events or perhaps require the development of work practice standards to minimize such emissions.

D. Region 6 Has No Basis to Disapprove the Visibility Modeling Prepared by PNM, Which Confirms that the Installation of SCRs at San Juan Will Have a Negligible Impact on Visibility Levels at Nearby Class I Areas.

Region 6 modeled the visibility improvements associated with its proposal to require SCRs at San Juan and determined that the maximum visibility improvement expected to result would be a 3.11 deciview (dv) improvement at the Canyonlands Class I area. In contrast, refined modeling conducted by PNM in March 2009 to support the 2007 BART determination indicates that the installation of SCRs with sorbent injection at San Juan will not improve visibility at any Class I area by more than 1.3 dv, which occurs at Mesa Verde. Recent modeling conducted by CALPUFF model developer, Joseph S. Scire (discussed in more detail below), indicates that SCRs with sorbent injection at San Juan for each unit would not improve visibility at any Class I area by more than 0.5 dv, which is the threshold that EPA has established for "contributing to visibility impairment" and below which humans cannot perceive differences in visibility.

The most significant difference is that PNM modeled the more realistic 0.07 lb/mmBtu NO_x emission rate during SCR operation, instead of the unachievable 0.05 lb/mmBtu emission rate assumed by Region 6. PNM's comments above explain the error in Region 6's decision to assume a NO_x emission rate of 0.05 lb/mmBtu. As such, Region 6 must recognize that, once the proper emission rate is utilized, its proposal to require SCRs at San Juan may not result in any meaningful visibility improvements at all. In addition, the attempt to aggregate visibility improvements across multiple Class I areas is logically flawed and potentially misleading, and therefore not be considered a valid metric for evaluating the potential visibility improvements associated with installing SCR at San Juan.

1. Region 6 Has Provided No Justifiable Basis for Rejecting PNM's Modeling Results.

Region 6 characterizes the modeling performed by PNM and accepted by NMED in its draft June 23, 2010 regional haze SIP as follows:

> Although we generally regard the visibility modeling analyses performed by NMED to be of high quality, we noted some minor issues we wished to rectify in order to address consistency with modeling guidance we have provided to the states.

The "minor issues" referenced by Region 6, however, inflate the visibility improvement calculations in the SCR analysis by nearly a factor of three. In other words, the minor "tweaks" Region 6 applied to the PNM / NMED modeling, which was also much more similar to the WRAP modeling, multiplies the expected visibility improvements associated with installing SCRs at San Juan by **nearly three times**.

There are two categories of "minor issues" that were "rectified" in the modeling relied upon by the proposed FIP. The first category of changes involved changes to basic assumptions about the performance of SCRs at San Juan, namely sulfuric acid emissions levels, the catalyst oxidation rate, and, most importantly, the unrealistic assumption that a retrofit SCR would be able to achieve a NO_x emission rate of 0.05 lb/mmBtu. The second category of "minor issues" addressed by Region 6 involved selecting different modeling versions or assumptions, such as (a) selecting a different "post-processing" method, (b) using constant background ammonia concentrations instead of variable background ammonia concentrations, and (c) the manner in which SO_2 emissions are accounted for in the modeling.

Region 6 should not use a selection of different modeling techniques to triple the modeling results. Although Region 6 claims its tweaks are needed for "consistency," the Region's tweaks are not, in fact, consistent with EPA guidance. Moreover, despite discussions with NMED over several years regarding proper modeling techniques, Region 6 did not raise any of its concerns to PNM or NMED until the issuance of the proposed FIP.[78] Thus, rather than seeking consistency, it appears that Region 6 performed various modeling iterations by changing each one of the assumptions and, in the end, chose the version that resulted in the highest visibility improvement of the resulting values. PNM questions this approach to modeling visibility impacts and questions the assumptions relied upon in Region 6's chosen modeling analysis.

a. Differences in "Post-Processing" Method Chosen

CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model that simulates the effects of meteorological conditions on pollution transport, transformation, and removal. The preamble to EPA's 2005 regional haze rule describes the three parts of the CALPUFF model: "a diagnostic meteorological model [CALMET], a gaussian puff dispersion model with algorithms for chemical transformation and complex terrain [CALPUFF], and a post processor for calculating concentration fields and visibility impacts [CALPOST]." Within CALPOST, there are two options for "post-processing" known as "Method 6" and "Method 8."

In preparing its 2007-2009 BART modeling for the San Juan BART determination, PNM utilized Method 6 "post-processing."[79] NMED utilized the same method of post-processing in the SIP submittal it published on June 23, 2010, upon which Region 6 purports to rely heavily. PNM chose Method 6 to match the version used by WRAP, which prepared the modeling upon which the reasonable progress goals for Western states are based. Region 6 appears to accept the use of Method 6 because it relies on the results of the WRAP modeling as the basis for proposing a new SO_2 emission limit at San Juan.

However, for modeling Region 6 used in its NO_x BART analysis, the Region selected Method 8 post-processing, which resulted in much higher visibility impacts and improvements than would be predicted using Method 6 (the method chosen by PNM, NMED, and WRAP). Although Region 6 generally justified its choice of model versions in its proposal by referring to

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[78] EPA and NMED discussed BART modeling on numerous occasions beginning in November 2007 and NMED actually provided EPA with a hard drive of modeling results in May 2009.

[79] "Post-processing" is the methodology used within the model to process the various model outputs and other applicable variables into model predicted results.

the "regulatory version" used for EPA rulemaking activities, Method 8 processing is not supported by the "regulatory version" Region 6 used in its analysis. PNM agrees that there is no regulatory requirement to use a particular post-processing method, and therefore does not disagree in principle with the Region's decision to stray from its "regulatory version."[80] However, it is clearly inconsistent for Region 6 to justify its rejection of PNM's modeling based on the need for a "regulatory version" when the Region's own modeling isn't the "regulatory version" either. Region 6's SCR modeling analysis is also internally inconsistent because Region 6 relies on Method 6 for SO_2 (using the WRAP modeling) and on its own Method 8 modeling for NO_x. This internal inconsistency alone draws Region 6's modeling into question.

b. Differences in Background Ammonia Concentrations.

Background ammonia concentrations are relevant to visibility modeling because chemical reactions between ammonia and certain pollutants (NO_x and SO_2) result in particulate matter that contributes to regional haze. Recognizing the importance of background ammonia concentrations to the formation of regional haze, PNM's consultant, Black & Veatch, reviewed published information and obtained area-specific ammonia values based on Region 6 research performed in the Four Corners area, including ammonia data that had been approved by the NPS for the Desert Rock Energy Facility and the Toquop Energy Projects.[81] The information obtained confirmed that the use of variable monthly ammonia values would better reflect the seasonal variations in ammonia concentrations than would a constant, assumed ammonia concentration.

The ammonia value utilized in PNM's modeling are provided in Table 2 below:

Table 2
Variable Monthly Ammonia
Background Concentration

Month	Background Ammonia Concentration (ppb)
January	0.2
February	0.2
March	0.2
April	0.5
May	0.5
June	1.0
July	1.0
August	1.0
September	1.0

[80] EPA has specifically allowed states significant leeway in choosing an appropriate model version, including more advanced modeling techniques as they became available.

[81] In April 2008 Region 6 indicated to NMED that key NPS members approved for EPA the variable ammonia background concentration values in an e-mail from Scott Bohning (EPA Region 6) dated April 8, 2008 to Gi-Dong Kim (NMED Modeling Scientist).

October	0.5
November	0.5
December	0.2

The developer of the CALPUFF model, Joseph Scire, reviewed the variable ammonia data utilized in PNM's analysis. After reviewing a set of 33 reports, papers, and documents[82] to assess the appropriate ammonia concentrations for the CALPUFF modeling, Mr. Scire concluded the following:

- The use in CALPUFF of the monthly-varying ammonia concentrations in Table 2 is appropriate and consistent with the observed seasonal variability of ammonia observations in the Mesa Verde area.

- The range of assumed ammonia concentrations from 0.2 ppb in the winter to 1.0 ppb in the summer is still a conservative approach (*i.e.*, likely to over-predict nitrate impacts), given actual ammonia observations in the Mesa Verde area.[83]

Although PNM supported its use of monthly background ammonia concentrations with significant data, and its analysis has been confirmed by the developer of CALPUFF, Region 6 rejected the use of variable ammonia concentrations and assumed a generic, constant background ammonia concentration of 1 ppb instead. Region 6 notes in the supporting documentation for its modeling analysis that there is "uncertainty over background ammonia concentrations" and that "there is some debate about what to use historically for background ammonia levels."[84] Region 6's supporting documentation also admits that "alternative levels may be used if supported by data."[85] As such, Region 6 has no basis for criticizing the ammonia levels used in the modeling prepared by PNM. The Region's decision to rely on constantly high background ammonia concentrations unjustifiably results in higher visibility improvements than expected by PNM's more realistic modeling results.

c. Differences in Baseline Emission Rate for SO_2 and NO_x

Modeling visibility improvements associated with a particular control technology requires the modeler to develop a baseline level of emissions against which to compare expected visibility impacts following the installation of the new controls. In its modeling, PNM assumed a baseline SO_2 emission rate of 0.18 lb/mmBtu based on the current, federally enforceable emission limit. Even though future SO_2 emissions will likely be lower due to expected regional

82 One of the reports reviewed Mr. Scire actually consisted of Region 6's own analysis of background ammonia concentrations, which is consistent with the values PNM used in its modeling.

83 Joseph S. Scire, CCM, "Analysis of Ammonia in the Four Corners Area" (March 2011) (Attachment D).

84 EPA's technical Support document, Visibility Modeling for BART Determination: San Juan Generating Station, New Mexico, EPA-R06-OAR-2010-0003, page 46.

85 EPA's technical Support document, Visibility Modeling for BART Determination: San Juan Generating Station, New Mexico, EPA-R06-OAR-2010-0003, page 39.

haze requirements (under a Section 309 SIP), future SO_2 emissions were also assumed to be 0.18 lb/mmBtu to match the baseline, thus isolating the impact of NO_x reductions for purposes of the modeling. Region 6 also used the same SO_2 emission rate in its baseline and expected modeling cases, but instead used an SO_2 rate of 0.15 lb/mmBtu for both the baseline and future cases. Region 6's justification for using the lower SO_2 rate is that the lower rate is expected in the future. PNM believes that utilizing the current SO_2 limit is the more appropriate modeling method, even though the use of the current limit actually results in higher expected visibility improvements.

d. The Overall Effect of "Minor Issues" in PNM / NMED Modeling on Visibility Improvements Expected with SCRs at San Juan is Significant.

Although it is not surprising that different modeling techniques will generate different modeling results, it is surprising that Region 6 would perform numerous different visibility models and choose the one with the highest visibility improvements, even though the chosen model results are the least consistent and the least realistic of the modeling runs prepared. The results from the Region's modeling runs based on the changes in the assumptions described above are provided in Table 3 below:

Table 3: Comparison of EPA Modeling Results for Mesa Verde

EPA Modeling Runs	Variable NH_3		Constant NH_3	
	Method 6	Method 8	Method 6	Method 8
Visibility Improvements with SCRs at San Juan	0.97	1.45	2.31	2.88*
*This value was chosen by EPA in making its proposed BART determination.				

As shown above, Region 6 chose the highest modeled value of the different modeling runs. That value suggests that visibility improvements associated with installing SCRs at San Juan will be three times higher than the model that would assume more realistic, site-specific background ammonia concentrations and the Method 6 post-processing that has been relied upon by PNM, NMED, and WRAP and by Region 6 itself with regard to SO_2 (by relying on the WRAP modeling). Thus, Region 6's rejection of PNM's modeling is unjustified and unnecessarily inflates the expected visibility improvements associated with SCRs.

2. The "Total dv" Metric Is Logically Flawed and Potentially Misleading.

PNM disagrees with Region 6's reference to "total" visibility improvements in the proposed FIP because it is meaningless to add deciview improvements together across different Class I areas. Region 6 states that its "total dv" metric aids in the determination of BART by providing "a single number for comparing control scenarios to each other." Region 6 also asserts that, with the "total dv" metric, "overall impact can be assessed more or less **intuitively**."[86]

[86] EPA Region 6 Technical Support Document EPA-R06-OAR-2010-0846-0003, page 43 (emphasis added).

Region 6's "total dv" metric, however, is not "intuitive." Adding deciviews from different locations together simply results in a meaningless overstatement of the visibility improvements expected with a particular control scenario. The visibility improvement modeled for each Class I area represents the improvement expected to occur at a specific location on the 8th worst day of visibility impairment (98th percentile) at that particular location. The 8th worst day is likely to be a different day from area to area, and even if those conditions were to occur on the same day, it is not possible to view two Class I areas at once. Even if standing near the border of one area looking toward another, a viewer will experience only the prevailing level of degradation at that location, not twice that level. Simply put, a 0.5 dv improvement at two Class I areas does not result in a 1 dv improvement overall. Adding visibility improvements across multiple Class I areas essentially multiplies the visibility improvement by the number of Class I areas. The lack of "intuitiveness" in Region 6's "total dv" metric should be obvious – if Region 6's "total dv" theory were applied to snowfall, for example, 1 inch of snow fall in each of two nearby Class I areas would suggest that the area actually received 2 inches of snow (or 3 inches, if there were 3 nearby Class I areas; 4 inches, if there were 4 Class I areas; etc.). The visibility impacts to a region should not depend on the number of Class I areas present.

The use of a "total dv" metric is also inconsistent with the BART Guidelines, which directs states to "[u]se CALPUFF or other appropriate dispersion model to **determine the visibility improvement expected at <u>a Class I area</u>** ...."[87] The Guidelines further suggest that visibility improvements should be determined based on the maximum impact to a single Class I area as follows:

> One important element of the protocol is in establishing the receptors that will be used in the model. **The receptors that you use should be located in the nearest Class I area** with sufficient density to identify the likely visibility effects of the source. **For other Class I areas in relatively close proximity to a BART-eligible source, you may model a few strategic receptors to determine whether effects at those areas may be greater than at the nearest Class I area.** For example, you might chose to locate receptors at these areas at the closest point to the source, at the highest and lowest elevation in the Class I area, at the IMPROVE monitor, and at the approximate expected plume release height. **If the highest modeled effects are observed at the nearest Class I area, you may choose not to analyze the other Class I areas any further as additional analyses might be unwarranted.**[88]

As such, the use of the "total dv" metric by Region 6 is not only not "intuitive," it is also inconsistent with EPA regulations and guidance. Region 6 should eliminate the misleading "total dv" metric from consideration in its BART analysis.

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87 40 C.F.R. Part 51, Appendix Y, IV.D.5 (emphasis added).

88 40 C.F.R. Part 51, Appendix Y, IV.D.5 (emphasis added).

3. Recent Refinements to the CALPUFF Model Made at the Advice of the Model's Creator, Joseph S. Scire, Further Confirm SCRs at San Juan Will Have a Negligible Impact on Visibility in the Surrounding Class I Areas.

In September of 2010, PNM contacted Joseph Scire, Vice President and Manager of the Atmospheric Studies Group at TRC Solutions, to request a review of PNM's BART modeling. Mr. Scire is often referred to as the "father of CALPUFF" because he played a major role in the development of several widely-used models, including the CALPUFF modeling system, the CALGRID photochemical model, the Buoyant Line and Point Source (BLP) model, the MESOPUFF II mesoscale puff dispersion model, the building downwash algorithm in the Industrial Source Complex (ISC) model, a new building downwash model (PRIME), and the FOG cooling tower model. Mr. Scire has over 26 years experience in the design, development, and application of air quality models, including the CALPUFF modeling system, and has taught more than 60 training courses on the CALPUFF model for government agencies, private industry, and universities in the United States and abroad. In a report he prepared regarding PNM's modeling, Mr. Scire states the following:

> One task of this review was to determine if [PNM's] modeling was conducted in accordance with the modeling protocols and general industry standards and practices, and another was to determine if any refinements or enhancements should be made to the modeling to make it more representative. In addition various elements of the modeling analysis were independently conducted to confirm the calculations, and while all the data was reviewed, due to the extensive amount of data, only the final SCR plus sorbet [SIC] injections runs were recreated and reproduced. The conclusion of this analysis was the B&V modeling files were properly prepared and implemented. These analyses followed general industry standards and practices and the B&V protocol, which followed and was consisted with the WRAP protocol.[89]

Thus, Mr. Scire not only confirmed that PNM's modeling was consistent with the methodology developed for the model he helped create, he also confirmed that PNM's modeling was prepared in a manner consistent with the modeling prepared by WRAP. Given that Region 6 accepted the WRAP modeling, and used it to support its own positions with regard to SO_2 in the proposed FIP, the fact that PNM's modeling was prepared in a manner consistent with the WRAP modeling suggests that Region 6 need not alter that modeling. It also suggests that the different modeling results achieved by Region 6 are merely a function of Region 6's modeling method, rather than true differences in visibility impacts.

In addition to confirming that PNM's modeling was conducted appropriately, Mr. Scire also determined that more recent developments in air quality modeling science and chemistry could be used to make a more accurate and realistic prediction of the visibility improvements that might result from installing SCRs at San Juan. Specifically, Mr. Scire considered the following improvements to the model: (1) a new chemical mechanism introduced in CALPUFF Version 6.4 that more accurately models the conversion of SO_2 and NO_x into sulfate and nitrate

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[89] Joseph S. Scire, CCM, "Analysis of the Issues related to the BART Determination of the San Juan Generating Station in New Mexico" (March 2011) (Attachment E).

particles, (2) refining the grid spacing from 4 km to 1 km, and (3) use of the "ammonia limiting method" (ALM) for determining background ammonia concentrations. Using these three more recently developed modeling techniques, Mr. Scire found that the greatest visibility improvement that could be achieved at any Class I area by installing SCRs at San Juan would be **less than 0.5 dv per unit**, and thus less than what a human can perceive.

E. Summary of Comments on the Cost-Effectiveness Calculations Upon Which the Proposed FIP Relies

All told, the differences between Region 6's and PNM's cost analyses and the modeling analyses have a dramatic impact on the final results of the cost-effectiveness calculations for SCR installations at San Juan. As noted above, PNM's cost effectiveness values for SCR range from $5,946 to $7,398 per ton. Region 6's range of $1,579 – $1,920 per ton represents only one quarter of that estimate. PNM's cost analysis relies on the expert opinion of engineers with practical experience that took into account site-specific concerns, and its modeling estimate relies on more realistic assumptions and more accurate modeling methodologies. As such, Region 6 should reconsider its BART determination in light of PNM's cost-effectiveness values.

In addition, although EPA's BART Guidelines indicate that cost-effectiveness may be considered in terms of dollars per ton of pollutant removed, PNM also believes that a dollar per deciview of visibility improvement metric would be more in line with the overall goal of the regional haze program, namely to improve visibility in national parks and wilderness areas. Region 6 should recognize that the BART determination it has proposed is not required by a health-based program – as noted above, San Juan already has sufficient pollution control technology in place to meet all health-based standards under the Clean Air Act. To properly gauge cost-effectiveness of Region 6's proposal in terms of visibility improvements, Region 6 must consider the fact that installing SCRs at San Juan will cost between $78 million and $336 million per deciview, depending on the Class I area. These metrics are highly relevant to determining the cost-effectiveness of controls proposed solely for the purpose of visibility improvements, as they confirm the exorbitant costs associated with the Region 6 proposal.

IV. CONCLUSION

PNM appreciates the opportunity to comment on Region 6's proposed FIP and hopes its comments will be helpful in ensuring that the proposal properly takes into account the realistic costs and engineering challenges associated with installing SCRs at San Juan, the minimal visibility improvements that would result, and the other regulatory alternatives available to Region 6 in satisfying the regional haze and interstate transport programs in New Mexico. In particular, PNM hopes Region 6 will fully consider the additional information provided regarding the potential economic impact of its proposal on the region, given that the proposed FIP would impose an additional $82 annual burden on every household, where 18 percent of the population lives below the poverty line, and have a significant impact on every business in the area as well. Most importantly, PNM asks Region 6 to delay finalization of a BART determination for San Juan until New Mexico can complete its SIP revision process and submit a complete regional haze program to EPA for approval.

