South Dakota's Regional Haze State Implementation Plan

5-Year Progress Report

South Dakota Department of Environment and Natural Resources

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Executive Summary

The 5-year progress report consists of eight elements states are required to look at to determine if its Regional Haze State Implementation Plan is achieving reasonable progress towards meeting the national visibility goal and if not, what changes are needed to meet the national visibility goal. After reviewing the eight elements, the Department of Environment and Natural Resources (DENR) believes South Dakota's Regional Haze State Implementation Plan is adequate and achieving reasonable progress toward the national visibility goal. Therefore, no revisions are being recommended.

South Dakota's only BART source, Big Stone I, is in the process of installing the air pollution controls required by South Dakota's Regional Haze State Implementation Plan and will begin operating the air pollution controls in the fall of 2015. Once the air pollution controls are operational, the sulfur dioxide and nitrogen oxide emissions will be reduced by approximately 89% and 86%, respectively. In addition, many of the BART sources in states such as North Dakota and Wyoming are also in the process of installing their BART air pollution controls, which will decrease emissions even further.

As discussed throughout this report, South Dakota's impact on the visibility at our Class I areas is quite small. Based on Western Regional Air Partnership's (WRAP's) modeling, the main contributors are from point sources outside of South Dakota and smoke from wildfires that occur throughout the western United States and Canada. The 5-year progress report has identified prescribed fires within South Dakota's two Class I areas conducted by the Federal Land Managers do have an impact on South Dakota's ability to meet its Uniform Glide Path for particulate organic mass. Despite those impacts, the deciview levels at both Class I areas are on or very near the Uniform Glide Slope. The DENR believes the current Regional Haze State Implementation Plan is still capable of meeting the 2018 Uniform Rate of Progress targets. The DENR will continue to work with the Federal Land Managers in minimizing the impacts on visibility from prescribed fires within the two Class I areas.

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1.0 Introduction

Section 169A of the Clean Air Act (CAA) established visibility protection for 156 national parks and wilderness areas across the country. The Environmental Protection Agency (EPA) finalized the Regional Haze Rule under 40 CFR § 51.308 which required states to develop long-term plans to reduce pollution that contributes to visibility degradation and sets goals to improve visibility within the Class I areas. South Dakota is home to two of the national parks and wilderness areas – Badlands National Park and Wind Cave National Park. South Dakota's Regional Haze State Implementation Plan was originally submitted to the EPA on January 21, 2011 with amendments submitted on September 19, 2011. The plan received final approval from EPA on April 26, 2012.

The Regional Haze Rule requires states to regularly report on the progress the state's Regional Haze State Implementation Plan is accomplishing towards improving visibility in the Class I areas and update the State Implementation Plan, if necessary. South Dakota's first progress report is due to EPA by February 4, 2016, 5 years after EPA received the state's submittal of its initial Regional Haze State Implementation Plan. In addition, the Regional Haze Rule requires a full update of the State Implementation Plan every ten years; the first one due in 2018.

The 5-year progress report is intended to provide a progress report on, and if necessary, a mid-course correction to the state's Regional Haze State Implementation Plan. The required elements that must be addressed in the 5-year progress report include:

1. Status of control strategies in the state's Regional Haze State Implementation Plan (40 CFR § 51.308(g)(1));
2. Emissions reductions from the state's Regional Haze State Implementation Plan Strategies (40 CFR § 51.308(g)(2));
3. Visibility progress (40 § CFR 51.308(g)(3));
4. Emissions progress (40 § CFR 51.308(g)(4));
5. Assessment of changes impeding visibility progress (40 CFR § 51.308(g)(5));
6. Assessment of current strategy (40 § CFR 51.308(g)(6));
7. Review of visibility monitoring strategy (40 §CFR 51.308(g)(7)); and
8. Determination of adequacy (40 CFR § 51.308(h)).

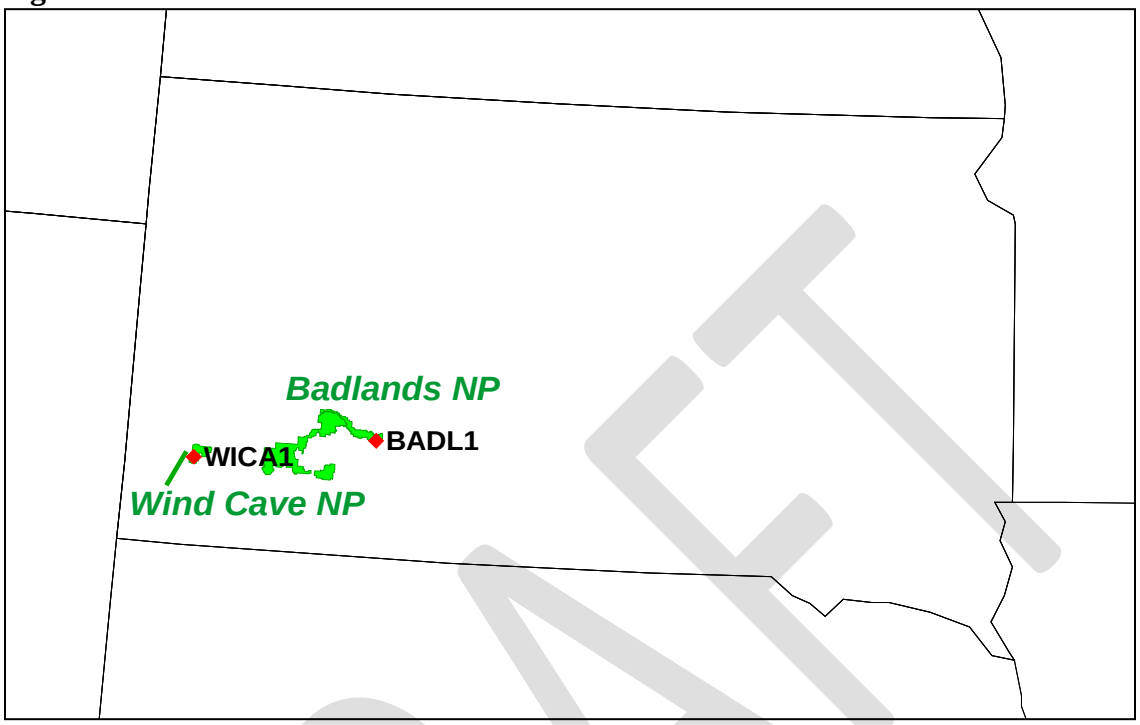
The 5-year progress report provides an opportunity for public input on the state's assessment of whether the approved Regional Haze State Implementation Plan is being implemented appropriately and whether reasonable visibility progress is being achieved consistent with the projected visibility in the Regional Haze State Implementation Plan.

2.0 South Dakota's Class I Areas

There are 156 national parks and wilderness areas in the nation that are considered Class I areas. South Dakota is home to two of the Class I areas. They are Badlands National Park and Wind

Cave National Park and both parks are located in the southwestern corner of South Dakota (see Figure 2-1).

Figure 2-1 – South Dakota's Class I Areas



The National Park Service operates the IMPROVE monitoring sites at both Badlands National Park and Wind Cave National Park. The Badlands IMPROVE site was one of the earliest sites to be established and began operating March 2, 1988. The Wind Cave site began operating January 12, 2000. Table 2-1 provides the name of each IMPROVE site for South Dakota and also gives the latitude, longitude and elevation of each of the IMPROVE monitoring sites.

Table 2-1 – South Dakota's Representative IMPROVE Monitors

Class I Area	Representative IMPROVE Site	Latitude	Longitude	Elevation (m)
Badlands National Park	BADL1	43.74	-101.94	736
Wind Cave National Park	WICA1	43.56	-103.48	1296

The Badlands National Park is located in southwestern South Dakota and consists of 244,000 acres of sharply eroded buttes, pinnacles, and spires blended with the largest protected mixed grass prairie in the United States (see Figure 2-2). The general topography is plains; therefore this site is well exposed to regional scale transport winds. The surrounding terrain is predominantly mixed grass prairie and bare rock and sand. It was established as the Badlands National Monument in 1939, and was re-designated as a national park in 1978. The area of the park that is actually considered a Class I area is the Badlands Wilderness Area, which consists of 64,000 acres in the north unit.

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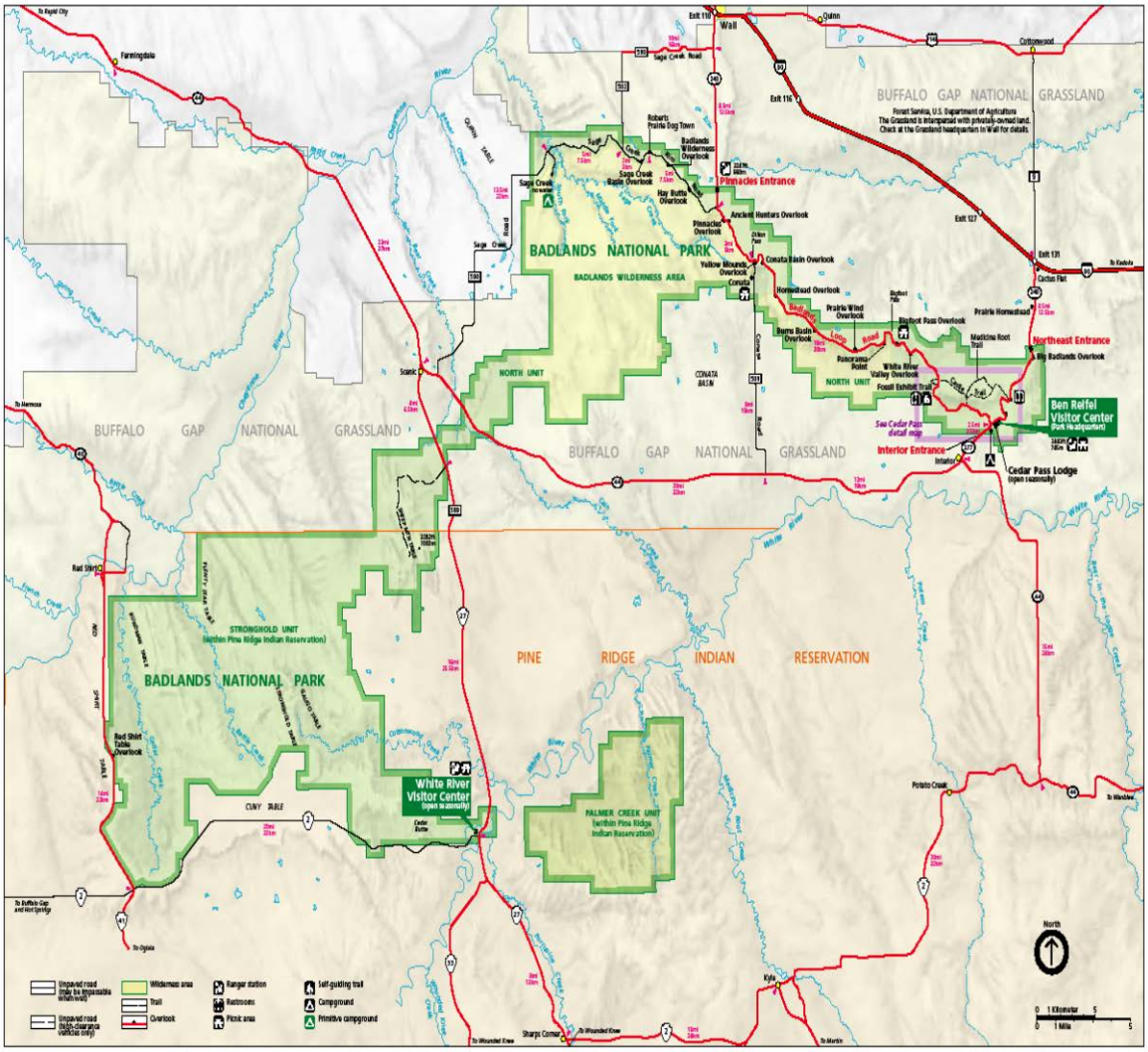
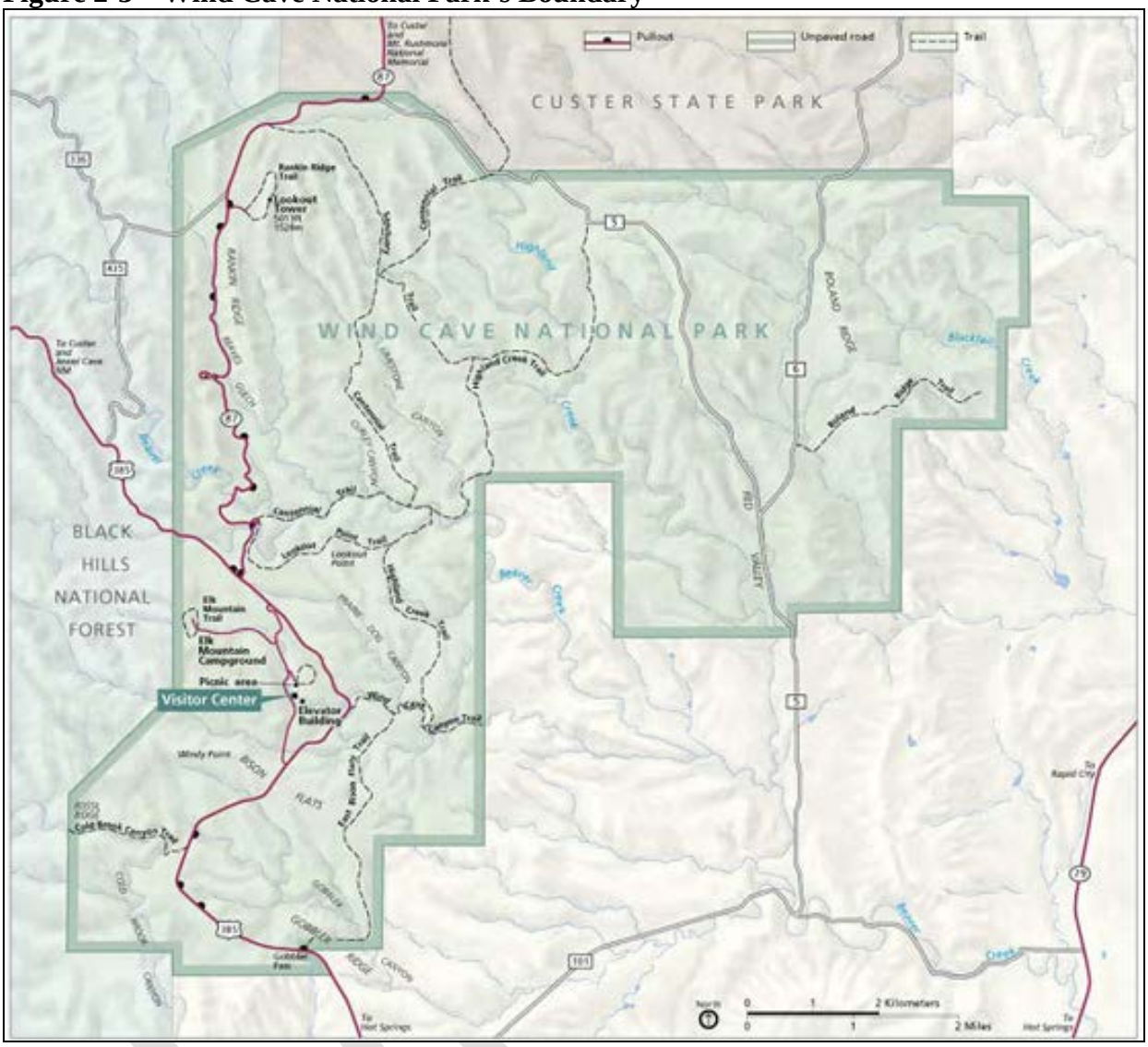
Figure 2-2 – Badlands National Park's Boundary



Wind Cave National Park lies approximately 10 miles north of Hot Springs in southwestern South Dakota (see Figure 2-3). It was the first cave to be designated a national park anywhere in the world and is currently the fourth longest cave in the world with 119.58 miles (192.45 kilometers) of explored cave passageways. Aboveground, the park includes 28,295 acres of mixed grass prairie, ponderosa pine forest, and associated wildlife. The park's mixed grass prairie is one of the largest remaining and home to bison, elk, pronghorn, mule deer, and prairie dogs.

Figure 2-3 – Wind Cave National Park's Boundary



Visibility impairment typically occurs when pollution in the form of small particles scatters or absorbs light. Air pollution is emitted from a variety of natural and anthropogenic (man-made) sources. Natural sources can include windblown dust and smoke from wildfires. Anthropogenic sources can include motor vehicles, electric utility and industrial fuel burning, prescribed burning, and manufacturing operations.

Particles that cause haze are sometimes directly emitted into the air while others are formed when gases emitted into the air form particles as they are carried from the source of the pollutants. These particles can travel great distances causing visibility impairment in Class I areas great distances from the actual sources.

South Dakota's visibility impairment is primarily due to sources outside of the state, including the Central Regional Air Planning Association (CENRAP) states, Eastern United States, Canada, some of our surrounding states and outside domain. There are very few sources of pollution in

South Dakota and the lone Best Available Retrofit Technology (BART) source, Big Stone I, is currently undergoing upgrades that will lower emissions for sulfur dioxide and nitrogen oxides and improve the visibility, not only at the Badlands National Park and the Wind Cave National Park, but other Class I areas in North Dakota, Minnesota and Michigan.

3.0 Required Elements of the 5-Year Progress Report

3.1 Status of Control Strategies

In accordance with 40 CFR § 51.301(g)(1), the 5-year progress report shall include a description of the status of the measures approved in the state's Regional Haze State Implementation Plan. This section summarizes the measures identified in South Dakota's approved Regional Haze State Implementation Plan for achieving reasonable progress goals for the Badlands and Wind Cave National Parks and the status of those measures. This section also describes other state and federal regulations that are helping achieve South Dakota's reasonable progress goals.

3.1.1 Best Available Retrofit Technology (BART) Requirements

South Dakota has one Best Available Retrofit Technology (BART) eligible source. This BART eligible source is the Big Stone I coal-fired power plant owned by Montana-Dakota Utilities Company, NorthWestern Energy, and Otter Tail Power Company. The Big Stone I power plant is located near Milbank in the northeastern corner of South Dakota.

In December 2010, South Dakota finalized its BART determination for the Big Stone I power plant. South Dakota's BART determination required the Big Stone I power plant's main boiler (Unit #1) to install a selective catalytic reduction (SCR) system and separated over-fire-air (SOFA) for nitrogen oxide (NO_x) control, a dry flue gas desulfurization (FGD) system for sulfur dioxide (SO_2) control and a fabric filter system for particulate matter (PM) control.

The air pollution controls and limits established under the BART determination are required to be installed and implemented within five years of EPA's approval of South Dakota's Regional Haze State Implementation Plan. EPA approved South Dakota's Regional Haze State Implementation Plan on April 26, 2012. Therefore, the Big Stone I power plant is required to meet the emission limits established in the BART determination by April 26, 2017.

South Dakota issued a construction permit to the Big Stone I power plant for the air quality control system project on September 30, 2013. The permit incorporated the BART emission limits established in ARSD § 74:36:21:06. Installation of the air quality control system project is scheduled to be completed by the fall of calendar year 2015. The Big Stone I power plant is ahead of schedule in meeting the deadline established in South Dakota's Regional Haze State Implementation Plan.

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3.1.2 Other State Rules

South Dakota's current air quality rules under ARSD article 74:36 – Air Pollution Control Program, currently protects and improves visibility in Class I areas. Examples of existing rules that protect and improve visibility in Class I areas are listed below:

1. ARSD § 74:36:01:05 – Applicable requirements of Clean Air Act defined: Subsection (12) states "*Any national ambient air quality standard or increment or visibility requirement under Part C of Title I of the Clean Air Act, but only as it would apply to temporary sources permitted pursuant to § 504(e) of the Clean Air Act*";
2. ARSD § 74:36:01:10 – Modification defined: Subsection (3) states "*The change requires or changes a case-by-case determination of an emission limit or other standard, a source-specific determination for temporary sources of ambient impacts, or a visibility or increment analysis*";
3. ARSD § 74:36:02:01 – Air quality goals: Subsection (3) states one of the goals is "*Optimization of visibility*";
4. ARSD § 74:36:04 – Operating permits for minor sources and § 74:36:05 – Operating permits for Part 70 sources: The permits issued under these chapters require sources to meet all applicable emission limits, demonstrate compliance, monitoring, recordkeeping and reporting requirements to ensure compliance with all applicable requirements of the Clean Air Act;
5. ARSD §§ 74:36:06 – Regulated Air Pollutant Emissions; 74:36:07 – New Source Performance Standards; 74:36:08 – National Emission Standards for Hazardous Air Pollutants, and ARSD § 74:36:12 – Control of Visible Emissions: These chapters restrict air emissions from regulated entities that contribute to visibility impairment and prohibits certain open burning practices such as open burning waste oil, rubber, waste tires, asphalt shingles, railroad ties, etc.;
6. ARSD § 74:36:09 – Prevention of Significant Deterioration: This chapter requires a visibility analysis to prevent sources subject to these requirements from contributing to visibility impairment in Class I areas;
7. ARSD § 74:36:10 – New Source Review: This chapter requires a visibility analysis to prevent sources subject to these requirements from contributing to visibility impairment in Class I areas;
8. ARSD § 74:36:18 – Regulations for State Facilities in the Rapid City Area: This chapter restricts visible emissions from fugitive sources; and
9. ARSD § 84:36:20 – Construction permits for new sources or modifications: The permits issued under this chapter requires newly constructed sources and modifications to existing sources to meet all applicable emission limits, demonstrate compliance, monitoring, recordkeeping, and reporting requirements to ensure compliance will all applicable requirements under the Clean Air Act .

