APPENDICIES

Appendix A

Control Options 1, 2, 3 & 4

NO_x Control Options for Existing and New Coal Fired Boilers:

<u>Background:</u>

Most of the NO_x formed in a fossil-fuel-fired power plant is formed in one of two ways:

1. Nitrogen bound in the fuel is converted to NO_x (called "fuel NO_x").
2. When temperatures are particularly high in the boiler (>2800^{o}F), nitrogen molecules from air are broken down and recombine with oxygen to form "thermal NO_x."

Fuel NO_x is about 75% of the total NO_x, and thermal NO_x is about 25%.

In addition, minor amounts of NO_x are formed through reactions of molecular nitrogen and hydrocarbons in an early phase of combustion at the flame front. This is referred to as "prompt NO_z."

Through *combustion processes*, by staging combustion (i.e., delaying the mixing of the fuel and air) so that temperatures are limited and the boiler gases remain fuel rich, inhibiting the formation, and breaking down, NO_x. *Flue gas treatments* that reduce NO_x to N_2 and O_2, using a reducing agent, such as ammonia or urea, with or without a catalyst, are relatively efficient, but more expensive. Combustion processes are generally less expensive (<$1000/ton) but generally are limited in efficiency (<60%). Flue gas treatments are more expensive (>$1000/ton), but can achieve high efficiencies (90%). *Hybrid processes*, using more than one technology on a given boiler are the most efficient and most economical. Examples include combining low-NO_x burners, overfire air, selective non-catalytic reaction and selective catalytic reaction. Using these technologies together limits what has to be achieved by any single technology and minimizes catalyst costs.

Control Option Description - Flue Gas Treatments:

Selective Catalytic Reduction (SCR) is the most effective control technique for NO_x, with control efficiencies as high as 90% (or more). However, it is the most expensive because of the need for vanadium/titanium catalyst. A reducing agent, usually ammonia, sometimes urea, is injected in the flue gas stream. Nitric oxide is reduced to molecular nitrogen and oxygen in the presence of the catalyst. The cost effectiveness is in the range $1700 – 3200/ton. [See SCR control option section]

Selective catalytic reduction (SCR) is a post combustion unit process where a reducing agent, usually ammonia or urea, is added to the flue gas stream and is absorbed onto the catalyst (typically vanadium or titanium) enabling the chemical reduction of NOx to elemental nitrogen and water. It can achieve 0.06-pound-per-million Btu or less.

The main Selective Catalytic Reduction reaction is $4NH_3 + 4NO + O_2 \text{->} 4 N_2 + 6H_2 0$

There are numerous information sources that discuss in detail technical factors related to this technology including the catalyst reactor design, optimum operating temperature, sulfur content of the fuel, catalyst de-activation due to aging or poisoning, ammonia slip emissions, and design of the ammonia injection system. See references below.

The SCR system is comprised of a number of subsystems. These include the SCR reactor and flues, ammonia injection system and ammonia storage and delivery system.

The proposed Desert Rock Energy in New Mexico is planning to build their facility with Selective Catalytic Reduction technology to control NO_x emissions. They expect 85-90% control of NOx. The EPA proposed permit limit for NOx emissions will be 0.060 lbs/mmBTU fuel input.

Xcel Energy has begun construction on its first new coal-fired electric generation unit in nearly 30 years, located in Pueblo, Comanche Unit 3 (750 MW) is being built with LNB and SCR controls which is expected to be on-line in the fall of 2009.

Retrofitting a Selective Catalytic Reduction to existing power plants would be more difficult than installing equipment with the construction of the plant. However, this control technology can greatly reduce NOx emissions from existing sources. It may be able to reduce NOx emissions from existing sources by as much as of 80-90% from uncontrolled emissions.

<u>Benefits of SCR Control:</u>

It is a control option that can greatly reduce NOx emissions from existing sources. It may be able to reduce emissions from existing coal-fired sources by as much as 90%. SCR may have some co-benefit reductions of Mercury emissions.

- NOx emission reductions of 80-90% from uncontrolled emissions are achieved.
- Potential to reduce hydrocarbon, hazardous air pollutant, and condensable particulate matter (PM) emissions based on emissions tests.
- Technology is available currently.

<u>Costs/Tradeoffs Associated with SCR:</u>

The SCR process requires precise control of the ammonia injection rate. An insufficient injection may result in unacceptably low NO_x conversions. An injection rate which is too high results in release of undesirable ammonia to the atmosphere. These ammonia emissions from SCR systems are known as *ammonia slip*. Ammonia slip will also occur when exhaust gas temperatures are too cold for the SCR Reaction to occur. Ammonia slip can potentially be controlled by an oxidation catalyst installed downstream of the SCR catalyst.

Ammonium salts could also form increase loading to the particulate collection stage as PM10 (and PM2.5). SCR tends to increase the reaction of SO_2 to SO_3 and increases the formation of acid mists. This could require additional treatment of the flue gas.

