APPENDIX E

Regional Haze State Implementation Plan

Colorado Regional Haze Plan 5-Year Progress Report

Colorado Department of Public Health and Environment

Air Pollution Control Division

Approved by Colorado's Air Quality Control Commission

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Executive Summary

Visibility impairment has long been an important concern to the residents of Colorado, where the Air Quality Control Commission established the first urban visibility standard in the nation. In January of 2011, the Commission adopted the Colorado Regional Haze State Implementation Plan which aimed at protecting the best visibility days and over the long term, improving visibility on the worst days in Colorado's 12 mandatory Federal Class I areas, or Class I areas. This progress report provides a 5 year update on the status of visibility at the Class I areas, the level of emissions improvements statewide and efforts to maintain and improve these planning goals for Colorado.

In this update to the Regional Haze State Implementation Plan (RH SIP), we present updated visibility records from the IMPROVE monitoring network representing Colorado's Class I areas, updated emissions for haze-related air pollutants and an analysis of the progress towards the goals for each of the 12 Colorado Class I areas as well as new efforts to reduce air pollution in the State. Visibility conditions, compared to the RH 2002 baseline period (2000-2004 average), show progress towards natural conditions at all IMPROVE monitoring sites in Colorado. During the current five year averaging period (2009-2013), all IMPROVE sites in Colorado achieved visibility standards for the 20% Best Days. During the same averaging period, 9 of the 12 Colorado Class I areas (5 of 6 IMPROVE monitor locations) have 20% Worst Days visibilities (in deciviews) that are better than original RH 2018 Reasonable Progress Goals (RPGs) glide slope values.

The remaining three Class I areas (represented by the WEMI1 IMPROVE monitor) show improving visibility and very good progress toward the 2018 Reasonable Progress Goals. Emissions of significant haze precursors including nitrogen oxides and sulfur oxides continue to decline in Colorado. Past modeling showed emissions from Colorado have a small impact (>10%) on one Class I area in New Mexico (WHPE1 IMPROVE monitor), although it can reasonably be expected that effects on this site from Colorado emissions are declining as a result of RH controls in Colorado. Colorado has exceeded the emission reduction goals listed in the 2011 RH SIP. There are several potential emission sources that are beyond the control of the State of Colorado that may impede visibility progress including international and interstate pollution transport, wildfires and regional dust storms. In this progress report, Colorado proposes to continue its current successful emission control programs for improving visibility at our Class I areas and does not see a need to consider additional emission control programs in this RH SIP update.

1. Background and Introduction

1.1 Introduction

The Clean Air Act (CAA) defines the requirement of protecting visibility in each of the 156 Mandatory Class I Federal Areas across the nation. The federal visibility regulations (40 CFR Part 51 Subpart P – Visibility Protection 51.300 - 309) detail a two-phased process to determine existing impairment in each of the Class I areas; how to remedy such impairment; and how to establish goals to restore visibility to 'natural conditions' by the year 2064.

Section 169B was added to the Clean Air Act Amendments of 1990 to address Regional Haze. Since Regional Haze and visibility problems do not respect state and tribal boundaries, the amendments authorized EPA to establish visibility transport regions as a way to combat regional haze.

In 1999 the EPA finalized the Regional Haze Rule (RHR) requiring States to adopt State Implementation Plans (SIPs) to address visibility impairment in the Class I areas.

Colorado initially submitted a Regional Haze State Implementation Plan (SIP) to EPA in 2008, but was directed to revise the SIP in several iterations. Colorado's Regional Haze SIP for the Twelve Mandatory Class I Federal Areas in the state was approved by Colorado's Air Quality Control Commission on January 7, 2011 and by the US EPA on December 31, 2012 (40 CFR 52 subpart G, 70 FR 76871).

Colorado's Regional Haze SIP addresses Phase 1: reasonably attributable visibility impairment (RAVI) and Phase 2: Regional Haze visibility impairment in federal Class I areas within the state. This Progress Report updates Phase 2 of the program, Regional Haze.

The two key requirements of the Regional Haze program are:

- Improve visibility for the most impaired days, and
- Ensure no degradation in visibility for the least impaired days.

The Regional Haze Rule requires that continuous progress towards visibility improvement goals is evaluated at periodic checkpoints, with State Implementation Plans (SIPs) required every 10 years and interim progress reports every five years. This Regional Haze Plan first 5-Year Progress Report is intended to meet the requirements of EPA's Regional Haze interim update.

This first 5-Year Progress Report evaluates progress made towards the 2018 RPGs and addresses the following:

- Status of RH Plan State strategy;
- Emissions reductions from RH Plan control strategies;
- Visibility progress;
- Emission trends;
- Assessment of changes impeding visibility progress;
- Assessment of current strategy;
- Review of visibility monitoring strategy;
- RH Plan adequacy determination; and
- Federal Land Manager comments.

In this progress report, we will assess progress towards the 2018 Reasonable Progress Goals set forth in Colorado's Regional Haze SIP by several methods. First, we will present monitoring data from the IMPROVE network, followed by emissions inventory trends including projections for 2020. We will also present the results of existing regulations both as a result of the RH rule and through other state regulatory methods. We will include an examination of other data sources available and conclude with an updated assessment of the status of Colorado's efforts to maintain the standards set forth in the RH SIP.

Colorado Mandatory Federal Class I Areas:

1. *Black Canyon of the Gunnison National Park*
2. *Eagles Nest Wilderness Area*
3. *Flat Tops Wilderness Area*
4. *Great Sand Dunes National Park*
5. *La Garita Wilderness Area*
6. *Maroon Bells-Snowmass Wilderness Area*
7. *Mesa Verde National Park*
8. *Mount Zirkel Wilderness Area*
9. *Rawah Wilderness Area*
10. *Rocky Mountain National Park*
11. *Weminuche Wilderness Area*
12. *West Elk Wilderness Area*

A detailed description of each of these areas, along with photographs, summaries of monitoring data containing an overview of current visibility conditions and sources of pollution in each area, is contained in individual Technical Support Documents (TSDs) for Colorado's 2011 Regional Haze SIP:

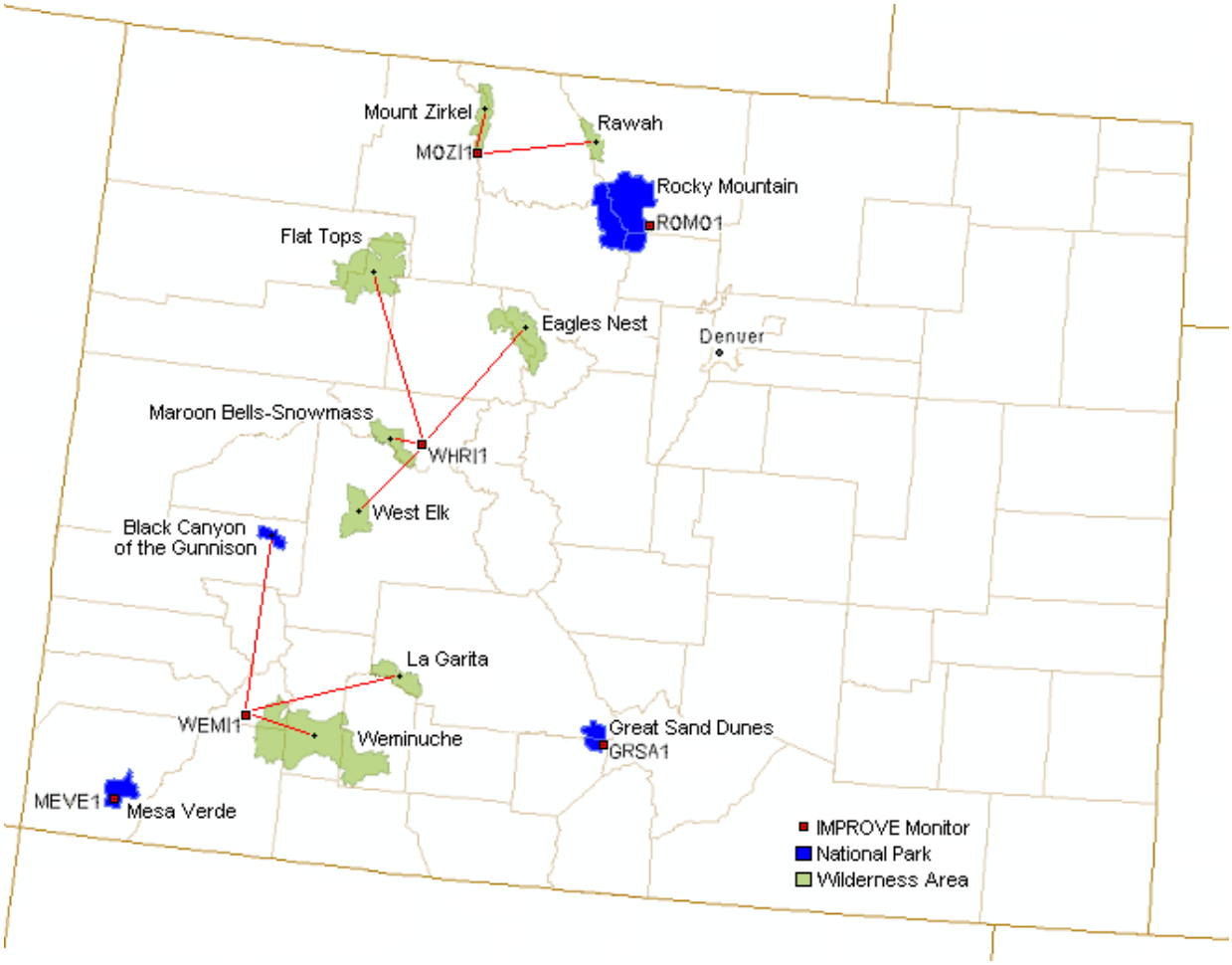
https://www.colorado.gov/pacific/cdphe/regional-haze-plan

Each Class I area has been designated as impaired for visual air quality by the Federal Land Manager responsible for that area. Under the federal visibility regulations, the Colorado visibility SIP needs to address the visibility status of and control programs specific to each area.

Monitoring Data from the IMPROVE Network. Figure 1 and Table 1 show the location of the Class I areas and the Inter-Agency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites that measures particulate air pollution representative of each Class I area.

Colorado utilizes data from the IMPROVE monitoring system: http://vista.cira.colostate.edu/improve/ which is designed to provide a representative measure of visibility in each of Colorado's Class I areas.

Figure 1. Colorado Class I Areas and IMPROVE Monitor Locations



1.2 Visibility

Federal regulations in 40 CFR 51.305 and 51.308(d)(4) require states to have a monitoring strategy in the SIP sufficient to characterize reasonable progress at each of the Class I areas within the state. Because Colorado adopted a visibility SIP to address the Phase 1 Reasonably Attributable Visibility Impairment requirements (51.305) and Phase 2 (51.308) Regional Haze requirements, a monitoring strategy is currently in place through an approved SIP.

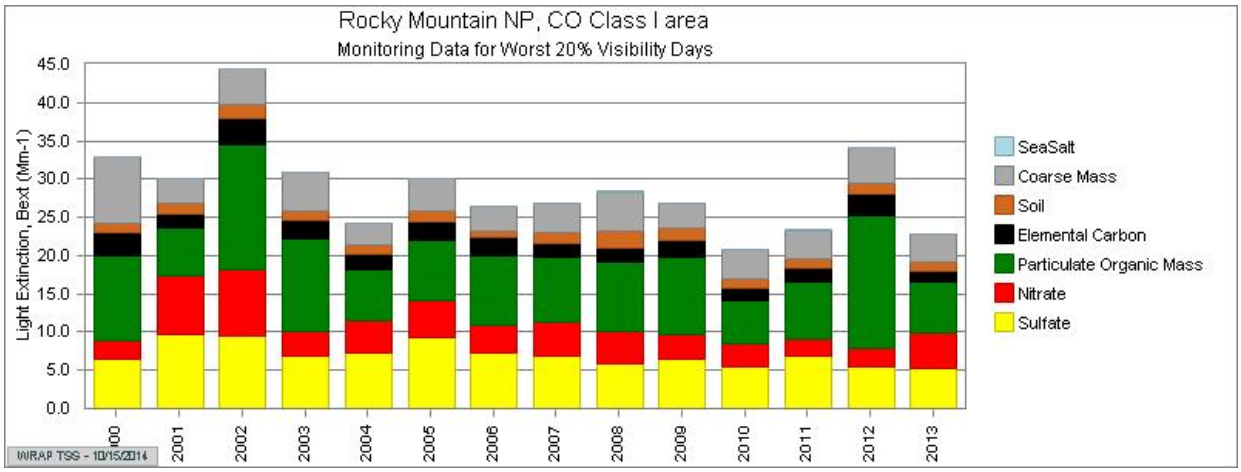
Table 1. Colorado IMPROVE Monitoring Site Information

Mandatory Class I Federal Area	Operating Agency	IMPROVE Monitor	Elevation [ft]	Start Date
Great Sand Dunes National Park	NPS	GRSA1	8,215	5/4/1988
Mesa Verde National Park	NPS	MEVE1	7,142	3/5/1988
Mount Zirkel Wilderness	USFS	MOZI1	10,640	7/30/1994
Rawah Wilderness				
Rocky Mountain National Park	NPS	ROMO1	9,039	9/19/1990
Weminuche Wilderness	USFS	WEMI1	9,072	3/2/1988
Black Canyon of Gunnison NP				
La Garita Wilderness				
Eagles Nest Wilderness	USFS	WHRI1	11,214	7/17/2000
Flat Tops Wilderness				
Maroon Bells-Snowmass Wilderness				
West Elk Wilderness				

Each IMPROVE monitor collects particulate concentration data which are converted into reconstructed light extinction through a complex calculation using the IMPROVE equation (see 2011 Technical Support Documents for any Class I area). Reconstructed light extinction (denoted as b_{ext}) is expressed in units of inverse megameters (1/Mm or Mm^{-1}). In 40 CFR 51.308(d)(2), the Regional Haze Rule requires the tracking of visibility conditions in terms of the Haze Index (HI) metric expressed in the deciview (dv) unit Generally, a one deciview change in the haze index is likely humanly perceptible under ideal conditions regardless of background visibility conditions.

In 40 CFR 51.308(d)(2)(i) and (ii), the rule requires the calculation of baseline conditions. The baseline condition for each Colorado Class I area is defined as the five year average (annual values for 2000 - 2004) of IMPROVE monitoring data (expressed in deciviews) for the most-impaired (20% worst) days and the least-impaired (20% best) days. For the first regional haze SIP, 2002 baseline conditions (the 5 year measurement period average from 2000-2004) were defined, which are the reference point against which visibility improvement is tracked. Baseline conditions are used to calculate progress from the beginning of the regional haze program towards 2018 Reasonable Progress Goals (RPGs).

Figure 2. Example IMPROVE monitoring data from the WRAP TSS for the Rocky Mountain National Park monitor. This monitor has the highest visibility impairment baseline value in Colorado (13.80 dv).



Current conditions for the best and worst days are calculated from a multiyear average, based on the most recent 5-years of monitored data available, as required in 40 CFR 51.308(f)(1). For the purposes of this first 5-year progress report, the most recent data available are from 2013 and we report the most recent 5 year average values from 2009-2013. Figure 2 shows the historic trends for the IMPROVE monitor located at Rocky Mountain National Park from 2000-2013 for the 20% Worst Visibility Days. All IMPROVE data presented in this Progress Report are obtained from the Western Regional Air Partnership (WRAP) Technical Support System (TSS) at: http://vista.cira.colostate.edu/tss/Results/HazePlanning.aspx

Plots for 20% Best and Worst Days at all 6 IMPROVE sites in Colorado are available in the data appendix to this Progress Report.

Table 2. Comparison of Baseline and Recent Visibility Conditions for Class I areas in Colorado, and 2018 Reasonable Progress Goals for Each Class I Area.