3.1.3 Federal Programs

The following EPA rules are also helping to protect and improve visibility in Class I areas throughout the nation:

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1. Heavy-Duty Highway Diesel Rule – 40 CFR Part 86: Within this rule, EPA set a particulate matter (PM) emissions standard for new heavy-duty engines of 0.01 gram per brake horsepower-hour (g/bhp-hr), which took full effect for diesel engines in the 2007 model year. The rule also included standards for oxides of nitrogen and non-methane hydrocarbons of 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively. The two standards were successfully phased in together between 2007 and 2010. The rule also required the sulfur in highway diesel fuel be reduced to 15 parts per million (ultra-low sulfur diesel fuel). This amounted to a 97% reduction in the sulfur content. The requirements of the rule were implemented within the time frames established by the rule.
2. Tier 2 Vehicle and Gasoline Sulfur Program – 40 CFR Part 80 Subpart H; Part 85; Part 86: EPA's Tier 2 Program set federal emission standards for on-road vehicles, including sport utility vehicles, minivans, vans, and pick-up trucks, as well as passenger cars. The program created fleet-averaging standards for nitrogen oxide, allowing manufacturers to produce vehicles with varying emissions, as long as the fleet of vehicles produced by a manufacturer had average nitrogen oxide emissions below a specified value. The standards became effective in the 2005 model year. Mobile emissions continue to benefit from this program as consumers replace older, more polluting vehicles with cleaner vehicles.
3. Non-road Diesel Rule – 40 CFR Part 89: This rule sets standards for emissions of nitrogen oxide, hydrocarbons, and carbon monoxide from non-road engines, including industrial spark-ignition engines, recreational non-road vehicles and a variety of farm and construction equipment. These rules were initially effective in 2004 and were fully phased in by 2012. The non-road diesel rule also set limits on the sulfur content of non-road diesel fuel. Starting in 2007, the rule reduced sulfur levels by 99 percent from previous levels. The reduction in fuel sulfur levels applied to most non-road diesel fuel in 2010 and applied to fuel used in locomotives and marine vessels in 2012.

3.2 Emissions Reductions from Regional Haze SIP Strategies

In accordance with 40 CFR § 51.308(g)(2), the 5-year progress report should provide a summary of the emission reductions achieved throughout the state through the implementation of the measures approved in the state's Regional Haze State Implementation Plan. As identified earlier, the BART emission controls for the Big Stone I power plant are scheduled to be installed in the fall of 2015 which is ahead of schedule. Therefore, South Dakota and the states impacted by the Big Stone I power plant's emissions will not realize the reduction in emissions until calendar year 2016.

Table 3-1 compares the Big Stone I power plant's actual emission rates for the last five years to the BART emission limits to illustrate the emission reductions once the BART controls are installed and operational. Table 3-1 provides the average emission rate for 2010 through 2014. The BART emission limit is derived from ARSD § 74:36:21:06(4) and (6). The percentage of emission reduction is based on the emission rate for each pollutant. Once the air pollution controls necessary for meeting the BART requirements are installed, costing approximately $384 million, the sulfur dioxide and nitrogen oxide emissions will be reduced by approximately 89% and 86%, respectively.

Table 3-1 – Big Stone Power Plant Comparison of Actual Emission Rates to Bart Limits

Calendar Year	2010	2011	2012	2013	2014
Actual SO_2 Emissions (lbs/MMBtus)	0.72	0.77	0.81	0.98	0.92
BART SO_2 Limit (lbs/MMBtus)	0.09	0.09	0.09	0.09	0.09
% Emission Reduction	88%	88%	89%	91%	90%
Actual NOx Emissions (lbs/MMBtus)	0.70	0.70	0.69	0.71	0.69
BART NOx Limit (lbs/MMBtus)	0.10	0.10	0.10	0.10	0.10
% Emission Reduction	86%	86%	86%	86%	86%

Table 3-2 shows the results of emission inventories for the Western Regional Air Partnership's (WRAP's) 2002 Plan 02d, WRAP's 2008 West Jump project and the WRAP's 2011Western Air Quality Data Warehouse project for South Dakota. Based on WRAP's emission inventories, South Dakota has already experienced significant reductions in sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate mass coarse (PMC), volatile organic compounds (VOCs), and carbon monoxide (CO) emissions from 2002 through 2011. Although not as sizeable, reductions were also seen in elemental carbon (EC) and particulate mass fine (PMF) during the same time frame. Primary organic aerosols (POA) and ammonia (NH3) showed a slight increase over the two periods. The changes shown in Table 3-2 are broken out into more detail in Section 3.4.

Table 3-2 – South Dakota Emissions [1]

Pollutant	2002	2008	2011	Change (2002-2011)	
				Tons	Percentage
SO_2	22,725	16,089	13,582	-9,143	-40%
NO_X	146,822	89,853	75,609	-71,213	-49%
POA	9,166	5,980	9,562	396	4%
EC	4,703	3,529	2,692	-2,011	-43%
PMF	82,414	61,266	79,065	-3,349	-4%
PMC	615,355	433,813	557,508	-57,847	-9%
NH_3	120,406	133,126	129,973	9,567	8%
VOC	518,981	204,573	259,129	-259,852	-50%
CO	509,702	280,241	272,363	-237,339	-47%

[1] – The 2002, 2008, and 2011 emissions are in tons.

3.3 Visibility Progress

In accordance with 40 CFR § 51.308(g)(3), for each mandatory Class I federal area within the state, the state shall assess the following visibility conditions and changes, with values for most impaired and least impaired days expressed in terms of 5-year averages of these annual values:

1. The current visibility conditions for the most impaired days and least impaired days;
2. The difference between current visibility conditions and baseline conditions for the most impaired and least impaired days;
3. The change in visibility impairment for the most impaired and least impaired days over the past 5 years.

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Regional haze progress in federal Class I areas is tracked using calculations based on speciated aerosol mass collected by the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors at each Class I area. The Regional Haze Rule calls for tracking haze in units of deciview (dv), where the deciview metric was designed to be linearly associated with human perception of visibility. In a pristine atmosphere, the deciview metric is near zero, and a one deciview change is approximately equivalent to a 10% change in cumulative species extinction. To better understand visibility conditions, summaries here include both the deciview and light extinction due to the various aerosol species which are measured in inverse mega meters (Mm^{-1}).

3.3.1 Current Visibility Conditions

In accordance with 40 CFR§ 51.308 (g)(3)(i), the report shall address the current visibility conditions for the most impaired and least impaired days for each Class I area. In EPA's 2003 Guidance for Tracking Progress under the Regional Haze Rule, it specifies that progress is tracked against the 2000-2004 baseline period using corresponding averages of successive 5-year periods; i.e., 2005-2009, 2006-2010, etc. For this 5-year progress report South Dakota used the most current visibility data available which is the 5-year period of 2009-2013.

Tables 3-3 and 3-4 represent the 20% most impaired and 20% least impaired days, respectively, for both Badlands and Wind Cave National Parks. The tables provide the average haze index, measured in deciviews, and the average percent contribution to light extinction, measured in inverse mega meters, for each aerosol species for the 2009-2013 progress period.

Table 3-3 – Percent Contribution to Extinction - 20% Most Impaired Days (2009-2013)

National Park	Haze Index Deciview (dv)	Percent Light Extinction						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
Badlands	15.7	46%	16%	19%	4%	2%	12%	1%
Wind Cave	14.1	30%	17%	36%	6%	2%	9%	0%

For the 20% most impaired days, nearly half of the light extinction at the Badlands National Park comes from ammonium sulfate. The second largest contributor is particulate organic mass at 19% followed closely by ammonium nitrate at 16% and then coarse mass at 12%. Elemental carbon, soil and sea salt contribute minor amounts to the light extinction.

For the 20% most impaired days at the Wind Cave National Park, just over one-third of the light extinction comes from particulate organic mass and just under a third from ammonium sulfate. Ammonium nitrate is the third largest contributor to the light extinction at 17%. Elemental carbon, soil, coarse mass, and sea salt contribute minor amounts to the light extinction.

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Table 3-4 – Percent Contribution to Extinction - 20% Least Impaired Days (2009-2013)

National Park	Haze Index Deciview (dv)	Percent Light Extinction						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
Badlands	5.8	41%	14%	18%	7%	4%	16%	0%
Wind Cave	3.9	42%	11%	20%	8%	4%	16%	0%

For the 20% least impaired days at the Badlands and Wind Cave National Parks the makeup of extinction between the two national parks is very similar, which is expected as the least impaired days are usually impacted by local sources rather than large regional sources or events that can travel great distances. Ammonium sulfate is the largest contributor to the light extinction at both parks with a little more than 40%. The next largest contributor is particulate organic mass, followed by coarse mass and ammonium nitrate. Elemental carbon, fine soil and sea salt have very little impact at either park on the least impaired days.

The haze index and light extinction were broken out by year to determine if one or more years influenced the five year average. Tables 3-5 and 3-6 represent the annual visibility conditions for the 20% most impaired days at the Badlands and Wind Cave National Parks, respectively, for the haze index and light extinction by aerosol species.

Table 3-5 – Badlands Aerosol Concentrations from 2009-2013

Year	Haze Index Deciview (dv)	Badlands 20% Most Impaired Days (Mm^{-1})						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2009	15.1	19.08	4.04	5.69	1.17	0.74	4.04	0.16
2010	16.7	22.19	10.90	5.01	1.39	0.70	2.81	0.14
2011	15.7	17.45	6.72	6.80	1.61	0.77	4.74	0.16
2012	15.8	12.65	4.92	11.00	2.22	1.15	6.80	0.08
2013	15.0	15.43	4.60	6.89	1.36	0.98	5.29	0.06
Average	**15.7**	**17.36**	**6.24**	**7.08**	**1.55**	**0.87**	**4.74**	**0.12**

While reviewing the annual values for the aerosol species at the Badlands National Park, the Department of Environment and Natural Resources (DENR) noticed higher values for ammonium sulfate and ammonium nitrate in 2010. The DENR also noticed a high annual value for ammonium nitrate at the Wind Cave National Park in 2010, but not for ammonium sulfate. The DENR then looked at the 20% most impaired days for ammonium nitrate at both parks for 2010 and found that half of the 20% most impaired days were the same value for both parks including some of the highest days. This would indicate a regional issue such as transport from an outside source causing the high ammonium nitrate value in 2010. The DENR was unable to identify a reason for the high ammonium sulfate concentration in 2010 for the Badlands National Park.

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Table 3-6 – Wind Cave Annual Aerosol Concentrations 2009-2013

Year	Haze Index Deciview (dv)	Wind Cave 20% Most Impaired Days (Mm^{-1})						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2009	13.9	13.40	3.74	8.35	1.58	1.23	3.42	0.2
2010	15.4	10.60	11.28	30.17	3.58	0.70	2.86	0.10
2011	13.7	11.91	5.87	6.78	1.64	0.70	3.37	0.15
2012[1]	14.2	7.93	4.71	11.58	2.28	1.04	4.04	0.12
2013	13.1	10.37	4.11	7.73	1.59	0.78	2.62	0.04
Average	**14.1**	**10.84**	**5.94**	**12.92**	**2.13**	**0.89**	**3.26**	**0.12**

[1] - The 2012 data for the Wind Cave National Park was missing Coarse Mass for the 3rd and 4th quarters. Data was patched using seasonal means, following the Regional Haze Rule's methodology

The DENR reviewed the annual values for the aerosol species at the Wind Cave National Park, because the DENR was concerned about the extremely high value for particulate organic mass and elemental carbon in 2010. Due to the fact that particulate organic mass and elemental carbons are typically associated with fire, the DENR researched a fire database. In 2010, the National Park Service conducted a 5,500 acre prescribed fire at the Wind Cave National Park just a mile from the monitoring site. This fire created two of the 20% most impaired days at the park and the main contributor was particulate organic mass. The results of this fire are discussed in more detail in Section 3.5 and 3.6.

Tables 3-7 and 3-8 represent the annual visibility conditions for the 20% least impaired days at Badlands and Wind Cave National Parks for the current planning period represented by the 5-year period 2009 – 2013 as well as the 5-year averages for the haze index and light extinction by species. A review of the data for the least impaired data does not indicate any outliers for either park. The values for each park for each haze index and light extinction by species seem to be consistent over the years, which would indicate no degradation to the least impaired days.

Table 3-7 – Badlands Annual Aerosol Concentrations 2009 – 2013

Year	Haze Index Deciview (dv)	Badlands 20% Least Impaired Days (Mm^{-1})						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2009	6.1	3.17	1.02	1.51	0.51	0.26	0.98	0.01
2010	6.4	3.39	1.12	1.51	0.50	0.36	1.18	0.02
2011	5.6	2.55	0.87	1.20	0.44	0.18	1.10	0.15
2012	5.4	2.70	0.80	0.95	0.40	0.25	1.18	0.05
2013	5.4	2.24	0.99	1.18	0.43	0.24	1.16	0.03
Average	**5.8**	**2.81**	**0.96**	**1.27**	**0.46**	**0.26**	**1.12**	**0.05**

Table 3-8 – Wind Cave Annual Aerosol Concentrations 2009 – 2013

Year	Haze Index Deciview (dv)	Wind Cave 20% Least Impaired Days (Mm^{-1})						
		Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2009	3.8	2.06	0.58	0.89	0.38	0.19	0.64	0.01
2010	4.6	2.52	0.59	1.38	0.44	0.22	0.79	0.01
2011	3.6	1.92	0.40	0.83	0.36	0.14	0.62	0.09
2012[1]	3.5	1.65	0.42	0.77	0.36	0.19	0.81	0.03
2013	3.9	1.92	0.56	0.86	0.38	0.16	0.94	0.02
Average	**3.9**	**2.01**	**0.51**	**0.95**	**0.38**	**0.18**	**0.76**	**0.03**

[1] - The 2012 data for Wind Cave National Park was missing Coarse Mass for the 3rd and 4th quarters. Data was patched using seasonal means, following the Regional Haze Rule's methodology

3.3.2 Differences between Current and Baseline Conditions

In accordance with 40 CFR§ 51.308 (g)(3)(ii), the 5-year progress report shall address the difference between current visibility conditions and baseline visibility conditions for the 20% most impaired days and 20% least impaired days. The baseline values consist of data from 2000 – 2004 and the current conditions are represented by the 2009 – 2013.

Table 3-9 represents the difference between the baseline period and the current progress period for the 20% most impaired days at Badlands National Park. Additional 5 year periods were added to show the gradual progress being made at the park. Each aerosol species showed a decrease in light extinction other than a slight increase for ammonium nitrate. The largest improvement in light extinction was seen from particulate organic mass. The haze index value improved slightly over each progress period and had an overall improvement of 1.4 deciviews.

Table 3-9 – Difference in Extinction – Badlands - 20% Most Impaired Days (Mm^{-1})

Year	Haze Index Deciview (dv)	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
Baseline 2000-2004	17.1	18.85	5.85	11.78	2.59	0.98	5.94	0.19
2005-2009	16.6	18.81	5.38	10.48	1.92	0.96	5.12	0.55
2006-2010	16.6	18.88	6.32	10.32	1.79	0.93	4.91	0.56
2007-2011	16.3	18.73	6.56	9.08	1.56	0.85	4.51	0.58
2008-2012	16.1	17.69	6.23	9.22	1.61	0.92	4.96	0.55
2009-2013	15.7	17.33	6.1	7.17	1.56	0.87	4.77	0.12
Difference	**-1.4**	**-1.52**	**0.25**	**-4.61**	**-1.03**	**-0.11**	**-1.17**	**-0.07**

Table 3-10 represents the difference between the baseline period and the current progress period for the 20% most impaired days at Wind Cave National Park. Additional 5 year periods were also added to show the gradual progress being made at the park. At the Wind Cave National Park

ammonium sulfate, ammonium nitrate, elemental carbon and coarse mass all showed light extinction improvements from the baseline to the current progress period. Despite slight increases in light extinction for particulate organic mass and sea salt, the haze index value improved by 1.7 deciviews.

Table 3-10 – Difference in Extinction - Wind Cave - 20% Most Impaired Days (Mm^{-1})

Year	Haze Index Deciview (dv)	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
Baseline 2000-2004	15.8	13.2	6.98	13.22	2.92	0.85	3.52	0.03
2005-2009	15.5	13.69	5.90	13.35	2.58	1.01	3.76	0.28
2006-2010	15.4	12.88	6.40	17.14	2.73	1.0	3.71	0.27
2007-2011	14.9	12.03	6.45	15.69	2.4	0.93	3.53	0.29
2008-2012	14.5	11.5	6.34	15.6	2.31	0.9	3.5	0.36
2009-2013	14.1	11.57	6.24	13.25	2.09	0.85	3.06	0.12
Difference	**-1.7**	**-1.63**	**-0.74**	**0.03**	**-0.83**	**0**	**-0.46**	**0.09**

Table 3-11 represents the difference between the baseline period and the current progress period for the 20% least impaired days at Badlands National Park and also includes subsequent progress periods to show the gradual improvements. All aerosol species showed improvement in light extinction other than sea salt, with ammonium sulfate and particulate organic mass showing the largest improvements. Although the Regional Haze Rule requires no degradation on the least impaired days, the haze index value at Badlands National Park improved by 1.1 deciviews over the baseline period.

Table 3-11 – Difference in Extinction – Badlands - 20% Least Impaired Days (Mm^{-1})

Year	Haze Index Deciview (dv)	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
Baseline 2000-2004	6.9	3.36	1.20	1.81	0.79	0.33	1.51	0.02
2005-2009	6.8	3.47	1.13	2.15	0.55	0.34	1.22	0.03
2006-2010	6.7	3.35	1.10	2.06	0.49	0.35	1.25	0.02
2007-2011	6.5	3.25	1.10	2.01	0.45	0.31	1.18	0.04
2008-2012	6.3	3.07	0.97	1.85	0.42	0.28	1.12	0.04
2009-2013	5.8	2.81	0.95	1.26	0.44	0.26	1.13	0.05
Difference	**-1.1**	**-0.55**	**-0.25**	**-0.55**	**-0.35**	**-0.07**	**-0.38**	**0.03**

Table 3-12 represents the difference between the baseline period and the current progress period for the 20% least impaired days at Wind Cave National Park and also includes subsequent progress periods to show the gradual improvements. Ammonium sulfate showed the largest improvement followed by particulate organic mass, elemental carbon and ammonium nitrate.

Although course mass and sea salt showed a slight increase at the Wind Cave National Park the deciview level improved by 1.2 deciviews.

Table 3-12 – Difference in Extinction Wind Cave - 20% Least Impaired Days (Mm^{-1})

Year	Haze Index Deciview (dv)	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
Baseline 2000-2004	5.1	2.58	0.80	1.42	0.71	0.23	1.05	0.01
2005-2009	4.6	2.47	0.65	1.19	0.53	0.21	0.84	0.02
2006-2010	4.6	2.44	0.64	1.25	0.48	0.21	0.84	0.02
2007-2011	4.4	2.37	0.63	1.19	0.43	0.18	0.73	0.02
2008-2012	4.1	2.17	0.58	1.09	0.40	0.17	0.68	0.03
2009-2013	3.9	2.11	0.54	0.98	0.39	0.17	0.73	0.02
Difference	**-1.2**	**-0.47**	**-0.26**	**-0.44**	**-0.31**	**-0.06**	**0.32**	**0.01**

3.3.3 Change in Visibility Impairment

In accordance with 40 CFR§ 51.308 (g)(3)(iii), the 5-year progress report shall address the change in visibility impairment for the most impaired and least impaired days over the past 5 years. Tables 3-13 and 3-14 show the haze index (deciview) and the light extinction for each aerosol species for the 20% most impaired days on a yearly basis for 2009 – 2013. Despite some minor increases in some of the aerosol species, the deciview value shows a small improvement at Badlands National Park and a better improvement at Wind Cave National Park. The greatest improvements at the Badlands National Park were from ammonium sulfate. The Wind Cave National Park also showed its largest improvement in ammonium sulfate, followed by coarse mass and particulate organic mass.

