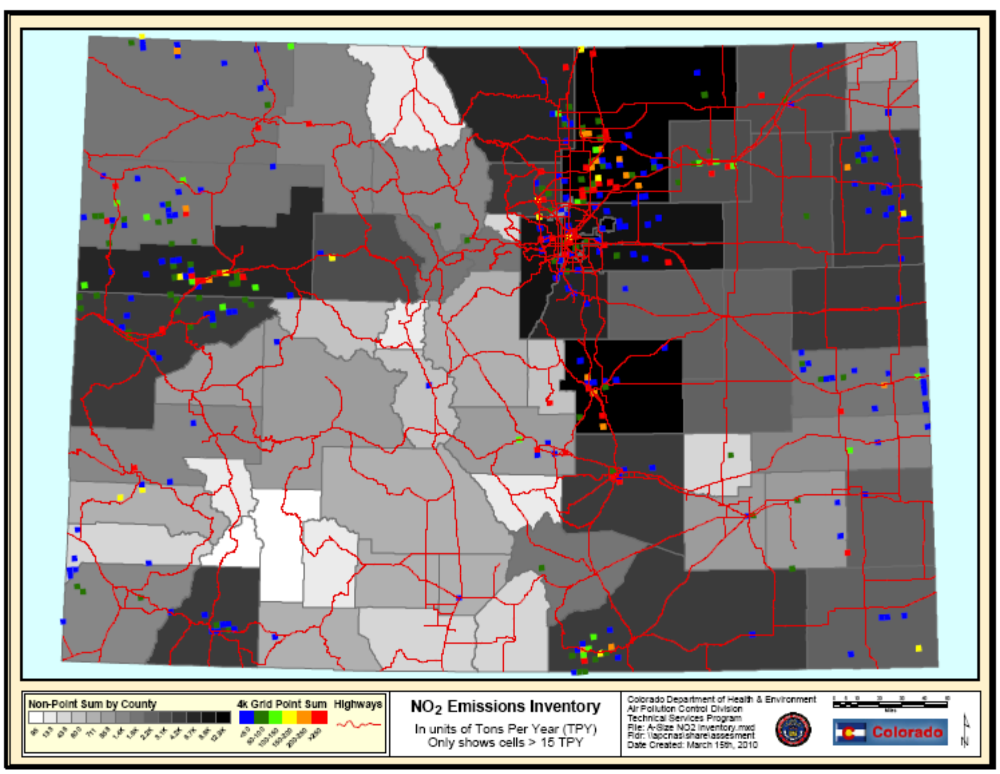


Figure 14. NO_2 Emissions Inventory Map 2007

Table 29. NO_2 Emissions Inventory Analysis and Scores

AQS ID	Sum Emissions (TPY)	Polygon Area (mi^2)	Emissions Density (TPY/mi^2)	Avg. Dist. from Point Sources to Monitor (mi)	Score
08 059 0002	354	53	7	2	1.00
08 031 0014	580	35	17	2	1.00
08 059 0005	119	80	1	3	1.00
08 059 0011	1,583	189	8	3	1.00
08 031 0025	3,238	99	33	4	1.00
08 035 0004	109	334	0	4	1.00
08 005 0002	176	338	1	5	1.00
08 069 0011	1,834	269	7	7	0.75
08 059 0006	312	135	2	9	0.75
08 069 1004	1,346	805	2	9	0.75
08 001 3001	13,072	498	26	10	0.50
08 013 0011	5,397	2,487	2	14	0.50
08 123 0009	13,897	2,214	6	14	0.50
08 069 0012	27	4,285	0	28	0.25
08 059 0013	62	4,244	0	34	0.00
08 083 0006	3,070	11,004	0	36	0.00
08 045 0012	32,060	15,667	2	37	0.00
08 077 0020	3,565	9,137	0	37	0.00
08 041 0016	23,878	15,774	2	67	0.00
08 005 0006	5,289	1,594	3	81	0.00
08 041 0013	2,021	1,642	1	106	0.00

2.4.2.5. Trends Impact

This analysis was performed by ranking the sites based on the length of the continuous measurement record of the pollutant of interest. Sites that have a long historical record are very valuable for tracking pollutant trends, and therefore have the most importance according to this assessment technique. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—trend tracking and emission reduction evaluation. In addition, it provides a measure of the historical consistency of the data sets generated. The main advantages of this method are its simplistic analytical approach, and its usefulness for identifying long-term trend sites. The main disadvantages of the method are: (1) that it doesn't take into account changes in population, emission, or meteorology; (2) the magnitude and direction of past trends are not necessarily good predictors of future trends; and, (3) the length of a continuous record does not ensure that data are of good quality throughout the time period.

Table 30 lists the O_3 network sites, the total number of years the site has been in operation monitoring for O_3, and the score associated with each monitor's ranking. Sites with greater than 30 years in operation received a 1, between 20 and 30 years received a 0.75, between 10 and 20 years received a 0.5, between 5 and 10 years received a 0.25, and less than 5 years monitored received a 0 (zero).

As shown in the table, four sites have been monitoring for greater than or equal to 30 years, and one site has been monitoring for between 20 and 29 years. The sites monitoring for 37 years would be considered the most valuable for the network objectives of trend tracking and emission reduction evaluation. Site 08 001 3001 is the Welby site, and site 08 059 0002 is the Arvada site.

Table 30. O_3 Trends Impact Analysis Scores

AQS ID	Years in Operation	Score
08 001 3001	37	1.00
08 059 0002	37	1.00
08 005 0002	32	1.00
08 069 1004	30	1.00
08 031 0014	28	0.75
08 059 0005	19	0.50
08 059 0006	18	0.50
08 013 0011	16	0.50
08 059 0011	16	0.50
08 041 0013	14	0.50
08 123 0009	8	0.25
08 041 0016	6	0.25
08 035 0004	5	0.25
08 069 0011	4	0.00
08 031 0025	2	0.00
08 045 0012	2	0.00
08 077 0020	2	0.00
08 083 0006	1	0.00
08 059 0013	1	0.00
08 005 0006	1	0.00
08 069 0012	1	0.00

2.4.2.6. Deviation from NAAQS

For this analysis, sites that measure design values that are very close to the NAAQS exceedance threshold are ranked higher than those sites with values well above or below it. Sites that are close to the threshold are considered more valuable for the purpose of determining NAAQS compliance, whereas sites well above or below do not provide as much information. The main advantage of this analysis is that it gives the ability to assess monitor importance for determining NAAQS compliance. The disadvantages of the analysis are: (1) if design values vary from year to year, historical data should be included in the analysis, and (2) care is needed in interpreting absolute differences. The objectives assessed by this analysis are regulatory compliance and forecasting assistance.

The technique is based on the difference between the standard and actual measurements. The design values are calculated as they apply to regulatory compliance. For O_3, the values were calculated and compared to the 3-year average of the 4^{th} maximum 8-hour concentration standard. The absolute value of the percent difference between the measured design value and the standard is used to score each monitor. Monitors having the smallest absolute percent difference rank as most important. Sites that were less than a 10% difference from the NAAQS received a 1, between 10 to 20% received a 0.75, between 20 to 30% received a 0.5, between 30 to 40% received a 0.25, and greater than 40% received a 0 (zero).

The 3-year averages of the 4th maximum 8-hour ozone concentrations found in the 2007 to 2009 time period were used for the NAAQS comparisons, as they are the most recent values available. Table 31 lists the analysis results and scores for the primary O_3 standards. Figure 15 illustrates the results graphically, showing the value of the absolute percent difference over the approximate geographic location of the monitoring sites. There were eleven sites that had an absolute percent difference of 10% or less from the standard value, and as such are considered to be the most valuable sites in terms of determining NAAQS compliance.

Table 31. Deviation from NAAQS 8-hr O_3 Standard Analysis Scores

AQS ID	2007-2009 NAAQS 3-year Design Value (ppm)	NAAQS 3-year Standard Value (ppm)	Absolute Percent Difference	Score
08 059 0002	0.074	0.075	1%	1.00
08 059 0005	0.074	0.075	1%	1.00
08 035 0004	0.077	0.075	3%	1.00
08 059 0011	0.077	0.075	3%	1.00
08 001 3001	0.072	0.075	4%	1.00
08 013 0011	0.078	0.075	4%	1.00
08 069 0011	0.078	0.075	4%	1.00
08 123 0009	0.071	0.075	5%	1.00
08 031 0014	0.070	0.075	7%	1.00
08 041 0016	0.069	0.075	8%	1.00
08 059 0006	0.082	0.075	9%	1.00
08 041 0013	0.067	0.075	11%	0.75
08 069 1004	0.065	0.075	13%	0.75

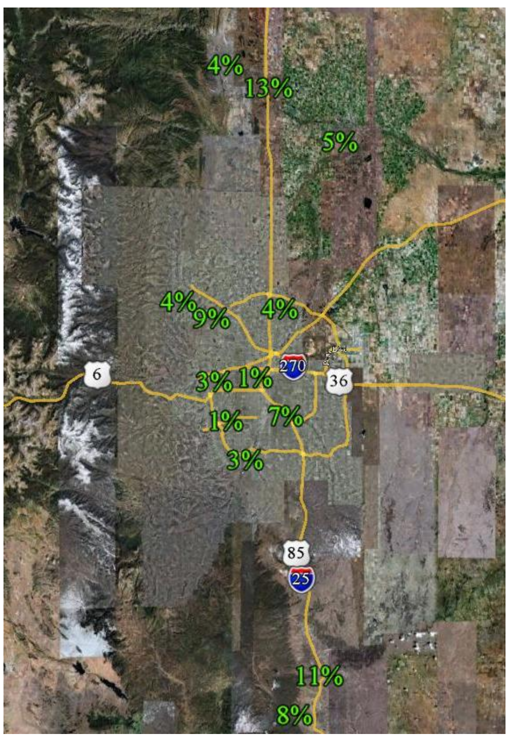


Figure 15. Deviation from NAAQS 8-hr O_3 Standard Map

2.4.2.7. Area Served

For this analysis, sites are ranked based on their area of coverage. Calculating the area of representation of a particular monitor requires GIS software. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon area values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

This method gives the most weight to rural sites and those on the edges of urban areas or other monitor clusters. It addresses the network objectives of background concentration, spatial coverage and interpolation. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) it does not take into account population or emissions, and (3) it may artificially weight monitors at the edge of the analysis domain. The main advantages are: (1) the simplicity and quickness of performing the method, and (2) it gives weight to remote and urban boundary sites that are necessary for proper interpolation.

Figure 16 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction site in the west to the Front Range sites in the east, and from the Fort Collins site in the north to the Colorado Springs site in the south. The dots mark the locations of the O_3 network monitors, and the red lines mark the highways in the area.

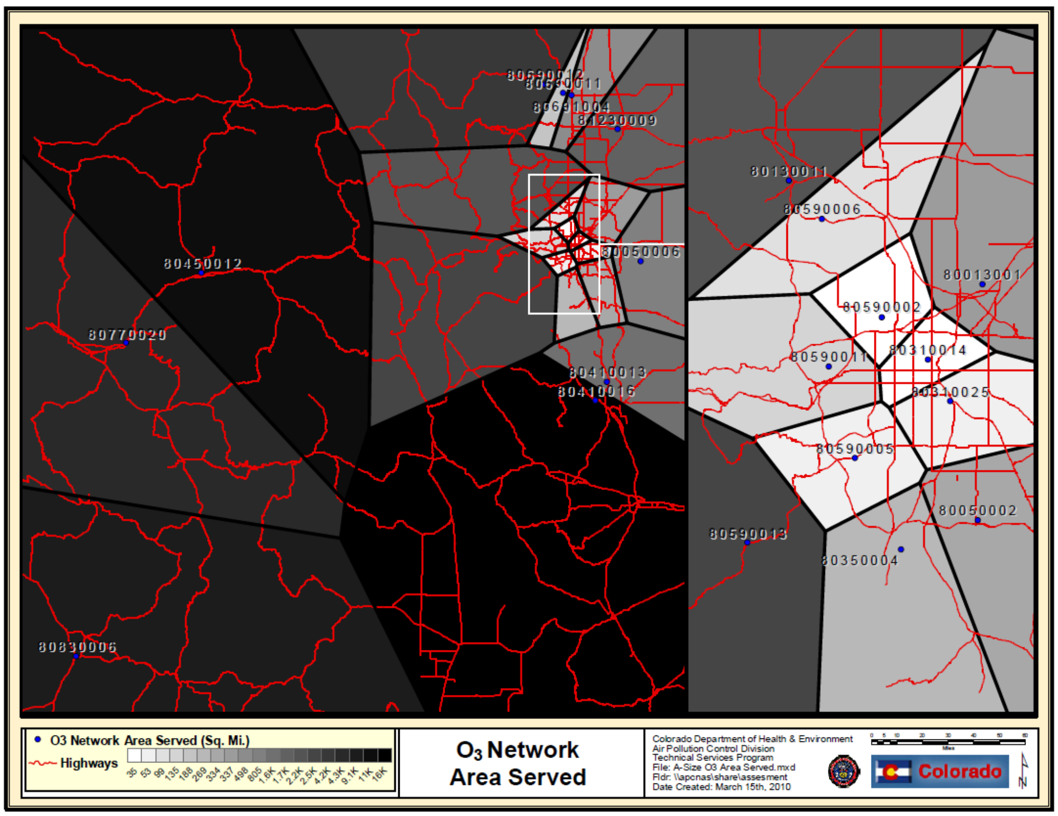


Figure 16. **O_3 Area Served Map**

Table 32 lists the O_3 network sites, the total area served by the monitoring area, and the score associated with each monitor’s ranking. Sites with an area served of 7,500 square miles or greater received a 1, between 5,000 and 7,499 square miles received a 0.75, between 2,500 and 4,999 square miles received a 0.5, between 250 and 2,500 square miles received a 0.25 and less than 250 square miles received a 0 (zero).

As shown in the table and the figure, four sites serve areas that are greater than or equal to 7,500 square miles. The site serving an area of 15,774 square miles would be considered to be the most valuable for the network objective of spatial coverage. Site 08 041 0016 is the Manitou Springs site.

Table 32. O_3 Area Served Analysis Scores

AQS ID	Area (sq. mi.)	Score
08 041 0016	15,774	1.00
08 045 0012	15,667	1.00
08 083 0006	11,004	1.00
08 077 0020	9,137	1.00
08 069 0012	4,285	0.50
08 059 0013	4,244	0.50
08 013 0011	2,487	0.25
08 123 0009	2,214	0.25
08 041 0013	1,642	0.25
08 005 0006	1,594	0.25
08 069 1004	805	0.25
08 001 3001	498	0.25
08 005 0002	338	0.25
08 035 0004	334	0.25
08 069 0011	269	0.25
08 059 0011	189	0.00
08 059 0006	135	0.00
08 031 0025	99	0.00
08 059 0005	80	0.00
08 059 0002	53	0.00
08 031 0014	35	0.00

2.4.2.8. Monitor to Monitor Correlation

2.4.2.8.6. Non-Weather Corrected Data Analysis

Before beginning this section, it should be noted here that the data used for this analysis only includes data from the years 2004 through 2008, and not 2009. Two key metrics for assessing redundancy in monitoring networks are site-to-site correlations and average relative differences. The correlations used for the first are the squared values of the Pearson's correlation coefficients, or r-squared. Average relative differences are calculated by taking the absolute value of the difference between concurrent concentrations at two sites and dividing this by the average of the two concentrations. Site-to-site correlation coefficients and average relative differences were calculated for the May through September daily maximum 8-hour ozone concentrations for the Denver-Boulder-Greeley Consolidated Metropolitan Statistical Area (CMSA) monitors, the Larimer County monitors, and the Colorado Springs area monitors. Correlation coefficients and average relative differences were not calculated for ozone monitors in western and southwestern Colorado. These sites are few in number, often recently deployed, and specifically created to target oil and gas development activities, population exposure, and possible emerging ozone problem areas in the state. Other considerations carry significantly more weight for these sites.

For this analysis, sites are ranked based on the correlation of their measured design values with those of the other monitors in the network. Monitors measuring concentrations that correlate well with concentrations at other monitors are considered redundant, and are consequently scored low. Monitors with concentrations that do not correlate with other monitored concentrations that are nearby are considered unique, and as such have more value for spatial monitoring objectives. These monitors are scored high. The advantages of this method are that it gives a measure of the site's uniqueness and representativeness, and that it is useful for identifying redundant sites. The disadvantages are that it requires large amounts of data with a high data completeness rate, and that the correlations are likely pollutant specific. The objectives assessed by this analysis are model evaluation, spatial coverage and interpolation.

Sites that do not correlate well with other sites have unique temporal concentration variation relative to other sites, and are likely to be important for assessing local emissions, transport and spatial coverage. It is assumed here that sites having an r-squared value of 0.6 or greater are well correlated. The sites with r^2 values of 0.6 or higher when compared to the other O_3 sites were counted. The analysis was scored as follows: sites correlating with zero or one sites at 0.6 or greater scored a one, those correlating with two other sites at 0.6 or greater scored a 0.75, those correlating with three other sites at 0.6 or greater scored a 0.5, those correlating with four other sites at 0.6 or greater scored a 0.25, and those correlating with five or more sites at 0.6 or greater scored a 0 (zero).

Figure 17 shows a plot of the r-squared values between ozone monitoring sites in the Denver-Boulder-Greeley CMSA (May through September, 2004 through 2008, for most site pairs), versus the monitors' distances from each other. Welch station correlations were calculated for 2006 through 2008 because of an apparent change in site conditions at the Welch monitor after 2005. Of those sites not in exceedance of the standard, Welch, Arvada, Carriage, and DMAS tend to have the highest levels of redundancy with other sites.

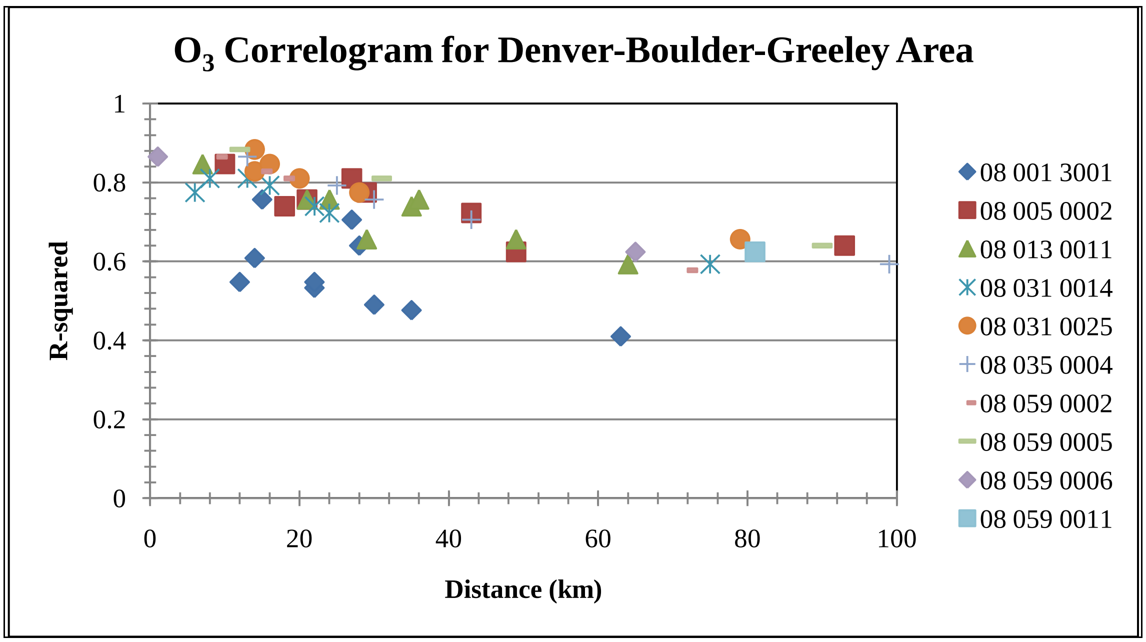


Figure 17. O_3 Non-Weather Corrected Correlogram for Denver-Boulder-Greeley Area

Table 33 shows the average relative differences between ozone monitoring sites in the Denver-Boulder-Greeley CMSA, (May through September, 2004 through 2008, for most site pairs). The values highlighted in yellow show the sites having an average relative difference of less than 0.10. Once again, the calculations for Welch were based on 2006 through 2008. Of those sites not in exceedance of the standard, Welch, Arvada, Highland, and DMAS tend to have the highest levels of redundancy with other sites. Table 34 shows the average relative difference between the Fort Collins ozone monitoring sites in Larimer County (May through September, 2006 through 2008).

Table 33. O_3 Average Relative Differences for Denver-Boulder-Greeley Monitors

	08 001 3001	08 005 0002	08 013 0011	08 031 0014	08 031 0025	08 035 0004	08 059 0002	08 059 0005	08 059 0006	08 059 0011	08 123 0009
08 001 3001	--										
08 005 0002	0.19	--									
08 013 0011	0.17	0.12	--								
08 031 0014	0.15	0.13	0.14	--							
08 031 0025	0.12	--	0.12	0.07	--						
08 035 0004	0.21	0.08	0.12	0.17	0.14	--					
08 059 0002	0.15	0.12	0.11	0.09	0.10	0.13	--				
08 059 0005	0.11	0.09	0.08	0.11	0.10	0.08	0.08	--			
08 059 0006	0.20	0.10	0.09	0.17	0.16	0.09	0.13	0.10	--		
08 059 0011	0.18	0.08	0.10	0.13	0.10	0.09	0.09	0.06	0.07	--	
08 123 0009	0.20	0.11	0.12	0.16	0.12	0.12	0.15	0.11	0.12	0.12	--

Table 34. O_3 Average Relative Differences for Larimer County Monitors

	08 069 0011	08 069 1004	08 069 0007
08 069 0011	--		
08 069 1004	0.18	--	

Site-to-site correlation coefficients and average relative differences were also calculated for the May through September 2006 through 2008 daily maximum 8-hour ozone concentrations for the two monitors near Colorado Springs, the US Air Force Academy and the Manitou Springs sites (08 041 0013 and 08 041 0016, respectively). The r-squared value for the Air Force Academy and Manitou Springs monitors is 0.79, which is moderately high. The average relative difference is 0.05, which is very low. The sites are 22.5 kilometers apart. Analysis of stratospheric ozone intrusions that occurred in Colorado in 2010 has just begun. Preliminary results suggest that the Manitou Springs site is a good indicator site for intrusions caused by mesoscale tropopause folding that occurs in the lee of the Front Range.

Table 35 shows the results of the scoring method for this analysis on the non- weather corrected O_3 data. Four sites scored a one for not correlating at 0.6 or greater with more than one O_3 site. These were the two Larimer County sites and the two Colorado Springs sites run by CDPHE. The remaining sites scored zeros, as they all Correlated at least five other sites. These sites are Denver-Boulder-Greeley CMSA sites.

Table 35. O_3 Monitor to Monitor Analysis Scores (Non-Weather Corrected Data)

AQS ID	# Monitors Correlated at ≥ 0.6	Score
08 041 0013	1	1.00
08 041 0016	1	1.00
08 069 0011	1	1.00
08 069 1004	1	1.00
08 001 3001	5	0.00
08 005 0002	9	0.00
08 013 0011	10	0.00
08 031 0002	9	0.00
08 031 0014	9	0.00
08 031 0025	9	0.00
08 035 0004	9	0.00
08 059 0002	10	0.00
08 059 0005	11	0.00
08 059 0006	10	0.00
08 059 0011	10	0.00
08 123 0009	5	1.00

2.4.2.8.7. Weather Corrected Data Analysis

Before beginning this section, it should be noted here that the data used for this analysis only includes data from the years 2004 through 2008, and not 2009. Ozone monitoring data can be used to identify long-term trends in ozone and its precursor emissions. A variety of ozone trend-decomposition or filtering methods can be used to remove the effects of meteorology from an ozone time series. This filtering or decomposition can make it possible to see the effects of changes in emissions in relative isolation from many of the meteorological factors that also affect ozone concentrations. The weather-corrected ozone time series for each monitoring site provides important clues for understanding the roles of emissions reductions or increases in an area. As a result, the ability of a site to provide evidence of emissions impacts should be a key consideration in the assessment of a monitoring network. The utility of data from specific sites in validation of dispersion and photochemical modeling should also be considered.

For the ozone Early Action Compact of 2004 (Colorado Department of Public Health and Environment, Air Pollution Control Division, 2004), the Zurbenko-Rao method (Porter, Rao, Zurbenko, Zalewsky, Henry, & Ku, 1996) (Eskridge, Ku, Porter, Rao, & Zurbenko, 1997) (Rao, Zurbenko, Neagu, Porter, Ku, & Henry, 1997) was used to cleanly separate ozone time series into distinct short and long-term components. The resulting long-term components were relatively independent of the effects of meteorology. Since 2004, the Division has developed a new method of correcting ozone time series for weather for monitoring sites along the Front Range. This new method is documented in the “Denver Metropolitan Area and North Front Range 8-Hour Ozone State Implementation Plan - Weight of Evidence to Support the Modeled Attainment Demonstration” (Alpine Geophysics, Regional Air Quality Council, Colorado Department of Public Health and Environment, and ENVIRON International Corporation, 2008).

For summer months, the mean strength of upper level high pressure systems that strongly affect weather in Colorado is represented by the monthly mean 500-millibar height. Monthly mean 500-millibar heights are an excellent predictor of monthly mean daily maximum 8-hour ozone concentrations, and can be used to separate much of the effects of weather from the ozone time series. July monthly mean daily maximum 8-hour ozone is more strongly correlated with 500-millibar heights than a host of other logical choices for significant predictors of ozone, including mean surface temperatures, mean temperatures aloft, winds aloft, cloud cover, solar radiation, and number of days with temperatures above 90 degrees. While annual fourth maximum 8-hour ozone concentrations can occur in any of the months of summer, it turns out that the mean July 500-millibar height over Denver is one of the single best predictors for this value at sites along the Front Range Urban Corridor. The predictive power of mean August and June meteorological variables and meteorological data for shorter averaging times (e.g., daily, weekly, etc.) is substantially lower. The use of monthly mean heights and ozone data reduces the impacts of shorter-time scale weather phenomena that introduce biases in long-term trend analyses.

Figure 18, Figure 19 and Figure 20 show the relationship between July monthly mean daily maximum 8-hour ozone concentrations and July monthly mean 500-millibar heights at Rocky Flats North, NREL, and Chatfield Reservoir, three of the four key ozone monitors identified in the Ozone State Implementation Plan (SIP) modeling (there are not enough years of data for a similar analysis for the fourth key site, Fort Collins West.). The 500-millibar height data are from the National Center for Environmental Prediction (NCEP) Reanalysis data set. (Kalnay, 1996) These data are calculated for grid cells with dimensions of 2.5 degrees latitude by 2.5 degrees longitude. The grid cell with data having the highest predictive power for the Front Range extends north from near Colorado Springs to near Cheyenne Wyoming, and west from Denver to near Glenwood Springs (essentially the northern Front Range and north central mountains of Colorado). Data from the grid cell immediately to the east, which covers much of the urban corridor and the northeast plains, had slightly weaker correlations with mean ozone concentrations.

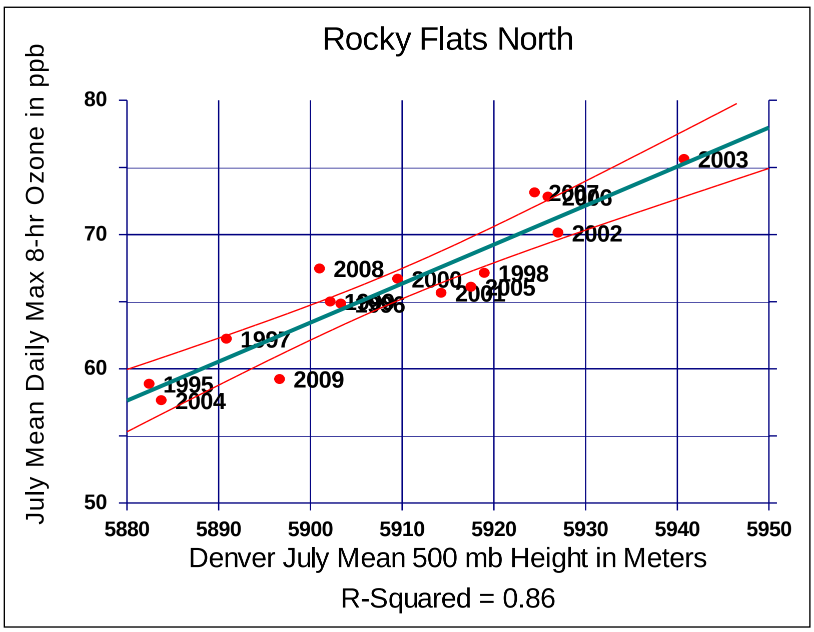


Figure 18. July Monthly Mean Daily Max 8-hour O_3 vs. 500-mb Heights at Rocky Flats North

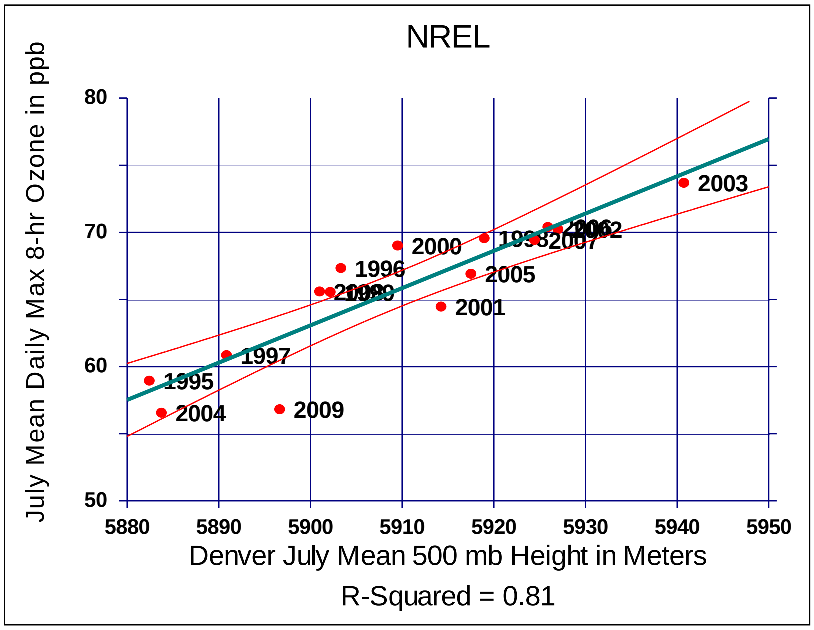


Figure 19. **July Monthly Mean Daily Max 8-hour O_3 vs. 500-mb Heights at NREL**

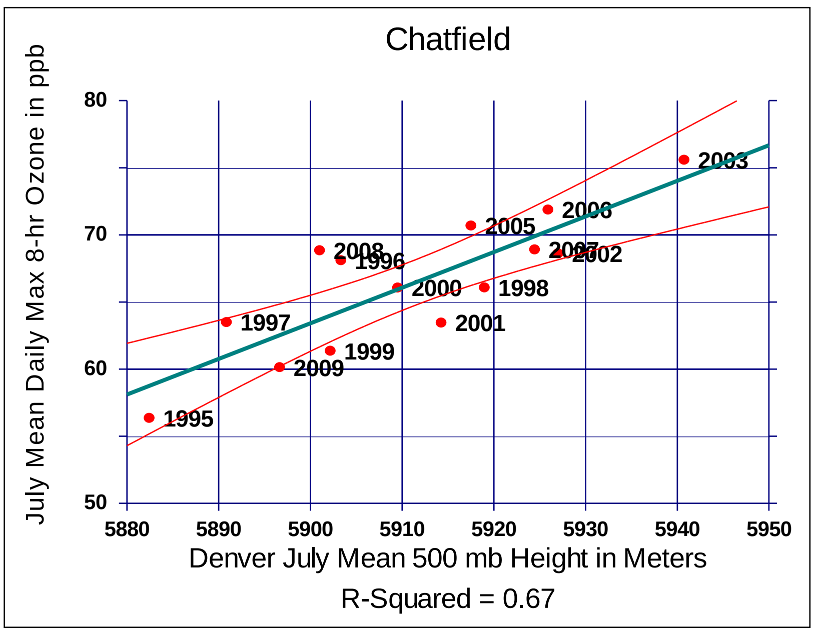


Figure 20. **July Monthly Mean Daily Max 8-hour O_3 vs. 500-mb Heights at Chatfield**

Figure 18, Figure 19 and Figure 20 also show the linear regression between July mean daily maximum 8-hour ozone and July mean 500-millibar heights, the confidence intervals for the regression line, and the coefficient of determination or r-squared value for the regression. The r-squared value describes the fraction of the variance, or fraction of the year-to-year variation, that can be explained by mean 500-millibar heights. This coefficient ranges from 0.67 to 0.86 for these three sites, suggesting that 67% to 86% of the year-to-year variation in July mean daily maximum ozone at these sites can be explained by changes in July mean 500-millibar heights and the ozone-conducive weather associated with upper-level high pressure systems.

Table 36 lists regression statistics for twelve Front Range ozone monitors. The trend for increasing ozone with increasing high-pressure strength is statistically significant for all sites but Welby, which may be disconnected from the influence of heights because of the effects of local NOx sources, siting issues, and/or local flow regimes. R-squared values for sites with statistical significance range from 0.27 to 0.86. Welch was included, but ozone time series for this site have probably been affected by a local anomaly caused by facility activities and restructuring at the Colorado Department of Transportation workstation where it is located.

Table 36. Regression Stats for July Mean Daily Max 8-hour O_3 vs. 500-mb Heights for 1995-2009

Monitoring Site	Slope	R-Squared Value	Passed t-test for Statistical Significance
Arvada	0.274	0.62	yes
Chatfield State Park	0.353	0.67	yes
Carriage	0.277	0.84	yes
Fort Collins	0.208	0.57	yes
Greeley/Weld County Tower	0.191	0.74	yes
NREL	0.277	0.81	yes
Rocky Flats North	0.290	0.86	yes
South Boulder Creek	0.285	0.68	yes
Welby	0.040	0.01	no
Highland	0.296	0.86	yes
Air Force Academy	0.296	0.49	yes
Welch	0.210	0.27	yes
Mean Statistics without Welby and Welch	0.275	0.71	

Figure 21, Figure 22 and Figure 23 show the relationship between the annual 4th maximum 8-hour ozone concentrations and the July monthly mean 500-millibar heights at Rocky Flats North, NREL, and Chatfield State Park. R-squared values for these monitors range from 0.53 to 0.77. This suggests that 53% to 77% of the year-to-year variation in annual 4th maximum values can be explained by changes in July mean 500-millibar heights. Table 37 shows the linear regression statistics for the same 12 Front Range monitors described above. Regression lines show significance for all sites but Welby and the Air Force Academy site. R-squared values for sites with statistical significance (excluding Welch) range from 0.48 to 0.77.

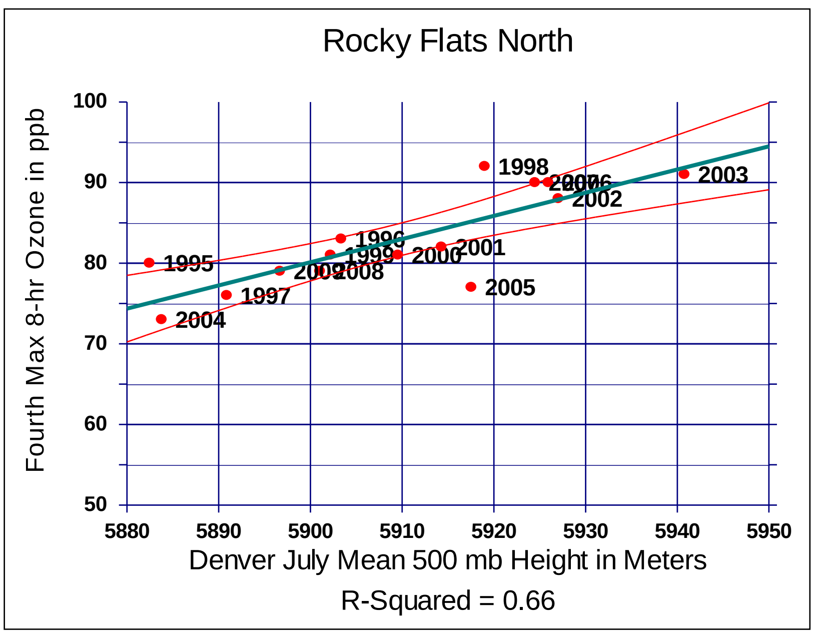


Figure 21. Regression of Annual 4th Max 8-hour O_3 vs. July Monthly Mean 500-mb Height at RFN

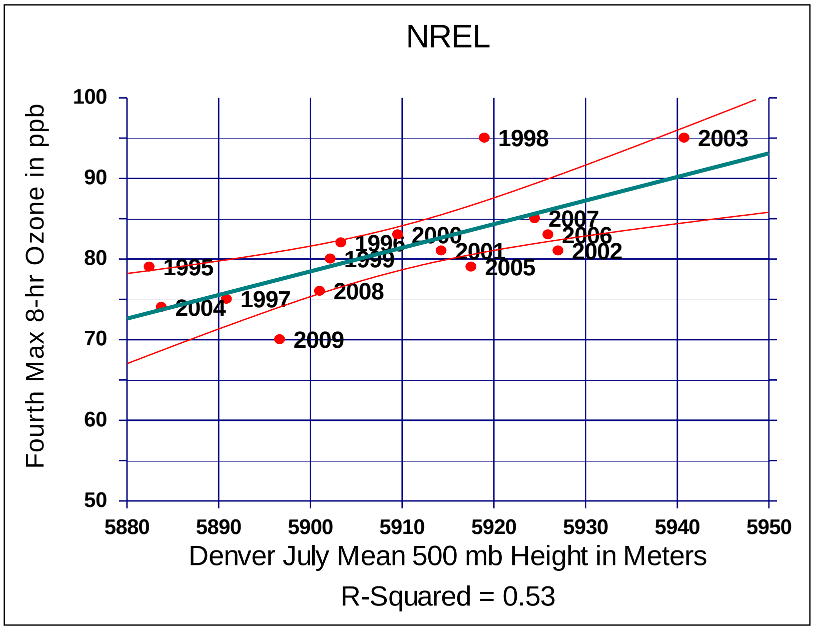


Figure 22. **Regression of Annual 4th Max 8-hour O_3 vs. July Monthly Mean 500-mb Height at NREL**

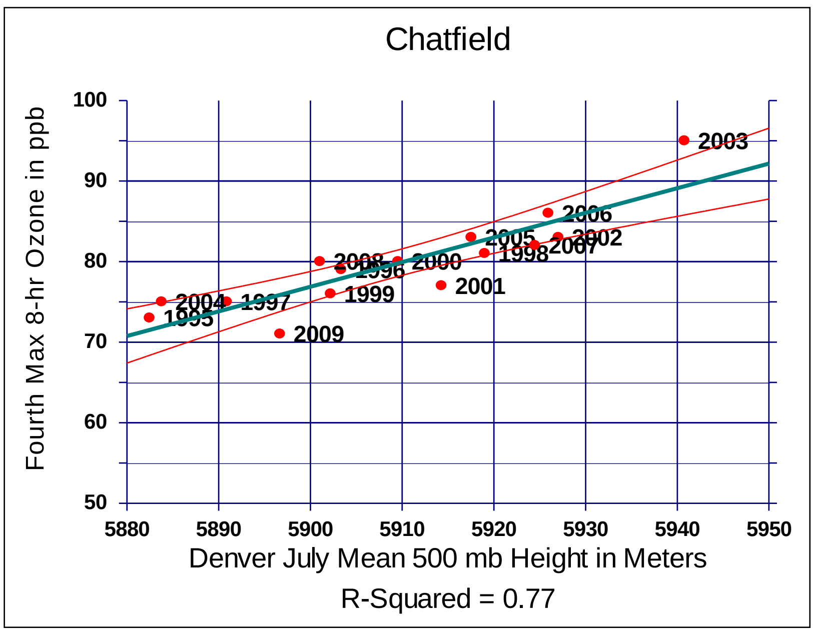


Figure 23. **Regression of Annual 4th Max 8-hour O_3 vs. July Monthly Mean 500-mb Height at Chatfield**

Table 37. Regression Stats for Annual 4th Max 8-hour O_3 and July Mean 500-mb Heights for 1995-2009

Monitoring Site	Slope	R-Squared Value	Passed t-test for Statistical Significance
Arvada	0.262	0.58	yes
Chatfield	0.306	0.77	yes
Carriage	0.290	0.60	yes
Fort Collins	0.231	0.60	yes
Greeley/Weld County Tower	0.247	0.67	yes
NREL	0.293	0.53	yes
Rocky Flats North	0.288	0.66	yes
South Boulder Creek	0.234	0.48	yes
Welby	-0.027	0.01	no
Highland	0.324	0.71	yes
Air Force Academy	0.210	0.24	no
Welch	0.200	0.30	yes
Mean Statistics without Welby, Air Force Academy, & Welch	0.269	0.58	

The correspondence between the 500-millibar heights and ozone concentrations can be used to correct ozone time series for the effects of weather. The differences between the linear regression concentrations and the actual concentrations (the differences are the residuals) can be plotted by year to show weather-corrected trends in ozone. These corrected trends or time series are much more likely to show the effects of changes in emissions than the uncorrected time series.