Sincerely,

Patrick Themig, Vice President, Generation
Public Service Company of New Mexico

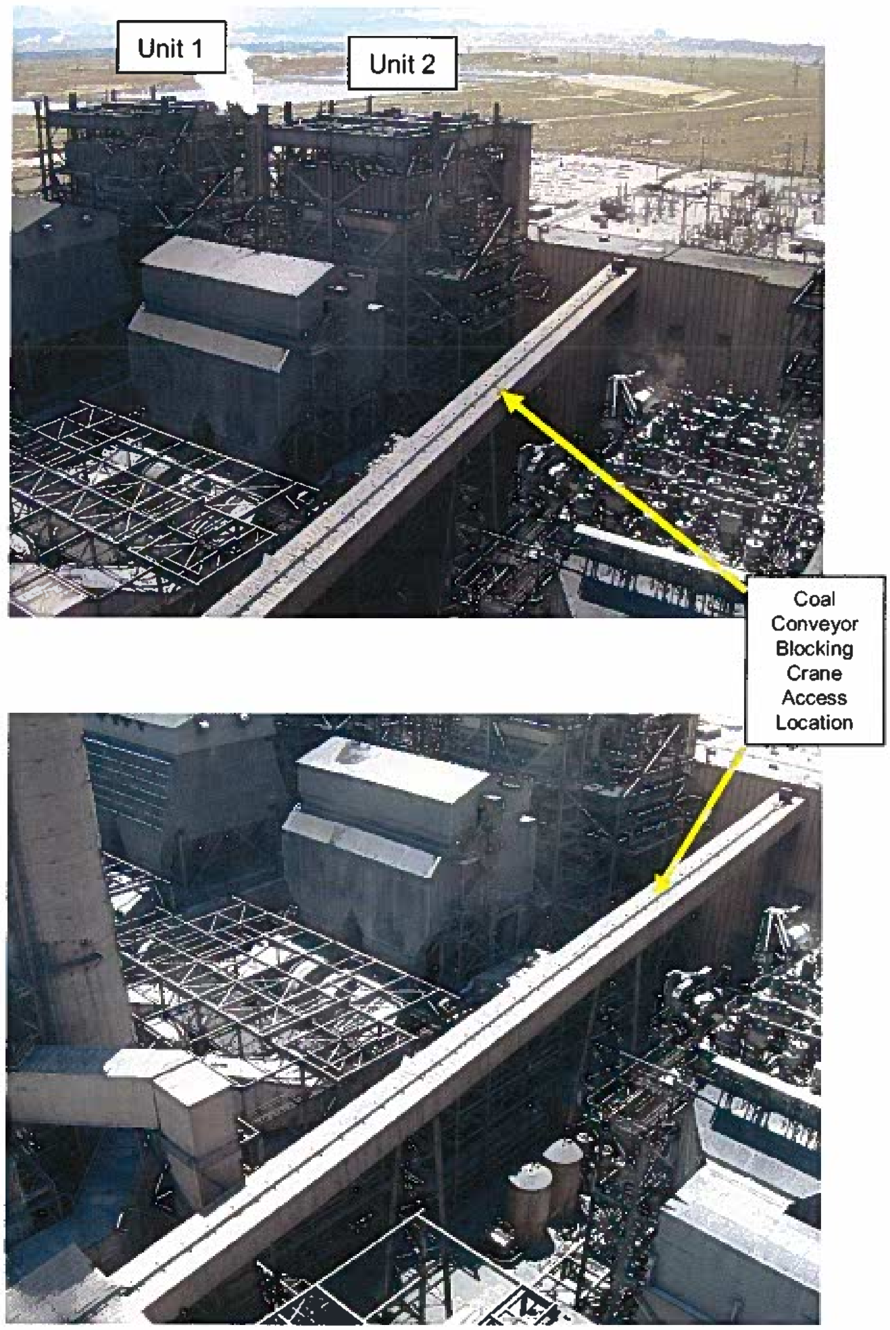
Attachment A: Table of Proposed NO_x BART Determinations
for Coal-Fired Electric Generating Units

Proposed NO_x BART Determinations for Coal-Fired Electric Generating Units

Plant	Unit	Size	State / EPA	Date	Existing Controls	BART Controls	BART Limit	Units	$/ton	Imp. Time	$/ton SCR	Notes
PNM San Juan Generating Station	1	350	EPA 6	1/5/2011	LNB, OFA	SCR	0.05	lb/mmBtu (30-day)	1,847	3 years	1,847	
PNM San Juan Generating Station	2	360	EPA 6	1/5/2011	LNB, OFA	SCR	0.05	lb/mmBtu (30-day)	1,920	3 years	1,920	
PNM San Juan Generating Station	3	544	EPA 6	1/5/2011	LNB, OFA	SCR	0.05	lb/mmBtu (30-day)	1,610	3 years	1,610	
PNM San Juan Generating Station	4	544	EPA 6	1/5/2011	LNB, OFA	SCR	0.05	lb/mmBtu (30-day)	1,579	3 years	1,579	
APS Four Corners	1	170	EPA 9	10/19/2010	None	SCR	0.11	lb/mmBtu (30-day)	2,515	5 years	2,515	
APS Four Corners	2	170	EPA 9	10/19/2010	None	SCR	0.11	lb/mmBtu (30-day)	3,163	5 years	3,163	
APS Four Corners	3	220	EPA 9	10/19/2010	None	SCR	0.11	lb/mmBtu (30-day)	2,678	5 years	2,678	
APS Four Corners	4	750	EPA 9	10/19/2010	None	SCR	0.11	lb/mmBtu (30-day)	2,622	5 years	2,622	
APS Four Corners	5	750	EPA 9	10/19/2010	None	SCR	0.11	lb/mmBtu (30-day)	2,908	5 years	2,908	
APS Cholla	2	300	AZ	12/2/2010	LNB, SOFA	LNB, SOFA	0.22	lb/mmBtu	192	5 years	1898*	
APS Cholla	3	300	AZ	12/2/2010	LNB, SOFA	LNB, SOFA	0.22	lb/mmBtu	303	5 years	2551*	
APS Cholla	4	425	AZ	12/2/2010	LNB, SOFA	LNB, SOFA	0.22	lb/mmBtu	242	5 years	2206*	
SRP Coronado	1	395	AZ	12/2/2010	LNB*, OFA	LNB, OFA	0.32	lb/mmBtu (30-day)	210	5 years	1,021	*Required by 2008 Consent Decree; **SCR calculations based on SCR on both units together
SRP Coronado	2	390	AZ	12/2/2010	LNB*, OFA, SCR*	LNB, OFA	0.32	lb/mmBtu (30-day)	210	5 years	1,021	*Required by 2008 Consent Decree; **SCR calculations based on SCR on both units together
AEPCO Apache	2	195	AZ	12/2/2010	OFA, under-fired air	New LNB, OFA	0.31	lb/mmBtu (30-day)	408	5 years	1,878	
AEPCO Apache	3	195	AZ	12/2/2010	OFA, under-fired air	New LNB, OFA	0.31	lb/mmBtu (30-day)	575	5 years	2,183	
PSCo Comanche	1	325	CO	1/17/2011	LNB, OFA	LNB, OFA	0.20 / 0.15	lb/mmBtu (30-day/tpy)	*	5 years	15,920	*Controls already installed
PSCo Comanche	2	335	CO	1/17/2011	LNB, OFA	LNB, OFA	0.20 / 0.15	lb/mmBtu (30-day/tpy)	*	5 years	9,900	*Controls already installed
Tri-State Craig	1	428	CO	1/17/2011	LNB, OFA	SNCR	0.27	lb/mmBtu (30-day)	4,877	5 years	6,432	
Tri-State Craig	2	428	CO	1/17/2011	LNB, OFA	SNCR*	0.27	lb/mmBtu (30-day)	4,712	5 years	6,299	*308(e)(2) alternative - agreed to SCR @ 0.08
PSCo Hayden	1	190	CO	1/17/2011	LNB, OFA	SCR	0.08	lb/mmBtu (30-day)	3,385	5 years	3,385	
PSCo Hayden	2	275	CO	1/17/2011	LNB, OFA	SCR	0.07	lb/mmBtu (30-day)	4,064	5 years	4,064	
CSU Martin Drake	5	51	CO	1/17/2011	LNB	ULNB	0.31	lb/mmBtu (30-day)	1,342	5 years	7,314	
CSU Martin Drake	6	85	CO	1/17/2011	LNB	ULNB	0.31	lb/mmBtu (30-day)	664	5 years	5,395	
CSU Martin Drake	7	142	CO	1/17/2011	LNB	ULNB	0.29	lb/mmBtu (30-day)	616	5 years	4,981	
KCP&L La Caygne	1	840	KS	7/14/2008	OFA, SCR	SCR*	0.13**	lb/mmBtu (30-day)	1,990*	5 years	not listed	*SCR already under construction on Unit 1; **Limit averaged between two units
KCP&L La Caygne	2	710	KS	7/14/2008	None	LNB, LNB/OFA, or SCR*	0.13**	lb/mmBtu (30-day)	983	5 years	1,990	*Combustion controls determined BART, KCP&L planning SCR; **Limit averaged between two units
Westar Jeffrey	1	720	KS	7/14/2008	None	LNB	0.15	lb/mmBtu	432	5 years	2,211	
Westar Jeffrey	2	720	KS	7/14/2008	None	LNB	0.15	lb/mmBtu	312	5 years	1,738	
MN Power Taconite Harbor	3	225*	MN	10/26/2009	None	ROFA w/ Rotamix	0.20	lb/mmBtu (30-day)	3,400		4,600	*3 boilers @ 75 MW each
MN Power Boswell (tangential)	3		MN	10/26/2009	LNB, OFA, SCR	LNB, OFA, SCR*	0.07	lb/mmBtu (30-day)	3,201	*	3,201	*Already planning to install controls before BART analysis began; construction began in 2007
Northshore Mining Co. Silver Bay	2	75	MN	10/5/2009	None	LNB, OFA	0.40	lb/mmBtu (30-day)	596	End of 2012	4,712	
Xcel Energy Sherburne County	1	690	MN	10/26/2009	LNB, SOFA	New LNB, SOFA	0.15	lb/mmBtu (30-day)	430	5 years	2500*	*Considers installation of controls on both units, SCR cost includes combustion controls
Xcel Energy Sherburne County	2	683	MN	10/26/2009	OFA	Combustion Controls	0.15	lb/mmBtu (30-day)	360	5 years	4600*	*Considers installation of controls on both units, SCR cost includes combustion controls
Rochester Silver Lake	3	24	MN	10/26/2009	None	None*	None*	None*	*	5 years	1,703	*Unit visibility impact considered "marginal," no controls imposed in light of controls on Unit 4
Rochester Silver Lake	4	60	MN	10/26/2009	None	Mobotec*	0.21	lb/mmBtu (30-day)	1,769	5 years	2,841	*Mobotec is comprised of ROFA and Rotamix SNCR
NPPD Gerald Gentlemen	1	681	NE	12/17/2007	LNB, OFA	LNB, OFA	0.23	lb/mmBtu	198	5 years	2,297*	*Includes LNB, OFA
NPPD Gerald Gentlemen	2	681	NE	12/17/2007	LNB, OFA planned	LNB, OFA	0.23	lb/mmBtu	198	5 years	2,297*	*Includes LNB, OFA
OPPD Nebraska City	1	650	NE	12/17/2007	OFA	LNB, OFA	0.23	lb/mmBtu	136	5 years	2706*	*Includes LNB, OFA; incremental SCR cost effectiveness is $8,583
BEPC Leland Olds	1	216	ND	3/3/2010	LNB	SNCR & SOFA	0.19	lb/mmBtu (30-day)	2,854	5 years	7,849-13,626*	*Range based on different SCR designs (low-dust, tail end, etc.)
BEPC Leland Olds	2	440	ND	3/3/2010	None	SNCR & ASOFA	0.35	lb/mmBtu (30-day)	1,659	5 years	3,581-5,838*	*Range based on different SCR designs (low-dust, tail end, etc.)
GRE Coal Creek	1	550	ND	3/3/2010	LNB, SOFA	LNB, SOFA	0.17	lb/mmBtu (30-day)	411	5 years	13,101	
GRE Coal Creek	2	550	ND	3/3/2010	LNB, SOFA	LNB, SOFA	0.17	lb/mmBtu (30-day)	411	5 years	13,101	
GRE Stanton	1	188	ND	3/3/2010	LNB	LNB, SOFA, SNCR	0.23 / 0.29*	lb/mmBtu (30-day)	3,052	5 years	6,475	*0.23 limit applies to PRB; 0.29 limit applies to lignite
MPC Milton Young	1	257	ND	3/3/2010	None	SNCR, ASOFA	0.36	lb/mmBtu (30-day)	1,265	5 years	4,124-6,901*	*Range based on different SCR designs (low-dust, tail end, etc.)
MPC Milton Young	2	477	ND	3/3/2010	None	SNCR, ASOFA	0.35	lb/mmBtu (30-day)	1,268	5 years	4,109-7,081*	*Range based on different SCR designs (low-dust, tail end, etc.)
PSNH Merrimack	2	320	NH	1/14/2011	SCR	SCR*	0.30*	lb/mmBtu (30-day)	800*	7/1/2013	312	*SCR already installed
NV Energy - Reid Gardner	1	100	NV	11/18/2009	LNB, OFA	ROFA w/ Rotamix	0.20	lb/mmBtu (12-month)	1,109	5 years	2,566-2,916*	*SCR cost range depending on other controls included (ROFA vs. LNB)
NV Energy - Reid Gardner	2	100	NV	11/18/2009	LNB, OFA	ROFA w/ Rotamix	0.20	lb/mmBtu (12-month)	1,038	5 years	2,386-2,721*	*SCR cost range depending on other controls included (ROFA vs. LNB)
NV Energy - Reid Gardner	3	100	NV	11/18/2009	LNB, OFA	ROFA w/ Rotamix	0.28	lb/mmBtu (12-month)	1,588	5 years	2,660-3,045*	*SCR cost range depending on other controls included (ROFA vs. LNB)
OG&E Sooner	1	570	OK	2/17/2010	Comb. Control	LNB, OFA	0.15	lb/mmBtu (30-day)	494	5 years	5,260	
OG&E Sooner	2	570	OK	2/17/2010	Comb. Control	LNB, OFA	0.15	lb/mmBtu (30-day)	785	5 years	7,200	
AEP-PSO Northeast	3	490	OK	2/17/2010	LNB,OFA	LNB, OFA	0.15	lb/mmBtu (30-day)	313	5 years	4,044	
AEP-PSO Northeast	4	490	OK	2/17/2010	LNB,OFA	LNB, OFA	0.15	lb/mmBtu (30-day)	313	5 years	4,044	
OG&E Muskogee	4	572	OK	2/17/2010	Comb. Control	LNB, OFA	0.15	lb/mmBtu (30-day)	809*	5 years	7,676	*BART conclusions suggests $260-281/ton
OG&E Muskogee	5	572	OK	2/17/2010	Comb. Control	LNB, OFA	0.15	lb/mmBtu (30-day)	679*	5 years	6,871	*BART conclusions suggests $260-281/ton
PGE Boardman	1	617	OR	6/19/2009	LNB, OFA	LNB, OFA	0.23	lb/mmBtu (30-day/tpy)	1,263	5 years	8,337	*SCR cost-estimate based on retirement from coal 12/31/2020, Region 10 has proposed to approve
Otter Tail Big Stone I (cyclone)	1	475	SD	1/21/2011	OFA	SOFA, SCR	0.10	lb/mmBtu (30-day)	825	5 years	825	
TransAlta - Centralia	1	702.5	WA	12/1/2010	LNC3*, Flex Fuels**	LNC3*, Flex Fuels**	0.24	lb/mmBtu (30-day)	3,563	5 years	8,205-9,091***	*LNC3 = low NOx combustion controls; **Switch to PRB coal; ***Range depends on 1 or 2 SCRs
TransAlta - Centralia	2	702.5	WA	12/1/2010	LNC3*, Flex Fuels**	LNC3*, Flex Fuels**	0.24	lb/mmBtu (30-day)	3,563	5 years	8,205-9,091***	*LNC3 = low NOx combustion controls; **Switch to PRB coal; ***Range depends on 1 or 2 SCRs
Basin Electric Laramie	1	550	WY	1/7/2011	LNB	LNB, OFA	0.21	lb/mmBtu (30-day)	2,077	5 years	3,372	
Basin Electric Laramie	2	550	WY	1/7/2011	LNB	LNB, OFA	0.21	lb/mmBtu (30-day)	2,088	5 years	3,391	
Basin Electric Laramie	3	550	WY	1/7/2011	LNB	LNB, OFA	0.21	lb/mmBtu (30-day)	2,036	5 years	3,305	
PacifiCorp - Dave Johston (cell-fired)	3	230	WY	1/7/2011	None	LNB, OFA	0.28	lb/mmBtu (30-day)	648	5 years	3,243*	*Includes cost of SCR and LNB/OFA
PacifiCorp - Dave Johston (tangential)	4	330	WY	1/7/2011	LNB	LNB, OFA	0.15	lb/mmBtu (30-day)	137	5 years	2,210*	*Includes cost of SCR and LNB/OFA
PacifiCorp - Jim Bridger	1	530	WY	1/7/2011	LNB	LNB, OFA	0.26	lb/mmBtu (30-day)	225	5 years	2,258*	*Includes cost of SCR and LNB/OFA
PacifiCorp - Jim Bridger	2	530	WY	1/7/2011	LNB, OFA	LNB, OFA	0.26	lb/mmBtu (30-day)	*	3/31/2010	4,275**	*Controls already installed; **Includes cost of SCR and LNB/OFA
PacifiCorp - Jim Bridger	3	530	WY	1/7/2011	LNB	LNB, OFA	0.26	lb/mmBtu (30-day)	225	3/31/2010	2,258*	*Includes cost of SCR and LNB/OFA
PacifiCorp - Jim Bridger	4	530	WY	1/7/2011	LNB	LNB, OFA	0.26	lb/mmBtu (30-day)	225	3/31/2010	2,258*	*Includes cost of SCR and LNB/OFA
PacifiCorp - Naughton	1	160	WY	1/7/2011	None	LNB, OFA	0.26	lb/mmBtu (30-day)	426	2012	2,750*	*Includes cost of SCR and LNB/OFA
PacifiCorp - Naughton	2	210	WY	1/7/2011	None	LNB, OFA	0.26	lb/mmBtu (30-day)	357	2011	2,848*	*Includes cost of SCR and LNB/OFA
PacifiCorp - Naughton	3	330	WY	1/7/2011	LNB, OFA	LNB, OFA, SCR	0.07	lb/mmBtu (30-day)	2,830*	5 years	2,830*	*Includes cost of SCR and LNB/OFA
PacifiCorp - Wyodak	1	335	WY	1/7/2011	LNB	LNB, OFA	0.23	lb/mmBtu (30-day)	881	12/31/2011	4252*	*Includes cost of SCR and LNB/OFA

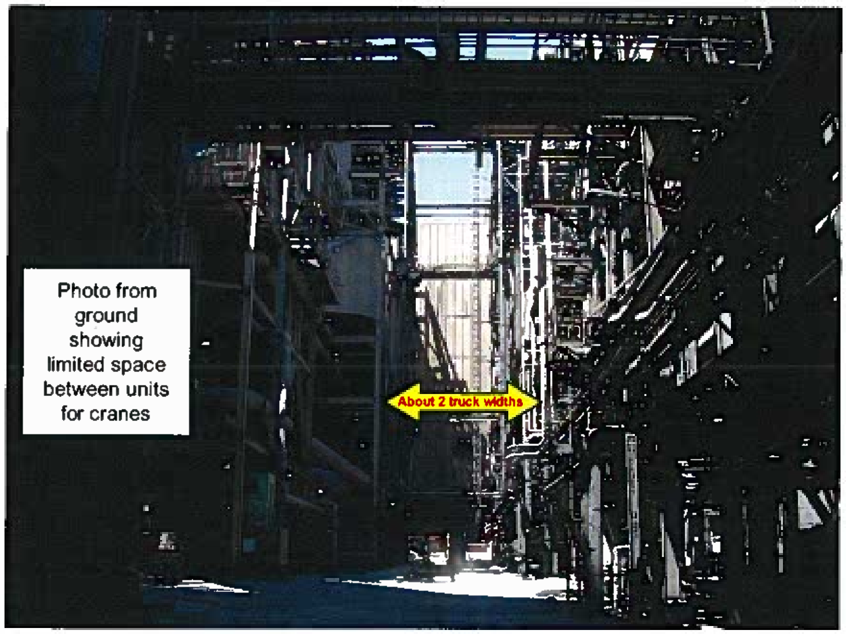
Attachment B: Pictures Comparing Site Congestion at
St. John River Power Park and San Juan Generating Station

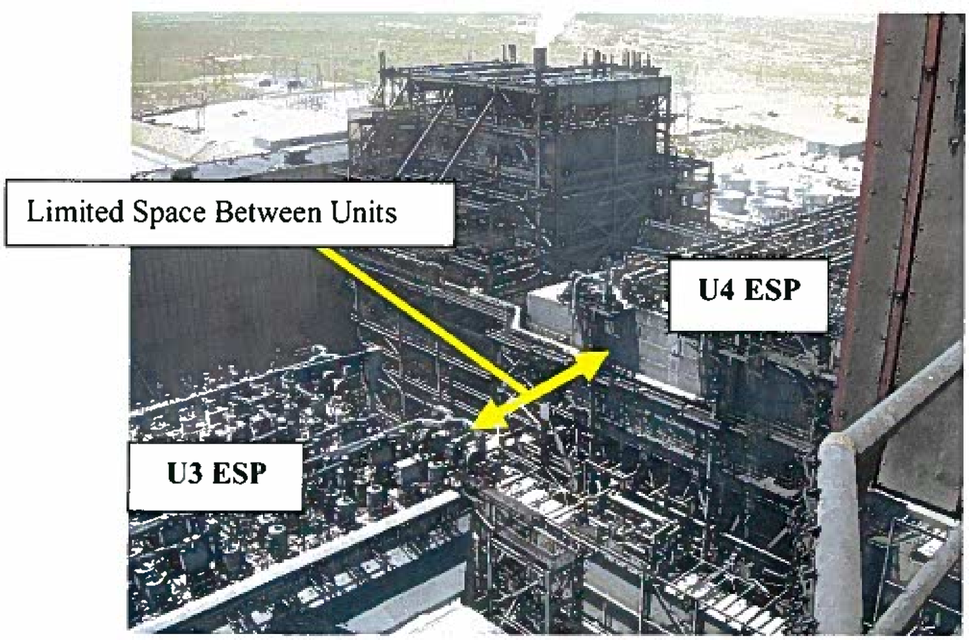
Photos of San Juan Generating Station Showing Examples of Site Congestion