Table 3-13 – Change in Light Extinction – Badlands - 20% Most Impaired Days (Mm^{-1})

Year	Haze Index (Deciview)	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2009	15.1	19.08	4.04	5.69	1.17	0.74	4.04	0.16
2010	16.7	22.19	10.9	5.01	1.39	0.7	2.81	0.14
2011	15.7	17.45	6.72	6.8	1.61	0.77	4.74	0.16
2012	15.8	12.65	4.92	11	2.22	1.15	6.8	0.08
2013	15	15.43	4.6	6.89	1.36	0.98	5.29	0.06
	-0.01	**-3.65**	**0.56**	**1.2**	**0.19**	**0.24**	**1.25**	**-0.01**

Table 3-14 – Change in Light Extinction – Wind Cave - 20% Most Impaired Days (Mm^{-1})

Year	Deciview	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2009	13.9	13.4	3.7	8.4	1.6	1.2	3.4	0.2

Year	Deciview	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2010	15.4	10.6	11.3	30.2	3.6	0.7	2.9	0.1
2011	13.7	11.9	5.9	6.8	1.6	0.7	3.4	0.2
2012	14.2	7.9	4.7	11.6	2.3	1.0	4.0	0.1
2013	13.1	10.4	4.1	7.7	1.6	0.8	2.6	0.0
	-0.8	**-3.0**	**0.4**	**-0.7**	**0.0**	**-0.4**	**-0.8**	**-0.2**

Tables 3-15 and 3-16 show the haze index (deciview) and the extinction for each species for the 20% least impaired days for each year of the 2009 – 2013. All of the aerosol species except for coarse mass and sea salt show a reduction at both Badlands and Wind Cave National Park. The deciview value improved slightly over the 5 years at the Badlands National Park and showed a slight increase at the Wind Cave National Park.

Table 3-15 – Change in Light Extinction – Badlands - 20% Least Impaired Days (Mm^{-1})

Year	Deciview (dv)	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2009	6.1	3.17	1.02	1.51	0.51	0.26	0.98	0.01
2010	6.4	3.39	1.12	1.51	0.5	0.36	1.18	0.02
2011	5.6	2.55	0.87	1.2	0.44	0.18	1.1	0.15
2012	5.4	2.7	0.8	0.95	0.4	0.25	1.18	0.05
2013	5.4	2.24	0.99	1.18	0.43	0.24	1.16	0.03
	-0.7	**-0.93**	**-0.03**	**-0.33**	**-0.08**	**-0.02**	**0.18**	**0.02**

Table 3-16 – Change in Light Extinction - Wind Cave - 20% Least Impaired Days (Mm^{-1})

Year	Deciview (dv)	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
2009	3.8	2.06	0.58	0.89	0.38	0.19	0.64	0.01
2010	4.6	2.52	0.59	1.38	0.44	0.22	0.79	0.01
2011	3.6	1.92	0.4	0.83	0.36	0.14	0.62	0.09
2012	3.5	1.65	0.42	0.77	0.36	0.19	0.81	0.03
2013	3.9	1.92	0.56	0.86	0.38	0.16	0.94	0.02
	0.1	**-0.14**	**-0.02**	**-0.03**	**0**	**0.03**	**0.3**	**0.01**

As discussed in Chapter 3.2.1, reasonable progress is tracked using 5 year periods. Tables 3-17 and 3-18 show the improvement for the progress periods from the baseline of 2000 – 2004 through the current progress period of 2009 – 2013 and also the improvement needed for natural conditions at each Class I area. Both Class I areas show improvement on the 20% most impaired and 20% least impaired days.

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Table 3-17 – Average Haze Index for 5 – Year Planning Periods - Badlands (deciview)

Impairment	2000-2004	2005-2009	2007-2011	2008-2012	2009-2013	Natural Conditions
20% Most	17.1	16.6	16.3	16.1	15.7	8.1
20% Least	6.9	6.8	6.5	6.2	5.8	2.9

Table 3-18 – Average Haze Index for 5 – Year Planning Periods - Wind Cave (deciview)

Impairment	2000 - 2004	2005 - 2009	2007 - 20011	2008 - 2012	2009 - 2013	Natural Conditions
20% Most	15.8	15.5	14.9	14.5	14.1	7.7
20% Least	5.1	4.6	4.4	4.1	3.9	1.9

3.4 Emissions Progress

In accordance with 40 CFR§ 51.308 (g)(4), the progress report requires an analysis tracking the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the state. Emission changes should be identified by type of source or activity. The analysis must be based on the most recent updated emissions inventory, with estimates projected forward as necessary and appropriate, to account for emissions changes during the applicable 5-year period.

The emissions for the baseline years are represented using a 2002 inventory, which was developed with support from the WRAP for use in the original Regional Haze Rule State Implementation Plan strategy development (termed plan02d). The most current emission inventory is a 2011 inventory which leverages recent inventory development work performed by the WRAP for the Western Air Quality Data Warehouse modeling project (termed 2011WAQDW). Note that the comparison of differences between inventories does not necessarily reflect a change in emissions, as a number of methodology changes and enhancements have occurred between developments of the individual inventories. Inventories for all major visibility impairing pollutants are presented for major source categories and categorized as either anthropogenic or natural emissions. State-wide inventory totals and differences are presented here and inventory totals on a county level basis are available on the WRAP Technical Support System website (http://vista.cira.colostate.edu/tss/).

Anthropogenic sources are the primary cause of sulfur dioxide emissions. These sources can include coal burning power plants, other industrial sources such as refineries and cement plants, and both on and off-road diesel engines. Table 3-19 and Figure 3-1 shows the changes in sulfur dioxide emissions from 2002 through 2011.

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Table 3-19 – Changes in Sulfur Dioxide Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	14,024	11,835	-2,189
Area	1,071	1,200	129
On-Road Mobile	872	89	-783
Off-Road Mobile	5,732	48	-5,684
Area Oil and Gas	5	1	-4
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	5	251	246
Total Anthropogenic	**21,709**	**13,424**	**-8,285**
Natural Sources			
Natural Fire	362	194	-168
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**362**	**194**	**-168**
All Sources			
Total Emissions	**22,071**	**13,618**	**-8,453**

During that time frame, sulfur dioxide emissions in South Dakota decreased by just less than 8,500 tons per year. The largest decreases were seen in anthropogenic off-road mobile and point sources with a small decrease in natural fire. The decrease in off-road mobile was likely due to a combination of actual changes in source contributions and methodology differences. One major methodology difference was the reclassification of some off-road mobile sources into the area source category in 2008, which may have contributed to decreases in the off-road inventory totals and increases in area source totals.

Nitrogen oxide emissions can react with ammonia from area and mobile sources and produce ammonium nitrate. Both anthropogenic and natural activities produce nitrogen oxide emissions. Some of the more common anthropogenic sources include combustion activities, especially those involving automobiles. Table 3-20 and Figure 3-2 shows the changes in nitrogen oxide emissions from 2002 through 2011.

During that time frame, nitrogen oxide emissions in South Dakota decreased by just over 71,000 tons per year. The largest decrease was seen in natural biogenic which is primarily related to changes in the methodology and not actual reductions. Nitrogen oxide emissions from anthropogenic off-road mobile, on-road mobile and point sources were also reduced by just over 33,000 tons, which is most likely a result of new fuel and engine standards. The only real increase in nitrogen oxide emissions was from anthropogenic fires with an increase of 970 tons per year.

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Figure 3-1 – 2002 and 2011 Emissions and Differences for Sulfur Dioxides

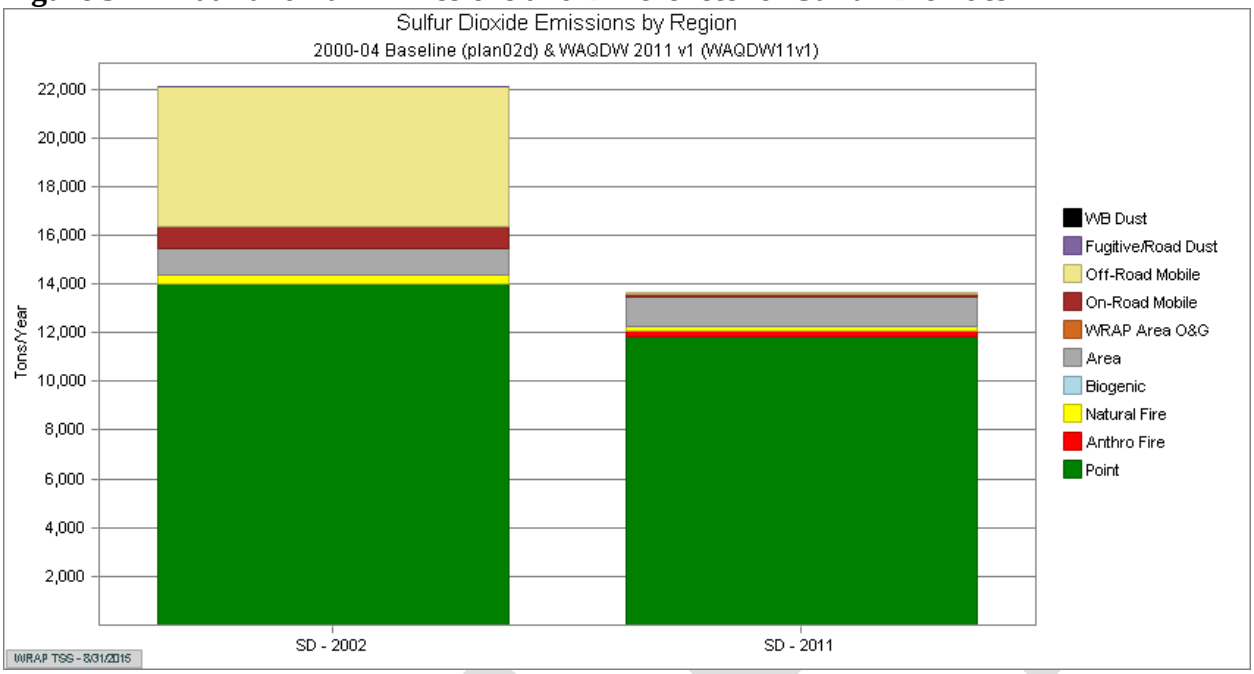
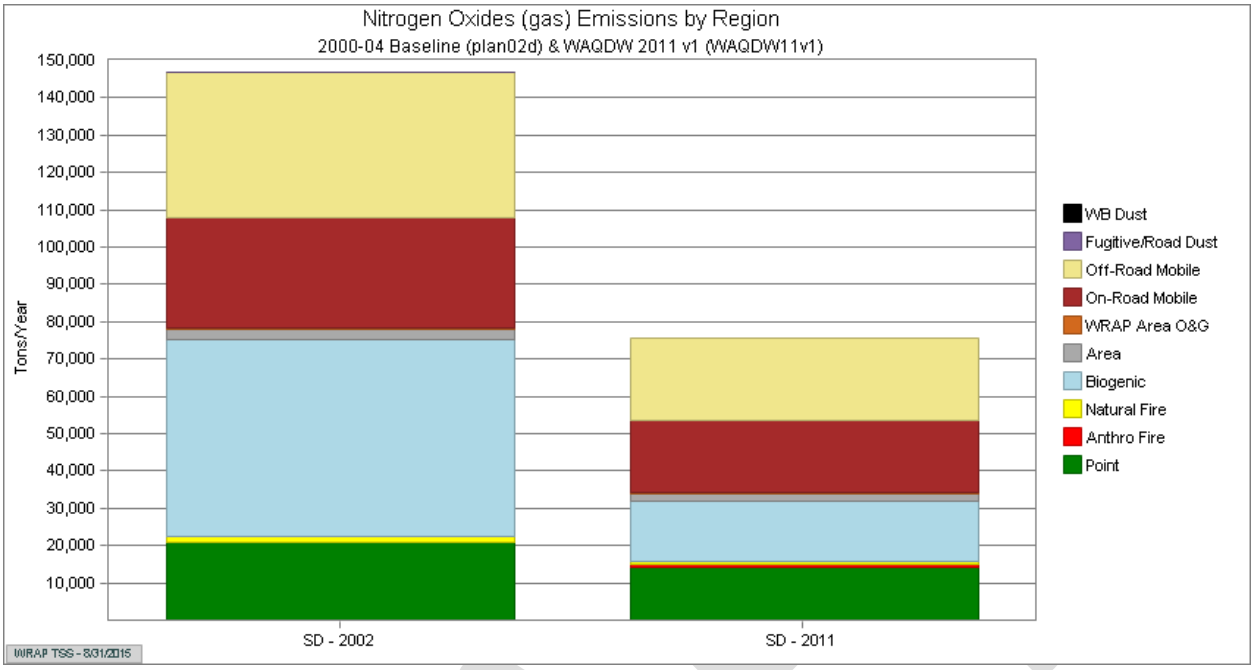


Table 3-20 – Changes in Nitrogen Oxide Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	20,697	13,994	-6,703
Area	2,896	2,053	-843
On-Road Mobile	29,223	19,291	-9,932
Off-Road Mobile	39,038	22,193	-16,845
Area Oil and Gas	360	256	-104
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	40	1,010	970
Total Anthropogenic	**92,254**	**58,797**	**-33,457**
Natural Sources			
Natural Fire	1,658	577	-1,081
Biogenic	52,852	16,186	-36,666
Wind Blown Dust	0	0	0
Total Natural	**54,510**	**16,763**	**-37,747**
All Sources			
Total Emissions	**146,764**	**75,560**	**-71,204**

Figure 3-2 – 2002 and 2011 Emissions and Differences for Nitrogen Oxides



Primary organic aerosol emissions are produced by both anthropogenic and natural sources but are most commonly associated with fire. Table 3-21 and Figure 3-3 shows the changes in primary organic aerosol emissions from 2002 through 2011.

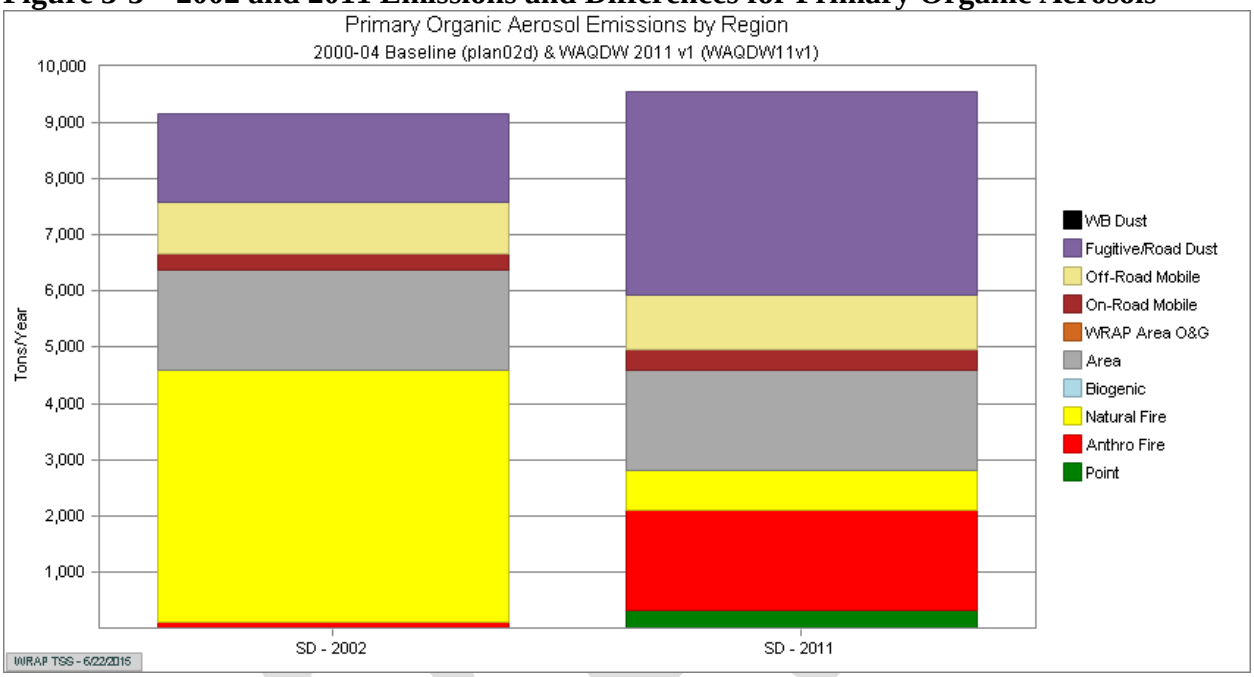
Table 3-21 – Changes in Primary Organic Aerosol Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	10	310	300
Area	1,792	1,804	12
On-Road Mobile	278	360	82
Off-Road Mobile	942	962	20
Area Oil and Gas	0	1	1
Fugitive and Road Dust	1,571	3,636	2,065
Anthropogenic Fire	91	1,792	1,701
Total Anthropogenic	**4,684**	**8,865**	**4,181**
Natural Sources			
Natural Fire	4,483	698	-3,785
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**4,483**	**698**	**-3,785**
All Sources			
Total Emissions	**9,167**	**9,563**	**396**

During that time period primary organic aerosol emissions increased by just under 400 tons. The largest decrease was seen in natural fires at just fewer than 4,000 tons. Anthropogenic sources increased over that time period with the largest increase related to fugitive and road dust

followed by anthropogenic fire. The plan 02d fire emissions are averaged over the 2000 – 2004 period while the 2011WAQDW emissions consist of fires that occurred only in 2011 so it's difficult to know if there were actual decreases over the two time periods. The increase in fugitive and road dust emissions is most likely due to methodology changes in the inventory rather than actual changes.

Figure 3-3 – 2002 and 2011 Emissions and Differences for Primary Organic Aerosols



Elemental carbon emissions are a product of both anthropogenic and natural sources. One of the most common sources of elemental carbon is anthropogenic off-road mobile while natural sources include fire. Table 3-22 and Figure 3-4 show the changes in elemental carbon from 2002 through 2011.

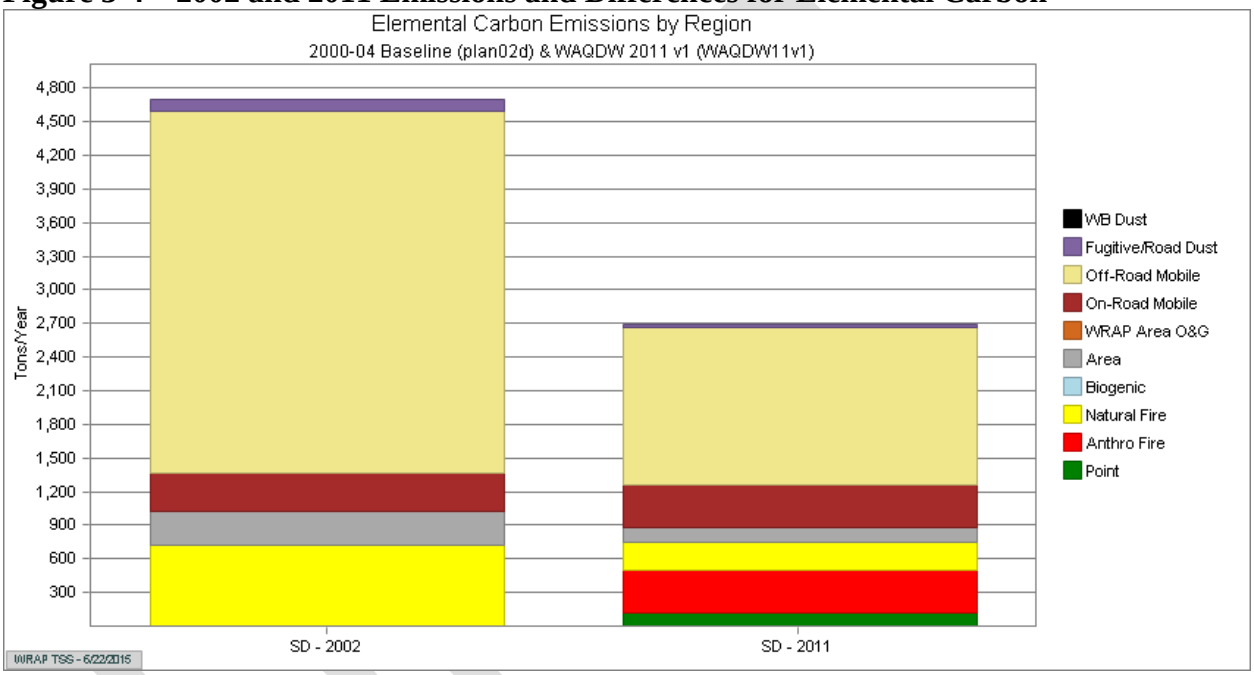
Table 3-22 – Changes in Elemental Carbon Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	0	121	121
Area	306	128	-178
On-Road Mobile	339	390	51
Off-Road Mobile	3,234	1,394	-1,840
Area Oil and Gas	0	0	0
Fugitive and Road Dust	108	35	-73
Anthropogenic Fire	5	384	379
Total Anthropogenic	**3,992**	**2,452**	**-1,540**
Natural Sources			
Natural Fire	712	240	-472
Biogenic	0	0	0
Wind Blown Dust	0	0	0

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Total Natural	**712**	**240**	**-472**
All Sources			
Total Emissions	**4,699**	**2,692**	**-2,007**

Elemental carbon showed an overall decrease in emissions of just over 2,000 tons. The largest decrease was seen in anthropogenic off-road mobile at a little less than 1,900 tons, with smaller decreases in natural fire and area sources. Minor increases were seen in anthropogenic fire and point sources. The differences in off-road mobile emissions were likely due to a combination of actual changes in source contributions and changes in methodology.