- Minimum and maximum temperature ranges limit the effectiveness of the SCR system. The SCR system requires a minimum exhaust temperature of 572°F (300°C) and maximum of 986°F (530°C) for NOx reduction to occur (optimal range).
- The SCR system needs operator attention. Typically SCR catalysts require frequent cleaning even with pure reducing agents, as the reducing agent can coat the inlet surface of the catalyst while the exhaust gas stream temperature is too low for the SCR reaction to take place.
- Cost (Retrofit)

- Capital cost of approximately $50-110/kW to achieve 85-95% NOX removal efficiency.
- Combined fixed and variable O&M costs for all boiler types about $1.0 to 1.7 million/yr for 85% NOX removal.
- Retrofit costs to existing power plants may be cost prohibitive for some existing plants because of the physical layout of the plant.
- Safety issues with handling of ammonia for use as reducing agent

Description of how to implement:

Could be mandatory or voluntary: Prior to determining whether this control option should be mandatory or voluntary more information is required on the contribution of NOx emissions from large utility boilers to the total nitrogen deposition rate at RMNP. In addition, it is unknown how the potential increase in ammonia emissions from SCR could impact nitrogen deposition and visibility at RMNP.

Feasibility of SCR:

The SCR technology is available and effective in reducing NOx emissions. SCR is a proven technology for reduction of NOx emissions. However, the potential increase of ammonia emissions and subsequent impact to nitrogen deposition and visibility at RMNP is not known.

The capital costs associated with a new SCR or installation of retrofit SCR may be feasible, and the additional costs associated with operation and maintenance are known.

Background data and assumptions used:

US Department of Energy (DOE) Pollution Control Innovations Program
http://www.fossil.energy.gov/programs/powersystems/publications/Clean_Coal_Topical_Reports/topical9.pdf

Cost of Selective Catalytic Reduction (SCR) Application for NOX Control on Coal-fired Boilers

http://www.epa.gov/nrmrl/pubs/600r01087/600sr01087.pdf

Uncertainty associated with the SCR:

It is clear that SCR is effective in reducing NOx emissions, however an understanding of the potential increase of ammonia emissions and the resulting impacts to nitrogen deposition and visibility at RMNP need to be understood.

Selective Non-Catalytic Reduction (SNCR) avoids the expense of the catalyst. The ammonia reactant is injected in the boiler in a very hot location at the top and backpass of the boiler. The reduction reaction at these temperatures (1700 – 2100^{o} F) does not require catalysis. SNCR is achieving 40% (20-55%) control. Cost effectiveness is $600 – 1300/ton. [See SNCR control option section]

Rotating Mixing (ROTAMIX) is a new form of SNCR, employed with ROFA. Ammonia is injected into the boiler with the ROFA air, achieving excellent mixing and improved performance. Using ROFA and ROTAMIX together can reduce NO_x emissions by 40-75%.

Rich Reagent Injection (RRI) is a new technique of reducing NO_x by injection of ammonia or urea into high temperature NO_x-containing fuel rich flue gases. This results in a reduction in NO_x of 80% or better without the need for a catalyst. While SNCR is based on the injection of reagent into fuel lean conditions at temperatures between 1700 and 2100^o F, RRI involves injections into fuel rich flue gas at significantly higher temperatures (2400 – 3100^o F).

Control Option Description - Combustion Processes:

Conventional Low-NO_x Burners (LNB). Staged combustion can be achieved with redesigned burners that separate some of the combustion air from the pulverized coal (or oil or natural gas). These burners can cut NO_x emissions by 30-60% to a range from 0.25 – 0.65 lb/MMBtu. These LNBs are highly cost effective ($150-300/ton)

Ultra-low-NO_x Burners (ULNB). New designs are getting a further 20% or more reduction in NO_x emission rates down to 0.15 – 0.25 lb/MMBtu. These are slightly less cost effective than LNBs: $200-400/ton.

Overfire air (OFA) uses air that is introduced high in the boiler in order to achieve the staged combustion. Advanced systems include separated overfire air (SOFA) and close-coupled overfire air (CCOFA) and achieve over 60% NO_x emission reductions in tangential fired boilers. Cost effectiveness: $400-1000/ton.

Flue gas recirculation (FGR) is used in combination with low NO_x burners and OFA. It is particularly effective in oil and gas fired units.

Re-burn is a comparatively new technology, capable of up to 50-60% NO_x control. Natural gas or coal is burned in a second fuel-rich combustion zone in order to reduce NO_x. Second Generation Advanced Reburning (SGAR) is currently being developed, capable of NO_x emission reductions of 90% or more.

Advanced combustion control systems, including neuro-networks, are effective at minimizing NO_x formation and maximizing boiler efficiency.

Rotating Opposed Fire Air (ROFA) is a new technique developed in Sweden. Secondary combustion air is injected under high pressure at the top of the boiler, creating a rotating fire-ball, achieving a uniform boiler temperature and reduced emissions. This technique also improves boiler operation.

Table A-1: 2005 NOx Emissions data from the EPA's Acid Rain Program for Colorado coal fired power plants:

NO_x Control Options for Existing and New Coal Fired Boilers							$/kW			$/ton	Avg lb/mmbtu	$/ton	Avg lb/mmbtu	$/ton
						(80% Control)	$ 80		(60% Control)	$ 950	0.45	$ 225	0.2	$ 300
						Scenerio 1-All SCR			Scenerio 2-All SNCR		Scenerio 3-All Low NOx Burners		Scenerio 4-All Ultra-Low NOx Burners	
Facility	Unit	MW Rating	Avg. NOx Rate (lb/mmBtu)	2005 CAMD NOx Emissions [tpy]	Existing NOx Controls	Estimated NOx Reduction [tpy]	Estimated SCR Cost ($80/kW) [$]	Estimated Control Cost [$/ton]	Estimated NOx Reduction [tpy]	Estimated SNCR Cost [$]	Estimated NOx Reduction [tpy]	Estimated LNB Cost [$]	Estimated NOx Reduction [tpy]	Estimated ULNB Cost [$]
Arapahoe	Unit 3	44	0.76	1447	NA	1,273	$ 3,520,000	$ 2,764	868	$ 824,790	449	$ 100,928	810	$ 243,096
Arapahoe	Unit 4	100	0.23	889	Low NOx Burner Technology w/ Overfire Air	782	$ 8,000,000	$ 10,226	533	$ 506,730			27	$ 8,001
						-	$ -		-	$ -			-	$ -
Cameo	Unit 2	44	0.36	731.5	Low NOx Burner Technology w/ Overfire Air	644	$ 3,520,000	$ 5,468	439	$ 416,955			117	$ 35,112
						-	$ -		-	$ -			-	$ -
Cherokee	Unit 1	100	0.35	1,439.60	Low NOx Burner Technology w/ Overfire Air	1,267	$ 8,000,000	$ 6,315	864	$ 820,572			216	$ 64,782
Cherokee	Unit 2	110	0.69	3,383.50	Overfire Air	2,977	$ 8,800,000	$ 2,956	2,030	$ 1,928,595	812	$ 182,709	1,658	$ 497,375
Cherokee	Unit 3	150	0.34	1,820.20	Low NOx Burner Technology w/ Overfire Air	1,602	$ 12,000,000	$ 7,492	1,092	$ 1,037,514			255	$ 76,448
Cherokee	Unit 4	350	0.3	4,157.60	Low NOx Burner Technology w/ Closed-coupled/Separated OFA	3,659	$ 28,000,000	$ 7,653	2,495	$ 2,369,832			416	$ 124,728
						-	$ -		-	$ -			-	$ -
Comanche	Unit 1	350	0.31	4,057.90	NA	3,571	$ 28,000,000	$ 7,841	2,435	$ 2,313,003			446	$ 133,911
Comanche	Unit 2	350	0.3	3,913.40	Overfire Air	3,444	$ 28,000,000	$ 8,131	2,348	$ 2,230,638			391	$ 117,402
						-	$ -		-	$ -			-	$ -
Craig	Unit 1	446	0.28	5,823.50	Low NOx Burner Technology w/ Overfire Air	5,125	$ 35,680,000	$ 6,962	3,494	$ 3,319,395			466	$ 139,764
Craig	Unit 2	446	0.27	5,415.60	Low NOx Burner Technology w/ Overfire Air	4,766	$ 35,680,000	$ 7,487	3,249	$ 3,086,892			379	$ 113,728
Craig	Unit 3	446	0.4	6,467.60	Low NOx Burner Technology (Dry Bottom only)	5,691	$ 35,680,000	$ 6,269	3,881	$ 3,686,532			1,294	$ 388,056
						-	$ -		-	$ -			-	$ -
Hayden	Unit 1	190	0.42	4,094.50	Low NOx Burner Technology w/ Overfire Air	3,603	$ 15,200,000	$ 4,219	2,457	$ 2,333,865			901	$ 270,237
Hayden	Unit 2	257	0.33	3,981.20	Low NOx Burner Technology w/ Closed-coupled/Separated OFA	3,503	$ 20,560,000	$ 5,868	2,389	$ 2,269,284			518	$ 155,267
						-	$ -		-	$ -			-	$ -
Martin Drake	Unit 5	59	0.41	768.2	Low NOx Burner Technology (Dry Bottom only)	676	$ 4,720,000	$ 6,982	461	$ 437,874			161	$ 48,397
Martin Drake	Unit 6	88	0.38	1,408.20	Low NOx Burner Technology (Dry Bottom only)	1,239	$ 7,040,000	$ 5,681	845	$ 802,674			253	$ 76,043
Martin Drake	Unit 7	147	0.44	2,767.90	Low NOx Burner Technology (Dry Bottom only)	2,436	$ 11,760,000	$ 4,828	1,661	$ 1,577,703			664	$ 199,209
						-	$ -		-	$ -			-	$ -
Nucla	Unit 1	79	0.41	1,921.70	Other	1,691	$ 6,320,000	$ 3,737	1,153	$ 1,095,369			404	$ 121,067
						-	$ -		-	$ -			-	$ -
Pawnee	Unit 1	500	0.21	3,668.10	Low NOx Burner Technology w/ Overfire Air	3,228	$ 40,000,000	$ 12,392	2,201	$ 2,090,817			37	$ 11,004
						-	$ -		-	$ -			-	$ -
Rawhide	Unit 1	285	0.32	3,729.10	Low NOx Burner Technology w/ Closed-coupled/Separated OFA (Began 02-OCT-05)	3,282	$ 22,800,000	$ 6,948	2,237	$ 2,125,587			447	$ 134,248
					Low NOx Burner Technology w/ Closed-coupled OFA (Retired 01-OCT-05)	-	$ -		-	$ -			-	$ -
						-	$ -		-	$ -			-	$ -
Ray D Nixon	Unit 1	230	0.26	2,168.20	Low NOx Burner Technology (Dry Bottom only)	1,908	$ 18,400,000	$ 9,644	1,301	$ 1,235,874			130	$ 39,028
						-	$ -		-	$ -			-	$ -
Valmont	Unit 5	166	0.32	2,514.10	Low NOx Burner Technology w/ Closed-coupled/Separated OFA	2,212	$ 13,280,000	$ 6,003	1,508	$ 1,433,037			302	$ 90,508
		4,937		**66,568**	Total NOx Reduction:	**58,579**	**$ 394,960,000**		**39,941**	**$ 37,943,532**	**1,261**	**$ 283,637**	**10,292**	**$ 3,087,488**