The trend in weather-corrected July mean daily max 8-hour ozone for Fort Collins and Greeley is shown in Figure 24 (with a simple cubic spline smoother applied). A continuous increase in ozone from the late 1990s through 2005 may be the result of local growth and increases in oil and gas emissions. A sudden drop from 2005 through 2007 may be the result of reductions in area oil and gas emissions. The increase in 2008 corresponds with an increase in area tropospheric NO_2 as measured for the Denver and Front Range ozone nonattainment area (NAA) by the GOME 2 satellite sensor. (Boersma, Eskes, & Brinksma, 2004) The data can be found at http://www.temis.nl/airpollution/no2.html. The decrease in 2009 is likely to be associated with the economic downturn. The GOME 2 data in Figure 25 also shows a pronounced drop in the NO_2 within the ozone NAA. These data are from a level 1 or preliminary data set.

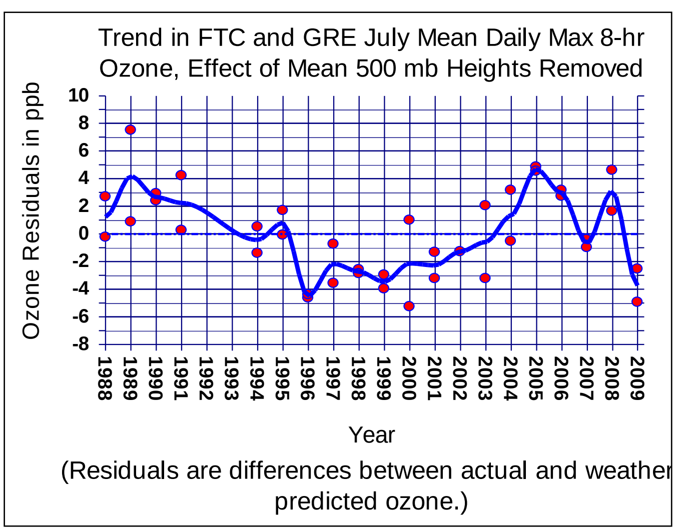


Figure 24. Trend in Weather-Corrected July Mean Daily Max 8-hour O_3 for Fort Collins and Greeley

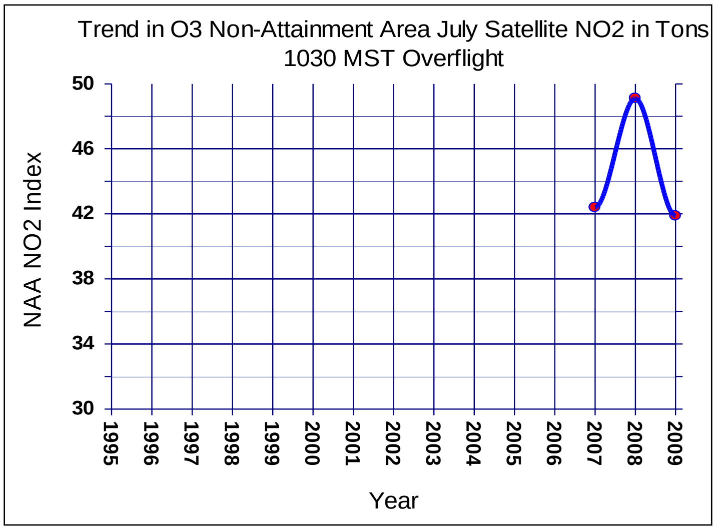


Figure 25. **Trend in Mean July GOME2 Satellite Derived Tropospheric NO_2 for Front Range O_3 NAA**

A similar analysis for Rocky Flats, NREL, Chatfield, Carriage, South Boulder Creek, and Arvada is shown in Figure 26. Gradual decreases through 2004 are replaced by apparent step increases in 2005 and 2008. The increases in 2008 in both plots suggest that there may have been an increase in background concentrations across all of the Front Range, with a magnitude of about 4 ppb. Many factors may have contributed to this increase, but it seems apparent that the increase in 2008 and decrease in 2009 are related to area NO_2 and the recession as discussed earlier.

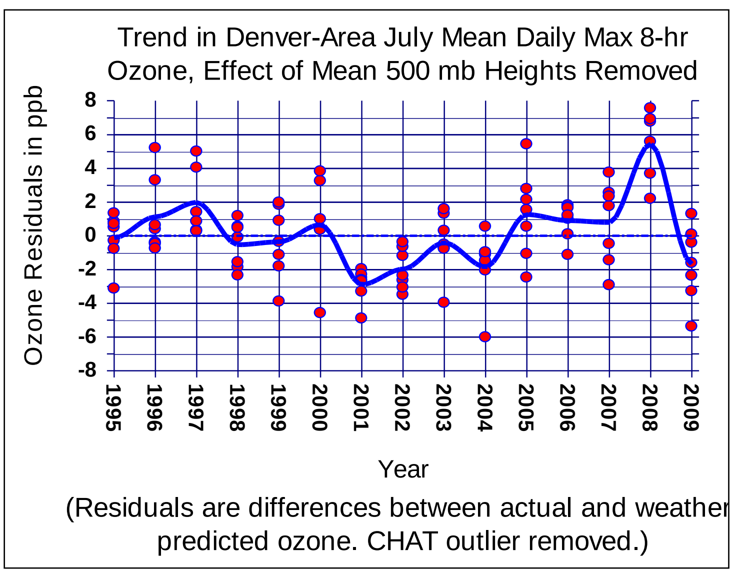


Figure 26. **Trend in Weather-Corrected July Mean Daily Max 8-hour O_3 for Denver Area Sites**

The weather-corrected trend for July ozone at the Welch monitor is shown in Figure 27. A major discontinuity is evident starting in 2006. This discontinuity is believed to be related to a physical restructuring of the Colorado Department of Transportation facility where the monitor is located. Figure 16 of the "Denver Early Action Ozone Compact Weight of Evidence to Support Attainment Demonstration" (Colorado Department of Public Health and Environment, Air Pollution Control Division, 2004) also indicates that this non-urban site had the highest weekend-weekday effect for ozone for the entire Front Range during July and August of 2003, suggesting that weekday activities at the site may have quenched ozone. The increase of 13 ppb in mean weather-corrected ozone between 2005 and 2006 is otherwise difficult to explain.

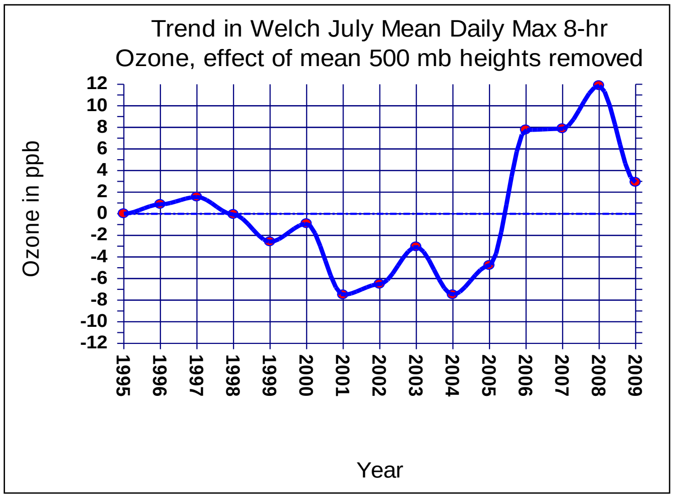


Figure 27. **Trend in Weather-Corrected July Mean Daily Max 8-hour O_3 for Welch**

Correcting all nine of the Front Range annual fourth max time series for weather leads to the pattern shown in Figure 28. Here the smoothing algorithm used is a Lowess curve with 40% weighting. When smoothed in this way, the trend shows a period of decline followed by a rise and ending in a gradual decline from 2005 through 2009. This is consistent with the idea that ozone is difficult to control but increases have ceased since 2004. In addition, the sharp increase in 2008 seen in earlier plots is not evident in these worst-case concentrations. The spike in individual residuals in 1998 may be related to El Nino, increased boreal forest fires in Canada and Siberia, and/or increased emissions in Asia. (Cooper, Large Upper Troposheric Ozone Enhancements Above Midlatitude north America During Summer: In Situ Evidence from the IONS and MOZAIC Ozone Measurement Network, 2007) (Koumoutsaris, Bey, Generoso, & Thouret, 2007) (Spichtinger, et al., 2004)

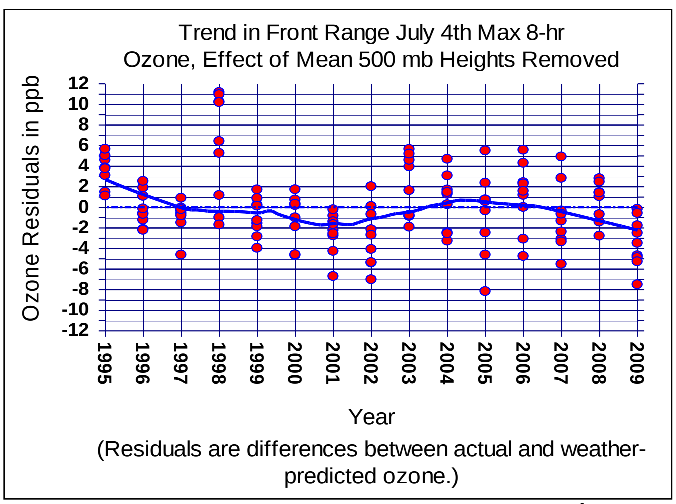


Figure 28. **Trend in Weather-Corrected July Mean 4th Max 8-hour O_3 for Front Range**

Why are ozone concentrations along the Front Range so highly correlated with July mean 500-millibar heights? Increased heights are associated with strong regional upper level high pressure systems. Strong regional upper level high pressure systems lead to light winds at the surface and aloft, decreased cloud cover and storms, increased temperatures at the surface and aloft, an enhancement of the local thermally driven circulations that tend to keep ozone and its precursors in the area, and a greater likelihood that ozone and its precursors will accumulate in regional circulation patterns.

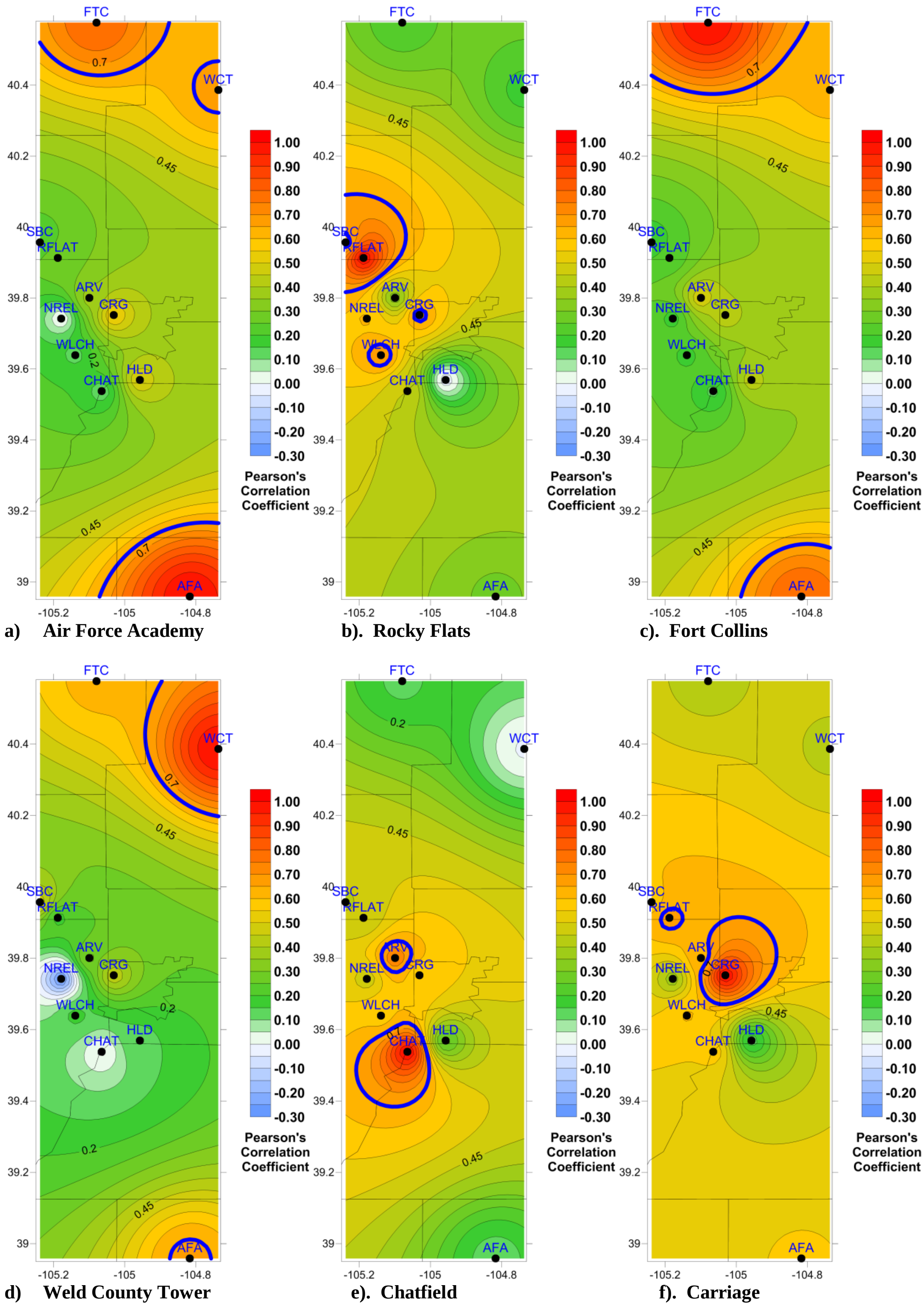
Recent research highlights the role of upper level high pressure systems in the accumulation of ozone aloft. (Cooper, Large Upper Troposheric Ozone Enhancements Above Midlatitude north America During Summer: In Situ Evidence from the IONS and MOZAIC Ozone Measurement Network, 2007) (Cooper, 2006) Because of deep vertical mixing during the afternoon over most of the state, this ozone aloft affects ground level concentrations, and ozone at ground level is ultimately mixed vertically into the upper level high. The Air Pollution Control Division believes that persistent upper level high pressure over Colorado in midsummer increases background concentrations, providing an increase in both mean and worst-case ozone concentrations.

Pearson Correlation Coefficients (R values) have been calculated for site-to-site comparisons of July mean daily maximum ozone corrected for the effects of 500-millibar heights for those CDPHE sites with useable weather-corrected time series. These correlation coefficients are presented in Table 38 below. Values of 0.65 or greater were bolded. The Air Force Academy site and Fort Collins - West have fairly high correlations, and this may reflect the effects of similar regional background ozone concentrations at each site. Fort Collins - West and the Air Force Academy, however, represent ozone exposure conditions for distinct areas of Colorado. Arvada and Chatfield show some degree of redundancy as do Welch and Arvada. Otherwise, the weather corrected data show only low to moderate redundancy.

Table 38. Pearson Correlation Coefficients for O_3 Sites (R)

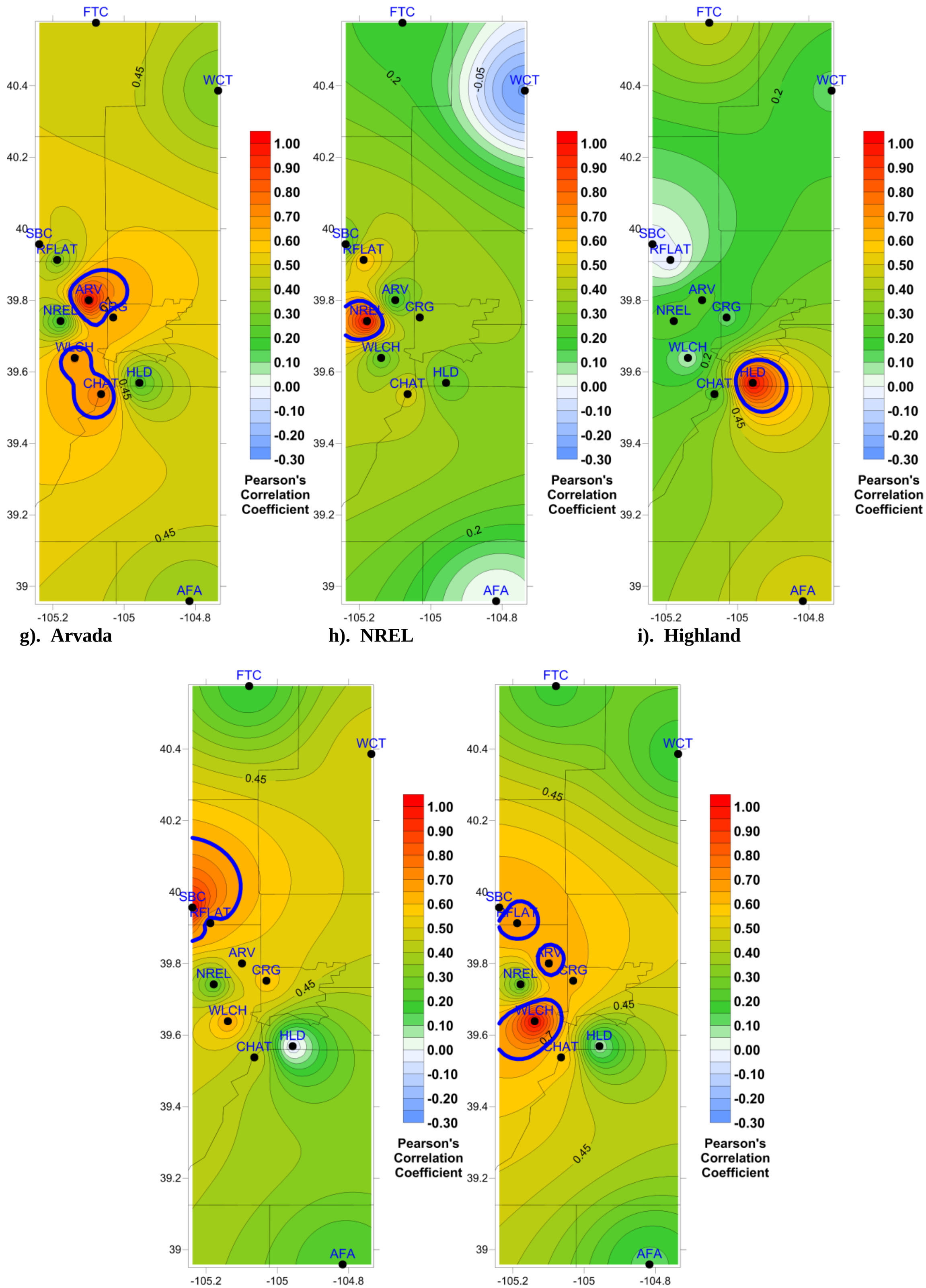
	08 041 0013	08 059 0006	08 069 0011	08 123 0009	08 035 0004	08 031 0014	08 059 0002	08 059 0011	08 005 0002	08 013 0011	08 059 0005
08 041 0013	--										
08 059 0006	0.29	--									
08 069 0011	**0.80**	0.22	--								
08 123 0009	**0.67**	0.18	0.62	--							
08 035 0004	0.13	0.45	0.14	-0.01	--						
08 031 0014	0.55	**0.67**	0.43	0.44	0.57	--					
08 059 0002	0.37	0.32	0.49	0.31	**0.75**	0.63	--				
08 059 0011	0.00	0.6	0.18	-0.26	0.47	0.37	0.18	--			
08 005 0002	0.49	-0.03	0.42	0.14	0.24	0.13	0.23	0.25	--		
08 013 0011	0.20	0.63	0.16	0.48	0.44	0.58	0.54	0.25	-0.04	--	
08 059 0005	0.14	**0.69**	0.18	0.16	0.59	0.60	**0.71**	0.26	0.06	0.64	--

Figure 29, letters a through k, show correlation coefficient contours for each of the sites in the table above. A value of 1.0 occurs over the site for the monitor which is the focus of the map. The dark blue line shown in the figures is a trace of the 0.65 coefficient value.



a) Air Force Academy
b). Rocky Flats
c). Fort Collins
d) Weld County Tower
e). Chatfield
f). Carriage

Figure 29 a-k. Contours of R Values for Weather Corrected O_3



g). Arvada h). NREL i). Highland

j). South Boulder Creek k). Welch

Figure 29 (continued) g-k. Contours of R Values for Weather Corrected O_3.

The Arvada, Carriage, Highland Ranch, South Boulder Creek, Weld County Tower, and Fort Collins - West monitors are very useful for weather-corrected trend analysis because they have records for all or most of the years from 1988 through 2009. The Weld County Tower site correlated well with the previous Greeley site during a long period of overlap, giving us confidence that the two monitors are representative of the same conditions. Consequently, a multi-decadal time series at each site can be used to evaluate the effects of changes in emissions regimes. Evaluation of emissions change signals in these times series is an important adjunct to photochemical dispersion modeling and can be a key factor in assessing the validity of model behavior (especially in Weight of Evidence Analyses for SIP documentation).

Table 39 shows the results of the scoring method for this analysis on the weather corrected O_3 data. All eleven sites that had valid data for use in the correlations scored a one for not correlating at 0.6 or greater with one or more O_3 sites. Typically, as the distance between monitors increases, the likelihood of a good correlation between the monitors drops off. The data tend to show this in Figure 30, however, there are some outliers. The point at r-squared equals 0.64 is a correlation between sites 08 041 0013 and 08 069 0011, the US Air Force Academy and Fort Collins – West sites, which are 183 kilometers apart.

Table 39. O_3 Monitor to Monitor Analysis Scores for Weather Corrected Data

AQS ID	# Monitors Correlated at ≥ 0.6	Score
08 005 0002	0	1.00
08 013 0011	0	1.00
08 031 0014	0	1.00
08 035 0004	0	1.00
08 041 0013	1	1.00
08 059 0002	0	1.00
08 059 0005	0	1.00
08 059 0006	0	1.00
08 059 0011	0	1.00
08 069 0011	0	1.00
08 123 0009	0	1.00

Note: Not all sites were included in weather corrected analysis.

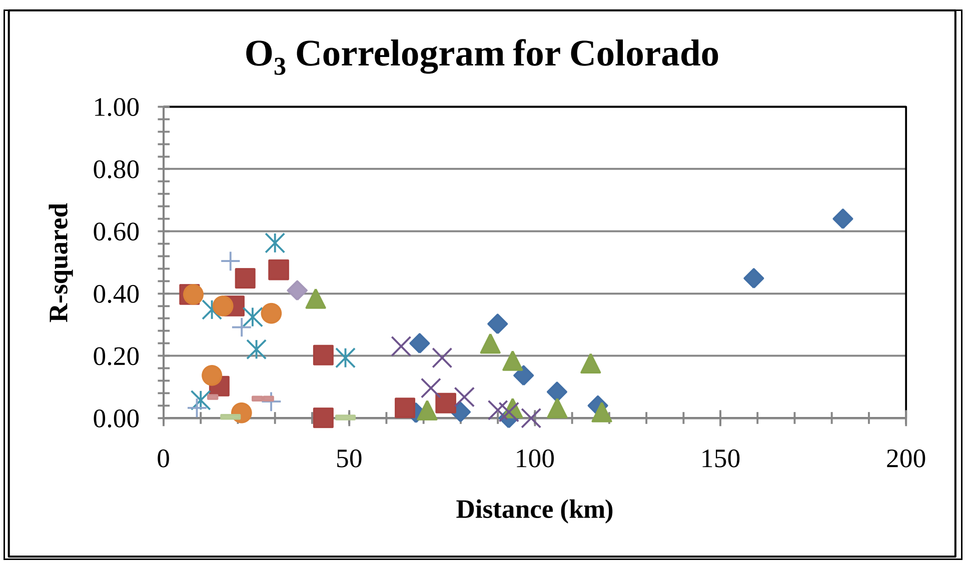


Figure 30. O_3 Weather-Corrected Correlogram for Colorado

2.4.2.8.8. Summary of Monitor to Monitor Analysis for Ozone

The final scores for this site correlation analysis are summarized in the table below. The scores from the analyses of the non-weather corrected and weather corrected ozone data were combined. Where there was a score for a monitor in both analyses, the score was averaged. Where there was score from only one of the analyses, that score was used by itself. There were four sites scoring a one. These are the Colorado Springs area and Fort Collins area sites. These sites are considered the most important for the purposes of this analysis.

Table 40. Weather Corrected and Non-Weather Corrected O_3 Analysis Scores

AQS ID	Average Score
08 041 0013	1.00
08 041 0016	1.00
08 069 0011	1.00
08 069 1004	1.00
08 005 0002	0.50
08 013 0011	0.50
08 031 0014	0.50
08 035 0004	0.50
08 059 0002	0.50
08 059 0005	0.50
08 059 0006	0.50
08 059 0011	0.50
08 123 0009	0.50
08 001 3001	0.00
08 031 0025	0.00

2.4.2.9. Measured Concentrations

For this analysis, sites are ranked based on the difference between the maximum pollutant concentrations measured and the value of the standard. The sites that measure high design values are ranked higher than those that measure low values. The objectives assessed by this analysis are maximum concentration location, model evaluation, regulatory compliance and population exposure. The main advantage of the technique is that it identifies key sites from a regulatory perspective, based on the maximum concentrations. The disadvantages are that it does not account for monitor-siting problems, and that is only focuses on high concentrations. Low concentration monitors may be useful for representing rural locations or background concentrations.

Sites that measure high design values are important for assessing NAAQS compliance and population exposure, and for performing model evaluations. The analysis is scored as follows: design values that are equal to or greater than 100% of the NAAQS are given a 1, values between 95 and 100% of the NAAQS receive a 0.75, values between 90 and 95% of the NAAQS received a 0.5, values between 80 and 90% of the NAAQS receive a 0.25, and values less than or equal to 80% of the NAAQS receive a 0 (zero).

The maximum daily ozone concentration from the 2004 to 2009 time period for each site was used in this analysis. Table 41 shows the scores for the design values recorded at each site, as well as the analysis scores and site rankings. Figure 31 illustrates the results graphically, with the value of the difference between NAAQS and the ozone concentrations representing the approximate geographic locations of the monitors. Values in green are below the NAAQS, while values in red are above it. Eighteen sites in the network scored ones when the maximum daily ozone concentrations were compared to the primary O_3 standard, and as such are considered the most valuable in the terms of this analysis. The majority of these sites lie along the Front Range area.

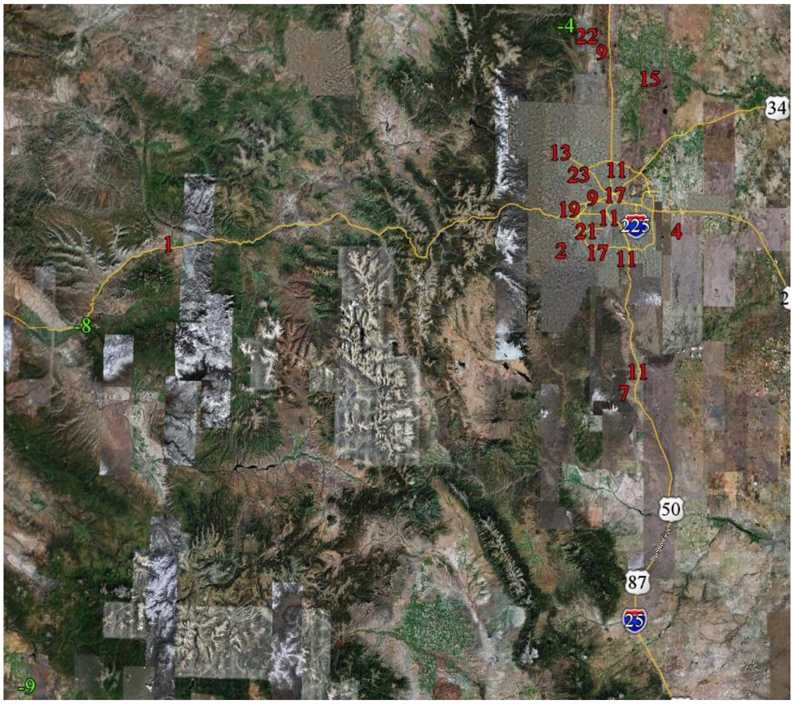


Figure 31. O_3 Maximum Measured Concentration 8-hr Standard Map

Table 41. O_3 Measured Concentration 8-hr Standard Analysis Scores

AQS ID	2004-2009 Max Daily Ozone Concentration (ppm)	NAAQS 3-year Standard Value (ppm)	% NAAQS	Score
08 059 0006	0.098	0.075	131%	1.00
08 069 0011	0.097	0.075	129%	1.00
08 059 0005	0.096	0.075	128%	1.00
08 059 0011	0.094	0.075	125%	1.00
08 031 0014	0.092	0.075	123%	1.00
08 035 0004	0.092	0.075	123%	1.00
08 123 0009	0.09	0.075	120%	1.00
08 013 0011	0.088	0.075	117%	1.00
08 001 3001	0.086	0.075	115%	1.00
08 005 0002	0.086	0.075	115%	1.00
08 031 0025	0.086	0.075	115%	1.00
08 041 0013	0.086	0.075	115%	1.00
08 059 0002	0.084	0.075	112%	1.00
08 069 1004	0.084	0.075	112%	1.00
08 041 0016	0.082	0.075	109%	1.00
08 005 0006	0.079	0.075	105%	1.00
08 059 0013	0.077	0.075	103%	1.00
08 045 0012	0.076	0.075	101%	1.00
08 069 0012	0.071	0.075	95%	0.75
08 077 0020	0.067	0.075	89%	0.25
08 083 0006	0.066	0.075	88%	0.25

2.4.2.10. Summary/Conclusions and Recommendations

Table 42 shows the summary of scores of each analysis performed on the ozone monitoring network. As with the CO network analyses, the Welby site was again scored the highest. For the purposes of this network assessment it would be considered the most important ozone site, and should be kept. However, collocation of NOx and ozone monitors is also a key requirement for model validation exercises. This pairing of monitors should ideally occur in the urban core and at high-concentration sites downwind. There are currently only two NOx monitoring sites in the Denver ozone non-attainment area, CAMP and Welby. Ozone is no longer monitored at CAMP. Welby ozone has very poor correlation with 500-millibar heights and shows some signs of being inexplicably low compared with other sites in the area. It may make sense to move the Welby NOx monitors to Rocky Flats, a high-concentration site downwind of Denver. Similarly, it would make sense to re-instate ozone monitoring at CAMP. Then there would be concurrent ozone and NOx data for a bare minimum number of sites needed to test and validate the modeling. Odd oxygen or total oxidant estimates can be derived by combining NOx and ozone concentrations. These estimates provide an important indicator of the ozone production potential at a location and help to differentiate low ozone production potential and NOx quenching. As such, they can shed light on the meaning of day-of-week differences in ozone concentrations which can be an important step in understanding what areas may be NOx or VOC limited.

The six lowest scoring sites were affected by their short data collection duration. Each of the sites was unable to be used in the NAAQS comparison analyses because of the short length of their data record. For the purposes of the network analysis, these sites would be considered candidates for removal, especially the Rist Canyon monitoring site. Twelve of the twenty-one monitoring sites listed in the table above are required by SIP plans for the Non-Attainment Area (NAA), and as such cannot be removed from the network. These sites are Ft. Collins – West (08 069 0011), Ft. Collins – Mason (08 069 1004), Weld County Tower (08 123 0009), South Boulder Creek (08 013 0011), Rocky Flats North (08 059 0006), NREL (08 059 0011), Arvada (08 059 0002), Welch (08 059 0005), Chatfield (08 035 0004), Highland (08 005 0002), Carriage (08 031 0014) and Welby (08 001 3001). The Rist Canyon site (08 069 0012) is intended to validate SIP modeling. The Aurora East (08 005 0006) site is intended for oil and gas related monitoring.

Professional judgment by staff meteorologists indicate that he Arvada (08 059 0002), Carriage (08 031 0014), Welby (08 001 3001) and Welch (08 059 0005) sites are redundant and could be removed. In addition, the re-installation of an ozone monitor at the Denver – CAMP site is recommended for weight of evidence determinations and model validation. The addition of an ozone monitor in support of the 3-State Pilot Project will take place in 2010. The monitor will be located by Maybell, in northwest Colorado. Finally, other new sites may need to be installed to meet proposed new requirements by the EPA.

Table 42. O_3 Network Analyses Score Summary

AQS ID	# Parameters Monitored	Population Served	Population Change	Emissions Inventory - VOCs	Emissions Inventory - NO_2	Trends Impact	Deviation from NAAQS	Area Served	Monitor to Monitor Correlation	Measured Concentration Difference from 8-hr NAAQS	*Total Score*
08 001 3001	0.25	0.25	0.50	1.00	1.00	0.75	1.00	0.25	0.50	1.00	***6.50***
08 069 1004	1.00	1.00	0.00	1.00	1.00	1.00	N/A	0.00	0.00	1.00	***6.00***
08 005 0002	0.00	0.50	0.00	1.00	1.00	1.00	1.00	0.00	0.50	1.00	***6.00***
08 031 0014	0.00	1.00	0.00	0.00	0.00	0.75	1.00	1.00	1.00	1.00	***5.75***
08 059 0002	0.00	0.75	0.25	0.50	0.50	1.00	1.00	0.25	0.50	1.00	***5.75***
08 035 0004	0.50	1.00	0.50	0.75	0.50	0.00	1.00	0.25	0.00	1.00	***5.50***
08 031 0025	0.25	0.50	0.25	0.75	0.75	0.00	0.75	0.25	1.00	1.00	***5.50***
08 059 0006	0.00	1.00	0.50	0.75	1.00	0.50	N/A	0.25	0.50	1.00	***5.50***
08 041 0016	0.00	0.50	0.00	1.00	1.00	0.25	1.00	0.00	0.50	1.00	***5.25***
08 013 0011	0.00	0.25	0.00	1.00	1.00	0.50	1.00	0.00	0.50	1.00	***5.25***
08 123 0009	0.00	0.50	0.75	0.50	0.50	0.25	1.00	0.25	0.50	1.00	***5.25***
08 041 0013	0.00	0.25	0.00	1.00	1.00	0.50	1.00	0.00	0.50	1.00	***5.25***
08 059 0005	0.00	0.00	0.00	1.00	0.75	0.00	1.00	0.25	1.00	1.00	***5.00***
08 069 0011	0.00	0.25	0.25	0.75	0.75	0.50	1.00	0.00	0.50	1.00	***5.00***
08 059 0011	0.00	0.75	0.50	0.00	0.00	0.50	0.75	0.25	1.00	1.00	***4.75***
08 005 0006	0.00	0.50	1.00	0.00	0.00	0.00	N/A	0.25	N/A	1.00	***2.75***
08 045 0012	0.00	0.25	0.25	0.00	0.00	0.00	N/A	1.00	N/A	1.00	***2.50***
08 083 0006	0.25	0.25	0.25	0.00	0.00	0.00	N/A	1.00	N/A	0.25	***2.00***
08 059 0013	0.00	0.25	0.25	0.00	0.00	0.00	N/A	0.50	N/A	1.00	***2.00***
08 077 0020	0.00	0.50	0.25	0.00	0.00	0.00	N/A	1.00	N/A	0.25	***2.00***
08 069 0012	0.00	0.00	0.25	0.00	0.25	0.00	N/A	0.50	N/A	0.75	***1.75***

N/A = Score unavailable. Total score is affected.

2.4.3. NO_2 Network

In the following sub-sections are the results of the network analyses performed for the NO_2 monitoring network. It is important to keep in mind the fact that the overall scores for some of the monitors may be artificially lowered since those sites could not be included in all of the analyses performed here. This is mainly due to a lack of usable data for the appropriate time periods.

In January 2010, the EPA set a new primary standard that is a supplement to the primary annual average standard of 0.053 ppm. This new one-hour standard was set at a level not to exceed 0.100 ppm, and is based on "…the 3-year average of the 98th percentile of the yearly distribution of the one-hour daily maximum concentrations…" (US EPA, 2010).

2.4.3.1. Number of Parameters Monitored

This analysis was performed by counting the number of other parameters that are measured at the monitoring site. Sites having the most parameters measured are ranked the highest. Each monitoring instrument was counted as one parameter, meaning collocated monitors were counted individually. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—model evaluation and source apportionment. Sites with collocated measurements of several pollutants are more cost-effective to keep in operation than those sites measuring only one parameter. The main advantage of this method is its simplicity to perform. The disadvantages of the method include: (1) it does not "weight" the measurements by pollutant, as some pollutant measurements may be more useful than others; and, (2) up-to-date information on the pollutants measured at particular sites can be difficult to acquire.

Table 43 lists the NO_2 network sites, the total number of parameters monitored at each site, and the score associated with each monitor's ranking. Sites with greater than 20 parameters monitored received a 1, between 15 and 20 parameters received a 0.75, between 10 and 15 parameters received a 0.5, between 5 and 10 received a 0.25, and less than 5 parameters monitored received a 0 (zero).

As shown in the table, both of the sites monitor for greater than or equal to ten parameters. The site measuring 13 parameters would be considered the most valuable for the network objectives of emission inventory reconciliation and source apportionment. Site 08 031 0002 is the Denver – CAMP monitoring site.

Table 43. NO_2 Number of Parameters Monitored and Assessment Scores

AQS ID	Total Number of Parameters Monitored	Score
08 001 3001	10	0.50
08 031 0002	13	0.50

2.4.3.2. Population Served

It has been well established that large populations are associated with high emissions. For this analysis, sites are ranked based on the total number of people they represent. Calculating the population served by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the population within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was for 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas of high population and have large areas of representation. It addresses the network objectives of population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) small network densities give very little usable information, and (3) highly resolved population data may be difficult to work with. The main advantage is that it assesses the sites importance for population exposure.

This analysis was not performed for the NO_2 monitoring network as there are only two sites in operation, and the analysis is intended to be performed on a moderately sized or larger network.

2.4.3.3. Population Changed

As population rates increase so to do the potentials for emissions activity. For this analysis, sites are ranked based on the population increase in the area of representation. Calculating the population change by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the 2000 census-tract and latest block-group populations within each area of representation.

The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population change values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was from the 2000 census and from 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas with high rates of population growth and large areas of representation. It addresses the network objectives of maximum precursor location, population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) highly resolved population data may be difficult to work with, and (3) changing census boundaries make it difficult to compare populated areas over time. The main advantages are: (1) the flexibility of the method, (2) that it assesses the sites importance for population exposure, (3) its helpfulness in determining where monitoring may be required in the future, and (4) its aid in identifying monitors near which emissions may have substantially changed.

This analysis was not performed for the NO_2 monitoring network as there are only two sites in operation.

2.4.3.4. Emissions Inventory

Emission inventory data are used to find locations where emissions of pollutants of concern are concentrated. These locations are then compared to the current network and proposed new monitoring sites to determine if the network captures the areas of maximum emissions. The emissions inventory data used in this report are from the 2007 emissions inventory, as the 2008 inventory was not yet completed at the time of this report.

For this analysis a gridded emission inventory for the State was mapped out. It was then overlain on the Thiessen polygon map generated for other analyses. From there, the point sources (and their associated emissions data) that were within each polygon were used to calculate the emissions density in tons per year per square mile (TPY/mi^2). The area source emissions, including vehicle emissions, were not included in the emissions sums for this analysis. Only the sums of the point source emissions were used. The sum of the total point source emissions in each polygon was divided by the area of the polygon. The distances from each point source to the monitor were then used to calculate an average distance from the monitor to the point sources. This average distance was used to rank the monitors based on their average proximity to the point sources. Sites with a five mile or less distance received a 1, between 5 and 10 miles received a 0.75, between 10 and 20 miles received a 0.5, between 20 and 30 miles received a 0.25 and a distance greater than or equal to 30 miles received a 0 (zero).

Sites scoring a one indicate areas that are adequately monitored, and not in need of any immediate changes. Sites scoring a zero indicate areas that may need additional monitors. One advantage of this method is that it is scalable in complexity and spatial resolution. In addition, it helps in finding areas where primary pollutant concentrations are high. The disadvantages include: (1) emission inventory data are not always current or may be incomplete or inaccurate, (2) emission inventory quality varies by pollutant and source type, (3) more useful high resolution emission inventory data are not readily available and difficult to produce, and (4) the method does not account for pollutant transport. The objectives assessed by this technique are emission reduction evaluation and maximum precursor location.

The emissions inventory for NO_2 can be seen in Figure 14 in the previous section on O_3. As there are only 2 active NO_2 sites in the monitoring network, no Thiessen Polygons were created, and therefore the Emissions

Inventory Analysis for this parameter cannot be performed in the same manner as the CO and O_3 emissions analyses were.