Figure 3-4 – 2002 and 2011 Emissions and Differences for Elemental Carbon



Both anthropogenic and natural activities produce fine soil emissions. Fine soil is represented by crustal material or soil that is particulate matter 2.5 microns or less. Table 3-23 and Figure 3-5 show the changes in fine soil emissions from 2002 through 2011.

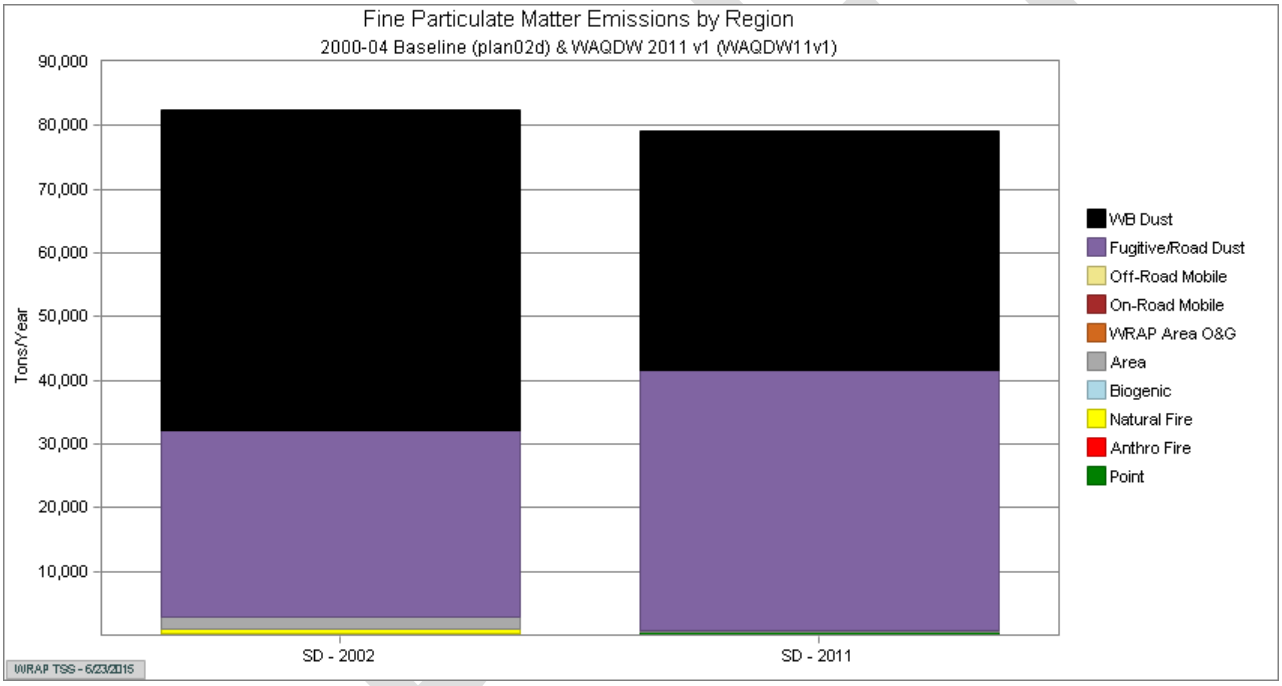
Table 3-23 – Changes in Fine Soil Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	216	475	259
Area	1,804	136	-1,668
On-Road Mobile	0	80	80
Off-Road Mobile	0	0	0
Area Oil and Gas	0	5	5
Fugitive and Road Dust	29,281	40,823	11,542
Anthropogenic Fire	38	1	-37
Total Anthropogenic	**31,339**	**41,514**	**10,175**

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Natural Sources			
Natural Fire	801	1	-800
Biogenic	0	0	0
Wind Blown Dust	50,274	37,543	-12,730
Total Natural	**51,075**	**37,544**	**-13,531**
All Sources			
Total Emissions	**82,414**	**79,058**	**-3,356**

During that time frame, fine soil emissions decreased in South Dakota by a little over 3,300 tons. The biggest decrease was seen in natural wind-blown dust at a little less than 13,000 tons. Decreases were also seen in natural fire and anthropogenic area sources. A fairly large increase was seen in anthropogenic fugitive and road dust at a little over 11,500 tons. Changes in wind-blown dust was observed throughout the WRAP states, which was likely due in large part to enhancements in the dust inventory methodology, rather than changes in actual emissions.

Figure 3-5 – 2002 and 2011 Emissions and Differences for Fine Soil



Coarse mass is measured by the IMPROVE samplers as the difference between particulate matter 10 microns in diameter or less and particulate matter 2.5 microns in diameter or less. Anthropogenic and natural sources produce coarse mass emissions. Table 3-24 and Figure 3-6 show the changes in coarse mass emission from 2002 through 2011.

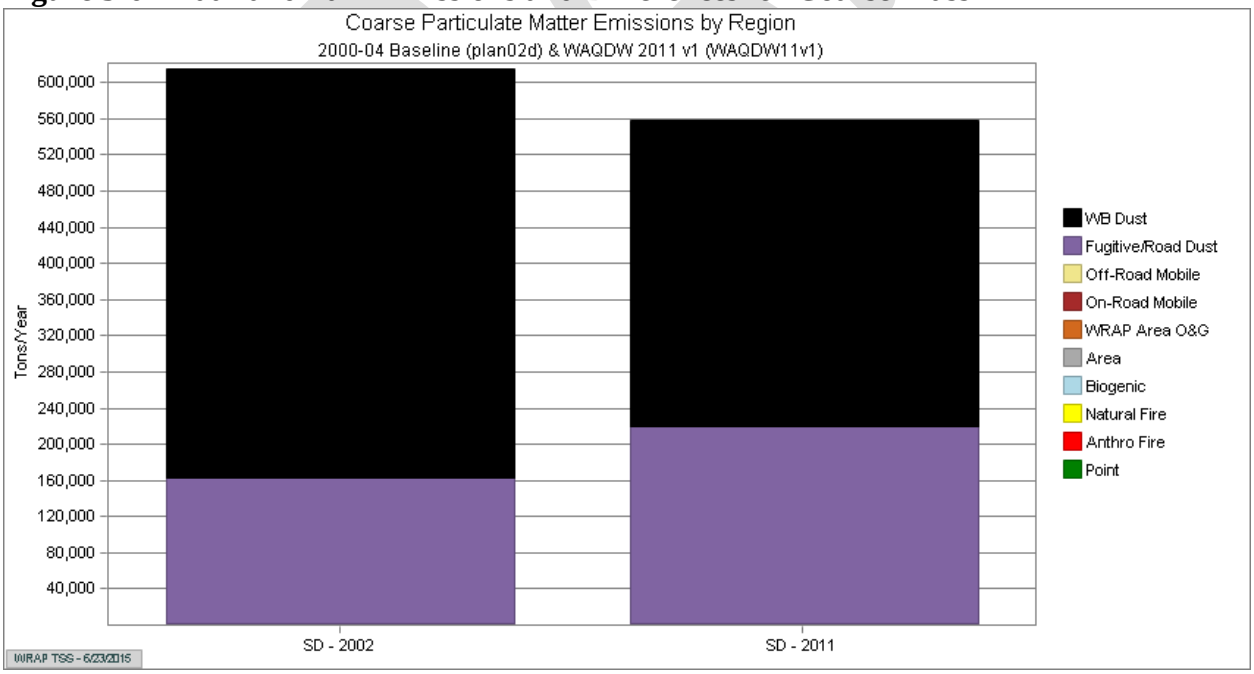
Table 3-24 – Changes in Coarse Mass Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	727	46	-681

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Area	156	727	571
On-Road Mobile	169	196	27
Off-Road Mobile	0	71	71
Area Oil and Gas	0	0	0
Fugitive and Road Dust	161,078	218,348	57,270
Anthropogenic Fire	6	229	223
Total Anthropogenic	**162,130**	**219,617**	**57,487**
Natural Sources			
Natural Fire	748	0	-748
Biogenic	0	0	0
Wind Blown Dust	452,470	337,891	-114,579
Total Natural	**453,218**	**337,891**	**-115,327**
All Sources			
Total Emissions	**615,348**	**557,508**	**-57,840**

South Dakota saw a decrease in coarse mass emissions of just over 57,000 tons during this time period. The largest decrease was seen in natural wind-blown dust at a little over 114,000 tons. The biggest increase was seen in anthropogenic fugitive and road dust at just over 57,000 tons. Similar to fine soil, the changes in coarse mass were likely due to enhancements in dust inventory methodology and not actual changes in emissions.

Figure 3-6 – 2002 and 2011 Emissions and Differences for Coarse Mass



Ammonia emissions are primarily a product of anthropogenic area sources such as feedlots, but can also be produced by vehicles and natural sources such as fire. Table 3-25 and Figure 3-7 show the changes in ammonia emissions from 2002 through 2011.

Table 3-25 – Changes in Ammonia Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	100	63	-37
Area	118,877	128,875	9,998
On-Road Mobile	842	345	-497
Off-Road Mobile	25	22	-3
Area Oil and Gas	0	0	0
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	20	511	491
Total Anthropogenic	**119,864**	**129,816**	**9,952**
Natural Sources			
Natural Fire	542	156	-386
Biogenic	0	0	0
Wind Blown Dust	0	0	0
Total Natural	**542**	**156**	**-386**
All Sources			
Total Emissions	**120,406**	**129972**	**9,566**

During this time period South Dakota saw an overall increase of just over 9,500 tons. The largest increase was seen in anthropogenic area sources at just under 10,000 tons. Small decreases were seen in anthropogenic on-road mobile and natural fire. The increase in area source emissions may be due to a combination of population changes and differences in methodologies used to estimate these emissions. As described earlier, one methodology change was the reclassification of some off-road mobile sources into the area source category, which may have contributed to the increase in area source inventory totals.

During that time frame, nitrogen oxide emissions in South Dakota decreased by just over 71,000 tons per year. The largest decrease was seen in natural biogenic which is primarily related to changes in the methodology and not actual reductions. Nitrogen oxide emissions from anthropogenic off-road mobile, on-road mobile and point sources were also reduced by just over 33,000 tons, which is most likely a result of new fuel and engine standards. The only real increase in nitrogen oxide emissions was from anthropogenic fires with an increase of 970 tons per year.

South Dakota saw an overall decrease in emissions of just fewer than 260,000 tons. The largest decrease was seen in natural biogenic at a little over 250,000 tons followed by anthropogenic area at a little less than 13,000 tons followed by smaller decreased in on-road mobile and off-road mobile. Increases of a little over 9,500 tons were seen in anthropogenic fire, while smaller increases were seen in area oil and gas and point sources. Estimates for biogenic emissions of VOCs have undergone significant updates since 2002, so changes reported are more reflective of methodology changes than actual changes in emissions.

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Figure 3-7 – 2002 and 2011 Emissions and Differences for Ammonia

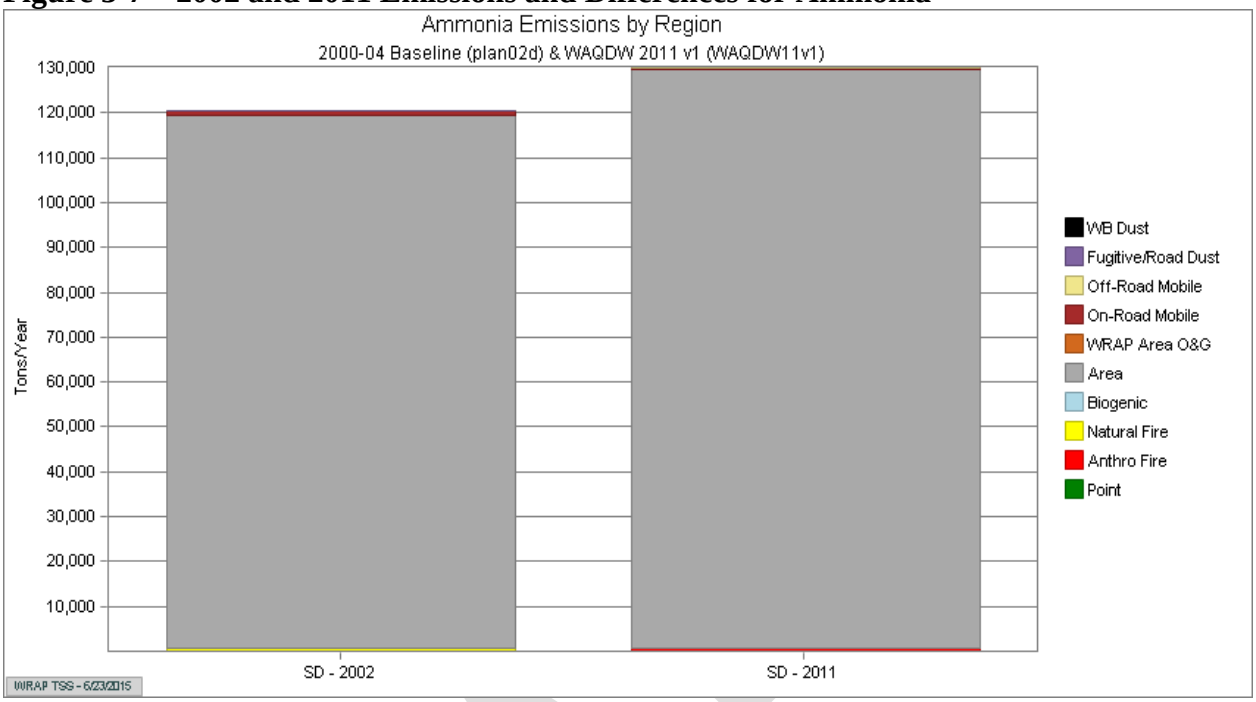
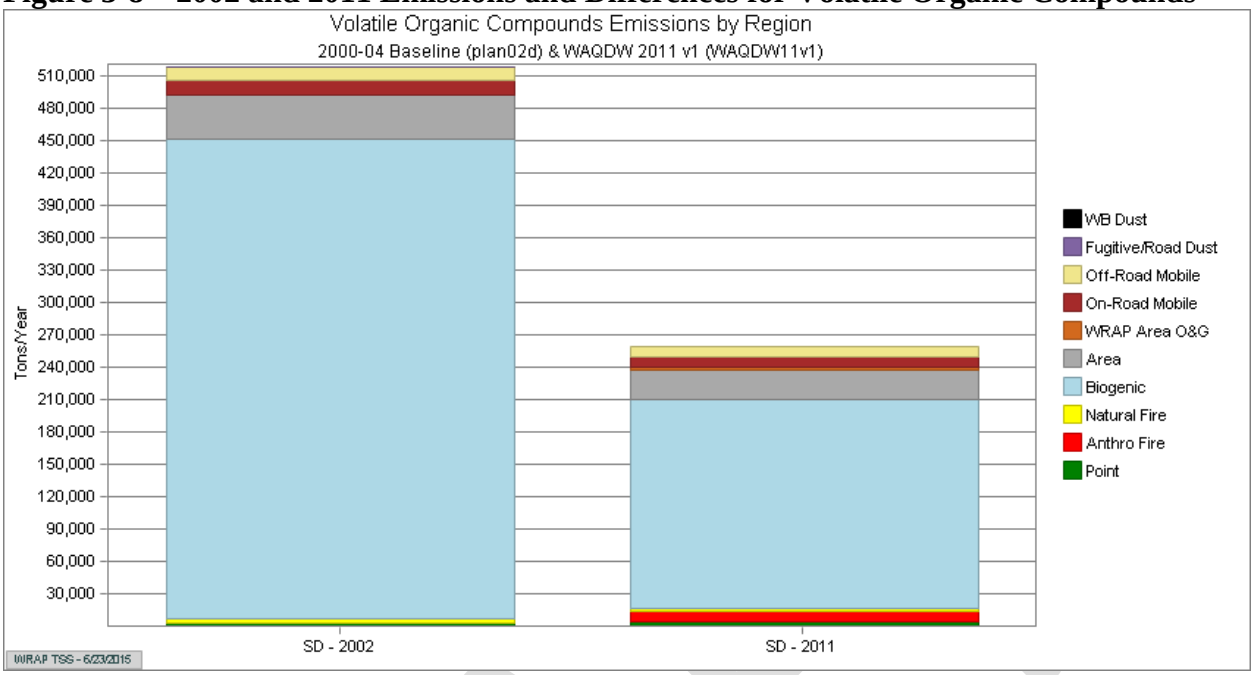


Table 3-26 – Changes in Volatile Organic Compounds Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	2,542	3,438	896
Area	40,551	27,810	-12,741
On-Road Mobile	13,741	9,978	-3,763
Off-Road Mobile	12,764	9,591	-3,173
Area Oil and Gas	288	1,444	1,156
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	95	9,646	9,551
Total Anthropogenic	**69,981**	**61,907**	**-8,074**
Natural Sources			
Natural Fire	3,758	3,886	128
Biogenic	445,241	193,337	-251,904
Wind Blown Dust	0	0	0
Total Natural	**448,999**	**197,223**	**-251,776**
All Sources			
Total Emissions	**518,980**	**259,130**	**-259,850**

Figure 3-8 – 2002 and 2011 Emissions and Differences for Volatile Organic Compounds



Carbon monoxide is produced from both anthropogenic and natural sources and is also naturally present in the atmosphere in small amounts. Vehicle exhaust is a major producer of carbon monoxide emissions as is anthropogenic and natural fire. Table 3-27 and Figure 3-9 show the changes in carbon monoxide emissions from 2002 through 2011.

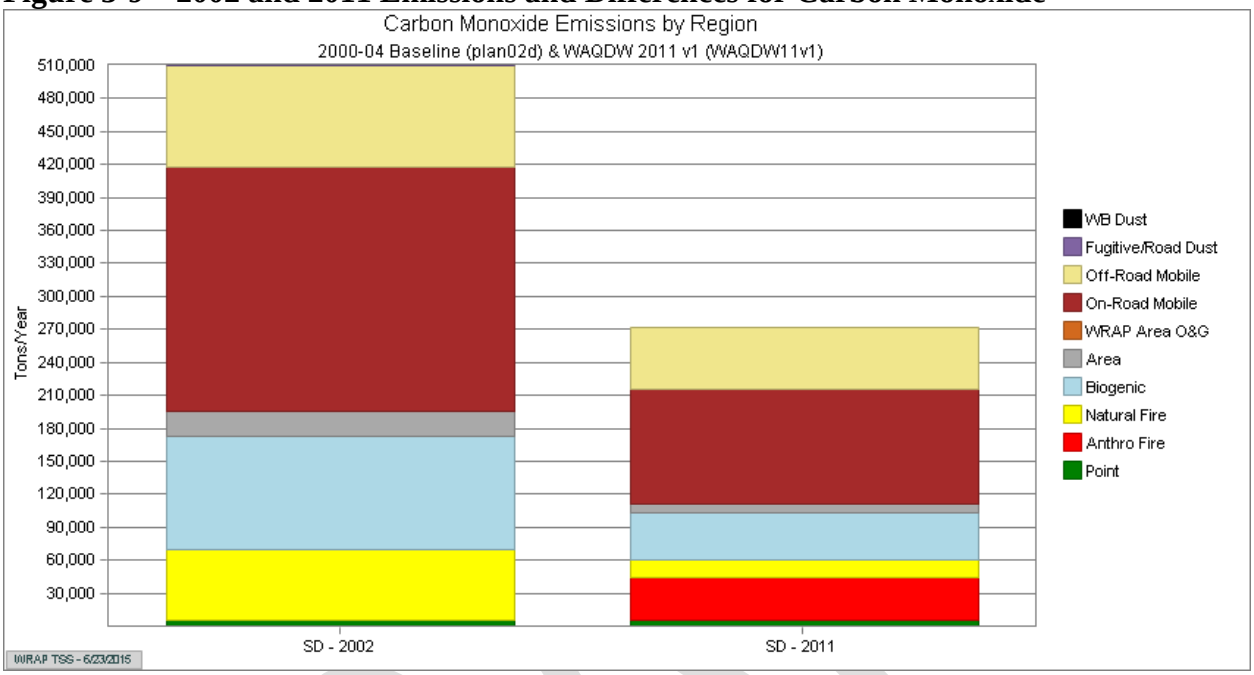
Table 3-27 – Changes in Carbon Monoxide Emissions (tons per year)

Major Source Category	2002 (Plan02d)	2011 (2011WAQDW)	Difference
Anthropogenic Sources			
Point	4,700	4,908	208
Area	23,029	8,738	-14,291
On-Road Mobile	221,726	104,678	-117,048
Off-Road Mobile	92,508	56,232	-36,276
Area Oil and Gas	11	307	296
Fugitive and Road Dust	0	0	0
Anthropogenic Fire	1,016	39,131	38,115
Total Anthropogenic	**342,990**	**213,994**	**-128,996**
Natural Sources			
Natural Fire	63,310	16,370	-46,940
Biogenic	103,402	42,000	-61,402
Wind Blown Dust	0	0	0
Total Natural	**166,712**	**58,370**	**-108,342**
All Sources			
Total Emissions	**509,702**	**272,364**	**-237,338**

South Dakota saw an overall decrease in emissions of just fewer than 240,000 tons. Large decreases were seen in anthropogenic on-road mobile, off-road mobile, area and natural biogenic

and fire. The only major increase was seen in anthropogenic fire at just over 38,000 tons. The large decrease in on-road and off-road mobile is likely due to new federal fuel and vehicle emission standards than have been implemented.