		Best 20% Days				Worst 20% Days					
IMPROVE Monitor	Colorado Class I Area(s)	Baseline (dv)	2009-2013 period (dv)	2018 Projection	Visibility Change (dv)	Baseline (dv)	2009-2013 period (dv)	Visibility change (dv)	2018 URP (dv)	2018 RPG (dv)	Progress to 2018 RPG by 2013
GRSA1	Great Sand Dunes National Park	4.50	3.80	4.16	0.70	12.80	11.56	1.24	11.35	12.20	207%
MEVE1	Mesa Verde National Park	4.32	3.00	4.10	1.32	13.00	11.24	1.76	11.58	12.50	352%
MOZI1	Mount Zirkel Wilderness Rawah Wilderness	1.60	0.46	1.29	1.14	10.50	9.12	1.38	9.48	9.91	234%
ROMO1	Rocky Mountain National Park	2.28	1.58	2.06	0.70	13.80	11.84	1.96	12.27	12.83	202%
WEMI1	Weminuche Wilderness Black Canyon of Gunnison NP La Garita Wilderness	3.10	2.06	2.93	1.04	10.30	9.88	0.42	9.37	9.83	89%
WHRI1	Eagles Nest Wilderness Flat Tops Wilderness Maroon Bells-Snowmass Wilderness West Elk Wilderness	0.73	-0.10	0.53	0.83	9.60	8.48	1.12	8.78	8.98	181%

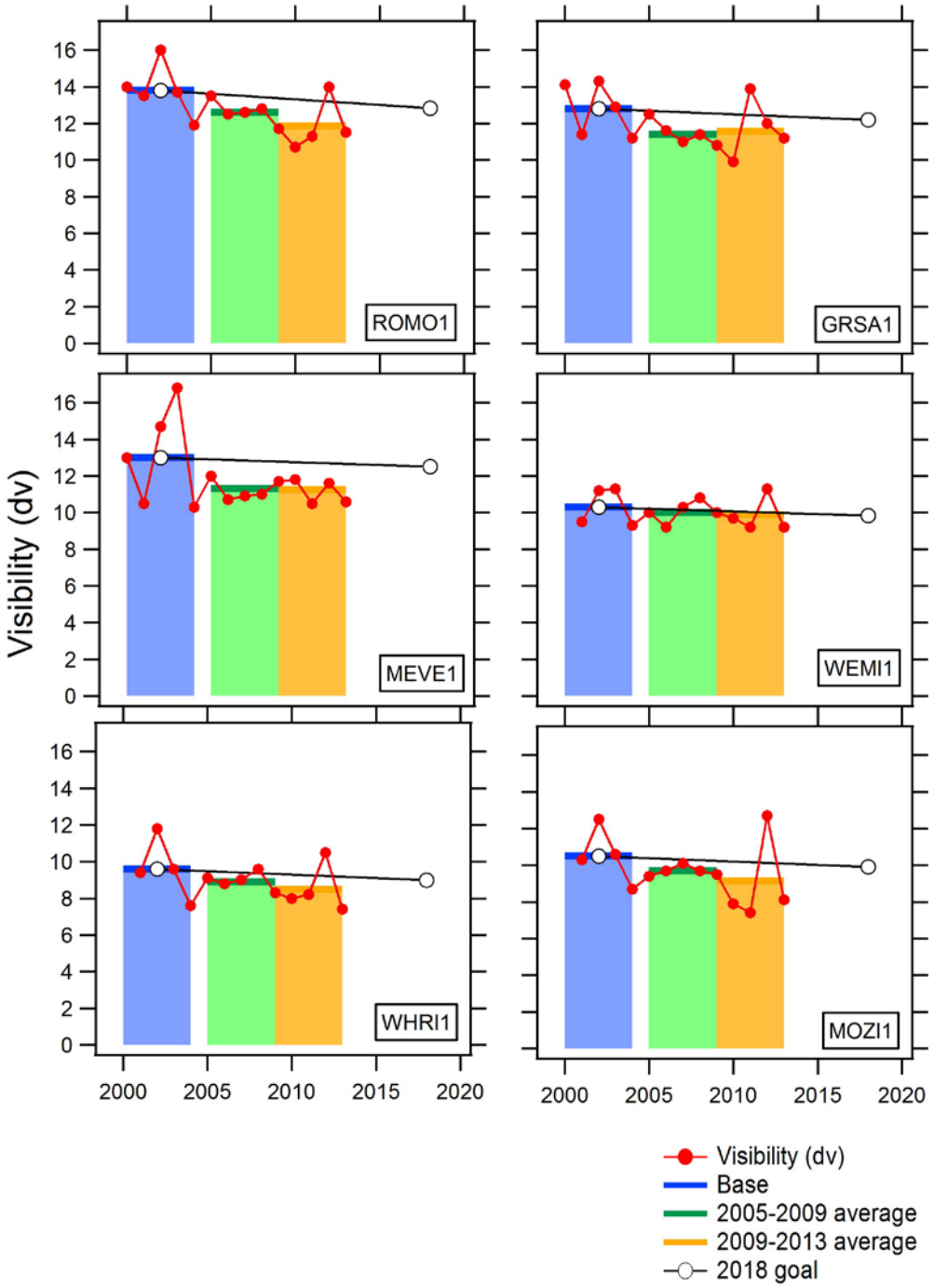
Colorado has established baseline visibility for the cleanest and worst visibility days for each Class I area based on, representative data gathered from the IMPROVE monitoring sites (Table 2). A five-year Baseline average (2000 to 2004) was calculated for each value (both best and worst). The calculations were made in accordance with 40 CFR 51.308(d)(2) and EPA's Guidance for Tracking Progress under the Regional Haze Rule (EPA-454/B-03-004, September 2003). The IMPROVE II algorithm, referred to as the new IMPROVE equation, as described in the referenced TSDs, has been utilized for the calculation of Uniform Rate of Progress glide slopes for all Class I areas, shown in Table 2. Table 2 summarizes the baseline conditions for each of the 6 IMPROVE monitor sites in Colorado as well as summary data for worst and best days for the period 2009-2013. Also included are the 2018 Reasonable Progress Goals (RPG) for each Class I area. Figure 3 plots the IMPROVE visibility data and compares it with RPG slopes.

More detailed information on the methodology for reconstructing light extinction along with converting between the haze index and reconstructed light extinction can be found in the Technical Support Documents for any of Colorado's twelve Class I areas. Data and plots provided in this progress report are obtained from the Western Regional Air Partnership TSS website:

http://vista.cira.colostate.edu/tss/Results/HazePlanning.aspx

Figure 3 shows visibility data, trends and the trend line to the 2018 Reasonable Progress Goals for each of the 3 data periods considered here.

Figure 3. Visibility trends for 20% Worst Days for each of the 6 Colorado IMPROVE sites with 2018 RPG Glide slopes. Averages for Baseline, Intermediate (2009-2009) and Current period data are shown.



For the current period, all 6 IMPROVE monitors show visibility better than 2018 Projection Values for the Best 20% Days (Table 2). For the Worst 20% Days, all 6 sites show significant visibility progress towards 2018 RGPs. 5 of 6 IMPROVE monitors, representing 9 of 12 Class I areas, show better visibility than the 2018 Reasonable Progress Glide Slope Values. For the Weminuche IMPROVE monitor (WEMI1), which represents three Class I areas, there is considerable progress from the baseline for the Worst 20% Days. However, the WEMI1 monitor falls just short (0.05 dv) of meeting the 2018 Reasonable Progress Glide Slope value. This small deviation is much less than what is perceptible to the human eye (1.0 dv). In fact, at the WEMI1 monitor the total expected visibility improvement is 0.47 dv from the baseline period to the 2018 RPG. The worst days glide slope for WEMI1 is the shallowest of any of the Colorado IMPROVE sites.

1.3 Source Impacts on Visibility

Emissions from both natural and anthropogenic sources can affect visibility in Class I Areas. For the purposes of this progress report, state emission inventories of SO_2, NOx, VOC, ammonia and Particulate Matter (PM) will be considered, as emissions of these species can influence visibility. Visibility in Colorado is significantly impacted both by anthropogenic emissions from within the State, and by regional blowing dust, wildfires, and transport of pollutants into Colorado from international emissions and other western states, much of which is not controllable by state level measures.

For more detailed technical information on source apportionment, inventory category aggregation, and other information on each IMPROVE site in Colorado, please see the RH SIP TSDs for each site at:

https://www.colorado.gov/pacific/cdphe/regional-haze-plan .

Additional detail and TSDs on inventory methodologies are available on the WRAP site:

http://www.wrapair2.org/WestJumpAQMS.aspx

Sulfur dioxide (SO_2) emissions produce sulfate particles in the atmosphere. Ammonium sulfate particles have a significantly greater impact on visibility than pollutants like dust from unpaved roads due to the physical characteristics causing greater light scattering from the particles. Sulfur dioxide emissions come primarily from coal combustion at electrical generation facilities but smaller amounts come from natural gas combustion, mobile sources and even wood combustion.

Nitrogen oxides (NO_x) are generated during any combustion process where nitrogen and oxygen from the atmosphere combine together under high temperature to form nitric oxide, and to a lesser degree nitrogen dioxide. Other oxides of nitrogen are also produced to a much smaller degree. Nitrogen oxides react in the atmosphere to form nitrate particles. Larger nitrate particles have a slightly greater impact on visibility than do sulfate particles of the same size and are much more effective at scattering light than mineral dust particles. Nitrogen oxide emissions in Colorado are expected to decline by 2018, primarily due to significant emission reductions from point, mobile and area sources. Off-road and on-road vehicles emissions will decline by more than 80,000 tons per year from the base case emissions total of 204,000 tons per year.

Volatile organic compounds (VOCs) from automobiles, the oil and natural gas industry, industrial and commercial facilities, solvent use, wildfires, and refueling activities all contribute to VOC loading in the atmosphere. Substantial natural emissions of VOCs come from vegetation. VOCs can directly impact visibility as emissions condense in the atmosphere to form an aerosol, however, the effect on haze is generally considered to be very small compared to impacts from nitrogen oxides and sulfur oxides. Additional information on the relative contribution by VOCs to haze in Colorado can be found in Colorado's RH SIP TSDs. Of more significance is the role VOCs play in the photochemical production of ozone in the troposphere. Volatile organic compounds react with nitrogen oxides to produce nitrate containing organic particles that impact visibility in the same series of chemical events that lead to ozone. Thus, strategies to reduce ozone in the atmosphere often lead to visibility improvements.

Ammonia (NH_3) is emitted into the atmosphere from a variety of human activities, most notably fertilizer application and animal husbandry, but also by automobiles, industrial activities and waste water treatment. Ammonia inventories are taken from the EPA National Emission Inventory, which assumes only small year to year variability. In Colorado, ammonia is thought to contribute to nitrogen deposition at Rocky Mountain National Park (RMNP) and has the potential to contribute to haze inducing particulate matter. More detail concerning Colorado's participation in collaborative efforts to reduce nitrogen deposition in RMNP can be found at: https://www.colorado.gov/cdphe/rocky-mountain-national-park-initiative .

Primary Particulate Matter (PM) can be introduced into the air through a variety of physical and anthropogenic methods. A variety of types of PM are examined here:

> **Coarse Particulate Matter (PM10)** is smaller than 10 µm and often arises from wind-blown dust, industrial and construction activities and road sanding. PM10 is commonly composed of minerals and sand type particles. Most PM10 observed at monitors represents primary PM.

Fine Particulate Matter (PM2.5) is sized below 2.5 µm. PM 2.5 can be directly emitted (primary) or formed from other pollutants (secondary). Only primary emissions of fine PM are considered in this progress report. Fires, both wildfires and prescribed burns, are major sources of PM2.5 in Colorado. Wildfire emissions are highly variable and can originate within Colorado, but also are often transported from other Western States and even from Canada and Mexico.

Primary Organic Aerosols (POAs) are organic carbon particles emitted directly from the combustion of organic material. A wide variety of sources contribute to this classification including cooking of meat, wood stove emissions, wildfires and prescribed burning, and diesel emissions. Area sources and mobile sources emissions dominate this classification. Increases in area and mobile source emissions of POA are due to population increases. These increases are offset by expected improvements in automobile emissions and by 2020 emissions from this category are expected to decline by about 3% from 2011 values. Note that organic aerosols can also form as a secondary product (Secondary Organic Aerosols or SOA). These can be a product of the natural atmospheric oxidation of (VOCs). Inventories in this plan address only primary emissions (POA), which are generally a small fraction of total aerosol. Analysis of SOA is a complex process requiring photochemical modeling that is beyond the scope of the inventory methods used in this progress report.

Elemental Carbon (EC), also called black carbon, are particles of soot produced by combustion processes. Major sources of EC in Colorado include mobile sources and fires.

Particulate oxides of Sulfur and Nitrogen are small by mass relative to other inventory species but have a large impact on regional haze. Because of their small mass relative to gas phase precursor emission of NOx and SO_2, particulate sulfur and nitrogen are inventoried here summed together with their gas phase precursor species.

Natural Sources of Visibility Impairment include anything not directly attributed to human-caused emissions of visibility-impairing pollutants. Natural events (e.g. windblown dust, wildfire, volcanic activity, biogenic emissions) also introduce pollutants contributing to haze in the atmosphere. Natural visibility conditions are not constant; they vary with changing natural processes throughout the year. Specific natural events can lead to high short-term concentrations of visibility-impairing particulate matter and its precursors. Natural visibility conditions, for the purpose of Colorado's regional haze program, are represented by a long-term average of conditions expected to occur in the absence of emissions normally attributed to human activities.

Natural visibility conditions reflect contemporary vegetated landscape, land-use patterns, and meteorological/climatic conditions. The 2064 goal is the natural visibility conditions for the 20% worst days. Natural sources contribute to visibility impairment but natural emissions cannot be realistically controlled or prevented by Colorado and therefore are beyond the scope of this plan. Current methods of analysis of IMPROVE data do not provide a distinction between natural and anthropogenic emissions. Instead, they are estimated as described in Section 4.4 of Colorado's Regional Haze SIP. We do distinguish natural and anthropogenic sources in statewide inventories and present the results below (Section 2.4).

Anthropogenic Sources of Visibility Impairment include anything directly attributable to human-caused activities producing emissions of visibility-impairing pollutants. Some examples include transportation, agriculture activities, mining operations, and fuel combustion. Anthropogenic visibility conditions are not constant and vary with changing human activities throughout the year. Generally anthropogenic emissions include not only those anthropogenic emissions generated or originating within the boundaries of the United States but also international emissions transported into a state. Some examples include emissions from Mexico, Canada, and maritime shipping emissions in the Pacific Ocean.

Although anthropogenic sources contribute to visibility impairment, international emissions cannot be regulated, controlled or prevented by the states and therefore are beyond the scope of this planning document. Any reductions in international emissions would likely fall under the purview of the U.S. EPA.

Fires. Fires are a significant source of haze in Colorado. Fire smoke from within and from outside of Colorado contribute to visibility impairment in the state. While wildfire smoke is highly variable and unpredictable, prescribed burning within the state is managed to ensure dispersion is adequate to minimize air quality impacts. Colorado regulates prescribed burning under an EPA-approved open burning permit program (Regulation 9) designed to protect air quality to the maximum extent possible. We include fire, both natural and anthropogenic as a source category in the inventories presented in this progress report. We also present updated historical trends in both wildfires and prescribed burns.

1.4 Initial Reporting Requirements

In this progress report, states are required to report the status of emission control measures intended to achieve 2018 Reasonable Progress Goals (RPGs). Colorado's first Progress Report is due to U.S. EPA on May 25, 2016. The Regional Haze Rule requires that a SIP revision undergo Federal Land Manager review. The most recent monitoring data available includes through 2013 for all six of Colorado's IMPROVE monitors.

In this Progress Report, "current" visibility conditions are the five-year average of 2009-2013, which is compared with "baseline" conditions, 2000-2004, from the initial Colorado Regional Haze Plan.

For the period from 2011-2013, Colorado and other western states relied on the Western Regional Air Partnership (WRAP) Regional Summary Reports. http://www.wrapair2.org/RHRPR.aspx. The WRAP Summary Report for Colorado was released in June 2013 and includes a comprehensive analysis of both measured visibility changes at the IMPROVE monitors and changes in emissions inventories between the baseline period and the five following years (2005-2009) to meet some of the RHR reporting requirements.

This progress report summarizes additional new information collected since the 2013 WRAP Summary Reports. It includes IMPROVE data from the most recent 5 year period (2009-2013) and an updated emissions inventory (2011) and projected inventory (2020) obtained from the Intermountain West Data Warehouse (IWDW), established by the WRAP and distributed via the WRAP Technical Support System at:

http://vista.cira.colostate.edu/tss/Results/HazePlanning.aspx

WRAP:

http://www.wrapair2.org/pdf/Memo1_PointSources_Mar15_2013final.pdf

Inventory Methods used in for 2002:

http://vista.cira.colostate.edu/TSS/Results/Emissions.aspx

Inventory Methods used in 2008 and 2011:

http://vibe.cira.colostate.edu/wiki/Attachments/Emissions/3SAQS_Emissions_Modeling_Report_v18Feb2015_Final.pdf

Detailed, County Level Emissions Totals for 2011 and 2020 projections:

http://views.cira.colostate.edu/tsdw/Documents/

2. Control Strategy Status and Emissions

In Colorado, the most important anthropogenic emission sources that influence worst day visibility are nitrate and sulfate. Most of the Colorado's efforts to control Regional Haze to date have focused on sources of nitrate and sulfate. Coal-fired power plants are a significant source of both sulfur dioxide (SO_2) and nitrogen oxides (NOx) in Colorado, which are precursors of the particles that cause visibility impairment. The Front Range of Colorado is non-attainment for the 2008 ozone standard and significant efforts to reduce both NOx and VOC emissions in the State likely have significant co-benefits which include reducing Regional Haze precursors (NOx, SO_2, and VOC).