2.4.3.5. Trends Impact

This analysis was performed by ranking the sites based on the length of the continuous measurement record of the pollutant of interest. Sites that have a long historical record are very valuable for tracking pollutant trends, and therefore have the most importance according to this assessment technique. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—trend tracking and emission reduction evaluation. In addition, it provides a measure of the historical consistency of the data sets generated. The main advantages of this method are its simplistic analytical approach, and its usefulness for identifying long-term trend sites. The main disadvantages of the method are: (1) that it doesn't take into account changes in population, emission, or meteorology; (2) the magnitude and direction of past trends are not necessarily good predictors of future trends; and, (3) the length of a continuous record does not ensure that data are of good quality throughout the time period.

Table 44 lists the NO_2 network sites, the total number of years the site has been in operation monitoring for NO_2, and the score associated with each monitor's ranking. Sites with greater than 30 years in operation received a 1, between 20 and 30 years received a 0.75, between 10 and 20 years received a 0.5, between 5 and 10 years received a 0.25, and less than 5 years monitored received a 0 (zero).

As shown in the table, both sites have been monitoring for greater than or equal to 30 years. Both sites would be considered the most valuable for the network objectives of trend tracking and emission reduction evaluation. Site 08 001 3001 is the Welby site, and site 08 031 0002 is the Denver – CAMP site.

Table 44. NO_2 Trends Impact Analysis Scores

AQS ID	Years in Operation	Score
08 031 0002	37	1.00
08 001 3001	34	1.00

2.4.3.6. Deviation from NAAQS

For this analysis, sites that measure design values that are very close to the NAAQS exceedance threshold are ranked higher than those sites with values well above or below it. Sites that are close to the threshold are considered more valuable for the purpose of determining NAAQS compliance, whereas sites well above or below do not provide as much information. The main advantage of this analysis is that it gives the ability to assess monitor importance for determining NAAQS compliance. The disadvantages of the analysis are: (1) if design values vary from year to year, historical data should be included in the analysis, and (2) care is needed in interpreting absolute differences. The objectives assessed by this analysis are regulatory compliance and forecasting assistance.

The technique is based on the difference between the standard and actual measurements. The design values are calculated as they apply to regulatory compliance. For NO_2, the values were calculated and compared to both the annual and 1-hour standards. The absolute value of the percent difference between the measured design value and the standard is used to score each monitor. Monitors having the smallest absolute percent difference rank as most important. Sites that were less than a 10% difference from the NAAQS received a 1, between 10 to 20% received a 0.75, between 20 to 30% received a 0.5, between 30 to 40% received a 0.25, and greater than 40% received a 0 (zero).

The maximum annual and 1-hour concentrations found in the 2004 through 2009 time period were used for the annual and 1-hour NAAQS comparisons at Welby (08 001 3001). Only the 2004 through 2007 data were used for the CAMP (08 031 0002) site, due to the QA issues mentioned earlier. The maximum value for the time period was used to show how far below the standard the sites are using the "worst" numbers for the time period in question. Table 45 and Table 46 list the analysis results and scores for the primary NO_2 standards.

Figure 32 and Figure 33 illustrate the results graphically, using the value of the absolute percent difference to mark the approximate monitor locations. Both monitoring sites in the network scored a zero on the annual NAAQS comparison, as the design values are well below the standard. The CAMP site scored a 1, and the Welby site a zero on the 1-hour NAAQS comparison, as they were close to the standard. The CAMP site would be considered more valuable than the Welby site based on the metrics of this analysis.

Figure 32. Deviation from NAAQS Annual NO_2 Standard Map

Table 45. Deviation from NAAQS Annual NO_2 Standard Analysis Scores

AQS ID	Annual Std. Design Value (ppm)	NAAQS Annual Std. Value (ppm)	Absolute Percent Difference	Score
*08 001 3001	0.015	0.053	72%	0.00
+08 031 0002	0.027	0.053	49%	0.00

* Indicates maximum value is for 2009

+ Indicates maximum value is for 2007

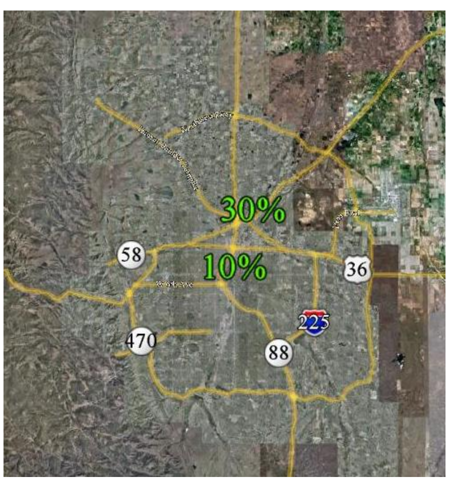


Figure 33. Deviation from NAAQS 1-hr NO_2 Standard Map

Table 46. Deviation from NAAQS 1-hr NO_2 Standard Analysis Scores

AQS ID	1-hr Std. Design Value (ppm)	NAAQS 1-Hr Std. Value (ppm)	Absolute Percent Difference	Score
+08 031 0002	0.090	0.1	10%	1.00
*08 001 3001	0.070	0.1	30%	0.50

* Indicates maximum value is for 2007-2009 time period

+ Indicates maximum value is for 2005-2007 time period

2.4.3.7. Area Served

For this analysis, sites are ranked based on their area of coverage. Calculating the area of representation of a particular monitor requires GIS software. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon area values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

This method gives the most weight to rural sites and those on the edges of urban areas or other monitor clusters. It addresses the network objectives of background concentration, spatial coverage and interpolation. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) it does not take into account population or emissions, and (3) it may artificially weight monitors at the edge of the analysis domain. The main advantages are: (1) the simplicity and quickness of performing the method, and (2) it gives weight to remote and urban boundary sites that are necessary for proper interpolation.

This analysis was not performed for the NO_2 monitoring network as there are only two sites in operation.

2.4.3.8. Monitor to Monitor Correlation

In this analysis, sites are ranked based on the correlation of their measured design values with those of the other monitors in the network. Monitors measuring concentrations that correlate well with concentrations at another monitor are considered redundant, and are consequently scored low. Monitors with concentrations that do not correlate with other monitored concentrations that are nearby are considered unique, and as such have more value for spatial monitoring objectives. These monitors are scored high. The advantages of this method are that it gives a measure of the site's uniqueness and representativeness, and that it is useful for identifying redundant sites. The disadvantages are that it requires large amounts of data with a high data completeness rate, and that the correlations are likely pollutant specific. The objectives assessed by this analysis are model evaluation, spatial coverage and interpolation.

Sites that do not correlate well with other sites have unique temporal concentration variation relative to other sites, and are likely to be important for assessing local emissions, transport and spatial coverage. It is assumed here that sites having an r-squared value of 0.6 or greater are well correlated. Sites having an r^2 value of 0.6 or higher when compared to the other NO_2 sites were counted. The analysis was scored as follows: sites correlating with zero or one sites at 0.6 or greater scored a one, those correlating with two other sites at 0.6 or greater scored a 0.75, those correlating with three other sites at 0.6 or greater scored a 0.5, those correlating with four other sites at 0.6 or greater scored a 0.25, and those correlating with five or more sites at 0.6 or greater scored a 0 (zero).

Site-to-site correlation coefficients and average relative differences have been calculated for the hourly nitric oxide concentrations at the CAMP and Welby monitors for 2004 through 2008. The r-squared value for these monitors is 0.40. The average relative difference is 1.40, which is very high. The score for this analysis would be a zero for both sites, as they do not correlate with each other.

Finally, site-to-site correlation coefficients and average relative differences have been calculated for the hourly nitrogen dioxide concentrations at the CAMP and Welby monitors for 2004 through 2008. The correlation coefficient for these monitors is 0.26. The average relative difference is 0.80, which is high. The score for this analysis would be a one for both sites, as they do not correlate with each other.

2.4.3.9. Measured Concentrations

For this analysis, sites are ranked based on the difference between the maximum pollutant concentrations measured and the value of the standard. The sites that measure high design values are ranked higher than those that measure low values. The objectives assessed by this analysis are maximum concentration location, model evaluation, regulatory compliance and population exposure. The main advantage of the technique is that it identifies key sites from a regulatory perspective, based on the maximum concentrations. The disadvantages are that it does not account for monitor-siting problems, and that is only focuses on high concentrations. Low concentration monitors may be useful for representing rural locations or background concentrations.

Sites that measure high design values are important for assessing NAAQS compliance and population exposure, and for performing model evaluations. The analysis is scored as follows: design values that are equal to or greater than 100% of the NAAQS are given a 1, values between 95 and 100% of the NAAQS receive a 0.75, values between 90 and 95% of the NAAQS received a 0.50, values between 80 and 90% of the NAAQS receive a 0.25, and values less than or equal to 80% of the NAAQS receive a 0 (zero).

Table 47 and Table 48 show the scores for the maximum design values recorded at each site, as well as the analysis scores and site rankings. Figure 34 and Figure 35 illustrate the results graphically, using the difference between the standard and the maximum annual NO_2 concentration (in ppb) to mark the approximate geographic locations of the monitors. Both sites scored zeros when maximum annual values were compared to the annual NAAQS. The CAMP site scored a 0.50 and the Welby site scored a 0.25 when compared to the 1-hour NAAQS.

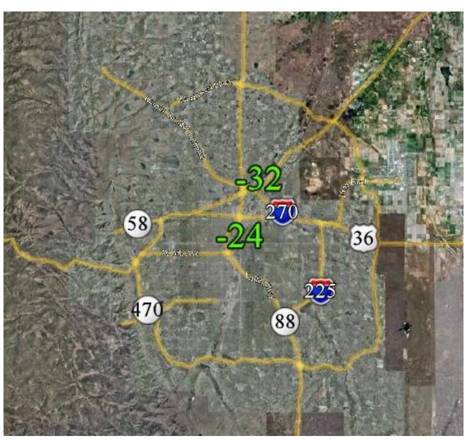


Figure 34. NO_2 Maximum Measured Concentration Annual Standard Map

Table 47. NO_2 Measured Concentration Annual Standard Analysis Scores

AQS ID	Maximum Annual Std. Design Value (ppm)	NAAQS Annual Std. Value (ppm)	%NAAQS	Score
*08 001 3001	0.021	0.053	40%	0.00
+08 031 0002	0.029	0.053	55%	0.00

* = Indicates annual average from 2004

+ = Indicates annual average from 2006

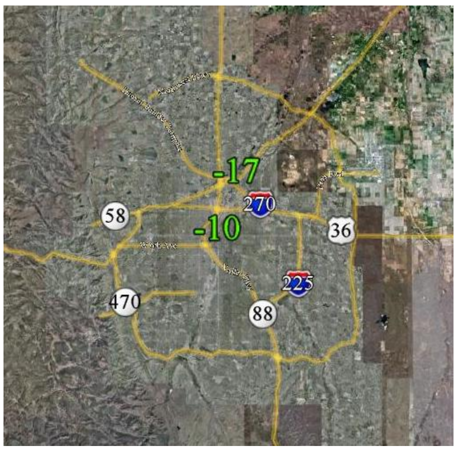


Figure 35. NO_2 Maximum Measured Concentration 1-hr Standard Map

Table 48. NO_2 Measured Concentration 1-hr Standard Analysis Scores

AQS ID	Maximum 1-hr Std. Design Value (ppm)	NAAQS 1-Hr Value (ppm)	% NAAQS	Score
08 031 0002	0.090	0.1	90%	0.50
08 001 3001	0.083	0.1	83%	0.25

* = Indicates 3-yr average from 2004-06

+ = Indicates 3-yr average from 2005-07

2.4.3.10. Summary/Conclusions and Recommendations

Table 49 is a summary of the scores from each network assessment analysis performed on the NO_2 monitoring network. Unlike the CO and O_3 results, the Welby site was not scored the highest in this assessment—the Denver – CAMP site was. This would indicate that this site was the most important for the purposes of this network analysis, and should be kept. Due to its location in the urban core, it is recommended that the CAMP site be retained. Also, to meet new monitoring requirements, additional near-roadway monitors will need to be added by 1/1/2013 in Denver and Colorado Springs. A downwind location with collocated NOx and O_3 monitors would also be beneficial for weight of evidence and modeling validations.

Table 49. NO_2 Network Analyses Score Summary

AQS ID	# Parameters Monitored	Population Served	Population Change	Emissions Inventory	Trends Impact	Deviation from Annual NAAQS	Deviation from 1-hr NAAQS	Area Served	Monitor to Monitor Correlation	Measured Concentration Difference from Annual NAAQS	Measured Concentration Difference from 1-hr NAAQS	*Total Score*
08 031 0002	0.50	N/A	N/A	N/A	1.00	0.00	1.00	N/A	1.00	0.00	0.50	***4.00***
08 001 3001	0.50	N/A	N/A	N/A	1.00	0.00	0.50	N/A	1.00	0.00	0.25	***3.25***

N/A = Score unavailable. Total score is affected.

Due to siting criteria issues, the monitor at Welby is being considered for removal/relocation to another site. The addition of NO_2 monitoring at Rocky Flats North has been suggested, as its continually high measured ozone concentrations make it a candidate for NOx monitoring for ozone weight of evidence and model verification. In addition, the reinstatement of ozone monitoring at the CAMP site would be a great benefit to the network for the same reasons. The addition of a NO_2 monitor at the DMAS NCore site to supplement the NOy monitor would also be beneficial for modeling purposes.

2.4.4. SO_2 Network

In the following sub-sections are the results of the network analyses performed for the SO_2 monitoring network. It is important to keep in mind the fact that the overall scores for some of the monitors may be artificially lowered since those sites could not be included in all of the analyses performed here. This is mainly due to a lack of usable data for the appropriate time periods.

The current primary NAAQS for sulfur dioxide is an annual mean not to exceed 0.03 ppm, with a 24-hour mean not to exceed 0.14 ppm (US EPA, 2009 ed.), while the secondary NAAQS is a 3-hour average not to exceed 0.5 ppm (US EPA, 2009 ed.). In June 2010, however, the EPA strengthened the primary NAAQS for SO_2. A new 1-hour standard of 75 ppb (0.075 ppm) was established, and the primary annual and 24-hour standards were revoked (US EPA, 2010). The EPA also changed the “form” of the new primary standard. The new form is the 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average concentrations (US EPA, 2010). A new secondary standard is currently being assessed.

2.4.4.1. Number of Parameters Monitored

This analysis was performed by counting the number of other parameters that are measured at the monitoring site. Sites having the most parameters measured are ranked the highest. Each monitoring instrument was counted as one parameter, meaning collocated monitors were counted individually. This analysis is valuable in that it addresses two of the APCD’s monitoring network purposes—model evaluation and source apportionment. Sites with collocated measurements of several pollutants are more cost-effective to keep in operation than those sites measuring only one parameter. The main advantage of this method is its simplicity to perform. The disadvantages of the method include: (1) it does not “weight” the measurements by pollutant, as some pollutant measurements may be more useful than others; and, (2) up-to-date information on the pollutants measured at particular sites can be difficult to acquire.

Table 50 lists the SO_2 network sites, the total number of parameters monitored at each site, and the score associated with each monitor’s ranking. Sites with greater than 20 parameters monitored received a 1, between 15 and 20 parameters received a 0.75, between 10 and 15 parameters received a 0.5, between 5 and 10 received a 0.25, and less than 5 parameters monitored received a 0 (zero).

As shown in the table, both of the sites monitor for greater than or equal to ten parameters. The site measuring 13 parameters would be considered the most valuable for the network objectives of emission inventory reconciliation and source apportionment. Site 08 031 0002 is the Denver – CAMP site.

Table 50. SO_2 Number of Parameters Monitored and Assessment Scores

AQS ID	Total Number of Parameters Monitored	Score
08 031 0002	13	0.50
08 001 3001	10	0.50

2.4.4.2. Population Served

It has been well established that large populations are associated with high emissions. For this analysis, sites are ranked based on the total number of people they represent. Calculating the population served by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the population within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was for 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas of high population and have large areas of representation. It addresses the network objectives of population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) small network densities give very little usable information, and (3) highly resolved population data may be difficult to work with. The main advantage is that it assesses the sites importance for population exposure.

This analysis was not performed for the SO_2 monitoring network as there are only two sites in operation, and the analysis is intended to be performed on a moderately sized or larger network.

2.4.4.3. Population Changed

As population rates increase so to do the potentials for emissions activity. For this analysis, sites are ranked based on the population increase in the area of representation. Calculating the population change by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the 2000 census-tract and latest block-group populations within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population change values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was from the 2000 census and from 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas with high rates of population growth and large areas of representation. It addresses the network objectives of maximum precursor location, population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) highly resolved population data may be difficult to work with, and (3) changing census boundaries make it difficult to compare populated areas over time. The main advantages are: (1) the flexibility of the method, (2) that it assesses the sites importance for population exposure, (3) its helpfulness in determining where monitoring may be required in the future, and (4) its aid in identifying monitors near which emissions may have substantially changed.

This analysis was not performed for the SO_2 monitoring network as there are only two sites in operation.

2.4.4.4. Emissions Inventory

Emission inventory data are used to find locations where emissions of pollutants of concern are concentrated. These locations are then compared to the current network and proposed new monitoring sites to determine if the network captures the areas of maximum emissions. The emissions inventory data used in this report are from the 2007 emissions inventory, as the 2008 inventory was not yet completed at the time of this report.

For this analysis a gridded emission inventory for the State was mapped out. It was then overlain on the Thiessen polygon map generated for other analyses. From there, the point sources (and their associated emissions data) that were within each polygon were used to calculate the emissions density in tons per year per square mile (TPY/mi^2). The area source emissions, including vehicle emissions, were not included in the emissions sums for this analysis. Only the sums of the point source emissions were used. The sum of the total point source emissions in each polygon was divided by the area of the polygon. The distances from each point source to the monitor were then used to calculate an average distance from the monitor to the point sources. This average distance was used to rank the monitors based on their average proximity to the point sources. Sites with a five mile or less distance received a 1, between 5 and 10 miles received a 0.75, between 10 and 20 miles received a 0.5, between 20 and 30 miles received a 0.25 and a distance greater than or equal to 30 miles received a 0 (zero).

Sites scoring a one indicate areas that are adequately monitored, and not in need of any immediate changes. Sites scoring a zero indicate areas that may need additional monitors. One advantage of this method is that it is scalable in complexity and spatial resolution. In addition, it helps in finding areas where primary pollutant concentrations are high. The disadvantages include: (1) emission inventory data are not always current or may be incomplete or inaccurate, (2) emission inventory quality varies by pollutant and source type, (3) more useful high resolution emission inventory data are not readily available and difficult to produce, and (4) the method does not account for pollutant transport. The objectives assessed by this technique are emission reduction evaluation and maximum precursor location.

The emissions inventory for SO_2 can be seen in Figure 36. As there are only 2 active SO_2 sites in the monitoring network, no Thiessen Polygons were created, and therefore the Emissions Inventory Analysis for this parameter cannot be performed in the same manner as the CO and O_3 emissions analyses were.

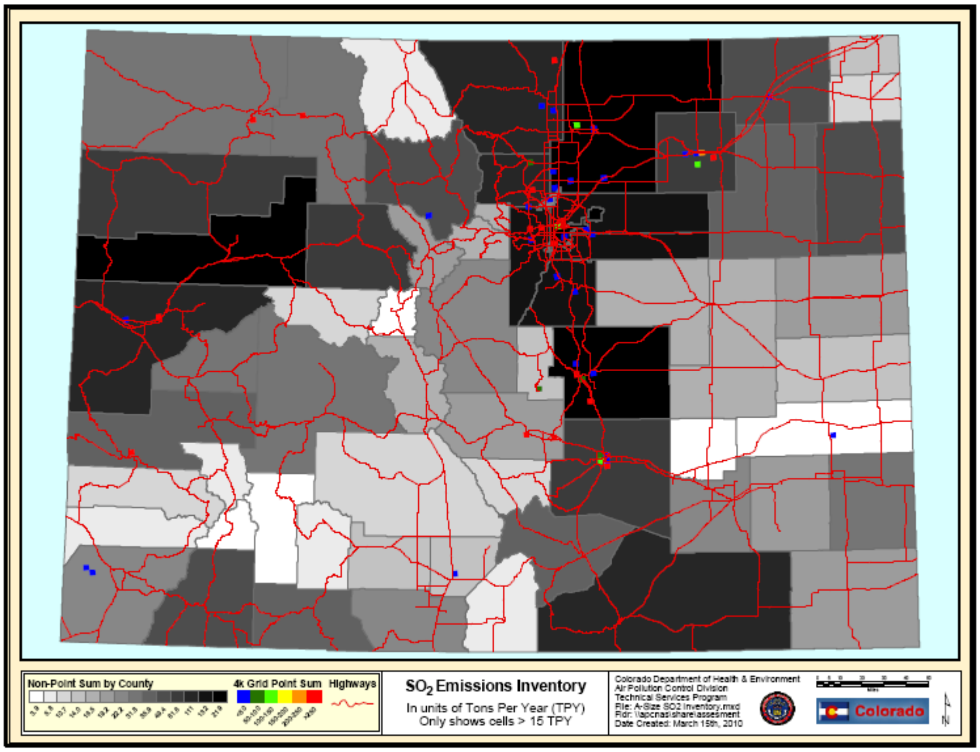


Figure 36. **SO_2 Emissions Inventory Map**

2.4.4.5. Trends Impact

This analysis was performed by ranking the sites based on the length of the continuous measurement record of the pollutant of interest. Sites that have a long historical record are very valuable for tracking pollutant trends, and therefore have the most importance according to this assessment technique. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—trend tracking and emission reduction evaluation. In addition, it provides a measure of the historical consistency of the data sets generated. The main advantages of this method are its simplistic analytical approach, and its usefulness for identifying long-term trend sites. The main disadvantages of the method are: (1) that it doesn't take into account changes in population, emission, or meteorology; (2) the magnitude and direction of past trends are not necessarily good predictors of future trends; and, (3) the length of a continuous record does not ensure that data are of good quality throughout the time period.

Table 51 lists the SO_2 network sites, the total number of years the site has been in operation monitoring for SO_2, and the score associated with each monitor's ranking. Sites with greater than 30 years in operation received a 1, between 20 and 30 years received a 0.75, between 10 and 20 years received a 0.5, between 5 and 10 years received a 0.25, and less than 5 years monitored received a 0 (zero).

As shown in the table, both sites have been monitoring for greater than or equal to 30 years. Both sites would be considered the most valuable for the network objectives of trend tracking and emission reduction evaluation. Site 08 001 3001 is the Welby site, and site 08 031 0002 is the Denver – CAMP site.

Table 51. **SO_2 Trends Impact Analysis Scores**

AQS ID	Years in Operation	Score
08 031 0002	43	1.00
08 001 3001	37	1.00

2.4.4.6. Deviation from NAAQS

For this analysis, sites that measure design values that are very close to the NAAQS exceedance threshold are ranked higher than those sites with values well above or below it. Sites that are close to the threshold are considered more valuable for the purpose of determining NAAQS compliance, whereas sites well above or below do not provide as much information. The main advantage of this analysis is that it gives the ability to assess monitor importance for determining NAAQS compliance. The disadvantages of the analysis are: (1) if design values vary from year to year, historical data should be included in the analysis, and (2) care is needed in interpreting absolute differences. The objectives assessed by this analysis are regulatory compliance and forecasting assistance.

The technique is based on the difference between the standard and actual measurements. The design values are calculated as they apply to regulatory compliance. For SO_2, the values were calculated and compared to the annual, 24-hour and 3-hour standards. The absolute value of the percent difference between the measured design value and the standard is used to score each monitor. Monitors having the smallest absolute percent difference rank as most important. Sites that were less than a 10% difference from the NAAQS received a 1, between 10 to 20% received a 0.75, between 20 to 30% received a 0.5, between 30 to 40% received a 0.25, and greater than 40% received a 0 (zero).

The maximum annual, 24-hour and 3-hour concentrations found in the 2004 to 2009 time period were used for the NAAQS comparisons at the Welby site (08 001 3001). The maximum annual, 24-hour and 3-hour concentrations found in the 2004 through 2007 time period were used for NAAQS comparisons at the CAMP (08 031 0002) site, as there were QA problems with the 2008 and 2009 data sets. The maximum value for the time period was used to show how far below the standard the sites are using the “worst” numbers for the six year period in question. Table 52, Table 53 and Table 54 list the analysis results and scores for the primary and secondary SO_2 standards. Figure 37, Figure 38, and Figure 39 illustrate the results graphically, using the value of the absolute percent difference to mark the approximate geographic location of the monitors. Both sites scored zeros on all three parts of the analysis, as they are all well below the level of the current SO_2 standards.

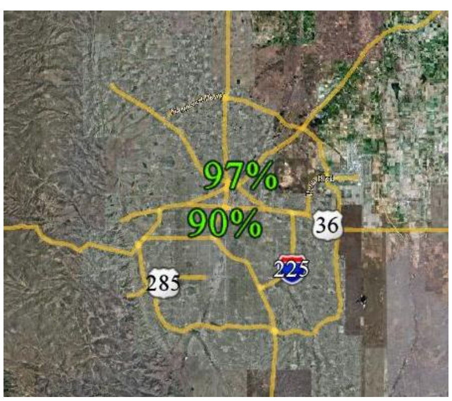


Figure 37. Deviation from NAAQS Annual SO_2 Standard Map

Table 52. Deviation from NAAQS Annual SO_2 Standard Analysis Scores

AQS ID	Annual Std. Design Value (ppm)	NAAQS Annual Std. Value (ppm)	Absolute Percent Difference	Score
*08 001 3001	0.001	0.030	97%	0.00
+08 031 0002	0.003	0.030	90%	0.00

* = Indicates annual value is from 2009

+ = Indicates annual value is from 2007

Figure 38. **Deviation from NAAQS 24-hr SO_2 Standard Map**

Table 53. **Deviation from NAAQS 24-hr SO_2 Standard Analysis Scores**

AQS ID	Max 24-hr Std. Design Value (ppm)	NAAQS 24-hr Std. Value (ppm)	Absolute Percent Difference	Score
*08 001 3001	0.01	0.14	93%	0.00
+08 031 0002	0.01	0.14	93%	0.00

* = Indicates annual value is from 2009

+ = Indicates annual value is from 2007

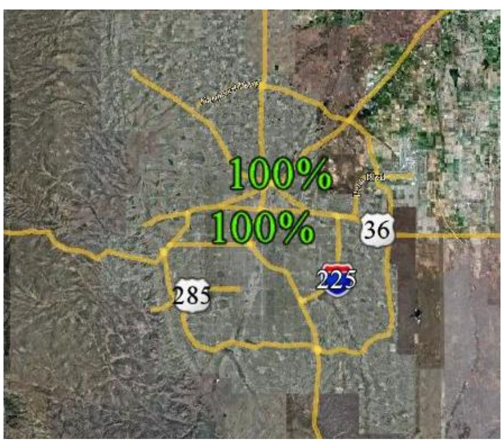


Figure 39. **Deviation from NAAQS 3-hr SO_2 Standard Map**

Table 54. **Deviation from NAAQS 3-hr SO_2 Standard Analysis Scores**

AQS ID	Max 3-hr Std. Design Value (ppm)	NAAQS 3-hr Std. Value (ppm)	Absolute Percent Difference	Score
*08 001 3001	0.0	0.5	100%	0.00
+08 031 0002	0.0	0.5	100%	0.00

* = Indicates annual value is from 2009

+ = Indicates annual value is from 2007

2.4.4.7. Area Served

For this analysis, sites are ranked based on their area of coverage. Calculating the area of representation of a particular monitor requires GIS software. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon area values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

This method gives the most weight to rural sites and those on the edges of urban areas or other monitor clusters. It addresses the network objectives of background concentration, spatial coverage and interpolation. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) it does not take into account population or emissions, and (3) it may artificially weight monitors at the edge of the analysis domain. The main advantages are: (1) the simplicity and quickness of performing the method, and (2) it gives weight to remote and urban boundary sites that are necessary for proper interpolation.

This analysis was not performed for the SO_2 monitoring network as there are only two sites in operation.

2.4.4.8. Monitor to Monitor Correlation

In this analysis, sites are ranked based on the correlation of their measured design values with those of the other monitors in the network. Monitors measuring concentrations that correlate well with concentrations at another monitor are considered redundant, and are consequently scored low. Monitors with concentrations that do not correlate with other monitored concentrations that are nearby are considered unique, and as such have more value for spatial monitoring objectives. These monitors are scored high. The advantages of this method are that it gives a measure of the site's uniqueness and representativeness, and that it is useful for identifying redundant sites. The disadvantages are that it requires large amounts of data with a high data completeness rate, and that the correlations are likely pollutant specific. The objectives assessed by this analysis are model evaluation, spatial coverage and interpolation.

Sites that do not correlate well with other sites have unique temporal concentration variation relative to other sites, and are likely to be important for assessing local emissions, transport and spatial coverage. It is assumed here that sites having an r-squared value of 0.6 or greater are well correlated. Sites having an r^2 value of 0.6 or higher when compared to the other SO_2 sites were counted. The analysis was scored as follows: sites correlating with zero or one sites at 0.6 or greater scored a one, those correlating with two other sites at 0.6 or greater scored a 0.75, those correlating with three other sites at 0.6 or greater scored a 0.5, those correlating with four other sites at 0.6 or greater scored a 0.25, and those correlating with five or more sites at 0.6 or greater scored a 0 (zero).

Site-to-site correlation coefficients and average relative differences have been calculated for the hourly sulfur dioxide concentrations at the CAMP and Welby monitors for 2004 through 2008. The r-squared value for these monitors is 0.09, which is very low. The average relative difference is 1.46, which is very high. This makes sense given the localized nature of SO_2 sources and plumes. The score for this analysis would be a one, as the sites did not correlate.

2.4.4.9. Measured Concentrations

For this analysis, sites are ranked based on the difference between the maximum pollutant concentrations measured and the value of the standard. The sites that measure high design values are ranked higher than those that measure low values. The objectives assessed by this analysis are maximum concentration location, model evaluation, regulatory compliance and population exposure. The main advantage of the technique is that it identifies key sites from a regulatory perspective, based on the maximum concentrations. The disadvantages are that it does not account for monitor-siting problems, and that is only focuses on high concentrations. Low concentration monitors may be useful for representing rural locations or background concentrations.

Sites that measure high design values are important for assessing NAAQS compliance and population exposure, and for performing model evaluations. The analysis is scored as follows: design values that are equal to or greater than 100% of the NAAQS are given a 1, values between 95 and 100% of the NAAQS receive a 0.75, values between 90 and 95% of the NAAQS received a 0.5, values between 80 and 90% of the NAAQS receive a 0.25, and values less than or equal to 80% of the NAAQS receive a 0 (zero).

Table 55, Table 56 and Table 57 show the scores for the maximum design values recorded at each site, as well as the analysis scores and site rankings. Figure 40, Figure 41 and Figure 42 illustrate the results graphically, using the value of the difference between the standard and design values to mark the approximate geographic location of the monitors. Both sites in the network scored zeros for all three parts of this analysis because their design values are much lower than the level of the SO_2 standards.

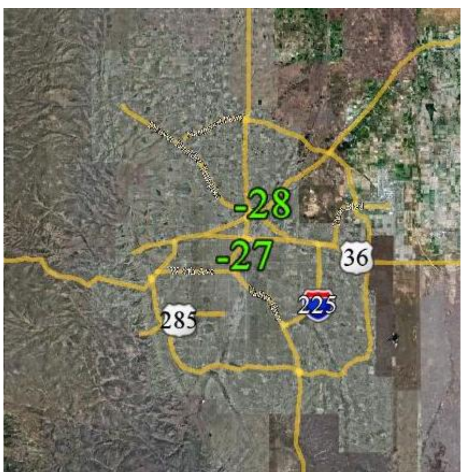


Figure 40. SO_2 Maximum Measured Concentration Annual Standard Map

Table 55. SO_2 Measured Concentration Annual Standard Analysis Scores

AQS ID	Max Annual Std. Design Value (ppm)	NAAQS Annual Std. Value (ppm)	%NAAQS	Score
*08 001 3001	0.002	0.030	7%	0.00
+08 031 0002	0.003	0.030	10%	0.00

* = Indicates annual design value from 2008
+ = Indicates annual design value from 2007

Figure 41. SO_2 Maximum Measured Concentration 24-hr Standard Map

Table 56. SO_2 Measured Concentration 24-hr Standard Analysis Scores

AQS ID	Max 24-Hr Std. Design Value (ppm)	NAAQS 24-hr Std. Value (ppm)	%NAAQS	Score
*08 001 3001	0.02	0.14	14%	0.00
+08 031 0002	0.02	0.14	14%	0.00

* = Indicates annual design value from 2007
+ = Indicates annual design value from 2004

Figure 42. SO_2 Maximum Measured Concentration 3-hr Standard Map

Table 57. SO_2 Measured Concentration 3-hr Standard Analysis Scores

AQS ID	Max 3-Hr Std. Design Value (ppm)	NAAQS 3-hr Std. Value (ppm)	%NAAQS	Score
*08 001 3001	0.1	0.5	20%	0.00
+08 031 0002	0.0	0.5	0%	0.00

* = Indicates annual design value from 2007
+ = Indicates annual design value from 2007

2.4.4.10. Summary/Conclusions and Recommendations

Table 58 lists the scoring results for the network analyses performed on the SO_2 monitoring network. As with all the previous analyses for the gaseous parameters, the Welby site again scored the highest of those sites in the monitoring network. The CAMP site was again affected by the loss of a large portion of its continuous data set due to QA issues. Pending new monitoring requirements for SO_2, it is not recommended that the number of monitors be reduced at this time.

Table 58. SO_2 Network Analyses Score Summary

AQS ID	# Parameters Monitored	Population Served	Population Change	Emissions Inventory	Trends Impact	Deviation from Annual NAAQS	Deviation from 24-hr NAAQS	Deviation from 3-hr NAAQS	Area Served	Monitor to Monitor Correlation	Measured Concentration Difference from Annual NAAQS	Measured Concentration Difference from 24-hr NAAQS	Measured Concentration Difference from 3-hr NAAQS	*Total Score*
08 001 3001	0.50	N/A	N/A	N/A	1.00	0.00	0.00	0.00	N/A	1.00	0.00	0.00	0.00	***2.50***
08 031 0002	0.50	N/A	N/A	N/A	1.00	0.00	0.00	0.00	N/A	1.00	0.00	0.00	0.00	***2.50***

N/A = Score unavailable. Total score is affected.

2.4.5. PM_{10} Network

In the following sub-sections are the results of the network analyses performed for the PM_{10} monitoring network. It is important to keep in mind the fact that the overall scores for some of the monitors may be artificially lowered since those sites could not be included in all of the analyses performed here. This is mainly due to a lack of usable data for the appropriate time periods.

The primary and secondary NAAQS for PM_{10} is a 24-hour average of less than 150 $\mu g/m^3$ (US EPA, 2009 ed.). The standard is attained when the number of days per year that the PM_{10} concentration exceeds 150 $\mu g/m^3$ is equal to or less than 1.

2.4.5.1. Number of Parameters Monitored

This analysis was performed by counting the number of other parameters that are measured at the monitoring site. Sites having the most parameters measured are ranked the highest. Each monitoring instrument was counted as one parameter, meaning collocated monitors were counted individually. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—model evaluation and source apportionment. Sites with collocated measurements of several pollutants are more cost-effective to keep in operation than those sites measuring only one parameter. The main advantage of this method is its simplicity to perform. The disadvantages of the method include: (1) it does not "weight" the measurements by pollutant, as some pollutant measurements may be more useful than others; and, (2) up-to-date information on the pollutants measured at particular sites can be difficult to acquire, (3) PM_{10} is usually a local pollutant, meaning the sources are nearby and the emissions generally do not travel far, especially during winter temperature inversions. However, the opposite is true during regional dust storms, which are natural events that cannot be controlled. Even during large regional dust storms sites only one mile apart can measure significantly different concentrations due to the nature of blowing dust plumes.

Table 59 lists the PM_{10} network sites, the total number of parameters monitored at each site, and the score associated with each monitor's ranking. Sites with greater than 20 parameters monitored received a 1, between 15 and 20 parameters received a 0.75, between 10 and 15 parameters received a 0.5, between 5 and 10 received a 0.25, and less than 5 parameters monitored received a 0 (zero).

As shown in the table, three of the sites monitor for greater than or equal to ten parameters. The site measuring 21 parameters would be considered the most valuable for the network objectives of emission inventory reconciliation and source apportionment. Site 08 031 0025 is the NCore site at the Denver Municipal Animal Shelter.

Table 59. PM_{10} Number of Parameters Monitored and Assessment Scores

AQS ID	Total Number of Parameters Monitored	Score	AQS ID	Total Number of Parameters Monitored	Score
08 031 0025	21	1.00	08 003 0001	1	0.00
08 031 0002	13	0.50	08 003 0003	1	0.00
08 001 3001	10	0.50	08 007 0001	1	0.00
08 001 0006	9	0.25	08 029 0004	1	0.00
08 045 0007	7	0.25	08 031 0017	1	0.00
08 077 0017	6	0.25	08 043 0003	1	0.00
08 069 0009	4	0.00	08 045 0005	1	0.00
08 013 0003	3	0.00	08 051 0007	1	0.00
08 041 0017	3	0.00	08 067 0004	1	0.00
08 097 0006	3	0.00	08 077 0019	1	0.00
08 123 0006	3	0.00	08 099 0001	1	0.00
08 013 0012	2	0.00	08 099 0002	1	0.00
08 051 0004	2	0.00	08 107 0003	1	0.00
08 101 0012	2	0.00	08 113 0004	1	0.00
08 003 0001	1	0.00	08 117 0002	1	0.00
08 003 0003	1	0.00	08 003 0001	1	0.00
08 007 0001	1	0.00	08 003 0003	1	0.00
08 029 0004	1	0.00			

2.4.5.2. Population Served

It has been well established that large populations are associated with high emissions. For this analysis, sites are ranked based on the total number of people they represent. Calculating the population served by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the population within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was for 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas of high population and have large areas of representation. It addresses the network objectives of population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) small network densities give very little usable information, and (3) highly resolved population data may be difficult to work with. The main advantage is that it assesses the sites importance for population exposure.

Figure 43 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction sites in the west to the Lamar sites in the east, and from the Fort Collins sites in the north to the

Pagosa Springs and Durango sites in the southwest. The dots mark the locations of the PM_{10} network monitors, and the red lines mark the highways in the area.

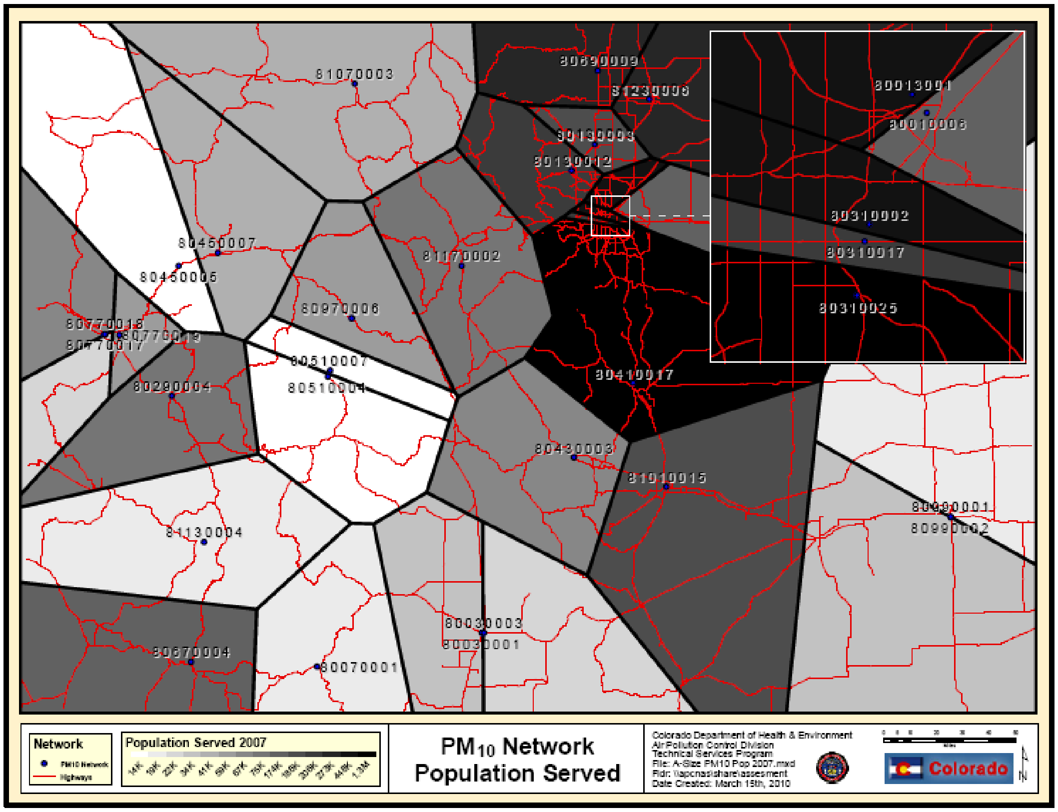


Figure 43. **PM_{10} Population Served Map**

Table 60 lists the PM_{10} network sites, the total number of people served in the monitoring area, and the score associated with each monitor's ranking. Sites serving 400,000 people or greater received a 1, between 300,000 and 399,999 people received a 0.75, between 200,000 and 299,999 people received a 0.5, between 100,000 and 199,999 people received a 0.25 and less than 100,000 people received a 0 (zero).