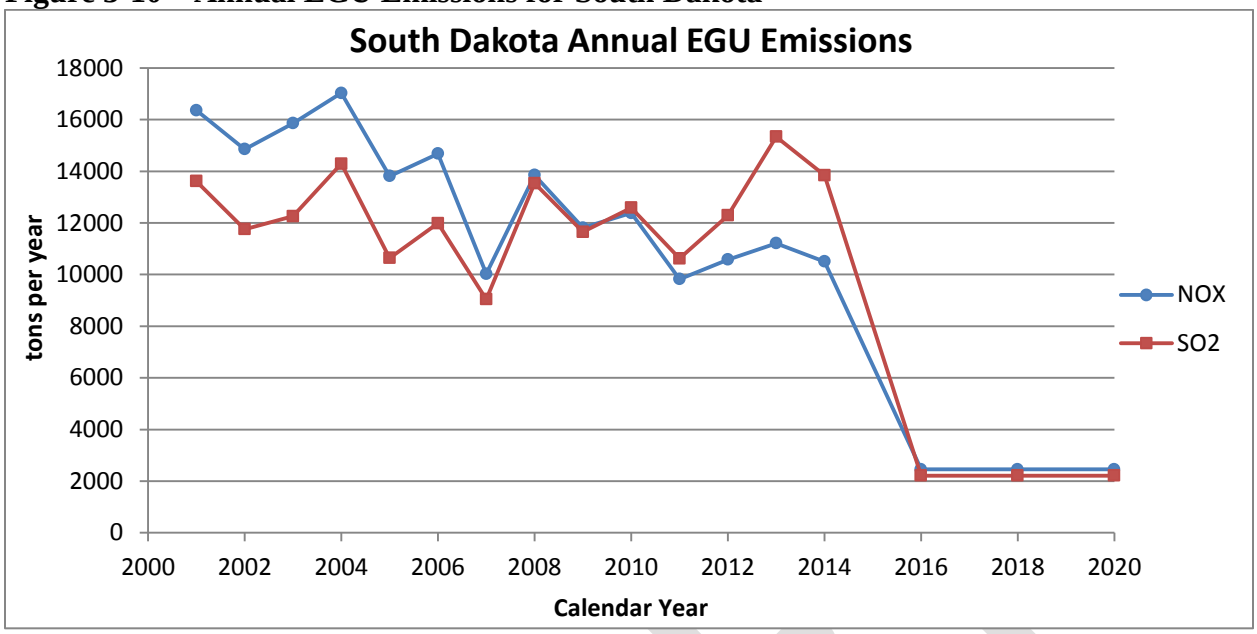
Figure 3-9 – 2002 and 2011 Emissions and Differences for Carbon Monoxide



As described in previous sections, differences between the baseline and progress period inventories presented here do not necessarily represent changes in actual emissions because numerous updates in inventory methodologies have occurred between the developments of the separate inventories. To better account for year-to-year changes in emissions, annual emission totals for South Dakota electrical generating units (EGU) are presented here. Electrical generating unit emissions are some of the more consistently reported emissions, as tracked in EPA's Air Markets Program Database for permitted Title V facilities in the state (http://ampd.epa.gov/ampd/). Regional Haze Rule implementation plans are required to pay specific attention to certain major stationary sources, including electrical generating units, built between 1962 and 1977.

Figure 3-10 presents a sum of annual nitrogen oxide and sulfur dioxide emissions as reported for South Dakota's electrical generating unit (Big Stone I) starting in 2001. While these types of facilities are targeted for controls in state regional haze state implementation plans, it should be noted that many of the controls planned for electrical generating units in the WRAP states are just starting to take effect. The new air pollution controls installed at Big Stone I will be operational in the fall of 2015 and the new limits are reflected in Figure 3-10.

Figure 3-10 – Annual EGU Emissions for South Dakota



3.5 Assessment of Changes Impeding Visibility Progress

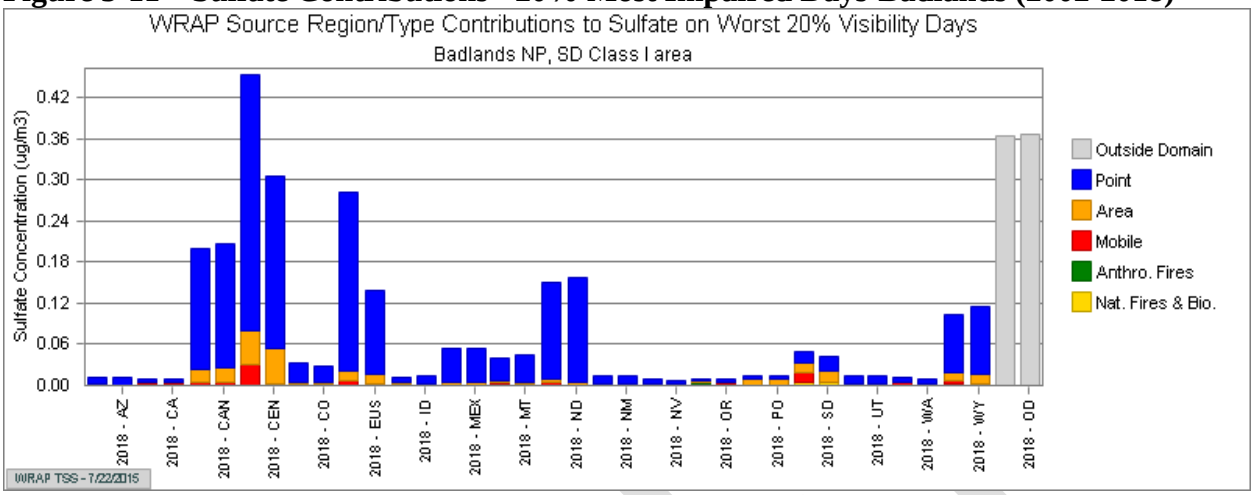
In accordance with 40 CFR§ 51.308 (g)(5) the report shall include an assessment of any significant changes in anthropogenic emissions within or outside the state that have occurred over the past 5 years that have limited or impeded progress in reducing pollutant emissions and improving visibility. As noted throughout this report, progress is being made to improve the visibility at both Badlands National Park and Wind Cave National Park for the 20% most impaired days and the 20% least impaired days.

The aerosol species which contributes the most to visibility impairment at the Badlands National Park is ammonium sulfate for the 20% most impaired days. According to the WRAP's source apportionment modeling used in South Dakota's Regional Haze State Implementation Plan, very little of the ammonium sulfate contribution comes from South Dakota sources. The largest contributors are point sources in the Central Regional Air Planning Association (CENRAP) region; Outside Domain, Eastern United States, Canada, North Dakota and Wyoming (see Figure 3-11). In Figure 3-11 WRAP identifies ammonium sulfate as sulfate which is one in the same.

The WRAP modeling indicates the major contributor to ammonium sulfate at the Badlands National Park by 2018 will be Outside Domain. Outside Domain is characterized by WRAP as emissions from all areas not included in the modeling domain. The modeling domain includes the United States, most of Canada and Mexico and Pacific offshore. While the Central Regional Air Planning Association region and Eastern United States show substantial decreases from 2002 to 2018, the Central Regional Air Planning Association region is still projected to be the second largest contributor for ammonium sulfates at the Badlands National Park by 2018. Canada, North Dakota and Wyoming all show slight increases over the same periods. South Dakota's contribution of ammonium sulfate shows an increase by 2018. The increase is based on three proposed sources being constructed in South Dakota which offsets the reductions occurring at

Big Stone I. The three proposed sources have since fell through and the DENR anticipates South Dakota's ammonium sulfate contribution from point sources will decline by 2018.

Figure 3-11 – Sulfate Contributions - 20% Most Impaired Days-Badlands (2002-2018)



At the Wind Cave National Park, particulate organic mass is the aerosol species which contributes the most to visibility degradation on the 20% most impaired days. Particulate organic mass is often a product of anthropogenic and natural fires. While comparing the fire data with the data for the 20% most impaired days from past years, the DENR noticed the majority of the 20% most impaired days occurred at both the Wind Cave and Badlands National Parks, indicating a more regional emissions problem such as large wildfires and long range transport from sources outside of South Dakota. However, the DENR did find prescribed fires that were conducted by the National Park Service at the Wind Cave National Park that contributed to very high levels of particulate organic mass and elemental carbon and caused the average deciview values at the IMPROVE site to increase substantially. Below are two examples of prescribed fires that were conducted at the Wind Cave National Park in 2009 and 2010.

The first prescribed fire was approximately 650 acres and began on September 3, 2009, and it took multiple days to complete. One of the 20% most impaired days at the Wind Cave National Park occurred on September 7, 2009. While reviewing the IMPROVE data for the time period of the fire the DENR discovered that September 4, 2009, which was an IMPROVE sampling day, was invalid. That day had extremely high levels of particulate organic mass but was missing values for fine soil and coarse mass because the fire and heavy smoke plugged one of the sampling modules. The DENR was informed by an IMPROVE representative, that if any module plugs and the data are missing, the whole day is considered invalid. Most likely, September 4, 2009, would have been considered one of the 20% most impaired days if it had not been considered invalid.

The DENR operates its own air monitoring station at the Badlands National Park and the Wind Cave National Park. During the prescribed fire, the DENR's air monitors at the Wind Cave National Park exceeded the National Ambient Air Quality Standard for particulate matter 2.5 microns in diameter or less (PM2.5) and particulate matter 10 microns in diameter or less (PM10), with values of 303 micrograms per cubic meter (ug/m³) and 337 ug/m³, respectively, on

September 4. The monitoring equipment also identified exceedances on September 3, 5 and 6 for PM2.5. Therefore, it is very likely that additional days would have been designated as a 20% most impaired day if the IMPROVE samplers operated daily rather than every third day.

Figure 3-12 shows the aerosol species contribution for each of the 20% most impaired days at the Wind Cave National Park for 2009. Clearly, particulate organic mass makes up the majority of the extinction on September 7, which is just days after the fire was started.

Figure 3-12 – Contributions to 20% Most Impaired Days at Wind Cave for 2009

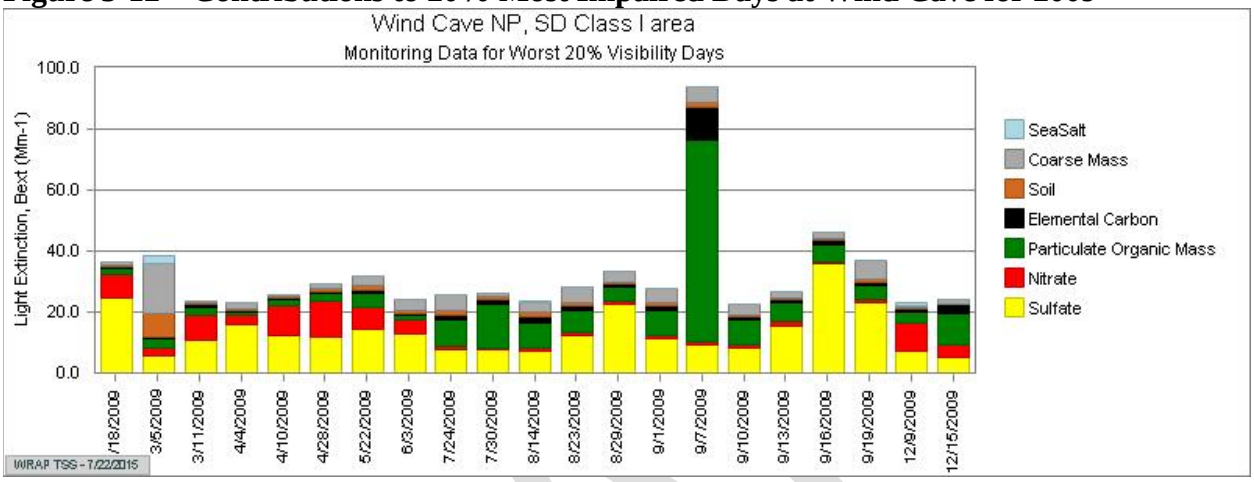


Figure 3-13 shows the deciview levels for the 20% most impaired days of 2009 and demonstrates how much higher the level is due to the influence of the prescribed fire conducted by the National Park Service.

Figure 3-13 – Deciview Values for Wind Cave - 20% Most Impaired Days – 2009

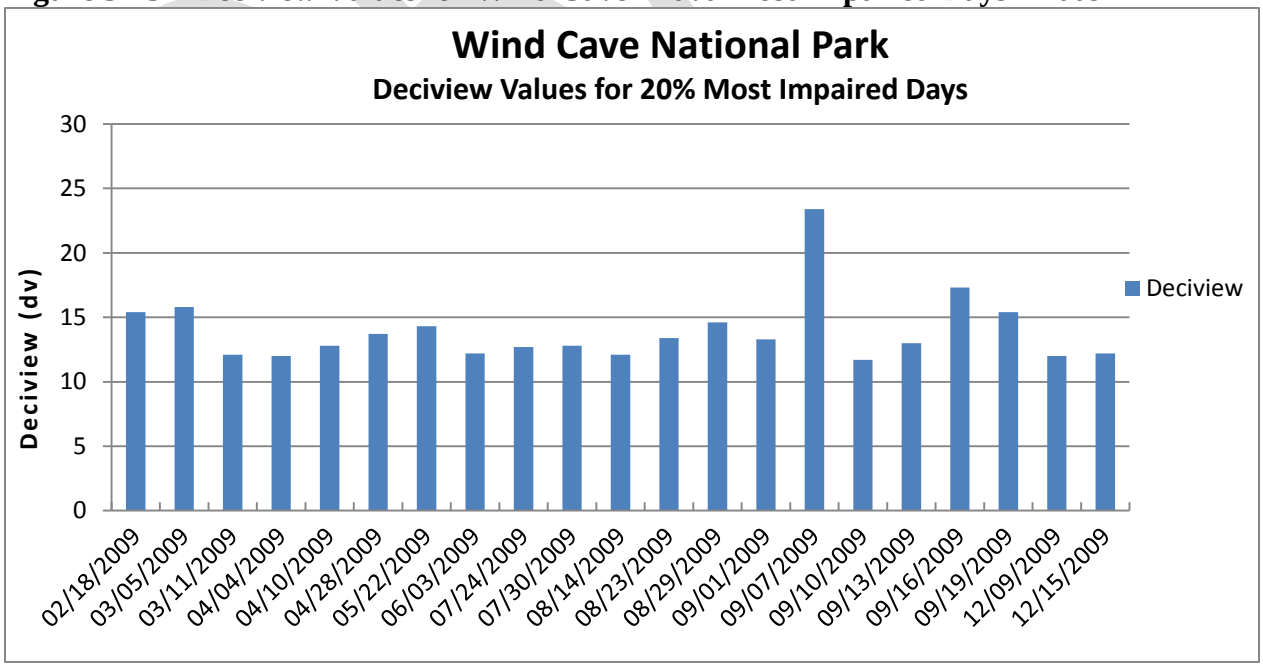


Table 3-28 shows the light extinction value of each aerosol species for the 20% most impaired days for the Wind Cave National Park in 2009. Here you can see how high the values are for particulate organic mass and elemental carbon on the sampling day during the fire compared to the other 20% most impaired days.

Table 3-28 – Aerosol Extinction Values - 20% Most Impaired Days - Wind Cave - 2009

Date	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
02/18/2009	24.79	7.45	2.01	0.81	0.37	1.15	0
03/05/2009	5.73	2.28	3.5	0.12	8.09	16.23	2.66
03/11/2009	10.68	8.07	2.65	1.02	0.78	0.41	0
04/04/2009	15.68	3.45	1.13	0.34	0.6	1.96	0
04/10/2009	12.43	9.56	1.9	0.52	0.67	0.8	0
04/28/2009	11.68	11.85	2.71	0.65	0.6	1.72	0
05/22/2009	14.43	7.12	4.65	1.07	1.58	2.94	0
06/03/2009	12.6	4.6	1.9	0.29	1.03	3.46	0
07/24/2009	7.94	0.66	8.91	1.34	1.61	5.02	0
07/30/2009	7.86	0.35	14.11	1.88	0.71	1.14	0
08/14/2009	7.29	0.93	8.3	2.09	1.33	3.19	0.43
08/23/2009	12.2	1.1	7.36	1.25	1.31	4.86	0
08/29/2009	22.78	0.85	4.56	0.91	0.85	3.24	0
09/01/2009	11.3	1.24	7.96	1.41	1.21	4.67	0
09/07/2009	9.32	1.14	**66**	**10.5**	1.57	5.37	0
09/10/2009	8.13	0.87	8.23	1.27	0.69	3.19	0
09/13/2009	15.21	1.8	5.9	1.12	0.45	2.26	0.12
09/16/2009	35.91	0.74	5.4	1.37	0.78	2.21	0
09/19/2009	22.88	1.18	4.61	0.95	1.29	5.81	0
12/09/2009	7.25	9.11	3.46	1.31	0.26	0.88	1.04
12/15/2009	5.35	4.1	10.2	2.9	0.16	1.33	0

The second prescribed fire was conducted on October 20, 2010 approximately 1 mile north of the monitoring site and consumed approximately 5,500 acres and lasted multiple days. The impact from this fire created two of the 20% most impaired days for 2010 on October 20 and 23. The extraordinarily high levels from the IMPROVE samplers can be seen in Table 3-29. As noted earlier, the DENR operates air sampling monitors for particulate matter at the Wind Cave National Park. The PM2.5 monitor showed values exceeding the National Ambient Air Quality Standard on October 20 and 21, which shows that days other than IMPROVE sampling days are being affected.

Figure 3-14 shows the aerosol species contribution for each of the 20% most impaired days at Wind Cave National Park for 2010. Clearly, particulate organic mass makes up nearly all of the extinction on two days, which were the day of the prescribed fire and the next sampling day.

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Figure 3-14 – Contributions to 20% Most Impaired Days at Wind Cave for 2010

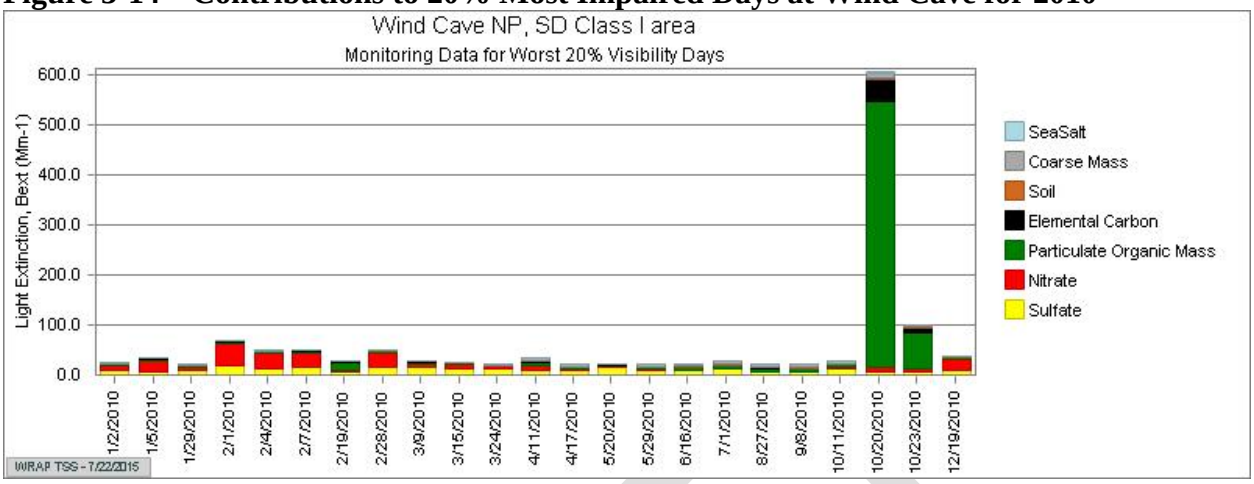

Figure 3-15 shows the deciview level for the 20% most impaired days of 2010 and demonstrates how high the level is due to the influence of the prescribed fire conducted by the National Park Service. The deciview level for October 20 was 41.2 followed by a 23.9 deciview reading on the next sampling day, which was October 23. The 2010 annual deciview average was 15.4 with the two high days. If you remove the 41.2 and the 23.9 deciview values and replace them with the annual average value of 15.4, it would bring the 2010 annual average down to 13.9 deciviews, which shows the tremendous impact even one event can have on the visibility.