Photos of San Juan Generating Station

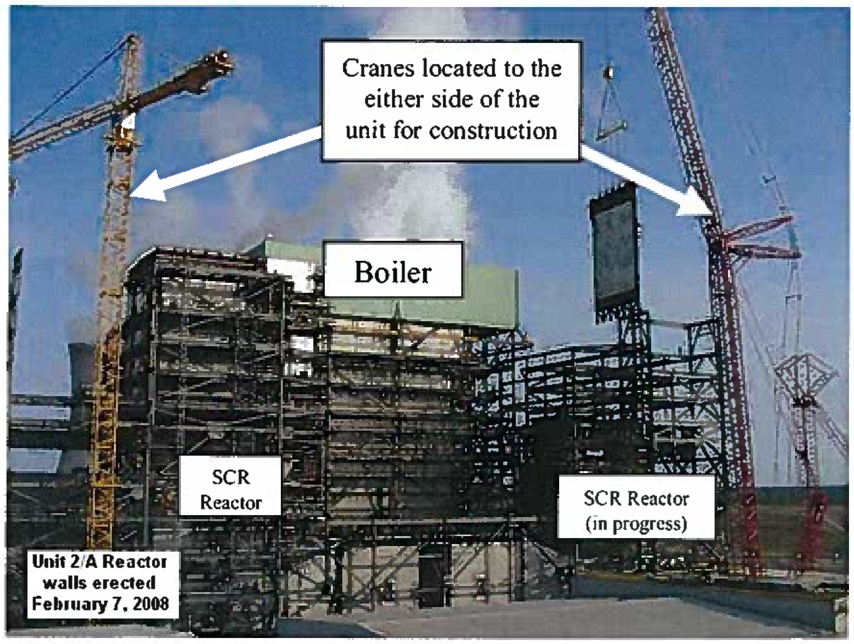
Showing Examples of Site Congestion

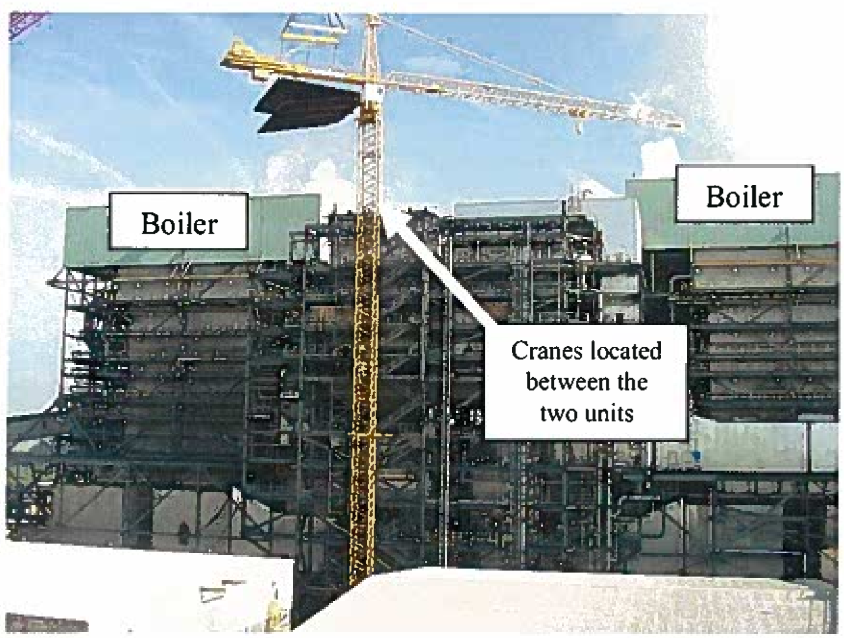




Photos of St. Johns River Power Park

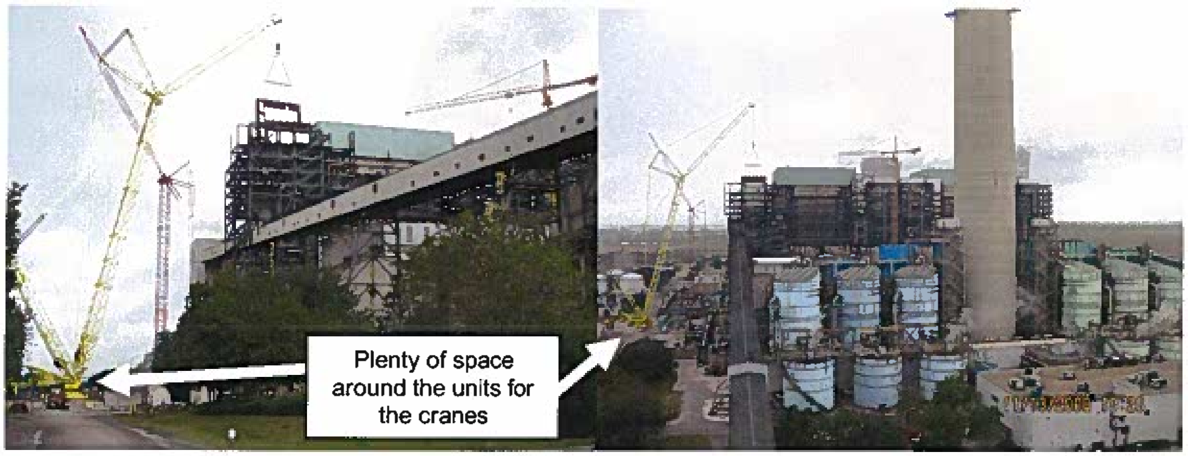
Showing Crane Access

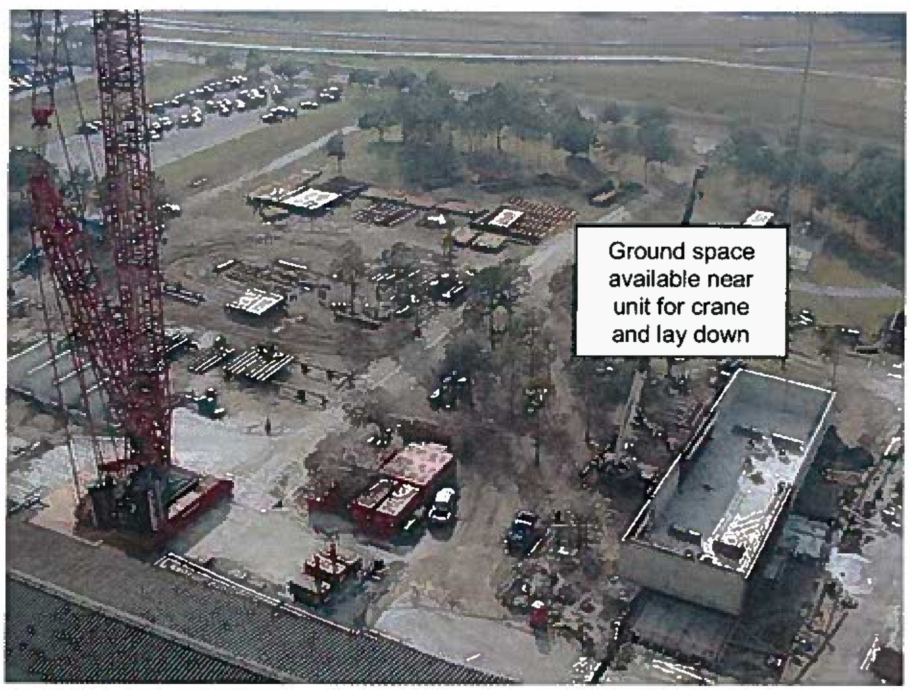




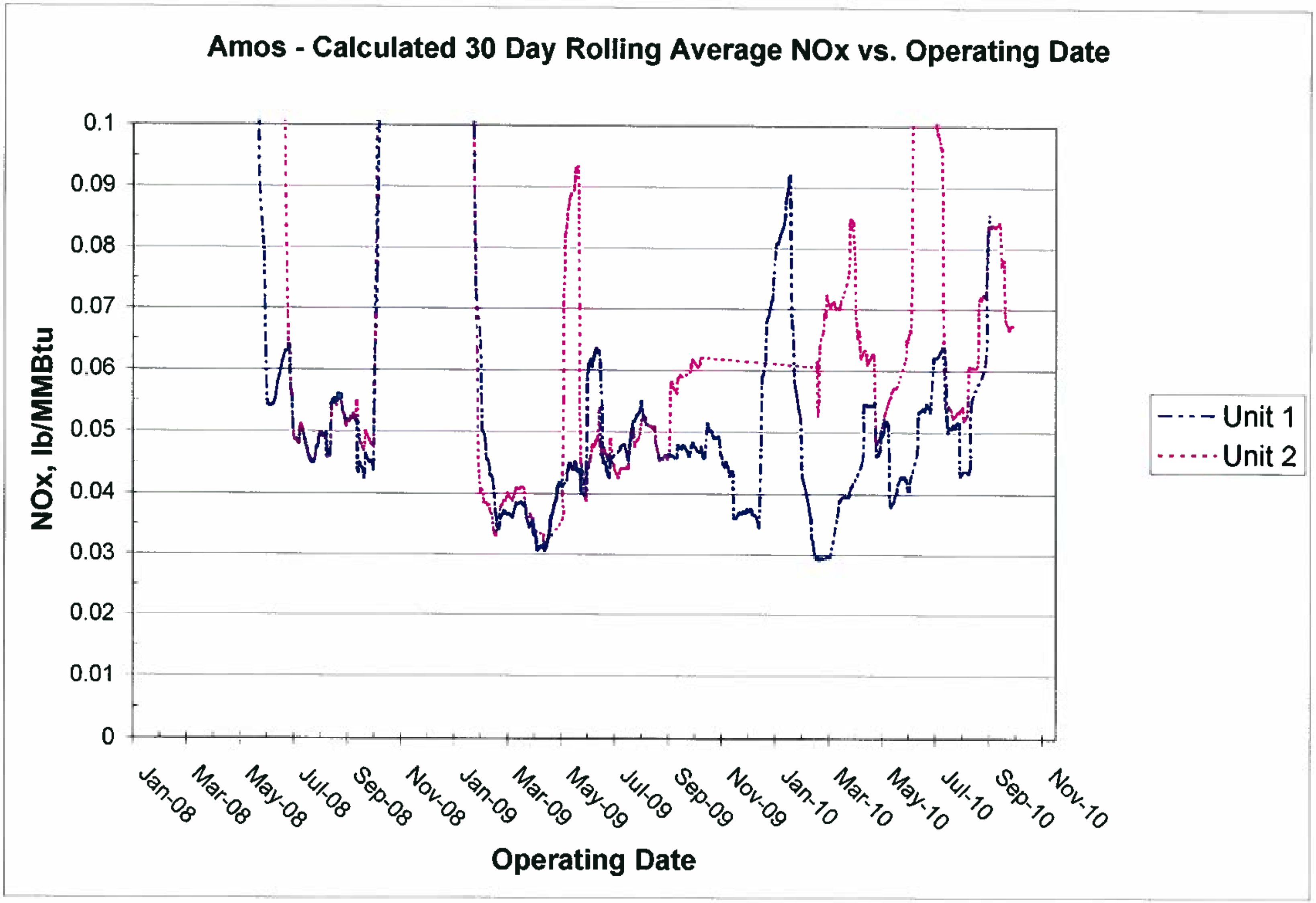
Photos of St. Johns River Power Park

Showing Crane Access

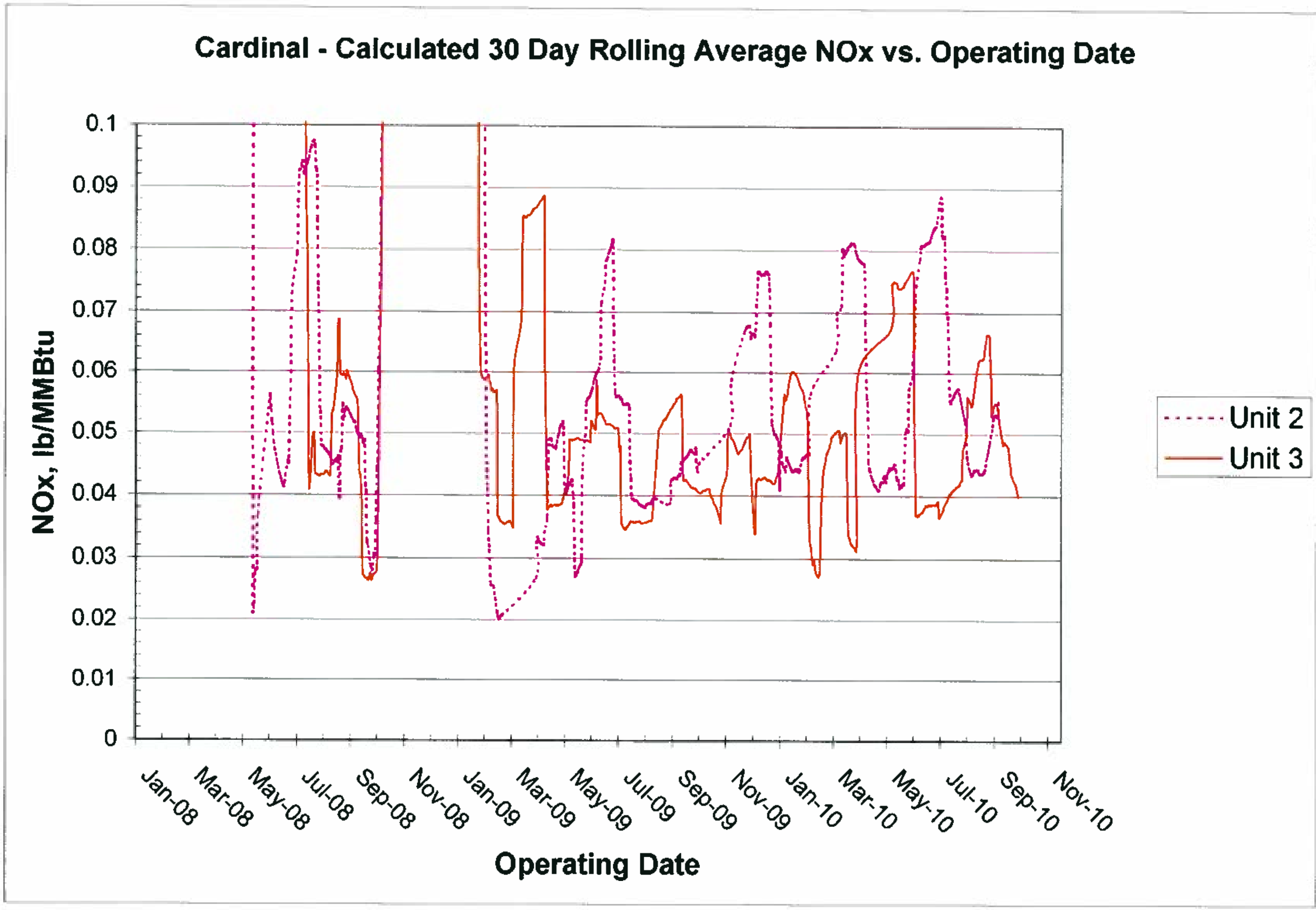




Attachment C: 30-Day Rolling Average NO_x Emission Rates at Facilities Cited in Region 6 Cost Analysis as Capable of Achieving 0.05 lb/mmBtu



Amos - Calculated 30 Day Rolling Average NOx vs. Operating Date
NOx, lb/MMBtu
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Operating Date
Unit 1
Unit 2


Cardinal - Calculated 30 Day Rolling Average NOx vs. Operating Date
NOx, lb/MMBtu
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
Jul-09
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Nov-09
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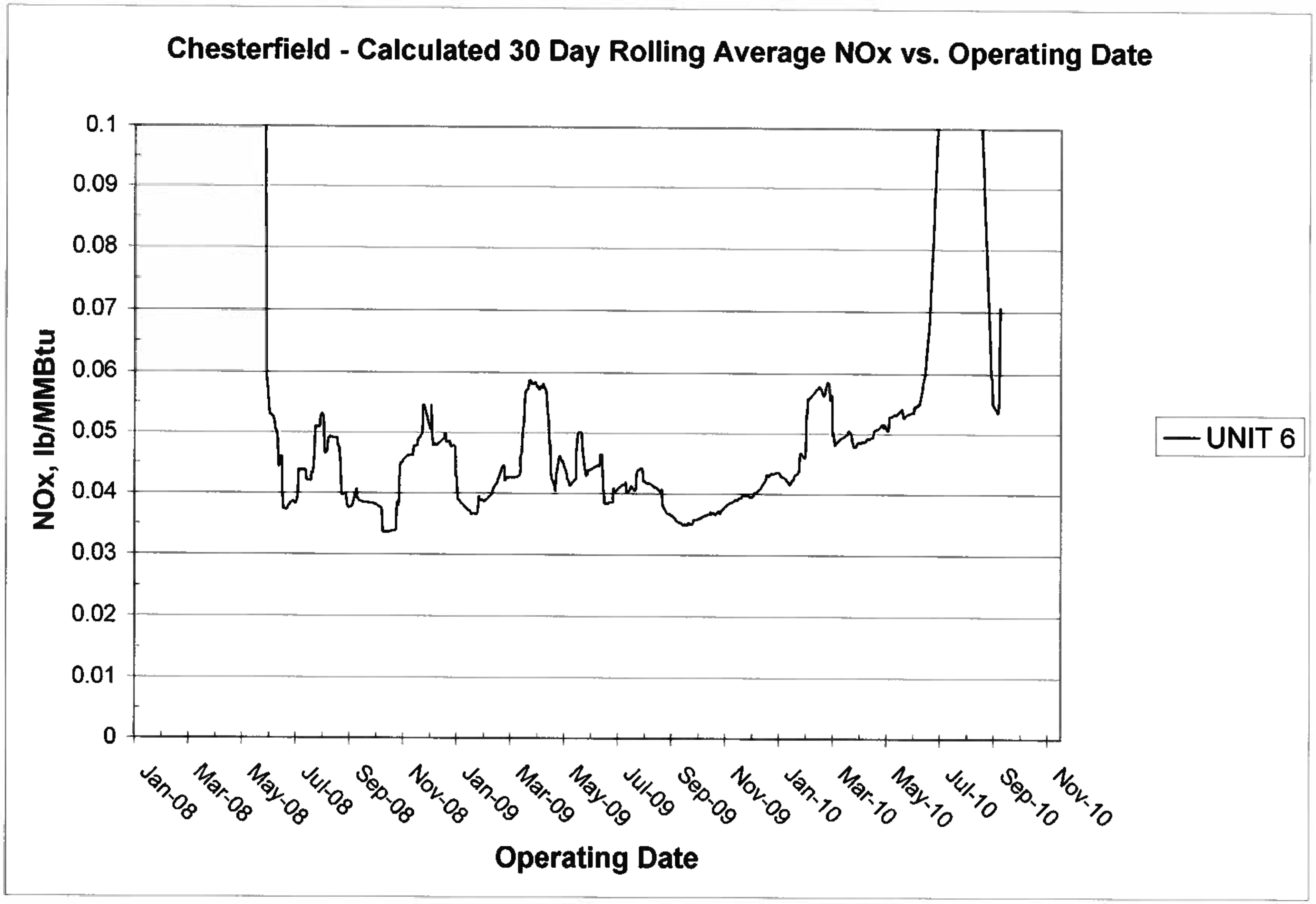
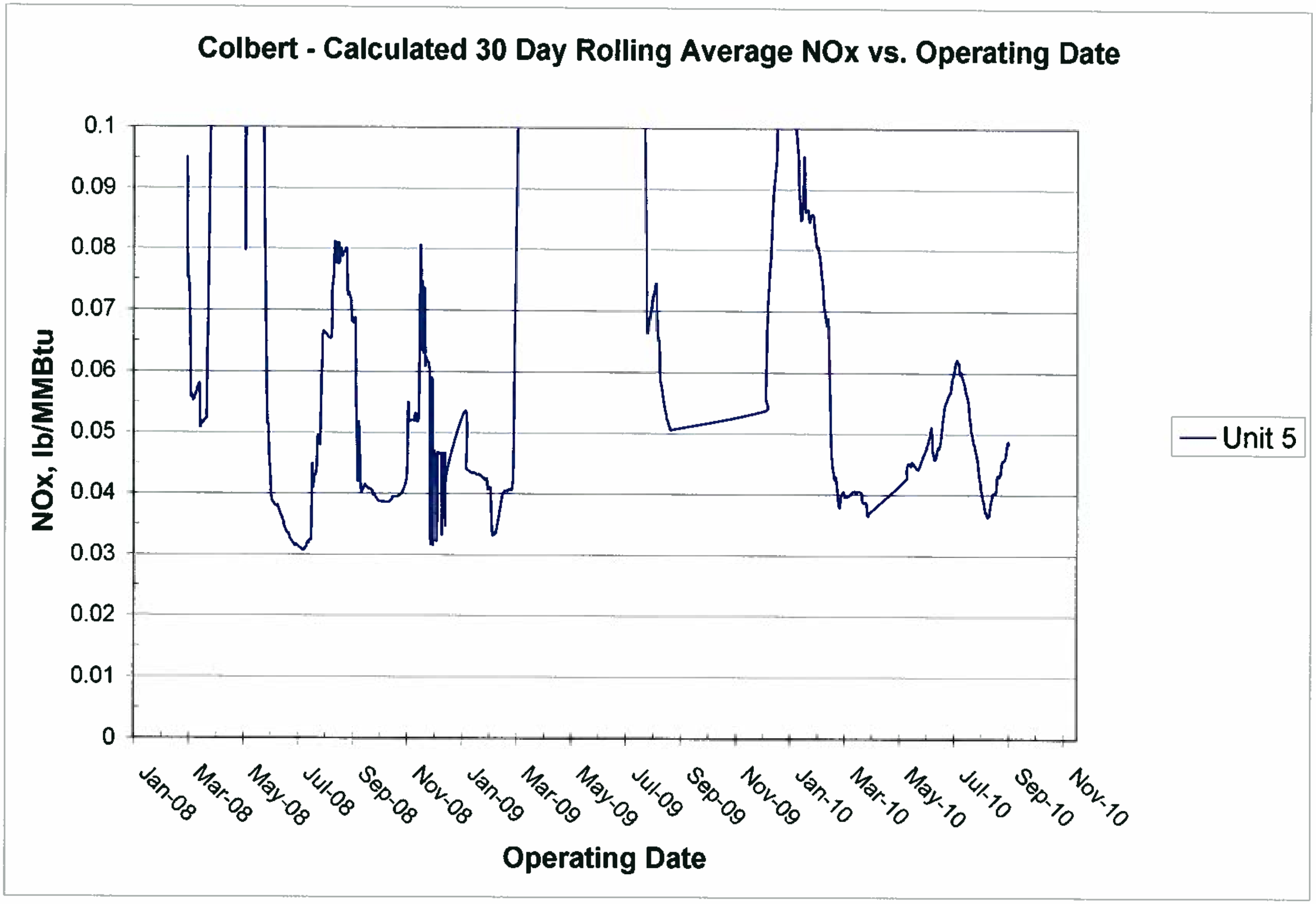
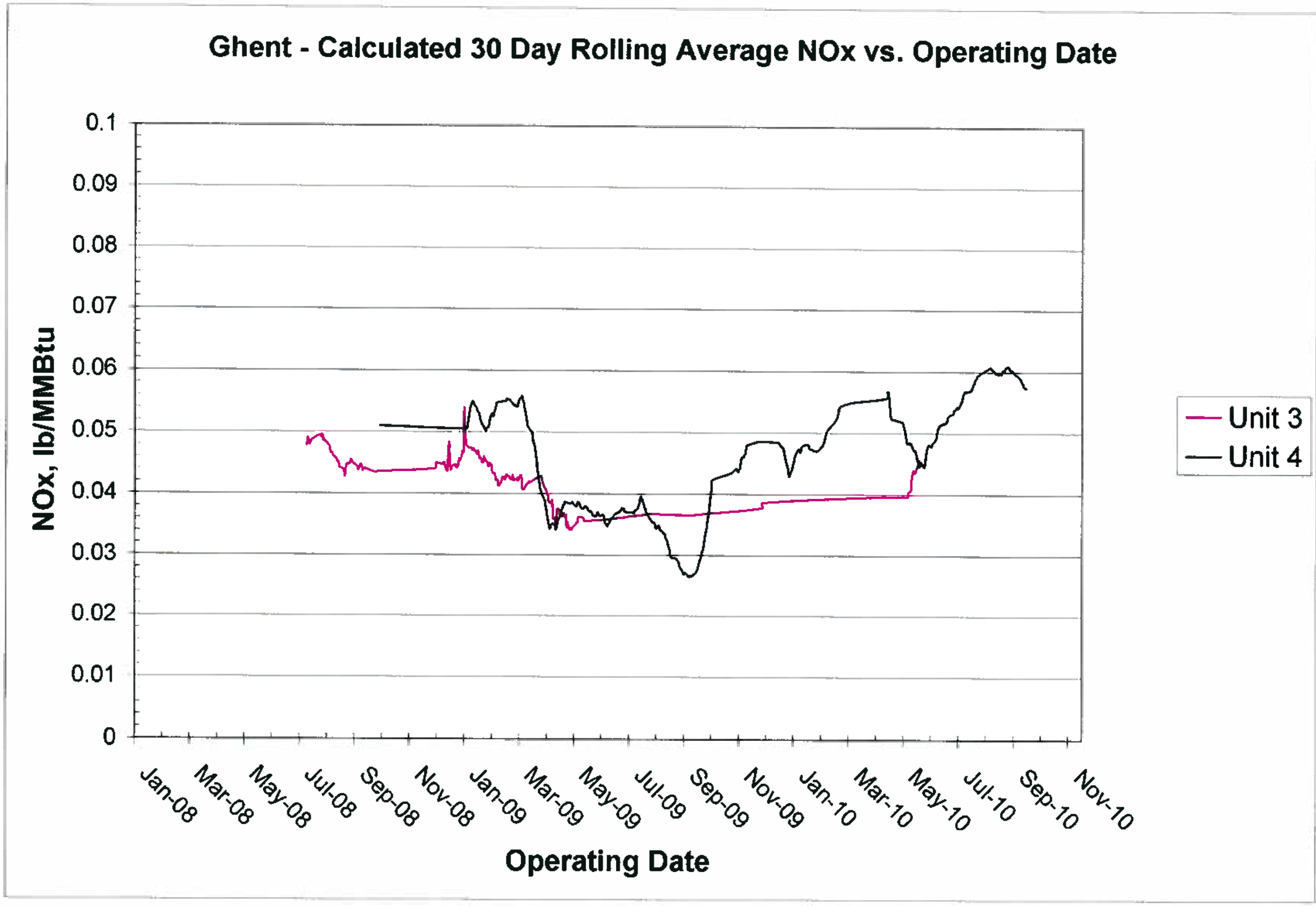
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Operating Date
Unit 2
Unit 3