Appendix B

Control Option 5

Control Option: Use of Lowest Achievable Emission Rate (LAER)

For major new sources and major modifications in non-attainment areas, LAER is the most stringent emission limitation derived from either of the following:

- the most stringent emission limitation contained in the implementation plan of any State for such class or category of source; or
- The most stringent emission limitation achieved in practice by such class or category of source.

The use of LAER in permitting of new or modified major sources could be used by Colorado to control growth related increases in NOx emissions, statewide or in the Front Range counties, in order reduce nitrogen deposition rates at RMNP consistent with the stated resource management goals. This would be a state only permit requirement and not be incorporated into Colorado's SIP.

The most stringent emissions limitation contained in a SIP for a class or category of source must be considered LAER, unless (1) a more stringent emissions limitation has been achieved in practice, or (2) the SIP limitation is demonstrated by the applicant to be unachievable. By definition LAER can not be less stringent than any applicable new source performance standard (NSPS).

EPA recommends these sources of information for determining LAER

- SIP limits for that particular class or category of sources;
- preconstruction or operating permits issued in other non-attainment areas; and
- The BACT/LAER Clearinghouse [http://cfpub.epa.gov/RBLC]

Several technological considerations are involved in selecting LAER. The LAER is an emissions rate specific to each emissions unit including fugitive emissions sources. The emissions rate may result from a combination of emissions-limiting measures such as (1) a change in the raw material processed, (2) a process modification, and (3) add-on controls. The reviewing agency, in this case CDPHE, determines for each new source whether a single control measure is appropriate for LAER or whether a combination of emissions-limiting techniques should be considered.

Unlike Best Available Control Technology (BACT) used for major sources in attainment areas, the LAER requirement does not consider economic, energy, or other environmental factors. A LAER is considered not achievable if the cost of control is so great that a major new source could not be built or operated.

Examples from EPA's RACT/BACT/LAER Clearinghouse showing the current range of LAER nationally for NOx emissions follows:

Utility and large industrial-size boilers/furnaces (>250 million BTU/H) - .07 to .1 lb/MM BTU. This is being achieved through the use of combined control technologies such SCR, overfire air, and low NOX burners.

Large Combustion Turbines Combined Cycle (> 25 MW) using natural gas (includes propane & liquefied petroleum gas) – 1.5ppm to 2ppm at 15% O2. This is being achieved through the use of combined control technologies such SCR and low NOX combustors.

Large Internal Stationary Combustion Engines (> 500 hp) using natural gas (includes propane & liquefied petroleum gas) - .0015 g/hp/hr - 1 g/hp/hr. This is being achieved through the use of clean burn technology (lean burn, NSCR).

Small Internal Stationary Combustion Engines (< 500 hp) using natural gas (includes propane & liquefied petroleum gas) - .15 g/hp/hr - 2 g/hp/hr. This is being achieved through the use of clean burn technology (lean burn, NSCR, air/fuel ratio controller).

See: http://cfpub.epa.gov/rblc/cfm/menu_search.cfm

Control Option: Use of Emissions Reductions "Offsets":

A major source or major modification planned in a nonattainment area must obtain emissions reductions as a condition for approval. These emissions reductions are generally obtained from existing sources located in the vicinity of a proposed source and must (1) offset the emissions increase from the new source or modification and (2) provide a net air quality benefit. The purpose of acquiring offsetting emissions decreases is to allow an area to move towards attainment of the NAAQS while still allowing some industrial growth. This same approach could be used by Colorado to control growth related increases in NOx emissions at new or modified major sources (statewide or front range counties) in order reduce nitrogen deposition rates at RMNP consistent with the stated resource management goals.

Since this would be a state only offset requirement (and not be incorporated into Colorado’s SIP), CDPHE would have significant flexibility in determining what requirements offsets must meet in order to achieve the objective of NOx control that benefits RMNP. EPA has set forth minimum considerations under the Interpretive Ruling (40 CFR 51, Appendix S) that could be used by CDPHE to develop a banking program. This ruling states that in general, emissions reductions which have resulted from some other regulatory action are not available as offsets. For example, emissions reductions already required by a state regulation cannot be counted as offsets. In addition, any emissions reductions already counted in major modification "netting" may not be used as offsets. Acceptable offsets also must be creditable, quantifiable, federally enforceable, and permanent. However, emissions reductions validly "banked" under a program developed by CDPHE could be used as offsets.

Usually an emissions offset must result in reasonable progress toward attainment of an air quality standard or goal. Therefore, the ratio of required emissions offset to the proposed source's emissions would have to be greater than one. However, since this would be an offset program limited to achieving NOx control that benefits RMNP, any offset that has a positive net air quality benefit for RMNP could be considered. Generally offsets should be located as close to the proposed site as possible, but for use in controlling growth related increases in NOx emissions that impact RMNP this should be modified to allow sources that are closer or impact RMNP to a greater extent to be used as preferential sources of offsets.