Figure 3-15 – Deciview Values for 20% Most Impaired Days at Wind Cave for 2010

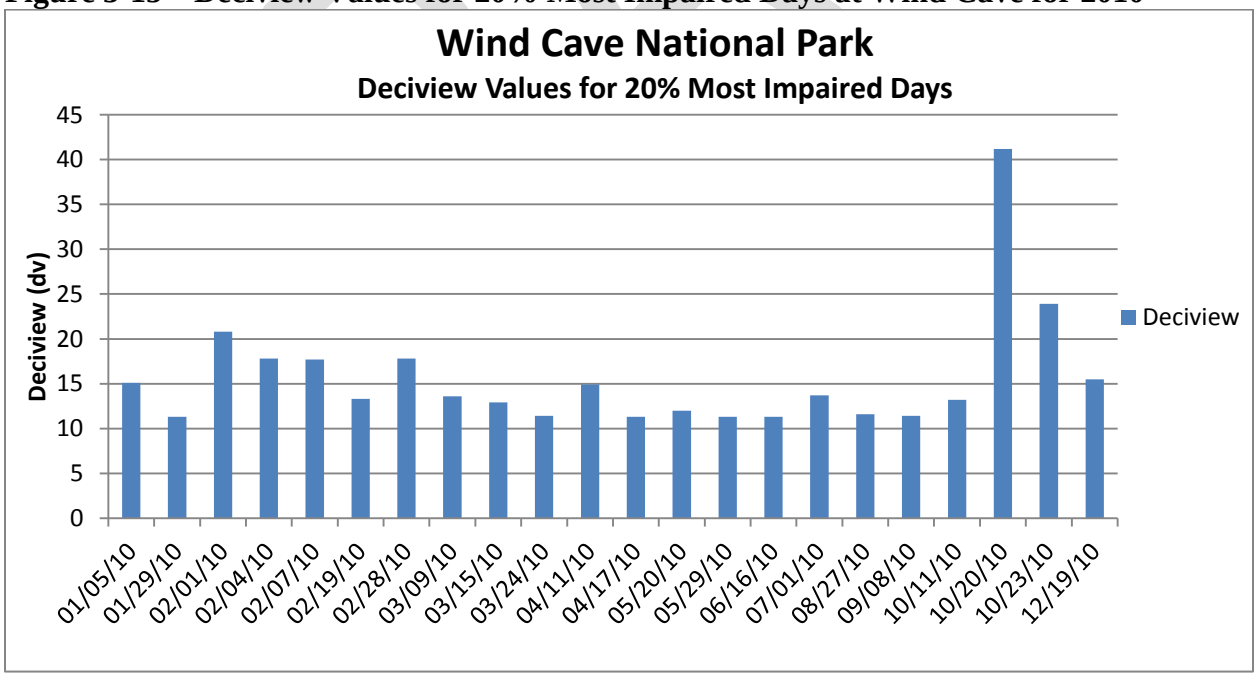

Table 3-29 shows the extinction value of each aerosol species for the 20% most impaired days for Wind Cave in 2010. Here you can see how high the values are for particulate organic mass and elemental carbon on the days of the fire compared to the other 20% most impaired days.

Table 3-29 – Aerosol Extinction Values - 20% Most Impaired Days - Wind Cave - 2010

Date	Ammonium Sulfate	Ammonium Nitrate	Particulate Organic Mass	Elemental Carbon	Soil	Coarse Mass	Sea Salt
01/02/2010	8.93	10.14	2.62	1.21	0.2	0.56	0
01/05/2010	6.21	21.89	3.92	1.89	0.13	1.26	0
01/29/2010	8.35	8.21	1.82	0.99	0.29	1.16	0
02/01/2010	19.92	43.28	3.78	1.29	0.32	1.51	0
02/04/2010	11.17	32.12	3.55	1.34	0.25	0.62	0
02/07/2010	15.39	28.26	3.61	1.33	0.14	0	0
02/19/2010	5.9	3.59	15.21	2.22	0.12	0.61	0
02/28/2010	16.31	28.66	2.6	0.92	0.27	0.79	0
03/09/2010	15.39	7.25	3.69	1.14	0.42	1.1	0
03/15/2010	13.9	8.27	2.28	0.74	0.32	0.91	0
03/24/2010	12.2	6.24	0.82	0.34	0.68	1.09	0
04/11/2010	10.06	8.34	7.02	2.09	1.36	5.51	0
04/17/2010	7.86	4.5	2.02	0.76	1.51	4.22	0
05/20/2010	15.08	2.88	1.62	1	0.51	2.04	0
05/29/2010	10.11	1.95	3.51	0.78	0.85	3.8	0
06/16/2010	9.35	1.48	5.18	1.02	0.57	3.32	0
07/01/2010	11.3	0.92	5.93	1.54	1.44	8.28	0
08/27/2010	4.91	0.67	8.34	1.75	1.38	4.71	0.01
09/08/2010	5.51	0.94	5.1	1.2	1.95	6.41	0
10/11/2010	13.85	1.52	5.53	1.5	0.98	3.94	0
10/20/2010	6.69	8.89	**532.39**	**44.37**	0.92	10.85	2.2
10/23/2010	7.12	5.47	**70.81**	**11.75**	1.34	2.12	0
12/19/2010	8.22	23.99	2.6	1.1	0.14	0.96	0

Although visibility progress is being made at both Class I areas in South Dakota, sources outside of South Dakota such as large wildfires and certain prescribed fires in-state continue to have the biggest impact on visibility. While this progress report was being developed, more events occurred in 2015 that will likely have an impact on the visibility at our Class I areas. A prescribed fire in April that started in the Wind Cave National Park escaped and became a wildfire event that burned for multiple days. The prescribe fire caused high values on the DENR's particulate monitors including an exceedance of the National Ambient Air Quality Standard for PM2.5 on April 13, which is the day the fire started. The DENR believes this will correlate to high deciview levels when the 2015 IMPROVE data become available for review. The other events the DENR believes will have a tremendous impact on our visibility are the wildfires that burned in Canada, Alaska and the west coast for much of the summer of 2015.

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South Dakota, along with many states saw a huge impact from the smoke including exceedances of the PM2.5 standard at all of South Dakota's monitoring sites across the state on July 6. Additional exceedances were recorded at various monitoring sites in South Dakota throughout late June and July. Again, we anticipate South Dakota's IMPROVE sites will record some of the 20% most impaired days during this time period.

3.6 Assessment of Current Strategy

In accordance with 40 CFR§ 51.308 (g)(6), the progress report requires an assessment of whether the current implementation plan elements and strategies are sufficient to enable the state, or other states with Class I areas affected by emissions from the state, to meet all established reasonable progress goals.

3.6.1 Assessment of Emissions Strategy

WRAP's modeling indicates the majority of the emissions that impact the Class I areas in South Dakota are transported in from outside of the state. The occurrence of the same or similar days making up the 20% most impaired days at South Dakota's two Class I areas supports this conclusion. The areas impacting South Dakota's two Class I areas include the CENRAP states, outside domain, the eastern United States and Canada. There are also impacts from some of the WRAP states and non-WRAP states bordering South Dakota. In addition, the 2015 wildfires occurring in California, Oregon, Washington, Idaho, Montana, and Canada have impacted not only the two Class I areas but all of South Dakota.

The WRAP modeling conducted for the initial Regional Haze State Implementation Plan identifies large decreases that are expected by 2018 from many of the point sources due to the implementation of the BART rules. One of the large decreases will occur in South Dakota. The BART controls being installed on Big Stone I will be completed and operational in the fall of 2015 and will result in an 89% decrease in sulfur dioxide emissions and 86% decrease in nitrogen oxide emissions on an annual basis. This, in addition to reductions associated with other federal and state regulations, some of which have already been realized will continue to improve South Dakota's air quality.

In addition, the 2018 projected air emissions for South Dakota included approximately 6,100 tons of sulfur dioxide, 4,900 tons of nitrogen oxides and 9,500 tons of carbon monoxide from three large facilities that were proposed but not constructed during the development of the Regional Haze State Implementation Plan. The first facility was Big Stone II, which was a proposed 600 megawatt coal-fired power plant located next to an existing coal-fired power plant (Big Stone I) in the northeast corner of the state near the Minnesota border. The second facility was the Hyperion Energy Center, which was planned to be built in the southeastern corner of the state near Elk Point, South Dakota. Hyperion Energy Center was a 400,000 barrel per day oil refinery and integrated gasification combine cycle power plant. The third facility was a coal-fired power plant proposed by Basin Electric and had a maximum capacity of 700 megawatts. Its location was in the north central part of the state.

All three of these facilities' emissions were included in the 2018 projections for South Dakota. However, not one of these facilities is being constructed and is no longer in the plans to be constructed in the future.

3.6.2 Uniform Rate of Progress

Table 3-30 shows the amount of progress achieved toward the Uniform Rate of Progress using the current progress period of 2009-2013 for the aerosol extinction species, the total light extinction and the deciview level for Badlands National Park on the 20% most impaired days. Ammonium sulfate and ammonium nitrate are the only two species that have not quite achieved the Uniform Rate of Progress for 2018. Despite the fact that ammonium sulfate and ammonium nitrate are above the Uniform Rate of Progress for 2018 at the Badlands National Park, the other aerosols are below the Uniform Rate of Progress for 2018 and the deciview value is approaching the 2018 Uniform Rate of Progress target. With the upgrades to Big Stone I and other BART sources' air pollution controls around the region, which will lower sulfur dioxide and nitrogen oxide emissions, the DENR believes the steady trend of improvement that is displayed in Figures 3-16 and 3-17 will continue and the Badlands National Park should meet the deciview target level of the Uniform Rate of Progress in 2018.

Table 3-30 – Progress Toward the 2018 Target, Badlands 20% Most Impaired Days

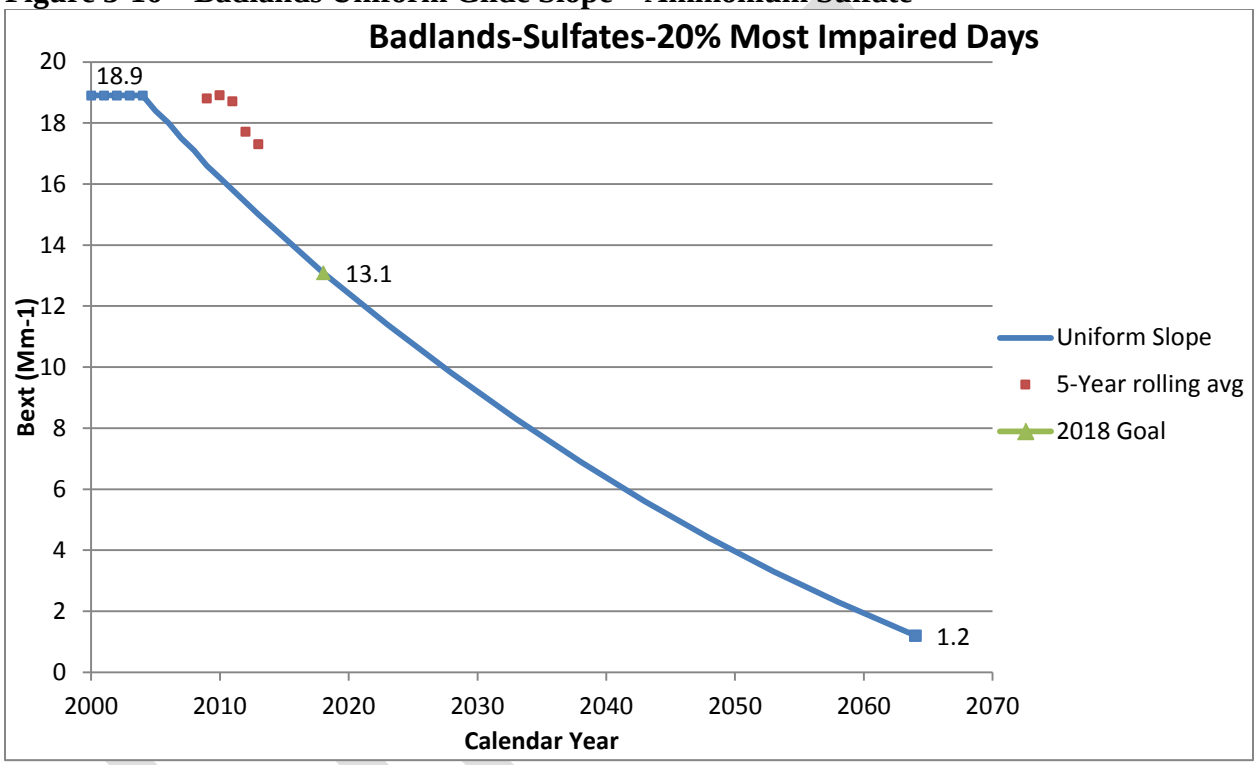
	Monitored	**Estimated**		**Monitored**
	2000 – 2004 Baseline Conditions (Mm^{-1})	**Current Visibility Conditions 2009-2013 (Mm^{-1})**	**2018 Uniform Rate of Progress Target (Mm^{-1})**	**2064 Natural Conditions (Mm^{-1})**
Ammonium Sulfate	18.9	17.3	13.1	1.2
Ammonium Nitrate	5.8	6.1	4.5	0.9
Particulate Organic Mass	11.8	7.2	9.7	4.1
Elemental Carbon	2.6	1.6	2.0	0.3
Fine Soil	1.0	0.9	1.0	1.0
Coarse Mass	5.9	4.8	5.5	4.0
Sea Salt	0.2	0.1	0.2	0.2
Total Extinction	57.2	49.0	46.0	22.7
Deciview	17.1	15.7	15.0	8.1

Figure 3-16, 3-17, 3-18, and 3-19 display the Uniform Glide Slope for ammonium sulfate, ammonium nitrate, particulate organic mass, and deciviews, respectively, for the 20% most impaired days at the Badlands National Park. In each figure, the Uniform Glide Slope starts with the baseline period of 2000-2004 and ends with the 2064 natural conditions. Displayed on the slope is the 2018 Uniform Rate of Progress target. The red squares in the graph represent the 5-year rolling average starting for calendar year 2009 through 2013. The 5-year rolling averages are derived from Table 3-9.

Ammonium sulfate is the largest contributor to light extinction during the 20% most impaired days at the Badlands National Park. The 2000-2004 baseline 5-year average for ammonium sulfate is 18.9 Mm^{-1}. The ammonium sulfate levels remained fairly steady in the 2005-2009 5-

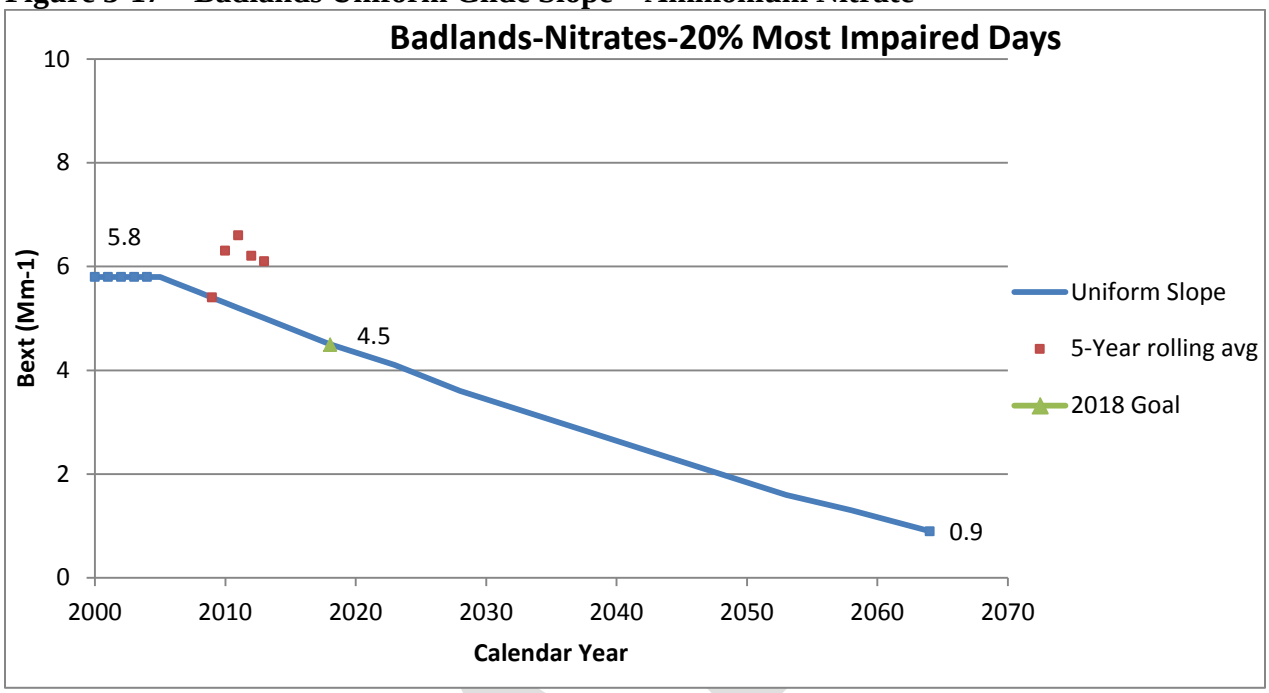
year average. However, a fairly high yearly average in 2010 of 22.2 Mm^{-1} raised the 5-year average above the baseline. The DENR is unsure of the cause of the high yearly average in 2010 since WRAP's 2011 emission inventory for South Dakota indicates a 40% decrease in sulfur dioxide emissions from 2002 through 2011. 2012 and 2013 saw significantly lower values and the DENR expects that trend to continue as Big Stone I and other facilities across the region start operating their BART air pollution controls and continue to reduce sulfur dioxide emissions. The DENR believes these reductions will put South Dakota's ammonium sulfate levels on or below the 2018 Uniform Rate of Progress target.

Figure 3-16 – Badlands Uniform Glide Slope – Ammonium Sulfate



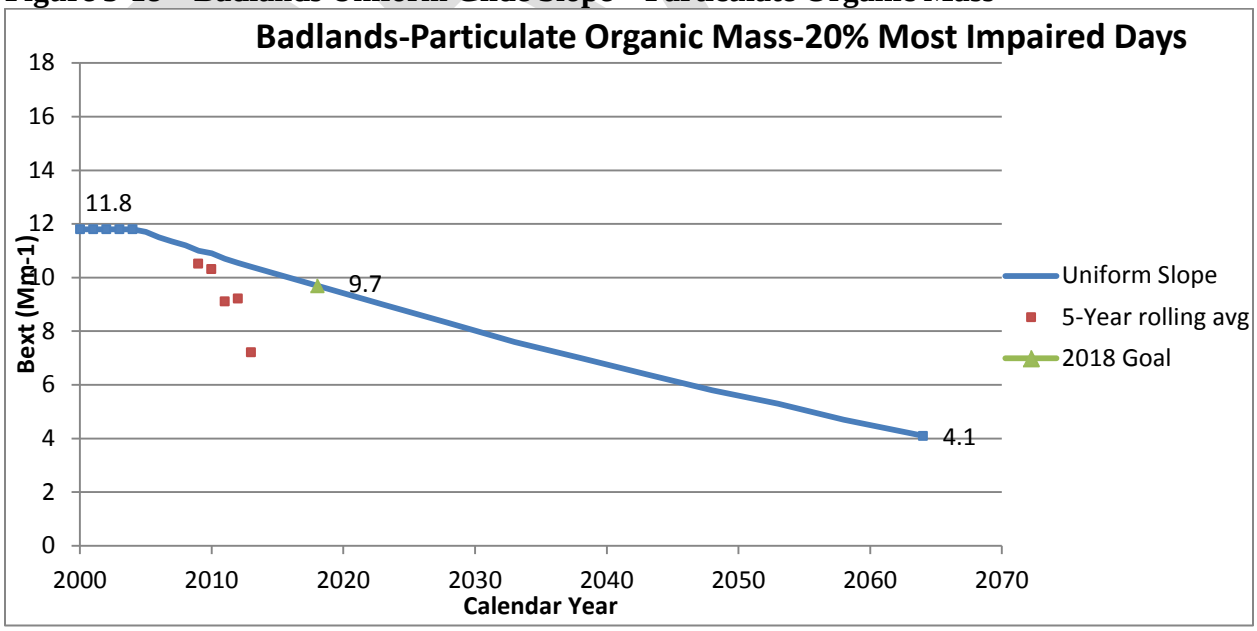
Ammonium nitrate has the third largest impact on visibility at the Badlands National Park during the 20% most impaired days. Similar to ammonium sulfate, the ammonium nitrate level in 2010 was very high, nearly twice as high as the baseline and subsequent years. The 2009 value was on the uniform glide slope and had it not been for the high value in 2010 of 10.9 Mm^{-1} the remaining years would have been on or very near the glide slope as well. Again, the DENR is unsure of the cause of the high yearly average in 2010 since WRAP's 2011 emission inventory for South Dakota indicates a greater decrease in nitrogen oxide emissions of 49% from 2002 through 2011. After 2010, the 5-year averages begin to drop again and the DENR believes the ammonium nitrate levels will also continue to fall as the BART air pollution controls at Big Stone I and other facilities across the region are installed and come online. The DENR believes these reductions will allow South Dakota's ammonium nitrate levels to be on or below the 2018 Uniform Rate of Progress target.