Coarse mass and soil fractions are relatively constant, but show variability driven for the most part by high wind events and associated blowing dust. Colorado is also impacted significantly by wildfires both within and from outside of Colorado. Wildfires tend to drive variability in the organic mass fraction of extinction. Emissions from other upwind states can also be transported into Colorado and contribute to visibility impairment. Existing and new control measures addressing PM, mobile source emissions, ozone precursors and prescribed burning are described in detail of Colorado's Regional Haze SIP and are summarized in Section 2.3 below.

2.1 Status of Control Strategies in the RH Plan

Emissions reductions resulting from Colorado's Regional Haze SIP are still in the process of being implemented. The current status of emission reductions in NOx, SO_2 and Particulate Matter (PM) from both Best Available Retrofit Technology (BART) and Reasonable Progress (RP) controls are summarized and compared with 2018 projections in Table 3. As of July, 2015, Colorado has documented actual reductions of 51% of NOx, 59% of SO2 and 93% of PM expected by 2018 under the Colorado Regional Haze plan (for BART and RP). Since the Colorado RH SIP was approved, Colorado has also pursued and negotiated further reductions including the 2013 shutdown of the Arapahoe Power Plant Unit 4 (originally scheduled to be converted from coal to gas) as well as the implementation of the control for NOX, assumed to be achievable by use of selective catalytic reduction (SCR) on Unit 1 of the Craig Power Plant, to be implemented by August 31, 2021.

2.2 BART Regulation

Colorado's Air Quality Control Commission approved a State-only Best Available Retrofit Technology (BART) regulation (Regulation 3 Part F) on March 16, 2006, that became effective in May 2006. A total of 15 sources in Colorado were determined to be subject to BART. In addition, 6 sources were subject to BART alternatives and 10 were subject to Reasonable Progress requirements. More detail is provided in Colorado Regulation Number 3 Part F, Appendix C. Regulation 3 and Associated Technical Support Documents (TSDs) are available at CDPHE's BART website at: http://www.cdphe.state.co.us/ap/RegionalHazeBART.html.

Colorado has been party to negotiations for further power plant emissions reductions beyond RHR requirements. Additional efforts and their effective emissions reductions are shown in Table 3.

Table 3. Status of emission reductions resulting from Regional Haze Rule controls (BART + RP) implemented in Colorado. Detailed methodology for calculation of Baseline for each source are available in the Federal Register Docket for Colorado's RH SIP: http://www.regulations.gov/#!docketBrowser;rpp=100;so=DESC;sb=docId;po=0;dct=SR;D=EPA-R08-OAR-2011-0770

Emission Reductions Resulting from the Regional Haze Program

	Facility or Unit	Location	Assumed Emissions Control Type			2006-2008 Baseline NOx Emissions (tons/year)	2015⊥ Statewide NOx Reductions (tons/year)	2018⊥ Statewide NOx Reductions (tons/year)	2006-2008 Baseline SO2 Emissions (tons/year)	2015⊥ Statewide SO2 Reductions (tons/year)	2018⊥ Statewide SO2 Reductions (tons/year)	2006-2008 Baseline PM Emissions (tons/year)	2015⊥ Statewide PM Reductions (tons/year)	2018⊥ Statewide PM Reductions (tons/year)
1/2	Black Hills Clark - Units 1 & 2*	Canon City	Retired in 2013			861	861	861	1,457	1,457	1,457	72	72	72
3	PSCo Cherokee-Unit 1*	Denver Metro	Retired - 30 APR 2012 (actual)			1,556	1,556	1,556	2,221	2,221	2,221	37	37	37
4	PSCo Cherokee-Unit 2*	Denver Metro	Retired - 15 OCT 2011 (actual)			2,895	2,895	2,895	1,888	1,888	1,888	35	35	35
5	PSCo Cherokee-Unit 3*	Denver Metro	Retire - no later than 31 DEC 2016			1,866	0	1,866	743	0	743	65	65	65
6	PSCo Cherokee-Unit 4*	Denver Metro	Natural Gas Operation by 31 DEC 2017			4,274	0	2,211	2,135	0	2,127	78	77	77
7	PSCo Arapahoe-Unit 3*	Denver Metro	Retired in 2013			1,771	1,771	1,771	925	925	925	109	109	109
8	PSCo Arapahoe-Unit 4*	Denver Metro	Retired in 2013 (shutdown not included in RH SIP)			1,148	1,148	1,148	1,765	1,765	1,765	20	20	20
9	PSCo Valmont-Unit 5*	Denver Metro	Retire - no later than 31 DEC 2017			2,314	0	2,314	758	0	758	42	0	42
10	PSCo Pawnee-Unit 1*	NE Colorado	NOx - SCR	SO2 - LSD	PM - baghouse**	4,538	3,135	3,135	13,472	11,066	11,066	108	0	0
11	PSCo Comanche-Unit 1	Pueblo	NOx - LNB**	SO2 - LSD**	PM - baghouse**	1,506	0	0	1,539	0	0	84	0	0
12	PSCo Comanche-Unit 2	Pueblo	NOx - LNB**	SO2 - LSD**	PM - baghouse**	2,349	0	0	1,244	0	0	63	0	0
13	PSCo Hayden-Unit 1	NW Colorado	NOx - SCR	SO2 - LSD**	PM - baghouse**	3,750	3,120	3,120	1,172	61	61	96	0	0
14	PSCo Hayden-Unit 2	NW Colorado	NOx - SCR	SO2 - LSD**	PM - baghouse**	3,743	0	3,032	1,469	39	39	119	0	0
15/16	PSCo Cameo-Units 1 & 2	W Colorado	Retired in 2010			1,140	1,140	1,140	2,618	2,618	2,618	225	225	225
17	TriState Craig-Unit 1	NW Colorado	NOx - SCR ‡	SO2 - WS**	PM - baghouse**	5,190	0	0	970	0	0	100	0	0
18	TriState Craig-Unit 2	NW Colorado	NOx - SCR	SO2 - WS**	PM - baghouse**	5,372	0	3,975	982	0	0	87	0	0
19	TriState Craig-Unit 3	NW Colorado	NOx - SNCR	SO2 - LSD**	PM - baghouse**	5,693	0	854	1,792	0	0	70	0	0
20	TriState Nucla-Unit 4	W Colorado	NOx - SNCR**	SO2 - LI**	PM - baghouse**	1,675	0	0	1,335	0	0	55	0	0
21	PRP Rawhide-Unit 101	Larimer County	NOx - ECC	SO2 - LSD**	PM - baghouse**	1,866	448	448	913	0	0	117	0	0
22	CSU Drake-Unit 5	Colo. Springs	NOx - ULNB+OFA	SO2 - DSI	PM - baghouse**	768	0	215	1,269	0	762	27	0	0
23	CSU Drake-Unit 6	Colo. Springs	NOx - ULNB+OFA	SO2 - LSD	PM - baghouse**	1,413	509	509	2,785	0	2,368	58	0	0
24	CSU Drake-Unit 7	Colo. Springs	NOx - ULNB+OFA	SO2 - LSD	PM - baghouse**	2,081	749	749	4,429	0	3,764	55	0	0
25	CSU Nixon-Unit 1	Fountain	NOx - ULNB+OFA	SO2 - LSD	PM - baghouse**	2,357	0	707	4,121	0	3,215	87	0	0
26	Holcim Cement Plant	Florence	NOx - SNCR	SO2 - WLS**	PM - baghouse**	3,186	0	1,099	287	0	0	58	0	0
27/28	Cemex Cement Plant	Denver Metro	NOx - SNCR	SO2 - none	PM - baghouse**	1,747	0	846	95	0	0	10	0	0
29	CENC-Boiler 3	Denver Metro	NOx - none	SO2 - none	PM - baghouse**	180	-66	-66	257	0	0	2	0	0
30	CENC-Boiler 4	Denver Metro	NOx - LNB+SOFA	SO2 - none	PM - baghouse**	599	214	214	780	0	0	11	0	0
31	CENC-Boiler 5	Denver Metro	NOx - LNB+SOFA+SN	SO2 - none	PM - baghouse**	691	354	354	1,406	0	0	18	0	0
					Total Emissions (tons/year):	*66,528*	*17,833*	*34,952*	*54,828*	*22,040*	*35,777*	*1,908*	*640*	*682*
					Total Emissions (tons/day):	*182*	*49*	*96*	*150*	*60*	*98*	*5*	*2*	*2*
					Percent of 2018 Emissions Goal:		*51%*	*100%*		*62%*	*100%*		*94%*	*100%*

The "Assumed Emissions Control Type" reflects the control option found to render the BART emission limit achievable. The "assumed" technology listed in the above table is not a requirement.

⊥ **Includes emission reductions for listed year and prior years** *** HB 10-1365 Source** **** existing controls**

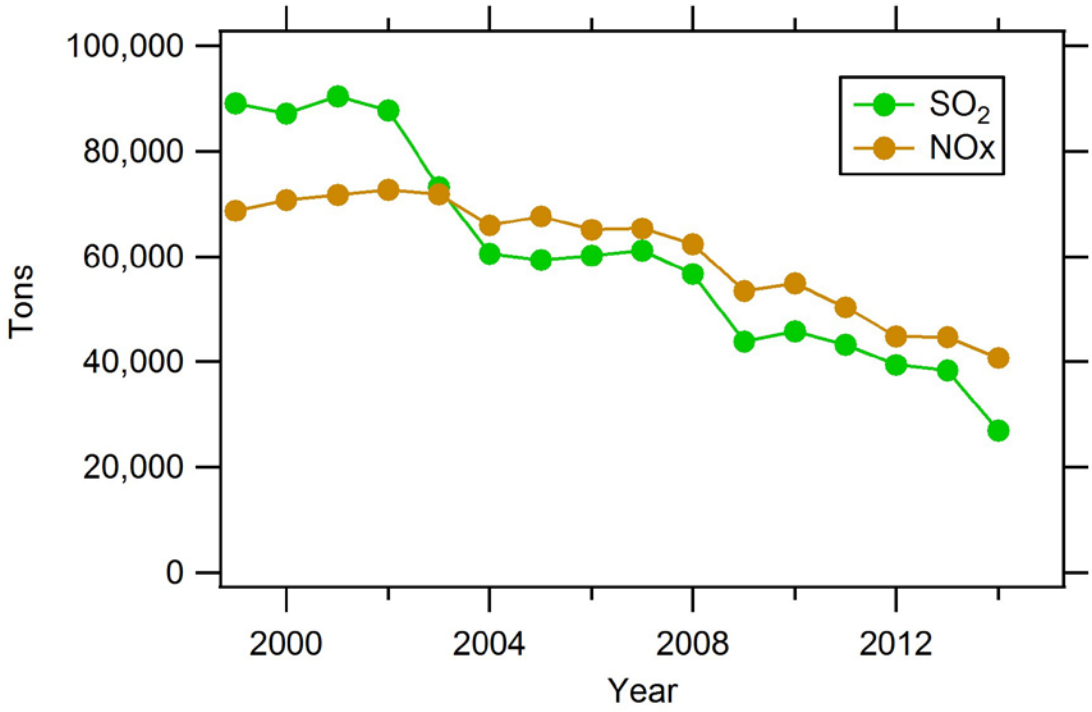
‡ Settlement Agreement changed NOx control from 0.28 lb/MMBtu to 0.07 lb/MMBtu – Compliance Date August 31, 2021

Abbreviation Key

DSI = dry sorbent injection
ECC = enhanced combustion control
LI = limestone Injection
LNB = low NOx burners
LSD = lime spray dryers
NOx = Nitrogen Oxides
PM = Particulate Matter
SCR = selective catalytic reduction
SNCR = selective non-catalytic reduction
SOFA = separated overfire air
SO2 = Sulfur Dioxide
ULNB+OFA = ultra LNB plus overfire air
WLS = wet lime scrubber
WS = wet scrubbers

Larger Electrical Generating Units (EGUs) statewide have in-stack Continuous Emissions Monitoring Systems (CEMS) that report data to the EPA Air Markets Data Program which is summarized in Figure 4. Both SO_2 and NOx show significant reductions between 1999 and 2014. http://www.epa.gov/airmarkets/index.html

Figure 4. Emissions trends in sources in Colorado reporting to the EPA Air Markets Data Program.



2.3 New and Ongoing Air Pollution Control Programs

Colorado is subject to a variety of Federal air quality regulations such as engine pollution standards, automotive standards, National Ambient Air Quality Standards (NAAQS) for NO2, SO2 and Ozone, all of which have significant co-benefits that act to reduce visibility impairment in Colorado's Class I areas. Colorado is currently working on SIPs related to the ozone and SO2 NAAQS that could go into effect prior to the end of the current RH planning period (2018). In addition, EPA has several new programs such as the Clean Power Plan and the SO2 Data Requirements Rule which could have Regional Haze benefits prior to 2018, although these are difficult to quantify at this time.

In addition to the Regional Haze Program and other Federal Requirements, Colorado has numerous ongoing air pollution control programs that reduce visibility impairing emissions throughout Colorado. Numerous emission reduction programs exist for

major and minor industrial sources of NOx, SO_2 and particulates throughout the state, as well as in the Denver Metro Area/Northern Front Range region for VOCs, NOx, and particulates from mobile, area, stationary and oil/gas sources, and are contained in the following Colorado Air Quality Control Commission Regulations:

- State only revisions to Regulations 3 and 7 were passed by Colorado's Air Quality Control Commission in February of 2013. These rules aimed to reduce VOC emissions from the Oil and Gas industry through a variety of programs such as enhanced Storage Tank Emissions Management (STEM) and expanded Leak Detection and Repair (LDAR) requirements. The regulations also extended certain control measures which had been applied only to the Ozone Non-Attainment air to statewide – state only.
- Regulation Number 1: Emission Controls for Particulates, Smoke, Carbon Monoxide and Sulfur Oxides
    - In the SIP (includes specific fugitive dust and open burning regulations)
- Regulation Number 3: Stationary Source Permitting and Air Pollutant Emission Notice Requirements
    - Parts A, B,D, F in the SIP or Submitted to EPA for inclusion in the SIP
    - Part C is the Title V program and is delegated by EPA to the state
- Regulation Number 4: New Wood Stoves and the Use of Certain Woodburning Appliances on High Pollution Days
    - Regulation Number 4 is in the SIP. One provision, the Masonry Heater Test Method, is state only. Colorado is waiting for EPA to develop their own test method – the state will adopt it when EPA goes final
- Regulation Number 6: Standards of Performance for New Stationary Sources
    - Part A – Federal NSPS's adopted by the state – EPA has delegated authority to the state to implement; Colorado has requested delegation for the most recent adoptions
    - Part B – state-only NSPS regulations
- Regulation Number 7: Control of Ozone Precursors
    - The majority of Regulation Number 7 for VOC and NOx control is in the SIP or has been submitted for approval into the SIP – these provisions relate to VOC and NOx control measures for the Denver Metro Area/North Front Range 8-hour ozone nonattainment area and are summarized below

- Regulation Number 9: Open Burning, Prescribed Fire and Permitting – state-only
- Regulation Number 11: Motor Vehicle Emission Inspection Program – Parts A-F in the SIP
- Regulation Number 16: Street Sanding Emissions – In the SIP

Some examples of these programs and the visibility-improving emission reductions they achieve are as follows. It is noted as to whether the program is federally enforceable, submitted by the state in an unrelated submittal for inclusion into the SIP, or state-only enforceable.