Appendix C

Control Option 6

Control Options Analysis for Rocky Mountain National Park Initiative

Proposed Implementation of BART to all major sources Statewide

Purpose

Purpose: This analysis presents the pros and cons of implementing Best Available Retrofit Technology from pre-1962 major sources (similar to the BART provisions adopted in March 2006) and would result in emission reductions from under- and non-controlled facilities

Cost/Benefit

Costs: There are 20 major pre-1962 sources present in Colorado, with several sources considered as one for PSD purposes. For implementing BART on pre-1962 major sources, the Colorado Air Pollution Control Division estimates that NOx reduction cost per ton to range from $1500 - $4000 (based on DOE and Northeast Air Management values), with a total NOx reduction expense for all sources ranging from $67 million to $180 million. Please refer to spreadsheet below for additional details about individual sources.

Benefits: This analysis assumes an average NOx reduction per source of 85% with the main control(s) being Non-Selective Catalytic Reduction (NSCR) and Selective Catalytic Reduction (SCR) implemented on major source engines and boilers. This analysis resulted in an annual NOx reduction of approximately 45,000 tons per year based on allowable emissions.

Disadvantages: The BART provisions are intended to reduce NOx emissions and will result in an increase in ammonia emissions. Several of the major sources are major for VOCs and are being controlled under the 1-hr ozone area under RACT, therefore these sources were not included in the analysis and should be examined separately.

Secondary Option: Low-NOx burners could be implemented instead or in place of SCR/NSCR on a case-by-case, there would be a 30 - 60% reduction in NOx and a cost of $150-300/ton as a secondary option. This option would result in approximately 29,000 tons/year of NOx reduction and the cost would range from $4.4 million to $8.7 million dollars.

Implementation

Both SCR/NSCR and Low-Nox control equipment is readily available and implementable. The BART analysis on these sources could take a considerable amount of time, especially when considering allowable versus actual emissions. Actual emissions could be used to determine new allowable limits for certain sources, thus exempting those sources from BART. The Commission would have to re-examine Public Service Company on an individual plant basis, rather than allow a cap for all facilities to acheive these NOx emission reductions.

Viability

The realistic implementation date would be over several years or up to a decade, as each source is examined and subjected to BART on a case-by-case basis. However, this option is viable and would result in a substantial reduction in NOx emissions around the state and would capture a large amount of uncontrolled NOx emissions.