Figure 3-17 – Badlands Uniform Glide Slope – Ammonium Nitrate



Particulate organic mass is the second largest contributor to visibility extinction at the Badlands National Park during the 20% most impaired days. Particulate organic mass is typically a product of fires, both wildfire and prescribed fire. The number and size of fires both locally and throughout the United States and Canada can vary greatly year by year. The 2009 through 2013 5-year averages for particulate organic mass are well below the uniform slope, which is a trend the DENR believes will continue.

Figure 3-18 – Badlands Uniform Glide Slope – Particulate Organic Mass



A good indication on if a Class I area is meeting the 2018 Uniform Rate of Progress target is looking at deciview values. Despite the fact that the ammonium sulfate and ammonium nitrate values are slightly higher than the Uniform Glide Slope, the deciview values are hovering near the line. This is due to lower levels of particulate organic mass as well as decreases in coarse mass, elemental carbon and fine soil mass. The DENR believes the deciview graph for the Badlands National Park's 20% most impaired days demonstrates South Dakota is on track in meeting the 2018 Uniform Rate of Progress target at the Badlands National Park.

Figure 3-19 – Badlands Uniform Glide Slope – Deciview

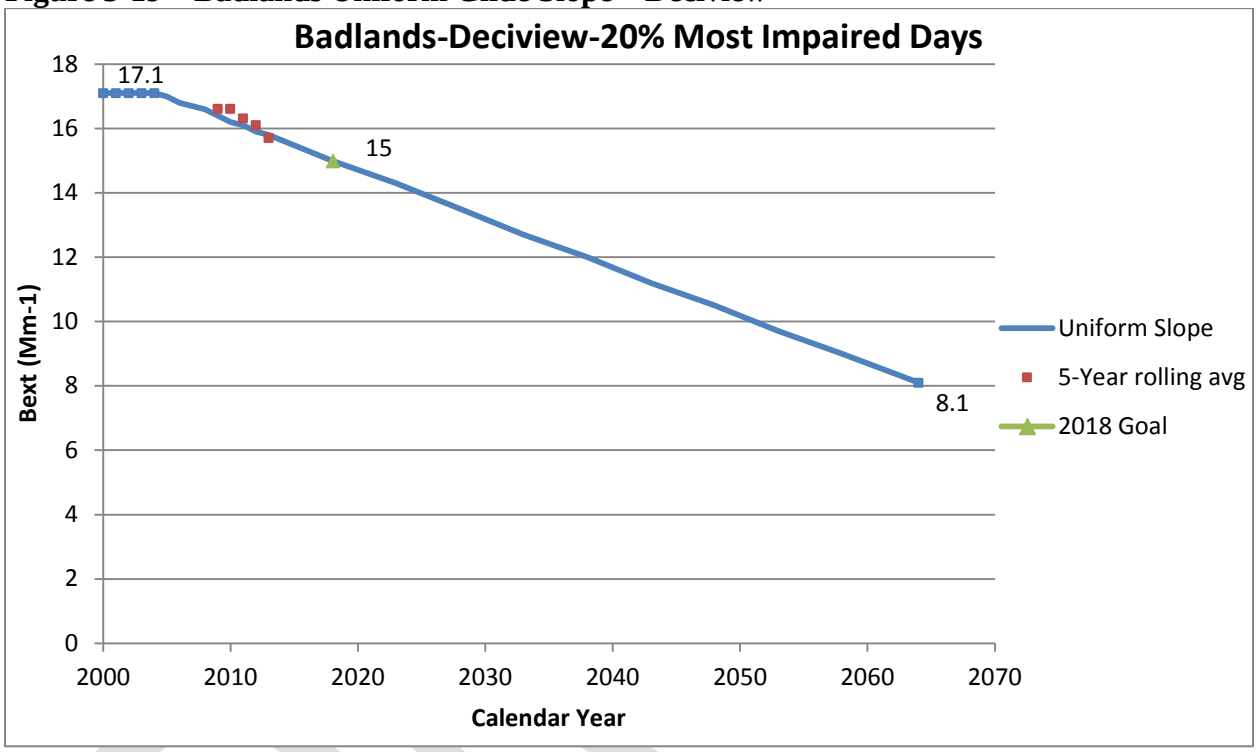


Table 3-31 shows the amount of progress achieved for the aerosol light extinction species, the total light extinction and the deciview level for the Wind Cave National Park on the 20% most impaired days. Ammonium sulfate, ammonium nitrate and particulate organic mass are very close to the 2018 projected levels, while elemental carbon, fine soil and coarse mass are at or below the 2018 projected levels. South Dakota's largest ammonium sulfate and ammonium nitrate contributor, Big Stone I will cut its sulfur dioxide emissions from approximately 13,000 tons per year down to 2,200 tons per year, while also cutting its nitrogen oxide emissions from approximately 10,000 tons per year to 2,400 tons per year starting in 2016. Particulate organic mass levels vary depending on the year and the number of wildfires in South Dakota, nationally, and Canada.

Table 3-31 – Progress Toward the 2018 Target, Wind Cave 20% Most Impaired Days

	Monitored	Estimated		Monitored
	2000 – 2004 Baseline Conditions (Mm^{-1})	**Current Visibility Conditions 2009-2013 (Mm^{-1})**	**2018 Uniform Rate of Progress Target (Mm^{-1})**	**2064 Natural Conditions (Mm^{-1})**
Ammonium Sulfate	13.2	11.6	9.5	1.1
Ammonium Nitrate	7.0	6.2	5.4	1.2
Particulate Organic Mass	13.2	13.2	10.8	4.4
Elemental Carbon	2.9	2.1	2.3	0.4
Fine Soil	0.9	0.9	0.9	1.0
Coarse Mass	3.5	3.1	3.6	3.8
Sea Salt	0.0	0.1	0.0	0.0
Total Extinction	50.7	47.2	41.7	21.9
Deciview	15.8	14.1	13.9	7.7

Figure 3-20, 3-21, 3-22, and 3-23 display the Uniform Glide Slope for ammonium sulfate, ammonium nitrate, particulate organic mass, and deciviews, respectively, for the 20% most impaired days at the Wind Cave National Park. In each figure, the Uniform Glide Slope starts with the baseline period of 2000-2004 and ends with the 2064 natural conditions. Displayed on the slope is the 2018 Uniform Rate of Progress target. The red squares in the graph represent the 5-year rolling average starting for calendar year 2009 through 2013. The 5-year rolling averages are derived from Table 3-10.

Ammonium sulfate is the second largest contributor to light extinction at the Wind Cave National Park during the 20% most impaired days. Although not shown on this graph, 2006 and 2007 had ammonium sulfate levels higher than the baseline which raised the 2009 value. The remaining years in the current progress period (2009-2013) have seen a gradual decline, which has put the values very near the uniform slope. The DENR anticipates that the ammonium sulfate levels will continue to drop with the air pollution control upgrades at Big Stone I and other BART sources throughout the region coming on line in the near future and the ammonium sulfate values will be at or below the Uniform Rate of Progress target by 2018.

Ammonium nitrate has the third largest impact to visibility at the Wind Cave National Park during the 20% most impaired days. The 2005-2009 5-year average value for ammonium nitrate was below the Uniform Glide Slope, but a value of 11.3 Mm^{-1} in 2010 brought the average values of the remaining years in the progress period up to a level just above the Uniform Glide Slope. The high ammonium nitrate value in 2010 was also experienced at the Badland National Park. After 2010, the ammonium nitrate values have seen a steady decline. The DENR anticipates the values will continue to drop and be at or below the Uniform Rate of Progress target by 2018 with the BART air pollution controls that are being implemented at Big Stone I and throughout the region and across the United States.

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Figure 3-20 – Wind Cave Uniform Glide Slope – Ammonium Sulfate

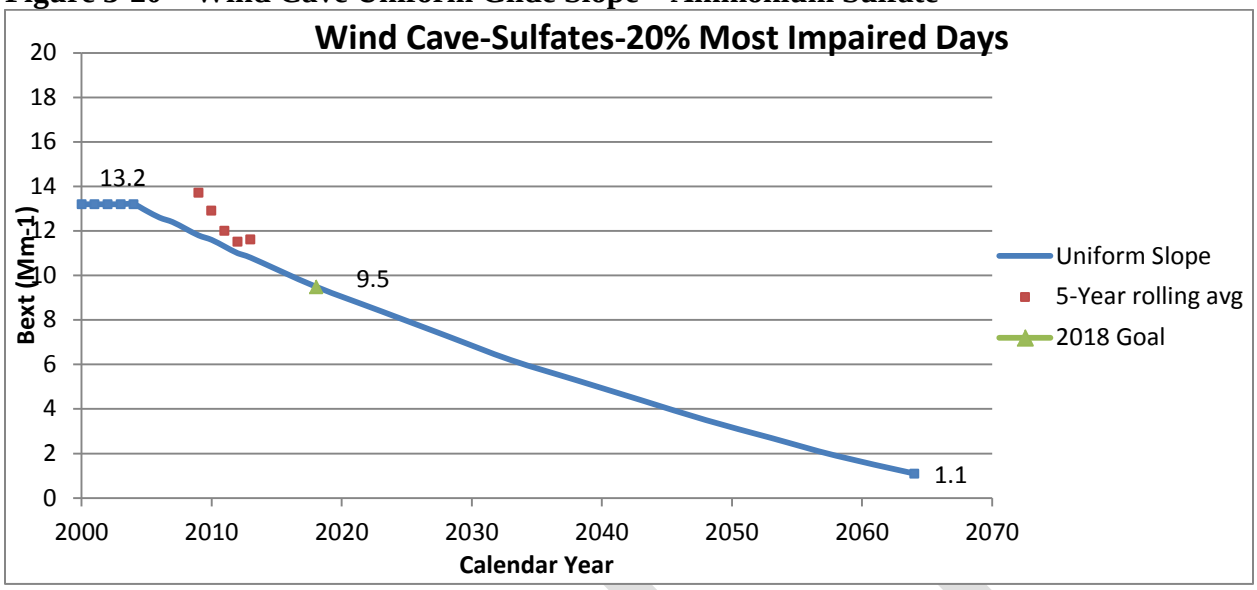
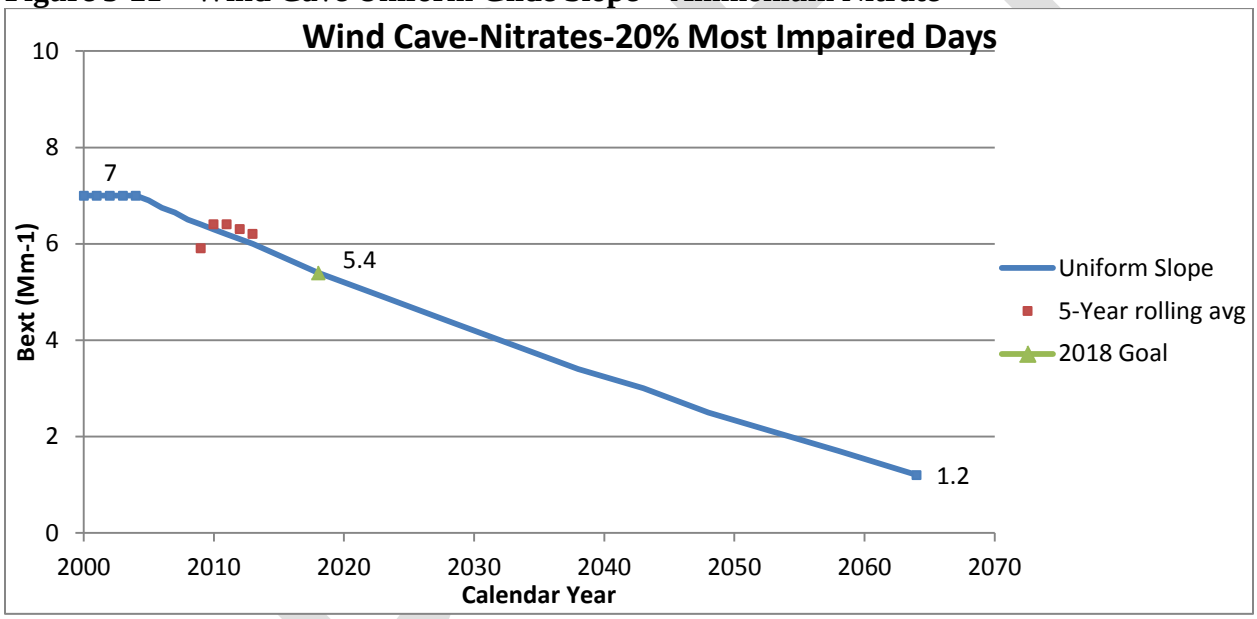


Figure 3-21 – Wind Cave Uniform Glide Slope – Ammonium Nitrate



Particulate organic mass is the number one contributor to visibility degradation at the Wind Cave National Park during the 20% most impaired days. As mentioned earlier, particulate organic mass is usually caused by fire, both wildfires and prescribed fires. The prescribed fire in 2010 at the Wind Cave National Park had a drastic impact on the values throughout the 2009 to 2013 progress periods. Figure 3-23 shows the particulate organic mass values of the 5-year rolling average without the two worst days on October 20 and 23, 2010 and the improvement that would occur without the fire. If the Wind Cave National Park would not have experienced the prescribed fire by the Federal Land Managers, the Wind Cave National Park's particulate organic

mass levels would be below the Uniform Glide Slope similar to the Badlands National Park Uniform Glide Slope for particulate organic mass.

Figure 3-22 – Wind Cave Uniform Glide Slope – Particulate Organic Mass

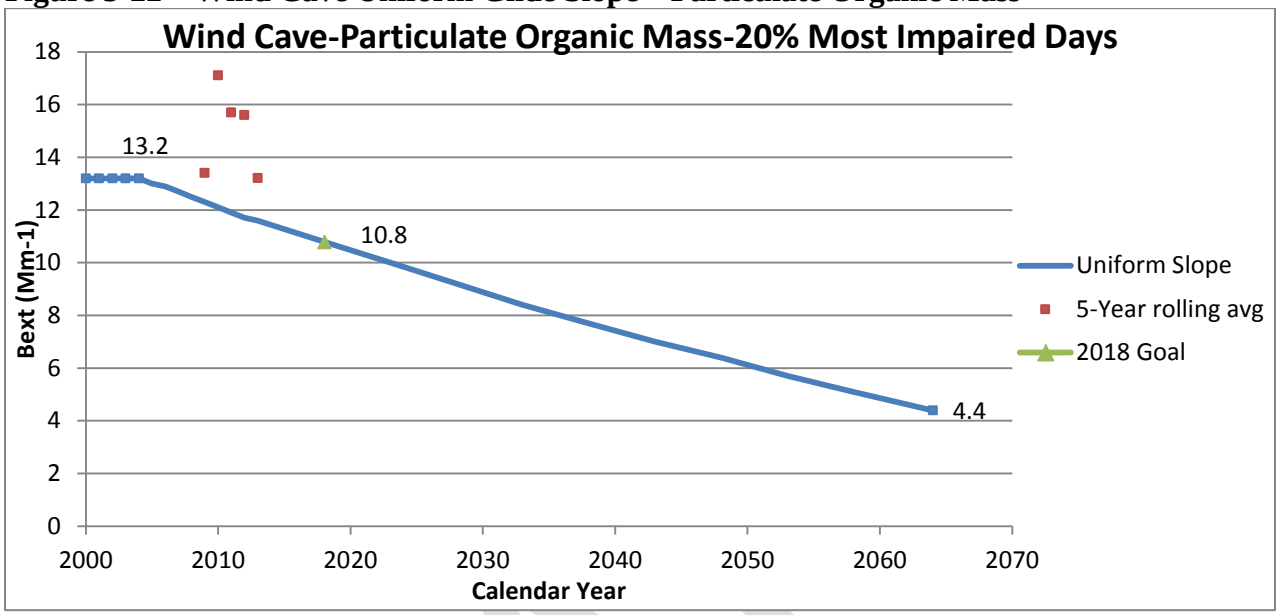
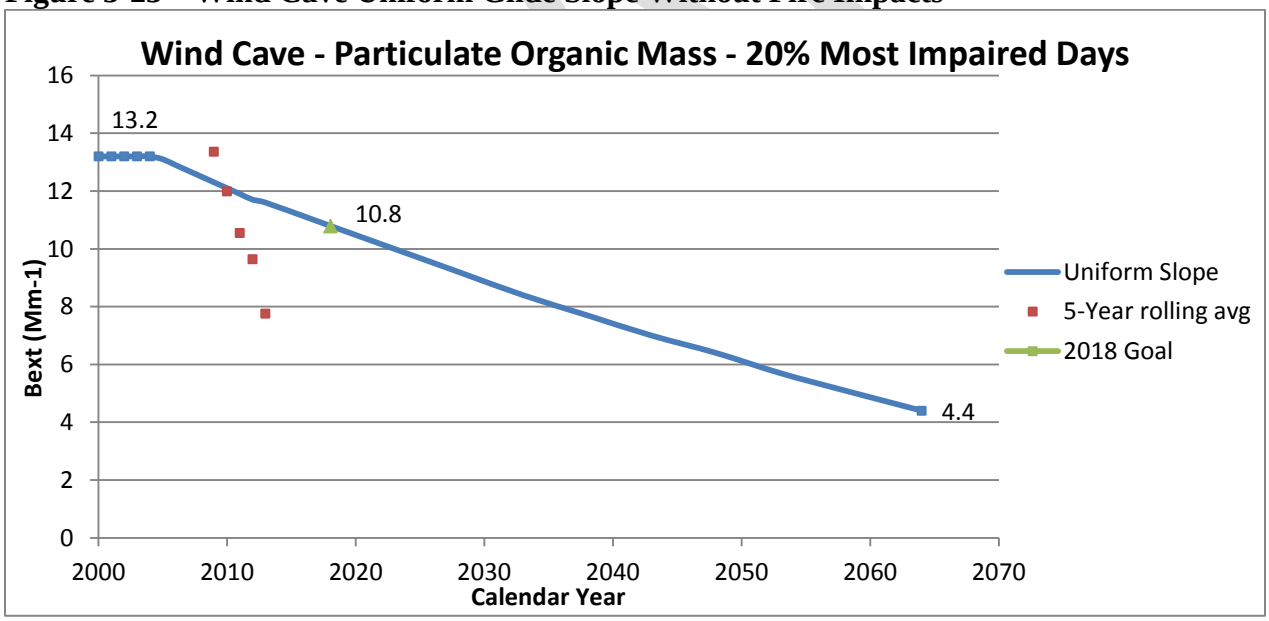


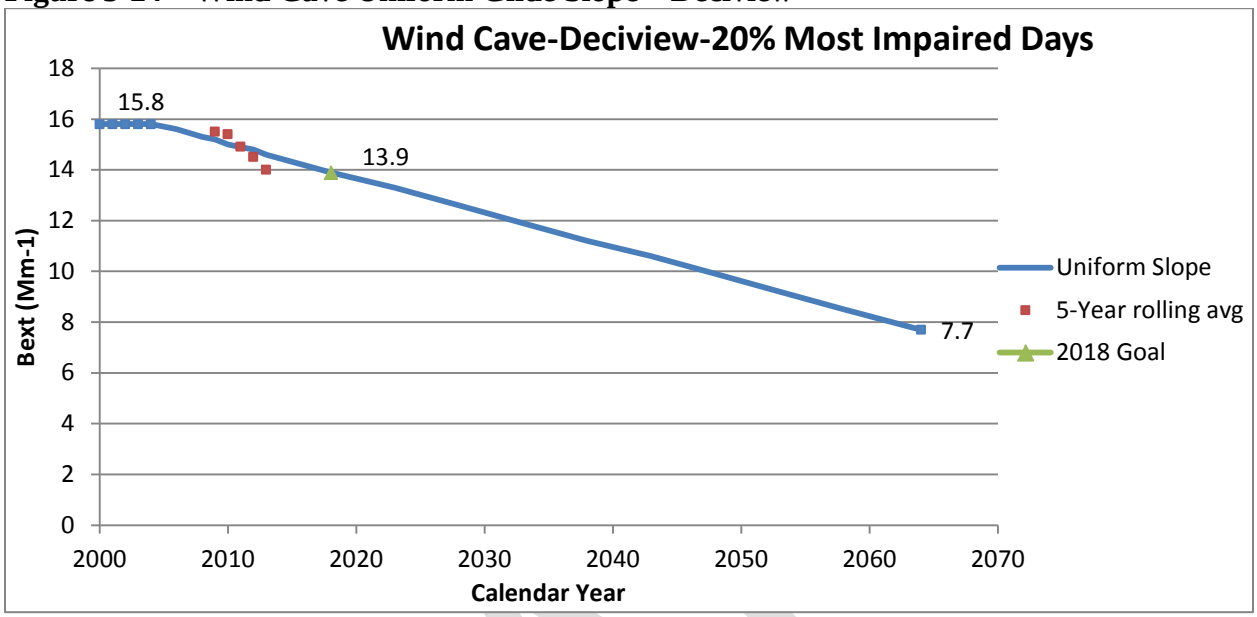
Figure 3-23 – Wind Cave Uniform Glide Slope Without Fire Impacts



A good indication on if a Class I area is meeting the 2018 Uniform Rate of Progress target is looking at deciview values. Despite the high values of particulate organic mass at Wind Cave, decreases in ammonium sulfate, ammonium nitrate and other aerosol species have led to decreased deciview levels at the Wind Cave National Park. The deciview values have dropped below the Uniform Glide Slope and are already within 0.1 deciviews of the 2018 Uniform Rate of Progress target. The DENR anticipates this trend will continue and improve as the DENR

continues to work with the National Park Service on prescribed fires in the Badlands and Wind Cave National Parks.