- Early reductions from BART sources include approximately 24,000 tpy of SO_2 from metro Denver power plants, approximately 6,500 tpy of SO_2 from the Comanche power plant, and approximately 18,000 tpy of SO_2 from the Craig and Hayden power plants – state-only
- Oil and gas condensate tank control regulations for the Front Range region that have achieved approximately 52,000 tpy of volatile organic compounds (VOC) emission reductions by 2007 - in the SIP - with additional projected reductions of 18,000 tpy by 2010 – Submitted for inclusion in the SIP
- Existing industrial engine control regulations for the Front Range region that have achieved NOx and VOC emissions reductions of approximately 8,900 tpy – In the SIP
- Oil and gas pneumatic actuated device control regulations for the Front Range region that have achieved VOC emission reductions of approximately 8,400 tpy – state-only
- Mobile source emissions controls for VOCs and NOx through vehicle inspection/maintenance and lower volatility gasoline programs for the Front Range region is estimated to reduce emissions by approximately 8,000 tpy by 2011 – Submitted for inclusion in the SIP
- Statewide condensate tank control regulations that have achieved approximately 5,600 tpy of VOCs emission reductions – state-only
- Statewide existing industrial engine control regulations that are estimated to have achieved NOx and VOC emissions reductions of approximately 7,100 tpy by 2010 – state-only
- PM10 emission reduction programs in PM10 maintenance areas throughout the state – In the SIP
- Fugitive dust control programs for construction, mining, vehicular traffic, and

industrial sources state-wide – In the SIP

- Smoke management programs for open burning and prescribed fire activities statewide – state-only
- Renewable energy requirements that are driving current and future NOx, SO2 and PM emission reductions from coal-fired power plants - Ballot Initiative 37 – by requiring electricity to be obtained from renewable resources – state-only
- Attaining and maintaining the PM10 and PM2.5 standards throughout the state
- Reducing Colorado Front Range Urban Visibility Impairment (Denver's Brown Cloud) by 28% between 1991 and 2006) – state-only
- Reducing Colorado emissions in the Four Corners area (which is upwind of numerous Class I areas in three states) through oil and gas control measures administered by the CDPHE and the Colorado Oil and Gas Conservation Commission, and by working with the Southern Ute Indian Tribe to develop a Title V permitting program and a minor source permitting program – state-only
- Federal mobile source tailpipe exhaust reductions of approximately 55,000 tpy of VOC and NOx emissions by 2020 – gained through fleet turn-over

Discussion of state-only measures in the Regional Haze SIP, including this progress update, are for informational purposes only and not intended to make such measures federally enforceable. However, such measures could be included in future SIP revisions if found necessary to meet National Ambient Air Quality Standards or visibility requirements.

2.4 Statewide Emission Inventory

Emissions Inventories for the base year period 2002 and 2008 were presented in Colorado's Regional Haze SIP. This plan presents updated statewide inventories for 2011 using the same methodologies. In addition, future 2020 projections are based on the 2011 statewide inventories. We note here that improvements in methodologies and understanding make comparing current inventories to past inventories difficult at times. In particular, our methodology for Area and Mobile sources, Fugitive Dust, Wildfires, and Oil and Gas sources has changed and become more detailed since the 2002 baseline was established. For example, EPA's Mobile emissions model, MOVES, has been updated several times since 2002.

Methods for calculating fire emissions have improved substantially, especially through the use of satellite monitoring of fires. Biogenic emissions were modeled with EPA's BEIS3 for the 2002 baseline, but the MEGAN model was used for 2011 estimates presented here. As a result of changes in model processing (EPA's SMOKE model) of

dust emissions, dust uptake on vegetation was subtracted from the inventory in 2002 but is included in the emissions shown for 2008 and 2011. In addition, Wildfire emissions for the 2002 baseline year are based on a 5-year average, while inventory values for 2008 and 2011 are single year estimates.

For example, Wildfire emissions of VOCs and POA shown in the tables below vary significantly. While fire emissions to vary considerably year-to-year, we note that differences in inventory methods make comparing these numbers difficult. Detailed documentation of inventory methods can be found in the references listed in Section 1.4. Tables 4a-4h summarize numerically base-year inventories with more recent 5-year periods (2008 and 2011) and project expected trends to 2020 for haze precursor pollutants. Figure 5a-5c present the same data graphically. Full citation via website links is presented in Section 1.4.

Nitrogen Oxides:

Nitrogen oxides emissions (Table 4a, Figure 5a) have decreased significantly since 2002 and are projected to continue to decrease through 2020. Most anthropogenic NOx source categories including Mobile and Area Oil and Gas are projected to decrease between 2011 and 2020. However, point source Oil and Gas NOx emissions are projected to rise over the same period due to continued growth in that industrial sector. Regional Haze and mobile source controls have been and continue to be very effective at reducing Colorado's NOx and particulate nitrate emissions. Monitoring data for EGUs in Colorado (Figure 4) shows similar trends for in-stack (CEMS) monitors from the EPA Air Markets Program website: http://ampd.epa.gov/ampd/. Satellite retrieval provides another affirmation of statewide reductions in NOx over time (see Figure 7 below).

Table 4a.

Source Category	Oxides of Nitrogen, particle + gas phase (tons/year)				
	2002 (Plan02d)	2008 (WestJump 2008c)	2011 (WAQDW 2011v1)	2020 Projection (WRAP 2011 Base20a)	Trend 2011-2020
Anthropogenic Sources					
Point (incl. Oil & Gas)	117,869	108,094	104,016	95,485	-8%
Area	11,645	22,885	8,234	8,304	1%
On-Road Mobile	141,883	129,596	83,104	36,404	-56%
Off-Road Mobile	62,447	31,366	41,945	30,942	-26%
Area Oil and Gas	23,351	27,054	23,120	19,457	-16%
Fugitive+Road Dust	14	17	30	30	-
Subtotal	**357,209**	**319,012**	**260,448**	**190,620**	**-27%**
Natural Sources					
Biogenic	37,349	9,542	10,799	10,799	-
Wind Blown Dust	-	-	-	-	-
Subtotal	**37,349**	**9,542**	**10,799**	**10,799**	**-**
Fire					
Anthropogenic Fire	520	236	815	815	-
Natural Fire	9,377	938	1,843	1,843	-
Subtotal	**9,897**	**1,174**	**2,658**	**2,658**	**-**
Total Emissions	**404,455**	**329,727**	**273,905**	**204,078**	**-25%**

Sulfur Oxides:

Table 4b and Figure 5a show decreasing trends for sulfur oxides in Colorado. Statewide anthropogenic sulfur oxides are consistently trending downward in inventory data (Table 4b, Figure 5a). EPA Air Markets Program data also show significant reductions in SO_2 emissions from the stacks of EGUs which are the primary source of SO_2 statewide (Figure 4). Much of this reduction can be attributed to the Regional Haze program and associated SO_2 emission controls resulting from the RH Rule.

Table 4b.

Source Category	Oxides of Sulfur, particle + gas phase (tons/year)				
	2002 (Plan02d)	2008 (WestJump 2008c)	2011 (WAQDW 2011v1)	2020 Projection (WRAP 2011 Base20a)	Trend 2011-2020
Anthropogenic Sources					
Point (incl. Oil & Gas)	97,016	64,660	51,561	20,354	-61%
Area	6,504	555	554	564	2%
On-Road Mobile	4,389	978	516	276	-47%
Off-Road Mobile	3,015	620	237	50	-79%
Area Oil and Gas	260	1,050	175	84	-52%
Fugitive+Road Dust	9	39	64	64	-
Subtotal	**111,194**	**67,901**	**53,107**	**21,391**	**-60%**
Natural Sources					
Biogenic	-	-	-	-	-
Wind Blown Dust	-	-	-	-	-
Subtotal	**-**	**-**	**-**	**-**	**-**
Fire					
Anthropogenic Fire	108	47	323	323	-
Natural Fire	3,335	170	591	591	-
Subtotal	**3,443**	**216**	**914**	**914**	**-**
Total Emissions	**114,636**	**68,118**	**54,021**	**22,306**	**-59%**

Volatile Organic Compounds (VOCs):

Table 5c and Figure 3a show statewide trends for VOC Emissions in Colorado. It is important to note that our understanding of VOC emissions is evolving and that the values presented here represent a current snapshot of current and projected VOC emissions. While Biogenic and Fire related VOCs show some variability, the trend of concern is in Area Oil and Gas emissions. Colorado has experienced significant growth in Oil and Gas development over the past decade, which is reflected in the VOC inventory. While emissions from this sector continue to grow, Colorado has shown national leadership in requiring strict VOC emission controls on a statewide basis. Colorado regulation Number 3 and Number 7 were updated in 2014 to reduce emissions of ozone precursor emissions and methane from the Oil and Gas industry.

2020 VOC projections presented here do not attempt to account for the VOC reductions expected as a result of these rules. Colorado considers VOCs to be primarily a concern for attainment of the ozone NAAQS. However, there are likely co-benefits to Regional Haze by reducing VOC emissions. Colorado continues to monitor the growth and emissions from the oil and gas sector as these VOC emissions contribute to Ozone formation.

Table 4c.

Source Category	Volatile Organic Compound Emissions (tons/year)				
	2002 (Plan02d)	2008 (WestJump 2008c)	2011 (WAQDW 2011v1)	2020 Projection (WRAP 2011 Base20a)	Trend 2011-2020
Anthropogenic Sources					
Point (incl. Oil & Gas)	91,750	109,435	51,960	69,186	33%
Area	98,695	67,133	56,497	54,568	-3%
On-Road Mobile	100,860	55,953	46,514	22,792	-51%
Off-Road Mobile	38,401	34,301	31,462	24,933	-21%
Area Oil and Gas	25,954	68,895	189,660	423,513	123%
Fugitive+Road Dust	-	-	-	-	-
Subtotal	**355,661**	**335,717**	**376,094**	**594,993**	**58%**
Natural Sources					
Biogenic	804,777	275,328	340,268	340,268	-
Wind Blown Dust	-	-	-	-	-
Subtotal	**804,777**	**275,328**	**340,268**	**340,268**	**-**
Fire					
Anthropogenic Fire	915	373	6,766	6,766	-
Natural Fire	20,404	900	11,993	11,993	-
Subtotal	**21,319**	**1,273**	**18,759**	**18,759**	**-**
Total Emissions	**1,181,756**	**612,318**	**735,121**	**954,020**	**30%**

Ammonia:

Ammonia sources in Colorado remain dominated primarily by area agricultural emissions in the WRAP inventory and EPA National Emission Inventory (NEI: http://www.epa.gov/ttn/chief/eiinformation.html). We do not have strong evidence for either growth or decline in ammonia emissions in Colorado and project ammonia emissions to remain approximately the same into 2020.

Table 4d.

Source Category	Ammonia Emissions (tons/year)				
	2002 (Plan02d)	2008 (WestJump 2008c)	2011 (WAQDW 2011v1)	2020 Projection (WRAP 2011 Base20a)	Trend 2011-2020
Anthropogenic Sources					
Point (incl. Oil & Gas)	539	469	475	606	28%
Area	60,770	70,451	70,699	71,126	1%
On-Road Mobile	4,317	2,201	1,774	1,262	-29%
Off-Road Mobile	43	35	43	51	18%
Area Oil and Gas	-	-	-	-	-
Fugitive+Road Dust	-	-	-	-	-
Subtotal	**65,668**	**73,156**	**72,992**	**73,046**	**0.1%**
Natural Sources					
Biogenic	-	-	-	-	-
Wind Blown Dust	-	-	-	-	-
Subtotal	**-**	**-**	**-**	**-**	**-**
Fire					
Anthropogenic Fire	137	153	287	287	-
Natural Fire	1,965	648	502	502	-
Subtotal	**2,103**	**802**	**789**	**789**	**-**
Total Emissions	**67,771**	**73,958**	**73,781**	**73,835**	**0.1%**

Particulate Matter: Primary Coarse and Fine

Primary Coarse and Fine Particulate Matter are dominated by fugitive and wind-blown dust (Figure 5b, Tables 4e-f). The particulate emission inventories show increasing trends for fugitive dust, though the origin of this effect is not clear. Colorado does have a long standing dust control program associated with road sanding in many areas that has significantly reduced PM emissions. Currently Colorado has no areas that violate the PM10 or PM2.5 NAAQS.

Table 4e.

Source Category	Coarse Particulate Matter (tons/year)				
	2002 (Plan02d)	2008 (WestJump 2008c)	2011 (WAQDW 2011v1)	2020 Projection (WRAP 2011 Base20a)	Trend 2011-2020
Anthropogenic Sources					
Point (incl. Oil & Gas)	21,096	11,632	9,679	9,438	-2%
Area	1,360	61	240	241	0%
On-Road Mobile	794	5,762	1,252	1,288	3%
Off-Road Mobile	-	146	178	149	-17%
Area Oil and Gas	-	60	184	1	-99%
Fugitive+Road Dust	57,327	122,035	204,209	204,868	-
Subtotal	**80,577**	**139,697**	**215,742**	**215,985**	**-**
Natural Sources					
Biogenic	-	-	-	-	-
Wind Blown Dust	135,945	118,244	138,102	138,102	-
Subtotal	**135,945**	**118,244**	**138,102**	**138,102**	**-**
Fire					
Anthropogenic Fire	51	88	240	240	-
Natural Fire	5,973	337	-	-	-
Subtotal	**6,024**	**424**	**240**	**240**	**-**
Total Emissions	**222,546**	**258,365**	**354,084**	**354,327**	**-**

Table 4f.

Source Category	Fine Particulate Matter (tons/year)				
	2002 (Plan02d)	2008 (WestJump 2008c)	2011 (WAQDW 2011v1)	2020 Projection (WRAP 2011 Base20a)	Trend 2011-2020
Anthropogenic Sources					
Point (incl. Oil & Gas)	6	424	5,404	7,188	33%
Area	4,091	4,064	20	20	0%
On-Road Mobile	812	536	453	398	-12%
Off-Road Mobile	-	86	-	-	-
Area Oil and Gas	-	1,517	1	-	-
Fugitive+Road Dust	12,466	22,998	36,341	36,495	0.4%
Subtotal	**17,375**	**29,626**	**42,220**	**44,101**	**4%**
Natural Sources					
Biogenic	-	-	-	-	-
Wind Blown Dust	15,105	13,138	15,345	15,345	-
Subtotal	**15,105**	**13,138**	**15,345**	**15,345**	**-**
Fire					
Anthropogenic Fire	253	173	2	2	-
Natural Fire	1,948	676	4	4	-
Subtotal	**2,201**	**849**	**7**	**7**	**-**
Total Emissions	**34,681**	**43,613**	**57,571**	**59,452**	**3%**

Particulate Matter: Elemental Carbon and Primary Organic Aerosol

Elemental Carbon and Primary Organic Aerosol inventories show declining trends from 2002-2020 (Figure 5c, Tables 4g-h). Fires have a significant effect on emissions of these pollutants. The sources of these emissions are poorly understood but methods used in inventory are well documented (see WRAP inventory citations, Section 1.4).

Table 4g.

Source Category	Elemental Carbon Emissions (tons/year)				
	2002 (Plan02d)	2008 (WestJump 2008c)	2011 (WAQDW 2011v1)	2020 Projection (WRAP 2011 Base20a)	Trend 2011-2020
Anthropogenic Sources					
Point (incl. Oil & Gas)	0	64	982	1,080	10%
Area	1,263	1,152	592	597	1%
On-Road Mobile	2,698	5,257	1,458	650	-55%
Off-Road Mobile	3,175	1,731	1,885	1,162	-38%
Area Oil and Gas	-	-	438	249	-43%
Fugitive+Road Dust	53	28	52	52	-
Subtotal	**7,190**	**8,232**	**5,407**	**3,791**	**-30%**
Natural Sources					
Biogenic	-	-	-	-	-
Wind Blown Dust	-	-	-	-	-
Subtotal	**-**	**-**	**-**	**-**	**-**
Fire					
Anthropogenic Fire	92	83	366	366	-
Natural Fire	6,337	329	761	761	-
Subtotal	**6,429**	**412**	**1,127**	**1,127**	**-**
Total Emissions	**13,619**	**8,644**	**6,534**	**4,917**	**-25%**

Table 4h.

Source Category	Primary Organic Aerosol (tons/year)				
	2002 (Plan02d)	2008 (WestJump 2008c)	2011 (WAQDW 2011v1)	2020 Projection (WRAP 2011 Base20a)	Trend 2011-2020
Anthropogenic Sources					
Point (incl. Oil & Gas)	17	323	1,777	1,995	12%
Area	8,444	9,629	12,716	12,797	1%
On-Road Mobile	2,189	3,279	1,679	1,183	-30%
Off-Road Mobile	1,286	1,236	2,317	2,045	-12%
Area Oil and Gas	0	88	609	346	-43%
Fugitive+Road Dust	761	1,248	3,935	3,946	-
Subtotal	**12,698**	**15,804**	**23,033**	**22,312**	**-3%**
Natural Sources					
Biogenic	-	-	-	-	-
Wind Blown Dust	-	-	-	-	-
Subtotal	**-**	**-**	**-**	**-**	**-**
Fire					
Anthropogenic Fire	850	458	1,064	1,064	-
Natural Fire	30,581	1,758	2,457	2,457	-
Subtotal	**31,431**	**2,217**	**3,521**	**3,521**	**-**
Total Emissions	**44,129**	**18,021**	**26,555**	**25,833**	**-3%**

Figure 5a. Inventory trends for nitrogen and sulfur oxides, VOC, and ammonia.