Chesterfield - Calculated 30 Day Rolling Average NOx vs. Operating Date
NOx, lb/MMBtu
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Operating Date
UNIT 6


Colbert - Calculated 30 Day Rolling Average NOx vs. Operating Date
NOx, lb/MMBtu
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Operating Date
Unit 5


Ghent - Calculated 30 Day Rolling Average NOx vs. Operating Date
NOx, lb/MMBtu
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
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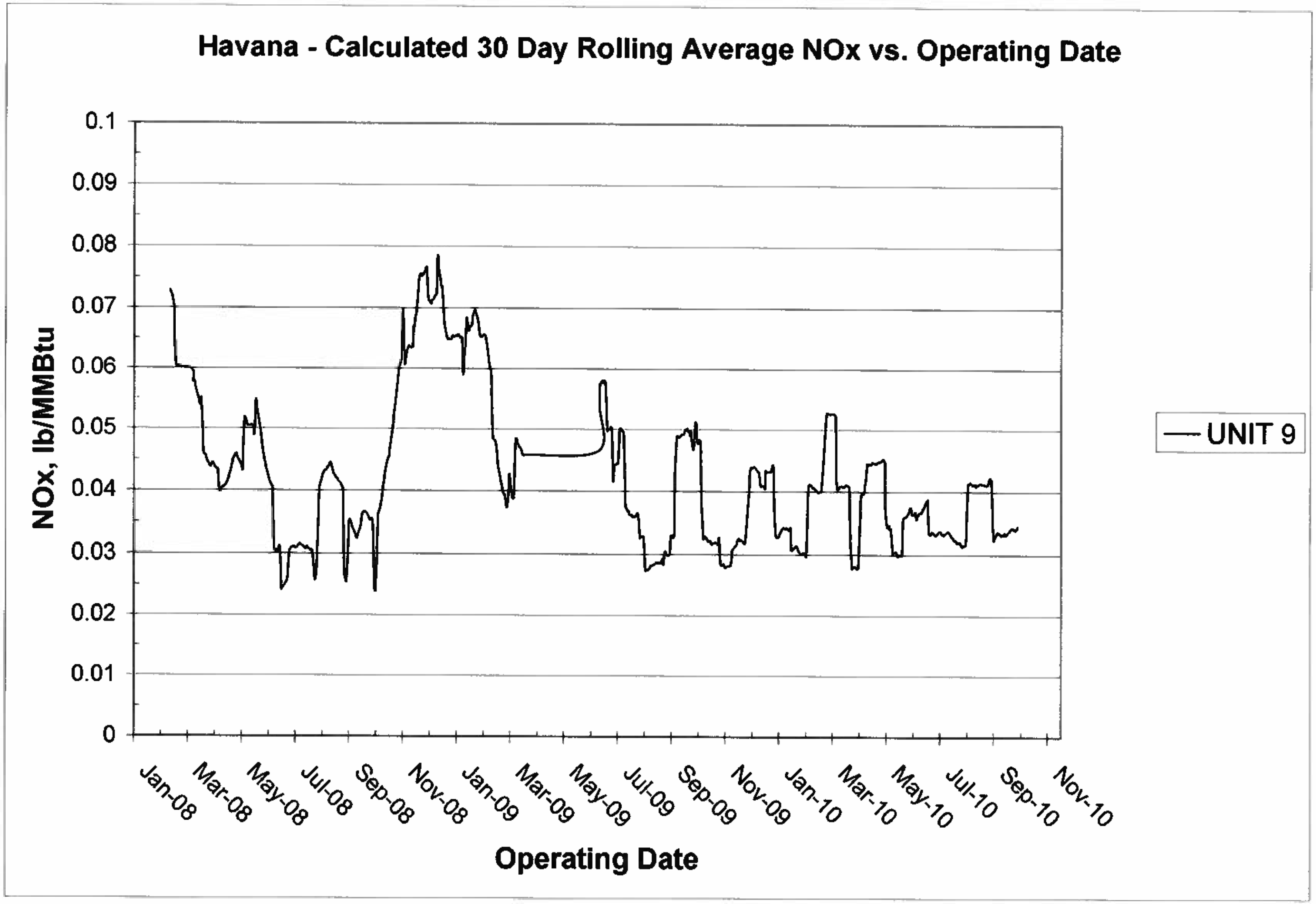
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Operating Date
Unit 3
Unit 4


Havana - Calculated 30 Day Rolling Average NOx vs. Operating Date
NOx, lb/MMBtu
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
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Nov-09
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Mar-10
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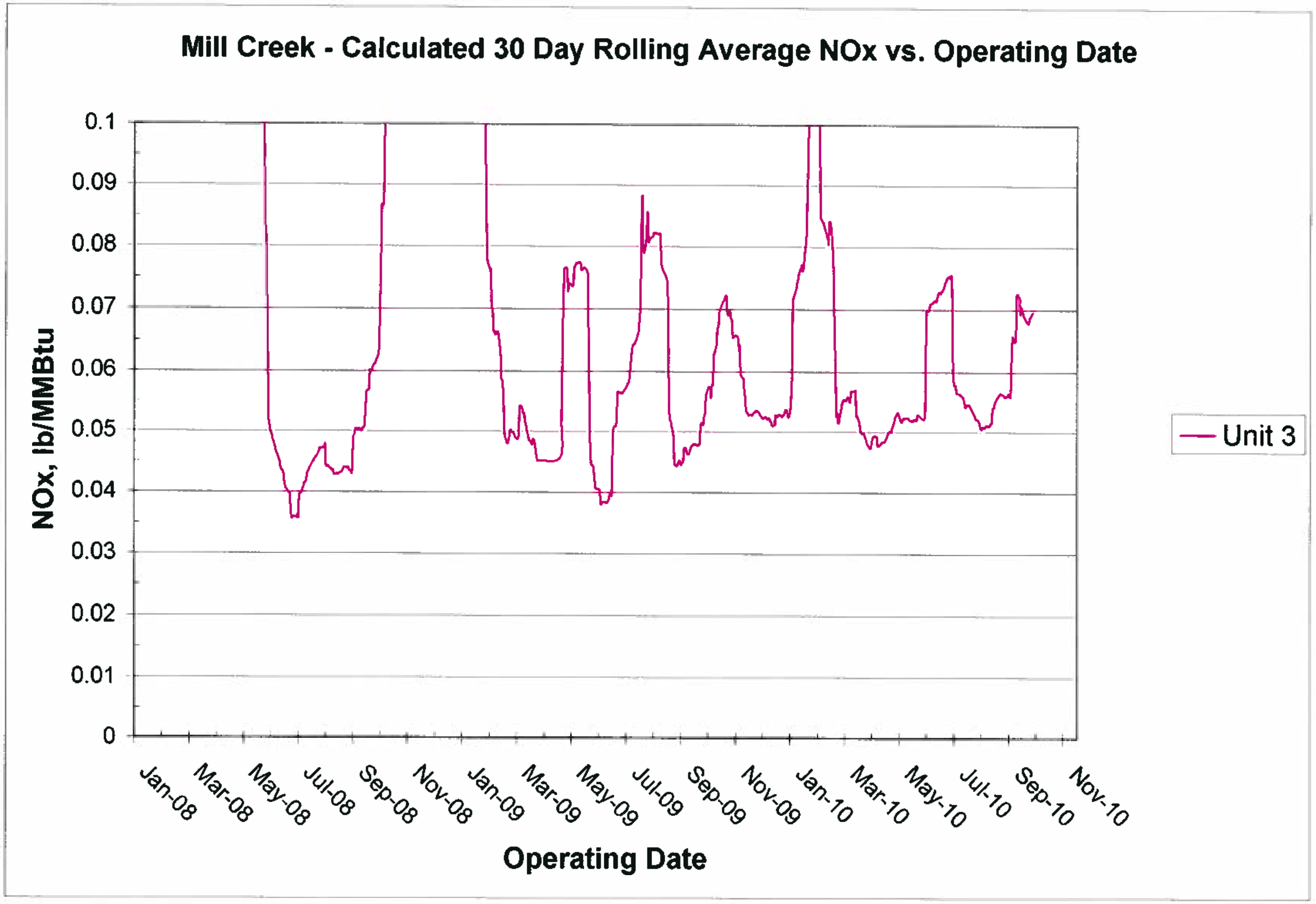
Jul-10
Sep-10
Nov-10
Operating Date
UNIT 9


Mill Creek - Calculated 30 Day Rolling Average NOx vs. Operating Date
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
NOx, lb/MMBtu
Jan-08
Mar-08
May-08
Jul-08
Sep-08
Nov-08
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Operating Date
Unit 3

Attachment D: Joseph S. Scire, CCM,
"Analysis of Ammonia in the Four Corners Area" (March 2011)

Analysis of Ammonia in the Four Corners Area

March 2011

Prepared by:

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Introduction

The CALPUFF model was used by the New Mexico Environmental Department's Air Quality Bureau (Department) to predict the impact of Best Available Retrofit Technology (BART) emission controls on the Public Service Company of New Mexico San Juan Generating Station (SJGS), Units 1-4. The Department concluded that Selective Catalytic Reduction (SCR) plus sorbet injection represented BART for these sources. This is based on a five factor analysis that included the prediction of visibility improvements at Class I areas in the vicinity of the SJGS relative to the cost of emission controls (e.g., dollars per deciview of visibility improvement). The highest visibility impacts were predicted at the Mesa Verde National Park, which were therefore used as the controlling impacts in the BART analysis.

The subject of this report is an analysis of the ambient background ammonia concentrations used in the air quality modeling by the Department and the SJGS consultant, Black & Veatch (B&V). Ammonia is an important parameter in the modeling of ammonium nitrate which is the primary pollutant affecting visibility due to NO_x emissions. Ammonia is a critical component in nitrate formation. Ammonium nitrate aerosols are in an equilibrium relationship with gaseous nitric acid that depends on temperature, relative humidity and the availability of sufficient ammonia. Nitrate tends to form at low ambient temperature and/or high relative humidity. However, nitrate formation can be blocked even under favorable temperature and humidity conditions if sufficient gaseous ambient ammonia is not available, which is referred to as an ammonia-limited condition.

CALPUFF requires the specification of monthly ambient ammonia concentrations. The ammonia can be used along with background sulfate and nitrate concentrations in the CALPUFF modeling system in a second stage called POSTUTIL to fully implement the technique known as the Ammonia Limiting Method (ALM). A set of 33 reports, papers and documents were reviewed in assessing the appropriate ammonia concentrations for the CALPUFF modeling. Of the references reviewed, the most relevant to ammonia concentrations for visibility assessment in the Mesa Verde National Park is Sather et al. (2008). The report by the Interagency Workgroup on Air Quality Modeling (IWAQM) (U.S. EPA, 1998) provides regulatory guidance for ammonia and discusses typical ammonia values and variability.

Discussion

In the Department's BART determination and B&V modeling, the monthly ammonia concentrations shown in Table 1 were used in the CALPUFF modeling.

The recommendations and comments in the IWAQM report include:

- A refined modeling analysis should include background concentrations of ozone and ammonia that "are allowed to vary in time and space" (p. 6, Section 2, Modeling Recommendations).
- Accurate specification of ammonia is critical to the accurate estimation of particulate nitrate concentrations (p. 14).
- Recommendations for average ammonia concentrations in forested areas is 0.5 ppb (within a factor of 2) (p. 14).
- IWAQM references Langford (1992) which provides strong evidence that background ammonia shows "strong dependence with ambient temperature (variations of a factor of 3 or 4) and a strong dependence on soil pH." (pp. 14-15). This refers to the significant seasonal dependence of ammonia that leads to much smaller ammonia concentrations during the winter months when ambient temperature conditions are favorable to nitrate formation.

Figure 1 is a plot of monthly average ammonia concentrations predicted by the EPA CMAQ model. The months shown are January and April, which correspond to the lowest and highest overall ammonia concentrations. The CMAQ results confirm the IWAQM statements regarding the importance of considering spatial and time variability of ammonia as well as the temperature dependence. Winter ammonia concentrations are less than 0.1 ppb in January in the Mesa Verde area and those in April several times higher in the range of 0.1-0.5 ppb.

Sather et al. (2008) reports on ammonia measurements at several locations, including in the Mesa Verde National Park over a one-year time period starting in December 2006. Figure 2 is a plot of the ammonia measurements at five sites, with the purple line corresponding to the measurements at Mesa Verde. The ammonia measurements during the months of December-March averaged about 0.1 ppb when the modeling assumed a value of 0.2 ppb. During April-May and October-November, when the modeling assumed 0.5 ppb ammonia, the observed readings averaged about 0.3 ppb at Mesa Verde. During June-September, the measured ammonia ranged from 0.2 – 0.6 ppb. The modeling assumed a value of 1.0 ppb during these months.

The sensitivity of CALPUFF to ammonia concentrations is illustrated in Figure 3 (Scire et al., 2003) for an IMPROVE site in Wyoming. Using the Ammonia Limiting Method, the predicted concentrations of nitrate show very little bias with observed and predicted values within about 20-30%. Higher average background ammonia of 0.5 ppb shows an overprediction of observations by a factor of 2-3 times, while ammonia of 1.0 ppb overpredicts the observations by a factor of 3-4 times.

The main conclusions regarding the background ammonia concentrations are the following.

- The use of monthly-varying ammonia concentrations in Table 1 in CALPUFF is appropriate and consistent with the observed seasonal variability of ammonia observations in the Mesa Verde area.
- The range of assumed ammonia concentrations from 0.2 ppb in the winter to 1.0 ppb in the summer is a conservative approach (i.e., likely to overpredict nitrate impacts) relative to ammonia observations in the Mesa Verde area.
- The application of further refinement of nitrate using the Ammonia Limit Method (ALM) in POSTUTIL is appropriate given the conservatism (averaging about a factor of two) of the assumed ammonia relative to observations. This is consistent with the recommendations of IWAQM to allow *time and space* varying ammonia in refined visibility modeling.

Table 1. Monthly Ammonia Concentrations (ppb) used in the SJGS BART Analysis.