As shown in the table and the figure, three sites serve populations of greater than or equal to 400,000 people. The site serving 1,308,013 people would be considered to be the most valuable for the network objective of population exposure. Site 08 031 0025 is the NCore site at the Denver Municipal Animal Shelter. Since PM_{10} is a local pollutant, the large areas of representation served by each polygon are far too large to be representative of PM_{10} exposure. This makes the Population Served analysis method a weak test of PM_{10} network worth.

Table 60. PM_{10} Population Served Analysis Scores

AQS ID	2007 Population	Score	AQS ID	2007 Population	Score
08 001 3001	1,308,013	1.00	08 043 0003	63,786	0.00
08 031 0025	637,269	1.00	08 045 0005	59,251	0.00
08 041 0017	448,195	1.00	08 045 0007	47,243	0.00
08 031 0002	305,946	0.75	08 051 0004	40,648	0.00
08 013 0012	273,407	0.50	08 051 0007	40,636	0.00
08 069 0009	244,765	0.50	08 067 0004	33,815	0.00
08 123 0006	206,357	0.50	08 077 0017	27,387	0.00
08 001 0006	196,866	0.25	08 077 0019	19,821	0.00
08 013 0003	186,281	0.25	08 097 0006	19,412	0.00
08 031 0017	178,727	0.25	08 099 0001	15,168	0.00
08 101 0015	174,422	0.25	08 099 0002	14,857	0.00
08 003 0001	75,799	0.00	08 107 0003	14,196	0.00
08 003 0003	74,787	0.00	08 113 0004	10,257	0.00
08 007 0001	70,840	0.00	08 117 0002	3,549	0.00
08 029 0004	66,633	0.00			

2.4.5.3. Population Change

As population rates increase so to do the potentials for emissions activity. For this analysis, sites are ranked based on the population increase in the area of representation. Calculating the population change by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the 2000 census-tract and latest block-group populations within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population change values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was from the 2000 census and from 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas with high rates of population growth and large areas of representation. It addresses the network objectives of maximum precursor location, population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) highly resolved population data may be difficult to work with, and (3) changing census boundaries make it difficult to compare populated areas over time. The main advantages are: (1) the flexibility of the method, (2) that it assesses the sites importance for population exposure, (3) its helpfulness in determining where monitoring may be required in the future, and (4) its aid in identifying monitors near which emissions may have substantially changed.

Figure 44 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction sites in the west to the Lamar sites in the east, and from the Fort Collins sites in the north to the Pagosa Springs site in the southwest. The dots mark the locations of the PM_{10} network monitors, and the red lines mark the highways in the area.

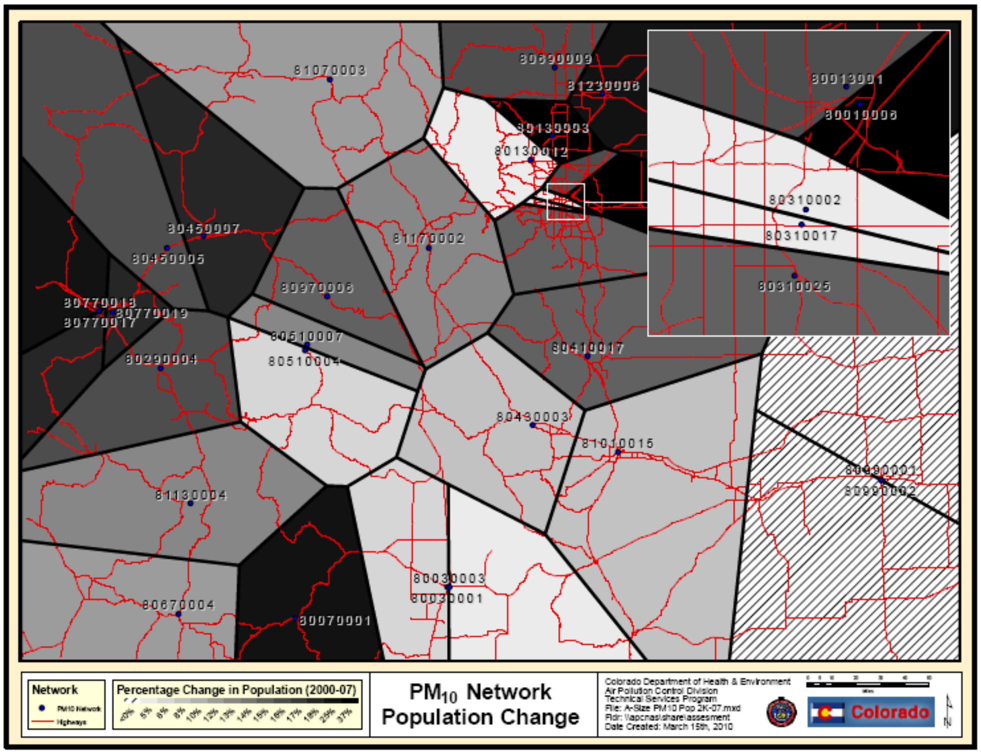


Figure 44. PM_{10} Population Change Map

Table 61 lists the PM_{10} network sites, the total population change from 2000 to 2007 in the monitoring area, and the score associated with each monitor's ranking. Sites with a 40 percent or greater change received a 1, between 30 and 39 percent received a 0.75, between 20 and 29 percent received a 0.5, between 10 and 19 percent received a 0.25 and less than 10 percent received a 0 (zero).

As shown in the table and the figure, no sites serve an area that experienced a population change of 40 percent or greater. The site with a 36 percent increase in population would be considered to be the most valuable for the network objective of population exposure. Site 08 001 0006 is the Alsup Elementary School – Commerce City site. Again, PM_{10} is a local pollutant during inversions and most of these polygons represent very large areas. Also, there is very complex terrain in the mountain areas of the state. Thus, the Thiessen Polygon Method is a weak indicator of network value for PM_{10}.

Table 61. PM_{10} Population Change Analysis Scores

AQS ID	% Population Change	Score	AQS ID	% Population Change	Score
08 001 0006	36%	0.75	08 051 0007	13%	0.25
08 013 0003	27%	0.50	08 113 0004	12%	0.25
08 007 0001	24%	0.50	08 067 0004	12%	0.25
08 123 0006	22%	0.50	08 107 0003	10%	0.25
08 045 0007	19%	0.25	08 101 0015	8%	0.00
08 077 0017	17%	0.25	08 043 0003	7%	0.00
08 077 0019	17%	0.25	08 051 0004	6%	0.00
08 069 0009	16%	0.25	08 003 0001	5%	0.00
08 029 0004	16%	0.25	08 003 0003	5%	0.00
08 001 3001	16%	0.25	08 031 0002	4%	0.00
08 045 0005	15%	0.25	08 031 0017	2%	0.00
08 097 0006	15%	0.25	08 013 0012	2%	0.00
08 041 0017	15%	0.25	08 099 0001	-4%	0.00
08 031 0025	14%	0.25	08 099 0002	-4%	0.00
08 117 0002	13%	0.25			

2.4.5.4. Emissions Inventory

Emission inventory data are used to find locations where emissions of pollutants of concern are concentrated. These locations are then compared to the current network and proposed new monitoring sites to determine if the network captures the areas of maximum emissions. The emissions inventory data used in this report are from the 2007 emissions inventory, as the 2008 inventory was not yet completed at the time of this report.

For this analysis a gridded emission inventory for the State was mapped out. It was then overlain on the Thiessen polygon map generated for other analyses. From there, the point sources (and their associated emissions data) that were within each polygon were used to calculate the emissions density in tons per year per square mile (TPY/mi^2). The area source emissions, including vehicle emissions, were not included in the emissions sums for this analysis. Only the sums of the point source emissions were used. The sum of the total point source emissions in each polygon was divided by the area of the polygon. The distances from each point source to the monitor were then used to calculate an average distance from the monitor to the point sources. This average distance was used to rank the monitors based on their average proximity to the point sources. Sites with a five mile or less distance received a 1, between 5 and 10 miles received a 0.75, between 10 and 20 miles received a 0.5, between 20 and 30 miles received a 0.25 and a distance greater than or equal to 30 miles received a 0 (zero).

Sites scoring a one indicate areas that are adequately monitored, and not in need of any immediate changes. Sites scoring a zero indicate areas that may need additional monitors. One advantage of this method is that it is scalable in complexity and spatial resolution. In addition, it helps in finding areas where primary pollutant concentrations are high. The disadvantages include: (1) emission inventory data are not always current or may be incomplete or inaccurate, (2) emission inventory quality varies by pollutant and source type, (3) more useful high resolution emission inventory data are not readily available and difficult to produce, (4) the method does not account for pollutant transport, (5) point sources do not always account for the majority of PM_{10} emissions at a monitor (area sources, mobile sources, and fugitive dust sources can often be much higher than point sources), and (6) most of the polygons are far too large to represent PM_{10} emissions, especially given complex terrain in the mountain areas. PM_{10} emissions are usually quite local and atmospheric retention time is usually quite short, thus PM_{10} is not well represented by a single monitor within a large polygon area. The objectives assessed by this technique are emission reduction evaluation and maximum precursor location.

The emissions inventory map for PM_{10} can be seen in Figure 45. It shows PM_{10} emissions point sources in a four kilometer gridded scale (colored squares), as well as the non-point source emissions (black and white) by county. The majority of the PM_{10} emissions point and mobile sources lie in the Front Range area.

As shown in Table 62, there are three sites with an average distance between the monitor and the point sources of less than five miles. The high scores and low average distance from the PM_{10} monitors to the point sources indicate that these areas are monitored well based on the precursor source locations. The top scoring site for this analysis was the Grand Junction – Powell Building site.

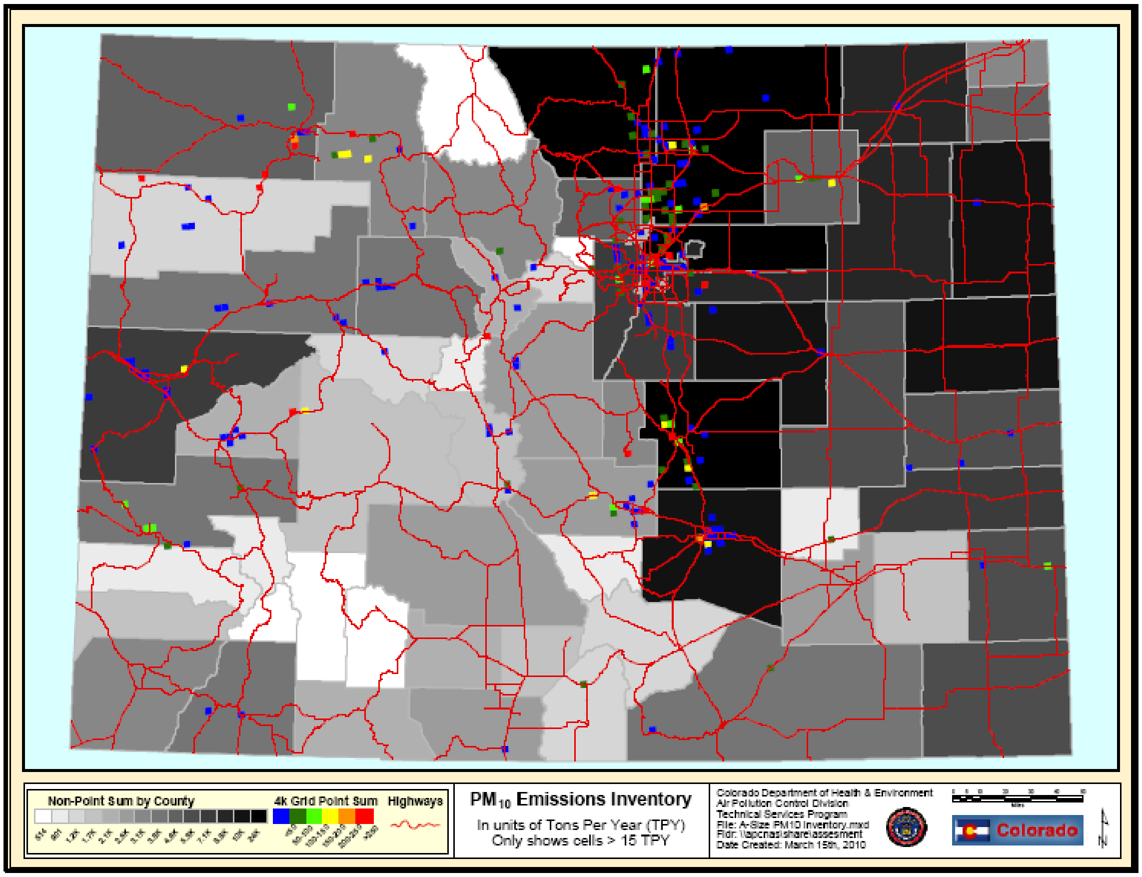


Figure 45. **PM_{10} Emissions Inventory Map**

Table 62. PM_{10} Emissions Inventory Analysis Scores

AQS ID	Sum Emissions (TPY)	Polygon Area (mi^2)	Emissions Density (TPY/mi^2)	Avg. Dist. from Point Sources to Monitor (mi)	Score
08 077 0017	76	1,161	0.1	4	1.00
08 031 0002	307	79	3.9	4	1.00
08 031 0017	157	55	2.9	4	1.00
08 077 0019	306	659	0.5	6	0.75
08 045 0005	1,258	4,999	0.3	7	0.75
08 001 3001	550	282	1.9	8	0.75
08 013 0003	1,613	650	2.5	10	0.50
08 069 0009	794	2,188	0.4	10	0.50
08 031 0025	793	1,986	0.4	12	0.50
08 013 0012	371	1,637	0.2	12	0.50
08 007 0001	40	3,506	0.0	12	0.50
08 041 0017	1,696	4,924	0.3	13	0.50
08 001 0006	3,018	2,599	1.2	14	0.50
08 043 0003	1,073	3,805	0.3	15	0.50
08 029 0004	701	3,121	0.2	17	0.50
08 045 0007	13,024	3,531	3.7	19	0.50
08 117 0002	1,732	3,850	0.4	22	0.25
08 101 0015	1,125	7,816	0.1	24	0.25
08 051 0004	558	3,155	0.2	25	0.25
08 003 0001	113	2,847	0.0	26	0.25
08 067 0004	170	4,429	0.0	27	0.25
08 097 0006	242	2,339	0.1	30	0.00
08 051 0007	5	949	0.0	33	0.00
08 107 0003	2,088	6,705	0.3	42	0.00
08 113 0004	114	5,001	0.0	42	0.00
08 099 0002	112	7,764	0.0	42	0.00
08 123 0006	1,740	10,374	0.2	44	0.00
08 003 0003	190	4,010	0.0	49	0.00
08 099 0001	411	8,624	0.0	52	0.00

2.4.5.5. Trends Impact

This analysis was performed by ranking the sites based on the length of the continuous measurement record of the pollutant of interest. Sites that have a long historical record are very valuable for tracking pollutant trends, and therefore have the most importance according to this assessment technique. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—trend tracking and emission reduction evaluation. In addition, it provides a measure of the historical consistency of the data sets generated. The main advantages of this method are its simplistic analytical approach, and its usefulness for identifying long-term trend sites. The main disadvantages of the method are: (1) that it doesn't take into account changes in population, emission, or meteorology; (2) the magnitude and direction of past trends are not necessarily good predictors of future trends; and, (3) the length of a continuous record does not ensure that data are of good quality throughout the time period.

Table 63 lists the PM_{10} network sites, the total number of years the site has been in operation monitoring for PM_{10}, and the score associated with each monitor's ranking. Sites with greater than 30 years in operation received a 1, between 20 and 30 years received a 0.75, between 10 and 20 years received a 0.5, between 5 and 10 years received a 0.25, and less than 5 years monitored received a 0 (zero).

As shown in the table, no sites have been monitoring for greater than or equal to 30 years, and eleven sites have been monitoring for between 20 and 29 years. The site in operation for 27 years would be considered the most valuable for the network objectives of trend tracking and emission reduction evaluation. Site 08 029 0004 is the Delta – Health Department site.

Table 63. PM_{10} Trends Impact Analysis Scores

AQS ID	Years in Operation	Score	AQS ID	Years in Operation	Score
08 029 0004	27	0.75	08 045 0005	10	0.50
08 013 0003	25	0.75	08 001 0006	9	0.25
08 031 0002	24	0.75	08 007 0001	9	0.25
08 051 0004	23	0.75	08 003 0003	8	0.25
08 099 0001	23	0.75	08 067 0004	8	0.25
08 099 0002	23	0.75	08 097 0006	8	0.25
08 107 0003	23	0.75	08 043 0003	6	0.25
08 123 0006	23	0.75	08 031 0025	5	0.25
08 003 0001	21	0.75	08 045 0007	5	0.25
08 001 3001	20	0.75	08 051 0007	5	0.25
08 113 0004	20	0.75	08 077 0017	5	0.25
08 031 0017	18	0.50	08 041 0017	3	0.00
08 117 0002	18	0.50	08 077 0019	3	0.00
08 013 0012	16	0.50	08 101 0015	1	0.00
08 069 0009	11	0.50			

2.4.5.6. Deviation from NAAQS

For this analysis, sites that measure design values that are very close to the NAAQS exceedance threshold are ranked higher than those sites with values well above or below it. Sites that are close to the threshold are considered more valuable for the purpose of determining NAAQS compliance, whereas sites well above or below do not provide as much information. The main advantage of this analysis is that it gives the ability to assess monitor importance for determining NAAQS compliance. The disadvantages of the analysis are: (1) if design values vary from year to year, historical data should be included in the analysis, and (2) care is needed in interpreting absolute differences. The objectives assessed by this analysis are regulatory compliance and forecasting assistance.

The technique is based on the difference between the standard and actual measurements. The design values are calculated as they apply to regulatory compliance. For PM_{10}, the values were calculated and compared to the 24-hour standard. It should be noted that these values may include data from natural events that at this time have not received concurrence from EPA, which skews the results high. The absolute value of the percent difference between the measured design value and the standard is used to score each monitor. Monitors having the smallest absolute percent difference rank as most important. Sites that were less than a 10% difference from the NAAQS received a 1, between 10 to 20% received a 0.75, between 20 to 30% received a 0.5, between 30 to 40% received a 0.25, and greater than 40% received a 0 (zero).

The maximum 24-hour concentrations found in the 2004 to 2009 time period were used for the NAAQS comparisons. The maximum value for the time period was used to show a “worst case scenario” for the six year period in question. Table 64 lists the analysis results and scores for the primary PM_{10} standard. Figure 46 illustrates the results graphically, using the value of the absolute percent difference to mark the approximate geographic locations of the monitors. Only two sites received a score of one in this analysis, making them the most valuable according to the metrics for this analysis.

Figure 46. Deviation from NAAQS 24-hr PM_{10} Standard Map

Table 64. Deviation from NAAQS 24-hr PM_{10} Standard Analysis Scores

AQS ID	Max 24-hr Std. Design Value ($\mu g/m^3$)*	NAAQS Standard Value ($\mu g/m^3$)	Absolute Percent Difference	Score
08 077 0019	147	150	2%	1.00
08 003 0003	157	150	5%	1.00
08 113 0004	130	150	13%	0.75
08 099 0002	176	150	17%	0.75
08 029 0004	186	150	24%	0.50
08 117 0002	101	150	33%	0.25
08 051 0004	99	150	34%	0.25
08 067 0004	203	150	35%	0.25
08 001 0006	96	150	36%	0.25
08 003 0001	207	150	38%	0.25
08 051 0007	93	150	38%	0.25
08 045 0005	88	150	41%	0.00
08 045 0007	83	150	45%	0.00
08 107 0003	83	150	45%	0.00
08 099 0001	233	150	55%	0.00
08 077 0017	65	150	57%	0.00
08 001 3001	54	150	64%	0.00
08 031 0017	53	150	65%	0.00
08 031 0025	48	150	68%	0.00

AQS ID	Max 24-hr Std. Design Value (μg/m^3)*	NAAQS Standard Value (μg/m^3)	Absolute Percent Difference	Score
08 031 0002	47	150	69%	0.00
08 097 0006	47	150	69%	0.00
08 007 0001	255	150	70%	0.00
08 013 0003	40	150	73%	0.00
08 013 0012	38	150	75%	0.00
08 043 0003	38	150	75%	0.00
08 041 0017	35	150	77%	0.00

* May include data from natural events.

2.4.5.7. Area Served

For this analysis, sites are ranked based on their area of coverage. Calculating the area of representation of a particular monitor requires GIS software. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon area values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

This method gives the most weight to rural sites and those on the edges of urban areas or other monitor clusters. It addresses the network objectives of background concentration, spatial coverage and interpolation. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) it does not take into account population or emissions, and (3) it may artificially weight monitors at the edge of the analysis domain. The main advantages are: (1) the simplicity and quickness of performing the method, and (2) it gives weight to remote and urban boundary sites that are necessary for proper interpolation. However, interpolation is not possible in the western U. S. where there is a sparse network of PM_{10} monitors.

Figure 47 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction sites in the west to the Lamar sites in the east, and from the Fort Collins site in the north to the Pagosa Springs site in the southwest. The dots mark the locations of the PM_{10} network monitors, and the red lines mark the highways in the area.

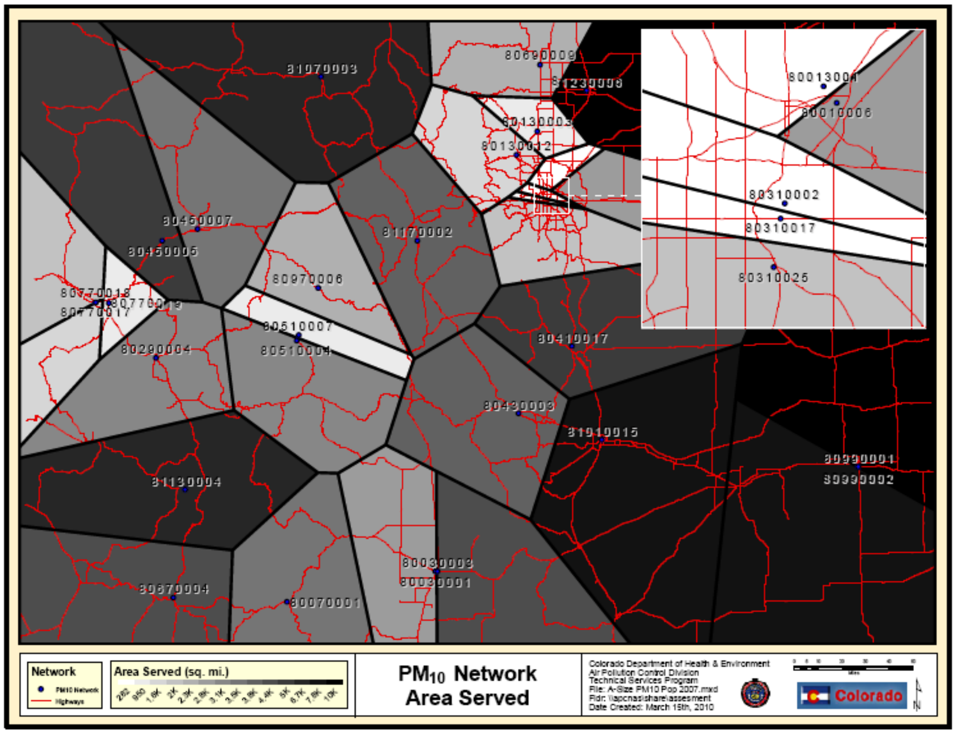


Figure 47. **PM_{10} Area Served Map**

Table 65 lists the PM_{10} network sites, the total area served by the monitoring area, and the score associated with each monitor's ranking. Sites with an area served of 7,500 square miles or greater received a 1, between 5,000 and 7,499 square miles received a 0.75, between 2,500 and 4,999 square miles received a 0.5, between 250 and 2,500 square miles received a 0.25 and less than 250 square miles received a 0 (zero).

As shown in the table and the figure, four sites serve areas that are greater than or equal to 7,500 square miles. The site serving an area of 10,374 square miles would be considered to be the most valuable for the network objective of spatial coverage. Site 08 123 0006 is the Greeley – Hospital site.

Table 65. **PM_{10} Area Served Analysis Scores**

AQS ID	Area (sq. mi.)	Score	AQS ID	Area (sq. mi.)	Score
08 123 0006	10,374	1.00	08 029 0004	3,121	0.50
08 099 0001	8,624	1.00	08 003 0001	2,847	0.50
08 101 0015	7,816	1.00	08 001 0006	2,599	0.50
08 099 0002	7,764	1.00	08 097 0006	2,339	0.25
08 107 0003	6,705	0.75	08 069 0009	2,188	0.25
08 113 0004	5,001	0.75	08 031 0025	1,986	0.25
08 045 0005	4,999	0.50	08 013 0012	1,637	0.25
08 041 0017	4,924	0.50	08 077 0017	1,161	0.25
08 067 0004	4,429	0.50	08 051 0007	949	0.25
08 003 0003	4,010	0.50	08 077 0019	659	0.25
08 117 0002	3,850	0.50	08 013 0003	650	0.25
08 043 0003	3,805	0.50	08 001 3001	282	0.25
08 045 0007	3,531	0.50	08 031 0002	79	0.00
08 007 0001	3,506	0.50	08 031 0017	55	0.00
08 051 0004	3,155	0.50			

2.4.5.8. Monitor to Monitor Correlation

In this analysis, sites are ranked based on the correlation of their measured design values with those of the other monitors in the network. Monitors measuring concentrations that correlate well with concentrations at another monitor are considered redundant, and are consequently scored low. Monitors with concentrations that do not correlate with other monitored concentrations that are nearby are considered unique, and as such have more value for spatial monitoring objectives. These monitors are scored high. The advantages of this method are that it gives a measure of the site's uniqueness and representativeness, and that it is useful for identifying redundant sites. The disadvantages are that it requires large amounts of data with a high data completeness rate, and that the correlations are likely pollutant specific. The objectives assessed by this analysis are model evaluation, spatial coverage and interpolation.

Sites that do not correlate well with other sites have unique temporal concentration variation relative to other sites, and are likely to be important for assessing local emissions, transport and spatial coverage. It is assumed here that sites having an r-squared value of 0.6 or greater are well correlated. Sites having an r^2 value of 0.6 or higher when compared to the other PM_{10} sites were counted. The analysis was scored as follows: sites correlating with zero or one sites at 0.6 or greater scored a one, those correlating with two other sites at 0.6 or greater scored a 0.75, those correlating with three other sites at 0.6 or greater scored a 0.5, those correlating with four other sites at 0.6 or greater scored a 0.25, and those correlating with five or more sites at 0.6 or greater scored a 0 (zero).

Table 66 shows the results of the scoring method for this analysis. Site IDs that are bolded indicate low volume samplers. Sites that are italicized indicate monitors that are continuous, and IDs in regular type are high volume samplers. There are fourteen sites that scored a one for not correlating at 0.6 or greater with any other PM_{10} sites, and ten that scored a one for correlating with one other site. As the distance between monitors increases, the likelihood of a good correlation between the monitors drops off. This is illustrated in Figure 48.

Table 66. PM_{10} Monitor to Monitor Analysis Scores

AQS ID	# Monitors Correlated at ≥ 0.60	Score	AQS ID	# Monitors Correlated at ≥ 0.60	Score
08 007 0001 3	0	1.00	08 051 0004 3	1	1.00
08 013 0003 2	0	1.00	**08 077 0017 3**	1	1.00
08 013 0012 1	0	1.00	08 077 0019 1	1	1.00
08 029 0004 1	0	1.00	08 099 0001 2	1	1.00
08 043 0003 1	0	1.00	08 099 0002 2	1	1.00
08 045 0005 1	0	1.00	08 123 0006 2	1	0.75
08 045 0007 1	0	1.00	**08 001 0006 1**	2	0.50
08 051 0007 1	0	1.00	**08 077 0017 4**	2	0.00
08 067 0004 1	0	1.00	08 101 0015 1	3	0.00
08 069 0009 1	0	1.00	*08 001 3001 3*	4	0.00
08 097 0006 1	0	1.00	08 001 3001 2	6	0.00
08 107 0003 2	0	1.00	08 031 0002 1	6	1.00
08 113 0004 1	0	1.00	08 031 0002 2	6	1.00
08 117 0002 1	0	1.00	*08 031 0002 3*	6	1.00
08 003 0001 1	1	1.00	08 031 0017 1	6	1.00
08 003 0003 1	1	1.00	08 031 0025 1	8	1.00
08 041 0017 1	1	1.00	08 031 0025 2	9	1.00
08 051 0004 2	1	1.00	*08 031 0025 3*	10	1.00

Bold type indicates low volume samplers, while italics indicate continuous samplers. The remaining sites have high volume samplers.

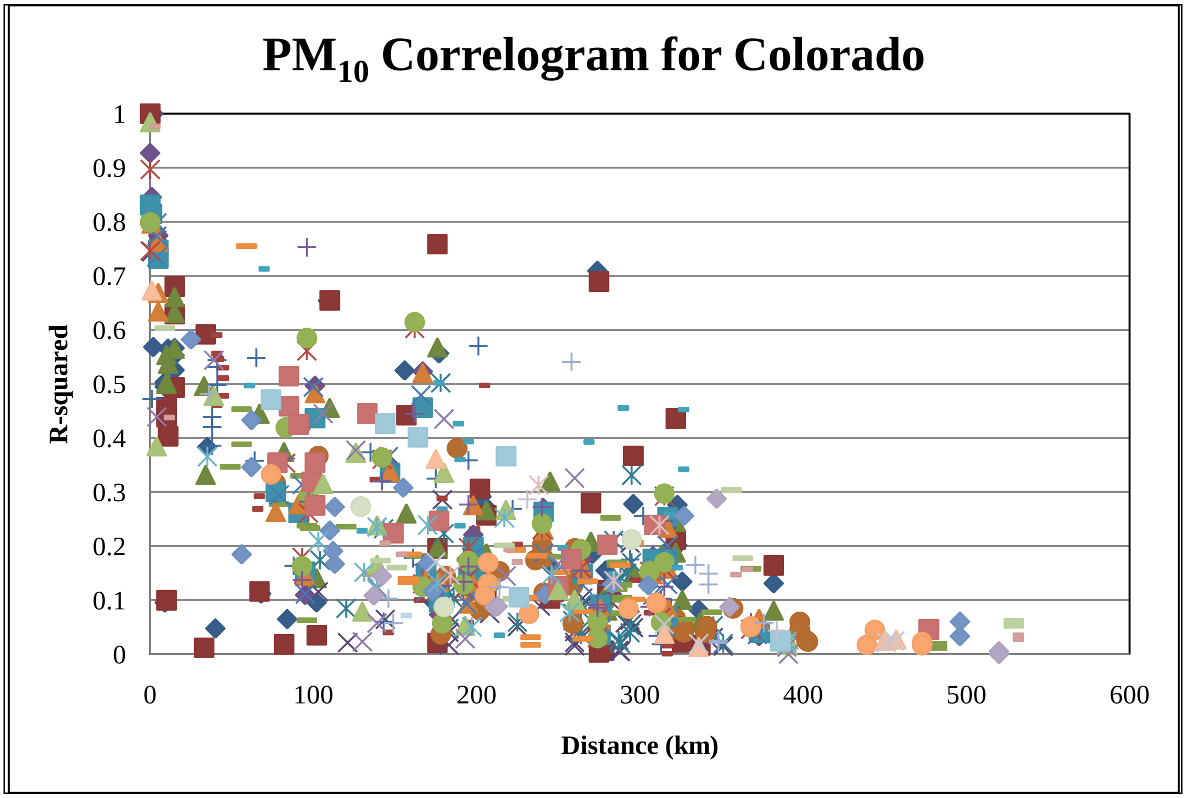


Figure 48. **PM_{10} Correlogram for Colorado**

2.4.5.9. Measured Concentrations

For this analysis, sites are ranked based on the difference between the maximum pollutant concentrations measured and the value of the standard. The sites that measure high design values are ranked higher than those that measure low values. The objectives assessed by this analysis are maximum concentration location, model evaluation, regulatory compliance and population exposure. The main advantage of the technique is that it identifies key sites from a regulatory perspective, based on the maximum concentrations. The disadvantages are that it does not account for monitor-siting problems, and that is only focuses on high concentrations. Low concentration monitors may be useful for representing rural locations or background concentrations.

Sites that measure high design values are important for assessing NAAQS compliance and population exposure, and for performing model evaluations. The analysis is scored as follows: design values that are equal to or greater than 100% of the NAAQS are given a 1, values between 95 and 100% of the NAAQS receive a 0.75, values between 90 and 95% of the NAAQS received a 0.5, values between 80 and 90% of the NAAQS receive a 0.25, and values less than or equal to 80% of the NAAQS receive a 0 (zero).

Table 67 shows the scores for the maximum design values recorded at each site, as well as the analysis scores and site rankings. Figure 49 illustrates the results graphically, using the value of the difference between the standard and the design value to mark the approximate geographic locations of the monitors. Values shown in green are below the level of the standard, while values shown in red are above it. Seven sites scored a one in this analysis, and as such are considered the most valuable in the network for the purposes of this analysis. However, most of the NAAQS exceedances were the result of natural windblown regional dust events that cannot be controlled by the APCD. These concentrations are also included in this analysis.

Figure 49. PM$_{10}$ Maximum Measured Concentration 24-hr Standard Map

Table 67. PM$_{10}$ Measured Concentration 24-hr Standard Analysis Scores

AQS ID	24-hr Max Value (µg/m^3)	NAAQS Standard Value (µg/m^3)	Difference (µg/m^3)	% NAAQS	Score
08 007 0001	255	150	105	170%	1.00
08 099 0001	233	150	83	155%	1.00
08 003 0001	207	150	57	138%	1.00
08 067 0004	203	150	53	135%	1.00
08 029 0004	186	150	36	124%	1.00
08 099 0002	176	150	26	117%	1.00
08 003 0003	157	150	7	105%	1.00
08 077 0019	147	150	-3	98%	0.75
08 113 0004	130	150	-20	87%	0.25
08 117 0002	101	150	-49	67%	0.00
08 051 0004	99	150	-51	66%	0.00
08 001 0006	96	150	-54	64%	0.00
08 051 0007	93	150	-57	62%	0.00
08 045 0005	88	150	-62	59%	0.00
08 045 0007	83	150	-67	55%	0.00
08 107 0003	83	150	-67	55%	0.00
08 077 0017	65	150	-85	43%	0.00
08 001 3001	54	150	-96	36%	0.00
08 031 0017	53	150	-97	35%	0.00
08 031 0025	48	150	-102	32%	0.00
08 031 0002	47	150	-103	31%	0.00
08 097 0006	47	150	-103	31%	0.00
08 013 0003	40	150	-110	27%	0.00
08 013 0012	38	150	-112	25%	0.00
08 043 0003	38	150	-112	25%	0.00
08 041 0017	35	150	-115	23%	0.00

2.4.5.10. Summary/Conclusions and Recommendations

Table 68 is a summary listing of the scores received by each monitor for each network analysis performed on the PM_{10} monitoring network. The monitors at the Delta and Lamar Municipal sites scored the highest for the overall score total. These monitors would be considered valuable for the purposes of this network assessment, and would be kept. There were four monitors that had a cumulative score of 2.00 or less. These were the Mt. Crested Butte, Pueblo Fountain Magnet School, Denver Visitor Center and Aspen – Library monitors (in respective order from the table below). As such, they would be candidates for removal/relocation based on the purposes of this network assessment.

While the monitors mentioned above would be good candidates for removal/relocation, many are SIP required monitors. These monitors are: Aspen Library, Canon City Municipal Bldg., Denver Visitor Center, Welby, Lamar-Municipal, Lamar-Power Plant, Pagosa Springs School, Steamboat Springs Municipal Bldg. and the Telluride Health Department. The Pueblo Fountain Magnet School site was recently established to replace another site and thus does not have sufficient data to determine its usefulness. This leaves the Mt. Crested Butte monitor as the best candidate for removal from the network, based on these analyses. This analysis, combined with the new siting criteria issues recently discovered (construction of a new hotel next to the monitoring site), provides strong reasoning for removal/relocation of the monitor. However, the Mt. Crested Butte site is important as it was established as part of a Memorandum of Understanding (MOU) between the town and the APCD to prevent the town from slipping into non-attainment.

Table 68. PM_{10} Network Analyses Score Summary

AQS ID	# Parameters Monitored	Population Served	Population Change	Emissions Inventory	Trends Impact	Deviation from 24-hr NAAQS	Area Served	Monitor to Monitor Correlation	Measured Concentration Difference from 24-hr NAAQS	*Total Score*
08 029 0004	0.00	0.00	0.25	0.50	0.75	0.50	0.50	1.00	1.00	***4.50***
08 099 0002	0.00	0.00	0.00	0.00	0.75	0.75	1.00	1.00	1.00	***4.50***
08 077 0019	0.00	0.00	0.25	0.75	0.00	1.00	0.25	1.00	0.75	***4.00***
08 003 0001	0.00	0.00	0.00	0.25	0.75	0.25	0.50	1.00	1.00	***3.75***
08 003 0003	0.00	0.00	0.00	0.00	0.25	1.00	0.50	1.00	1.00	***3.75***
08 007 0001	0.00	0.00	0.50	0.50	0.25	0.00	0.50	1.00	1.00	***3.75***
08 099 0001	0.00	0.00	0.00	0.00	0.75	0.00	1.00	1.00	1.00	***3.75***
08 113 0004	0.00	0.00	0.25	0.00	0.75	0.75	0.75	1.00	0.25	***3.75***
08 123 0006	0.00	0.50	0.50	0.00	0.75	N/A	1.00	1.00	N/A	***3.75***
08 001 0006	0.25	0.25	0.75	0.50	0.25	0.25	0.50	0.75	0.00	***3.50***
08 001 3001	0.50	1.00	0.25	0.75	0.75	0.00	0.25	0.00	0.00	***3.50***
08 067 0004	0.00	0.00	0.25	0.25	0.25	0.25	0.50	1.00	1.00	***3.50***
08 013 0003	0.00	0.25	0.50	0.50	0.75	0.00	0.25	1.00	0.00	***3.25***
08 031 0025	1.00	1.00	0.25	0.50	0.25	0.00	0.25	0.00	0.00	***3.25***
08 041 0017	0.00	1.00	0.25	0.50	0.00	0.00	0.50	1.00	0.00	***3.25***
08 031 0002	0.50	0.75	0.00	1.00	0.75	0.00	0.00	0.00	0.00	***3.00***
08 045 0005	0.00	0.00	0.25	0.75	0.50	0.00	0.50	1.00	0.00	***3.00***
08 069 0009	0.00	0.50	0.25	0.50	0.50	N/A	0.25	1.00	N/A	***3.00***
08 077 0017	0.25	0.00	0.25	1.00	0.25	0.00	0.25	1.00	0.00	***3.00***
08 013 0012	0.00	0.50	0.00	0.50	0.50	0.00	0.25	1.00	0.00	***2.75***
08 045 0007	0.25	0.00	0.25	0.50	0.25	0.00	0.50	1.00	0.00	***2.75***

AQS ID	# Parameters Monitored	Population Served	Population Change	Emissions Inventory	Trends Impact	Deviation from 24-hr NAAQS	Area Served	Monitor to Monitor Correlation	Measured Concentration Difference from 24-hr NAAQS	*Total Score*
08 051 0004	0.00	0.00	0.00	0.25	0.75	0.25	0.50	1.00	0.00	***2.75***
08 107 0003	0.00	0.00	0.25	0.00	0.75	0.00	0.75	1.00	0.00	***2.75***
08 117 0002	0.00	0.00	0.25	0.25	0.50	0.25	0.50	1.00	0.00	***2.75***
08 043 0003	0.00	0.00	0.00	0.50	0.25	0.00	0.50	1.00	0.00	***2.25***
08 051 0007	0.00	0.00	0.25	0.00	0.25	0.25	0.25	1.00	0.00	***2.00***
08 101 0015	0.00	0.25	0.00	0.25	0.00	N/A	1.00	0.50	N/A	***2.00***
08 031 0017	0.00	0.25	0.00	1.00	0.50	0.00	0.00	0.00	0.00	***1.75***
08 097 0006	0.00	0.00	0.25	0.00	0.25	0.00	0.25	1.00	0.00	***1.75***

N/A = Score unavailable. Total score is affected.

2.4.6. $PM_{2.5}$ Network

In the following sub-sections are the results of the network analyses performed for the $PM_{2.5}$ monitoring network. It is important to keep in mind the fact that the overall scores for some of the monitors may be artificially lowered since those sites could not be included in all of the analyses performed here. This is mainly due to a lack of usable data for the appropriate time periods.

The primary and secondary $PM_{2.5}$ NAAQS are 15.0 μg/m^3 annually, and 35 μg/m^3 in a 24-hour period (US EPA, 2009 ed.).