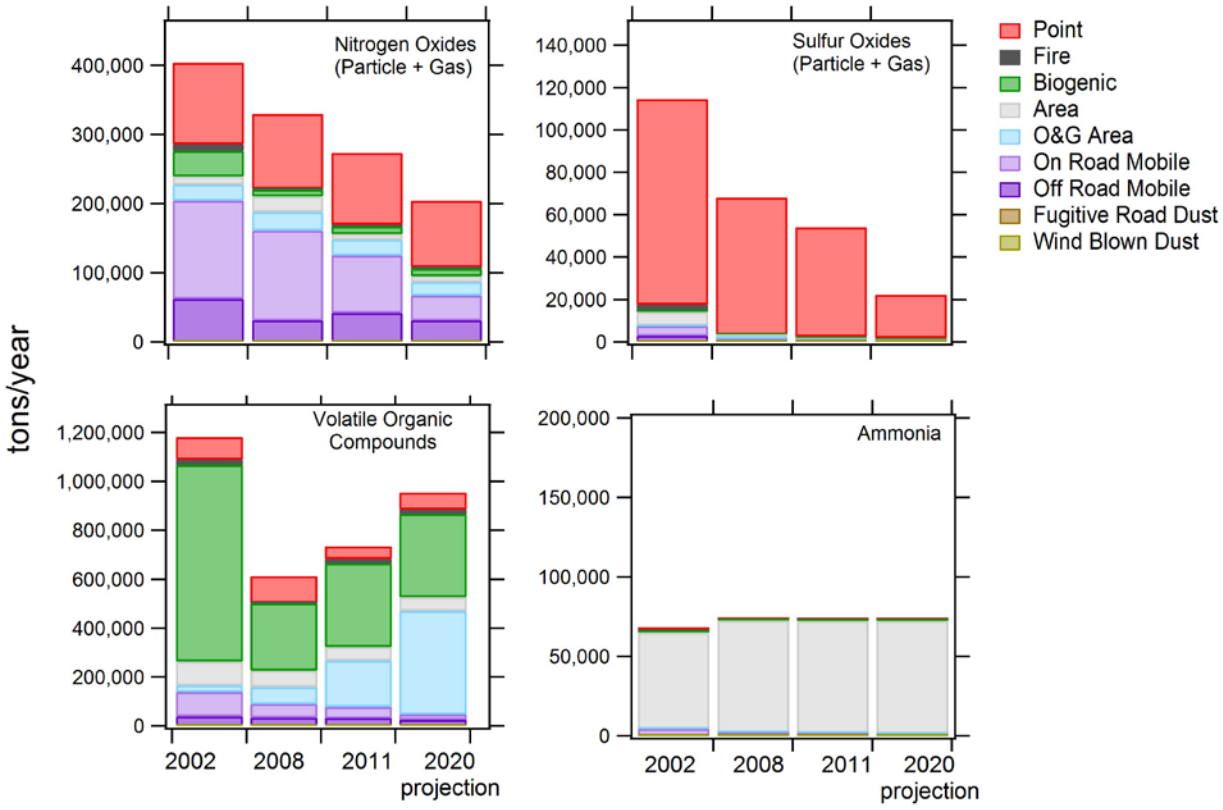


Figure 5b. Inventory trends for coarse and fine particulate matter. Lower panel shows detail the same plot with dust removed for clarity.

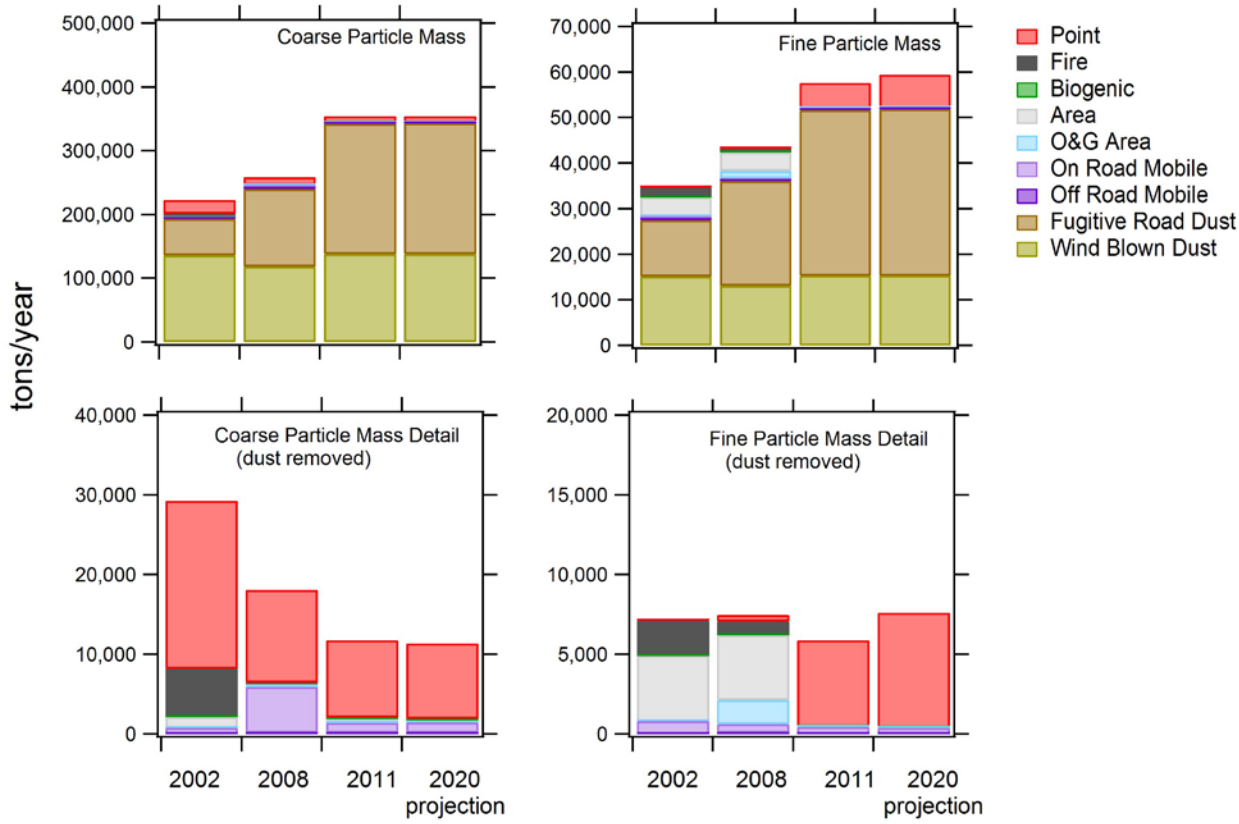
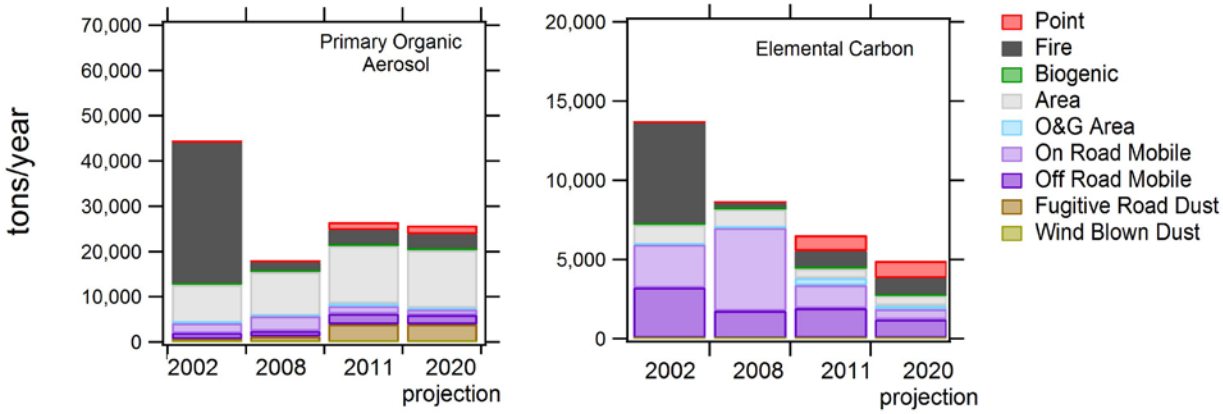


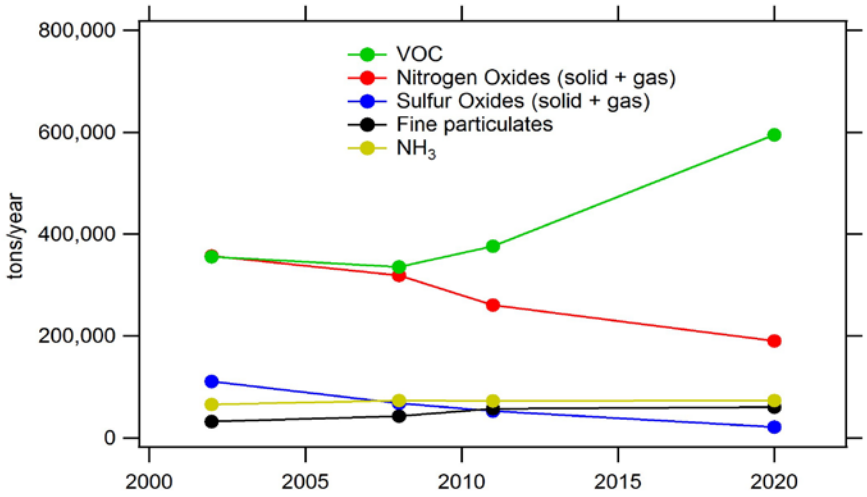
Figure 5c. Inventory trends for primary organic aerosol and elemental carbon.



2.5. Control Measure Emission Reductions

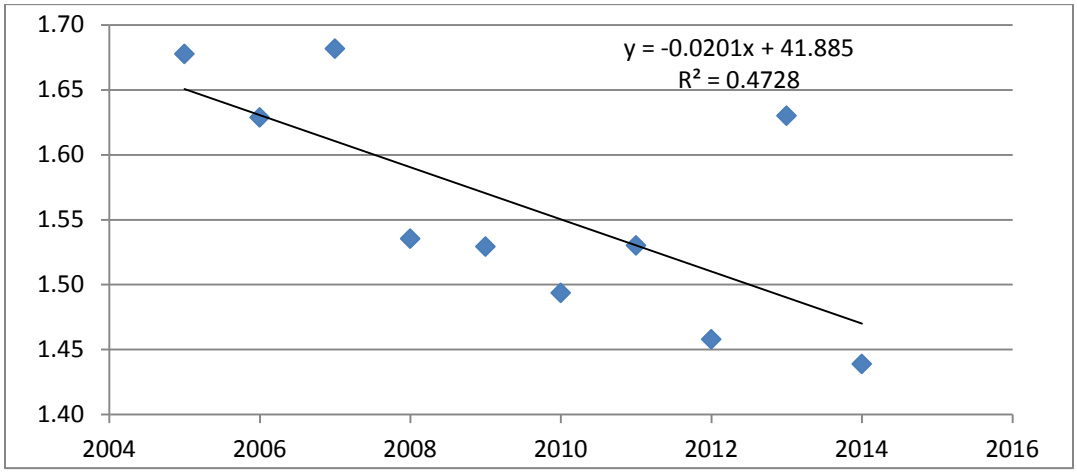
Figure 6 shows statewide inventory trends for air pollutants from anthropogenic sources (fire and biogenic sources removed). Figure 6 shows that, with the exception of VOCs, anthropogenic haze precursors are either stable or declining, especially for the most important haze precursors, nitrogen and sulfur oxides.

Figure 6. Colorado Trends in Anthropogenic Emissions (Fire and Biogenic Emissions excluded)



As further evidence of declining emissions, the NO_2 data collected by the NASA OMI satellite (Figure 7), shows a downward trend in statewide NO_2 columns for Colorado. Figure 7 shows Colorado level 3 annual mean 30% cloud screened tropospheric OMI NO_2 in units of 10^{15} molecules/cm^2. OMI data are publically available online: http://disc.sci.gsfc.nasa.gov/Aura

Figure 7. OMI NO_2 Satellite trends for Colorado



3. Visibility Progress

Regional Haze Reasonable Progress Goals (RPGs) are set forth in Colorado's Regional Haze SIP. Colorado participates in the Western Regional Air Partnership (WRAP). WRAP provides a variety of useful services for member states including fire tracking tools, visibility monitoring (IMPROVE) and modeling and Reasonable Progress Reports. Regional Haze Reasonable Progress Reports (2013) for WRAP member states including Colorado are available online at: http://www.wrapair2.org/RHRPR.aspx. Colorado also uses the WRAP Technical Support System (TSS) as a data source for extracting and plotting IMPROVE monitor data:

http://vista.cira.colostate.edu/tss/Results/HazePlanning.aspx. Data are presented earlier in this Progress report in Table 2 and Figure 3. TSS data for individual IMPROVE sites for both Best 20% and Worst 20% days are present in the Appendix to this Progress Report.

Table 2 shows that for the Best 20% days, all six Colorado IMPROVE sites show visibility improvements over the 2000-2004 baseline when averaged for the 2009-2013 period. This demonstrates that visibility conditions are maintained on the best days at all 12 Colorado Class I areas.

For the 20% Worst Days, there is a similar visibility improvement trend at all 6 IMPROVE sites. At 5 of the 6 IMPROVE sites (9 of 12 Class I areas) visibility is better than the RPG guide slope value for 2009-2013. At the 6th site (WEMI1), the 2009-2013 average visibility is much improved compared to the baseline period, but the visibility is slightly (0.05 dv) worse than RPG glide slope value for the same period.

Four IMPROVE sites (WEMI1, WHRI1, ROMO1, MOZI1) that show very high 20% Worst Day deciview values in 2012 for particulate organic mass while other values remained relatively constant (nitrate, sulfate, EC, Soil and Coarse Mass). This trend is most likely due to heavy wildfire activity in the area during the 2012 year. Colorado experienced two devastating wildfire seasons from 2012 and 2013. 2011 had very large wildfires in Arizona. This explanation is consistent with wildfire acres burned shown below in Section 4.

The three IMPROVE sites in the south west portion of Colorado (WEMI1, MEVE1 and GRSA1) are not close to major Colorado population centers or significant in-state industrial sources. However, these sites are impacted by interstate transport from both point and stationary sources. The Technical Support Documents for each of these sites demonstrate significant impact for these sites from out of state sources.

Despite these conditions, Colorado fell only slightly short of Reasonable Progress Goals on the 20% Worst Days at one site and achieved RPGs at all 5 other sites.

Inventory trends and the 2020 inventory projection presented here show declining statewide emissions of both nitrogen oxides and sulfur oxides, the primary precursor emissions for visibility reducing haze. Anthropogenic emissions of most other precursors, with the exception of VOCs, are generally stable. VOC emissions from Oil and Gas continue to increase in the Colorado. However, other efforts to reduce these emissions are already underway by means of statewide rules aimed at reducing ozone precursors. Ozone precursor reduction efforts to reduce NOx and VOC have likely Regional Haze co-benefits.

4. Assessment of Changes Impeding Visibility Progress/Inventories

The State control measures detailed in Section 2.3 continue to result in emissions reduction. Power plant/EGU emissions are continuing to decline in Colorado. Colorado has implemented numerous local measures with Regional Haze co-benefits to address ozone and SO_2 non-attainment (efforts in progress simultaneously with this progress report). Considerable future efforts to address the Clean Power Plan currently being promulgated by the EPA are also expected to further reduce haze precursor emissions such as SO_2 and NOx. Emissions reductions for mobile sources, aggressive controls on oil and gas aimed at reduction of ozone precursors will also likely benefit regional haze.

Wildfires are a major factor in the Western United States and Colorado is no exception. Colorado is downwind from many wildfire prone areas and can be impacted by fires in adjacent states but also from as far away as California, the Pacific Northwest and Canada. The State of Colorado maintains an EPA-approved prescribed burn program (Regulation 9) and tracks emissions statewide of both PM 10 and PM 2.5 resulting from these burns. Recent trends in PM emissions from prescribed burns are shown in Figure 8. These figures account for PM generated from acres burned and also account for the PM emitted from burning woodpiles.

Data from the National Interagency Fire Center, https://www.nifc.gov/, track both wild land fires and prescribed burns by acre burned. Here, we present trends in acres burned in Colorado in Figure 9. Figure 9 shows that while the acres burned for prescribed fires remains relatively constant, there is significant variability in wild land fire acres burned from year to year. In most years, PM emissions from wildfires inside Colorado significantly exceed those from prescribed burning. The variability in natural fire acreage shown in Figure 9 helps explain inventory trends observed for emissions from natural fires (Tables 4a-4h). Large fires inside Colorado in 2002 were included in the baseline inventory, driving the baseline average up. Natural variability in fires continues to pose a significant challenge to evaluating the impacts of anthropogenic emissions on Regional Haze.

Factors beyond the control of state control measures such as wildfires (both inside and outside of Colorado) and regional dust storms will likely impede future progress to Regional Progress Goals. Colorado does flag exceptional event and submit relevant reports to EPA when appropriate. Colorado can also not control emissions from upwind western states. Regional transport of pollution from densely populated urban centers such as California and intercontinental transport of dust and pollution from Asia are potential progress impediments. The effects of these regional and international transport are difficult to quantify, but can affect visibility measured at IMPROVE sites.