Month	Ammonia (ppb)
January	0.2
February	0.2
March	0.2
April	0.5
May	0.5
June	1.0
July	1.0
August	1.0
September	1.0
October	0.5
November	0.5
December	0.2

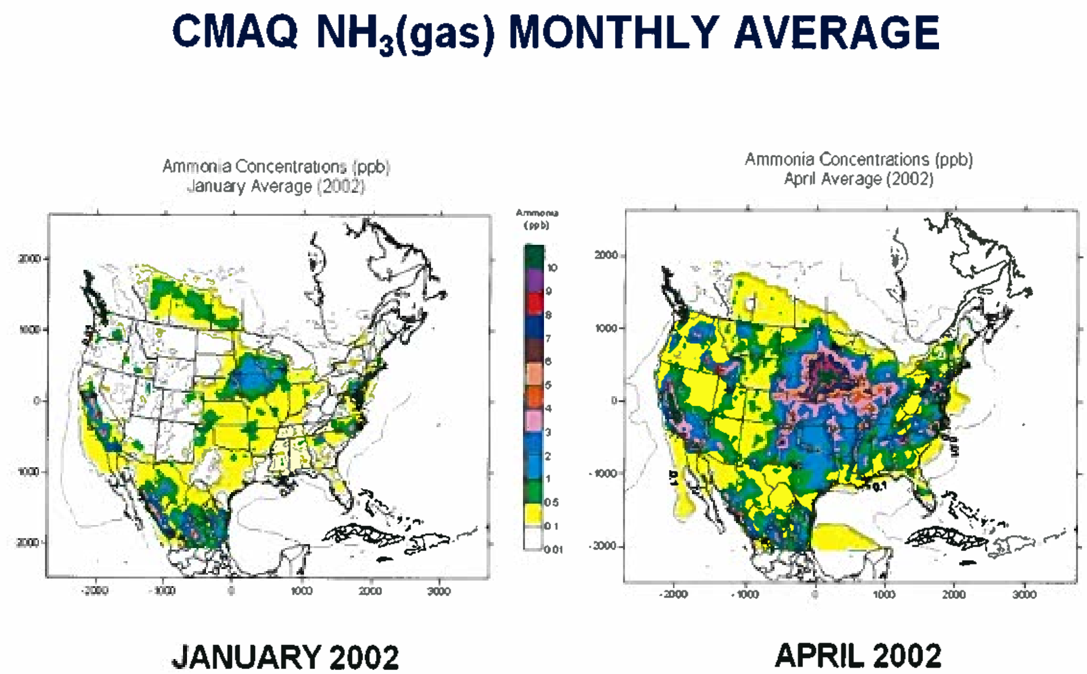

Figure 1. Time and spatial variation of ammonia showing strong seasonal and spatial variability [From Escoffier-Czaja and Scire, 2007, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes Cambridge, UK]

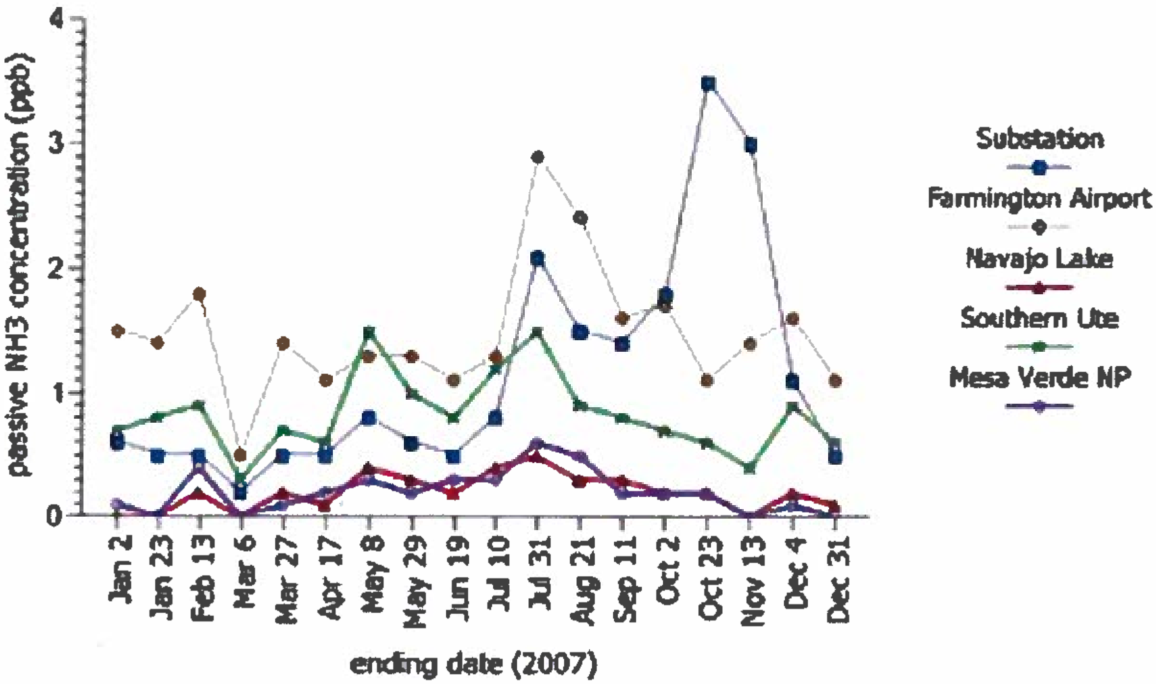

Figure 2. Passive ammonia data time series (3-week integrated samples) for the Four corners area sites. Data collected from December 2006 through January 22, 2008 for the Mesa Verde site. [From Sather et al., 2008].

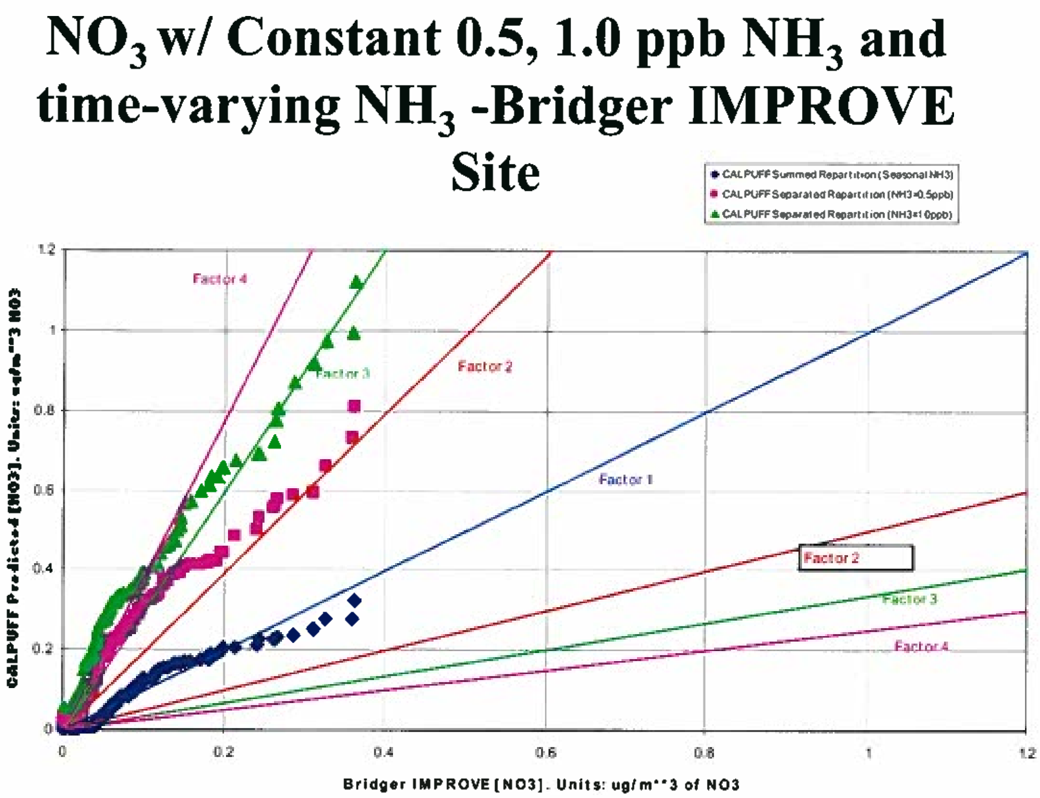

Figure 3. Impact of using ALM vs. constant ammonia of 0.5 ppb and 1.0 ppb on predicted nitrate vs. observed nitrate at the Bridger IMPROVE monitor in Wyoming. [From Scire et al., 2003, AWMA Specialty Conference, *Guideline on Air Quality Models: The Path Forward,* Mystic, Connecticut]

References

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Scire, J.S., D.G. Strimaitis and R.J. Yamartino, 2000b: A User's Guide for the CALPUFF Dispersion Model. (Version 5.0). Earth Tech, Inc., Concord, MA. (Available from http://www.src.com).

Scire, J.S., Z-X. Wu and G.E. Moore, 2003: Evaluation of the CALPUFF Model in Predicting Concentration, Visibility and Deposition Impacts at Class I Areas in Wyoming. Presentation made at the A&WMA Specialty Conference, Guideline on Air Quality Models: The Path Forward, 22-24 October 2003, Mystic, CT.

State of New Mexico, 2010: *New Mexico State Implementation Plan, Regional Haze, Section 308,* New Mexico Environment Department, Air Quality Bureau. June 21, 2010.

U.S. EPA, 1998: Interagency Workgroup on Air Quality Modeling (IWAQM), Phase 2 Report: Summary Report and Recommendation for Modeling Long Range Transport and Impacts on Regional Visibility. EPA-454/R-98-019.

Attachment E: Joseph S. Scire, CCM, "Analysis of the Issues related to the BART Determination of the San Juan Generating Station in New Mexico" (March 2011)

Analysis of the Issues Related to the BART Determination of the San Juan Generating Station in New Mexico

March 2011

Prepared by:

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650 Suffolk Street
Lowell, MA 01854

TABLE OF CONTENTS

1. Introduction

On July 6, 2005 the U.S. Environmental Protection Agency (U.S. EPA) published in the Federal Register the "Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations" (40 CFR Part 51). The regional haze rule requires States to submit implementation plans (SIPs) to address regional haze visibility impairment in 156 Federally-protected parks and wilderness areas, commonly referred to as "Class 1 Areas". The final rule addresses BART-eligible sources, which are defined as sources that have the potential to emit 250 tons or more of a visibility-impairing air pollutant, were put in place between August 7, 1962 and August 7, 1977 and whose operations fall within one or more of 26 specifically listed source categories, of which Coal-Fired Power Plants are one.

The New Mexico Environmental Department's Air Quality Bureau issued a report dated June 21, 2010 on its Best Available Retrofit Technology (BART) determination for the Public Service Company of New Mexico San Juan Generating Station (SJGS), Units 1-4. The Department concluded that Selective Catalytic Reduction (SCR) plus sorbet injection represented BART for these sources. This is based on a five factor analysis that includes the prediction of visibility impacts at Class I areas in the vicinity of the SJGS using the CALPUFF dispersion model.

In this report, an analysis was conducted on the air quality modeling conducted in the BART determination. It was concluded that the BART modeling of the SJGS conducted by the Department and by Black & Veatch (B&V) was done properly but still overestimates the visibility impacts of the facility and overestimates the projected visibility changes (deciviews of improvement in visibility) that would result from the application of SCR with sorbet injection) technology for NO_x control.

There are three main issues within the current BART modeling which lead to an overestimation of the results. The first is the spatially uniform background values of ammonia were used in the calculation of ammonium nitrate concentrations. Nitrate is the primary factor affecting visibility due to NO_x emissions. Its formation is sensitive to background ammonia concentrations in the atmosphere. The use of spatially constant background ammonia concentrations neglects the changes in ammonia across the modeling domain. In addition, the BART modeling did not include the effect of consumption of ammonia by background sources of sulfate and nitrate but rather assumed 100% of the background ammonia was available to the SJGS facility's plume. Techniques known as the Ammonia Limiting Method (ALM) have been developed and implemented in the CALPUFF modeling system to account for these effects (Scire et al., 2003; Escoffier-Czaja and Scire, 2007). Evaluations using observational data in Wyoming have demonstrated significant overpredictions of nitrate when neglecting these effects, while the application of ALM in the CALPUFF model produced good performance in predicting nitrate.

The second item is the refinement of the CALPUFF chemical mechanism by Karamchandani, *et al.* (2008). The updated chemistry corroborates the conclusions regarding the importance of ALM and higher grid resolution for the BART analysis.

The third issue is that the coarse grid resolution of 4 kilometers in the BART modeling is insufficient for the complex terrain environment in the Class I areas of interest in the BART analysis. More refined, higher resolution simulations with 1-km grid cells more properly simulates the physical environment of the Class I areas.

An evaluation of the importance of each factor has been conducted at the Mesa Verde Class I area, which produced the control limits for the Department's BART analysis of SJGS's impacts. The most important factor is the application of the ALM, which results in deciview (dv) changes due to SCR plus sorbet injection on Units 1, 2,3 and 4 at the Rank 8 level (or 8^{th} highest day per year as used in the Division's BART analysis) of less than 0.5 dv in all cases. The use of higher grid resolution and the new chemical methodology provide additional refinements and corroborate the conclusions regarding overestimation of visibility impacts in the Department's simulations.

2. Review of Previous Modeling

An extensive review was conducted of BART modeling of the SJGS conducted by Black & Veatch (B&V) and that reported by the Department. This review included four specific air quality control scenarios including low NO_x burners (LNB) and over-fired air (OFA), Selective Non-catalytic Reduction (SNCR), Selective Catalytic Reduction (SCR), and Selective Catalytic Reduction (SCR) and sorbent injection. B&V modeling files were made available to TRC for this review, including geophysical data, meteorological data, the CALPUFF input and output files, and supporting written documentation and reports.

One task of this review was to determine if the modeling was conducted in accordance with the modeling protocols and general industry standards and practices, and another was to determine if any refinements or enhancements should be made to the modeling to make it more representative. In addition various elements of the modeling analysis were independently conducted to confirm the calculations, and while all the data was reviewed, due to the extensive amount of data, only the final SCR plus sorbet injections runs were recreated and reproduced. The conclusion of this analysis was the B&V modeling files were properly prepared and implemented. These analyses followed general industry standards and practices and the B&V protocol, which followed and was consisted with the WRAP protocol.

Tables 1 and 2 contain a listing of each CALMET and CALPUFF input parameter, with the WRAP protocol value listed along with the B&V protocol value and the value actually used in the modeling input files. There are a couple of typos in the protocol documents such as inconsistencies in the number of layers and the layer heights, but these were reconciled and determined to be errors in the protocol document only. There is some discrepancy in the monthly ammonia listed in the Department's summary document versus the B&V protocol as shown in Table 3, but using the values listed below as "control file" values, the results reported by both the Department and B&V were reproduced, so the protocol documents were considered to have typos.

In terms of model refinements, there were three important refinements identified: (a) use of spatially varying background ammonia and background sulfate, nitrate and nitric acid based on CMAQ data with the Ammonia Limiting Method (ALM), (b) use of finer grid resolution to more accurately characterize the significant terrain in the modeling domain, and (c) use of an updated chemical mechanism to better characterize gas to particle conversion and nitric acid-nitrate equilibrium. The rationale and impact of these enhancements are discussed in Sections 4-7 below. It should be noted that these refinements were not required for the modeling performed by B&V as they were outside of the modeling protocol submitted to support the project and should not be considered additional enhancements to provide more accurate data.

3. Regional Haze Visibility Calculations

The CALMET and CALPUFF non-steady-state models (Scire et al., 2000a,b) are recommended by the U.S. EPA (*Federal Register*, 6 July 2005) to perform source-specific subject-to-BART screening. The CALPUFF system was therefore used for this modeling analysis. The U.S. EPA has promulgated the CALPUFF modeling system as a *Guideline Model* for Class I impact assessments and other long range transport applications or near-field applications on a case-by-case basis in situations involving complex flows (U.S. EPA, 2000), and the model is recommended by both the Federal Land Managers (FLM) Air Quality Workgroup (FLAG, 2010) and the Interagency Workgroup on Air Quality Modeling (IWAQM, 1998).

CALPUFF predicts the chemical transformation of SO_2 to sulfate (SO_4) and NO_x to nitric acid (HNO_3) and nitrate (NO_3) as well as the transport and dispersion of primary (emitted) particulate matter (PM). For purposes of visibility, the pollutants of interest are small particles such as sulfate and nitrate as well as primary PM. The NO_2 (gas) may also play a role in light absorption, although it is usually a small factor. Each pollutant is associated with a "light extinction" efficiency which relates its concentration to the amount of light extinction caused in the atmosphere. For example, large particles between 2.5-10 microns in diameter have a low light extinction efficiency of 0.6 while elemental carbon (soot) has a large light extinction of 10.

Sulfate and nitrate are hygroscopic, meaning they will absorb moisture and therefore their effect on light extinction is a function of relative humidity.

There are three methods used in CALPUFF to predict the effect of pollutants on light extinction and visibility. They are called Methods 2, 6 and 8. The main differences are in the basis of the light extinction factors and how relative humidity is derived for determining the impact of the hygroscopic aerosols (sulfate and nitrate). A summary of the major methods is:

Method 2: Recommended by IWAQM (1998). Uses hourly relative humidity in the calculation of hygroscopic aerosols with an upper limit, which is normally 95% as recommended by the FLMs. Hourly values of concentration are used to determine hourly light extinction values, which are then averaged over 24 hours for assessment against a 0.5 deciview or 5% change in light extinction threshold. The facility impacts on light extinction are then compared to background values, which the FLMs have determined for each Class I area. These background values represent pristine conditions, not actual background values of light extinction. The light extinction equation, called the IMPROVE equation (FLAG (2000)) is:

The equation is:

$$B_{ext} = 3f(RH)[(NH_4)_2SO_4] + 3f(RH)[NH_4NO_3] + 4[OC] + 1[Soil] + 0.6[Coarse\ Mass] + 10[EC] + b_{ray} \quad (1)$$

Where B_{ext} is the light extinction (1/Mm), RH is relative humidity (%), $(NH_4)_2SO_4$ is ammonium sulfate (ug/m^3), NH_4NO_3 is ammonium nitrate (ug/m^3), OC of organic mass (ug/m^3), EC is elemental carbon mass (ug/m^3), Soil is fine particulate matter less than 2.5 microns in diameter (ug/m^3) and Coarse Mass is coarse particulate matter between 2.5-10 microns in diameter (ug/m^3). The term b_{ray} is Rayleigh scattering of light (1/Mm) due to the clean atmosphere. The f(RH) term is a factor to account for aerosol growth due to humidity, which affects the sulfate and nitrate components only.

Method 6: Recommended by EPA (2005) for BART assessments. Similar to Method 2, except the relative humidity is based on monthly average values for each Class I area. The background values of light extinction and background monthly average relative humidity for each Class I area are provided in tables by the FLMs.

Method 8: Recommended by the FLMs (FLAG, 2010). The main differences between the light extinction calculations used in Methods 2 and 6 and Method 8 is that Method 8 equations based on recent work on light extinction called the new IMPROVE algorithm (FLAG (2010). It has separate equations for small and large sulfate, nitrate and organic particulate matter mass, uses a site-specific term for Rayleigh scattering (due to the clean atmosphere) and considers the impact of NO_2 (gas).

This algorithm provides a better correspondence between the measured visibility and that calculated from particulate matter component concentrations (Tombach, 2006). The equation is:

$$
\begin{aligned}
b_{ext} = {} & 2.2 f_S(RH) \bullet [small\ sulfate] + 4.8 f_L(RH) \bullet [large\ sulfate] \\
& + 2.4 f_S(RH) \bullet [small\ nitrate] + 5.1 f_L(RH) \bullet [large\ nitrate] \\
& + 2.8 \bullet [small\ organics] + 6.1 \bullet [large\ organics] \\
& + 10 \bullet [elemental\ carbon] \\
& + 1 \bullet [fine\ soil] \\
& + 1.7 f_{SS}(RH) \bullet [sea\ salt] \\
& + 0.6 \bullet [coarse\ matter] \\
& + Rayleigh\ scattering\ (site-specific) \\
& + 0.17 \bullet [NO_2]
\end{aligned}
$$

All of the concentrations are in $\mu g/m^3$. In Method 8, the 8th highest (98th percentile) predicted light extinction or deciview change for each year modeled is compared to the threshold value of 0.5 deciview change (approximately 5% change in light extinction). The 0.5 deciview change at the 98th percentile level is considered by the FLMs (FLAG, 2010) and in the BART guidelines (EPA, 2005) to *contribute* to regional haze visibility impairment. A change of 1.0 deciview (or approximately 10% change in light extinction) is considered as be a just noticeable change in visibility on its own and therefore *causing* visibility impairment. Values below 0.5 deciview at the 98th percentile level are considered below the point at which a change causes or contributes to a change in visibility. However, the perception of visibility is a complex phenomenon that depends on many factors not included in the BART analysis, including presence of natural background effects such as precipitation, fog and biogenic extinction, time of day, lighting, differences in among human observers, and other factors. In many cases in the real atmosphere, a change of 1.0 deciview may not be perceived as a noticeable change.

There are several methods used to determine visibility or light extinction. One method is to "reconstruct" light extinction by measuring the components concentrations of the light extinction equations above. With this method, 24-hour average concentrations of sulfate, nitrate, elemental carbon, secondary organic aerosols, fine and coarse particulate matter are analyzed from filters. In additional measurements of NO_2 gas are used to compute the light absorption due to NO_2. Another measurement technique is the use of a transmissometer. Transmissometers measure light extinction over a finite atmospheric path. Their reading are hourly, and normally data are restricted to conditions with relative humidity less than 90%. A third approach is the use of nephelometers, which measure scattering of light. As such nephelometers only measure a portion of the light extinction budget, i.e., that due to light scattering but not the component due to light absorption due to gases such as NO_2 or particles such as soot (elemental carbon).

4. Ammonia Limiting Method

One of the key factors in defining the amount of ammonium nitrate (NH_4NO_3) formed in the atmosphere is the availability of ammonia (NH_3). The chemistry involves the following:

1. SO_2 (gas) is converted to ammonium sulfate $(NH_4)_2SO_4$ aerosols (particles) in the atmosphere.
2. NO_x (gas) is converted to nitric acid gas (HNO_3) and ammonium nitrate particles (NH_4NO_3) in the atmosphere.
3. Gases such as SO_2 and HNO_3 do not affect visibility. The sulfate and nitrate particles formed from the conversion process have the major impact on visibility from most power plants. Other contributors such as organic aerosols, elemental carbon particles, coarse and fine non-hygroscopic particles and light absorption from NO_2 gas usually have secondary impacts on visibility.
4. The formation of sulfate is a "one way street" process – SO_2 is converted to sulfate and remains in this form until removed from the atmosphere. The formation of nitrate is a "two way street" meaning nitrate aerosols can switch back and forth from the gaseous nitric acid form (HNO_3) to the particle ammonium nitrate form (NH_4NO_3). This is a very fast equilibrium relationship which depends on temperature, relative humidity and the availability of ammonia (NH_3). Nitrate aerosols tend to form when the temperature is cold and/or the relative humidity is high. But even when the temperature and humidity are "calling for" formation of nitrate, whether nitrate will form depends on the availability of ammonia (NH_3). If it is not available in sufficient quantities, nitric acid will remain as a gas meaning it will have no impact on visibility. When ammonia is insufficient, the situation is called "ammonia limited". The ammonia limiting method (ALM) in CALPUFF evaluates whether the "ammonia limited" situation is present or not.
5. There is a competition for available ammonia between sulfate and nitrate. Sulfate preferentially scavenges ammonia over nitrate because sulfate has a great affinity for ammonia. This means the ammonia left after ammonium sulfate has formed is what is available for forming nitrate. This is a feature of the ALM method – computing scavenging of ammonia by total background sulfate.
6. Ammonia is known to vary substantially spatially as well as temporally (see Figure 1). This is very important because ammonia concentrations tend to be low in the winter when low temperatures make formation of nitrate more likely. When ammonia levels are

higher, typically in spring and summer, nitrate formation is limited because of the higher ambient temperatures.