Table C-1: Pre-1962 Sources Eligible for BART-like controls

SOURCE	Pre-1962?	NOx (tpy)	VOCs (tpy)	PM (tpy)	Comments	Additional Details Controls?	85% NOx Reduction (assuming SCR)	NOx Removal (assume 85%)	45% NOx Reduction (assuming low NOx)	NOx removal (assume 45%)
1 Aquila, Inc. - W. N. Clark Plant	Yes - 1955	1666		170.7	2 Boilers totaling 572 MMBtu/hr fueled by coal only	Equipped with baghouse, PM emissions mostly fug	249.9	1416.1	916.3	749.7
2 Aquila, Inc. - Pueblo	Yes - 1949 for n.g. boiler and 1964 for diesel generators	boiler - 832.04		115.32	One steam driven unit and five diesel fired	No controls; however plants actuals low due to output of only 10 MW and primary usage of boiler (steam)	124.806	707.234	457.622	374.418
3 Colorado Interstate Gas - Springfield	Yes - 1933	639.4	26.3		6 natural gas fired engines (1360 hp each) for NG compression	NONE	95.91	543.49	351.67	287.73
4 Colorado Interstate Nat Gas - Kit Carson	Yes - 1949 - 1934	1574	60		13 natural gas fired engines (1000 hp first 10 and 326 hp last 3) for NG compression	NONE	236.1	1337.9	865.7	708.3
5 Colorado Springs - Birdsall	Yes - 1953 - 1957	2211.15	26.74		Three steam boilers with associated turbine-generators and cooling towers running on n.g. or fuel oil	NONE	331.6725	1879.4775	1216.1325	995.0175
6 Philips Pipeline Company - Denver Terminal	Boiler and tanks pre-1973	28.5	141.83		Bulk gasoline terminal	Vapor combustion unit for loadout; not all tanks connected to VCU. However, substantial reduction in VOCs may not be achievable			15.675	12.825
7 Coors - Brewing and Packaging	1800's		450	46	single source with Tri-Gen-Golden and RMMC - grain loadout	PM baghouse - rerouting of VOC venting to boilers for destruction. Subject to RACT 1-hr ozone area and must achieve 69.5 tons/year of VOC reduction through special projects	0	0	0	0
8 Delta Municipal Light & Power	Yes - 1953 - 1956	859.4	85.06	69.17	seven (7) internal combustion engines, three diesel fuel fired and four that burn diesel or a combination of diesel and natural gas (dual-fuel)	NONE	128.91	730.49	472.67	386.73
9 Northwest Pipeline - Rangley Compressor Station	Yes - 1956	1366.4	43		four (4) internal combustion engines, all natural gas fired at 2,000 hp and 2 cycle standard lean burn	NONE	204.96	1161.44	751.52	614.88
10 Public Service Company - Arapahoe	Yes - 1951, 1955	12443	50		Four coal fired boilers with coal as primary fuel burned with natural gas as a back-up fuel	Unit No. 1 is a 48 MW boiler equipped with electrostatic precipitator for PM. Unit 2 is also equipped with EP and 2 baghouses. Unit No. 4 is a 118 MW boiler equipped with a baghouse, low NOX burners with overfire air to control NOX emissions	1866.45	10576.55	6843.65	5599.35
11 Public Service Company - Cameo	Yes - 1957, 1960	1890	19.4		This facility consists of 2 boilers used to produce electricity	Each boiler exhausts through a baghouse to reduce particulate emissions. 2nd Boiler has a low Nox burner installed	283.5	1606.5	1039.5	850.5
12 Public Service Company - Cherokee Station	Yes - 1957 - 1962	21655	96		Four coal fired boilers with coal as primary fuel burned with natural gas as a back-up fuel. UNIT 4 IS SUBJECT TO BART	All 4 units equipped with baghouses and low NOx burners with over-fire air	3248.25	18406.75	11910.25	9744.75
13 Public Service Company - Denver Steam Plant	Yes - 2 boilers pre-1972	1091	4		Two boilers using natural gas or fuel oil rated at 210 mmBtu/hr	NONE	163.65	927.35	600.05	490.95
14 Questar Gas Management Company-E. Hiawatha C.S.	Yes - one engine from 1957, rest 1970/71/74	239	50		Five (5) internal combustion engines natural gas fired, rated at 660, 660, 265 hp, 60 hp, and 60 hp installed in 1971, 1974, 1957, and 1970 respectively	NONE	35.85	203.15	131.45	107.55
15 Questar Pipeline-Powder Wash C.S.	Yes - one engine from 1946, rest 1974/79/80/94	377.3	152		Six (6) internal combustion engines, all natural gas fired as 4 cycle standard rich burn	One engine was replaced in 1990 and took synthetic minor emission limitations (hours of operation and production). Another engine was placed in service in 1994 and has a NSCR. Four engines are uncontrolled	56.595	320.705	207.515	169.785
16 Rocky Mountain Metal Container	Yes - 1800s	29	553		Can Line Cleaning, Manufacturing, and Internal Can Coating; Aluminum Scrap System	Subject to VOC RACT - limits VOC content of can coatings and requires minimization of fugitive emissions	4.35	24.65	15.95	13.05
17 Rocky Mountain Pipeline System LLC - DuPont Termi	Yes - 1948 (with additions afterwards - unclear)	9.78	180.97		Nineteen (19) storage tanks, tank truck loading rack	Two tanks subject to fixed roof requirements; loading/unloading equipped with vapor collection system and combustion device; limits on gas throughput; MTBE use restricted to 6 months; facility limits on pollutants and HAPs	27.5805	156.2895	5.379	4.401
18 Springfield Municipal Power Plant	Yes - 4 engines 1930s and 1960s	528	36		Four (4) internal combustion engines diesel fired or combination natural gas and diesel	Plant primarily serves as standby/backup electric generation; all pollutants actual less tan 1 tpy However, there NO controls on this facility	79.2	448.8	290.4	237.6
19 Trigen-Colorado - Golden Facility	Yes - 3 boilers pre-1971	3693	55	3456	Five (5) boilers and associated coal and ash handling equipment. Boilers 1 and 2 equipped for natural gas and fuel oil. Boiler 3 uses only coal for fuel. Boiler 4/5 use natural gas as primary fuel and fuel oil for backup. Auxiliary fuel (ethanol, sludge, and on-site oil) used in Boilers 4/5.	PM baghouse for boilers 4/5. NOV NOx reduction of 255 tpy using emission limitations (hours and throughput) and SIP reduction of 255 tpy (again using throughput limits) for a total reduction fo 510 tpy - These reductions are on boilers 4/5 only. Boilers 1,2,3 have NO controls. The coal and ash handling operations have 4 fabric filters, hopper capture, and 3 cyclones for PM control	553.95	3139.05	2031.15	2937.6
20 Western Sugar Co- Fort Morgan Facility	Yes - 2 boilers 1947(n.g. conversion 1960's) 2 dryers 1934 mills/coolers 1933 others pre-1930	1385.16	95.6	576.6	Facility operates 5 months/year processing harvested beets. Sugar storage bins and associate dust collectors rest of year as sugar is shipped. Two (2) boilers fired on coal. Two (2) dryers fired on natural gas. Four (4) beet pulp pelletmills and coolers. Two (2) sugar granulators (two steam dryers and coolers)	Boilers have venturi scrubber to control PM and SO2. The dryers have 4 cyclones for PM control. NO NOx controls present at facility	207.774	1177.386	761.838	490.11

	SCR/NSCR Reduction (85%)		Low-Nox Burners (45%)	
TOTAL NOx Emission Reduction	**44763**	**tons per year**	**28884**	**tons per year**
minimum $/ton estimate	**$ 1,500**	**per ton removal**	**$ 150**	**per ton removal**
maximum $/ton estimate	**$ 4,000**	**per ton removal**	**$ 300**	**per ton removal**
SOURCES				
Department of Energy (National Energy Modeling System)				
NOx Control Status Report - 2000 - Northeast States for Coordinated Air Use Management (NESCAUM)				
MINIMUM TOTAL NOx Reduction COST:	**$67,144,968**		**$ 4,332,663**	
MAXIMUM TOTAL NOx Reduction COST:	**$179,053,248**		**$ 8,665,326**	