Figure 8. CDPHE data for Emissions from prescribed fires.

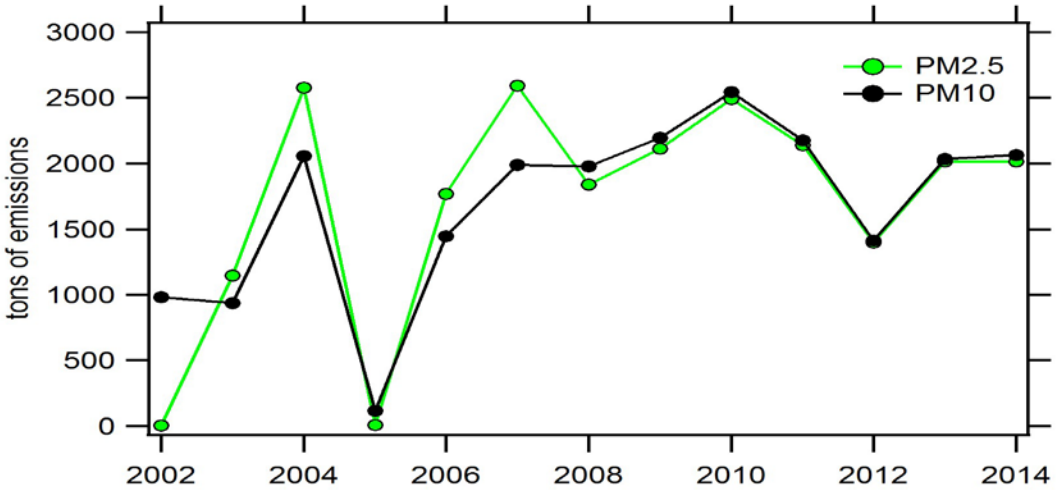
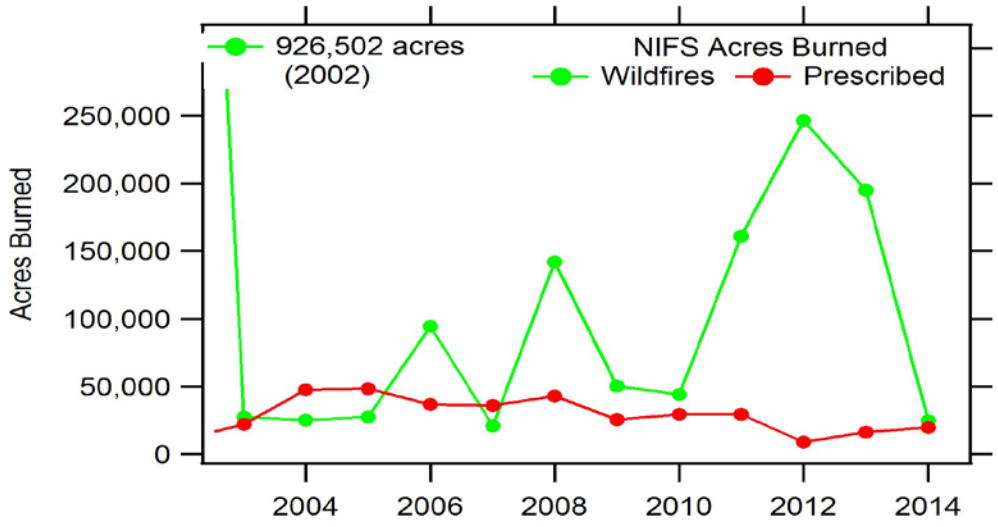


Figure 9. NICFs fire data for Colorado



5. Assessment of Current Control Strategy, RPGs

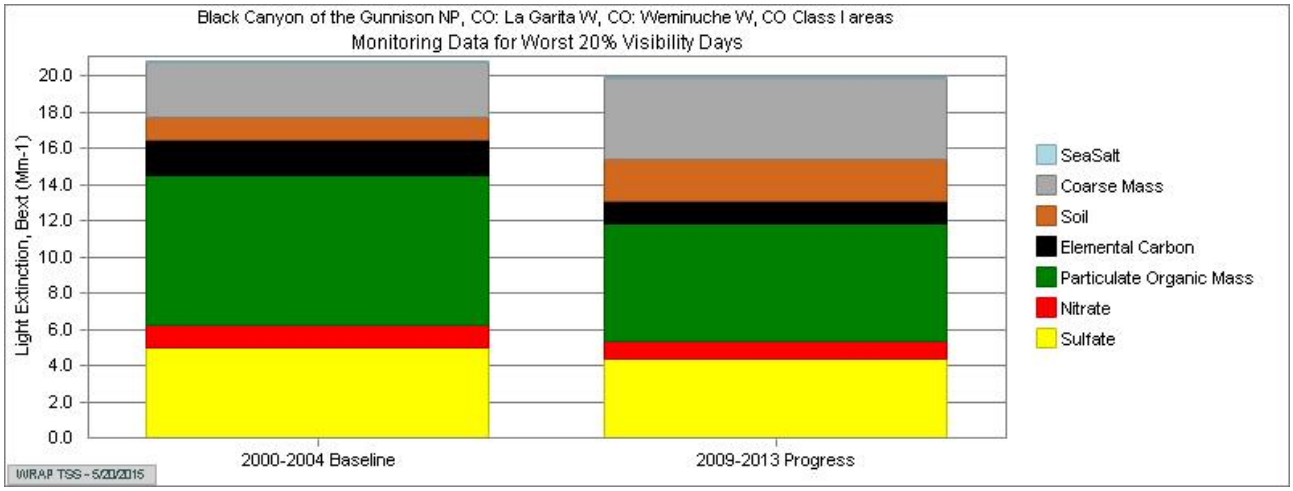
Both Colorado and neighboring states set Regional Haze Reasonable Progress Goals based on controls modeled by the Western Regional Air Partnership (WRAP). For the 20% best days, 5-year rolling average visibilities are below the 2000-2004 Baseline for all 6 IMPROVE monitors in Colorado. In addition, for the 20% worst days, all 6 monitors show improving visibility conditions relative to the Baseline period. Five of the 6 monitors in Colorado meet the 2018 Reasonable Progress Glide Slope Goals set forth in Colorado's State Implementation Plan. One IMPROVE monitoring site, Weminuche (WEMI1) shows improvement, but has visibility that is does not quite meet the Reasonable Progress Glide Slope Goal by a small margin (0.05 dv). We observe these improvements despite several significant wildfire events inside the state during this period.

Figure 10 compares current period speciated data from the WEMI1 monitor with baseline data. Clear reductions in organic, sulfate and nitrate fractions are observed, which are the main air pollutant species evaluated in this 5 year progress report. Speciated plots for 20% Best and Worst Days at all 6 IMPROVE sites in Colorado are available in the data appendix to this Progress Report.

Figure 3 shows the Weminuche IMPROVE monitoring site, which represents three Class I areas (Weminuche, Black Canyon of the Gunnison, and La Garita) in context with other IMPROVE sites in Colorado. The WEMI1 site shows least variability and has the most modest deciview 2018 RPG (0.47 dv improvement) in the State. Trends in Coarse Mass and Soil fractions at WEMI1 do show slight increases in emission inventories.

However, this site is impacted not only by regional dust events, but also by wildfire activity and inter-state pollution, all of which are not reasonably controllable by statewide emission control measures. Colorado will continue to monitor these concerns and evaluate possible additional controls on anthropogenic emissions impacting this site. However, Colorado believes that at this time, the WEMI1 site is mostly impacted by natural variability in regional wind-blown dust and does not specifically recommend further analysis at this time.

Figure 10. Speciated IMPROVE data for the Weminuche Wilderness WEMI1 monitor.



In 2010, Colorado submitted to EPA, and EPA approved (2011) a SIP addressing Interstate Transport of air pollution from Colorado to neighboring States. The analysis submitted with this SIP showed marginal impacts from Colorado emissions on Class I areas in other states, with a 2018 projected impact to exceed a 10% contribution at only Wheeler Peak& Pecos Wilderness (WHPE1) IMPROVE monitor in New Mexico. Further information, including the approved analysis can be found in the Federal Register: http://www.regulations.gov/#!docketDetail;D=EPA-R08-OAR-2007-1036.

Colorado continues to monitor the Regional Haze progress of other western upwind states. Several upwind states including California and New Mexico have had their RH progress reports approved and several others have plans in process (UT, AZ, NV).

In conclusion, Colorado believes that state efforts are sufficient in demonstrating progress in meeting the 2018 RPGs for the 12 mandatory Class I Areas in Colorado.

6. Visibility Monitoring Strategy

All 6 IMPROVE sites in Colorado continue to provide adequate and complete data records. Measurements at all 6 IMPROVE sites in Colorado meet 2018 Reasonable Progress Goals for the 20% Best Days. For 20% Worst days, only one IMPROVE site (WEMI1) does not meet 2018 RPGs, and this site shows significant progress, only missing the RPG goal by a small margin (0.05 dv). Colorado finds that the current monitoring network is sufficient at this time to monitor progress towards Reasonable Progress Goals.

7. Regional Haze Plan Commitments and Continued Consultation

Colorado actively participates in maintenance of commitments associated with RH plan requirements. In addition, Colorado continues active participation in regional planning efforts through WESTAR and WRAP. CDPHE shows leadership in participation of voluntary programs involving our Federal Land Manager (FLM) partners such as the 3 State Air Quality Study, and the Rocky Mountain National Park Initiative. Colorado also provided significant funding of two major air quality field campaigns (FRAPPE and Discover-AQ) in 2014 that further our understanding of statewide emissions trends, assist in evaluating bottom-up inventories and plan for future air quality improvements within the state. We continue to work collaboratively with the scientific research community to refine our understanding of air quality issues in Colorado.

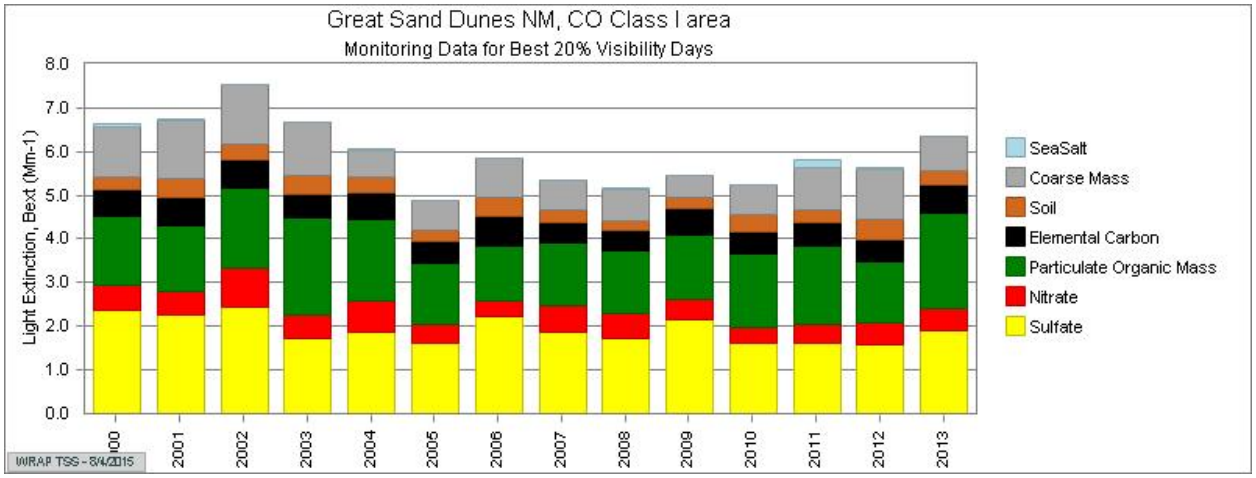
As required by the Regional Haze Rule, the state will provide, at a minimum, the opportunity for consultation with the FLMs at least 60 days prior to any public hearing on any element of the Class I Visibility SIP including Long Term Strategy (LTS) revisions and review. In addition the state will publish as part of the SIP process any formal comments received by the FLMs as a result of their review along with a listing of responses the state made in regard to such comments. As part of the development of this progress update, FLM comments are solicited and considered in the development of this progress update.

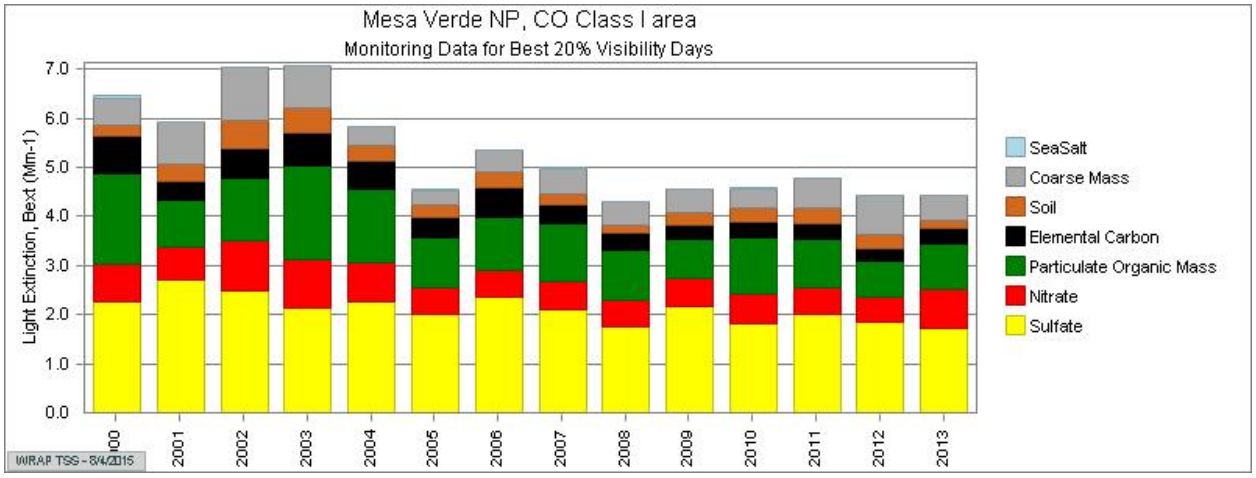
8. Conclusion: Statement of Adequacy of Regional Haze Plan

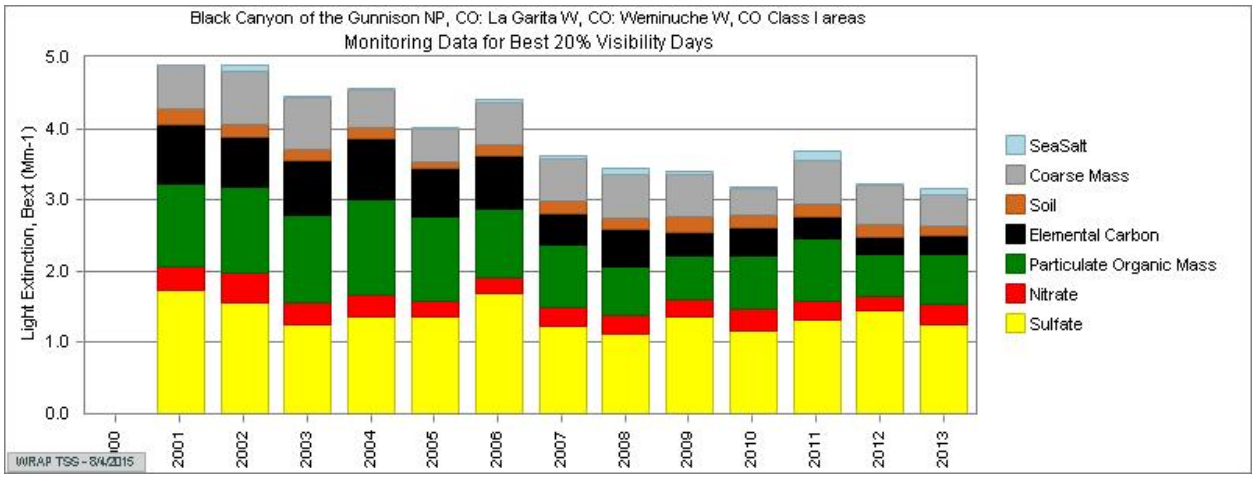
Colorado is making adequate progress toward Regional Haze Rule goals as set forth in the State Implementation Plan. Additional reductions associated with power plants, ozone precursors and other programs supplement these efforts. Considerable efforts with new rules such as the Clean Power Plan, SO_2 court settlements, and tightened ozone standards will undoubtedly have Regional Haze co-benefits in the near future. Colorado concludes that the current visibility improvements measured at the 12 Colorado Class I areas are sufficient and aside from this 5-year Progress Report, no revision of the Regional Haze Plan is necessary at this time.