7. The BART modeling used constant monthly ammonia values (i.e., no spatial variability) over the entire domain and neglected the fact that ammonia can be scavenged by background sources. This can greatly overestimate the amount of nitrate formed (see Figure 2). The following example shows that when using the ALM method in CALPUFF, model results match the observations at the Bridger Wilderness Area in Wyoming fairly well, with no significant bias when considering background sources, but using constant 0.5 ppb of ammonia without considering background ammonia consumption overestimates nitrate by a factor of 2-3, while using a constant value of 1 ppb ammonia and no background consumption, nitrate was overestimated by a factor of 3-4.

In order to evaluate the impact of ALM in refining the modeling predictions, simulations of the SJGS facility were conducted using the B&V's CALPUFF simulations as the basis. The ALM is applied as a post-processing step after the CALPUFF runs are made in a program called POSTUTIL. The POSTUTIL program is a standard component of the CALPUFF modeling system.

The data used to provide background ammonia concentrations as well as background concentrations of sulfate, nitrate and nitric acid were derived from modeling simulations of the EPA Community Multiscale Air Quality Modeling System (CMAQ) of the USA for the year 2002 in order to provide seasonal variability in these parameters. Monthly average data of concentrations of ammonia and other species were extracted from the CMAQ hourly output at 36-km resolution at the Mesa Verde Class I area. ALM was also applied to other simulations as described below.

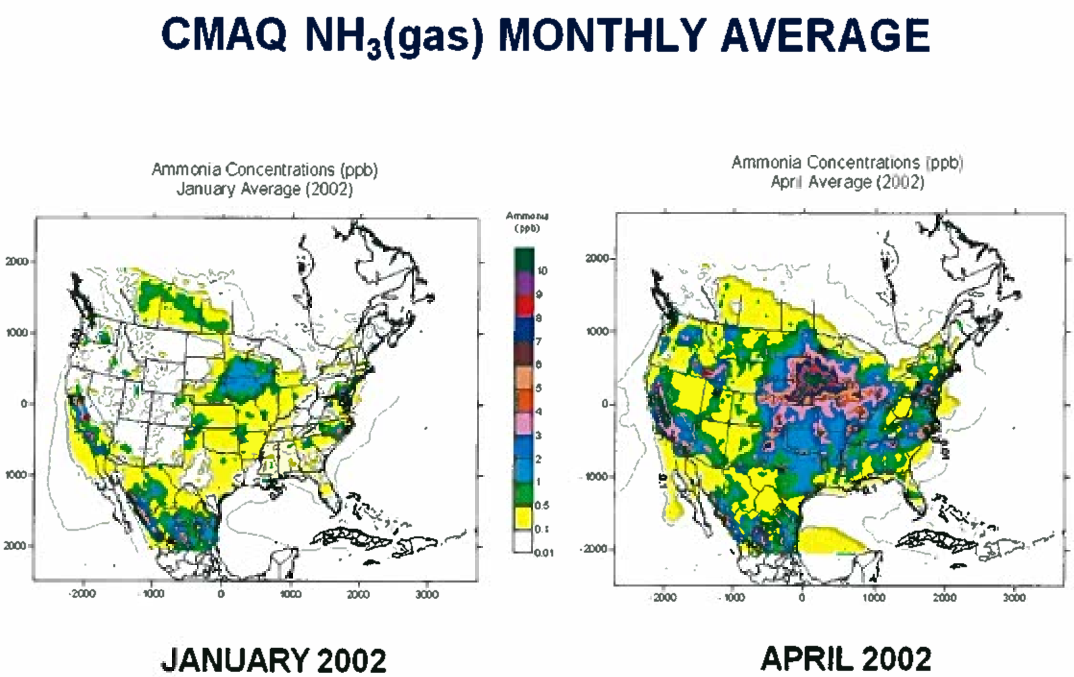

Figure 1. Time and spatial variation of ammonia showing strong seasonal and spatial variability [From Escoffier-Czaja and Scire, 2007, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes Cambridge, UK]

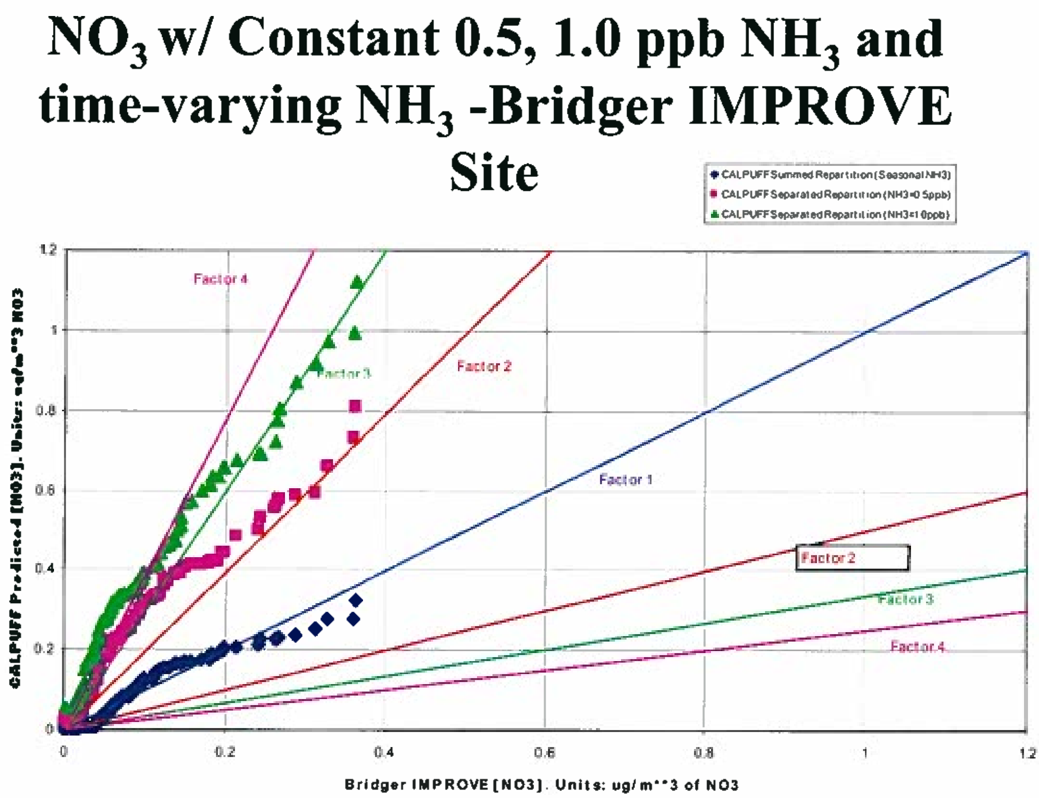

Figure 2. Impact of using ALM vs. constant ammonia of 0.5 ppb and 1.0 ppb on predicted nitrate vs. observed nitrate at the Bridger IMPROVE monitor in Wyoming. [From Scire et al., 2003, AWMA Specialty Conference, *Guideline on Air Quality Models: The Path Forward,* Mystic, Connecticut]

5. Updated API Chemistry

A new chemical mechanism has been introduced into a new version of CALPUFF (Version 6.4) which has been found to improve the accuracy of sulfate and nitrate formation (Karamchandani, *et al.*, 2009). This mechanism (Karamchandani, *et al.*, 2008) includes better science for the conversion of SO_2 and NO_x into sulfate and nitrate. The development of this new chemistry module was sponsored by the American Petroleum Institute (API). The API chemistry option is now available in an updated CALPUFF code and it represents a potentially better, more accurate method for computing visibility impacts. Version 6.4 of the CALPUFF program was released in December 2010 to the public is available on the TRC CALPUFF website (http://www.src.com). This version was not available to B&V during the study period.

Using the latest and best science allows visibility benefits associated with controls to be more accurately assessed including the cost-benefit calculations of BART analyses. As a result, the most efficient and cost effective emission controls can be better assessed using the best available science.

The ALM method can be applied with the new API chemistry as well as with the original chemical mechanisms in CALPUFF.

6. Grid Resolution.

The Federal Land Managers (FLMs) and EPA have claimed modeling results with CALPUFF tend to give lower impacts when finer grid resolution is used in the analysis (EPA, *et al.*, 2009). Without properly examining all of the factors related to grid resolution, they developed a strategy to require coarse grid resolution to be used, even though finer grid resolution provides many technical benefits, including better resolution of terrain in complex terrain areas (such as Colorado), better resolution of land use variability and a more accurate solution to the chemical conversion equations. The FLMs and EPA have failed to recognize the relationship between the grid resolution and the accuracy of the numerical solutions in the model. The modeling developed by B&V for this project was based on a 4 x 4 km grid resolution and is consistent with the B&V protocol and the WRAP protocol. For this exercise, a 1 x 1 km grid resolution was implemented to better represent the wind flow in a complex terrain regime.

7. Previous Testimony.

Mr. Joseph Scire of TRC previously conducted a review of air quality modeling of the Hayden Generating Station (Hayden) near Hayden, Colorado by the Colorado Air Pollution Control Division (Division) in its determination of the Best Available Retrofit Technology (BART) for the facility. He prepared an expert report and presented testimony at a meeting of the Colorado Air Quality Control Commission on November 18, 2010. The main conclusion of the analysis of the Colorado BART modeling is that the Division's modeling of Hayden significantly overestimated visibility impacts and overestimates the projected visibility changes (deciviews of improvement in visibility) that would result from the application of Selected Catalytic Reduction (SCR) technology for NO_x control.

There were three main issues with the Division's modeling. The first was the use of a temporally and spatially constant background value of ammonia in the calculation of ammonium nitrate concentrations. Nitrate is the primary factor affecting visibility due to NO_x emissions. Its formation is sensitive to background ammonia concentrations in the atmosphere. The Division assumed background ammonia concentrations remained constant at 1 ppb throughout the year, neglecting the substantial seasonal changes in ammonia concentrations. In addition, the Division did not include the effect of consumption of ammonia by background sources of sulfate and nitrate but rather assumed 100% of the background ammonia was available to the Hayden facility's plume. The Ammonia Limiting Method (ALM) has been developed and implemented in the CALPUFF modeling system to account for these effects (Scire et al., 2003; Escoffier-Czaja and Scire, 2007), but the ALM was not used in the Hayden BART modeling. Evaluations using observational data in Wyoming have demonstrated significant overpredictions of nitrate by factors of 3-4 when using constant ammonia of 1 ppb, while the application of ALM in the CALPUFF model produced good performance in predicting nitrate.

The second issue was that the coarse grid resolution of 4 kilometers in the Division's modeling is insufficient for the complex terrain environment in the Class I areas of interest in the BART analysis. More refined, higher resolution simulations with 1-km grid cells would more properly simulate the physical environment of the Class I areas.

The third item is the refinement of the CALPUFF chemical mechanism by Karamchandani, *et al.* (2008). The updated chemistry corroborates the conclusions regarding the importance of ALM and higher grid resolution for the BART analysis.

Additionally, a meeting was held with TRC and a group of Federal Land Managers (FLMs) representing the National Park Service and Fish and Wildlife Service in Denver, Colorado on December 10, 2010 to discuss the new chemistry upgrades, model performance results and

Model Change Bulletins (MCBs) implemented in Version 6.4 of CALPUFF. A second meeting was held with the U.S. EPA in RTP, North Carolina along with representatives of the western states utility organization WEST Associates, the American Petroleum Institute (API) and TRC on February 16, 2011. The FLMs participated in this meeting by a teleconference line. It was agreed at the meeting that the FLMs will take the lead on a review and testing of the CALPUFF model code changes including the new chemistry modules, and MCBs and coordinate with EPA regarding this issue.

8. Summary of Refined Modeling.

A set of simulations have been conducted of emissions from the SJGS facility representing the SCR and sorbent injection using the three refinements discussed above for 2001-2003 at the Mesa Verde National Park. Visibility impacts at Mesa Verde defined the controlling impacts for BART as compared to those impacts predicted at the other 15 class 1 areas. Except for the changes discussed above involving ALM, grid resolution and chemistry, the simulations used the same configuration as in the B&V and Department's modeling, including the input meteorological datasets and various model options.

Tables 4-6 summarizes the predicted impacts of the base case SJGS impacts as defined by the Department and additional simulations with Units 1, 2, 3 and 4 separately and together as a facility using SCR plus sorbet injection controls. The results indicate with ALM alone (i.e., using the Department's CALPUFF modeling results, but with ALM applied in the post-processing step), the change in deciview for each Unit separately for the Rank 8 impacts are less than 0.5 dv. The impacts with finer grid resolution and the new API chemistry are also provided in the table. The results in all cases using ALM show impacts from BART controls below 0.5 dv for each individual unit. For all units combined the changes in dv resulting from the modeling refinements is from 2-37% lower than in the base case without the refinements.

The conclusions from this analysis are that the Department's modeling overestimated the impacts of the baseline emissions of NO_x from SJGS as well as the predicted visibility benefits associated with SCR plus sorbet injection controls. The predicted impacts of NO_x controls, including the modeling refinement of ALM, show deciview changes for each unit of the SJGS individually from the baseline case less than 0.5 dv for the Rank 8 values using the Department's CALPUFF modeling results for Mesa Verde. Cases using ALM with higher grid resolution (1-km) and/or the new API chemistry option confirm impacts less than the 0.5 dv threshold of perceptibility for the NO_x control scenarios. For the case of all four units together with NO_x controls, the combined change in dv with the modeling refinements ranges from 0.69-1.01 dv versus the baseline modeling of 1.1-1.4 dv.

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Table 1. CALMET Input Parameters.

CALMET Inputs

4/11/2007

Variable	Description	Model Default	WRAP Values	NM B&V Protocol	NM Values used	Notes
GEO.DAT	Name of Geophysical data file	GEO.DAT	GEO.DAT		GEO_NM.DAT	
SURF.DAT	Name of Surface data file	SURF.DAT	SURF.DAT		SUR_1_NM.DAT	
PRECIP.DAT	Name of Precipitation data file	PRECIP.DAT	PRECIP.DAT		PRE_1_NM.DAT	
NUSTA	Number of upper air data sites	User Defined	0	10 (typo?)	0	
UPN.DAT	Names of NUSTA upper air data files	UPN.DAT	NA		0	
IBYR	Beginning year	User Defines	User Defines	2001-2003	2001-2003	
IBMO	Beginning month	User Defines	User Defines	1	1	
IBDY	Beginning day	User Defines	User Defines	1	1	
IBHR	Beginning hour	User Defines	User Defines	0	0	
IBTZ	Base time zone	User Defines	User Defines	7	7	
IRLG	Number of hours to simulate	User Defines	User Defines	8760 (monthly)	8760 (monthly)	
IRTYPE	Output file type to create (must be 1 for CALPUFF)	1	1	1	1	
LCALGRD	Are w-components and temperature needed?	T	T	T	T	
NX	Number of east-west grid cells	User Defines	Table 3-1	216	216	
NY	Number of north-south grid cells	User Defines	Table 3-1	216	216	
DGRIDKM	Grid spacing	User Defines	4	4	4	
XORIGKM	Southwest grid cell X coordinate	User Defines	Table 3-1	-1368	-1368	
YORIGKM	Southwest grid cell Y coordinate	User Defines	Table 3-1	-900	-900	
XLATO	Southwest grid cell latitude	User Defines	Table 3-1			
YLONO	Southwest grid cell longitude	User Defines	Table 3-1			
IUTMZN	UTM Zone	User Defines	NA	N/A	N/A	
LLCONF	When using Lambert Conformal map coordinates, rotate winds from true north to map north?	F	F			
XLAT1	Latitude of 1st standard parallel	30	33	33N	33N	
XLAT2	Latitude of 2nd standard parallel	60	45	45N	45N	
RLON0	Longitude used if LLCONF = T	90	97	97W	97W	
RLAT0	Latitude used if LLCONF = T	40	40	40N	40N	
NZ	Number of vertical Layers	User Defines	11	10 (typo?)	11	NZ should be 11
ZFACE	Vertical cell face heights (NZ+1 values)	User Defines	0, 20, 100, 200, 350, 500, 750, 1000, 2000, 3000, 4000, and 5000	0, 20, 100, 200, 350, 500, 750, 1000, 2000, 3000, 4000, 5000	0.,20.,100.,200.,350.,500.,750.,1000.,2000.,3000.,4000.,5000.	
LSAVE	Save met. Data fields in an unformatted file?	T	T	T	T	
IFORMO	Format of unformatted file (1 for CALPUFF)	1	1	1	1	
NSSTA	Number of stations in SURF.DAT file	User Defines	Domain dependent, see Figure 3-1 for locations	112	112	
NPSTA	Number of stations in PRECIP.DAT	User Defines	Domain dependent, see Figure 3-1 for locations	112	112	
ICLOUD	Is cloud data to be input as gridded fields? 0=No)	0	0	0	0	
IFORMS	Format of surface data (2 = formatted)	2	2	2	2	
IFORMP	Format of precipitation data (2= formatted)	2	2	2	2	
IFORMC	Format of cloud data (2= formatted)	2	2	2	2	
IWFCOD	Generate winds by diagnostic wind module? (1 = Yes)	1	1	1	1	
IFRADJ	Adjust winds using Froude number effects? (1= Yes)	1	1	1	1	
IKINE	Adjust winds using Kinematic effects? (1 = Yes)	0	0	0	0	
IOBR	Use O'Brien procedure for vertical winds? (0 = No)	0	0	0	0	
ISLOPE	Compute slope flows? (1 = Yes)	1	1	1	1	
IEXTRP	Extrapolate surface winds to upper layers? (-4 = use similarity theory and ignore layer 1 of upper air station data)	-4	1	1	1	
ICALM	Extrapolate surface calms to upper layers? (0 = No)	0	0	0	0	
BIAS	Surface/upper-air weighting factors (NZ values)	NZ*0	NZ*0	NZ*0	NZ*0	
IPROG	Using prognostic or MM-FDDA data? (0 = No)	0	14	14	14	
LVARY	Use varying radius to develop surface winds?	F	F	F	F	
RMAX1	Max surface over-land extrapolation radius (km)	User Defines	50	50	50	
RMAX2	Max aloft over-land extrapolations radius (km)	User Defines	100	100	100	
RMAX3	Maximum over-water extrapolation radius (km)	User Defines	100	100	100	
RMIN	Minimum extrapolation radius (km)	0.1	0.1	0.1	0.1	
RMIN2	Distance (km) around an upper air site where vertical extrapolation is excluded (Set to -1 if IEXTRP = ±4)	4	4	4	4	
TERRAD	Radius of influence of terrain features (km)	User Defines	10	10	10	
R1	Relative weight at surface of Step 1 field and obs	User Defines	100	100	100	
R2	Relative weight aloft of Step 1 field and obs	User Defines	200	200	200	
DIVLIM	Maximum acceptable divergence	5.00E-06	5.00E-06	5.00E-06	5.00E-06	
NITER	Max number of passes in divergence minimization	50	50	50	50	
NSMTH	Number of passes in smoothing (NZ values)	2,4*(NZ-1)	2,4*(NZ-1)	2,4*(NZ-1)	2,4*(NZ-1)	
NINTR2	Max number of stations for interpolations (NA values)	99	99	99	99	
CRITFN	Critical Froude number	1	1	1	1	
ALPHA	Empirical factor triggering kinematic effects	0.1	0.1	0.1	0.1	
IDIOPT1	Compute temperatures from observations (0 = True)	0	0	0	0	
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	User Defines	1	42, (43, and 46)	42, (43, and 46)	
IDIOPT2	Compute domain-average lapse rates? (0 = True)	0	0	0	0	
IUPT	Station for lapse rates (between 1 and NUSTA)	User Defines	1	0	0	
ZUPT	Depth of domain-average lapse rate (m)	200	200	200	200	
IDIOPT3	Compute internally initial guess winds? (0 = True)	0	0	0	0	
IUPWND	Upper air station for domain winds (-1 = 1/r**2 interpolation of all stations)	-1	-1	-1	-1	
ZUPWND	Bottom and top of layer for 1st guess winds (m)	1., 1000.	1., 1000.	1., 1000.	1., 1000.	
IDIOPT4	Read surface winds from SURF.DAT? (0 = True)	0	0	0	0	
IDIOPT5	Read aloft winds from UPn.DAT? (0 = True)	0	0	0	0	
CONSTB	Neutral mixing height B constant	1.41	1.41	1.41	1.41	
CONSTE	Convective mixing height E constant	0.15	0.15	0.15	0.15	
CONSTN	Stable mixing height N constant	2400	2400	2400	2400	
CONSTW	Over-water mixing height W constant	0.16	0.16	0.16	0.16	
FCORIOL	Absolute value of Coriolis parameter	1.00E-04	1.00E-04	1.00E-04	1.00E-04	
IAVEZI	Spatial averaging of mixing heights? (1 = True)	1	1	1	1	
MNMDAV	Max averaging radius (number of grid cells)	1	1	1	1	
HAFANG	Half-angle for looking upwind (degrees)	30	30	30	30	
ILEVZI	Layer to use in upwind averaging (between 1 and NZ)	1	1	1	1	
DPTMIN	Minimum capping potential temperature lapse rate	0.001	0.001	0.001	0.001	
DZZI	Depth for computing capping lapse rate (m)	200	200	200	200	
ZIMIN	Minimum over-land mixing height (m)	50	50	50	50	
ZIMAX	Maximum over land mixing height (m)	3000	4500	4500	4500	
ZIMINW	Minimum over-water mixing height (m)	50	50	50	50	
ZIMAXW	Maximum over-water mixing height (m)	3000	4500	4500	4500	
IRAD	Form of temperature interpolation (1 = 1/r)	1	1	1	1	
TRADKM	Radius of temperature interpolation (km)	500	500	500	500	
NUMTS	Max number of stations in temperature interpolations	5	5	5	5	
IAVET	Conduct spatial averaging of temperature? (1 = True)	1	0	1	1	
TGDEFB	Default over-water mixed layer lapse rate (K/m)	-0.0098	-0.0098	-0.0098	-0.0098	
TGDEFA	Default over-water capping lapse rate (K/m)	-0.0045	-0.0045	-0.0045	-0.0045	
JWAT1	Beginning landuse type defining	999	51	55	55	
JWAT2	Ending landuse type defining water	999	55	55	55	
NFLAGP	Method for precipitation interpolation (2= 1/r**2)	2	2	2	2	
SIGMAP	Precip radius for interpolations (km)	100	100	100	100	
CUTP	Minimum cut off precip rate (mm/hr)	0.01	0.01	0.01	0.01	
SSn	NSSTA input records for surface stations	User Defines	Figure 3-1	Appendix A	112	
Usn	NUSTA input records for upper-air stations	User Defines	NA	NA	NA	
PSn	NPSTA input records for precipitations stations	User Defines	Figure 3-1	Appendix A	112	
NOOBS		0	1	1	1	
ITWPROG	Option for overwater lapse rates used in convective mixing height growth	0			0	
ITPROG	3D temperature from observations or from prognostic data?	0		1	1	

Table 2. CALPUFF Input Parameters.