Figure 3-24 – Wind Cave Uniform Glide Slope – Deciview



3.7 Review of Visibility Monitoring Strategy

In accordance with 40 CFR §51.308(g)(7), the progress report requires a review of the state's visibility monitoring strategy and any modifications to the strategy as necessary. The primary monitoring network for regional haze in South Dakota and throughout the nation is the IMPROVE monitoring network. The IMPROVE network currently collects and reports aerosol monitoring data which is used to track long term progress at the Class I sites.

Because the DENR is relying on the IMPROVE network to meet monitoring and data collection goals and given the fact that IMROVE monitoring data from 2000 – 2004 serves as the baseline for the regional haze program it is imperative that the network continues to operate at its current level. As such, the DENR will work with the Environmental Protection Agency and the Federal Land Managers to ensure these monitors will continue to operate and any changes to the IMPROVE network will not jeopardize the use of the data in the monitoring strategy.

The DENR also operates additional non-IMPROVE monitors at its Class I areas that can be used in assessing whether the reasonable progress goals are being met. The data collected by these sites are reported to EPA's AIRS database. Table 3-32 provides a summary of what instruments the DENR currently operates at the IMPROVE sites in the two Class I areas.

Table 3-32 – Ambient Air Monitoring Site Parameters Next to IMPROVE Sites

Monitoring Site	Parameter	Sampling &Analysis Method	Operating Schedule
Badlands National Park	Sulfur Dioxide	Instrumental pulsed florescent	Continuous

Monitoring Site	Parameter	Sampling &Analysis Method	Operating Schedule
	Nitrogen Dioxide	Instrumental chemiluminescence	Continuous
	Ozone	Instrumental ultra violet	Continuous
	$PM_{2.5}$	Met One BAM – 1020 Very Sharp Cut Cyclone Gravimetric	Continuous
	PM_{10}	Thermal Anderson Series FH62 C14 BETA Gravimetric	Continuous
	Wind Speed	Electronic signal	Continuous
	Wind Direction	Electronic signal	Continuous
	Ambient Temperature	Electronic signal	Continuous
	Delta Temperature	Electronic signal	Continuous
	Ambient Pressure	Barometric pressure transducer	Continuous
	Solar Radiation	Pyranometer	Continuous
	Relative Humidity	Hygroscopic Plastic Film	Continuous
Wind Cave National Park	Ozone	Instrumental Ultra Violet	Continuous
	$PM_{2.5}$	Met One BAM – 1020 Very Sharp Cut Cyclone Gravimetric	Continuous
	PM_{10}	Thermal Anderson Series FH62 C14 BETA Gravimetric	Continuous
	Wind Speed	Electronic signal	Continuous
	Wind Direction	Electronic signal	Continuous
	Ambient Temperature	Electronic signal	Continuous
	Ambient Pressure	Barometric Pressure Transducer	Continuous
	Relative Humidity	Hygroscopic Plastic Film	Continuous

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4.0 Conclusion

The DENR developed this 5-year progress report to satisfy the requirements of the federal Regional Haze Rule, which requires states to make updates to their Regional Haze State Implementation Plans within 5 years of submitting the original plan to the Environmental Protection Agency. The 5-year progress report has 8 elements states are required to look at in determining if its Regional Haze State Implementation Plan is achieving natural conditions along the Uniform Glide Slope.

The first element addresses the status of control strategies identified in the South Dakota's Regional Haze State Implementation Plan. South Dakota's control strategy consisted of BART limits for the Big Stone I power plant, which is South Dakota's only BART eligible source located near Big Stone City, South Dakota. Big Stone I is in the process of installing the air pollution controls required by South Dakota's Regional Haze State Implementation Plan and will begin operating the air pollution controls in the fall of 2015, which is ahead of the schedule.

The second element addresses emission reductions achieved throughout the state through the implementation of the South Dakota's Regional Haze State Implementation Plan. Based on WRAP's emission inventories for 2002 and 2011, current state and federal regulations have already reduced sulfur dioxide and nitrogen oxide emissions by 40% and 49%, respectively. Once the air pollution controls for Big Stone I are operational in the fall of 2015, the sulfur dioxide and nitrogen oxide emissions will be reduced annually by approximately 89% and 86%, respectively. In addition, many of the BART sources in states such as North Dakota and Wyoming are also in the process of installing their BART air pollution controls, which will decrease sulfur dioxide and nitrogen oxide emissions even further.

The third element addresses the current visibility in each Class I area and how it compares to the baseline period of 2000-2004 and the last five years. The baseline period was the starting point for showing progress which is compared to 5-year annual averages or progress periods. South Dakota used the 2009-2013 progress period for its comparisons since it was the most current years during the timeframe for submitting the 5-year progress report. For the 20% most impaired days at both Class I areas, ammonium sulfate, ammonium nitrate, and particulate organic mass contributed approximately 82% of the light extinction. For the 20% least impaired days at both Class I areas, ammonium sulfate, particulate organic mass, and coarse mass contributed approximately 77% of the light extinction. In comparison between the baseline period and the 2009-2013 progress period, in both Class I areas some of the aerosols have increased slightly and some have decreased slightly, but overall, the haze index from the baseline period to the current progress period has demonstrated improvement for the 20% most impaired days and shown no degradation for the 20% least impaired days.

The fourth element requires an analysis tracking the changes over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the state. The DENR based this analysis on WRAP emission inventories for calendar year 2002 and 2011. The differences between the two emission inventories indicated decreases and increases of the pollutants. In some cases the differences were related to differences in methodology while other changes were related to state and federal regulations reducing emissions. The DENR provides a graph of actual sulfur dioxide and nitrogen oxide emissions from South Dakota's coal-fired power plant from 2001 through 2014 which demonstrated that emissions for both air pollutants are trending lower. This declining trend will be enhanced once the air pollution controls related to BART are operational in the fall of 2015.

The fifth element requires an assessment of any significant changes in anthropogenic emissions within and outside of the date over the last 5 years that limit or impede progress on reducing air emissions or improve visibility. Based on WRAP's modeling, sources outside of South Dakota

will have the biggest impact in South Dakota but emissions from outside of South Dakota will decrease as BART air pollution controls are installed and operational. In South Dakota, ammonium sulfate contributions will also decrease with the installation of BART air pollution controls and the removal of three proposed projects in South Dakota that will no longer be built. The DENR did determine that prescribed fires by the Federal Land Managers within the Wind Cave National Park have contributed to the 20% most impaired days in the park. The DENR will continue to work with the Federal Land Managers to minimize the impacts of prescribed fires in South Dakota's Class I areas.

The sixth element requires an assessment of the current implementation plan elements and strategies are sufficient to enable the Class I areas to meet reasonable progress goals. The DENR's assessment identifies certain aerosols that are above and some below the Uniform Glide Slope but overall the deciview values for the 20% most impaired days are on or below the Uniform Glide Slope. Therefore, the DENR believes the current implementation plan is meeting the reasonable progress goals.

The seventh element requires a review of South Dakota's visibility monitoring strategy and any modifications if necessary. South Dakota relies on the IMPROVE monitoring network to track its progress, but also operates its own real-time instruments for sulfur dioxide, nitrous oxides and ozone as well as PM2.5 and PM10 in the Class I areas. The DENR believes this monitoring strategy is sufficient.

The eighth element is the DENR's determination of adequacy. Based on the 5-year progress report, South Dakota's two Class I areas will achieve the 2018 Uniform Rate of Progress targets. Therefore, no revisions are being recommended.

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Appendix A

South Dakota's Regional Haze Program
5 – Year Progress Report
Comments during the Federal Land Manager Review

In accordance with Title 40 of the Code of Federal Regulations (CFR), § 51.308(i)(2), the state must provide the Federal Land Managers with an opportunity for consultation, in person and at least 60 days prior to holding any public hearing on an implementation plan (or plan revisions) for regional haze. On September 30, 2015, DENR fulfilled this obligation and submitted South Dakota's 5-Year Progress Report to the following Federal Land Managers:

1. Patricia Brewer, United States Department of Interior - National Park Service;
2. Tim Allen, U.S. Fish and Wildlife Service;
3. Bret Anderson, United States Department of Agriculture - Forest Service; and
4. Gail Fallon, Environmental Protection Agency.

In addition, DENR took this opportunity to solicit comments from the South Dakota Department of Agriculture and the South Dakota Department of Game, Fish and Parks.

DENR requested that comments be submitted by November 30, 2015. DENR received comments from the United States Department of Agriculture – Forest Service and the United States Department of Interior – National Park Service.

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USDA United States Department of Agriculture | Forest Service | Rocky Mountain Region

740 Simms Street
Golden, CO 80401
303-275-5350
FAX: 303-275-5366

File Code: 2580
Date: NOV 25 2015

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DEC 02 2015
AIR QUALITY PROGRAM

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DEC - 1 2015
Dept. of Environment and Natural Resources Secretary's Office

Steven M. Pirner
Department Secretary, Department of Environment and Natural Resources
523 E Capitol Ave
Pierre, SD 57501

Dear Mr. Pirner,

Thank you for the opportunity to comment on the draft South Dakota Regional Haze State Implementation Plan 5-Year Progress Report. We have reviewed the document and commend you on the quality of the report. In addition, we have the following specific comments:

- 40 CFR 51.308 (g) requires that 5-year progress reports submitted under the Regional Haze Rule must evaluate "progress towards the reasonable progress goal for each mandatory Class I Federal area located within the State and in each mandatory Class I Federal area located outside the State which may be affected by emissions from within the State." The report, however, does not contain analyses or discussion for any Class I areas located outside of South Dakota. The initial state implementation plan, completed in August 2011, identified several Class I areas outside of the state as being affected by emissions from within South Dakota, including Boundary Waters. These Class I areas should be included in this 5-year progress report.

- Tables 3-28 and 3-29 indicate that some unusually high ammonium sulfate and ammonium nitrate concentrations were observed at Wind Cave National Park in 2009 and 2010, respectively. The report also notes that both particulate species are not meeting the uniform rate of progress needed to meet the 2018 target. These particulates are significant contributors to visibility impairment on the 20% haziest days at both Class I areas. We suggest performing some additional analysis to determine the cause of the high concentrations that occurred for these species. Examining back trajectories for these particular days may shed light on the potential source areas. If an analysis suggests possible source areas outside of the state, it may be helpful to examine expected emissions reductions in upwind areas to determine if they will be sufficient to meet the uniform rate of progress goals.

We appreciate the opportunity to comment on this report and look forward to continuing to work with you in the future. If you have any questions contact Acting Air Resource Program Manager Debbie Miller, at (303) 275-5319 or dcmiller@fs.fed.us.

Sincerely,

for DANIEL J. JIRÓN
Regional Forester

cc: Rick Boddicker (Rick.Boddicker@state.sd.us)

United States Department of the Interior

NATIONAL PARK SERVICE
Air Resources Division
P.O. Box 25287
Denver, CO 80225-0287

TRANSMITTED VIA ELECTRONIC MAIL - NO HARDCOPY TO FOLLOW

N3615 (2350)

December 2, 2015

Rick Boddicker
Air Quality Program
South Dakota Department of Environment and Natural Resources
523 E Capitol
Pierre, SD 57501

Dear Mr. Boddicker:

Thank you for the opportunity to review and comment on South Dakota's draft Regional Haze 5-Year Progress Report. South Dakota Department of Environment and Natural Resources (DENR) has addressed most of the requirements for the periodic progress report as outlined in 40 CFR 41.508 (g) and (h). DENR has demonstrated that organic carbon, ammonium sulfate, and ammonium nitrate are the major contributors to visibility impairment at Badlands and Wind Cave National Parks in South Dakota and that visibility for the 2009-2013 period is close to meeting the 2018 Uniform Rate of Progress. Our suggestions to strengthen the draft report are summarized below.

Adequacy of South Dakota Regional Haze Plan: In addition to referencing the 2018 Uniform Rate of Progress, DENR should also report the 2018 Reasonable Progress Goals for Badlands and Wind Cave National Parks that were included in South Dakota's 2011 Regional Haze Plan. To address 308(g)(6), DENR should document that all the emissions reductions have been or will be implemented by 2018 that were included in the regional air quality modeling that was used by western and Midwestern states to set their Reasonable Progress Goals.

Prescribed Fire in Wind Cave: To support your demonstration that smoke from prescribed fire in Wind Cave National Park impacted the visibility monitor in Wind Cave in 2009 and 2010, DENR could cite the prescribed fire records from the western states' Fire Emissions Tracking System.[1] Despite these fires, Wind Cave is on track to meet the Uniform Rate of Progress by 2018.

[1] http://wrapfets.org/

Visibility Progress: The Regional Haze Rule uses the deciview metric to evaluate progress in improving visibility. Please clarify that aerosol extinction as illustrated in Figures 3-16 to 3-18 and Figures 3-20 to 3-23 is used as weight of evidence to demonstrate that contributions to visibility impairment from these individual aerosol species are also declining.

We appreciate the opportunity to work with South Dakota DENR to improve visibility in our Class I national park and wilderness areas. If you have questions, please contact me at patricia_f_brewer@nps.gov or 303-969-2153.

Sincerely,

Pat Brewer

cc:
David Pohlman, NPS Midwest Region
Gail Fallon, EPA Region 8

Appendix B

South Dakota's Regional Haze Program
5 – Year Progress Report
Response to Comments
During Federal Land Manager Review

This section contains DENR's responses to the comments received during the Federal Land Manager consultation period. A summary of the comments and DENR's responses follows.

United States Department of Agriculture - Forest Service Comments:

1. The Forest Service states that 40 CFR 51.308 (g) requires that 5 – year progress reports submitted under the Regional Haze Rule must evaluate "progress towards the reasonable progress goal for each mandatory Class I Federal area located within the State and in each mandatory Class I area located outside the State which may be affected by emissions from within the State." The initial state implementation plan, completed in August 2011, identified several Class I areas outside of the state as being affected by emissions from within South Dakota, including Boundary Waters.

   Response: The initial state implementation plan did identify Class I areas in other states that were impacted by emissions from South Dakota. DENR conducted a BART analysis for the initial state implementation plan, which showed the Big Stone power plant as the only facility in South Dakota having an impact on class I areas outside of South Dakota. As mentioned in the progress report, the BART controls proposed by DENR and approved by EPA for the Big Stone power plant will be operational in the fall of 2015. Therefore, DENR has provided its progress to date for Class I areas outside of the state being impacted by facilities in South Dakota. The analysis the Forest Service recommends will be reviewed once the BART controls have been operational for a sufficient period of time so that enough data is available to review and DENR can determine its impact on the Class I areas outside of South Dakota.

2. The Forest Service states that Tables 3-28 and 3-29 indicate that some unusually high ammonium sulfate and ammonium nitrate concentrations were observed at Wind Cave National Park in 2009 and 2010, respectively. The Forest Service suggests performing some additional analysis to determine the cause of these high concentrations. If an analysis suggests possible source areas outside of the state, it may be helpful to examine expected emissions reductions in upwind areas to determine if they will be sufficient to meet the uniform rate of progress goals.

   Response: The DENR created Tables 3-28 and 3-29 to show the extraordinarily high values of particulate organic mass and elemental carbon due to prescribed fires at Wind Cave National Park. Because the fire related values were so much greater, the DENR

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conducted a statistical analysis and found the particulate organic mass and elemental carbon values for the fire days were greater than 4 standard deviations from the average. The same statistical analysis showed that only one day for ammonium sulfate and ammonium nitrate in each year showed a standard deviation greater than 2. For this reason, DENR did not think it was necessary to conduct an additional analysis and perform back trajectories for these pollutants.

In addition, the WRAP conducted a source apportionment analysis for the original Regional Haze State Implementation Plan. The analysis showed that the majority of ammonium sulfate and ammonium nitrate comes from sources outside of South Dakota. This has been well documented throughout this report. Many of these sources are in the process of adding BART controls that will become operational in the very near future. Therefore, DENR decided to wait until the BART controls are added and operational and there is sufficient data to evaluate the impacts to our Class I areas.

United States Department of the Interior – National Park Service comments:

1. The National Park Service states that in addition to referencing the 2018 Uniform Rate of Progress, DENR should also report the 2018 Reasonable Progress Goals for Badlands and Wind Cave National Parks that were included in South Dakota's 2011 Regional Haze Plan. The National Park Service also states that to address 308(g)(6), DENR should document that all the emissions reductions have been or will be implemented by 2018 that were included in the regional air quality modeling that was used by western and Midwestern states to set their Reasonable Progress Goals.

   Response: South Dakota's 2011 Regional Haze Plan did establish reasonable progress goals for Badlands National Park and Wind Cave National Park at 16.30 and 15.28 deciviews, respectively. The reasonable progress goals were considered interim goals which would represent incremental improvement in visibility over time and are compared to the uniform rate of progress for achieving natural visibility by 2064. The first year in determining if states are meeting their reasonable progress goals is 2018. South Dakota's Class I areas have exceeded the reasonable progress goals that were established and are essentially on the uniform rate of progress line, which is shown in Figures 3-19 and 3-24. With emissions reductions that are expected from the addition of BART controls at Big Stone and other facilities throughout the region, DENR expects that the improvements will continue and South Dakota's Class I areas will meet the 2018 uniform rate of progress goals.

2. The National Park Service states that DENR could cite the prescribed fire records from the western states' Fire Emissions Tracking System to support our demonstration that smoke from prescribed fires in Wind Cave National Park impacted the visibility monitor in Wind Cave in 2009 and 2010.

   Response: The DENR has looked at the Fire Emissions Tracking System and agrees that it may be a useful tool going forward as we continue to track prescribed fires and their

impacts on our Class I areas. The DENR and Federal Land Managers in South Dakota have improved coordination and communications over the past few years and plan to continue that effort to help mitigate the impacts of prescribed fires on our Class I areas.

3. The National Park Service states that the Regional Haze Rule uses the deciview metric to evaluate progress in improving visibility and that DENR should clarify that aerosol extinction as illustrated in Figures 3-16 to 3-18 and Figures 3-20 to 3-23 is used as weight of evidence to demonstrate that contributions to visibility impairment from these individual aerosol species are also declining.

   Response: The DENR agrees with the comment that the Regional Haze Rule uses the deciview metric to evaluate progress in improving visibility and that the aerosol species should be used as evidence that their contributions to visibility impairment are declining. The DENR added the referenced figures to show declining impairment, how a single event can impact the yearly average and how one high year can skew the 5 year averages. The DENR will clarify the National Park Services' point about the deciview metric in future implementation plan updates.

DRAFT