Appendix D

Control Option 7

Control Option: NOx/NH3 Emissions Cap and Trade Program

Description:

A NOx and NH3 cap and trade program is one approach available for controlling the growth in, and/or obtaining reductions of, NOx and NH_3 emissions. The basic concept entails capping emissions at some level that puts a ceiling on total allowable emissions from sources over a defined area. To achieve the RMNP goal of reduced nitrification, emission caps would initially be set at levels less than current emissions to ensure that emission reductions occur over a defined time period. Future years would be selected as timeframes for setting and attaining incrementally lower emissions caps until monitoring indicates nitrogen deposition below the critical load at RMNP. Even with growth in new sources of NOx and NH_3 emissions, the emissions cap program would restrict total emissions to a level that is less than the cap in order to stay on track for reducing nitrogen deposition in RMNP.

Emission caps work by assigning emission allowances to sources covered by the program – each unit of emissions is represented by one allowance - like the Acid Rain Program which set a nationwide cap on sulfur dioxide emissions from electric utilities and set each allowance equal to one ton of sulfur dioxide. Since allowances would be limited, covered sources must have enough allowances at the end of each year to cover their actual emissions or be fined and surrender future year allowances to cover any shortfall. Unused allowances may be sold, traded or saved (banked) for future use. The trading aspect of the program would provide Colorado sources with the flexibility to achieve NOx and NH_3 reductions through methods of their choosing, allowing market forces to drive the effort.

With the credit system of allowances, sources could choose from many alternatives that would best meet their needs with respect to meeting the overall emissions caps. Such alternatives include installing pollution control equipment; switching fuels; employing energy-efficiency measures and/or renewable energy generation; process, materials or activity changes to reduce emissions; purchasing excess allowances from other sources that have reduced their emissions; or using any combination of these and other options.

There are various ways to structure a cap and trade program that would help ensure it is reasonable and effective: ranging from which sources or source categories to include, seasonal versus annual caps, whether to allow inter-pollutant trading, the geographic extent of the program, and whether to geographically weight emissions based on the relative importance of source areas affecting the Park. The degree of enforceability of the program is a key issue – whether to implement cap and trade as a State-only program which would lack federal enforcement authority or include applicable parts of it in either the State's federally-enforceable regional haze or ozone SIPs. A voluntary approach is more likely to have shortfalls and be less effective as discussed further below.

Benefits of a Cap and Trade Program:

A market-based cap and trade program generally has multiple benefits as compared to a command and control approach.

- There is more environmental certainty that overall impacts of emissions will be reduced as caps are lowered to limit total emissions. Command and control does not ensure that aggregate emissions will not increase as new sources add new emissions and existing sources add capacity and are used more.
- A market system reduces the cost of compliance. It allows all sources to take advantage of the most cost-effective and/or lowest-cost compliance options.
- Incentives are created for early reductions and for reductions beyond those required by regulation. There is economic value in allowances – since they are limited and relatively scarce, they are valuable and can be banked or sold, creating incentives for sources with low compliance costs to make additional reductions and offers sources not currently regulated to generate reductions (allowances) for sale to those sources that are regulated.
- Technological innovation is promoted by providing sources with an economic incentive to find new ways to generate cost-effective reductions.
- Environmental benefits may be accelerated through the economic incentives created by early reductions and by decreasing emissions beyond the caps.
- State and local air regulatory authorities retain flexibility to impose stricter limits on sources necessary to address specific local air quality issues, regardless of a source's accumulated allowances.
- Tracking emissions from sources to assure compliance improves accountability and the accuracy and comprehensiveness of emissions inventories.

Costs/Tradeoffs Associated with Cap and Trade

EPA's market-based approach to the Acid Rain Program using cap and trade has demonstrated significant cost savings to affected sources and in administration of the program by air regulatory agencies. A cap and trade program for NOx and NH3 that includes some of the same features as EPA's national Acid Rain Program could realize similar cost benefits. These features include the cap, accurate and complete emissions inventories, and substantial and automatic penalties for noncompliance.

- Technological innovation and energy efficiency measures taken by sources resulted in a 40% drop in scrubber costs for sulfur dioxide at power plants in the 1990's from expected costs and efficiencies of removal improved from 90 to 95%.
- Costs have been lower than expected in many areas due to previously "grandfathered" sources being among those that have reduced their emissions by the greatest amounts due to their potential to achieve large emission reductions more cheaply than newer, less polluting sources.
- More oversight by air regulators may be required to assure emissions are accurately tracked. This has the benefit of assuring the effectiveness and equity of the program, however, by accurately administering the allowances and enforcing compliance requirements that are essential to success of the program.

Description of How to Implement:

Using EPA's model for cap and trade, a mandatory program would provide the only certainty that needed emissions reductions would be achieved using this air management approach. A voluntary program could not be enforced to assure compliance.

Feasibility of Cap and Trade:

The cap and trade program is an available approach to air quality management.

Uncertainty Associated with Cap and Trade:

The primary uncertainty is not knowing in advance where emission reductions will occur. This is an inherent characteristic of the market-based program and not necessarily a deficiency or significant cause for concern. The flexibility provided by a cap and trade program is one of its main attractions, allowing for a lowest cost approach while achieving substantial emission reductions.