CALPUFF Inputs

Variable	Description	Model Default	WRAP Values	NM B&V Protocol	NM Values used	Notes
METDAT	CALMET input data filename	CALMET DAT	CALMET DAT	CALMET DAT	CALMET DAT	
PUFLST	Filename for general output from CALPUFF	CALPUFF.LST	CALPUFF LST	CALPUFF LST	CALPUFF LST	
CONDAT	Filename for output concentration data	CONC DAT	CONC DAT	CONC.DAT	CONC.DAT	
DFDAT	Filename for output dry deposition fluxes	DFLX DAT	DFLX DAT	DFLX DAT		
WFDAT	Filename for output wet deposition fluxes	WFLX DAT	WFLX DAT	WFLX DAT		
VISDAT	Filename for output relative humidities (for visibility)	VISB.DAT	VISB DAT	VISB.DAT		
METRUN	Do we run all periods (1) or a subset (0)?	0	0	0	0	
IBYR	Beginning year	User Defined	User Defined	2001-2003	2001-2003	
IBMO	Beginning month	User Defined	User Defined	1	1	
IBDY	Beginning day	User Defined	User Defined	1	1	
IBHR	Beginning hour	User Defined	User Defined	0	0	
IRLG	Length of runs (hours)	User Defined	User Defined	8760	8760	
NSPEC	Number of species modeled (for MESOPUFF II chemistry)	5	5-9	11	11	
NSE	Number of species emitted	3	2-9	7	9	
MRESTART	Restart options (0 = no restart), allows splitting runs into smaller segments	0	2 or 3		0	
METFM	Format of input meteorology (1 = CALMET)	1	1	1	1	
AVET	Averaging time lateral dispersion parameters (minutes)	60	60	60	60	
MGAUSS	Near-field vertical distribution (1 = Gaussian)	1	1	1	1	
MCTADJ	Terrain adjustments to plume path (3 = Plume path)	3	3	3	3	
MCTSG	Do we have subgrid hills? (0 = No), allows CTDM-like treatment for subgrid scale hills	0	0	0	0	
MSLUG	Near-field puff treatment (0 = No slugs)	0	0	0	0	
MTRANS	Model transitional plume rise? (1 = Yes)	1	1	1	1	
MTIP	Treat stack tip downwash? (1 = Yes)	1	1	1	1	
MSHEAR	Treat vertical wind shear? (0 = No)	0	0	0	0	
MSPLIT	Allow puffs to split? (0 = No)	0	0	0	0	
MCHEM	MESOPUFF-II Chemistry? (1 = Yes)	1	1	1	1	
MWET	Model wet deposition? (1 = Yes)	1	1	1	1	
MDRY	Model dry deposition? (1 = Yes)	1	1	1	1	
MDISP	Method for dispersion coefficients (3 = PG & MP)	3	3	3	3	
MTURBVW	Turbulence characterization? (Only if MDISP = 1 or 5)	3	3	-	-	
MDISP2	Backup coefficients (Only if MDISP = 1 or 5)	3	3	-	-	
MROUGH	Adjust PG for surface roughness? (0 = No)	0	0	0	0	
MPARTL	Model partial plume penetration? (0 = No)	1	1	1	1	
MTINV	Elevated inversion strength (0 = compute from data)	0	0	0	0	
MPDF	Use PDF for convective dispersion? (0 = No)	0	0	0	0	
MSGTIBL	Use TIBL module? (0 = No) allows treatment of subgr	0	0	0	0	
MREG	Regulatory default checks? (1 = Yes)	1	1	1	1	
CSPECn	Names of species modeled (for MESOPUFF II, must be SO2, SO4, NOx, HN03, NO3)	User Defined	5	11	11	
Species Names	Manner species will be modeled	User Defined	SO2, SO4, NOX, NO3, HNO3, PM25 (depends on emissions data provide by States)	SO2, SO4, NOX, HNO3, NO3, PM8 00, PM4 25, PM1.88, PM1 25, PM0.813, PM0 625	SO2, SO4, NOX, HNO3, NO3, PM8 00, PM4 25, PM1.88, PM1 25, PM0.813, PM0 625	
Specie Group	Grouping of species, if any	User Defined				
NX	Number of east-west grids of input meteorology	User Defined	Table 3-1	216	216	
NY	Number of north-south grids of input meteorology	User Defined	Table 3-1	216	216	
NZ	Number of vertical layers of input meteorology	User Defined	11	10 (typo?)	11	NZ should be 11
DGRIDKM	Meteorology grid spacing (km)	User Defined	4	4	4	
ZFACE	Vertical cell face heights of input meteorology	User Defined	Table 3-2	0, 20, 100, 200, 350, 500, 750, 1000, 2000, 3000, 4000, 5000	0, 20, 100, 200, 350, 500, 750, 1000, 2000, 3000, 4000, 5000	
XORIGKM	Southwest corner (east-west) of input meteorology	User Defined	Table 3-1	-1368	-1368	
YORIGIM	Southwest corner (north-south) of input meteorology	User Defined	Table 3-1	-900	-900	
IUTMZN	UTM zone	User Defined	NA	NA	NA	
XLAT	Latitude of center of meteorology domain	User Defined	Table 3-1			
XLONG	Longitude of center of meteorology domain	User Defined	Table 3-1			
XBTZ	Base time zone of input meteorology	User Defined	MST	7	7	
IBCOMP	Southwest of Xindex of computational domain	User Defined	Table 3-1	1	1	
JBCOMP	Southwest of Y-index of computational domain	User Defined	Table 3-1	75	75	
IECOMP	Northeast of Xindex of computational domain	User Defined	Table 3-1	192	192	
JECOMP	Northeast of Y- index of computational domain	User Defined	Table 3-1	216	216	
LSAMP	Use gridded receptors (T = Yes)	F	F	F	F	
IBSAMP	Southwest of Xindex of receptor grid	User Defined	NA	-	-	
JBSAMP	Southwest of Y-index of receptor grid	User Defined	NA	-	-	
IESAMP	Northeast of Xindex of receptor grid	User Defined	NA	-	-	
JESAMP	Northeast of Y-index of receptor grid	User Defined	NA	-	-	
MESHDN	Gridded receptor spacing = DGRIDKM/MESHDN	1	NA	-	-	
ICON	Output concentrations? (1 = Yes)	1	1		1	
IDRY	Output dry deposition flux? (1 = Yes)	1	1		0	
IWET	Output wet deposition flux? (1 = Yes)	1	1		0	
IVIS	Output RH for visibility calculations (1 = Yes)	1	1		0	
LCOMPRS	Use compression option in output? (T = Yes)	T	T		T	
ICPRT	Print concentrations? (0 = No)	0	0		0	
IDPRT	Print dry deposition fluxes (0 = No)	0	0		0	
IWPRT	Print wet deposition fluxes (0 = No)	0	0		0	
ICFRQ	Concentration print interval (1 = hourly)	1	1		1	
IDFRQ	Dry deposition flux print interval (1 = hourly)	1	1		1	
IWFRQ	Wet deposition flux print interval (1 = hourly)	1	1		1	
IPRTU	Print output units (1 = g/m**3, g/m**2/s)	1	1		1	
IMESG	Status messages to screen? (1 = Yes)	1	1		2	
Output Speci	Where to output various species	User Defined	Default		Saved on Disk	
LDEBUG	Turn on debug tracking? (F = No)	F	F		F	
Dry Gas Dep	Chemical parameters of gaseous deposition species	User Defined	Default		Default	
Dry Part. Dep	Chemical parameters of particulate deposition species	User Defined	Default		Default	
RCUTR	Reference cuticle resistance (s/cm)	30	30	30	30	
RGR	Reference ground resistance (s/cm)	10	10	10	10	
REACTR	Reference reactivity	8	8	8	8	
NINT	Number of particle-size intervals	9	9	9	9	
IVEG	Vegetative state (1 = active and unstressed)	1	1	1	1	
Wet Dep	Wet deposition parameters	User Defined	TBD		Default	
MOZ	Ozone background? (1 = read from ozone dat)	1	1	1	1	
BCKO3	Ozone default (ppb) (Use only for missing data)	80	80	12*80	12*80	
BCKNH3	Ammonia background (ppb)	10	1	12*1	0 20, 0 20, 0 20, 0 50, 0 50, 1 00, 1 00, 1 00, 1 00, 0.50, 0.50, 0.20	
RNITE1	Nighttime SO2 loss rate (%/hr)	0 2	0 2	0 2	0 2	
RNITE2	Nighttime NOx loss rate (%/hr)	2	2	2	2	
RNITE3	Nighttime HNO3 loss rate (%/hr)	2	2	2	2	
SYTDEP	Horizontal size (m) to switch to time dependence	550	550	550	550	
MHFTSZ	Use Heffter for vertical dispersion? (0 = No)	0	0	0	0	
JSUP	PG Stability class above mixed layer	5	5	5	5	
CONK1	Stable dispersion constant (Eq. 2.7-3)	0 01	0 01	0 01	0 01	
CONK2	Neutral dispersion constant (Eq. 2.7-4)	0.1	0.1	0.1	0.1	
TBD	Transition for downwash algorithms (0 5 = ISC)	0 5	0 5	0 5	0.5	
IURB1	Beginning urban landuse type	10	10	10	10	
IURB2	Ending urban landuse type	19	19	19	19	

Table 3. Background Monthly Ammonia Used in CALPUFF Modeling.

Note: dv changes results identical between March 31, 2008 B&V Submittal and June 21, 2010, New Mexico Env. Dep. BART Determination (Appendix A)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	In the CALPUFF/POSTUTIL control file
0.2	0.2	0.2	0.5	0.5	1.0	1.0	1.0	1.0	0.5	0.5	0.2	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	In the March 31, 2008 B&V Submittal
0.2	0.2	0.2	0.5	0.5	1.0	1.0	1.0	1.0	0.5	0.5	0.5	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	In the June 21, 2010, New Mexico Env. Dep. BART Determination (Appendix A)
0.2	0.2	0.5	0.5	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.2	

Table 4. Summary of Modeling Results for Mesa Verde for 2001.

MESA VERDE NP								BASELINE				SCR w/SI							
YEAR	SCENARIO	DOMAIN	GRID SPACING	BCKG NH3	CALPUFF Version	MCHEM	MEQPHASE	Delta DV Rank 1	Delta DV Rank 8	Days w/Delta DV > 0.5	Days w/Delta DV > 1.0	Delta DV Rank 8	Delta DV Rank 8	Days w/Delta DV > 0.5	Days w/Delta DV > 1.0	Δ Delta DV Rank 1	Δ Delta DV Rank 8	Δ Days w/Delta DV > 1.0	Δ Days w/Delta DV > 0.5
2001	SJGS	B&V/State	4km	Variable [2]	v6.112	1	--	4.654	3.382	157	90	3.606	2.275	112	42	-1.048	-1.107	-45	-48
2001	SJGS Unit 1	B&V/State	4km	Variable [2]	v6.112	1	--	2.227	1.352	38	14	1.010	0.676	14	1	-1.217	-0.676	-24	-13
2001	SJGS Unit 2	B&V/State	4km	Variable [2]	v6.112	1	--	2.218	1.351	38	13	1.006	0.673	14	1	-1.212	-0.678	-24	-12
2001	SJGS Unit 3	B&V/State	4km	Variable [2]	v6.112	1	--	2.961	1.559	64	19	1.372	0.867	25	5	-1.589	-0.692	-39	-14
2001	SJGS Unit 4	B&V/State	4km	Variable [2]	v6.112	1	--	2.943	1.552	64	19	1.382	0.861	24	5	-1.581	-0.691	-40	-14
2001	SJGS	B&V/State	4km	ALM	v6.112	1	--	4.038	3.096	138	62	2.658	2.007	99	37	-1.380	-1.089	-39	-25
2001	SJGS Unit 1	B&V/State	4km	ALM	v6.112	1	--	1.110	0.686	15	2	0.712	0.465	6	0	-0.398	-0.221	-9	-2
2001	SJGS Unit 2	B&V/State	4km	ALM	v6.112	1	--	1.107	0.684	15	2	0.710	0.462	6	0	-0.397	-0.222	-9	-2
2001	SJGS Unit 3	B&V/State	4km	ALM	v6.112	1	--	1.478	1.072	38	9	0.982	0.695	17	0	-0.496	-0.377	-21	-9
2001	SJGS Unit 4	B&V/State	4km	ALM	v6.112	1	--	1.467	1.053	34	8	0.974	0.681	17	0	-0.493	-0.372	-17	-8
2001	SJGS	TRC	1km	Variable [2]	v6.112	1	--	4.192	2.752	135	75	3.201	1.971	97	34	-0.991	-0.781	-38	-41
2001	SJGS Unit 1	TRC	1km	Variable [2]	v6.112	1	--	2.028	1.221	30	10	0.828	0.552	12	0	-1.200	-0.669	-18	-10
2001	SJGS Unit 2	TRC	1km	Variable [2]	v6.112	1	--	2.020	1.216	30	10	0.824	0.550	12	0	-1.196	-0.666	-18	-10
2001	SJGS Unit 3	TRC	1km	Variable [2]	v6.112	1	--	2.654	1.384	50	18	1.172	0.744	17	3	-1.482	-0.640	-33	-15
2001	SJGS Unit 4	TRC	1km	Variable [2]	v6.112	1	--	2.639	1.388	49	16	1.162	0.738	17	2	-1.477	-0.650	-32	-14
2001	SJGS	TRC	1km	ALM	v6.112	1	--	4.036	2.437	123	51	2.657	1.694	84	27	-1.379	-0.743	-39	-24
2001	SJGS Unit 1	TRC	1km	ALM	v6.112	1	--	1.054	0.586	10	1	0.671	0.389	4	0	-0.383	-0.197	-6	-1
2001	SJGS Unit 2	TRC	1km	ALM	v6.112	1	--	1.051	0.584	10	1	0.668	0.388	4	0	-0.383	-0.196	-6	-1
2001	SJGS Unit 3	TRC	1km	ALM	v6.112	1	--	1.420	0.861	26	5	0.897	0.595	11	0	-0.523	-0.266	-15	-5
2001	SJGS Unit 4	TRC	1km	ALM	v6.112	1	--	1.396	0.858	26	5	0.883	0.581	11	0	-0.513	-0.277	-15	-5
2001	SJGS	B&V/State	4km	Variable [2]	v6.4	6	2	3.817	3.134	135	66	2.658	2.256	101	36	-1.159	-0.878	-34	-30
2001	SJGS Unit 1	B&V/State	4km	Variable [2]	v6.4	6	2	1.355	0.816	20	3	0.734	0.465	5	0	-0.621	-0.351	-15	-3
2001	SJGS Unit 2	B&V/State	4km	Variable [2]	v6.4	6	2	1.362	0.812	20	3	0.731	0.463	5	0	-0.631	-0.349	-15	-3
2001	SJGS Unit 3	B&V/State	4km	Variable [2]	v6.4	6	2	1.662	1.136	35	11	1.012	0.751	16	1	-0.650	-0.385	-19	-10
2001	SJGS Unit 4	B&V/State	4km	Variable [2]	v6.4	6	2	1.603	1.132	33	11	1.000	0.730	16	1	-0.603	-0.402	-17	-10
2001	SJGS	B&V/State	4km	ALM	v6.4	6	2	3.818	3.016	132	63	2.606	2.252	100	35	-1.212	-0.764	-32	-28
2001	SJGS Unit 1	B&V/State	4km	ALM	v6.4	6	2	1.087	0.627	16	1	0.696	0.459	5	0	-0.391	-0.168	-11	-1
2001	SJGS Unit 2	B&V/State	4km	ALM	v6.4	6	2	1.083	0.625	16	1	0.694	0.457	5	0	-0.389	-0.168	-11	-1
2001	SJGS Unit 3	B&V/State	4km	ALM	v6.4	6	2	1.371	1.040	29	8	0.918	0.733	15	0	-0.453	-0.307	-14	-8
2001	SJGS Unit 4	B&V/State	4km	ALM	v6.4	6	2	1.356	1.022	29	8	0.909	0.716	15	0	-0.447	-0.306	-14	-8
2001	SJGS	TRC	1km	Variable [2]	v6.4	6	2	3.905	2.682	118	53	2.668	1.674	89	30	-1.237	-1.008	-29	-23
2001	SJGS Unit 1	TRC	1km	Variable [2]	v6.4	6	2	1.476	0.711	13	2	0.730	0.446	4	0	-0.746	-0.265	-9	-2
2001	SJGS Unit 2	TRC	1km	Variable [2]	v6.4	6	2	1.474	0.708	12	2	0.726	0.444	4	0	-0.748	-0.264	-8	-2
2001	SJGS Unit 3	TRC	1km	Variable [2]	v6.4	6	2	1.474	0.708	12	2	1.042	0.592	11	1	-0.432	-0.116	-1	-1
2001	SJGS Unit 4	TRC	1km	Variable [2]	v6.4	6	2	1.849	1.006	24	8	1.031	0.579	11	1	-0.818	-0.427	-13	-7
2001	SJGS	TRC	1km	ALM	v6.4	6	2	3.935	2.846	115	51	2.618	1.647	87	28	-1.317	-0.999	-28	-23
2001	SJGS Unit 1	TRC	1km	ALM	v6.4	6	2	1.117	0.534	9	1	0.678	0.357	4	0	-0.439	-0.177	-5	-1
2001	SJGS Unit 2	TRC	1km	ALM	v6.4	6	2	1.114	0.532	9	1	0.675	0.356	4	0	-0.439	-0.176	-5	-1
2001	SJGS Unit 3	TRC	1km	ALM	v6.4	6	2	1.401	0.918	23	6	0.892	0.591	10	0	-0.509	-0.327	-13	-6
2001	SJGS Unit 4	TRC	1km	ALM	v6.4	6	2	1.378	0.905	21	5	0.881	0.577	9	0	-0.497	-0.328	-12	-5

Table 5. Summary of Modeling Results for Mesa Verde for 2002.