2.4.6.1. Number of Parameters Monitored

This analysis was performed by counting the number of other parameters that are measured at the monitoring site. Sites having the most parameters measured are ranked the highest. Each monitoring instrument was counted as one parameter, meaning collocated monitors were counted individually. This analysis is valuable in that it addresses two of the APCD’s monitoring network purposes—model evaluation and source apportionment. Sites with collocated measurements of several pollutants are more cost-effective to keep in operation than those sites measuring only one parameter. The main advantage of this method is its simplicity to perform. The disadvantages of the method include: (1) it does not “weight” the measurements by pollutant, as some pollutant measurements may be more useful than others, and (2) up-to-date information on the pollutants measured at particular sites can be difficult to acquire.

Table 69 lists the $PM_{2.5}$ network sites, the total number of parameters monitored at each site, and the score associated with each monitor’s ranking. Sites with greater than 20 parameters monitored received a 1, between 15 and 20 parameters received a 0.75, between 10 and 15 parameters received a 0.5, between 5 and 10 received a 0.25, and less than 5 parameters monitored received a 0 (zero).

As shown in the table, two of the sites monitor for greater than or equal to ten parameters. The site measuring 21 parameters would be considered the most valuable for the network objectives of emission inventory reconciliation and source apportionment. Site 08 031 0025 is the NCore site at the Denver Municipal Animal Shelter.

Table 69. $PM_{2.5}$ Number of Parameters Monitored and Assessment Scores

AQS ID	Total Number of Parameters Monitored	Score	AQS ID	Total Number of Parameters Monitored	Score
08 031 0025	21	1.00	08 123 0006	3	0.00
08 031 0002	13	0.50	08 123 0008	3	0.00
08 001 0006	9	0.25	08 013 0012	2	0.00
08 045 0007	7	0.25	08 101 0012	2	0.00
08 035 0004	6	0.25	08 005 0005	1	0.00
08 077 0017	6	0.25	08 013 1001	1	0.00
08 083 0006	6	0.25	08 031 0013	1	0.00
08 069 0009	4	0.00	08 031 0023	1	0.00
08 013 0003	3	0.00	08 039 0001	1	0.00
08 041 0017	3	0.00			

2.4.6.2. Population Served

It has been well established that large populations are associated with high emissions. For this analysis, sites are ranked based on the total number of people they represent. Calculating the population served by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the population within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was for 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas of high population and have large areas of representation. It addresses the network objectives of population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) small network densities give very little usable information, and (3) highly resolved population data may be difficult to work with. The main advantage is that it assesses the sites importance for population exposure.

Figure 50 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction site in the west to the Front Range sites in the east, and from the Fort Collins sites in the north to the Pueblo site in the south. The dots mark the locations of the $PM_{2.5}$ network monitors, and the red lines mark the highways in the area.

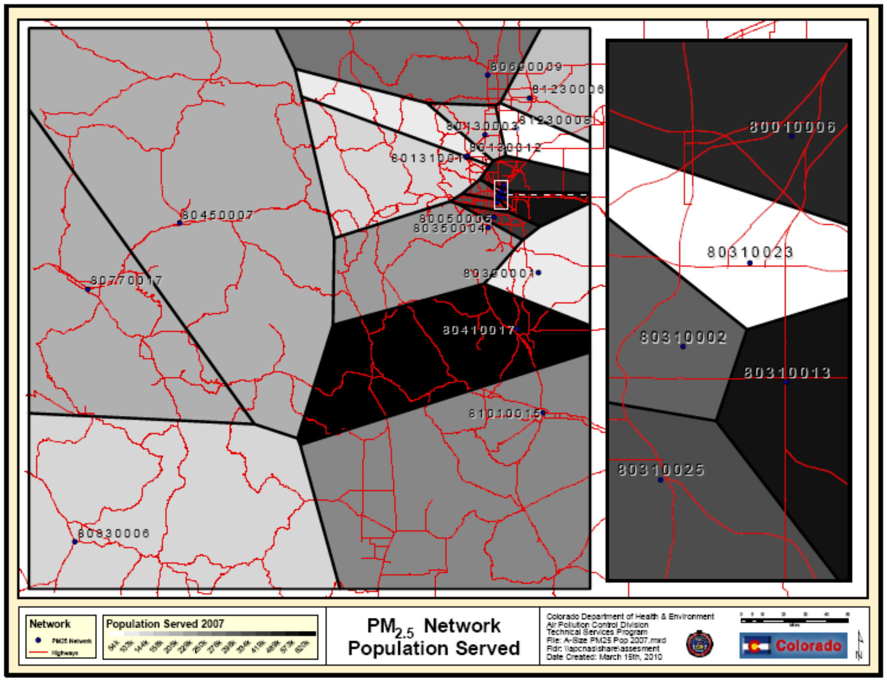


Figure 50. $PM_{2.5}$ **Population Served Map**

Table 70 lists the $PM_{2.5}$ network sites, the total number of people served in the monitoring area, and the score associated with each monitor's ranking. Sites serving 400,000 people or greater received a 1, between 300,000 and 399,999 people received a 0.75, between 200,000 and 299,999 people received a 0.5, between 100,000 and 199,999 people received a 0.25 and less than 100,000 people received a 0 (zero).

As shown in the table and the figure, four sites serve populations of greater than or equal to 400,000 people. The site serving 619,883 people would be considered to be the most valuable for the network objective of population exposure. Site 08 041 0017 is the Colorado Springs – Colorado College site.

Table 70. $PM_{2.5}$ **Population Served Analysis Scores**

AQS ID	2007 Population	Score	AQS ID	2007 Population	Score
08 041 0017	619,883	1.00	08 045 0007	170,480	0.25
08 031 0013	573,310	1.00	08 123 0006	158,714	0.25
08 001 0006	489,285	1.00	08 013 0003	153,367	0.25
08 005 0005	418,687	1.00	08 013 1001	144,214	0.25
08 031 0025	333,633	0.75	08 083 0006	103,648	0.25
08 031 0002	298,067	0.50	08 039 0001	103,288	0.25
08 069 0009	275,763	0.50	08 013 0012	98,913	0.00
08 101 0015	250,079	0.50	08 123 0008	54,271	0.00
08 035 0004	229,422	0.50	08 031 0023	52,502	0.00
08 077 0017	204,613	0.50			

2.4.6.3. Population Change

As population rates increase so to do the potentials for emissions activity. For this analysis, sites are ranked based on the population increase in the area of representation. Calculating the population change by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the 2000 census-tract and latest block-group populations within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population change values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was from the 2000 census and from 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas with high rates of population growth and large areas of representation. It addresses the network objectives of maximum precursor location, population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) highly resolved population data may be difficult to work with, and (3) changing census boundaries make it difficult to compare populated areas over time. The main advantages are: (1) the flexibility of the method, (2) that it assesses the sites importance for population exposure, (3) its helpfulness in determining where monitoring may be required in the future, and (4) its aid in identifying monitors near which emissions may have substantially changed.

Figure 51 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction site in the west to the Front Range sites in the east, and from the Fort Collins sites in the north to the Pueblo site in the south. The dots mark the locations of the $PM_{2.5}$ network monitors, and the red lines mark the highways in the area.

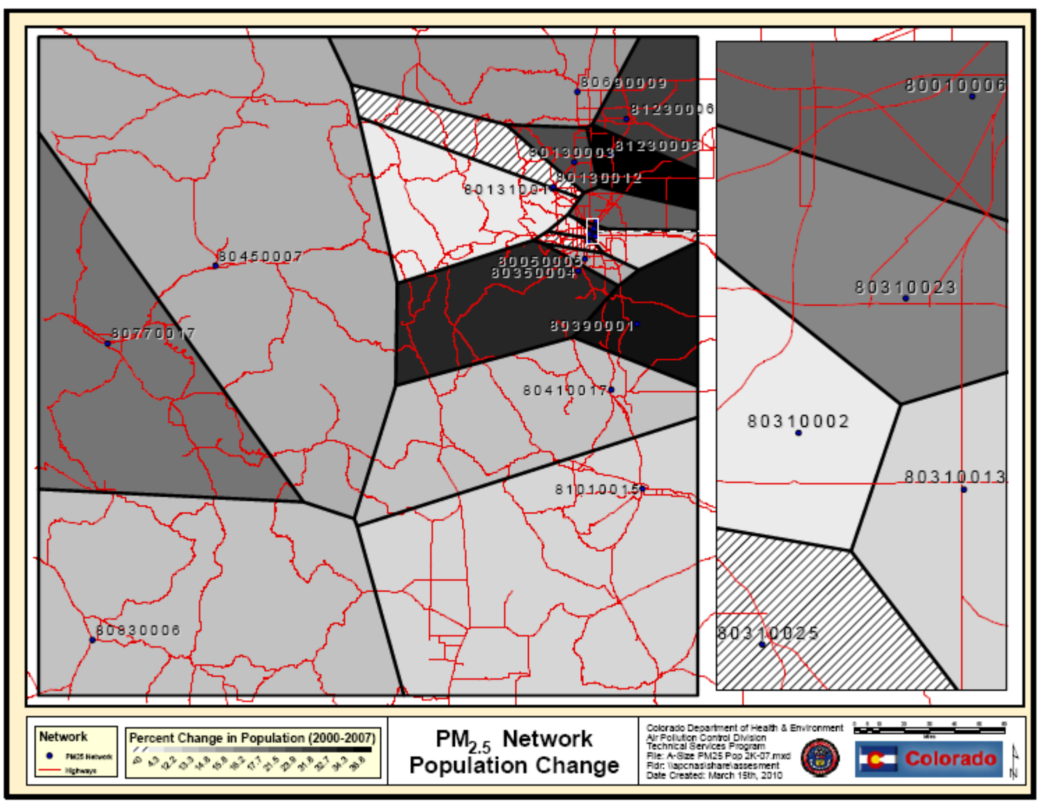


Figure 51. $PM_{2.5}$ Population Change Map

Table 71 lists the $PM_{2.5}$ network sites, the total population change from 2000 to 2007 in the monitoring area, and the score associated with each monitor's ranking. Sites with a 40 percent or greater change received a 1, between 30 and 39 percent received a 0.75, between 20 and 29 percent received a 0.5, between 10 and 19 percent received a 0.25 and less than 10 percent received a 0 (zero).

As shown in the table and the figure, no sites serve an area that experienced a population change of 40 percent or greater. The site with a 37 percent increase in population would be considered to be the most valuable for the network objective of population exposure. Site 08 123 0008 is the Platteville – South Valley Middle School site. The large population change in this area is likely due to the increase in oil/natural gas drilling and the transient working population associated with it.

Table 71. $PM_{2.5}$ Population Change Analysis Scores

AQS ID	% Population Change	Score
08 123 0008	37	0.75
08 039 0001	34	0.75
08 035 0004	33	0.75
08 123 0006	32	0.75
08 013 0003	24	0.50
08 001 0006	21	0.50
08 077 0017	18	0.25
08 031 0023	16	0.25
08 069 0009	16	0.25
08 005 0005	15	0.25
08 045 0007	15	0.25
08 083 0006	13	0.25
08 041 0017	13	0.25
08 031 0013	12	0.25
08 101 0015	8	0.00
08 013 1001	4	0.00
08 031 0002	3	0.00
08 013 0012	3	0.00
08 031 0025	-1	0.00

2.4.6.4. Emissions Inventory

Emission inventory data are used to find locations where emissions of pollutants of concern are concentrated. These locations are then compared to the current network and proposed new monitoring sites to determine if the network captures the areas of maximum emissions. The emissions inventory data used in this report are from the 2007 emissions inventory, as the 2008 inventory was not yet completed at the time of this report.

For this analysis a gridded emission inventory for the State was mapped out. It was then overlain on the Thiessen polygon map generated for other analyses. From there, the point sources (and their associated emissions data) that were within each polygon were used to calculate the emissions density in tons per year per square mile (TPY/mi^2). The area source emissions, including vehicle emissions, were not included in the emissions sums for this analysis. Only the sums of the point source emissions were used. The sum of the total point source emissions in each polygon was divided by the area of the polygon. The distances from each point source to the monitor were then used to calculate an average distance from the monitor to the point sources. This average distance was used to rank the monitors based on their average proximity to the point sources. Sites with a five mile or less distance received a 1, between 5 and 10 miles received a 0.75, between 10 and 20 miles received a 0.5, between 20 and 30 miles received a 0.25 and a distance greater than or equal to 30 miles received a 0 (zero).

Sites scoring a one indicate areas that are adequately monitored, and not in need of any immediate changes. Sites scoring a zero indicate areas that may need additional monitors. One advantage of this method is that it is scalable in complexity and spatial resolution. In addition, it helps in finding areas where primary pollutant concentrations are high. The disadvantages include: (1) emission inventory data are not always current or may be incomplete or inaccurate, (2) emission inventory quality varies by pollutant and source type, (3) more useful high resolution emission inventory data are not readily available and difficult to produce, and (4) the method does not account for pollutant transport. The objectives assessed by this technique are emission reduction evaluation and maximum precursor location. For the purposes of this analysis, the $PM_{2.5}$ precursor emissions of NO_2, SO_2 and VOCs were used. Per the EPA, they are three of the major contributors to $PM_{2.5}$ concentrations (Damberg, 2007). The distance from the emissions sources to the $PM_{2.5}$ monitor associated with the Thiessen polygon the sources are located in was used.

Figure 13, Figure 14, and Figure 36 are maps of the 2007 VOC, NO_2 and SO_2 emissions inventories, respectively. They show the respective pollutant's emissions point sources in a four kilometer gridded scale (colored squares), as well as the non-point source emissions (black and white) by county. The majority of the emissions sources lie in the Front Range area, as would be expected since the majority of the State's population is also in that area. As shown in Table 72, Table 73 and Table 74, there are four, four and five sites with a respective average distance between the monitor and the point sources of less than five miles. The top scoring sites for both the VOC and NO_2 emissions analyses were for the same four sites. The difference between the SO_2 analysis and the VOC and NO_2 analyses was the addition of the Longmont – Municipal site to the list of sites scoring a one. The high scores and low average distance from the $PM_{2.5}$ monitors to the point sources indicate that these areas are monitored well based on the precursor source locations. The top scoring site for all three analyses was the Swansea site. This site also has the largest values for the emissions density for all three analyses.

Table 72. $PM_{2.5}$ Emission Inventory Analysis Scores for VOCs

AQS ID	Sum Emissions (TPY)	Polygon Area (mi^2)	Emissions Density (TPY/mi^2)	Avg. Dist. from Point Sources to Monitor (mi)	Score
08 031 0023	2238	21	106	2	1.00
08 031 0025	1683	120	14	4	1.00
08 013 0012	689	1,249	1	5	1.00
08 031 0002	2207	89	25	5	1.00
08 005 0005	1642	214	8	6	0.75
08 013 0003	2620	490	5	7	0.75
08 123 0008	16364	821	20	8	0.75
08 031 0013	2558	449	6	8	0.75
08 069 0009	1814	3,280	1	9	0.75
08 001 0006	4236	619	7	11	0.50
08 041 0017	2629	5,456	0	11	0.50
08 123 0006	23498	1,537	15	14	0.50
08 035 0004	806	3,146	0	17	0.50
08 013 1001	736	3,003	0	22	0.25
08 077 0017	2722	7,511	0	29	0.25
08 045 0007	13183	17,264	1	30	0.00
08 083 0006	1249	10,618	0	36	0.00
08 101 0015	3297	11,470	0	64	0.00
08 039 0001	1608	1,626	1	86	0.00

Table 73. $PM_{2.5}$ Emissions Inventory Analysis Scores for NO_2

AQS ID	Sum Emissions (TPY)	Polygon Area (mi^2)	Emissions Density (TPY/mi^2)	Avg. Dist. from Point Sources to Monitor (mi)	Score
08 031 0023	11305	21	537.3	2	1.00
08 031 0002	2366	89	26.6	4	1.00
08 031 0025	3141	120	26.1	5	1.00
08 013 0012	2572	1,249	2.1	5	1.00
08 005 0005	264	214	1.2	6	0.75
08 013 0003	2630	490	5.4	7	0.75
08 031 0013	2347	449	5.2	7	0.75
08 123 0008	5646	821	6.9	7	0.75
08 069 0009	3207	3,280	1.0	11	0.50
08 001 0006	750	619	1.2	12	0.50
08 041 0017	8749	5,456	1.6	15	0.50
08 035 0004	144	3,146	0.0	15	0.50
08 123 0006	10530	1,537	6.9	15	0.50
08 013 1001	583	3,003	0.2	19	0.50
08 077 0017	4967	7,511	0.7	35	0.00
08 083 0006	1353	10,618	0.1	36	0.00
08 045 0007	32375	17,264	1.9	37	0.00
08 101 0015	17001	11,470	1.5	79	0.00
08 039 0001	2055	1,626	1.3	99	0.00

Table 74. $PM_{2.5}$ Emissions Inventory Analysis Scores for SO_2

AQS ID	Sum Emissions (TPY)	Polygon Area (mi^2)	Emissions Density (TPY/mi^2)	Avg. Dist. from Point Sources to Monitor (mi)	Score
08 031 0023	8474	21	402.8	2	1.00
08 031 0002	2778	89	31.3	4	1.00
08 031 0025	2666	120	22.2	4	1.00
08 013 0012	779	1,249	0.6	5	1.00
08 013 0003	119	490	0.2	5	1.00
08 005 0005	37	214	0.2	6	0.75
08 031 0013	77	449	0.2	7	0.75
08 001 0006	134	619	0.2	11	0.50
08 069 0009	924	3,280	0.3	11	0.50
08 123 0008	55	821	0.1	13	0.50
08 041 0017	14051	5,456	2.6	15	0.50
08 035 0004	68	3,146	0.0	16	0.50
08 013 1001	77	3,003	0.0	19	0.50
08 077 0017	4136	7,511	0.6	34	0.00
08 083 0006	36	10,618	0.0	37	0.00
08 045 0007	6303	17,264	0.4	45	0.00
08 123 0006	13703	1,537	8.9	59	0.00
08 101 0015	14615	11,470	1.3	81	0.00
08 039 0001	16	1,626	0.0	98	0.00

2.4.6.5. Trends Impact

This analysis was performed by ranking the sites based on the length of the continuous measurement record of the pollutant of interest. Sites that have a long historical record are very valuable for tracking pollutant trends, and therefore have the most importance according to this assessment technique. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—trend tracking and emission reduction evaluation. In addition, it provides a measure of the historical consistency of the data sets generated. The main advantages of this method are its simplistic analytical approach, and its usefulness for identifying long-term trend sites. The main disadvantages of the method are: (1) that it doesn't take into account changes in population, emission, or meteorology; (2) the magnitude and direction of past trends are not necessarily good predictors of future trends; and, (3) the length of a continuous record does not ensure that data are of good quality throughout the time period.

Table 63 lists the $PM_{2.5}$ network sites, the total number of years the site has been in operation monitoring for $PM_{2.5}$, and the score associated with each monitor's ranking. Sites with greater than 30 years in operation received a 1, between 20 and 30 years received a 0.75, between 10 and 20 years received a 0.5, between 5 and 10 years received a 0.25, and less than 5 years monitored received a 0 (zero).

As shown in the table, all sites have been in operation for eleven years or less. The sites in operation for 11 years would be considered the most valuable for the network objectives of trend tracking and emission reduction evaluation.

Table 75. $PM_{2.5}$ Trends Impact Analysis Scores

AQS ID	Years in Operation	Score	AQS ID	Years in Operation	Score
08 005 0005	11	0.50	08 077 0017	8	0.25
08 013 0003	11	0.50	08 031 0013	7	0.25
08 013 0012	11	0.50	08 013 1001	6	0.25
08 031 0002	11	0.50	08 031 0023	6	0.25
08 039 0001	11	0.50	08 035 0004	5	0.25
08 069 0009	11	0.50	08 041 0017	3	0.00
08 123 0006	11	0.50	08 045 0007	2	0.00
08 123 0008	11	0.50	08 083 0006	2	0.00
08 001 0006	9	0.25	08 101 0015	1	0.00
08 031 0025	8	0.25			

2.4.6.6. Deviation from NAAQS

For this analysis, sites that measure design values that are very close to the NAAQS exceedance threshold are ranked higher than those sites with values well above or below it. Sites that are close to the threshold are considered more valuable for the purpose of determining NAAQS compliance, whereas sites well above or below do not provide as much information. The main advantage of this analysis is that it gives the ability to assess monitor importance for determining NAAQS compliance. The disadvantages of the analysis are: (1) if design values vary from year to year, historical data should be included in the analysis, and (2) care is needed in interpreting absolute differences. The objectives assessed by this analysis are regulatory compliance and forecasting assistance.

The technique is based on the difference between the standard and actual measurements. The design values are calculated as they apply to regulatory compliance. For $PM_{2.5}$, the values were calculated and compared to the annual and 24-hour standards. The absolute value of the percent difference between the measured design value and the standard is used to score each monitor. Monitors having the smallest absolute percent difference rank as most important. Sites that were less than a 10% difference from the NAAQS received a 1, between 10 to

20% received a 0.75, between 20 to 30% received a 0.5, between 30 to 40% received a 0.25, and greater than 40% received a 0 (zero).

The maximum 24-hour concentrations found in the 2004 to 2009 time period were used for the NAAQS comparisons. The maximum value for the time period was used to show a "worst case scenario" for the six year period in question.
Table 76 and Table 77 list the analysis results and scores for the primary $PM_{2.5}$ standards. Figure 52 and Figure 53 illustrate the results graphically, using the value of the absolute percent difference to mark the approximate geographic location of the monitors. No sites received a score higher than 0.25 when comparing the design values to either standard, as the concentrations for all sites were well beneath the NAAQS exceedance thresholds.

Figure 52. Deviation from NAAQS Annual $PM_{2.5}$ Standard Map

Table 76. Deviation from NAAQS Annual $PM_{2.5}$ Standard Analysis Scores

AQS ID	Annual Std. Design Value (ppm)	NAAQS Annual Std. Value ($\mu g/m^3$)	Absolute Percent Difference	Score
08 001 0006	9.4	15.0	37%	0.25
08 077 0017	9.4	15.0	37%	0.25
08 031 0023	8.7	15.0	42%	0.00
08 123 0008	8.7	15.0	42%	0.00
08 031 0002	8.5	15.0	43%	0.00
08 123 0006	8.2	15.0	45%	0.00
08 013 0003	8.0	15.0	47%	0.00
08 005 0005	7.2	15.0	52%	0.00
08 069 0009	7.1	15.0	53%	0.00
08 013 0012	6.8	15.0	55%	0.00
08 035 0004	6.1	15.0	59%	0.00
08 039 0001	4.4	15.0	71%	0.00

Figure 53. **Deviation from NAAQS 24-hr $PM_{2.5}$ Standard Map**

Table 77. **Deviation from NAAQS 24-hr $PM_{2.5}$ Standard Analysis Scores**

AQS ID	24-hr Std. Design Value (ppm)	NAAQS 24-hr Std. Value (ppm)	Absolute Percent Difference	Score
08 077 0017	31	35	13%	0.75
08 001 0006	28	35	21%	0.50
08 123 0008	26	35	27%	0.50
08 123 0006	25	35	29%	0.50
08 031 0023	24	35	33%	0.25
08 013 0003	23	35	33%	0.25
08 031 0002	23	35	36%	0.25
08 013 0012	19	35	45%	0.00
08 005 0005	18	35	48%	0.00
08 069 0009	18	35	48%	0.00
08 035 0004	17	35	51%	0.00
08 039 0001	11	35	69%	0.00

2.4.6.7. Area Served

For this analysis, sites are ranked based on their area of coverage. Calculating the area of representation of a particular monitor requires GIS software. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon area values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

This method gives the most weight to rural sites and those on the edges of urban areas or other monitor clusters. It addresses the network objectives of background concentration, spatial coverage and interpolation. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) it does not take into account population or emissions, and (3) it may artificially weight monitors at the edge of the analysis domain. The main advantages are: (1) the simplicity and quickness of performing the method, and (2) it gives weight to remote and urban boundary sites that are necessary for proper interpolation.

Figure 54 graphically illustrates the Thiessen Polygon Method. The area covered by the map ranges from the Grand Junction sites in the west to the Front Range sites in the east, and from the Fort Collins site in the north to the Pueblo site in the southwest. The dots mark the locations of the $PM_{2.5}$ network monitors, and the red lines mark the highways in the area.

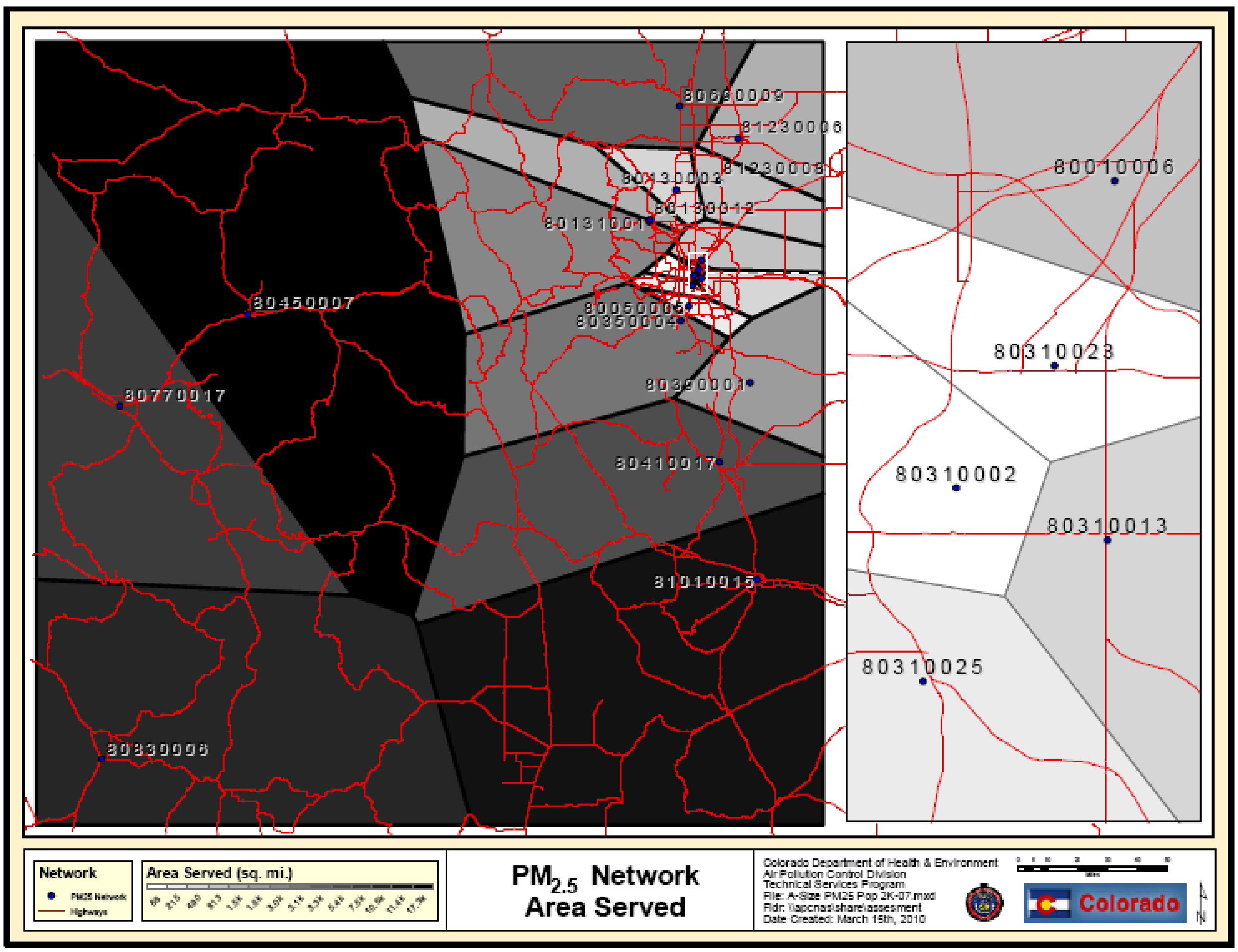


Figure 54. $PM_{2.5}$ Area Served Map

Table 78 lists the $PM_{2.5}$ network sites, the total area served by the monitoring area, and the score associated with each monitor's ranking. Sites with an area served of 7,500 square miles or greater received a 1, between 5,000 and 7,499 square miles received a 0.75, between 2,500 and 4,999 square miles received a 0.5, between 250 and 2,500 square miles received a 0.25 and less than 250 square miles received a 0 (zero).

As shown in the table and the figure, four sites serve areas that are greater than or equal to 7,500 square miles. The site serving an area of 17,264 square miles would be considered to be the most valuable for the network objective of spatial coverage. Site 08 045 0007 is the Rifle – Henry Building site.

Table 78. $PM_{2.5}$ Area Served Analysis Scores

AQS ID	Area (sq. mi.)	Score
08 045 0007	17,264	1.00
08 101 0015	11,470	1.00
08 083 0006	10,618	1.00
08 077 0017	7,511	1.00
08 041 0017	5,456	0.75
08 069 0009	3,280	0.50
08 035 0004	3,146	0.50
08 013 1001	3,003	0.50
08 039 0001	1,626	0.25
08 123 0006	1,537	0.25
08 013 0012	1,249	0.25
08 123 0008	821	0.25
08 001 0006	619	0.25
08 013 0003	490	0.25
08 031 0013	449	0.25
08 005 0005	214	0.00
08 031 0025	120	0.00
08 031 0002	89	0.00
08 031 0023	21	0.00

2.4.6.8. Monitor to Monitor Correlation

In this analysis, sites are ranked based on the correlation of their measured design values with those of the other monitors in the network. Monitors measuring concentrations that correlate well with concentrations at another monitor are considered redundant, and are consequently scored low. Monitors with concentrations that do not correlate with other monitored concentrations that are nearby are considered unique, and as such have more value for spatial monitoring objectives. These monitors are scored high. The advantages of this method are that it gives a measure of the site's uniqueness and representativeness, and that it is useful for identifying redundant sites. The disadvantages are that it requires large amounts of data with a high data completeness rate, and that the correlations are likely pollutant specific. The objectives assessed by this analysis are model evaluation, spatial coverage and interpolation.

Sites that do not correlate well with other sites have unique temporal concentration variation relative to other sites, and are likely to be important for assessing local emissions, transport and spatial coverage. It is assumed here that sites having an r-squared value of 0.6 or greater are well correlated. Sites having an r^2 value of 0.6 or higher when compared to the other $PM_{2.5}$ sites were counted. The analysis was scored as follows: sites correlating with zero or one sites at 0.6 or greater scored a one, those correlating with two other sites at 0.6 or greater scored a 0.75, those correlating with three other sites at 0.6 or greater scored a 0.5, those correlating with four other sites at 0.6 or greater scored a 0.25, and those correlating with five or more sites at 0.6 or greater scored a 0 (zero).

Table 79 shows the results of the scoring method for this analysis. There are five sites that scored a one for not correlating at 0.6 or greater with any other $PM_{2.5}$ sites. These sites all tend to have large distances between themselves and the next closest monitor. As the distance between monitors increases, the likelihood of a good correlation between the monitors drops off. This is illustrated in Figure 55.

Table 79. PM$_{2.5}$ Monitor to Monitor Correlation Analysis Scores

AQS ID	# Sites Correlated at ≥ 0.60	Score
08 039 0001 1	0	1.00
08 041 0017 1	0	1.00
08 077 0017 1	0	1.00
08 083 0006 1	0	1.00
08 101 0015 1	0	1.00
08 035 0004 1	2	0.75
08 013 0012 1	3	0.50
08 069 0009 1	3	0.50
08 123 0006 1	3	0.50
08 005 0005 1	5	0.00
08 013 0003 1	5	0.00
08 123 0008 1	5	0.00
08 031 0023 1	6	0.00
08 001 0006 1	7	0.00
08 001 0006 2	7	0.00
08 031 0002 1	7	0.00
08 031 0025 1	7	1.00
08 031 0002 2	8	1.00

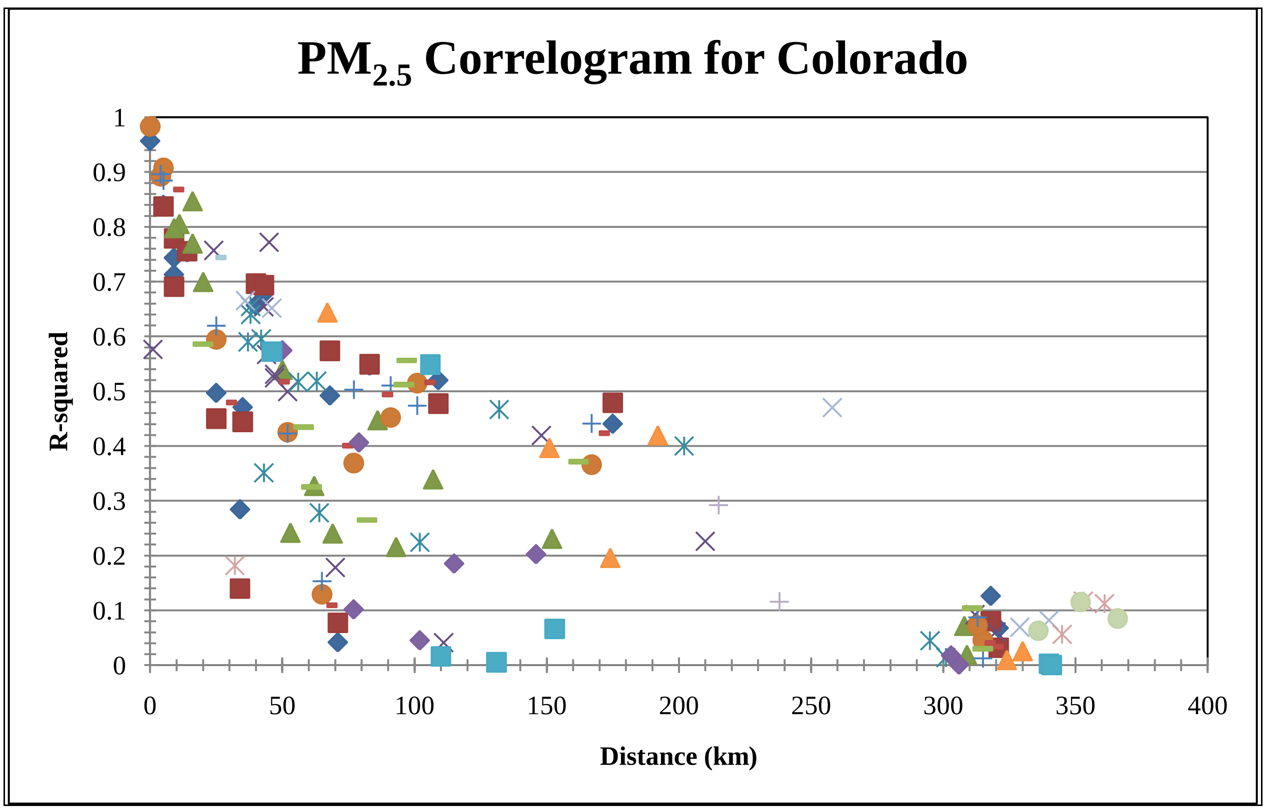


Figure 55. PM$_{2.5}$ Correlogram for Colorado

2.4.6.9. Measured Concentrations

For this analysis, sites are ranked based on the difference between the maximum pollutant concentrations measured and the value of the standard. The sites that measure high design values are ranked higher than those that measure low values. The objectives assessed by this analysis are maximum concentration location, model evaluation, regulatory compliance and population exposure. The main advantage of the technique is that it identifies key sites from a regulatory perspective, based on the maximum concentrations. The disadvantages are that it does not account for monitor-siting problems, and that is only focuses on high concentrations. Low concentration monitors may be useful for representing rural locations or background concentrations.

Sites that measure high design values are important for assessing NAAQS compliance and population exposure, and for performing model evaluations. The analysis is scored as follows: design values that are equal to or greater than 100% of the NAAQS are given a 1, values between 95 and 100% of the NAAQS receive a 0.75, values between 90 and 95% of the NAAQS received a 0.5, values between 80 and 90% of the NAAQS receive a 0.25, and values less than or equal to 80% of the NAAQS receive a 0 (zero).

Table 80 and Table 81 show the scores for the maximum design values recorded at each site, as well as the analysis scores and site rankings. Figure 56 and Figure 57 illustrate the results graphically, using the values of the difference between the standard and the design value to mark the approximate geographic location of the monitors. All sites scored zeros when compared to the annual standard, as their design values were all well below it. Three sites scored ones when compared to the 24-hour standard, and would be considered the most valuable for the purposes of this analysis.

Figure 56. $PM_{2.5}$ Maximum Measured Concentration Annual Standard Map

Table 80. PM$_{2.5}$ Measured Concentration Annual Standard Analysis Scores

AIRS ID	2007-09 Max. Annual Std. Design Value (ppm)	NAAQS Annual Std. Value (ppm)	Difference (ppm)	% NAAQS	Score
08 001 0006	10.7	15.0	-4	71%	0
08 123 0008	10.3	15.0	-5	69%	0
08 031 0023	10.2	15.0	-5	68%	0
08 031 0002	9.8	15.0	-5	65%	0
08 077 0017	9.7	15.0	-5	65%	0
08 123 0006	9.2	15.0	-6	61%	0
08 013 0003	8.9	15.0	-6	59%	0
08 005 0005	8.1	15.0	-7	54%	0
08 069 0009	8.0	15.0	-7	53%	0
08 013 0012	7.4	15.0	-8	49%	0
08 035 0004	6.8	15.0	-8	45%	0
08 039 0001	4.8	15.0	-10	32%	0
08 031 0025	N/A	15.0	N/A	N/A	N/A
08 083 0006	N/A	15.0	N/A	N/A	N/A
08 101 0015	N/A	15.0	N/A	N/A	N/A

N/A = Not enough data available to calculate design value.

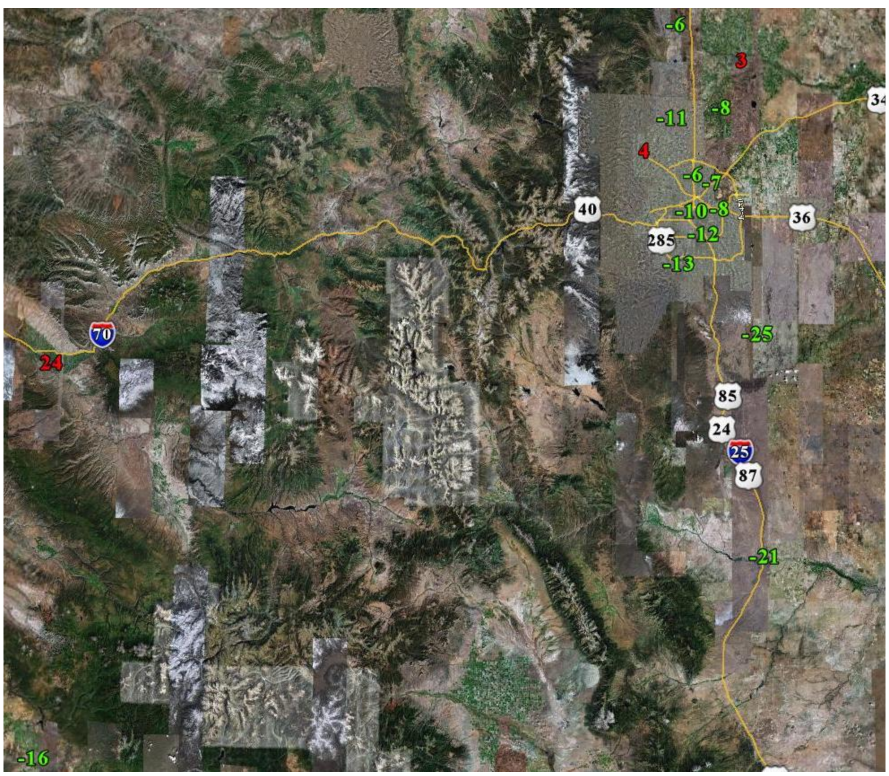


Figure 57. PM$_{2.5}$ Maximum Measured Concentration 24-hr Standard Map

Table 81. $PM_{2.5}$ Measured Concentration 24-hr Standard Analysis Scores

AQS ID	24-hr Maximum Value (μg/m^3)	NAAQS 24-hr Std. Value (μg/m^3)	Difference (μg/m^3)	% NAAQS	Score
08 077 0017	59.1	35	24	169%	1.00
08 013 0012	39.4	35	4	113%	1.00
08 123 0006	38.2	35	3	109%	1.00
08 031 0002	29.5	35	-6	84%	0.25
08 069 0009	28.7	35	-6	82%	0.25
08 001 0006	28.5	35	-7	81%	0.25
08 123 0008	26.6	35	-8	76%	0.00
08 031 0023	26.6	35	-8	76%	0.00
08 031 0025	25.0	35	-10	71%	0.00
08 013 0003	24.0	35	-11	69%	0.00
08 005 0005	22.6	35	-12	65%	0.00
08 035 0004	21.7	35	-13	62%	0.00
08 083 0006	19.3	35	-16	55%	0.00
08 101 0015	14.4	35	-21	41%	0.00
08 039 0001	10.5	35	-25	30%	0.00

2.4.6.10. Summary/Conclusions and Recommendations

Table 82 is a summary list of the network analysis scores for each analysis performed on the $PM_{2.5}$ monitoring network. The highest scoring monitor is located at the Grand Junction – Powell Building site. This would indicate that it is the most valuable monitor in the $PM_{2.5}$ monitoring network, and should be kept. It should be noted here that this site records some of the lowest $PM_{2.5}$ concentrations in the state, even less than those recorded at the background site in Elbert County. The lowest scoring monitor is found at the Rifle – Henry Building site. This site's cumulative score was affected by the fact that it was not included in five of the analyses due to its short term data record, and should not be removed as it was installed to monitor emissions from the oil and gas industry which was booming in 2008 when it was installed. Due to recent lower oil prices the drilling has slowed, but it is expected to increase again once the economy rebounds. There were two other sites that were affected in a similar manner.