Appendix E

Control Option 8

Control Option: Pollution Prevention (P2) and Voluntary Reductions

Description:

Pollution prevention, referred to as P2, is largely a type of voluntary emission reduction program that has potential for positively affecting air quality. P2 is a national policy for implementation at regional, state, and local levels that reduces or eliminates waste at the source by modifying production processes, promoting the use of non-toxic or less-toxic substances, implementing conservation techniques, and re-using materials rather than putting them in the waste stream. There are local and regional contacts for P2 assistance programs and resources, including from the U.S. Environmental Protection Agency (EPA) for partnership programs with industry, grants and funding to support state and tribal P2 programs, and technical assistance services offered through EPA and various state offices and partners.

There are numerous opportunities and measures available for industry, small businesses, government, and individuals to take part in P2; everything from agriculture to waste management to manufacturing, service industries and transportation can utilize P2 methods to lessen emissions and conserve energy. The specific P2 strategy related to renewable energy and energy efficiency is a separate topic discussed in this report.

Benefits of P2 and Voluntary Reductions:

Voluntary measures to reduce NOx and NH3 emissions from large and small sources would assist in reducing tropospheric ozone formation, fine PM and nitrogen deposition, as well as improving visibility. Voluntary measures are generally viewed by industry as a positive means for achieving environmental benefits while retaining the flexibility of a non-regulatory program. Many organizations, including environmental agencies, non-profits, and universities, offer P2 information and assistance to businesses at no charge and can assist them in finding ways to lessen their environmental impact through reducing waste while saving costs.

Costs/Tradeoffs Associated with P2 and Voluntary Reductions:

Many assistance programs exist from EPA and Departments of Defense and Energy offices to state and other levels of government that offer several easy and free options for businesses, government, and individuals wanting to benefit the environment and save costs by implementing P2. P2 alternatives are often no more costly (and sometimes even less costly) than traditional process add-on control solutions to air emissions-caused environmental problems.

Description of How to Implement:

Voluntary reduction measures would be useful elements of a comprehensive control strategy to benefit air quality, but it is impossible to quantify this strategy's ability to improve nitrogen deposition in RMNP because implementation details of State voluntary programs are not well defined. Enhanced policy direction for Colorado's existing P2 program could potentially be more effective by encouraging voluntary NOx and NH3 reduction measures through incentives, assistance programs, and reduction targets. This additional emphasis could contribute to air quality improvements generally and provide assurance that a directed program would yield more benefits. Outside of a voluntary P2 program, the State could provide disincentives to pollute within its existing regulatory programs by charging new or increasing current emissions fees on processes or activities that result in emissions that could be avoided or reduced by employing P2 alternatives.

Feasibility of P2 and Voluntary Reductions:

A P2 and voluntary reduction strategies at the State level are entirely feasible and only needs a focused commitment to boost its effectiveness from current levels of implementation. Many P2 efforts are already underway, largely driven by the open market and assistance being provided at regional and national levels of government. Additional emphasis by the State specific to achieving NOx and NH3 emission reductions could assure more successful implementation of these types of measures. A feasibility study could be conducted to assess potential for NOx and NH3 reductions through a directed program.

The Federal Pollution Prevention Act of 1990 established pollution prevention as a public policy of the United States. The Federal Act declares that pollution should be prevented or reduced at the source wherever feasible, while pollution that cannot be prevented should be recycled in an environmentally safe manner. In the absence of feasible prevention or recycling opportunities, pollution by-products should be treated. Disposal or other releases into the environment should be used only as a last resort and should be conducted in an environmentally safe manner.

P2 has been established as a public policy of the State of Colorado through the Pollution Prevention Act of 1992, which declares, “the state policy of Colorado shall be that P2 is the environmental tool of first choice.” The Colorado Pollution Prevention Act of 1992 created the following:

- A governor appointed Pollution Prevention Advisory Board (PPAB) to coordinate pollution prevention activities in Colorado.
- A pollution prevention Activities Program to collect and evaluate information on toxics use reduction and waste reduction through EPCRA or SARA Title III reporting, perform outreach, and provide technical and informational assistance to internal and external customers.
- A Pollution Prevention Grants Program designed to fund pollution prevention activities and provide technical assistance to small and medium sized businesses in the state. The pollution prevention Grant Program is funded by fees collected from facilities required to report under EPCRA or SARA Title III.

The Colorado Department of Public Health and Environment (CDPHE) attempts to integrate and incorporate pollution prevention and environmental leadership program strategies into the agency’s permitting, inspections, enforcement, rules development, remediation, assistance, and other functions. The CDPHE pollution prevention/environmental leadership program includes: policies, strategies, and projects designed to use flexibility and other incentives to encourage organizations to achieve results through pollution prevention, the Environmental Leadership Program and other innovations, for enhanced environmental outcomes.

Background Data and Assumptions Used:

EPA’s Office of Pollution Prevention and Toxics

EPA’s Environmental Technology Verification

EPA Region 8’s P2 Peaks to Prairies Information Center

Uncertainty Associated with P2 and Voluntary Reductions:

The benefits and costs of voluntary reductions cannot be quantified due to the uncertain penetration of P2 measures into the emissions-producing community through volunteerism. Qualitatively, there are both environmental and economic benefits to more utilization of P2. These benefits are more certain to occur through directed State efforts that promote education and public outreach on P2, place a high priority on P2 through use of incentives and disincentives, and encourage energy conservation, clean fuels, and development of renewable energy sources.