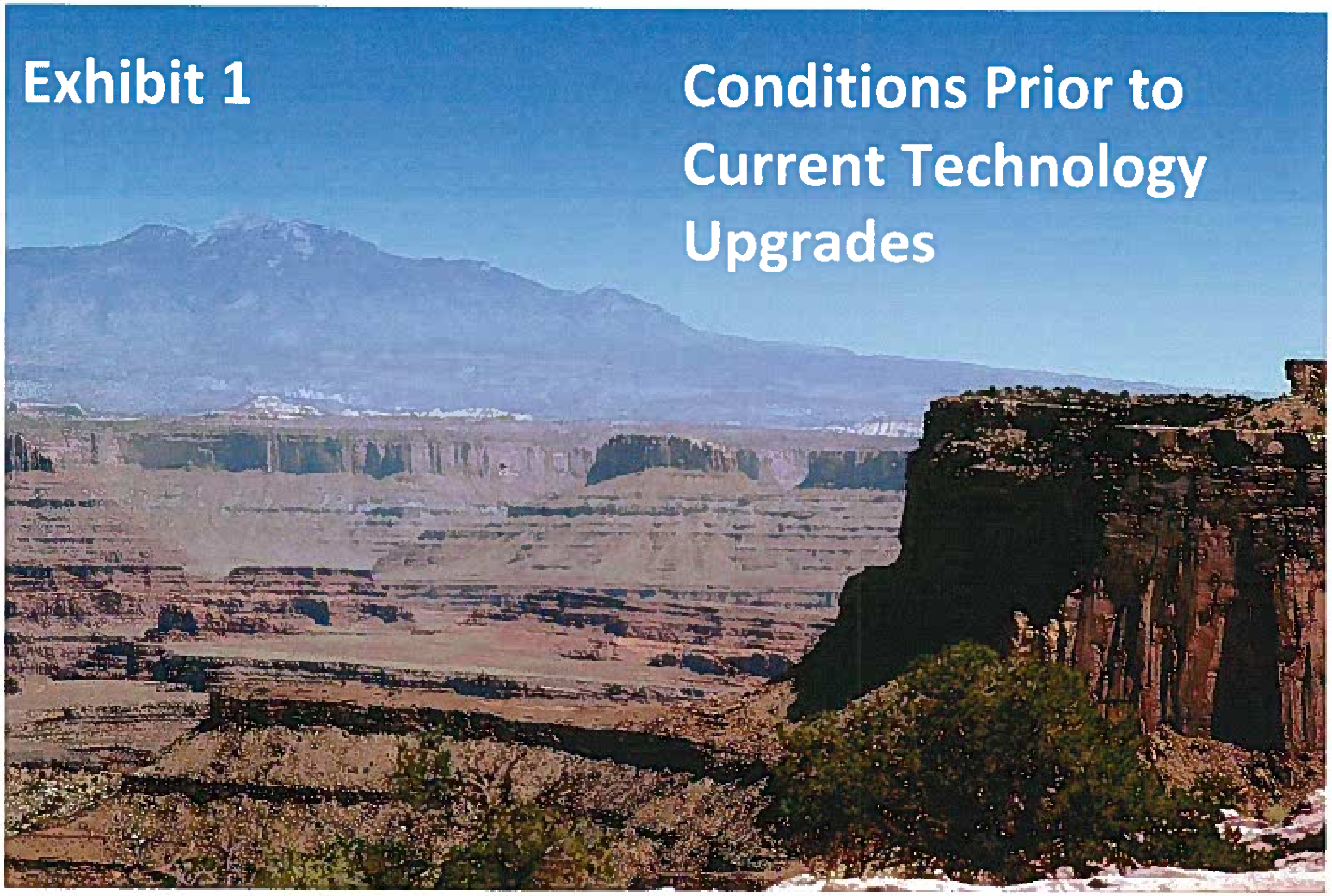
MESA VERDE NP								BASELINE				SCR w/SI							
YEAR	SCENARIO	DOMAIN	GRID SPACING	BCKG NH3	CALPUFF Version	MCHEM	MEQPHASE	Delta DV Rank 1	Delta DV Rank 8	Days w/Delta DV > 0.5	Days w/Delta DV > 1.0	Delta DV Rank 8	Delta DV Rank 8	Days w/Delta DV > 0.5	Days w/Delta DV > 1.0	Δ Delta DV Rank 1	Δ Delta DV Rank 8	Δ Days w/Delta DV > 1.0	Δ Days w/Delta DV > 0.5
2002	SJGS	B&V/State	4km	Variable [2]	v6.112	1	--	5.045	3.526	162	98	3.983	2.456	126	50	-1.062	-1.070	-36	-48
2002	SJGS Unit 1	B&V/State	4km	Variable [2]	v6.112	1	--	2.712	1.398	52	16	1.164	0.726	18	3	-1.548	-0.672	-34	-13
2002	SJGS Unit 2	B&V/State	4km	Variable [2]	v6.112	1	--	2.702	1.395	52	16	1.159	0.722	18	3	-1.543	-0.673	-34	-13
2002	SJGS Unit 3	B&V/State	4km	Variable [2]	v6.112	1	--	3.116	1.903	76	28	1.392	1.014	32	8	-1.724	-0.889	-44	-20
2002	SJGS Unit 4	B&V/State	4km	Variable [2]	v6.112	1	--	3.095	1.888	75	27	1.381	0.994	30	7	-1.714	-0.894	-45	-20
2002	SJGS	B&V/State	4km	ALM	v6.112	1	--	4.593	2.992	148	64	3.305	2.270	114	43	-1.288	-0.722	-34	-21
2002	SJGS Unit 1	B&V/State	4km	ALM	v6.112	1	--	1.305	0.897	25	4	0.830	0.589	9	0	-0.475	-0.308	-16	-4
2002	SJGS Unit 2	B&V/State	4km	ALM	v6.112	1	--	1.300	0.894	25	4	0.827	0.586	9	0	-0.473	-0.308	-16	-4
2002	SJGS Unit 3	B&V/State	4km	ALM	v6.112	1	--	1.584	1.053	49	9	1.093	0.744	24	2	-0.491	-0.309	-25	-7
2002	SJGS Unit 4	B&V/State	4km	ALM	v6.112	1	--	1.570	1.046	48	9	1.084	0.738	23	1	-0.486	-0.308	-25	-8
2002	SJGS	TRC	1km	Variable [2]	v6.112	1	--	4.650	3.197	139	79	3.070	2.432	93	40	-1.580	-0.765	-46	-39
2002	SJGS Unit 1	TRC	1km	Variable [2]	v6.112	1	--	2.174	1.265	41	12	0.880	0.696	13	0	-1.294	-0.569	-28	-12
2002	SJGS Unit 2	TRC	1km	Variable [2]	v6.112	1	--	2.165	1.262	41	12	0.876	0.693	13	0	-1.289	-0.569	-28	-12
2002	SJGS Unit 3	TRC	1km	Variable [2]	v6.112	1	--	2.395	1.614	65	20	1.175	0.896	23	3	-1.220	-0.718	-42	-17
2002	SJGS Unit 4	TRC	1km	Variable [2]	v6.112	1	--	2.377	1.604	66	20	1.160	0.893	23	3	-1.217	-0.711	-43	-17
2002	SJGS	TRC	1km	ALM	v6.112	1	--	4.300	2.869	120	56	2.820	2.121	83	33	-1.480	-0.748	-37	-23
2002	SJGS Unit 1	TRC	1km	ALM	v6.112	1	--	1.131	0.735	19	2	0.713	0.551	9	0	-0.418	-0.184	-10	-2
2002	SJGS Unit 2	TRC	1km	ALM	v6.112	1	--	1.126	0.732	19	2	0.710	0.548	9	0	-0.416	-0.184	-10	-2
2002	SJGS Unit 3	TRC	1km	ALM	v6.112	1	--	1.438	0.908	36	7	0.928	0.692	15	0	-0.510	-0.216	-21	-7
2002	SJGS Unit 4	TRC	1km	ALM	v6.112	1	--	1.418	0.897	36	7	0.915	0.692	13	0	-0.503	-0.205	-23	-7
2002	SJGS	B&V/State	4km	Variable [2]	v6.4	6	2	4.467	2.901	151	79	3.033	2.103	126	51	-1.434	-0.798	-25	-28
2002	SJGS Unit 1	B&V/State	4km	Variable [2]	v6.4	6	2	1.534	0.881	27	7	0.764	0.481	7	0	-0.770	-0.400	-20	-7
2002	SJGS Unit 2	B&V/State	4km	Variable [2]	v6.4	6	2	1.528	0.877	27	7	0.761	0.479	7	0	-0.767	-0.398	-20	-7
2002	SJGS Unit 3	B&V/State	4km	Variable [2]	v6.4	6	2	2.180	1.124	52	9	1.062	0.682	26	2	-1.118	-0.442	-26	-7
2002	SJGS Unit 4	B&V/State	4km	Variable [2]	v6.4	6	2	2.145	1.099	52	9	1.039	0.672	25	2	-1.106	-0.427	-27	-7
2002	SJGS	B&V/State	4km	ALM	v6.4	6	2	4.460	2.861	148	70	3.011	2.101	121	49	-1.449	-0.760	-27	-21
2002	SJGS Unit 1	B&V/State	4km	ALM	v6.4	6	2	1.212	0.817	22	3	0.762	0.464	7	0	-0.450	-0.353	-15	-3
2002	SJGS Unit 2	B&V/State	4km	ALM	v6.4	6	2	1.206	0.813	22	3	0.759	0.462	7	0	-0.447	-0.351	-15	-3
2002	SJGS Unit 3	B&V/State	4km	ALM	v6.4	6	2	1.562	0.994	44	7	1.007	0.652	25	1	-0.555	-0.342	-19	-6
2002	SJGS Unit 4	B&V/State	4km	ALM	v6.4	6	2	1.542	0.981	44	7	0.994	0.649	25	0	-0.548	-0.332	-19	-7
2002	SJGS	TRC	1km	Variable [2]	v6.4	6	2	4.396	2.703	126	60	2.954	2.035	91	35	-1.442	-0.668	-35	-25
2002	SJGS Unit 1	TRC	1km	Variable [2]	v6.4	6	2	1.732	0.781	21	4	0.721	0.515	9	0	-1.011	-0.266	-12	-4
2002	SJGS Unit 2	TRC	1km	Variable [2]	v6.4	6	2	1.727	0.777	21	4	0.718	0.513	9	0	-1.009	-0.264	-12	-4
2002	SJGS Unit 3	TRC	1km	Variable [2]	v6.4	6	2	2.032	0.974	39	6	0.955	0.659	15	0	-1.077	-0.315	-24	-6
2002	SJGS Unit 4	TRC	1km	Variable [2]	v6.4	6	2	2.006	0.955	39	6	0.940	0.652	15	0	-1.066	-0.303	-24	-6
2002	SJGS	TRC	1km	ALM	v6.4	6	2	4.385	2.642	120	52	2.930	1.956	84	34	-1.455	-0.686	-36	-18
2002	SJGS Unit 1	TRC	1km	ALM	v6.4	6	2	1.143	0.697	18	1	0.719	0.479	6	0	-0.424	-0.218	-12	-1
2002	SJGS Unit 2	TRC	1km	ALM	v6.4	6	2	1.138	0.694	17	1	0.715	0.477	6	0	-0.423	-0.217	-11	-1
2002	SJGS Unit 3	TRC	1km	ALM	v6.4	6	2	1.462	0.872	33	6	0.944	0.604	16	0	-0.518	-0.268	-17	-6
2002	SJGS Unit 4	TRC	1km	ALM	v6.4	6	2	1.441	0.857	33	6	0.931	0.609	14	0	-0.510	-0.248	-19	-6

Table 6. Summary of Modeling Results for Mesa Verde for 2003.

MESA VERDE NP								BASELINE				SCR w/SI							
YEAR	SCENARIO	DOMAIN	GRID SPACING	BCKG NH3	CALPUFF Version	MCHEM	MEQPHASE	Delta DV Rank 1	Delta DV Rank 8	Days w/Delta DV > 0.5	Days w/Delta DV > 1.0	Delta DV Rank 8	Delta DV Rank 8	Days w/Delta DV > 0.5	Days w/Delta DV > 1.0	Δ Delta DV Rank 1	Δ Delta DV Rank 8	Δ Days w/Delta DV > 1.0	Δ Days w/Delta DV > 0.5
2003	SJGS	B&V/State	4km	Variable [2]	v6.112	1	--	5.400	3.795	159	88	4.697	2.391	120	60	-0.703	-1.404	-39	-28
2003	SJGS Unit 1	B&V/State	4km	Variable [2]	v6.112	1	--	1.943	1.268	48	15	1.354	0.612	15	2	-0.589	-0.656	-33	-13
2003	SJGS Unit 2	B&V/State	4km	Variable [2]	v6.112	1	--	1.936	1.263	48	15	1.348	0.609	15	2	-0.588	-0.654	-33	-13
2003	SJGS Unit 3	B&V/State	4km	Variable [2]	v6.112	1	--	2.258	1.739	64	29	1.558	0.943	35	6	-0.700	-0.796	-29	-23
2003	SJGS Unit 4	B&V/State	4km	Variable [2]	v6.112	1	--	2.250	1.729	63	29	1.539	0.921	34	6	-0.711	-0.808	-29	-23
2003	SJGS	B&V/State	4km	ALM	v6.112	1	--	5.328	3.447	141	70	4.675	2.235	106	52	-0.653	-1.212	-35	-18
2003	SJGS Unit 1	B&V/State	4km	ALM	v6.112	1	--	1.521	0.854	28	5	1.289	0.513	9	1	-0.232	-0.341	-19	-4
2003	SJGS Unit 2	B&V/State	4km	ALM	v6.112	1	--	1.514	0.850	28	5	1.283	0.510	9	1	-0.231	-0.340	-19	-4
2003	SJGS Unit 3	B&V/State	4km	ALM	v6.112	1	--	1.835	1.235	43	15	1.509	0.822	22	3	-0.326	-0.413	-21	-12
2003	SJGS Unit 4	B&V/State	4km	ALM	v6.112	1	--	1.809	1.233	43	13	1.488	0.807	22	3	-0.321	-0.426	-21	-10
2003	SJGS	TRC	1km	Variable [2]	v6.112	1	--	4.633	3.646	130	70	3.948	2.437	93	47	-0.685	-1.209	-37	-23
2003	SJGS Unit 1	TRC	1km	Variable [2]	v6.112	1	--	1.636	1.190	38	12	1.251	0.591	10	1	-0.385	-0.599	-28	-11
2003	SJGS Unit 2	TRC	1km	Variable [2]	v6.112	1	--	1.630	1.186	38	12	1.246	0.589	10	1	-0.384	-0.597	-28	-11
2003	SJGS Unit 3	TRC	1km	Variable [2]	v6.112	1	--	2.277	1.613	56	22	1.271	0.948	26	5	-1.006	-0.665	-30	-17
2003	SJGS Unit 4	TRC	1km	Variable [2]	v6.112	1	--	2.249	1.597	56	21	1.253	0.939	26	4	-0.996	-0.658	-30	-17
2003	SJGS	TRC	1km	ALM	v6.112	1	--	4.571	3.192	107	58	3.925	2.198	87	38	-0.646	-0.994	-20	-20
2003	SJGS Unit 1	TRC	1km	ALM	v6.112	1	--	1.374	0.801	19	3	1.175	0.518	8	1	-0.199	-0.283	-11	-2
2003	SJGS Unit 2	TRC	1km	ALM	v6.112	1	--	1.368	0.798	19	3	1.169	0.515	8	1	-0.199	-0.283	-11	-2
2003	SJGS Unit 3	TRC	1km	ALM	v6.112	1	--	1.707	1.164	33	14	1.107	0.776	17	3	-0.600	-0.388	-16	-11
2003	SJGS Unit 4	TRC	1km	ALM	v6.112	1	--	1.673	1.141	33	14	1.134	0.763	17	3	-0.539	-0.378	-16	-11
2003	SJGS	B&V/State	4km	Variable [2]	v6.4	6	2	4.996	3.369	140	73	3.638	2.290	111	51	-1.358	-1.079	-29	-22
2003	SJGS Unit 1	B&V/State	4km	Variable [2]	v6.4	6	2	1.424	0.844	22	5	1.121	0.518	8	1	-0.303	-0.326	-14	-4
2003	SJGS Unit 2	B&V/State	4km	Variable [2]	v6.4	6	2	1.418	0.840	21	5	1.117	0.516	8	1	-0.301	-0.324	-13	-4
2003	SJGS Unit 3	B&V/State	4km	Variable [2]	v6.4	6	2	2.116	1.186	41	16	1.200	0.785	20	2	-0.916	-0.401	-21	-14
2003	SJGS Unit 4	B&V/State	4km	Variable [2]	v6.4	6	2	2.097	1.165	39	15	1.192	0.775	19	2	-0.905	-0.390	-20	-13
2003	SJGS	B&V/State	4km	ALM	v6.4	6	2	4.982	3.235	138	71	3.608	2.169	112	51	-1.374	-1.066	-26	-20
2003	SJGS Unit 1	B&V/State	4km	ALM	v6.4	6	2	1.233	0.734	17	2	1.007	0.492	7	1	-0.226	-0.242	-10	-1
2003	SJGS Unit 2	B&V/State	4km	ALM	v6.4	6	2	1.227	0.731	17	2	1.003	0.490	7	1	-0.224	-0.241	-10	-1
2003	SJGS Unit 3	B&V/State	4km	ALM	v6.4	6	2	1.794	1.116	40	10	1.132	0.710	19	2	-0.662	-0.406	-21	-8
2003	SJGS Unit 4	B&V/State	4km	ALM	v6.4	6	2	1.769	1.100	38	10	1.116	0.700	19	2	-0.653	-0.400	-19	-8
2003	SJGS	TRC	1km	Variable [2]	v6.4	6	2	4.497	3.093	111	62	3.270	2.066	92	36	-1.227	-1.027	-19	-26
2003	SJGS Unit 1	TRC	1km	Variable [2]	v6.4	6	2	1.371	0.744	16	4	1.105	0.451	5	1	-0.266	-0.293	-11	-3
2003	SJGS Unit 2	TRC	1km	Variable [2]	v6.4	6	2	1.367	0.740	16	4	1.102	0.449	5	1	-0.265	-0.291	-11	-3
2003	SJGS Unit 3	TRC	1km	Variable [2]	v6.4	6	2	1.830	1.100	37	11	1.112	0.694	15	2	-0.718	-0.406	-22	-9
2003	SJGS Unit 4	TRC	1km	Variable [2]	v6.4	6	2	1.800	1.072	35	11	1.087	0.688	15	2	-0.713	-0.384	-20	-9
2003	SJGS	TRC	1km	ALM	v6.4	6	2	4.493	3.078	111	57	3.237	2.066	91	34	-1.256	-1.012	-20	-23
2003	SJGS Unit 1	TRC	1km	ALM	v6.4	6	2	1.195	0.706	15	2	0.978	0.447	5	0	-0.217	-0.259	-10	-2
2003	SJGS Unit 2	TRC	1km	ALM	v6.4	6	2	1.191	0.703	15	2	0.973	0.445	5	0	-0.218	-0.258	-10	-2
2003	SJGS Unit 3	TRC	1km	ALM	v6.4	6	2	1.871	1.042	34	9	1.051	0.700	15	1	-0.820	-0.342	-19	-8
2003	SJGS Unit 4	TRC	1km	ALM	v6.4	6	2	1.837	1.033	31	8	1.028	0.694	15	1	-0.809	-0.339	-16	-7

Attachment F: Comparison of Visibility Improvements Expected with Different NO_x Control Technologies at San Juan Generating Station

It's All About ***VISIBILITY!***



Canyonlands National Park

BV Pre-Consent Decree

PNM

It's All About ***VISIBILITY!***

Canyonlands National Park

BV Baseline

PNM

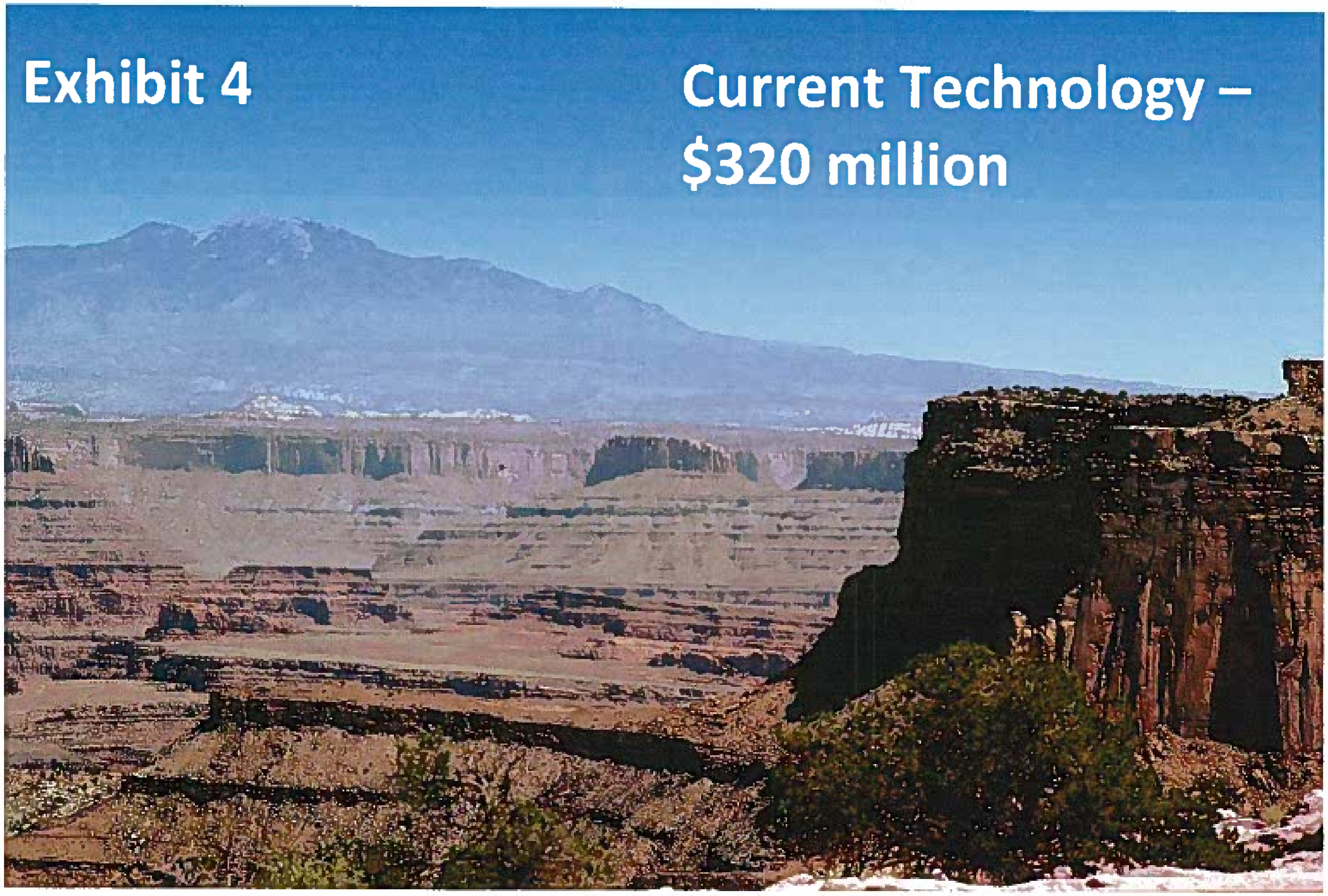
*It's All About **VISIBILITY**!*

Canyonlands National Park

BV SCR with Sorbent

PNM

It's All About ***VISIBILITY!***



Canyonlands National Park

EPA with Basecase

PNM

It's All About ***VISIBILITY!***

Canyonlands National Park

EPA with SCR

Major Emissions Reductions at San Juan

Exhibit 6