Table 82. $PM_{2.5}$ Network Analyses Score Summary

AQS ID	# Parameters Monitored	Population Served	Population Change	Emissions Inventory - VOCs	Emissions Inventory - NO_2	Emissions Inventory - SO_2	Trends Impact	Deviation from Annual NAAQS	Deviation from 24-hr NAAQS	Area Served	Monitor to Monitor Correlation	Measured Concentration Difference from Annual NAAQS	Measured Concentration Difference from 24-hr NAAQS	*Total Score*
08 077 0017	0.25	0.50	0.25	0.25	0.00	0.00	0.25	0.25	0.75	1.00	1.00	1.00	1.00	***6.50***
08 013 0012	0.00	0.00	0.00	1.00	1.00	1.00	0.50	0.00	0.00	0.25	0.50	1.00	1.00	***6.25***
08 031 0002	0.50	0.50	0.00	1.00	1.00	1.00	0.50	0.00	0.25	0.00	0.00	1.00	0.25	***6.00***
08 031 0025	1.00	0.75	0.00	1.00	1.00	1.00	0.25	N/A	N/A	0.00	0.00	1.00	0.00	***6.00***
08 001 0006	0.25	1.00	0.50	0.50	0.50	0.50	0.25	0.25	0.50	0.25	0.00	1.00	0.25	***5.75***
08 123 0006	0.00	0.25	0.75	0.50	0.50	0.00	0.50	0.00	0.50	0.25	0.50	1.00	1.00	***5.75***
08 035 0004	0.25	0.50	0.75	0.50	0.50	0.50	0.25	0.00	0.00	0.50	0.75	1.00	0.00	***5.50***
08 013 0003	0.00	0.25	0.50	0.75	0.75	1.00	0.50	0.00	0.25	0.25	0.00	1.00	0.00	***5.25***
08 069 0009	0.00	0.50	0.25	0.75	0.50	0.50	0.50	0.00	0.00	0.50	0.50	1.00	0.25	***5.25***
08 005 0005	0.00	1.00	0.25	0.75	0.75	0.75	0.50	0.00	0.00	0.00	0.00	1.00	0.00	***5.00***
08 123 0008	0.00	0.00	0.75	0.75	0.75	0.50	0.50	0.00	0.50	0.25	0.00	1.00	0.00	***5.00***
08 031 0023	0.00	0.00	0.25	1.00	1.00	1.00	0.25	0.00	0.25	0.00	0.00	1.00	0.00	***4.75***
08 041 0017	0.00	1.00	0.25	0.50	0.50	0.50	0.00	N/A	N/A	0.75	1.00	N/A	N/A	***4.50***
08 031 0013	0.00	1.00	0.25	0.75	0.75	0.75	0.25	N/A	N/A	0.25	N/A	N/A	N/A	***4.00***
08 083 0006	0.25	0.25	0.25	0.00	0.00	0.00	0.00	N/A	N/A	1.00	1.00	1.00	0.00	***3.75***
08 101 0015	0.00	0.50	0.00	0.00	0.00	0.00	0.00	N/A	N/A	1.00	1.00	0.75	0.00	***3.25***
08 039 0001	0.00	0.25	0.75	0.00	0.00	0.00	0.50	0.00	0.00	0.25	1.00	0.00	0.00	***2.75***
08 013 1001	0.00	0.25	0.00	0.25	0.50	0.50	0.25	N/A	N/A	0.50	N/A	N/A	N/A	***2.25***
08 045 0007	0.25	0.25	0.25	0.00	0.00	0.00	0.00	N/A	N/A	1.00	N/A	N/A	N/A	***1.75***

N/A = Score unavailable. Total score is affected.

2.4.7. TSP/Pb Network

In the following sub-sections are the results of the network analyses performed for the TSP/Pb monitoring network. It is important to keep in mind the fact that the overall scores for some of the monitors may be artificially lowered since those sites could not be included in all of the analyses performed here. This is mainly due to a lack of usable data for the appropriate time periods.

In October 2008 the EPA re-set the level of the lead NAAQS from 1.5 $\mu g/m^3$ (averaged over a calendar quarter), to 0.15 $\mu g/m^3$ (averaged over any three rolling consecutive three month periods) (US EPA, 2009 ed.).

2.4.7.1. Number of Parameters Monitored

This analysis was performed by counting the number of other parameters that are measured at the monitoring site. Sites having the most parameters measured are ranked the highest. Each monitoring instrument was counted as one parameter, meaning collocated monitors were counted individually. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—model evaluation and source apportionment. Sites with collocated measurements of several pollutants are more cost-effective to keep in operation than those sites measuring only one parameter. The main advantage of this method is its simplicity to perform. The disadvantages of the method include: (1) it does not "weight" the measurements by pollutant, as some pollutant measurements may be more useful than others; and, (2) up-to-date information on the pollutants measured at particular sites can be difficult to acquire.

Table 83 lists the TSP/Pb network sites, the total number of parameters monitored at each site, and the score associated with each monitor's ranking. Sites with greater than 20 parameters monitored received a 1, between 15 and 20 parameters received a 0.75, between 10 and 15 parameters received a 0.5, between 5 and 10 received a 0.25, and less than 5 parameters monitored received a 0 (zero).

As shown in the table, the Denver Municipal Animal Shelter site (08 031 0025) monitors for greater than or equal to ten parameters, and would be considered the most valuable for the network objectives of emission inventory reconciliation and source apportionment.

Table 83. TSP/Pb Number of Parameters Monitored and Assessment Scores

AQS ID	Total Number of Parameters Monitored	Score
08 031 0025	21	1.00

2.4.7.2. Population Served

It has been well established that large populations are associated with high emissions. For this analysis, sites are ranked based on the total number of people they represent. Calculating the population served by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the population within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was for 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas of high population and have large areas of representation. It addresses the network objectives of population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) small network densities give very little usable information, and (3) highly resolved population data may be difficult to work with. The main advantage is that it assesses the sites importance for population exposure.

This analysis was not performed for the TSP/Pb monitoring network as there was only one site in operation, and the analysis is intended to be performed on a moderately sized or larger network.

2.4.7.3. Population Change

As population rates increase so to do the potentials for emissions activity. For this analysis, sites are ranked based on the population increase in the area of representation. Calculating the population change by a particular monitor requires two steps: (1) a determination of the area of representativeness for each monitor; and (2) a determination of the 2000 census-tract and latest block-group populations within each area of representation. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon population change values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

The population data used was from the 2000 census and from 2007, as it was the latest data available for use in the software program. This method gives the most weight to sites that are in areas with high rates of population growth and large areas of representation. It addresses the network objectives of maximum precursor location, population exposure and environmental justice. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) highly resolved population data may be difficult to work with, and (3) changing census boundaries make it difficult to compare populated areas over time. The main advantages are: (1) the flexibility of the method, (2) that it assesses the sites importance for population exposure, (3) its helpfulness in determining where monitoring may be required in the future, and (4) its aid in identifying monitors near which emissions may have substantially changed.

This analysis was not performed for the TSP/Pb monitoring network as there was only one site in operation.

2.4.7.4. Emissions Inventory

Emission inventory data are used to find locations where emissions of pollutants of concern are concentrated. These locations are then compared to the current network and proposed new monitoring sites to determine if the network captures the areas of maximum emissions. The emissions inventory data used in this report are from the 2007 emissions inventory, as the 2008 inventory was not yet completed at the time of this report.

For this analysis a gridded emission inventory for the State was mapped out. It was then overlain on the Thiessen polygon map generated for other analyses. From there, the point sources (and their associated emissions data) that were within each polygon were used to calculate the emissions density in tons per year per square mile (TPY/mi^2). The area source emissions, including vehicle emissions, were not included in the emissions sums for this analysis. Only the sums of the point source emissions were used. The sum of the total point source emissions in each polygon was divided by the area of the polygon. The distances from each point source to the monitor were then used to calculate an average distance from the monitor to the point sources. This average distance was used to rank the monitors based on their average proximity to the point sources. Sites with a five mile or less distance received a 1, between 5 and 10 miles received a 0.75, between 10 and 20 miles received a 0.5, between 20 and 30 miles received a 0.25 and a distance greater than or equal to 30 miles received a 0 (zero).

Sites scoring a one indicate areas that are adequately monitored, and not in need of any immediate changes. Sites scoring a zero indicate areas that may need additional monitors. One advantage of this method is that it is scalable in complexity and spatial resolution. In addition, it helps in finding areas where primary pollutant concentrations are high. The disadvantages include: (1) emission inventory data are not always current or may be incomplete or inaccurate, (2) emission inventory quality varies by pollutant and source type, (3) more useful high resolution emission inventory data are not readily available and difficult to produce, and (4) the method does not account for pollutant transport. The objectives assessed by this technique are emission reduction evaluation and maximum precursor location.

The emissions inventory for lea can be seen in Figure 58. As there are only 2 active lead monitoring sites in the monitoring network, no Thiessen Polygons were created, and therefore the Emissions Inventory Analysis for this parameter cannot be performed in the same manner as the CO and O_3 emissions analyses were.

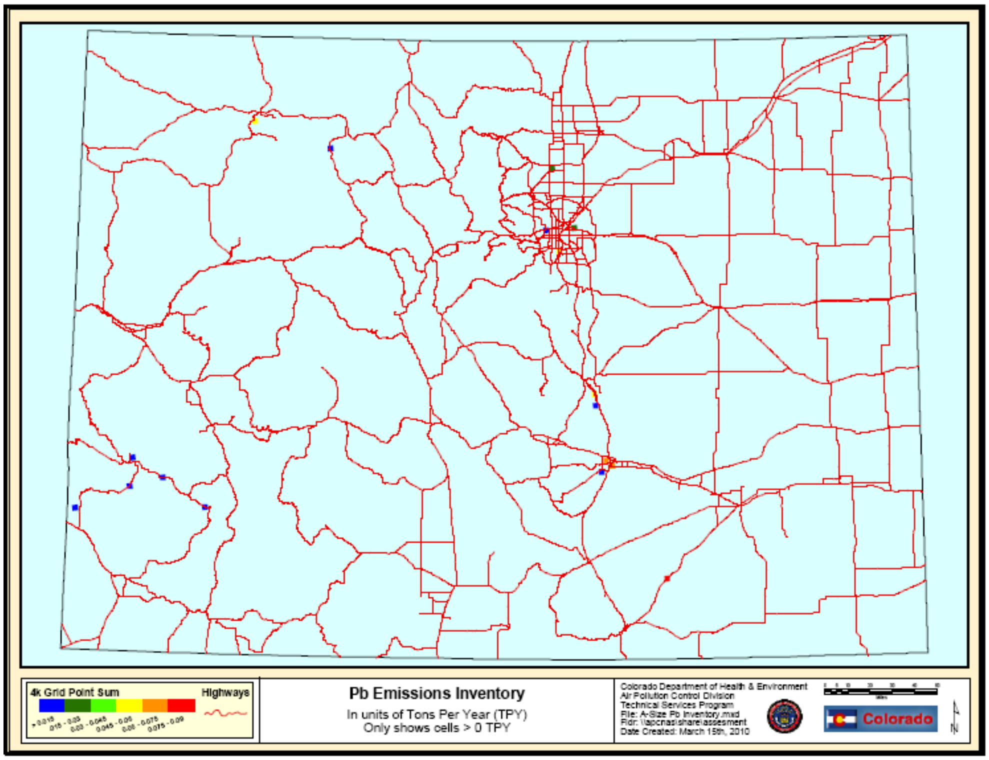


Figure 58. Lead Emissions Inventory Map

2.4.7.5. Trends Impact

This analysis was performed by ranking the sites based on the length of the continuous measurement record of the pollutant of interest. Sites that have a long historical record are very valuable for tracking pollutant trends, and therefore have the most importance according to this assessment technique. This analysis is valuable in that it addresses two of the APCD's monitoring network purposes—trend tracking and emission reduction evaluation. In addition, it provides a measure of the historical consistency of the data sets generated. The main advantages of this method are its simplistic analytical approach, and its usefulness for identifying long-term trend sites. The main disadvantages of the method are: (1) that it doesn't take into account changes in population, emission, or meteorology; (2) the magnitude and direction of past trends are not necessarily good predictors of future trends; and, (3) the length of a continuous record does not ensure that data are of good quality throughout the time period.

Table 63 lists the TSP/Pb network sites, the total number of years the site has been in operation monitoring for TSP/Pb, and the score associated with each monitor's ranking. Sites with greater than 30 years in operation received a 1, between 20 and 30 years received a 0.75, between 10 and 20 years received a 0.5, between 5 and 10 years received a 0.25, and less than 5 years monitored received a 0 (zero).

As shown in the table, the site has been in operation for five years. This site would not be considered the most valuable for the network objectives of trend tracking and emission reduction evaluation. Site 08 031 0025 is the NCore site at the Denver Municipal Animal Shelter.

Table 84. TSP/Pb Trends Impact Analysis Score

AQS ID	Years in Operation	Score
08 031 0025	5	0.25

2.4.7.6. Deviation from NAAQS

For this analysis, sites that measure design values that are very close to the NAAQS exceedance threshold are ranked higher than those sites with values well above or below it. Sites that are close to the threshold are considered more valuable for the purpose of determining NAAQS compliance, whereas sites well above or below do not provide as much information. The main advantage of this analysis is that it gives the ability to assess monitor importance for determining NAAQS compliance. The disadvantages of the analysis are: (1) if design values vary from year to year, historical data should be included in the analysis, and (2) care is needed in interpreting absolute differences. The objectives assessed by this analysis are regulatory compliance and forecasting assistance.

The technique is based on the difference between the standard and actual measurements. The design values are calculated as they apply to regulatory compliance. For lead, the values were calculated and compared to the 3-month standard. The absolute value of the percent difference between the measured design value and the standard is used to score each monitor. Monitors having the smallest absolute percent difference rank as most important. Sites that were less than a 10% difference from the NAAQS received a 1, between 10 to 20% received a 0.75, between 20 to 30% received a 0.5, between 30 to 40% received a 0.25, and greater than 40% received a 0 (zero).

The maximum 3-month concentrations found in the 2004 to 2009 time period were used for the NAAQS comparisons. The maximum value for the time period was used to show a “worst case scenario” for the six year period in question. Table 85 lists the analysis results and scores for the primary lead standard. Figure 59 illustrates the results graphically, using the value of the absolute percent difference to mark the approximate geographic location of the monitor. The only site in the network received a zero in this analysis as its design value is well below the NAAQS exceedance threshold.

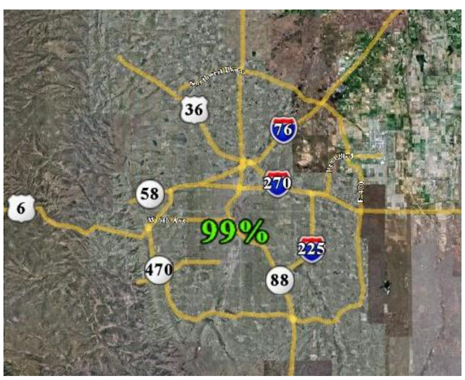


Figure 59. Deviation from NAAQS Pb 3-mo. Standard Map

Table 85. Deviation from NAAQS Pb 3-mo. Standard Analysis Scores

AQS ID	Rolling 3-mo. Avg. Design Value (ppm)	NAAQS 3-year Standard Value (ppm)	Absolute Percent Difference	Score
08 031 0025	0.01	0.15	99%	0.00

2.4.7.7. Area Served

For this analysis, sites are ranked based on their area of coverage. Calculating the area of representation of a particular monitor requires GIS software. The area of representation was determined using the Thiessen Polygon Method in ARC-GIS software. The software creates polygon features that divide the available space and allocate it to the nearest point feature. The result is similar to the Euclidean Allocation tool for rasters. Thiessen polygons are sometimes used instead of interpolation to generalize a set of sample measurements to the areas closest to them. Thiessen polygons are sometimes also known as Proximal polygons. They can be thought of as modeling the catchment area for the points, as the area inside any given polygon is closer to that polygon's point than any other. The polygons can be used to generalize measurements from a set of climate instruments to the areas around them. The polygons only cover a generalized area of the state that encompasses all the monitor locations, and do not extend to the state boundaries.

In an effort to reduce any bias introduced by the polygon method, the polygon area values were averaged for monitors that were located within 10 miles or less of each other. It was determined that this did not have any significant effect on the overall analysis scores, and therefore this data is not mentioned.

This method gives the most weight to rural sites and those on the edges of urban areas or other monitor clusters. It addresses the network objectives of background concentration, spatial coverage and interpolation. The disadvantages of this method include: (1) it does not take into account topography or actual air basins, (2) it does not take into account population or emissions, and (3) it may artificially weight monitors at the edge of the analysis domain. The main advantages are: (1) the simplicity and quickness of performing the method, and (2) it gives weight to remote and urban boundary sites that are necessary for proper interpolation.

This analysis was not performed for the TSP/Pb monitoring network as there was only one site in operation.

2.4.7.8. Monitor to Monitor Correlation

In this analysis, sites are ranked based on the correlation of their measured design values with those of the other monitors in the network. Monitors measuring concentrations that correlate well with concentrations at another monitor are considered redundant, and are consequently scored low. Monitors with concentrations that do not correlate with other monitored concentrations that are nearby are considered unique, and as such have more value for spatial monitoring objectives. These monitors are scored high. The advantages of this method are that it gives a measure of the site's uniqueness and representativeness, and that it is useful for identifying redundant sites. The disadvantages are that it requires large amounts of data with a high data completeness rate, and that the correlations are likely pollutant specific. The objectives assessed by this analysis are model evaluation, spatial coverage and interpolation.

Sites that do not correlate well with other sites have unique temporal concentration variation relative to other sites, and are likely to be important for assessing local emissions, transport and spatial coverage. It is assumed here that sites having an r-squared value of 0.6 or greater are well correlated. Sites having an r^2 value of 0.6 or higher when compared to the other CO sites were counted. The analysis was scored as follows: sites correlating with zero or one sites at 0.6 or greater scored a one, those correlating with two other sites at 0.6 or greater scored a 0.75, those correlating with three other sites at 0.6 or greater scored a 0.5, those correlating with four other sites at 0.6 or greater scored a 0.25, and those correlating with five or more sites at 0.6 or greater scored a 0 (zero).

This analysis was not performed for the TSP/Pb monitoring network as there was only one site in operation.

2.4.7.9. Measured Concentrations

For this analysis, sites are ranked based on the difference between the maximum pollutant concentrations measured and the value of the standard. The sites that measure high design values are ranked higher than those that measure low values. The objectives assessed by this analysis are maximum concentration location, model evaluation, regulatory compliance and population exposure. The main advantage of the technique is that it identifies key sites from a regulatory perspective, based on the maximum concentrations. The disadvantages are that it does not account for monitor-siting problems, and that is only focuses on high concentrations. Low concentration monitors may be useful for representing rural locations or background concentrations.

Sites that measure high design values are important for assessing NAAQS compliance and population exposure, and for performing model evaluations. The analysis is scored as follows: design values that are equal to or greater than 100% of the NAAQS are given a 1, values between 95 and 100% of the NAAQS receive a 0.75, values between 90 and 95% of the NAAQS received a 0.5, values between 80 and 90% of the NAAQS receive a 0.25, and values less than or equal to 80% of the NAAQS receive a 0 (zero).

Table 86 shows the scores for the maximum design values recorded at each site, as well as the analysis scores and site rankings. Figure 60 illustrates the results graphically, using the value of the difference between the standard and the design value to mark the approximate geographic location of the monitor. The one site in the network scored a zero when compared to the 3-month lead standard.

Figure 60. Pb Maximum Measured Concentration 3-month Standard Map

Table 86. Pb Measured Concentration 3-month Standard Analysis Scores

AQS ID	Max Design Value (μg/m³)	NAAQS 3-year Standard Value (μg/m³)	Difference (μg/m³)	% NAAQS	Score
08 031 0025	0.011	0.15	-0.14	7%	0.00

2.4.7.10. Summary/Conclusions and Recommendations

The total cumulative score for the one monitoring site in the TSP/Pb monitoring network was a one. The site scored a one in the Number of Other Parameters Monitored Analysis, a 0.25 in the Trends Impact analysis and zeros in the other analyses that could be performed on the data from the site. The addition of the new monitoring site at the Centennial Airport in April 2010 has enhanced the lead monitoring network. The APCD may also add three additional TSP-Pb sites at the following airports: Pueblo Memorial, Greeley – Weld County, and Rocky Mountain Metropolitan Airport in Jefferson County, pending final monitoring rule decisions by the EPA.

3. METEOROLOGICAL NETWORK ASSESSMENT

3.1. Overview

Meteorological measurements taken by the APCD consist of Wind Speed, Wind Direction, Temperature and Humidity. The wind speed and direction measurements are made as both scalar and vector averages. The last measurement that is made at the meteorological sites is the standard deviation of horizontal wind direction. This is a calculation, not a direct measurement of the variation of wind direction over time.

The meteorological monitors are:
08 001 0006 Alsup Elementary School - Commerce City, 7101 Birch Street
08 001 3001 Welby, 3174 E. 78th Avenue
08 005 0002 Highland Reservoir, 8100 S. University Boulevard
08 005 0006 Aurora-East, 36001 Quincy Avenue
08 031 0002 Denver-CAMP, 2105 Broadway
08 031 0014 Denver-Carriage, 2325 Irving Street
08 031 0021 Auraria Campus Met, 12th and Auraria Parkway
08 031 0025 Denver Municipal Animal Shelter, 678 S. Jason Street
08 035 0004 Chatfield State Park, 11500 N. Roxborough Park Road
08 059 0002 Arvada, 9101 W. 57th Avenue
08 059 0005 Welch, 12400 W. Hwy 285
08 059 0006 Rocky Flats-N, 16600 W. Hwy 128
08 059 0008 Rocky Flats-SE, 9901 Indiana Street
08 059 0013 Aspen Park, 26137 Conifer Road
08 069 0012 Rist Canyon, 11838 Rist Canyon Road
08 069 1004 Fort Collins-Mason, 708 S. Mason Street
08 077 0018 Grand Junction-Pitkin, 645 ¼ Pitkin Avenue
08 077 0020 Palisade Water Treatment, Rapid Creek Road
08 099 0003 Lamar Port of Entry, 7100 US Hwy 50

3.2. Planned Changes in Meteorological Monitoring for 2010/2011

The Rocky Flats SE site will be eliminated at the end of 2010. New sensors will be installed at the Greeley-Weld County Tower site and the Colorado Springs - Hwy 24 site. Additional sensors will be installed at the Denver Municipal Animal Shelter site. Auraria Campus site will likely be removed in 2010 due to planned construction of a new building next to the site.

4. IN STATE MONITORING BY OTHER AGENCIES

As of June 2, 2010, the following non-CDPHE owned/operated monitors listed in Table 87 are in operation in Colorado.

Table 87. Additional Monitoring by Other Agencies in Colorado

National Park Service (O_3)	Rocky Mountain National Park
	Colorado National Monument - Seasonal Monitoring – (2BTech)
	Dinosaur National Park - Seasonal Monitoring – (2BTech)
CASNET (O_3)	Rocky Mountain National Park (Different from NPS)
	Gothic
	Mesa Verde National Park
Forest Service (O_3)	Shamrock Mine (O_3 and NO_2)
	Forest Service Rocky Mountain Research Division – operates a network of 2BTech analyzers across the state of Colorado. This network is seasonal in nature changes from year to year. However, there are a few sites that are static and/or are run year round.
Desert Research Institute (O_3)	Storm Peak Lab
City/Town/County	Aspen – Pump House (O_3)
	Mesa County – Grand Junction Pitkin (PM_{10})
	Pitkin County (PM_{10})
	San Miguel County (PM_{10})
	Routt County (PM_{10})
Tribes – Southern Ute (O_3)	Bondad/Hwy 550 (O_3, NO_2, PM_{10}, $PM_{2.5}$)
	Ignacio (O_3, CO, NO_2, PM_{10}, $PM_{2.5}$)
NOAA (O_3)	Niwot Ridge Tundra
	Niwot Ridge
	Erie Tower
BLM	Meeker (O_3, NO_2, $PM_{2.5}$)
Private Sector	Encana Canyon Site (O_3, NO_2)
	Encana Mountain Site (O_3, NO_2)
	Xcel Energy Pueblo West (formerly Black Hills)(O_3)
	Holcim Cement, Florence (O_3)

5. FEDERAL REQUIREMENTS FOR NUMBER OF MONITORS

5.1. CFR

5.1.1. Carbon Monoxide

There are no minimum requirements for the number of CO monitoring sites. Operation of the existing CO sites in Colorado is required until CDPHE requests discontinuation of a site in the Annual Network Plan and the EPA Regional Administrator approves the request. Where CO monitoring is ongoing, it is required that at least one site must be a maximum concentration site for that area under investigation.

5.1.2. Ozone

In July 2009, the EPA proposed to revise the ozone air quality monitoring network design requirements. The proposed amendments would modify minimum monitoring requirements in urban areas, add new minimum monitoring requirements in non-urban areas, and extend the length of the required ozone monitoring season in some states. Currently, within an O_3 network, at least one O_3 site for each MSA, or CSA if multiple MSAs are involved, must be designed to record the maximum concentration for that particular metropolitan area. More than one maximum concentration site could be necessary in some areas. States must also operate other O_3 monitors to meet objectives that include: (1) assess NAAQS compliance, (2) investigate O_3 transport issues, (3) calculate the Air Quality index, (4) verify modeling efforts, and (5) assess ozone-related effects on ecosystems with natural plants sensitive to air pollution damage. The current requirements can be seen in the table below, which was taken from 40 CFR 58 Appendix D.

Table 88. Table D–2 of Appendix D to Part 58— SLAMS Minimum O_3 Monitoring Requirements

MSA population[1,2]	Most Recent 3-year Design Value Concentrations ≥ 85% of any O_3 NAAQS[3]	Most Recent 3-year Design Value Concentrations < 85% of any O_3 NAAQS[3,4]
>10 million	4	2
4–10 million	3	1
350,000–<4 million	2	1
50,000–<350,000[5]	1	0

[1]Minimum monitoring requirements apply to the Metropolitan statistical area (MSA).
[2]Population based on latest available census figures.

[3]The ozone (O_3) National Ambient Air Quality Standards (NAAQS) levels and forms are defined in 40 CFR part 50.
[4]These minimum monitoring requirements apply in the absence of a design value.
[5]Metropolitan statistical areas (MSA) must contain an urbanized area of 50,000 or more population.

The prospective maximum ozone concentration monitor site should be selected in a direction from the city that is most likely to observe the highest O_3 concentrations, more specifically, downwind during periods of photochemical activity. Since O_3 levels decrease significantly in the colder parts of the year in many areas, O_3 is required to be monitored only during the "ozone season" as designated in the 40 CFR Part 58 Appendix D, which in Colorado is March 1 through September 30. The appropriate spatial scales for O_3 sites are neighborhood, urban, and regional. Since O_3 requires appreciable formation time, the mixing of reactants and products occurs over large volumes of air, and this reduces the importance of monitoring small-scale spatial variability.

The proposed new monitoring requirements would add at least one additional monitor in each urban area with 50,000 to 350,000 people, if monitoring is not already being done in those areas. In non-urban areas, the proposal is that states would be required to operate a minimum of three O_3 monitors to allow for: (1) assessment of ozone concentrations in federal, state or tribal lands with ozone sensitive ecosystems, (2) assessment of at least one population center between 10,000 and 50,000 people with expected ozone concentrations of at least 85% of the NAAQS level of 0.075 ppm (averaged over an 8-hour period, and (3) monitoring in the location of expected maximum ozone concentration outside of any urban area.

5.1.3. Nitrogen Dioxide

Until January 2010, operation of the existing NO_2 sites in Colorado was required until CDPHE requests discontinuation of a site in the Annual Network Plan and the EPA Regional Administrator approves the request. Where NO2 monitoring is ongoing, it is required that at least one NO_2 monitor must be located to measure regional maximum concentration within the geographic area that it represents. In January 2010, the EPA's new primary NO_2 standards went into effect. The first new requirement is that at least one monitor must be located near a major road in any urban area with a population greater than or equal to 500,000 people. A second monitor is required near another major roadway in areas with either: (1) population greater than or equal to 2.5 million people, or (2) one or more road segments with an annual average daily traffic count greater than or equal to 250,000 vehicles.

The second new requirement pertains to community-wide monitoring. A minimum of one monitor must be placed in any urban area with a population greater than or equal to 1 million people to assess community-wide concentrations. The final new monitoring requirement involves monitoring to protect susceptible and vulnerable populations. For this requirement, the EPA Regional Administrators will work with states to site at least 40 additional NO_2 monitors to help protect communities that are susceptible and vulnerable to NO_2-related health effects. All new monitors must begin operating no later than January 1, 2013.

5.1.4. Sulfur Dioxide

Currently, there are no minimum requirements for the number of SO_2 monitoring sites. Operation of the existing SO_2 sites in Colorado is required until CDPHE requests discontinuation and the EPA Regional Administrator approves the request. The EPA Regional Administration has not approved SO_2 monitoring for discontinuation; hence, the APCD is required to operate at least one SO_2 monitor located to measure regional maximum concentrations within the geographic area that it represents. However, in June 2010 the EPA released its final revisions to the SO_2 primary National Air Quality Standard, which institutes new monitoring requirements, and changes the level and form of the primary standard.

The new monitoring requirements require placement of monitors in Core Based Statistical Areas (CBSAs) based on a population weighted emissions index for the area. This means that there must be 3 monitors in CBSAs with index values of 1 million or more, 2 monitors in CBSAs with index values between 100,000 and 1 million, and 1 monitor in CBSAs with index values greater than 5,000.

5.1.5. PM_{10}

Colorado must operate at least the minimum number of required PM_{10} SLAMS monitoring sites as listed in the table below, which was taken from 40 CFR 58 Appendix D. These required monitoring stations must be located to represent community-wide air quality.

Table 89. Table D–4 of Appendix D to Part 58—PM_{10} Minimum Monitoring Requirements

Population Category[1]	High Concentration[2]	Medium Concentration[3]	Low Concentration[4,5]
>1,000,000	6–10	4–8	2–4
500,000–1,000,000	4–8	2–4	1–2
250,000–500,000	3–4	1–2	0–1
100,000–250,000	1–2	0–1	0

[1]Selection of urban areas and actual numbers of stations per area will be jointly determined by EPA and the State agency.

[2]High concentration areas are those for which ambient PM_{10} data show ambient concentrations exceeding the PM_{10} NAAQS by 20 percent or more.

[3]Medium concentration areas are those for which ambient PM_{10} data show ambient concentrations exceeding 80 percent of the PM_{10} NAAQS.

[4]Low concentration areas are those for which ambient PM_{10} data show ambient concentrations less than 80 percent of the PM_{10} NAAQS.

[5]These minimum monitoring requirements apply in the absence of a design value.

5.1.6. $PM_{2.5}$

Colorado must operate at least the minimum number of required $PM_{2.5}$ sites listed in the table below, which was taken from 40 CFR 58 Appendix D. These required monitoring stations must be located to represent community-wide air quality. In addition, the following specific criteria also apply:

- At least one monitoring station is to be sited in a population-oriented area of expected maximum concentration.
- For areas with more than one required station, a monitoring station is to be located in an area of poor air quality.
- Each state shall install and operate at least one $PM_{2.5}$ site to monitor for regional background concentrations, and at least one $PM_{2.5}$ site to monitor for regional transport.

In addition, chemical speciation is encouraged at sites where the chemically resolved data would be useful in developing State Implementation Plan (SIP) and supporting health effects related studies.

Table 90. Table D–5 of Appendix D to Part 58—$PM_{2.5}$ Minimum Monitoring Requirements

MSA population[1,2]	Most Recent 3-Year Design Value ≥85% of any $PM_{2.5}$ NAAQS[3]	Most Recent 3-Year Design Value <85% of any $PM_{2.5}$ NAAQS[3,4]
>1,000,000	3	2
500,000–1,000,000	2	1
50,000–<500,000[5]	1	0

[1]Minimum monitoring requirements apply to the Metropolitan statistical area (MSA).

[2]Population based on latest available census figures.

[3]The $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) levels and forms are defined in 40 CFR part 50.

[4]These minimum monitoring requirements apply in the absence of a design value.

[5]Metropolitan statistical areas (MSA) must contain an urbanized area of 50,000 or more population.

5.1.7. Lead

On October 15, 2008 the EPA substantially strengthened the national ambient air quality standards (NAAQS) for lead (see 73 FR 66934). EPA revised the level of the primary (health-based) standard from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$, measured as total suspended particles (TSP); and, revised the secondary (welfare-based) standard to be identical in all respects to the primary standard. In conjunction with strengthening the lead NAAQS, EPA identified the need for states to improve existing lead monitoring networks by requiring monitors to be placed in areas with sources that emit one ton or more per year (tpy) of lead by January 1, 2010, and in urban areas with a population of 500,000 or greater by January 1, 2011. APCD, in conjunction with EPA Region VIII, has reviewed the 2007 lead emissions inventory and found one lead source with emissions of 1 tpy or greater. This source is the Centennial Airport. A source oriented lead monitor was established at this site in April 2010. APCD will propose locations for population based lead monitors in next year's network plan.

5.2. SIP

In Colorado, 11 communities formerly violated the federal standards for PM_{10} or carbon monoxide. These areas were classified as "nonattainment" by the U.S. Environmental Protection Agency. All these areas have since been redesignated by EPA to "attainment/maintenance" status. Once redesignated, the state creates a "Maintenance Plan" which requires monitoring to ensure the area stays in attainment. The state is required to provide monitoring in these areas, however it does have flexibility to open and close sites to maximize its monitoring efforts in these areas.

Ozone has emerged as a problem for the Front Range area, and in 2007 the Front Range Area violated the Federal 8-hour ozone standard and was designated "non-attainment." The following table lists the SIP required monitors by parameter.

Table 91. SIP Required Monitors in Colorado

Carbon Monoxide	Colorado Springs – Highway 24
	Denver – CAMP
	Denver – Welby
	Denver - Auraria
	Ft. Collins – CSU
	Greeley – Annex
	Longmont - Main
Ozone	Fort Collins – West
	Fort Collins - Mason
	Greeley – Weld County Tower
	South Boulder Creek
	Rocky Flats North
	NREL
	Arvada
	Welch
	Chatfield State Park
	Highland
	Carriage
	Welby
PM_{10}	Aspen Library
	Canon City Municipal Bldg
	Denver Visitor Center
	Welby
	Lamar – Municipal
	Lamar – Power Plant
	Pagosa Springs School
	Steamboat Springs – Municipal Bldg
	Telluride Health Department

6. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

6.1. Recommendations for the Overall Colorado Network

Colorado's ambient air monitoring network has been and will continue to be in a constant state of flux. Change within the network is most notably driven by changes to the NAAQS, changes in population demographics, changes in industrial land applications and validation for air modeling and forecasting tools. In early 2000, Colorado's air monitoring network made a significant expansion to include monitoring of fine particulate matter ($PM_{2.5}$). Concurrent with this expansion was a contraction of Colorado's TSP lead monitoring network, and to a lesser extent, the PM_{10} monitoring network.

In 2008, the EPA promulgated a more stringent ozone standard of 75 ppb that forced Colorado's Front Range solidly into non-attainment. In 2009, the EPA proposed lowering the ozone standard even further (60 to 70 ppb) to become more in line with recommendations proposed by the Clean Air Scientific Advisory Committee (CASAC). This standard will be promulgated in August 2010. The lowering of the ozone standard will force Colorado to enhance its ozone monitoring, identify potential precursor sources and to refine its scientific understanding of Colorado's ozone problems. In 2008 and 2009 the State expanded its ozone network in the Front Range and on the Western Slope. Expansion in the Front Range includes two sites in the western foothills and one on the eastern edge of the Denver-metro area. These sites were installed to further define the spatial extent of the Front Range's ozone problem and validate model projections. Expansion on the Western Slope included the installation of three sites located near areas of proposed or active oil and gas development. These sites were added to further Colorado's understanding of ozone development in areas of significant precursor production. These recent trends play a significant role in the understanding of how Colorado's air monitoring network will evolve in the future.

There are several emerging factors that will drive Colorado's air monitoring network in the future. Most notably are the introduction of the new NAAQS standards for ozone, nitrogen dioxide, sulfur dioxide and lead. It is anticipated that the implementation of the new ozone standard will only expand Colorado's network. The new ozone rule will require monitoring in at least one of Colorado's smaller metropolitan areas. To further understand regional background ozone concentrations, and to support the 3-State Pilot Project, additional monitoring on the West Slope is being considered. To further understand the spatial extent of the Front Range ozone problem, and as to where the non-attainment boundaries should be set, additional monitoring is being considered.

It is anticipated that the nitrogen dioxide network will expand in the future as well. The new nitrogen dioxide rule will require "near roadway" monitoring, and the possible reallocation of an existing monitor.

It is anticipated that the sulfur dioxide network will expand in the future. The new sulfur dioxide rule will require the installation of at least one new site, and possibly the reallocation of existing monitors.

It is anticipated that the PM_{10} and $PM_{2.5}$ networks will stay static in the future. The main changes would be the replacement of filter based monitoring with continuous monitoring in blowing dust areas. Also under discussion is meteorological tower/sensor installation at some particulate sites.

It is anticipated that the lead network will continue to expand. The new lead rule may require the installation of several new sites.

6.2. Parameter-Specific Recommendations

6.2.1. Carbon Monoxide

There are no planned changes in the Carbon Monoxide Monitoring Network for 2010. The APCD has decreased its CO monitoring network in recent years and removed most of the low value monitors. This was done to shift funding to add monitoring in areas with higher need, such as increased ozone monitoring.

6.2.2. Ozone

Planned ozone network changes for 2010 include the review of monitoring sites in the North Front Range for possible enhancement, and the possible installation of a new site in the Pueblo area in 2010 /2011 to meet the impending new Federal monitoring requirements. Finally, to support the 3-State Pilot Project, an ozone monitor will be installed by Maybell, in northwest Colorado in 2010.

Welby ozone has very poor correlation with 500-millibar heights and shows some signs of being inexplicably low compared with other sites in the area. Odd oxygen or total oxidant estimates can be derived by combining NOx and ozone concentrations. These estimates provide an important indicator of the ozone production potential at a location, and help to differentiate low ozone production potential and NOx quenching. As such, they can shed light on the meaning of day-of-week differences in ozone concentrations which can be an important step in understanding what areas may be NOx or VOC limited. Therefore, we are considering the relocation of the ozone monitor from Welby to CAMP, as it would strengthen the extended NO_2 data set there with collocated monitoring, and would give concurrent ozone and NOx data for a bare minimum number of sites needed to test and validate the modeling.

Professional judgment by staff meteorologists indicate that the Arvada (08 059 0002), Carriage (08 031 0014), Welby (08 001 3001) and Welch (08 059 0005) sites are redundant and could be removed. In addition, the re-installation of an ozone monitor at the Denver – CAMP site is recommended for weight of evidence determinations and model validation.

6.2.3. Nitrogen Dioxide

The planned changes in the Nitrogen Dioxide Monitoring Network for 2010 include the addition of a NO_Y analyzer at the Denver Municipal Animal Shelter. Also proposed is the addition of a NO_2 monitor to supplement the NOy monitor at the DMAS NCore site. This would serve the purpose of strengthening assessment and model prediction validation.

There are currently only two NOx monitoring sites in the Denver ozone non-attainment area, CAMP and Welby. It may make sense to move the Welby NOx monitors to Rocky Flats, a high-concentration site downwind of Denver. Similarly, it would make sense to re-instate ozone monitoring at CAMP. Then, there would be concurrent ozone and NOx data for a bare minimum number of sites needed to test and validate the modeling. Odd oxygen or total oxidant estimates can be derived by combining NOx and ozone concentrations. These estimates provide an important indicator of the ozone production potential at a location, and help to differentiate low ozone production potential and NOx quenching. As such, they can shed light on the meaning of day-of-week differences in ozone concentrations, which can be an important step in understanding what areas may be NOx or VOC limited. Therefore, we are considering moving the NO_2 monitor from Welby to the Rocky Flats – North site, where there is also an ozone monitor. This would also help strengthen assessment and model validation capabilities.

It is anticipated that further in the future the NO_2 network will expand to incorporate new monitoring sites based on the new NO_2 NAAQS. This monitoring may possibly include the addition of two roadway monitors in the Front Range area, and one roadway monitor in the Colorado Springs area, by 1/1/2013.