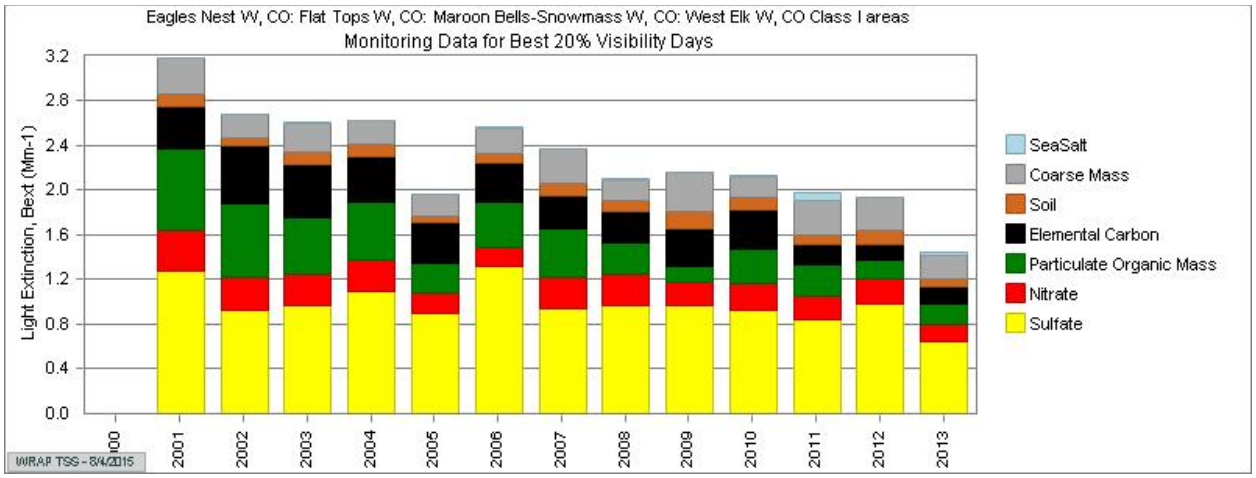
Data Appendix E.1

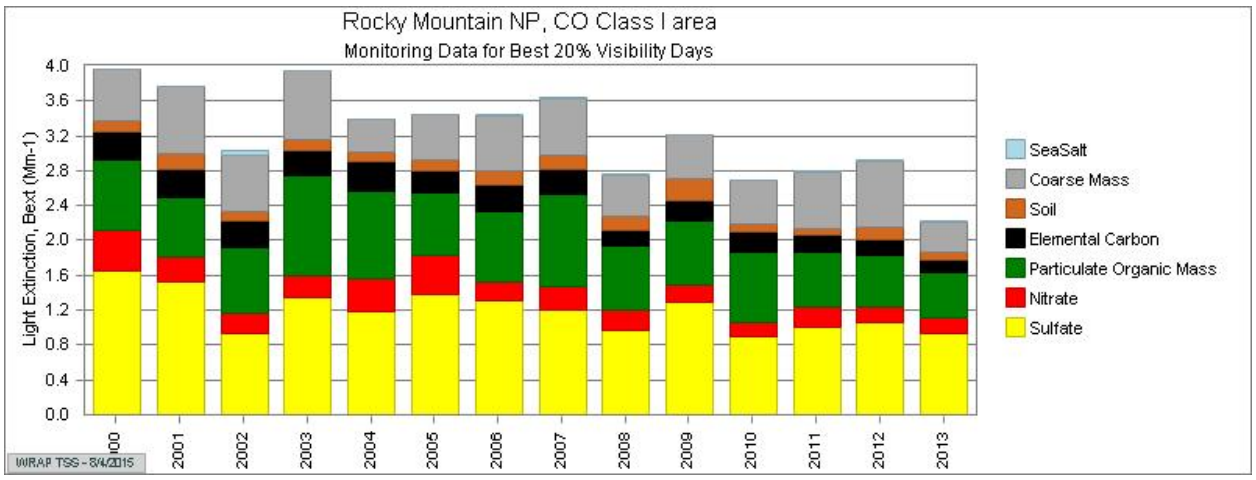
E.1.A Speciated Data Plots for 6 Colorado IMPROVE Sites 20% Best Days

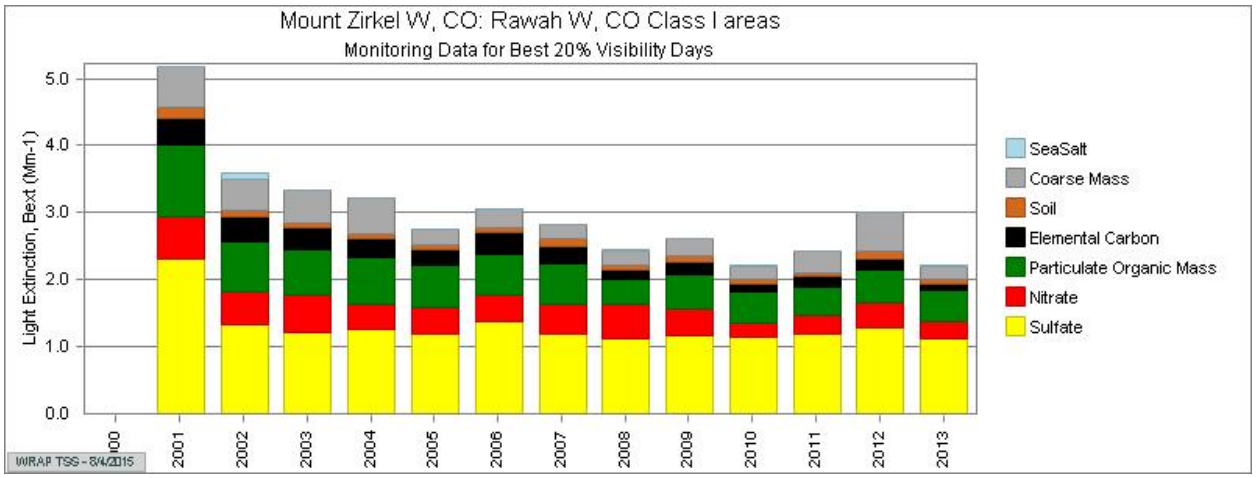




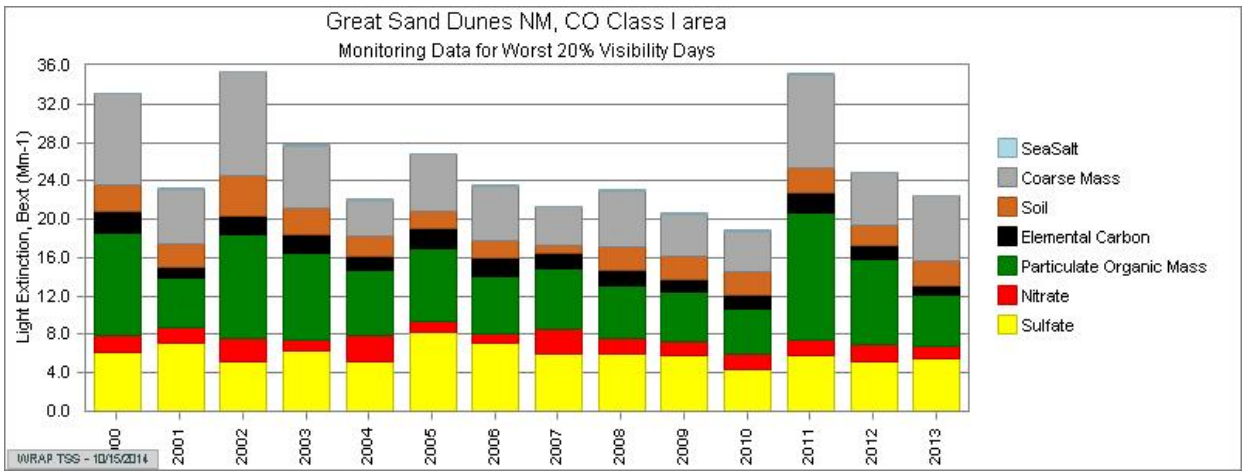


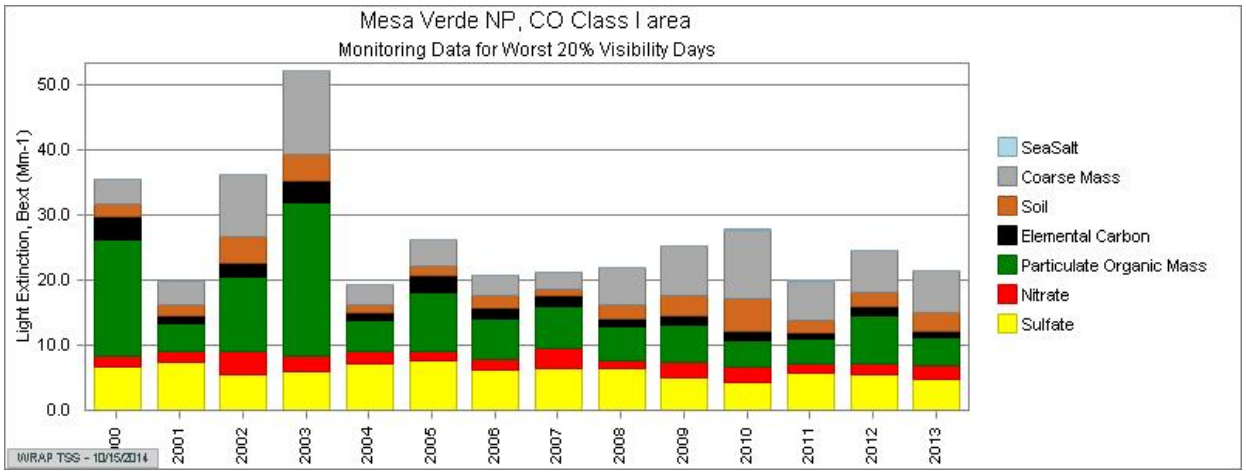

Eagles Nest W, CO: Flat Tops W, CO: Maroon Bells-Snowmass W, CO: West Elk W, CO Class I areas
Monitoring Data for Best 20% Visibility Days
Light Extinction, Bext (Mm-1)
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
WRAP TSS - 8/4/2015
SeaSalt
Coarse Mass
Soil
Elemental Carbon
Particulate Organic Mass
Nitrate
Sulfate

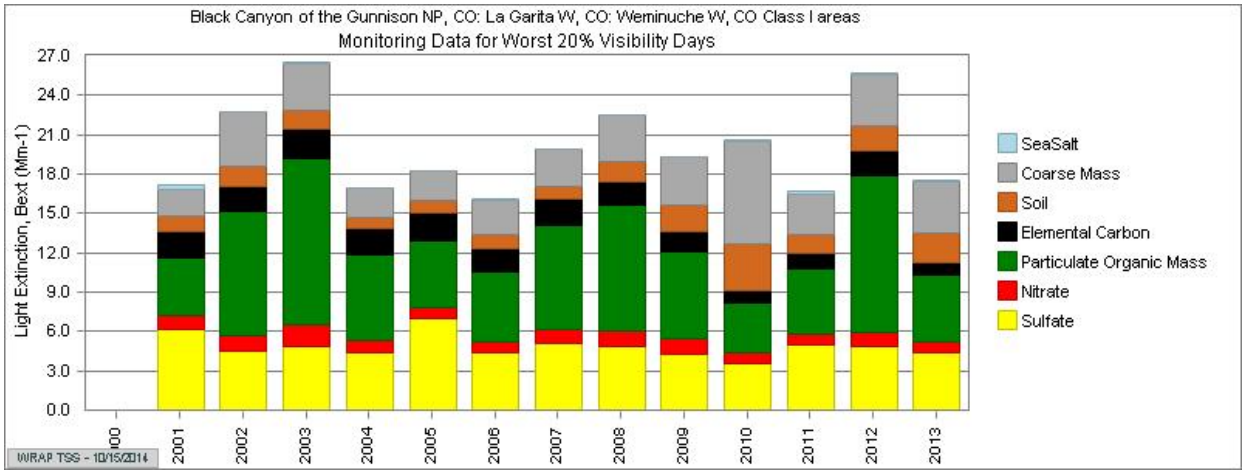

Rocky Mountain NP, CO Class I area
Monitoring Data for Best 20% Visibility Days
Light Extinction, Bext (Mm-1)
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
WRAP TSS - 8/4/2015
SeaSalt
Coarse Mass
Soil
Elemental Carbon
Particulate Organic Mass
Nitrate
Sulfate

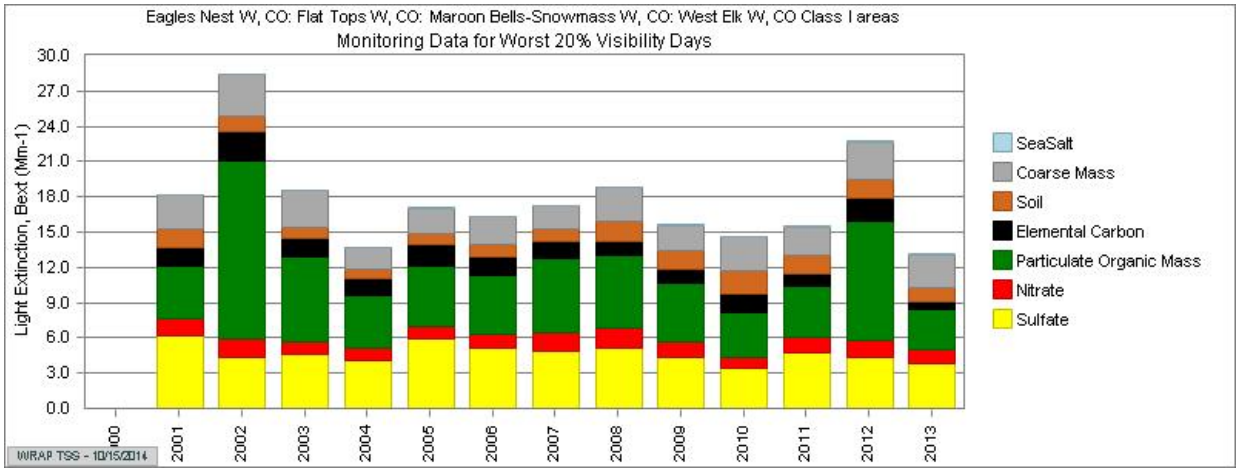

Mount Zirkel W, CO: Rawah W, CO Class I areas
Monitoring Data for Best 20% Visibility Days
Light Extinction, Bext (Mm-1)
5.0
4.0
3.0
2.0
1.0
0.0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
WRAP TSS - 8/4/2015
SeaSalt
Coarse Mass
Soil
Elemental Carbon
Particulate Organic Mass
Nitrate
Sulfate

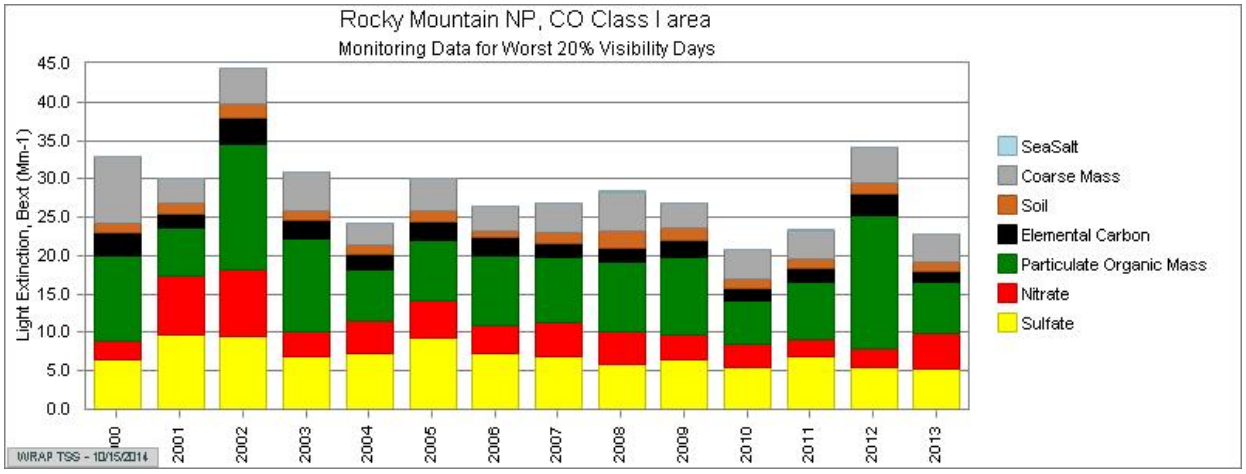
E.1.B Speciated Data Plots for 6 Colorado IMPROVE Sites 20% Worst Days