6.2.4. Sulfur Dioxide

In 2010 the only planned change to the SO_2 network is to fully install the trace analyzer at the DMAS NCore site. Further in the future, however, it is anticipated that additional monitors will need to be installed due to the new SO_2 NAAQS. Planning will begin for the placement and/or relocation of SO_2 monitors in support of the new rule. It is anticipated that one monitor will be added to the network in the Colorado Springs area, and one in the Front Range area will be relocated to a different monitoring site. Work will be completed by 1/1/2013.

6.2.5. PM_{10}

The Lamar Power Plant PM_{10} monitor will be considered for removal and replacement in 2010 due to conversion of the plant to coal burning, and because it is not located in ambient air. The Pueblo site was relocated in 2009 due to the construction of a tall building adjacent to the former site. In addition, the relocation of the Mt. Crested Butte site to a better location is also being considered.

6.2.6. $PM_{2.5}$

The Pueblo $PM_{2.5}$ site was relocated in 2009 due to the construction of a tall building next to the current building. Also, the addition of a $PM_{10/2.5}$ TEOM 1405 DF to the Fort Collins Edison St. site took place in 2009. The Boulder-CU/Athens TEOM site may be relocated in 2010 due to new construction near the site. A URS carbon sampler for $PM_{2.5}$ chemical speciation was added to the Platteville and Grand Junction-Powell sites in 2009. The $PM_{2.5}$ chemical speciation samplers were removed from the Grand Junction-Powell site in December 2009, and were placed at the DMAS NCore site.

6.2.7. Lead

In 2010, the Division established a source-oriented TSP/Lead monitor at Centennial Airport. This site was needed due to the changes in the lead monitoring regulations that require source-oriented monitoring at facilities with emissions of more than one ton per year. If the proposed new rule for monitoring sites with emissions of 0.5 TPY or greater is put into effect, it may require the APCD to expand its lead monitoring network with new sites in the coming years, primarily at some additional airports.

6.2.8. Meteorological

The Rocky Flats SE site will be eliminated at the end of 2010. New sensors and towers will be installed at the Colorado Springs - Hwy 24 site and at the Greeley – Weld County Tower site. Additional meteorological sensors are being considered for installation at the Denver Municipal Animal Shelter site. Auraria Campus met will likely be removed in 2010 due to planned construction of a new building next to the site. There is also the possibility of relocation of the Highland Reservoir and Fort Collins – Mason site meteorological towers to accommodate site construction and the Mason Street Corridor Project, respectively.

6.3. Responses to Original Network Assessment Questions

The objectives for this network assessment were three-fold. First, a determination of whether the existing network was meeting its intended monitoring objectives was necessary. Second, an evaluation of the network's adequacy for characterizing current air quality and impacts from future industrial and population growth were considered. Third, potential areas where new monitors could be sited or removed to support network optimization, and/or to meet new monitoring objectives were identified.

The following questions regarding the capabilities of the current monitoring network were asked at the beginning of this assessment, and are answered below.

- How well does the current monitoring network support current objectives? Which objectives are being met; which objectives are not being met? Are unmet objective(s) appropriate concerns for APCD? If so, what monitoring is necessary to meet those unaddressed objectives? What are potential future objectives for the monitoring network?

    The current CO monitoring network supports the APCD's monitoring objectives well. All sites are in place in support of state maintenance plans. Monitoring in support of these plans will continue until the plans expire. There have been no exceedances of the CO NAAQS for many years now. All monitoring objectives are being met. Currently, there are no anticipated changes to the future objectives for this monitoring network.

The current O_3 monitoring network supports the APCD's monitoring objectives reasonably well. Areas of high concentrations, as well as background concentration areas are being monitored all along the Front Range, and in several areas on the Western Slope. Most sites are in place in support of state maintenance plans. With the impending new lower NAAQS for ozone, the network will need to be expanded to monitor more areas of Colorado in the future.

The current NO_2 monitoring network supports the APCD's monitoring objectives. The sites meet the former Federal requirements for monitoring. The new standard will require expansion of the NO_2 network with additional monitoring near roadways in the future. Since the collocation of NOx and ozone monitors is a key requirement for model validation exercises, a pairing of NOx and O_3 monitors should ideally occur in the urban core and at high-concentration sites downwind. There are currently only two NOx monitoring sites in the Denver ozone non-attainment area, CAMP and Welby. Ozone is no longer monitored at CAMP. Welby ozone has very poor correlation with 500-millibar heights and shows some signs of being inexplicably low compared with other sites in the area. It may make sense to move the Welby NOx monitors to Rocky Flats, a high-concentration site downwind of Denver. Similarly, it would make sense to re-instate ozone monitoring at CAMP. Then there would be concurrent ozone and NOx data for a bare minimum number of sites needed to test and validate the modeling. Odd oxygen or total oxidant estimates can be derived by combining NOx and ozone concentrations. These estimates provide an important indicator of the ozone production potential at a location and help to differentiate low ozone production potential and NOx quenching. As such they can shed light on the meaning of day-of-week differences in ozone concentrations which can be an important step in understanding what areas may be NOx or VOC limited.

The current SO_2 monitoring network supports the APCD's monitoring objectives well. The sites meet the former Federal requirements for monitoring. The new standard will require the expansion of the SO_2 network with additional monitoring in the future.

The current PM_{10} monitoring network supports the APCD's monitoring objectives well. The sites meet the Federal requirements for monitoring. There are no suggested changes for this network. The APCD has decreased our PM_{10} monitoring network in recent years and removed all of our low value monitors. This was done to shift funding to add monitoring in areas with higher need. There is a need to add continuous FEM PM_{10} monitors and meteorological towers with at least wind speed and wind direction parameters with real time telemetry to several sites that have exceeded the NAAQS due to windblown dust several times each year. This will help in source contribution and apportionment as well as aid in forecasting and high pollution advisories. There is also a need to add PM_{10} monitors to a couple of sites in eastern Colorado to help define the extent of regional windblown dust and to protect human health in that area of the state.

The current $PM_{2.5}$ monitoring network supports the APCD's monitoring objectives well. The sites meet the Federal requirements for monitoring. There are no suggested changes for this network.

The current TSP/Pb monitoring network supports the APCD's monitoring objectives well. The sites meet the Federal requirements for monitoring. There are no suggested changes for this network, unless the EPA lowers the emissions threshold to 0.5 TPY for lead as proposed. In that case, the APCD will need to add three new TSP-Pb monitors at three Front Range airports: Pueblo Memorial, Greeley-Weld County, and Rocky Mountain Metropolitan Airport in Jefferson County.

➢ Are the existing sites collectively capable of characterizing all criteria pollutants? Are the existing sites capable of characterizing criteria pollutant trends (spatially and temporally)? If not, what areas lack appropriate monitoring? If needed, where should new monitors be placed? Does the existing network support future emissions assessment, reconciliation, and modeling studies? Are there parameters (at existing sites) or new sites that need to be added to support these objectives?

Yes, the existing sites are collectively capable of characterizing all criteria pollutants and their trends. As the newer sites are online longer, the data sets for characterizing the pollutant concentration long term trends will serve to strengthen the overall monitoring network objectives. As new criteria pollutant standards are promulgated, each network may have to expand in order to accommodate any new monitoring rules.

The addition of air toxics monitors at the established CAMP and Platteville sites, as well as the installation of a new monitoring site in the Kersey area would also be beneficial for assessment and model prediction validation.

- Is the current monitoring network sufficient to adequately assess regional air quality conditions with respect to all criteria pollutants? If not, where should monitors be relocated or added to improve the overall effectiveness of the monitoring network? How can the effectiveness of the monitoring network be maximized?

  Yes, the current network is sufficient to adequately assess regional air quality conditions with respect to all criteria pollutants. The effectiveness of the monitoring network can be maximized by a shifting of resources from some sites. The addition of several air toxics monitors to the network would also help maximize its efficiency by providing data to be used in ozone modeling studies. No, the current sites run by CDPHE , combined with those that are run by various other entities in the state, do not currently provide data to support the assessment of ozone/precursor transport from outside the region. Additional O_3, NOx and VOC monitoring in western Colorado would be desirable to meet this need.

6.4. Validity of Assessment

Throughout the process of completing this network assessment, it was discovered that many of the analyses used do not necessarily apply well to the sparse network density of the Colorado Air Monitoring Network. While these analyses may be more pertinent in areas with dense networks or simple topography, such as those located in the middle and eastern U.S., they do not apply well to Colorado's networks.

The Thiessen polygon analyses are a good example. While they might be useful in states with dense networks (California) or simple terrain (Illinois), they are not a practical tool for Colorado's network assessment. The resulting polygons in Colorado cross air sheds, and are not well-matched to emissions source regions and densities, population distributions, political boundaries, terrain, or any of the geographical features that we already know affect pollutant concentrations and impacts within Colorado. The use of Thiessen polygons as the base unit for assessing a variety of metrics has resulted in erroneous rankings of monitor sites. It would be far better to use counties as the base spatial unit for many of the other metrics (for county populations, population densities, emissions densities, etc.), although even these would result in some weights that we know would be unreasonable. With that in mind, future network assessments should include more heavily terrain/air shed-based types of analyses to provide a better look at what's going on in the State.

Other examples of skewed analyses results come in the form of using emissions densities for ozone monitor assessments, and using point source emissions and distance data without area and mobile sources. Some of the pollutants monitored by the network are secondary pollutants. One example is found in the ozone monitoring network. Since it is a secondary pollutant, ozone is more likely to be high at a significant distance from sources and more likely to be low within a high density emissions area. Because the relationship between emissions and ozone is a complex function of meteorology and photochemistry, using a scoring metric which places a higher value on sites that are close to emissions sources is misleading. However, it was decided to keep the scoring metric the same for all analyses in this first assessment attempt in an effort to avoid the introduction of any bias into the scores.

While many of the analyses performed in this assessment did provide erroneous or skewed site ranking results, it was decided to continue with those analyses for this assessment period, as time constraints were an issue in completing the assessment report. Relevant professional opinions of staff meteorologists and modelers were then sought and included as a basis for determining the overall addition or relocation of network monitors.

7. WORKS CITED

Alpine Geophysics, Regional Air Quality Council, Colorado Department of Public Health and Environment, and ENVIRON International Corporation. (2008). *Denver Metropolitan Area and North Front Range 8-Hour Ozone State Implementation Plan - Weight of Evidence to Support the Modeled Attainment Demonstration.*

Boersma, K. F., Eskes, H. J., & Brinksma, E. J. (2004). Error Analysis for Troposheric NO_2 retrieval from Space. *Journal of Geophysical Research , 109 D04311*.

Colorado Department of Public Health and Environment, Air Pollution Control Division. (2004). Denver Early Action Ozone Compact Weight of Evidence to Support Attainment Demonstration.

Colorado State Demography Office. (n.d.). *Population Totals for Colorado and Sub-State Regions.* Retrieved February 12, 2010, from http://www.dola.state.co.us/dlg/demog/population/forecasts/substate5yr.xls

Colorado State Demography Office. (n.d.). *Population Totals for Colorado and Sub-State Regions.* Retrieved February 12, 2010, from http://www.dola.state.co.us/dlg/demog/population/geoarea.pdf

Cooper, O. (2006). Evidence for a Recurring Eastern North America Upper Tropospheric Ozone Maximum During Summer. *Journal of Geophysical Research , 111* (D24S05).

Cooper, O. (2007). Large Upper Troposheric Ozone Enhancements Above Midlatitude north America During Summer: In Situ Evidence from the IONS and MOZAIC Ozone Measurement Network. *Journal of Geophysical Research , 112* (D23306).

Damberg, R. (2007, June 20). *U. S. Environmental Protection Agency.* Retrieved June 2, 2010, from http://www.epa.gov/ttnnaaqs/pm/presents/policies_for_pm25_precursors-rich_damberg.ppt

Eskridge, R. E., Ku, J. Y., Porter, P. S., Rao, S. T., & Zurbenko, I. G. (1997). Separating Different Scales of Motion in Time Series of Meteorological Variables. *Bulletin of the American Meteorological Society , 78* (7), 1473-1483.

Kalnay, e. a. (1996). The NCEP/NCAR 40-Year Reanalysis Project. *Bulletin of the American Meteorological Society , 77*, 437-470.

Koumoutsaris, S., Bey, I., Generoso, S., & Thouret, V. (2007). Influence of El Nino-Sourthern Oscillation on the Interannual Variability of Tropospheric Ozone in the Northern Midlatitudes. *Journal of Geophysical Research , 113* (D19301).

Porter, P. S., Rao, S. T., Zurbenko, I., Zalewsky, E., Henry, R. F., & Ku, J. Y. (1996). *Statistical Characteristics of Spectrally-Decomposed Ambient Ozone Time Series Data.*

Rao, S. T., Zurbenko, I. G., Neagu, R., Porter, P. S., Ku, J. Y., & Henry, R. F. (1997). Space and Time Scales in Ambient Ozone Data. *Bulletin of the American Meteorological Society , 78* (10), 2153-2166.

Sonoma Technologies, Inc. (2005, September). Analytical Techniques for Technical Assessments of Ambient Air Monitoring Networks. Petaluma, CA, USA.

Spichtinger, N., Damoah, R., Eckhardt, S., Forster, C., James, P., Beirle, S., et al. (2004). Boreal Forest Fires in 1997 and 1998: A Seasonal Comparison Using Transport Model Simulations and Measurement Data. *Atmospheric Chemistry and Physics Discussions , 4*, 2747-2779.

US EPA. (2009 ed.). National 8-Hour Primary and Secondary Ambient Air Quality Standards for Ozone. *Code of Federal Regulations , Title 40, Pt. 50.10* .

US EPA. (2010, January 19). National Ambient Air Quality Standards for Ozone. *Federal Register , 75, No. 11* .

US EPA. (2009 ed.). National Primary Ambient Air Quality Standards for Carbon Monoxide. *Code of Federal Regulations* .

US EPA. (2009 ed.). National Primary Ambient Air Quality Standards for Sulfur Oxides (Sulfur Dioxide). *Code of Federal Rgulations* (Title 40, Pt. 50.4).

US EPA. (2009 ed.). National Primary and Secondary Ambient Air Quality Standards for Lead. *Code of Federal Regulations* (Title 40, Part 50.12).

US EPA. (2009 ed.). National Primary and Secondary Ambient Air Quality Standards for PM_{10}. *Code of Federal Regulations* (Title 40, Pt. 50.6).

US EPA. (2009 ed.). National Primary and Secondary Ambient Air Quality Standards for $PM_{2.5}$. *Code of Federal Regulations* (Title 40, Pt. 50.7).

US EPA. (2009 ed.). National Secondary Ambient Air Quality Standards for Sulfur Oxides (Sulfur Dioxide). *Code of Federal Regulations* (Title 40, Pt. 50.5).

US EPA. (2010, June). Primary National Ambient Air Quality Standard for Sulfur Dioxide, Final Rule.

US EPA. (2010, February 9). Primary National Ambient Air Quality Standards for Nitrogen Dioxide; Final Rule. *Federal Register , 26* .

APPENDIX A - Monitoring Site Descriptions

This Appendix includes site information for all sites containing continuous gaseous monitors, meteorological monitors, or particulate monitors. The data is presented first in a tabular format, and is then followed by site descriptions. It is in the order of AQS ID number. A plus symbol (+) instead of an "X" indicates that the monitor will be fully installed by the end of 2010.

AQS #	*Site Name*	*CO*	*O_3*	*NO*	*NO_2*	*NOy*	*SO_2*	*PM_{10}*	*$PM_{2.5}$*	*TSP/Pb*	*Met*
08 001 0006	Alsup Elementary School - Commerce City							X	X		X
08 001 3001	Welby	X	X	X	X		X	X			X
08 003 0001	Alamosa – Adams State Coll.							X			
08 003 0003	Alamosa – Municipal Bldg.							X			
08 005 0002	Highland Reservoir		X								X
08 005 0005	Arapaho Comm. Coll.								X		
08 005 0006	Aurora - East		X								X
08 005 0007	Centennial Airport									X	
08 007 0001	Pagosa Springs School							X			
08 013 0003	Longmont-Municipal Bldg.							X	X		
08 013 0009	Longmont - Main	X									
08 013 0011	South Boulder Creek		X								
08 013 0012	Boulder Chamber of Commerce							X	X		
08 013 1001	Boulder – CU - Athens								X		
08 029 0004	Delta Health Dept							X			
08 031 0002	Denver - CAMP	X		X	X		X	X	X		X
08 031 0013	Denver - NJH-E								X		
08 031 0014	Denver - Carriage		X								X
08 031 0017	Denver Visitor Center							X			
08 031 0019	Denver - Firehouse #6	X									
08 031 0021	Auraria Met Station										X
08 031 0023	Denver – Swansea Elem.								X		
08 031 0025	Denver Municipal Animal Shelter	+	X			+	+	X	X	X	X
08 035 0004	Chatfield State Park		X						X		X
08 039 0001	Elbert – Ben Kelly Road								X		
08 041 0013	U. S. Air Force Academy		X								
08 041 0015	Colorado Springs Hwy. 24	X									X
08 041 0016	Manitou Springs		X								
08 041 0017	Colorado Springs Colorado College							X	X		
08 043 0003	Cañon City – City Hall							X			
08 045 0005	Parachute – High School							X			
08 045 0007	Rifle – Henry Bldg							X	X		X
08 045 0012	Rifle – Health Dept		X								
08 051 0004	Crested Butte							X			

AQS #	***Site Name***	***CO***	***O_3***	***NO***	***NO_2***	***NOy***	***SO_2***	***PM_{10}***	***$PM_{2.5}$***	***TSP/Pb***	***Met***
08 051 0007	Mt. Crested Butte - Realty							X			
08 059 0002	Arvada		X								X
08 059 0005	Welch		X								X
08 059 0006	Rocky Flats - N		X								X
08 059 0008	Rocky Flats - SE										X
08 059 0011	NREL		X								
08 059 0013	Aspen Park		X								X
08 067 0004	Durango-River City Hall							X			
08 069 0009	Fort Collins – CSU - Edison							X	X		
08 069 0011	Fort Collins - West		X								
08 069 0012	Rist Canyon		X								X
08 069 1004	Fort Collins - Mason	X	X								X
08 077 0017	Grand Junction – Powell Bldg							X	X		
08 077 0018	Grand Junction - Pitkin	X									X
08 077 0019	Clifton - Sanitation							X			
08 077 0020	Palisade Water Treatment		X								X
08 083 0006	Cortez – Health Dept		X						X		
08 097 0006	Aspen - Library							X			
08 099 0001	Lamar Power Plant							X			
08 099 0002	Lamar Municipal							X			
08 099 0003	Lamar Port of Entry										X
08 101 0012	Pueblo Public Works							X	X		
08 107 0003	Steamboat Springs							X			
08 113 0004	Telluride							X			
08 117 0002	Breckenridge							X			
08 123 0006	Greeley-Hospital							X	X		
08 123 0008	Platteville Middle School								X		
08 123 0009	Greeley –County Tower		X								X
08 123 0010	Greeley – West Annex	X									

Alsup Elementary School - Commerce City, 7101 Birch Street (08 001 0006):
The Alsup Elementary School - Commerce City site is in a predominantly residential area north of the Denver Central Business District (CBD) near the Platte River Valley, downstream from the Denver urban air mass. There are two schools in addition to the Alsup Elementary School in the immediate vicinity, a middle school to the north and a high school to the southeast. There is a large industrial area to the south and gravel pits to the west and northwest.

PM_{10} monitoring began in January 2001 and continues today. The maximum PM_{10} concentration recorded at this site in 2009 was 95.8 $\mu g/m^3$. There were no exceedances of the PM_{10} NAAQS at this site in 2009.

$PM_{2.5}$ monitoring began in January 2001 and continues today. There are a collocated set of monitors, along with a continuous monitor, a trends speciation monitor, and a $PM_{2.5}$ carbon monitor all in operation. The maximum concentration recorded by the primary monitor was 28.5 $\mu g/m^3$, while at the secondary monitor it was 15 $\mu g/m^3$.

Meteorological monitoring began in June of 2003.

Welby, 3174 E. 78th Avenue (08 001 3001):
Located 8 miles north-northeast of the Denver Central Business District (CBD) on the bank of the South Platte River, this site is ideally located to measure nighttime drainage of the air mass from the Denver metropolitan area and the thermally driven, daytime upriver flows. The monitoring shows that high carbon monoxide levels are associated with winds from the south-southwest. While this is the direction of five of the six major sources in the area, it is also the direction of the primary drainage winds along the South Platte River. This monitor is in the SLAMS network, and is population oriented for a neighborhood scale.

Carbon monoxide monitoring began in 1973 and continued through the spring of 1980. Monitoring was stopped from the spring of 1980 until October 1986 when it began again as a special study. Welby has not recorded an exceedance of either the 1-hour or 8-hour carbon monoxide standard since January 1988. In the last few years, its primary value has been as an indicator of changes in the air quality index (AQI). The 8-hour maximum value recorded in 2009 was 8.0 ppm, while the 1-hour maximum value was 2.8 ppm.

Ozone monitoring began at Welby in July of 1973. The Welby monitor has not recorded an exceedance of the old 1-hour ozone standard since 1998. However, the trend in the 3-year average of the 4th maximum 8-hour average has been increasing since 2002. The maximum 8-hour ozone concentration recorded at this site in 2009 was 0.078 ppm, while the maximum 1-hour concentration was 0.095 ppm. The three year average of the 4th highest 8-hour average value for this site from 2007 through 2009 is 0.072 ppm, which is only slightly less than the standard value of 0.075 ppm. When the standard is lowered in August 2010, this site will exceed it.

The Welby nitrogen dioxide monitor began operation in July 1976. The site's location provides an indication of possible exceedance events before they hit the Denver-Metro area. The site serves as a good drainage location, but it may be a target for deletion or relocation farther down the South Platte River Valley from Denver. The annual average NO_2 concentration for this site was 0.015 ppm in 2009, which is well below the standard of 0.053 ppm.

The Welby sulfur dioxide monitor began operation in July of 1973. The maximum 24-hour concentration recorded here was 0.01 ppm in 2009. The annual average was 0.001 ppm, and the maximum 3-hour average was 0.0 ppm. All values were well below the SO_2 standards of 0.14 ppm (24-hour max), 0.030 ppm (annual avg.), and 0.5 ppm (3-hour max).

PM_{10} monitoring began at Welby in June and July of 1990. The continuous monitor began operation in June, while the high volume monitor began operation in July. The maximum PM_{10} concentration recorded in 2009 was 54 $\mu g/m^3$.

Meteorological monitoring began in January of 1975.

Alamosa – Adams State College, 208 Edgemont Boulevard (08 003 0001):
This Alamosa – Adams State College site is located on the science building of Adams State College in a principally residential area. The only significant traffic is on US 160 through the center of town. The site is along this highway but far enough away to reduce direct impacts on the levels. Meteorological data are not available from the area. The city has a population of 8,458 (July 2007 population estimate). This is an increase of 6.2 percent from the 2000 census. The major particulate source is wind-blown dust. This site began operation in 1973 as a TSP monitor and was changed to a PM_{10} monitor in June 1990. This is a population oriented neighborhood scale SLAMS monitor that is on a daily sample schedule. The maximum PM_{10} concentration recorded at this site in 2009 was 207 $\mu g/m^3$, which was an exceedance of the NAAQS. There was only one exceedance recorded at this site in 2009.

Alamosa - Municipal, 425 4th Street (08 003 0003):
The Alamosa 425 4th Street was started in May 2002. The site was established closer to the center of the city to be more representative of the population exposure in the area. This is a population oriented neighborhood scale SLAMS monitor that is on a daily sample schedule. The maximum PM_{10} concentration recorded at this site in

2009 was 157 μg/m^3, which was an exceedance of the NAAQS. There was only one exceedance recorded at this site in 2009.

Highland Reservoir, 8100 S. University Boulevard (08 005 0002):

The Highlands site began operation in June of 1978. It was intended to be a background location. However, with urban growth and the construction of C-470, it has become a long-term trend site that monitors changes in the air quality of the area. It is currently believed to be near the southern edge of the ozone “cloud,” although it may not be in the area of maximum concentrations. This is a population oriented neighborhood scale SLAMS monitor. The maximum 8-hour ozone concentration recorded at this site in 2009 was 0.079 ppm, while the 1-hour maximum was 0.098 ppm. The 3-year average of the 4th maximum ozone concentration from 2007 through 2009 cannot be calculated for this site yet, as there was not enough data available in 2008 due to the site being shut down for reconstruction of other facilities at the location.

Meteorological monitoring began in July of 1978.

Arapahoe Community College (ACC), 6190 S. Santa Fe Drive (08 005 0005):

The ACC site is located in south suburban metropolitan Denver. It is located on the south side of the Arapahoe Community College in a distant parking lot. The site is near the bottom of the Platte River Valley along Santa Fe Drive (Hwy. 85) in the city of Littleton. It is also near the city of Englewood. There is a large residential area located to the east across the railroad and Light Rail tracks. The $PM_{2.5}$ monitor is located on a mobile shelter in the rarely used South parking lot. Located at 6190 S. Santa Fe Drive, this small trailer is close to the Platte River and the monitor has excellent 360^0 exposure. Based on the topography and meteorology of the area ACC is in an area where $PM_{2.5}$ emissions may collect. This location may capture high concentrations during periods of upslope flow and temperature inversion in the valley. However, since it is further south in a more sparsely populated area than the Broadway-CAMP site, the concentrations are usually not as high as other Denver locations.

Winds are predominately out of the south-southwest and south, with secondary winds out of the north and north-northeast (upslope). Observed distances and traffic estimates easily fall into the neighborhood scale in accordance with federal guidelines found in the 40 CFR, Part 58, Appendix D. The site meets all other neighborhood scale criteria, making the monitor a population oriented neighborhood scale SLAMS monitor on a 1 in 3 day sample schedule.

The maximum $PM_{2.5}$ value recorded at this site in 2009 was 22.6 μg/m^3, which is not an exceedance of the NAAQS.

Aurora – East, 36001 Quincy Ave (08 005 0006):

The Aurora East site began operation in June 2009. It is intended to act as a regional site and an aid in the determination of the easternmost extent of the ozone “cloud” in the metro area. It is located along the eastern edge of the former Lowry bombing range, on a flat, grassy plains area. This site is currently outside of the rapid urban growth area taking place around Aurora Reservoir. There are currently plans to begin developing the Lowry area in the near future, however, which would shift the focus of this site from being a regional site to a neighborhood scale site. This is a special projects monitor (SPM) for a regional scale. The maximum 8-hour average recorded at this site in 2009 was 0.079 ppm. The 3-year average of the 4th highest ozone concentration for 2007 through 2009 cannot be calculated at this time since the site began operation in 2009.

Pagosa Springs School, 309 Lewis Street (08 007 0001):

The Pagosa Springs School site was located on the roof of the Town Hall from April 24, 2000 through May 2001. When the Town Hall building was planned to be demolished, the PM_{10} monitor was relocated to the Pagosa Springs Middle School and the first sample was collected on June 7, 2001.

The Pagosa Springs School site is located next to Highway 160 near the center of town. Pagosa Springs is a small town spread over a large area. The San Juan River runs through the south side of town. The town sits in a small bowl like setting with hills all around. A small commercial strip area along Highway 160 and single-family homes surrounds this location. It is representative of residential neighborhood exposure. Pagosa Springs was a PM_{10} nonattainment area and a SIP was implemented for this area. PM_{10} concentrations were exceeded a few times in the late 1980's. However, the PM_{10} pollution was cleaned up through the SIP control measures and the area has only exceeded the PM_{10} standard three times since 1994. One exceedance was due to a regional blowing dust event in March of 1999, and the other two exceedances occurred in April of 2009. The highest PM_{10} concentration recorded at this site in 2009 was 225 $\mu g/m^3$, which is well above the standard of 150 $\mu g/m^3$.

Winds for this area predominantly blow from the north, with secondary winds from the north-northwest and the south. The predominant wind directions closely follow the valley topography in this rugged terrain. McCabe Creek, which is very near the meteorological station that was on the Town Hall building, runs north south through this area. This is a population oriented neighborhood scale SLAMS monitor on a daily sample schedule.

Longmont – Municipal Bldg., 350 Kimbark Street (08 013 0003):
The town of Longmont is a growing, medium sized; Front Range community Longmont is located between the Denver/Boulder Metro-area and Fort Collins. Longmont is both suburban and rural in nature. The town of Longmont is located approximately 30 miles north of Denver along the St. Vrain Creek and is about six miles east of the foothills. Longmont is partly a bedroom community for the Denver-Boulder area. The elevation is 4978 feet. The Front Range peaks rise to an elevation of 14,000 feet just to the west of Longmont. In general, the area experiences low relative humidity, light precipitation and abundant sunshine.

The station began operations in 1985 with the installation of PM_{10} and $PM_{2.5}$ monitors. In 1999 an additional $PM_{2.5}$ monitor was added to the site. The maximum PM_{10} concentration recorded at this site in 2009 was 40 $\mu g/m^3$, while the maximum $PM_{2.5}$ concentration recorded was 24 $\mu g/m^3$. Both values are well below their respective standards of 150 $\mu g/m^3$, and 35 $\mu g/m^3$ (over 24 hours).

Longmont's predominant wind direction is from the north through the west due to winds draining from the St. Vrain Creek Canyon. The PM_{10} site is near the center of the city near both commercial and residential areas. This location provides the best available monitoring for population exposure to particulate matter. The distance and traffic estimate for the controlling street easily falls into the neighborhood scale in accordance with federal guidelines found in 40 CFR, Part 58, and Appendix D. This is a population oriented neighborhood scale SLAMS monitor on a 1 in 6 day sample schedule.

Longmont, 440 Main Street (08 013 0009):
The town of Longmont is a growing, medium sized, Front Range community located between the Denver/Boulder Metro-area and Fort Collins. Longmont is both suburban and rural in nature. There are no major carbon monoxide sources within 12 miles of the monitor.

In January and February of 1988 and again in the winter of 1988/89 the APCD conducted a study at a site near 11th Avenue and Main Street, a few blocks north of the downtown area. Because two exceedances of the standard were recorded during the study, the Division felt that a permanent carbon monoxide site should be established closer to the downtown area. These exceedances resulted in Longmont being designated as a carbon monoxide nonattainment area and required a SIP for carbon monoxide be developed showing attainment by December 31, 1995. The Air Quality Control Commission accepted the Longmont SIP on June 16, 1995. In 1999, Longmont was redesignated as an attainment area.

Longmont has contended that its carbon monoxide problems are generally the result of transport from the Denver metropolitan area north to the Longmont area. The review of the time series plots for Longmont, Denver CAMP, Greeley and Boulder show that the carbon monoxide maximum at all four locations generally coincide. In addition, these peaks are bimodal at 7 to 9 A.M. and 4 to 6 P.M. at all four locations. This pattern is associated with locally generated emissions from traffic, not transport from another area. The carbon monoxide emissions inventories developed for the SIP show that 78 percent of the carbon monoxide comes from on-road mobile sources. These findings are consistent with the observed distribution of the data.

Carbon monoxide monitoring is expected to continue for the next several years at the current location since the monitoring is a part of the maintenance plan for Longmont. The monitor is in the SLAMS network, and is population oriented for a neighborhood scale. The 8-hour maximum CO concentration recorded at this site in

2009 was 1.9 ppm, while the maximum 1-hour concentration was 3.5 ppm. Both values are well below the NAAQS.

South Boulder Creek, 1405½ S. Foothills Parkway (08 013 0011):
The city of Boulder is located about 30 miles to the northwest of Denver. The Boulder Foothills, South Boulder Creek site was established as a special-purpose ozone monitor as a part of the "summer 1993 Denver Ozone Study." During that summer a 1-hour level of 0.128 ppm was recorded on July 2, 1993. In 1994, the monitor was converted from an SPM to a seasonal SLAMS monitor. In 1995 it was converted to a year-round ozone monitoring site when the instruments were moved into a new shelter. The South Boulder Creek monitor has not recorded an exceedance of the 1-hour NAAQS since the summer of 1993.

Although the Foothills monitor had not exceeded the previous standard of 0.085 ppm as an 8-hour average, it does exceed the current standard of 0.075 ppm as an 8-hour average five of the past six years, and will exceed the new standard (0.060 to 0.070 ppm) due to be released in August 2010 . The maximum 8-hour value recorded at this site in 2009 was 0.084 ppm, and the maximum 1-hour concentration was 0.094 ppm. The 3-year average of the 4^{th} maximum ozone concentration is 0.078 ppm for the 2007 through 2009 time period. This is a highest concentration oriented urban scale SLAMS monitor.

Boulder Chamber of Commerce, 2440 Pearl Street (08 013 0012):
The city of Boulder is located on the eastern edge of the Rocky Mountain foothills. Most of the city sits on rolling plains. The Boulder $PM_{2.5}$ site is approximately 7,000 feet east of the base of the Front Range foothills and about 27.4 feet south of a small branch of Boulder Creek, the major creek that runs through Boulder.

PM_{10} monitoring began at this site in December of 1994, while the $PM_{2.5}$ monitoring did not begin until January of 1999. The maximum PM_{10} concentration recorded here in 2009 was 38 $\mu g/m^3$, while the maximum $PM_{2.5}$ concentration was 39.4 $\mu g/m^3$. The PM_{10} values were all well below the standard of 150 $\mu g/m^3$. The $PM_{2.5}$ concentration was an exceedance of the standard that occurred on September 1, 2009. The exceedance was due to a wildfire that was burning in the area.

The predominant wind direction is from the west with secondary maximum frequencies from the west-northwest and west-southwest. The distance and traffic estimate for Pearl Street and Folsom Street falls into the neighborhood scale in accordance with federal guidelines found in 40 CFR, Part 58, and Appendix D. This is a population oriented neighborhood scale SLAMS monitor on a 1 in 6 day sample schedule.

Boulder – CU - Athens, 2102 Athens Street (08 013 1001):
The Boulder - CU site is located at the edge of a low usage parking lot to the north and the football practice field to the south. This location provides a good neighborhood representation for particulates. The site began operation in November 2004, and will be removed in 2010 due to construction of a new covered air-filled dome practice field that obstructs air flow. The dome is erected each Fall, and remains inflated until Spring. It is removed during the Summer months. The maximum $PM_{2.5}$ value recorded by the continuous monitor at this site in 2009 was 57.7 $\mu g/m^3$. This is a population oriented neighborhood scale special project monitor.

Delta, 560 Dodge Street (08 029 0004):
Delta is a small agricultural community midway between Grand Junction and Montrose. The topography in and around Delta is relatively flat as it sits in the broad flat Uncompaghre River Valley. There are high mesas and mountains surrounding this high valley. Delta sits in a large bowl shaped basin that can effectively trap air pollution, especially during persistent temperature inversions.

The Delta County Health Department site was chosen because it is a one story building near the downtown area. The site began operation in August 1993, and is representative of the large basin with the potential for high PM_{10} due to agricultural burning, automobile traffic and the former Louisiana Pacific waferboard plant. The maximum PM_{10} value recorded at this site in 2009 was 186 $\mu g/m^3$, which is an exceedance of the NAAQS. There was only one exceedance of the standard at this location in 2009. This is a population oriented neighborhood scale SLAMS monitor on a 1 in 3 day sample schedule.

Denver CAMP, 2105 Broadway (08 031 0002):
The City and County of Denver is located approximately 30 miles east of the foothills of the Rocky Mountains. Denver sits in a basin, and the terrain of the city is characterized as gently rolling hills, with the Platte River running from southwest to northeast, just west of the downtown area. The CAMP site is located in downtown Denver.

Carbon monoxide monitoring began in February 1965 as a part of the Federal Continuous Air Monitoring Program. It was established as a maximum concentration (micro-scale), population-oriented monitor. The CAMP site measures the exposure of the people who work or reside in the central business district (CBD). Its location in a high traffic street canyon causes this site to record most of the high pollution episodes in the metro area. The street canyon effect at CAMP results in variable wind directions for high carbon monoxide levels and as a result wind direction is less relevant to high concentrations than wind speed. Wind speeds less than 1 mph, especially up-valley, combined with temperature inversions trap the pollution in the area. The 8-hour maximum CO value recorded in 2009 at this site was $_{2.5}$ ppm, while the 1-hour maximum was 6.9 ppm. Both values are well below the NAAQS.

The nitrogen dioxide monitor began operation in January 1973 at this location. Late in 2009 a sampling manifold issue was discovered at the site, and the data from the first three quarters of 2009, and much of 2008 was invalidated due to the problem. As such, no annual average can be calculated for this site.

The sulfur dioxide monitor began operation in January 1967. As with the NO_2, most of the data from 2008 and 2009 was invalidated due to the sampling manifold issue. The data for the last quarter (from 9/3/2009 through the end of the year) did allow for the calculation of the 3-hour and 24-hour maximums for that time period. The 3-hour maximum value recorded was 0.0 ppm, while the 24-hour maximum was 0.01 ppm. Both values are well below the NAAQS.

The PM_{10} monitoring began in 1986 with the installation of collocated monitors, and was furthered by the addition of a continuous monitor in 1988. The maximum concentration recorded in 2009 by the primary monitor was 47 $\mu g/m^3$, and by the secondary monitor was 60 $\mu g/m^3$. Both values are well below the NAAQS.

The $PM_{2.5}$ monitoring began in 1999 with a continuous and an FEM monitor, and was furthered by the addition of a collocated FEM monitor in 2001. The maximum concentration recorded in 2009 by the primary monitor was 29.5 $\mu g/m^3$, and by the secondary was 24 $\mu g/m^3$. Both values are well below the NAAQS.

Meteorological monitoring began at this site in January of 1965.

Denver NJH-E, 14th Avenue & Albion Street (08 031 0013):
This site is located three miles east of the Denver CBD, close to one of the busiest intersections in Denver (Colorado Boulevard and Colfax Avenue). The current site began operations in 1982. Two previous sites were located just west of the current location. The first operated for only a few months before it was moved to a new and "temporary" site in the corner of the laboratory building at the corner of Colorado Boulevard and Colfax Avenue. The maximum $PM_{2.5}$ concentration recorded by the continuous monitor at this site in 2009 was 49.4 $\mu g/m^3$. The monitor here is a population oriented middle scale special project monitor.

Denver - Carriage, 2325 W. Irving Street (08 031 0014):
Carriage is located $_{2.5}$ miles west of the CBD. It began operations in January of 1982. The site represents an ideal neighborhood exposure setting due to its unique location in an old carriage lot in the center of the block surrounded by houses. It represents a good neighborhood site for ozone exposure since it is isolated enough to be unaffected by local traffic. Ozone levels at this site have not exceeded the old 1-hour NAAQS since 1987. The maximum 8-hour ozone concentration recorded at this site in 2009 was 0.068 ppm. The 3-year average of the 4th highest ozone concentration from 2007 through 2009 is 0.070 ppm, which is less than the current standard of 0.075 ppm. However, when the standard is changed in August 2010, the value will either be equal to the standard or above it, as the new standard will be in the range of 0.060 to 0.070 ppm. This is a population oriented neighborhood scale SLAMS monitor.

Denver Visitor Center, 225 W. Colfax Avenue (08 031 0017):
The Denver Visitor Center site is located near the corner of Colfax Avenue and Tremont Street. It began operation on December 28, 1992. In 1993, this site along with the Denver CAMP and Gates monitors recorded the first exceedances of the 24-hour PM_{10} standard in the Denver metropolitan area since 1987. The Visitor Center recorded a PM_{10} level of 161 $\mu g/m^3$ on January 14, 1993. Since then, the maximum value recorded at the site has been 119 $\mu g/m^3$ in 2001. In 2009 the maximum value recorded was 53 $\mu g/m^3$, which is well below the NAAQS of 150 $\mu g/m^3$. In the past ten years, the 24-hour maximum levels have trended downward, while the annual average has been relatively flat by remaining around 25 $\mu g/m^3$. This is a population oriented middle scale SLAMS monitor on a daily sample schedule.

Denver Firehouse #6, 1300 Blake Street (08 031 0019):
The Denver Firehouse #6 is located on the block between Auraria Parkway and Blake Street where they intersect with Speer Boulevard. This is one of the busiest intersections in downtown Denver, and computer modeling indicated that it would have high levels of carbon monoxide. The monitor is in the SLAMS network and is population oriented for a micro-scale.

In the winter of 1995, the monitor was converted from a special purpose monitor to a SLAMS monitor. In 1999, the Firehouse monitor recorded the last exceedance of the 8-hour CO standard in the Denver Metro area. The levels have continued their decline and in 2009 the maximum 8-hour concentration was 1.8 ppm, which is well below the NAAQS. It should be noted here that the data from this site are from the beginning of the year through 09/02/2009. The instrument was shut down after that while the fire station was being remodeled.

Auraria Met, 12th Street & Auraria Parkway (08 031 0021):
The Auraria meteorological monitor is located at the edge of the athletic fields and next to the parking lot for Metropolitan State College/ CU Denver. The monitor is 230 feet away from the Auraria Parkway and 350 feet from Speer Boulevard. It is one of the few locations in the CBD were wind data will be little affected by the street canyon effect of the buildings. This site will likely be removed in 2010 due to a planned building to be constructed near it.