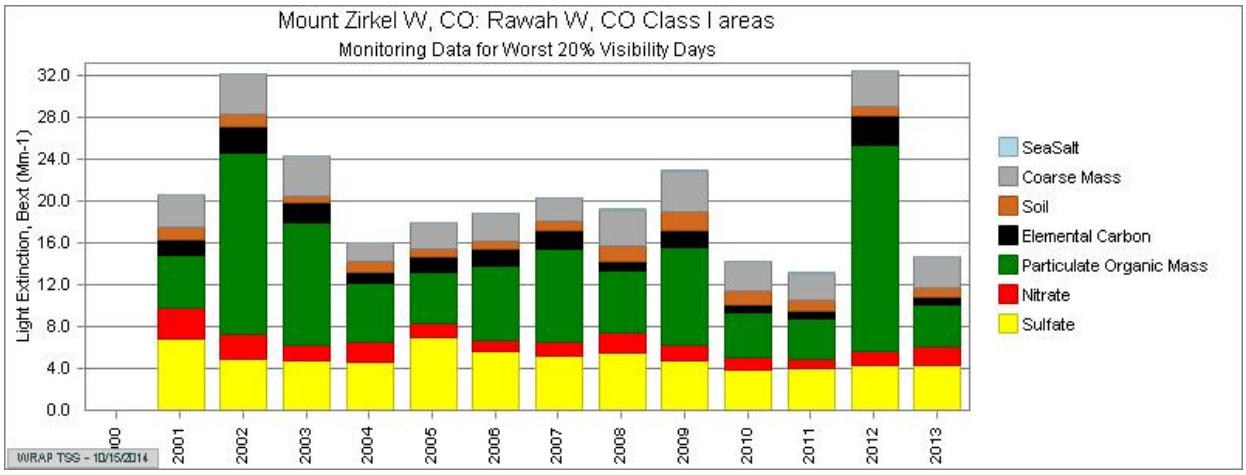




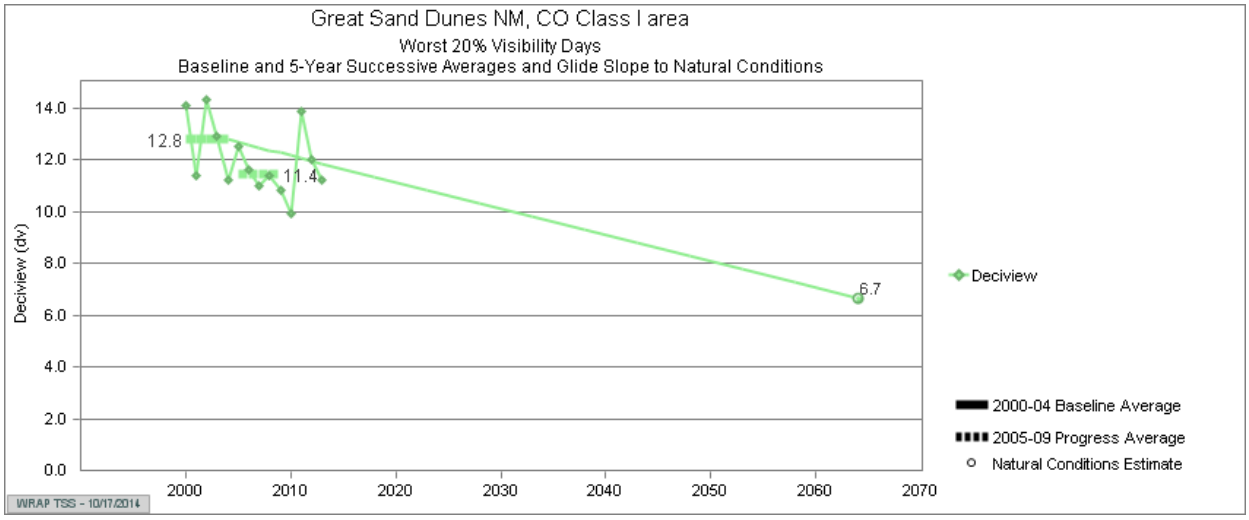


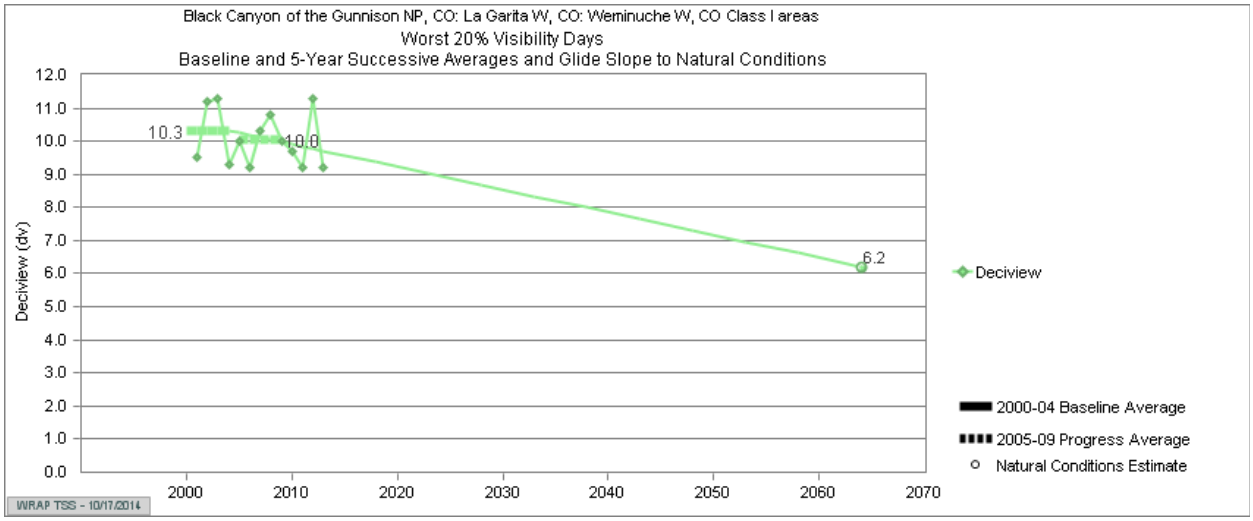

Eagles Nest W, CO: Flat Tops W, CO: Maroon Bells-Snowmass W, CO: West Elk W, CO Class I areas
Monitoring Data for Worst 20% Visibility Days
Light Extinction, Bext (Mm-1)
30.0
27.0
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
WRAP TSS - 10/15/2014
SeaSalt
Coarse Mass
Soil
Elemental Carbon
Particulate Organic Mass
Nitrate
Sulfate

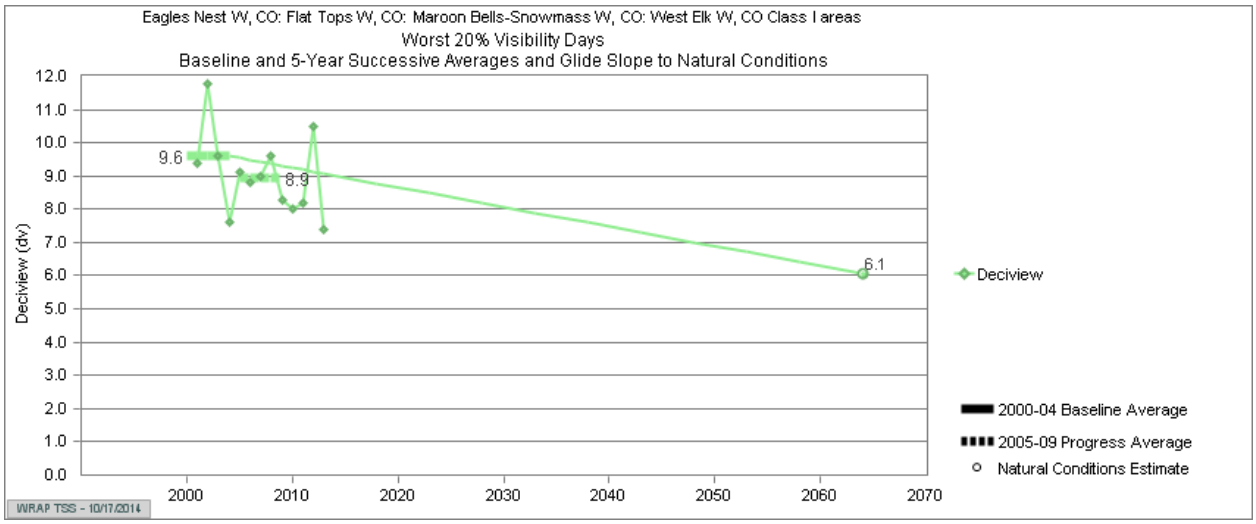

Rocky Mountain NP, CO Class I area
Monitoring Data for Worst 20% Visibility Days
Light Extinction, Bext (Mm-1)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
WRAP TSS - 10/15/2014
SeaSalt
Coarse Mass
Soil
Elemental Carbon
Particulate Organic Mass
Nitrate
Sulfate

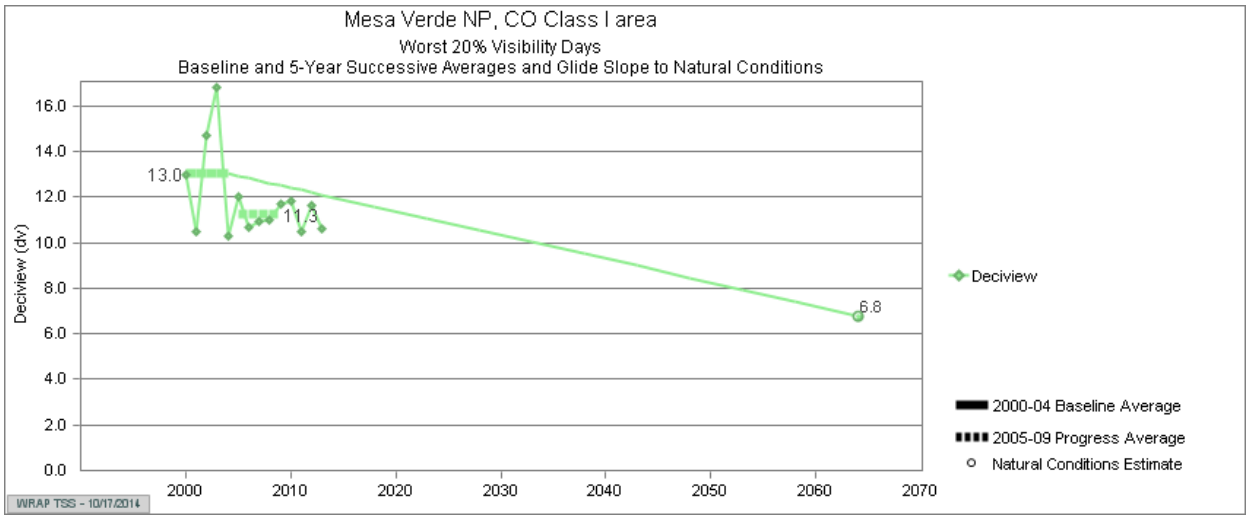

Mount Zirkel W, CO: Rawah W, CO Class I areas
Monitoring Data for Worst 20% Visibility Days
Light Extinction, Bext (Mm-1)
32.0
28.0
24.0
20.0
16.0
12.0
8.0
4.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
WRAP TSS - 10/15/2014
SeaSalt
Coarse Mass
Soil
Elemental Carbon
Particulate Organic Mass
Nitrate
Sulfate

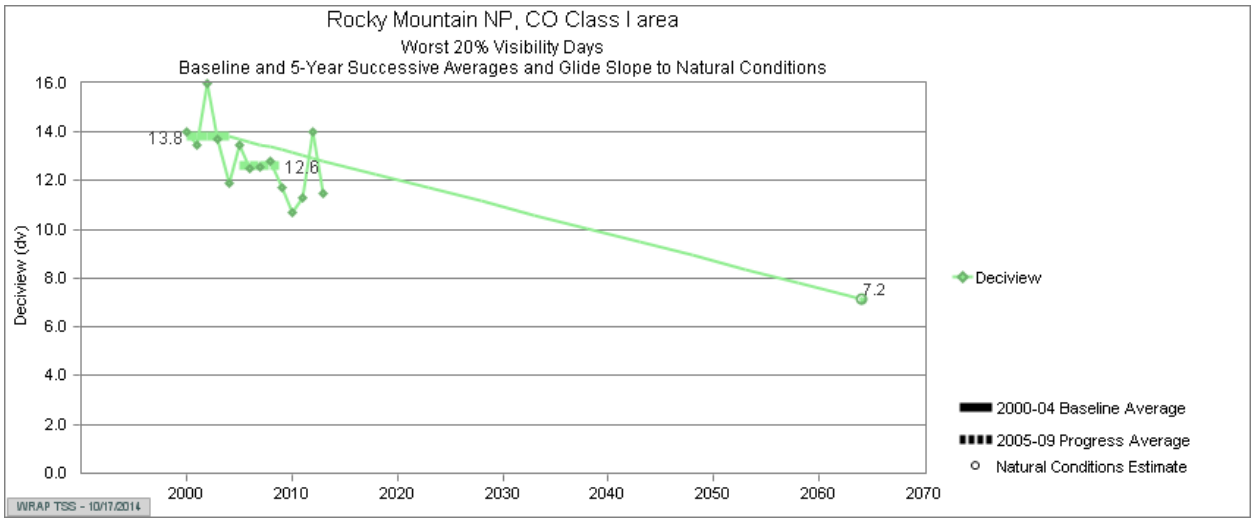
E.1.C Baseline and Natural Conditions Glide Slope for the 6 Colorado IMPROVE Monitoring Sites

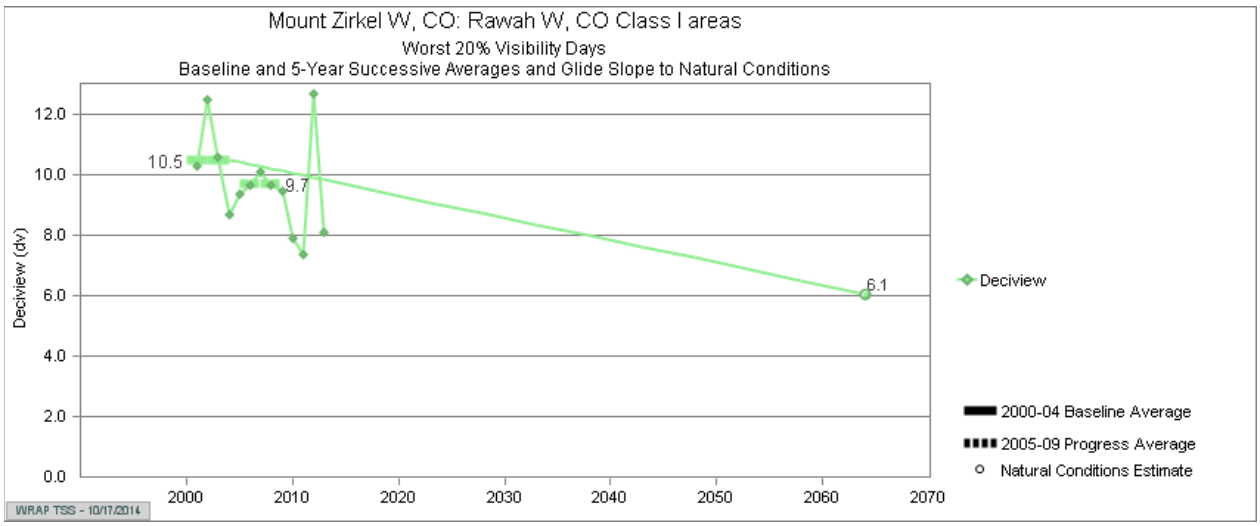







Mesa Verde NP, CO Class I area
Worst 20% Visibility Days
Baseline and 5-Year Successive Averages and Glide Slope to Natural Conditions
Deciview (dv)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2000
2010
2020
2030
2040
2050
2060
2070
13.0
11.3
6.8
Deciview
2000-04 Baseline Average
2005-09 Progress Average
Natural Conditions Estimate
WRAP TSS - 10/17/2014


Rocky Mountain NP, CO Class I area
Worst 20% Visibility Days
Baseline and 5-Year Successive Averages and Glide Slope to Natural Conditions
Deciview (dv)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2000
2010
2020
2030
2040
2050
2060
2070
13.8
12.6
7.2
Deciview
2000-04 Baseline Average
2005-09 Progress Average
Natural Conditions Estimate
WRAP TSS - 10/17/2014


Mount Zirkel W, CO: Rawah W, CO Class I areas
Worst 20% Visibility Days
Baseline and 5-Year Successive Averages and Glide Slope to Natural Conditions
Deciview (dv)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2000
2010
2020
2030
2040
2050
2060
2070
10.5
9.7
6.1
Deciview
2000-04 Baseline Average
2005-09 Progress Average
Natural Conditions Estimate
WRAP TSS - 10/17/2014