Denver – Swansea Elementary, 4650 Columbine Street (08 031 0023):
The Denver - Swansea Elementary school site was established as a part of the toxicological study associated with the ASARCO Study conducted by the Colorado Department of Public Health and Environment. The site was established in December of 2004. The highest concentration recorded at this site in 2009 was 26.6 $\mu g/m^3$, which is below the NAAQS. This population oriented neighborhood scale special project monitor is on a daily sampling schedule.

Denver Municipal Animal Shelter, 678 S. Jason Street (08 031 0025):
The Denver Municipal Animal Shelter (DMAS) site was established as a replacement for the Denver Gates particulate monitor that was located at 1050 S. Broadway, about one half mile south-southeast and on the other side of the South Platte River. The DMAS location represents the core area of the South Platte drainage in Denver. It has a good mixture of light industrial and residential areas, and is strongly affected by the mobile sources along I-25 as well as South Santa Fe Drive. The openness of the area also permits the meteorological data to be representative of the larger core Denver area. Finally, the site is on city owned property and will presumably be available for long-term trend analysis. When fully developed, the site will be established as the NCore site for the Denver Metropolitan area and will include a trace/precursor-level carbon monoxide analyzer and a NOy analyzer, in addition to the trace level sulfur dioxide, ozone, meteorology and particulate monitors. The site is intended as a population oriented neighborhood scale monitoring area.

The maximum 8-hour ozone concentration recorded at this site in 2009 was 0.070 ppm, while the maximum 1-hour value was 0.082 ppm. The 3-year average of the 4th maximum ozone concentration for this site from 2007 through 2009 cannot be calculated since the monitor did not start up until April of 2008.

The meteorological monitoring began in July of 2008. During the course of 2010 $_{\text{additional}}$ sensors will be added to the met monitoring network. These sensors will monitor relative humidity, barometric pressure, solar radiation and precipitation.

PM_{10} monitoring began in July 2005. Currently, there is a pair of collocated high volume samplers in addition to a continuous monitor on site. The maximum value recorded by the primary monitor was 48 $\mu g/m^3$, while that recorded by the secondary monitor was 50 $\mu g/m^3$. Both values are well below the NAAQS.

$PM_{2.5}$ monitoring began in 2002 with the installation of a supplemental speciation monitor, and was furthered by the addition of an FEM monitor and a continuous monitor in 2007, and a carbon speciation monitor in 2009. The maximum value recorded by the FEM monitor in 2009 was 25 $\mu g/m^3$, which is below the NAAQS.

TSP/lead monitoring began in July of 2005. The largest value of the 3-month rolling average recorded by the primary and collocated lead instruments was 0.01 $\mu g/m^3$, which is well below the level of the standard at 0.15 $\mu g/m^3$.

Chatfield State Park, 11500 N. Roxborough Park Road (08 035 0004):

The Chatfield State Park location was established as the result of the 1993 Summer Ozone Study. The site is located on the south side of Chatfield State Park at the park offices. This location was selected over the Corps of Engineers Visitor Center across the reservoir because it was more removed from the influence of traffic along C-470. Located in the South Platte River drainage, this location is well suited for monitoring southwesterly ozone formation in the Denver metro area.

The Chatfield monitor has exceeded the ozone standard each of the past five years and the trend of the 3-year averages is increasing. The 8-hour maximum concentration recorded at this site in 2009 was 0.085 ppm, while the 1-hour maximum was 0.109 ppm. The 3-year average of the 4th maximum ozone concentration for 2007 through 2009 is 0.077 ppm, which exceeds the current standard, and will exceed the new lowered standard to be announced in August 2010. The new standard is expected to be in the 0.060 to 0.070 ppm range. This is a highest concentration oriented urban scale SLAMS monitor.

$PM_{2.5}$ monitoring began at this site in 2004 with the installation of a continuous monitor, and was furthered by the addition of an FEM monitor in 2005. The maximum concentration recorded at this site in 2009 was 21.7 $\mu g/m^3$, which is below the NAAQS.

Meteorological monitoring began in April of 2004.

Elbert County, 24950 Ben Kelly Road (08 039 0001):

The Elbert County site is believed to be a good location to measure urban background concentrations of $PM_{2.5}$. Winter winds at Elbert are from the southwest to southeast at 4-5 m/s during the morning hours. During the afternoon hours, brisk winds are generally from the south-southwest to the southeast. This shows that the Denver Metropolitan Area does not influence the winds moving across the monitoring site. A July 1981 analyses of surface streamline was done to study summer wind patterns in this same area. The study shows that in the later morning hours (0800), winds predominately blow from the north and northeast, placing the Denver Metro-Area upwind of the site. Although, during the early morning hours, wind flows off the Cheyenne Ridge and Palmer Lake Divide into the river basins to the north and south, away from the Elbert County monitoring site. By early afternoon (1100) and continuing through later afternoon (1400), up slope flow occurs over nearly the entire region, bringing clean air from the east and northeast to the site. By the evening hours, winds again predominately flow from the mountain region, with these westerly winds again flowing off the Palmer Lake Divide, away from the monitoring site. This would suggest that the Elbert County site is a very clean location for winter months and for early morning, afternoon and evening hours during the summer months. The low $PM_{2.5}$ measured concentrations since 2001 also indicate that this is a clean background site. The annual average for 2009 was 3.9 $\mu g/m^3$, and the 98th percentile concentration was 9.7 $\mu g/m^3$.

The location of this Elbert County site classifies it as an urban background site, in accordance with federal guidelines found in 40 CFR, Part 58, Appendix D. The site meets all guidelines for the urban background site. This monitor is a background oriented regional scale SLAMS monitor on a 1 in 6 day sampling schedule. The maximum $PM_{2.5}$ concentration recorded at this site in 2009 was 10.5 $\mu g/m^3$, which is well below the NAAQS.

Colorado Springs, USAFA Road 640 (08 041 0013):
The United States Air Force Academy site was installed as a replacement maximum concentration ozone monitor for the Chestnut Street (08 041 0012) site. Modeling in the Colorado Springs area indicates that high ozone concentrations should generally be found along either the Monument Creek drainage to the north of the Colorado Springs central business district (CBD), or to a lesser extent along the Fountain Creek drainage to the west of the CBD. The decision was made to locate this site near the Monument Creek drainage, approximately 9 miles north of the CBD. This location is near the south entrance of the Academy but away from any roads. This is a population oriented urban scale SLAMS monitor.

The Academy monitor did record an exceedance of the old 1-hour standard in 2003 but it would not have recorded any exceedances of the current 8-hour standard. However the trend in values over the past ten years is increasing. The maximum 8-hour ozone concentration recorded at this site in 2009 was 0.064 ppm, with a 1-hour max of 0.076 ppm. The 3-year average of the 4^{th} maximum ozone concentration for 2007 through 2009 is 0.067 ppm, which is below the current NAAQS, but will likely be above the new ozone standard set to be released in August 2010. The new standard value is expected to lie between 0.060 and 0.070 ppm.

Colorado Springs Hwy-24, 690 W. Highway 24 (08 041 0015):
The 690 W. Highway 24 site is located just to the west of I-25 and just to the east of the intersection of U.S. Highway 24 and 8^{th} Street, approximately 0.8 miles to the west of the Colorado Springs CBD. Commencing operation in November 1998, this site is a replacement for the Tejon Street (08 041 0004) carbon monoxide monitor. The site is located in the Fountain Creek drainage and is in one of the busiest traffic areas of Colorado Springs. Additionally, traffic is prone to back-up along Highway 24 due to a traffic light at 8^{th} Street. Thus, this site is well suited for the SLAMS network to monitor maximum concentrations of carbon monoxide in the area both from automotive sources and also from nearby industry, which includes a power plant. It also provides a micro-scale setting for the Colorado Springs area, which has not been possible in the past.

The 8-hour maximum CO value recorded at this site in 2009 was 2.7 ppm, and the 1-hour max was 3.8 ppm, which are both well below their respective NAAQS.

In 2010 the APCD expects to install meteorological monitors at this site.

Manitou Springs, 101 Banks Place (08 041 0016):
Manitou Springs is a located 4 miles west of Colorado Springs. It was established because of concern that the "ozone cloud" was traveling farther up the canyon and the current monitoring network was not adequate. The Manitou Springs monitor began operations in April 2004. It is located in the foothills above Colorado Springs in the back of the maintenance area at the site. In its four seasons of operation it has not recorded any levels greater than the current standard. The trend in 8-hour concentrations is increasing, however.

The 8-hour maximum ozone value recorded at this site in 2009 was 0.071 ppm, which is below the current NAAQS. The 3-year average of the 4^{th} maximum ozone value for 2007 through 2009 is 0.069. This value will likely exceed the new standard (0.060 to 0.070 ppm) due to be released in August 2010. This is a population oriented neighborhood scale SLAMS monitor.

Colorado Springs - Colorado College, 130 W. Cache la Poudre Street (08 041 0017):
The Colorado Springs - Colorado College monitoring site was established in 2007 after the revised particulate regulations required that Colorado Springs needed a continuous $PM_{2.5}$ monitor. The Department elected to collocate the new $PM_{2.5}$ monitor with the corresponding filter based monitors from the RBD site at the Colorado College location, which included a FEM $PM_{2.5}$ monitor and a low volume PM_{10} monitor. The continuous monitor began operation in January of 2008.

The nearest representative meteorological site is located at the Colorado Springs Airport. Wind flows at the Colorado College site are affected by its proximity to Fountain Creek, so light drainage winds will follow the creek in a north/south direction. The three monitors here are population oriented neighborhood scale monitors, two on the SLAMS network (PM_{10} and $PM_{2.5}$) and one that is a special projects monitor ($PM_{2.5}$ continuous).

The maximum value recorded by the PM_{10} monitor at this site in 2009 was 35 $\mu g/m^3$, which is well under the NAAQS. The maximum value recorded by the $PM_{2.5}$ monitor at this site in 2009 was 15.5 $\mu g/m^3$; again this value is well under the NAAQS.

Cañon City - City Hall, 128 Main Street (08 043 0003):

Cañon City is located 39 miles west of Pueblo. Particulate monitoring began on January 2, 1969 with the operation of a TSP monitor located on the roof of the courthouse building at 7th Avenue and Macon Street. The Macon Street site was relocated to the City Hall in October of 2004.

The Cañon City PM_{10} site began operation in December 1987. On May 6, 1988, the Macon Street monitor recorded a PM_{10} concentration of 172 $\mu g/m^3$. This is the only exceedance of either the 24-hour or annual NAAQS since PM_{10} monitoring was established at Cañon City. This is a population oriented neighborhood scale SLAMS monitor on a 1 in 6 day sample schedule.

The maximum PM_{10} concentration recorded at this site in 2009 was 38 $\mu g/m^3$, which is well below the NAAQS.

Parachute – High School, 100 E. 2nd Street (08 045 0005):

The parachute site began operation in May 2000 with the installation of a PM_{10} monitor at the high school. The annual average has been trending upward, but is still just over one half of the former annual standard for PM_{10} which was 50$\mu g/m^3$. The maximum value recorded at this site in 2009 was 88 $\mu g/m^3$, which is below the NAAQS. This is a population oriented neighborhood scale SLAMS monitor on a 1 in 3 day sample schedule.

Rifle - Henry Building, 144 3rd Street (08 045 0007):

The first Rifle site began operation in June 1985 and ended operation in May 1986. The next site began operation in December 1987 and continued until 2001. The levels at that site, with the exception of the March 31, 1999 high wind event, were always less than one half of both the annual and the 24-hour standards. The current location on the Henry Building began operation in May of 2005 with the installation of a PM_{10} monitor as a part of the Garfield County study. There are now two population oriented neighborhood scale special project PM_{10} monitors: one on a 1 in 3 day sample schedule, and one that is continuous. There is also a continuous $PM_{2.5}$ monitor, a continuous PM Course monitor, and meteorological monitors. The maximum PM_{10} value recorded at this site in 2009 was 83 $\mu g/m^3$, which is below the NAAQS.

Rifle – Health Dept., 195 14th Ave (08 045 0012):

The Rifle Health site is located at the Garfield County Health Department building. The site is 1km to the north of the downtown area and next to the Garfield County fairgrounds. The site is uphill from the downtown area. A small residential area is to the north and a commercial area to the east. This site was established to measure ozone in Rifle, which is the largest population center in the oil and gas impacted area of the Grand Valley. Monitoring commenced in June 2008. This is a special projects monitor with a neighborhood scale. The 8-hour maximum ozone concentration recorded at this site in 2009 was 0.064 ppm, which is below the current standard. This may change, however, when the new standard is introduced in August 2010. It is expected to be in the range of 0.060 to 0.070 ppm. A 3-year 4th maximum ozone concentration for 2007 through 2009 cannot be calculated for this site yet, as operations only began in 2008.

Crested Butte, 603 6th Street (08 051 0004):

The Crested Butte PM_{10} site began operation in June 1985. Crested Butte is a high mountain ski town. The monitor is at the east end of town near the highway and in the central business district. Any wood burning from the residential area to the west directly affects this location. The physical setting of the town, near the end of a steep mountain valley, makes wood burning, street sanding and wintertime inversions a major concern. The town is attempting to regulate the number of wood burning appliances, since this is a major source of wintertime PM_{10}.

There are two population oriented neighborhood scale monitors here, one in the SLAMS network (1 in 3 day sample schedule) and one that is a quality assurance collocated monitor (1 in 6 day sample schedule). Crested Butte has not recorded an exceedance of the NAAQS since it began monitoring. The maximum PM_{10} value recorded at this site by the primary monitor in 2009 was 99 $\mu g/m^3$, while the value recorded by the collocated secondary monitor was 103 $\mu g/m^3$. Both values are below the standard of 150 $\mu g/m^3$.

Mt. Crested Butte Realty, 19 Emmons Road (08 051 0007):
Mount Crested Butte is located at an elevation of 8,940 feet (2,725 m) at the base of the Crested Butte Mountain Resort ski area. Mount Crested Butte is a unique location for high particulate matter concentrations because it is located on the side of a mountain (Crested Butte 12,162 ft. or 3,707 m), not in a bowl, valley, or other topographic feature that would normally trap air pollutants. There is not a representative meteorological station in or near Mt. Crested Butte.

The location for the Mt. Crested Butte site was selected because it had an existing PM_{10} site that had several high PM_{10} concentrations including five exceedances of the 24-hour standard in 1997 and one in 1998. Mt. Crested Butte also exceeded the PM_{10} annual average standard in 1997. A CMB source apportionment from $_{10}$ PM_{10} filters identified crustal material as the mostly likely source (91 percent) of PM_{10}. Carbon, which is most likely from residential wood smoke, made up 8 percent of the statistically composite sample and secondary species made up the remaining 1 percent. The Mt. Crested Butte site was also selected because it is an area representative of the residential impact of $PM_{2.5}$. This is a population oriented neighborhood scale SLAMS monitor on a daily sample schedule.

The maximum PM_{10} value recorded at this site in 2009 was 83 $\mu g/m^3$, which is less than the NAAQS of 150 $\mu g/m^3$.

Arvada, 9101 57th Avenue (08 059 0002):
The city of Arvada is located 15 miles west-northwest of the Denver central business district (CBD). The Arvada site began operation before 1973. It is located to the northwest of the Denver CBD near the western end of the diurnal midday wind flow of the ozone "cloud." As a result, when conditions are proper for daylong ozone production, this site has received some of the highest levels in the city. In the early and mid 1970s, these wind patterns caused Arvada to have the most exceedances in the metro area.

The Arvada monitor has exceeded the ozone standard six of the past ten years, and the years that it would not have exceeded the standard it was just below the level of the standard. The 8-hour maximum ozone value recorded at this site in 2009 was 0.078 ppm. The 3 year average of the 4th maximum ozone concentration for 2007 through 2009 is 0.074 ppm, which is just below the level of the current standard (0.075 ppm). When the new standard comes out in August 2010, this site will not be in compliance with it, as it is expected to be in the 0.060 to 0.070 ppm range. This is a population oriented neighborhood scale SLAMS monitor.

Meteorological monitoring began in 1975.

Welch, 12400 W. Highway 285 (08 059 0005):
The Division conducted a short-term ozone study on the grounds of Chatfield High School from June 14, 1989 until September 28, 1989. The Chatfield High School location was chosen because it sits on a ridge southwest of the Denver CBD. Wind pattern studies showed a potential for elevated ozone levels in the area on mid to late afternoon summer days. There were no exceedances of the NAAQS recorded at the Chatfield High School site, but the levels were frequently higher than those recorded at the other monitoring sites south of the metro area.

One finding of the study was the need for a new, permanent site further north of the Chatfield High School location. As with most Denver locations, the predominant wind pattern is north/south. The southern flow occurs during the upslope, daytime warming period. The northern flow occurs during late afternoon and nighttime when drainage is caused by cooling and settling. The major drainages of Bear Creek and Turkey Creek were selected as target downwind transport corridors. These are the first major topographical features north of the Chatfield High School site. A point midway between the valley floor (Englewood site) and the foothill's hogback ridge was modeled to be the best estimate of the maximum downwind daytime transport area. These criteria were used to evaluate available locations. The Welch site best met these conditions. This site is located off State Highway 285 between Kipling Street and C-470.

The Welch monitor has not exceeded the new standard in the past ten years. However, since 2002 the trend in values is increasing, and in 2008 the 3-year average was above the level of the standard. In 2009 the maximum 8-hour ozone value recorded at this site was 0.078 ppm. The 3-year average of the 4th maximum ozone concentration is 0.074 ppm for 2007 through 2009, which is just below the level of the current standard of 0.075 ppm. Once the standard is revised in August 2010, this site will be in exceedance of the new standard, which is expected to be in the range of 0.060 and 0.070 ppm. This is a population oriented urban scale SLAMS monitor.

Rocky Flats - N, 16600 W. Highway 128 (08 059 0006):
The Rocky Flats - N site is located north-north east of the plant on the south side of Colorado Highway 128, approximately 1¼ miles to the west of Indiana Street. The site began operation in June 1992 with the installation of an ozone monitor and meteorological monitors as a part of the first phase of the APCD's monitoring effort around the Rocky Flats Environmental Technology Site.

Ozone monitoring began as a part of the "Summer 1993 Ozone Study." The monitor recorded some of the highest ozone levels of any of the sites during that study. Therefore, it was included as a regular part of the APCD ozone-monitoring network. The Rocky Flats – N monitor has exceeded the current standard each of the last eleven years and fourteen out of the last sixteen years. The 8-hour maximum ozone concentration recorded at this site in 2009 was 0.086 ppm. The 3-year average of the 4th maximum ozone concentration for 2007 through 2009 is 0.082 ppm, which exceeds the level of the current standard, and will exceed the level of the proposed new standard (0.060 to 0.070 ppm). This is a highest concentration oriented urban scale SLAMS monitor.

Rocky Flats - SE, 9901 Indiana Street (08 059 0008):
This site is located along Indiana Street southeast of Rocky Flats. The winds at this location are appreciably different from either the Rocky Flats North site or the Arvada site. The site began operation in August of 1991. The site is scheduled for shut-down and removal in 2010.

NREL Solar Radiation Research Laboratory, 2054 Quaker Street (08 059 0011):
The National Renewable Energy Laboratory (NREL) site is located on the south rim of South Table Mountain, near Golden, and was part of the "1993 Summer Ozone Study." Based on the elevated concentrations found at this location, it was made a permanent monitoring site in 1994. This site typically records some of the higher 8-hour ozone concentrations in the Denver area. It has exceeded the current standard each of the past 14 years it has been in operation. The 8-hour maximum concentration recorded at this site in 2009 was 0.081 ppm. The 3-year average of the 4th maximum ozone concentration for 2007 through 2009 is 0.077 ppm, which is above the level of the current standard, and will be above the level of the proposed new standard (0.060 to 0.070 ppm). This is a highest concentration oriented urban scale SLAMS monitor.

Aspen Park, 26137 Conifer Road (08 059 0013):
The Aspen Park site began operation in May 2009. It is intended to verify/refute model predictions of above normal ozone levels. In addition, passive ozone monitors used in the area in a 2007 study indicated the possibility of higher ozone levels. The monitor is located in an urban setting at a Park N Ride facility off of Highway 285, at an elevation of just over 8,100 feet. Because the site is nearly 3,000 feet higher than the average metro area elevation, it should see ozone levels that are larger than those seen in the metro area, as ozone concentrations increase with increasing elevation. Whether or not the increased concentrations will be a health concern will be determined with the data gathered from this monitor. This is a special purpose neighborhood scale monitor.

The 8- hour maximum ozone concentration recorded at this site in 2009 was 0.077 ppm. A 3-year average of the 4th maximum ozone concentration cannot be calculated for this site from 2007 through 2009 as it began operation in 2009.

Durango - River City Hall, 1235 Camino del Rio (08 067 0004):
Durango is the second largest city on the western slope. The town is situated in the Animas River Valley in southwestern Colorado. Its elevation is approximately 6,500 feet (1981 meters) above mean sea level. The Animas valley through Durango is steep and narrow. Even though little meteorological information is available

for the area, the microclimate of Colorado mountain communities is characterized by cold air subsidence, or drainage flows during the evening and early morning hours and up valley flows during afternoon and early evening hours when solar heating is highest. Temperature inversions that trap air pollutants near the surface are common during night and early morning hours. This is a population oriented neighborhood scale SLAMS monitor that samples continuously.

The maximum PM_{10} concentration recorded at this site in 2009 was 203 $\mu g/m^3$, which is an exceedance of the NAAQS. This site also exceeded the NAAQS one other time with a value of 198 $\mu g/m^3$.

Fort Collins – CSU – Edison, 251 Edison Street (08 069 0009):
Fort Collins does not have the population to require a particulate monitor under Federal regulations. However, it is one of the largest cities along the Front Range. There are two population oriented neighborhood scale SLAMS monitors, a PM_{10} and a $PM_{2.5}$, that sample on a 1 in 3 day sample schedule. There are also two continuous monitors, one PM_{10} and one $PM_{2.5}$.

The maximum PM_{10} concentration recorded at this site in 2009 was 61$\mu g/m^3$. The maximum $PM_{2.5}$ concentration recorded was 28.7 $\mu g/m^3$. Both values are below their respective NAAQS.

Fort Collins - West, 3416 W. La Porte Avenue (08 069 0011):
The Fort Collins-West monitor began operation in May of 2006. The location was established based on modeling and to satisfy permit conditions for a major source in Fort Collins area. The levels recorded for the first season of operation showed consistently higher concentrations than the 708 S. Mason Street monitor. For 2009 the 3-year average of the 4th maximum 8-hour average value was 0.078 ppm. The same average at the Mason Street monitor was 0.065 ppm for the same period. This site exceeds the current standard of 0.075 ppm, and will exceed the proposed new standard of 0.060 to 0.070 ppm when it is introduced in August 2010. The highest 8-hour average recorded here in 2009 was 0.082 ppm. This is a highest concentration oriented urban scale SLAMS monitor.

Rist Canyon, 11838 Rist Canyon Road, (08 069 0012):
The Rist Canyon site began operation in May 2009. The monitor is located within the Rist Canyon Volunteer Fire Department Station Number 1, in the foothills west of Fort Collins. The monitor is at an elevation of 6,750 feet, which is roughly 1,600 feet above the Fort Collins – West monitor. Model predictions have indicated possible elevated ozone levels in this area. The site is intended to verify/refute the model prediction. This is an urban scale special purpose monitor.

In 2009 the largest 8-hour average ozone concentration recorded at this site was 0.071 ppm. A 3-year average of the 4th maximum ozone concentration for 2007 though 2009 cannot yet be calculated for this site as it just began operation in 2009.

Fort Collins- Mason, 708 S. Mason Street (08 069 1004):
The 708 S. Mason Street site began operation in December 1980 and is located one block west of College Avenue in the Central Business District. The 1-hour carbon monoxide standard of 35 ppm as a 1-hour average has only been exceeded on December 1, 1983, at 4:00 P.M. and again at 5:00 P.M. The values reported were 43.9 ppm and 43.2 ppm respectively. The 8-hour standard of 9 ppm was exceeded one or more times a year from 1980 through 1989. The last exceedances were in 1991 on January 31 and December 6 when values of 9.8 ppm and 10.0 ppm respectively were recorded.

Fort Collins does not have the population to require a carbon monoxide monitor under Federal regulation. However, it is one of the largest cities along the Front Range and was declared in nonattainment for carbon monoxide in the mid-1970s after exceeding the 8-hour standard in both 1974 and 1975. The current level of monitoring is in part a function of the resulting carbon monoxide SIP for the area. It is a population oriented neighborhood scale SLAMS monitor. The 8-hour maximum concentration recorded at this site in 2009 was 1.9 ppm. The 1-hour max recorded was 3.5 ppm. Both values are well below the NAAQS for CO.

Ozone monitoring began in 1980, and continues today. The 8-hour average ozone maximum value recorded here in 2009 was 0.074 ppm, which is just below the level of the current standard. The 3-year average of the 4th

maximum ozone concentrations for 2007 through 2009 is 0.065 ppm, which is below the level of the current standard, but could be above the level of the proposed new standard depending on where it is set (0.060 to 0.070 ppm).

Grand Junction - Powell, 650 South Avenue (08 077 0017):

Grand Junction is the largest city on the western slope in the broad valley of the Colorado River. The monitors are on county owned buildings in the south side of the city. The site is on the southern end of the central business district and close to the industrial area along the train tracks. It is about a half a mile north of the river and about a quarter mile east of the railroad yard. This site monitors for 24-hour and hourly PM_{10} as well as for 24-hour and hourly $PM_{2.5}$.

The maximum PM_{10} concentration recorded at this site in 2009 was 68.4 $\mu g/m^3$, which is below the level of the standard. The maximum $PM_{2.5}$ concentration recorded here in 2009 was 59.1 $\mu g/m^3$. This is an exceedance of the standard. The $PM_{2.5}$ monitor recorded a total of 6 exceedances throughout 2009.

Grand Junction - Pitkin, 645¼ Pitkin Avenue (08 077 0018):

The Grand Junction-Pitkin CO monitor began operation in January 2004. This monitor replaced the site at the Stocker Stadium. The Stocker Stadium location had become less than ideal with the growth of the trees surrounding the park and the Division felt that a location nearer to the central business district (CBD) would provide a better representation of carbon monoxide concentration values for the city. The carbon monoxide concentrations at the Stocker Stadium site had been declining from an 8-hour maximum in 1991 of 7.8 ppm to a 3.3 ppm in 2003. The Pitkin monitor has shown a continuing decline in the 8- hour average values to 2.2 ppm in 2009, which is well below the standard. It is a population oriented, micro-scale SLAMS monitor.

Meteorological monitors were installed in 2004, and include wind speed, wind direction, temperature and relative humidity sensors.

Clifton, Hwy 141 & D Road (08 077 0019):

The Clifton PM_{10} monitor is located in the town of Clifton which is a southeastern suburb of Grand Junction, Colorado. The monitor is in a low usage parking lot operated by the sanitation district. It is one half mile north of the Colorado River. The site was established at the request of the Mesa County Health Department to address concerns of oil and gas related industries in the area.

The population oriented neighborhood scale SLAMS monitor began operations in October 2007, and operates on an every third day schedule. The maximum PM_{10} concentration recorded at this site in 2009 was 147 $\mu g/m^3$, which is very near the level of the standard.

Palisade Water Treatment, Rapid Creek Rd (08 077 0020):

The Palisade site is located at the Palisade Water Treatment Plant. The site is 4 km to the east-northeast of downtown Palisade, just into the De Beque Canyon area. The site is remote from any significant population and was established to measure maximum concentrations of ozone that may result from summertime up-flow conditions into a topographical trap. Monitoring commenced in May 2008. This is an urban scale special purpose monitor. The maximum 8-hour average ozone concentration recorded at this site in 2009 was 0.067 ppm, which is below the level of the current standard. This could change, however, when the proposed new ozone standard is announced in August 2010. It is expected to be in the range of 0.060 to 0.070 ppm. A 3-year average of the 4th maximum 8-hour ozone values cannot be calculated for this site for 2007 through 2009 as it only began operating in 2008.

Cortez, 106 W. North St (08 083 0006):

The Cortez site is located in downtown Cortez at the Montezuma County Health Department building. Cortez is the largest population center in Montezuma County in the southwest corner of Colorado. Currently, there are ozone and $PM_{2.5}$ monitors in operation at this site.

The ozone site was established to address community concerns of possible high ozone from oil and gas and power plant emissions in the area. Many of these sources are in New Mexico. Monitoring commenced in May

2008. This is an urban scale special purpose monitor. The maximum 8-hour average value recorded here in 2009 was 0.066 ppm, which is below the level of the current standard. This could change, however, when the proposed new ozone standard is announced in August 2010. It is expected to be in the range of 0.060 to 0.070 ppm. A 3-year average of the 4th maximum 8-hour ozone values cannot be calculated for this site for 2007 through 2009 as it only began operating in 2008.

Aspen - Library, 120 Mill Street (08 097 0006):

Aspen is at the upper end of a steep mountain valley. Aspen does not have an interstate running through it. Aspen was classified as nonattainment for PM_{10}, but it is now under an attainment/maintenance plan. The valley is more restricted at the lower end, and thus forms a tighter trap for pollutants. The transient population due to winter skiing and summer mountain activities greatly increases the population and traffic during these seasons. There is also a large down valley population that commutes to work each day from as far away as the Glenwood Springs area, which is 41 miles to the northeast.

There have been several particulate monitors in the Aspen area. Only three have not been short-term special studies. The first PM_{10} monitor began operation in June 1985. The next, the Sport Stalker, was chosen after an intense effort involving EPA, State and local agency personnel. The need was to find an acceptable middle scale location. The population oriented neighborhood scale SLAMS monitor is on a 1 in 3 sample schedule. The largest PM_{10} concentration recorded at this site in 2009 was 47 $\mu g/m^3$, which is below the level of the standard.

Lamar Power Plant, 100 2nd Street (08 099 0001):

Lamar is one of the largest cities on the eastern plains. Particulate monitoring in Lamar began in August 1975 with the installation of a TSP site at the Lamar power plant at 100 2nd Street. It operated as a TSP site until August of 1986. The first Lamar PM_{10} site began operation in June 1985 at the power plant. In August 1986, the monitoring site was moved to the Municipal Complex (08 099 0002).

On March 19, 1976, the Lamar power plant monitor recorded a TSP concentration of 1,033 $\mu g/m^3$. This is the fourth highest particulate concentration ever reported in Colorado. Lamar has regularly recorded its highest TSP and PM_{10} levels in March. Between 1975 and 1986 the power plant monitor reported 25 concentrations greater than the 24-hour TSP NAAQS of 260 $\mu g/m^3$, twelve of these occurred in March, no other month had more than three. Three of the seven exceedances of the 24-hour PM_{10} NAAQS have also occurred in March. The primary reason for this relationship is due to the combination of low humidity and high winds that are common during the month of March. Lamar is the only Colorado city east of Denver to have been designated as a PM_{10} nonattainment area, and is now under an attainment/maintenance plan. In 1992, the Division reinstated the power plant location as well. This was done after a review showed that levels at the power plant were generally higher than those at the City Complex. As a part of the SIP for Lamar, a meteorological site was established in 1992 at the city complex location. Analysis of these data was included as a part of the SIP process. This is a population oriented neighborhood scale SLAMS monitor on a daily sample schedule.

The highest PM_{10} concentration recorded at this site in 2009 was 233 $\mu g/m^3$, which exceeds the level of the standard. There were also two other exceedances of the standard at this site in 2009 with values of 174 and 171 $\mu g/m^3$.

This site will likely be relocated in 2010 due to conversion of the power plant to coal-fired.

Lamar - Municipal Building, 104 Parmenter Street (08 099 0002):

The Lamar Municipal site was established in January of 1996 as a more population oriented location than the Power Plant. The Power Plant site is located on the northern edge of town while the Municipal site is near the center of the town. Both sites have recorded exceedances of the 24-hour standard of 150 $\mu g/m^3$, and both sites regularly record values above 100$\mu g/m^3$ as a 24-hour average. This is a population oriented neighborhood scale SLAMS monitor on a daily sample schedule.

The highest PM_{10} concentration recorded at this site in 2009 was 176 $\mu g/m^3$, which exceeds the level of the standard. There was also one other exceedance of the standard at this site in 2009 with a value of 173 $\mu g/m^3$.

Lamar Port of Entry, 7100 US Highway 50, (08 099 0003):
The particulate monitors in Lamar have recorded some of the highest readings in the state. These readings are primarily associated with east winds in excess of 20 mph. The Division first established a meteorological monitor in Lamar at the Municipal Building but this location was too protected and the monitor was moved to the Port of Entry location in March of 2005.

Pueblo – Fountain Magnet School, 925 N. Glendale Ave (08 101 0015):
Pueblo is the third largest city in the state, not counting communities that are part of Metropolitan Denver. Pueblo is principally characterized by rolling plains and moderate slopes with elevations ranging from 4,474 ft to 4,814 ft (1,364 to 1,467 m). The Rocky Mountain Front Range is about 25 miles (40 km) west and the sight of Pikes Peak is easily visible on a clear day.

Meteorologically, Pueblo can be described as having mild weather with an average of about 300 days of sunshine per year. Generally, wind blows up valley from the southeast during the day and down valley from the west at night. Pueblo experiences average wind speed ranges from 7 miles per hour in the fall and early winter to 11 miles per hour in the spring.

This site was formerly located on the roof of the Public Works Building at 211 E. D St., in a relatively flat area found two blocks northeast of the Arkansas River. At the end of June in 2009 the Public Works site was shut down and moved to the Magnet School site as the construction of a new multi-story building caused a major change in the flow dynamics of the site. The new site began operations in 2009. The distance and traffic estimate for the surrounding streets easily falls into the middle scale in accordance with federal guidelines found in 40 CFR, Part 58, and Appendix D.

The largest PM_{10} concentration recorded at this site in the last quarter of 2009 was 30 $\mu g/m^3$, which is lower than the level of the standard. The largest $PM_{2.5}$ concentration here in the last quarter of 2009 was 14.4 $\mu g/m^3$, which is lower than the level of the standard.

Steamboat Springs, 136 6th Street (08 107 0003):
Like other ski towns, Steamboat Springs has problems with wintertime inversions, high traffic density, wood smoke and street sand. These problems are exacerbated by temperature inversions that trap the pollution in the valleys.

The first site began operation in Steamboat Springs in June 1985 at 929 Lincoln Avenue. It was moved to the current location in October 1986. The 136 6th Street location not only provides a good indication of population exposure, since it is more centrally located, but it has better accessibility than the previous location. This is a population oriented neighborhood scale SLAMS monitor on a daily sample schedule.

The largest PM_{10} concentration recorded at this site in 2009 was 83 $\mu g/m^3$, which is below the level of the standard.

Telluride, 333 W. Colorado Avenue (08 117 0002):
Telluride is a high mountain ski town in a narrow box end valley. The San Miguel River runs through the south end of town and the town is only about ½ mile wide from north to south. The topography of this mountain valley regime creates temperature inversions that can last for several days during the winter. Temperature inversions can trap air pollution close to the ground. Telluride sits in a valley that trends mainly east to west, which can trap air pollutants more effectively since the prevailing winds in this latitude are the westerly and the San Miguel River Valley is closed off on the east end. This is a population oriented neighborhood scale SLAMS monitor on a 1 in 3 day sample schedule.

The largest PM_{10} concentration recorded at this site in 2009 was 130 $\mu g/m^3$, which is below the level of the standard.

Breckenridge - 501 N. Park Avenue (08 119 0002):
The City of Breckenridge is located in the valley of the Blue River. It is a tourist center with skiing in the winter and numerous summertime festivals and activities. The resulting wood smoke and traffic caused

sufficient concern that the city of Breckenridge requested that the APCD establish PM_{10} monitoring in the area. The Breckenridge site began operation in April 1992 and it recorded exceedances of the level of the 24-hour standard in both 2000 and in 2005. The site is currently operating on an every third day sampling schedule. This is a population oriented neighborhood scale SLAMS monitor on a 1 in 3 day sample schedule.

The largest PM_{10} concentration recorded at this site in 2009 was 101 $\mu g/m^3$, which is below the level of the standard.

Greeley - Hospital, 1516 Hospital Road (08 123 0006):

The Greeley PM_{10} monitor is on the roof of a hospital office building at 1516 Hospital Road. Greeley Central High School is located immediately to the east of the monitoring site. Overall, this is in an area of mixed residential and commercial development that makes it a good population exposure, neighborhood scale monitor. The distance and traffic estimate for the most controlling street easily falls into the neighborhood scale in accordance with federal guidelines found in 40 CFR, Part 58. This is a population oriented neighborhood scale SLAMS monitor on a 1 in 3 day sample schedule.

Winds in this area are primarily out of the northwest, with dominant wind speeds less than 3.1 m/s. Secondary winds are from the north, north-northwest and east-southeast, with the most frequent wind speeds also being less than 3.1 m/s. The most recent available wind data for this station is for the period December 1986 to November 1987. Predominant residential growth patterns are to the west and north with large industrial growth expected to the west. There are two feedlots located about 11 miles east of the town. There was a closer feedlot on the east edge of town, but it was shut down in early 1999, after the town of Greeley purchased the land in 1997.

The largest PM_{10} concentration recorded at this site in 2009 was 63 $\mu g/m^3$, which is below the level of the standard. The largest $PM_{2.5}$ concentration recorded at this site in 2009 was 38.1 $\mu g/m^3$, which exceeds the level of the standard. This was the only $PM_{2.5}$ exceedance at this site in 2009.

Platteville, 1004 Main Street (08 123 0008):

Platteville is located immediately west of Highway 85 along the Platte River valley bottom approximately five miles east of I -25, at an elevation of 4,825 feet. The area is characterized by relatively flat terrain and is located about one mile east of the South Platte. The National Oceanic and Atmospheric Administration operated the PROFS (Prototype Regional Observational Forecasting System) Mesonet network of meteorological monitors from the early 1980's through the mid 1990's in the northern Colorado Front Range area. Based on this data, the area around Platteville is one of the last places in the wintertime that the cold pool of air that is formed by temperature inversions burns off. This is due to solar heating. The upslope/down slope Platte River Valley drainage and wind flows between Denver and Greeley make Platteville a good place to monitor $PM_{2.5}$. These characteristics also make it an ideal location for chemical speciation sampling, which began at the end of 2001.

The Platteville site is located at 1004 Main Street at the South Valley Middle School, located on the south side of town on Main Street. The school is a one-story building and it has a roof hatch from a locked interior room providing easy access to its large flat roof. There is a 2-story gym attached to the building approximately 28 meters to the Northwest of the monitor. The location of the Platteville monitor easily falls into the regional transport scale in accordance with federal guidelines found in 40 CFR, Part 58, and Appendix D. There are three monitors here. Two are population oriented regional scale monitors, one of which is on the SLAMS network and the other is for supplemental speciation. The SLAMS monitor is on a 1 in 3 day sample schedule, while the speciation monitor is on a 1 in 6 day schedule. The remaining monitor is a population oriented neighborhood scale supplemental speciation monitor on a 1 in 6 day sample schedule.

The largest $PM_{2.5}$ concentration recorded at this site in 2009 was 26.6 $\mu g/m^3$, which is below the level of the standard.

Greeley - Weld County Tower, 3101 35th Avenue (08 123 0009):

The Weld County Tower ozone monitor began operation in June 2002. The site was established after the 811 15th Street building was sold and was scheduled for conversion to other uses. The Weld County Tower site has generally recorded levels greater than the old site and would have exceeded the new standard each year since it began operation in 2002. This is a population oriented neighborhood scale SLAMS monitor.

The maximum 8-hour average ozone concentration recorded at this site in 2009 was 0.071 ppm, which is below the level of the current standard (0.075 ppm). The 3-year average of the 4th maximum ozone concentrations from 2007 through 2009 is 0.071 ppm, which is just below the level of the current standard. This will change, however, when the new ozone standard is introduced in August 2010. The new standard will be in the range of 0.060 to 0.070 ppm, which would put this monitor as exceeding the standard.

Greeley West Annex Bldg, 905 10th Avenue (08 123 0010):
Greeley does not have the population to require a carbon monoxide monitor under Federal regulation. However, it is one of the larger cities along the Front Range and was declared in nonattainment for carbon monoxide in the late-1970s after exceeding the 8-hour standard in 1976 and 1977. The first Greeley monitor operated from December 1976 to December 1980. It was located at 15th Street and 16th Avenue and exceeded the 8-hour standard numerous times from 1976 through 1980. The monitor is a population oriented neighborhood scale SLAMS monitor.

The 811 15th Street location began operation in November 1981 and was discontinued in 2002. The current monitor is located in the Weld County West Annex building, and began operations in December 2003. This location is in the Greeley central business district (CBD). The levels recorded at this site are comparable but slightly lower than those at the former 811 15th Street site, about a quarter of the 8-hour standard.

The maximum 8-hour average CO concentration recorded at this site in 2009 was 2.3 ppm, which is below the level of the current standard (9 ppm). The 1-hour maximum CO concentration recorded at this site was 4.3 ppm, which is also well below the level of the standard (35 ppm).